

# Introduction

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The rapid decline in the cost of storage, computation, and transmission of data has changed how many businesses operate and how many kinds of products and services are sold. It has also led to the arrival of new products, new services, and new ways of doing business. Increasingly, economic activity is digital.

There is a small and growing literature that explores the impact of digitization in a variety of contexts, but its economic consequences remain poorly understood. This volume aims to set an agenda for future research in the economics of digitization. Each chapter identifies a promising area of research. While no one volume can be comprehensive, the objective is to identify topics with some research already underway that warrant further exploration from economists.

Of the various technology drivers enabling the rise of digital technology, growth in digital communication – particularly the internet – has played a central role. Not surprisingly, therefore, this book emphasizes research on internet-related phenomena and its economics. There are several reasons why it is constructive to focus a volume on one particular set of technologies. In addition to the growing importance of digitization, digital technologies have some features that suggest that many well-studied economic models may not apply. Digital products and services have very low marginal costs of production and distribution. Digital markets are often easy to enter. Digital technologies often complement skilled labor more than unskilled labor. Low communications costs, even over long distances, create opportunities for new marketplaces if they can overcome information asymmetries between buyers and sellers. Search costs are low. Public goods can be consumed by hundreds of millions of people. Digital information can be stored easily and aggregated to improve measurement, but also to create challenges to privacy and security.

While these features do not generally require fundamentally new economic models, they do require more than simply taking theoretical and empirical results from other markets and assuming the implications will be the same. Many policies that have been settled for many years seem poorly adapted to digital markets. Firms and governments have struggled to apply copyright, privacy, security, and antitrust regulations to the digital context.

The chapters in this volume emphasize many open questions. The first set of chapters discusses the basic supply and demand for internet access. The next set of chapters discusses various ways in which digitization reduces economic frictions and creates new opportunities and challenges for business. The final set of chapters lays out some policy challenges that these opportunities and challenges create.

## Internet Supply and Demand

The internet is not a single piece of equipment with components from multiple suppliers. It is a multilayered network in which different participants operate different pieces. Originally, the 'internet' referred to the networking technology that enables computer networks to communicate, but it has now come to mean also the combination of standards, networks, and applications (such as streaming and file-sharing) that have accumulated around the networking technology.

Internet technology has evolved through technological competition. Many firms possess in-house technical leadership that enables them to develop and sell components and services that are valuable to computer users. Firms that do not possess such capabilities can acquire them through the market, for example by hiring a small team of qualified engineers. Bresnahan and Greenstein (1999) call this feature of market structure 'divided technical leadership,' contrasting it with earlier eras in which a single firm controlled the vast majority of inputs near the technical frontier.

Computing market segments are typically defined by 'platforms', which Bresnahan and Greenstein define as "a reconfigurable base of compatible components on which users build applications." Platforms are identified by a set of technical standards, or by engineering specifications for compatible hardware and software. The emergence of platforms with many stakeholders (including firms, academics, and non-profits) increased the importance of organizations that design standards and platforms: Standard-setting committees (Mowery and Simcoe, 2002; Simcoe, 2013). The key standard-setting committees for the internet, such as the Internet Engineering Task Force (IETF), the Institute for Electrical and Electronics Engineers (IEEE), and the World Wide Web Consortium (W3C), made decisions that shaped much of the equipment that underlies the internet, with the IETF shaping the infrastructure layer, the IEEE local area network and wireless communications, and the W3C shaping the web-based software and applications layer.

The essay by **Simcoe** (Chapter 1) examines the role of modularity in shaping technological competition and specialization. The chapter offers an empirical examination of the consequences of the internet architecture, using data from the IETF and W3C. Both organizations adopted modular

architectures, which produced specialized division of labor in designing and operating protocols. The paper analyzes citations between internet standards as further evidence of this specialization. Such specialization is the key to avoiding diminishing marginal returns in scaling up these networks. Modularity helps these technologies adapt to new circumstances and heterogeneous applications, helping them deploy more widely. This particular approach arises frequently with digital technologies and, the chapter argues, warrants attention as a fundamental feature of the digital economy.

In his comments Timothy Bresnahan stresses that modularity should be distinguished from openness. The former is a partitioning of the technical architecture, while the latter arises from the policies and actions of those involved with commercialization. Openness involves the design of organizing processes that make information accessible to others without restriction. Bresnahan stresses these two aspects of the TCP/IP commercial experience, and argues that these processes turned TCP/IP into what it is today, a prominent example of a modular design and successful commercialization without proprietary interest. That leads Bresnahan to raise questions about platform governance and the evolution of general-purpose technologies. In his view, Simcoe's chapter illustrates a major unaddressed question in digitization economics, namely, why processes that depart from strict contractual approaches have had a successful historical record. Bresnahan concludes that Simcoe's chapter teaches us about the role of *ex post* flexibility in the design of processes for commercialization. Modularity's value, therefore, depends on more than merely the specialization that it permits, but also the institutional processes that guide the specialists. In that sense, Bresnahan shows that Simcoe has introduced the reader to a potentially rich new agenda.

Many fundamental questions remain open. Competition between platforms determines prices for customers deciding between platforms, and divided technical leadership shapes the supply of vendor services that build on top of a platform. How does such competition shape the division of returns within a platform? How do these two margins differ when a third type of participant, such as an advertiser, plays an important role in creating market value for the platform? If platforms differentiate in terms of their capabilities and approaches to generating revenue, does that alter the composition of applications? If platforms develop in collective organizations, what type of firm behavior shapes participation in standards committees? How do these incentives shape the direction of innovation in markets connecting multiple platforms? These are rich areas for additional research, and some of the following chapters also touch on these questions.

In addition to understanding how the technology evolved, how the infrastructure was built, and how decentralized platforms develop standards, it is also important to understand demand for digital

technology. Without an understanding of the value of the technology to users, it is difficult to tease out policy implications. Several recent studies have examined demand for services. For example, Greenstein and McDevitt (2011) examine the diffusion of broadband internet and its associated consumer surplus, by looking at revenue of internet service providers over time. Rosston et al (2011) use survey data to estimate household demand.

**Wallsten (Chapter 2)** examines the micro-behavior comprising demand to look at what people do when they are online. The chapter provides detailed insight into the debate about how the internet has changed lives, particularly in households, where many of the changes involve the allocation of leisure time. Often these changes involve the allocation of time or other assets that lack prices and do not necessarily show up in GDP statistics. The chapter shows how some online activities, such as obtaining news, are new ways of doing old activities. Some new activities, like social media, have an opportunity cost in terms of the activities they crowd out. The chapter is also novel for its use of the American Time Use Survey from 2003 – 2011 to estimate the crowdout effects. That data shows that time spent online and the share of the population engaged in online activities has been steadily increasing after 2000. At the margin, each minute of online leisure time is correlated with 0.29 fewer minutes on all other types of leisure, with about half of that coming from time spent watching TV and video, 0.05 minutes from (offline) socializing, 0.04 minutes from relaxing and thinking, and the balance from time spent at parties, attending cultural events, and listening to the radio. Each minute of online leisure is also correlated with 0.27 fewer minutes working, 0.12 fewer minutes sleeping, 0.10 fewer minutes in travel time, 0.07 fewer minutes in household activities, and 0.06 fewer minutes in educational activities. The findings show how allocation of leisure time has changed, and suggest that any valuation of these changes must account for both opportunity costs and new value created, both of which are hard to measure.

Chris Forman's discussion of Wallsten's chapter emphasizes a household's tradeoff in terms of opportunity costs and links it to prior literature on the implications of online behavior on offline markets. The discussion suggests opportunities for future research to leverage differences across locations in order to understand how the relative value of the internet varies with the availability of offline substitutes.

Many open questions remain. If internet use changes the allocation of leisure time, then what about the converse? How do changes in leisure time (for example, over the life cycle) affect internet use and demand for internet access? Does wireless access and ubiquitous connectivity (for example, in transit) change the relative benefit of internet use for particular applications? How do particular applications (e.g. social networks, online shopping) affect the adoption and usage intensity of wireless

and wireline internet by consumers and businesses? Will improvements in technology, such as speed and memory, change demand and spill over into other areas of economic activity? How do these changes in demand reshape the allocation of supply? Many of these issues will arise in later chapters, especially because public policy shapes copyright and other legal features of the markets.

## **Digitization, Economic Frictions, and New Markets**

Among the major themes in the literature on digitization is an assessment of how it changes economic transactions. In particular, the literature identifies a variety of economic frictions that are increased or decreased as a consequence of digitization.

Much of the literature on digitization has emphasized the impact of the cost of storage, computation, and transmission of data on the nature of economic activity. In particular, technology makes certain economic transactions easier, reducing several market frictions. This could lead to increased market efficiency and increased competition. At the same time, if the technology reduces some frictions but not others, it could distort market outcomes, helping some players and hurting others.

Perhaps the oldest and largest stream of this research on the internet and market frictions emphasized reduced search costs. This literature, still going strong, builds on an older theory literature in economics (Stigler, 1961; Diamond, 1971; Varian, 1980; etc.) that examines how search costs affect prices. This older literature showed that prices and price dispersion should fall when search costs fall. Digitization of retail and marketing meant that consumers could easily compare prices across stores, so the empirical work on internet pricing examined the impact on prices and price dispersion. Initially hypothesized by Bakos (1997), the first wave of this research documented lower prices, but still substantial dispersion (Brynjolfsson and Smith 2000, Baye, Morgan, and Scholten 2004, Ellison and Ellison 2009).

**Baye, De los Santos, and Wildenbeest (chapter 3)** dig into online search to examine the actual search process that consumers undertake when looking for a product online. They focus on the question of how consumers search for books and booksellers online. This is of itself an interesting topic, both because books have often been the focus of studies that explore the “long tail” and because there have been policy concerns about how the online sales of books has affected offline channels. An extreme example of this has been the recent crackdown in France on Amazon combining discounts of 5% with free shipping, in an effort to protect local booksellers.

The chapter's authors find that increasingly the focus of book search has been conducted on proprietary systems such as Amazon's Kindle and Barnes and Noble's Nook rather than consumers searching on general search engines such as Google or Bing. This emphasizes that though many analysts tend to think of search engines such as Google or Bing as the major pathway to product purchases online, often the final stage of purchase is controlled by a more familiar retail environment. This result also emphasizes the growing importance of standards and platforms in the distribution of creative content.

A third stream of research around digitization emphasizes that it has become cheap to store and process information. This massive influx of data, combined with improvements in the tools for data analysis, has created new opportunities for firms and policymakers. The economics literature on the opportunities presented by data analysis of this kind is relatively sparse. Goldfarb and Tucker (2012) describe the opportunities with respect to online advertising; Einav and Levin (2013) describe the opportunities for economics researchers; and Brynjolfsson, Hitt, and Kim (2011) document that companies that use data do better.

Two different chapters in this book emphasize the opportunity provided by data. In the policy section below, we will discuss two other chapters that emphasize the challenges created by ubiquitous data. Just as predicting the weather had profound consequences for much economic activity, such as agriculture, better prediction of a wide range of economic activity could generate profound economic gains for many participants in the economy. **Wu and Brynjolfsson (chapter 4)** highlight the potential of online data to predict business activity, and illustrate that potential. They demonstrate a simple but accurate way to use search data to predict market trends and apply the method to the housing market. After showing the predictive power of their method, they suggest several directions for future work regarding the potential of detailed data to help consumers, businesses, and policymakers improve decision-making.

**Scott and Varian (chapter 5)** also highlight the potential of online data to improve the information that goes into decision-making. Rather than prediction, they emphasize "nowcasting", or the ability of online data in general (and search data in particular) to provide early signals of economic and political indicators. They develop an approach to deal with one of the main challenges in using online data for prediction: there are many more potential predictors than there are observations. Their method helps identify the key variables that are most useful for prediction. They demonstrate the usefulness of the method in generating early measures of consumer sentiment and of gun sales.

A third stream of this research has emphasized that near-zero marginal costs of distribution for information goods might change where and how information goods get consumed. Geographic boundaries might be less important if information can travel long distances for free (Sunstein 2001, Sinai and Waldfodell 2004, Blum and Goldfarb 2006). The impact of low distribution costs might vary by location, with locations with fewer offline options generating a larger benefit from digitization (Balasubramanian 1998; Forman, Ghose, and Goldfarb 2009; Goldfarb and Tucker 2011a).

**Gentzkow and Shapiro (ch 6)** explore the potential of near-zero marginal costs of distribution to affect political participation and the nature of news consumption. In particular, they ask whether technology-driven reductions in the costs of news distribution, both within and across geographic boundaries, affect the diversity of media production and consumption. Digital media could increase the diversity of news consumption because it enables inexpensive access to a broad range of sources; digital media could decrease the diversity of news consumption because it may permit specialized outlets that serve niche tastes that are not viable when physical production costs are high or when demand is limited to a geographically localized market. They estimate demand and model the supply of media. Complementing their descriptive work in Gentzkow and Shapiro (2011), they find that ideological segregation is low online, both in absolute terms and relative to other media channels. They then build a structural model and describe how it could be used to evaluate the impact of changing tastes or technology. This contribution addresses the fear often expressed surrounding the digitization of news content, that it will exacerbate existing political divisions as consumers access only content that supports their existing political ideology. The work of these authors does not stoke these fears. Their findings suggest that those who have niche tastes in news are still obtaining the majority of their news content from mainstream sources.

**Agrawal, Horton, Lacetera, and Lyons (ch 7)** examine online markets for contract labor, another area in which digitization reduces frictions. In particular, digitization makes it easier for an employer to hire someone for information-related work without ever meeting the employee in person. If the work can be described digitally, completed off site, and then sent back to the employer digitally (such as with computer programming), then there might be an opportunity for long-distance North-South trade in skilled labor. The key challenges relate to information asymmetries regarding the quality of the employee and the trustworthiness of the employer. The chapter discusses the role of online platforms to reduce these information asymmetries, thereby changing the types of contract labor transactions that are feasible online. The authors show evidence that online contract labor is a rapidly growing market, that such markets often facilitate contracts over long distances, and that market design plays an

important role. They lay out a clear research agenda around the key players, their incentives, and the potential welfare consequences of this market. Stanton's discussion [chapter xxx] extends the agenda behind this finding. His discussion speculates on whether the digitization of labor relationships enables labor outsourcing to other countries even without a platform intermediary.

The Agrawal et al. chapter also extends a fourth stream of research related to frictions and digitization, the potential for new markets and new business models that take advantage of the lower frictions. Many successful internet firms provide platforms that facilitate exchange, including eBay, Monster, Prosper, and oDesk. This is another channel through which digitization has restructured the supply of services. New policies – such as for copyright, privacy, and identity protection – directly shape firm incentives by shaping the laws that apply to these new business models. Several other chapters also touch on these themes.

Addressing an important policy issue for governments, **Gans and Halaburda (chapter 8)** discuss the potential of digitization to create markets for private currencies that support activities on a particular platform, seemingly bypassing state-sponsored monetary authorities. They focus on the viability of the market for private digital currencies with non-currency-specific platforms and speculate on the potential for a privacy-oriented entity to launch a real currency to compete with government-backed currencies such as the dollar and the euro. They lay out a model in which a platform currency offers 'enhancements' to people who spend time on the platform. People allocate time between working and using the platform. They show that platforms have little incentive to allow users to exchange at full convertibility private digital currency for government-backed currency, though they do have an incentive to allow users to buy the private currency with government-backed currency. Although they can be an important tool for platforms to enhance value to their users, they conclude that private currencies in support of a platform are unlikely to have implications beyond the platform.

For many pure information goods, online platforms link readers to advertisers. Given the challenges of protecting online information content from being shared (a topic we discuss below in the context of policy), advertising has become an important source of revenue for many providers of pure information goods. Because of this, it is important to understand how online advertising works in order to understand the opportunities and challenges faced by providers of digital information goods. Goldfarb and Tucker (2011b) emphasize that online advertising is better-targeted and better-measured because of the ease of data collection.

The study of online advertising continues to attract attention because this is the principal means for generating revenues in much of the internet eco-system. Most of the content on the internet and



many of the services (such as search or social networking) rely on advertising revenues for support. So far, the internet eco-system has been incredibly successful in using advertising revenues to support a vast quantity of content. **Lewis, Rao, and Reiley (chapter 9)** discuss the methods used for measuring the effects of advertising. To do this, they draw on their previous and current work which has used multiple field experiments to try and measure how effective online display advertising is at converting eyeballs into actual incremental sales. They emphasize that an important challenge to the accurate measurement of advertising is the high noise-to-signal ratio. In particular, the variance of purchasing behavior is so large that it makes it difficult to measure precisely the impact of advertising on purchasing. The authors highlight the limitations of current methods and then speculate on the potential of new technology to overcome some of these limitations. This chapter suggests that as clients become increasingly sophisticated about measurement, this revenue source may be called into question.

Before concluding this section, we want to mention several important topics related to these topics but not emphasized in the chapters. In particular, other promising research programs include, but are not limited to, rating mechanisms and quality signals (e.g. Cabral and Hortaçsu 2010; Jin and Kato 2007; Chevalier, Dover, and Mayzlin 2013), user generated content and the provision of public goods (e.g. Zhang and Zhu 2011; Greenstein and Zhu 2012), niche products and superstar effects (e.g. Brynjolfsson, Hu, and Smith 2003; Fleder and Hosanagar 2009; Bar Isaac, Caruana, and Cunit 2012), online banking and finance (e.g. Agrawal, Catalini, and Goldfarb 2013; Rigbi 2013; Zhang and Liu 2012), and skill-biased technical change and the organization of work (e.g. Autor 2001; Garicano and Heaton 2010). In other words, this is a big and growing area of research, where much remains to be done.

## Government Policy and Digitization

Increasing digitization has implications for policy, but the literature on the impact of digitization on policy is still in its infancy. As hinted above, ubiquitous data yields new challenges to privacy and security that policymakers need to address (e.g. Goldfarb and Tucker 2012, Miller and Tucker 2011, Arora et al 2010). Near-zero marginal costs of distribution and the non-rival nature of digital goods pose challenges to copyright policy (e.g. Rob and Waldfogel 2006, Oberholzer-Gee and Strumpf 2007). The ease with which digital goods can be transferred over long distances and across borders might affect tax policy (e.g. Goolsbee 2000), financial regulation (e.g. Agrawal, Catalini, and Goldfarb 2013), and trade policy (Blum and Goldfarb 2006).

Privacy and data security are an area where digitization has substantially changed the costs and benefits to various economic actors. The current policy structure was implemented in a different

regime, when data sharing was costly and data security was not an everyday concern. It is important to assess whether such laws match with the needs of a digital era in which everyone is of sufficient interest (relative to costs) to warrant data tracking by firms and governments.

**Komarova, Nekipelov, and Yakovlev** (ch 10) make an important contribution. They combine a technically rich approach to econometrics with the question of how researchers, and research bodies who share data with those researchers, can protect the security and privacy of the people in the data. This is important because, all too often, researchers are unable to make use of the increasing scale and detail of datasets collected by government bodies because access is restricted due to unspecified privacy and data security concerns. This means that potentially many important research questions are being left unanswered, or are being answered using less adequate data, because of our technical inability to share data without creating privacy concerns. The authors develop the notion of the risk of 'statistical partial disclosure' to describe the situation where researchers are able to infer something sensitive about the individual by combining public and private data sources.

They use an example from Russian data that asks potentially sensitive questions on health and background but from which location information has been removed. As a motivating research question, they study the effect of the religious affiliation of the neighborhood on the decision of a parent to vaccinate. They explore the extent to which they are able to recover the location of the individual from the provided demographic data and show an empirical relationship between the decision to vaccinate and the number of Muslim families in the neighborhood. This example illustrates the main technical points they make in the paper. In particular, it emphasizes there is a risk to individual privacy due to researchers' ability to combine multiple anonymized datasets. However, beyond that, they also suggest that there are ways that data-gathering research bodies can minimize such risks by adjusting the privacy guarantee level.

**Mann (ch 11)** looks at the question of data security. She provides several frameworks for analyzing how the question of data breaches should be evaluated in economic terms. She argues that markets for data security are incomplete and suggests that a good market analog to consider is the market for pollution. This market similarly is characterized by negative economies of scale, asymmetric information and systematic uncertainty. She also provides useful data to calibrate just how large the problem of data breaches actually is, and why breaches tend to occur. Interestingly, despite policy emphasis on external threats such as hacking and fraud, most breaches occur because of carelessness on the part of the data curator. She emphasizes that typically the number of records involved in a data breach is surprisingly small, and that many data breaches stem from the medical sector, though the data

breaches which involve the release of a social security number are often from retail. She concludes by emphasizing the complexity introduced into the issue by question of international jurisdiction.

Miller's discussion of Mann (ch xx) provides a useful synthesis of other literature on this topic. She focuses on the extent to which traditional policy making on data security issues can backfire if it distorts incentives. For example, emphasizing the need for encryption to firms can lead firms to focus only on external outsider threats to data and ignore internal threats to the security data of data from employee fraud or incompetence. She also points to the difficulty of making policy recommendations about differences in US and EU approaches to data security when there is so far scant information about the relative perceived costs to firms and consumers of data breaches.

A second area of policy interest concerns intellectual property. The digitization process resembles the creation of an enormous free photocopier that can almost costlessly duplicate any creative endeavor. Varian (2005) supplies a theoretical framework for thinking about this change from an economics perspective. Usually, the economic effect on copyright-holders in the context of free copying is considered to be negative. However, this chapter suggests an important counter-argument. If the value a consumer puts on the right to copy is greater than the reduction in sales, a seller can increase profits by allowing that right. This chapter also provides a detailed description of several business models which potentially address the greater difficulty of enforcing copyrights as digitization increases. These models span strategies based on: Balancing prices, selling complementary goods, selling subscriptions, personalization, and supporting the good being sold through advertising. Empirical research has not reached the point of having established a set of accepted facts about the merits or demerits of these different strategies, which the earlier sociological and political science literature has discussed in broad terms (Castells, 2003).

This volume provides a sample of the range of new thinking in this area. It complements existing work on the effect of the digitization of music downloads on copyright holders, such as Rob and Waldfogel (2006), Hong (2007), and Oberholzer-Gee and Strumpf (2007).

**McGarvie and Moser** (ch 12) provides a study addressing an argument often made by proponents of stronger copyright terms. Due to the scarcity of data about the profitability of authorship under copyright, they go to historical events to discover whether a historical episode that increased copyright terms did, in fact, encourage creativity by increasing the profitability of authorship. Their historical study also encounters a setting with much shorter copyright lengths than our current copyright length of 70 years after the author's death. That is an advantage, since further extensions today – beyond 70 – may not have any effects on the profitability of authorship, whereas in their study further extensions could

have major consequences. The chapter introduces a new data set of publishers' payments to authors of British fiction between 1800 and 1830. These data indicate that payments to authors nearly doubled following an increase in the length of copyright in 1814. These findings are consistent with the argument that strengthening copyright terms may, in fact, increase the profitability of authorship in settings where the pre-existing levels of protection are quite low.

Further exploring themes related to copyright's influence on the incentives to distribute creative works, this volume also includes a chapter by **Danaher, Dhanasobhon, Smith, Taleng** (ch 13). It examines the research about the erosion of copyright caused by internet file-sharing. Digitization has created many new opportunities to empirically analyze open questions by leveraging new data sources. This chapter discusses methodological approaches to leverage the new data and natural experiments in digital markets to address these questions. The chapter closes with a specific proof-of-concept research study that analyzes the impact of legitimate streaming services on the demand for piracy. The chapter uses ABC's decision to add its content to Hulu.com as a natural experiment and show that it resulted in an economically and statistically significant drop in piracy of that content.

**Waldfoegel** (ch 14) explores another side to these questions, incentives to create music. Revenue for recorded music has collapsed since the explosion of file sharing, and, yet, argues Waldfoegel, the quality of new music has not suffered. He considers an explanation that stresses changes on the supply-side, namely, that digitization has allowed a wider range of firms to bring far more music to market using lower-cost methods of production, distribution, and promotion. Prior to the supply change, record labels found it difficult to predict which albums would find commercial success. In that situation many released albums necessarily would fail, and, relatedly, many nascent but unpromoted albums might have been successful. After the change in supply conditions, the increasing number of products released would allow consumers to discover more appealing choices if they can sift through the offerings. The chapter argues that digitization is responsible for such a supply shift. Waldfoegel argues that internet radio and a growing cadre of online music reviewers provide alternatives to radio airplay as means for new product discovery. The chapter assembles data on new works of recorded music released between 1980 and 2010, along with data on particular albums' sales, airplay on both traditional and internet radio, and album reviews at Metacritic since 2000. The evidence shows that despite a substantial drop in major-label album releases, the total quantity of new albums released annually has increased sharply since 2000, driven by independent labels and purely digital products. Increased product availability also has been accompanied by a reduction in the concentration of sales in the top albums. Consistent with the argument, new information channels – Internet radio and online criticism – change the number and

kinds of products about which consumers have information. In the most recent experience, increasing numbers of albums find commercial success without substantial traditional airplay. Finally, albums from independent labels – which previously might not have made it to market – account for a growing share of commercially successful albums.

Despite a long history of piracy software markets, researchers have not been able to assemble informative data about the phenomenon, much less their causes. **Athey and Stern (chapter 15)** make a novel contribution by analyzing data that permits direct measurement of piracy for a specific product – Windows 7. They are able to use anonymized telemetry data to characterize the ways in which piracy occurs, the relative incidence of piracy across different economic and institutional environments, and the impact of enforcement efforts on choices to install pirated versus paid software. The chapter has several provocative new observations. For example, most piracy in this setting can be traced back to a small number of widely distributed “hacks” that are available through the internet. Despite the availability of these hacks to any potential internet user, they do not get used everywhere. The microeconomic and institutional environment appears to play a crucial role in fostering or discouraging piracy. Moreover, it tends to focus on the most “advanced” version of Windows (Windows Ultimate). The chapter lays out a broad agenda for this area of research. After controlling for a small number of measures of institutional quality and broadband infrastructure, one important candidate driver of piracy – GDP per capita – has no significant impact on the observed piracy rate. Instead, the innovation orientation of an economy is associated with a lower rate of piracy. They also find no systematic evidence that enforcement efforts against peer-to-peer networks have had an impact on the incidence of software piracy.

As should be evident from these chapters, many open policy questions remain. Questions about the role of policy in determining copyright rules, privacy norms, and security practices arise in many markets for digital goods and services. Questions about the principles for redesigning these policies also remain elusive. We hope this book motivates further investigation into the economics underlying these policy issues.

## Conclusions

Digitization enables outcomes that were not possible a few decades earlier. It not only reduces existing costs, but has also enabled the development of new services and processes that did not exist before because they were just too costly or merely technologically infeasible. The opportunities generated by digitization have generated dramatic resource reallocation, and restructuring of routines,

market relationships, and patterns of the flow of goods and services. This in turn has led to a new set of policy questions and made several existing policy questions more vexing.

Overall, we emphasize that the agenda of open questions in the economics of digitization touches a large and wide ranging part of economic activity. It also continues to be of first-order importance to understanding economic prosperity and for many unsettled issues in public policy.

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