# Improving Market Performance in the Digital Economy

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**Abstract**. The digital economy has substantially reduced market frictions but also posed new challenges for the efficient functioning of markets. In particular, the drastic reductions of costs for search, entry, transportation, and reproduction have profound implications on the role of platforms, the value of innovation, and the balance between firms' data needs and consumer privacy. I review some recent economic research that sheds light on these issues, and discuss how well-designed policies on competition, regulation, IP protection, and consumer privacy can improve market performance in the digital economy.

**Key words**: Digital economy, digitization, platforms, search, innovation, data protection, privacy

**JEL Classification Number**: D2, D8, L86, O3

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# 1. INTRODUCTION

The "digital economy" is sometimes defined narrowly as economic activities in the information and communication technology (ICT) sector, which includes telecommunications, the Internet, IT services, hardware and software. The broad definition of the digital economy includes the combined value of ICT production and digital inputs to the rest of the economy. Because of the differences in the defintion, there are different estimates about the size of the digital economy. In 2017, the narrowly-defined digital economy accounted for about 6.9 percent of the GDP in the U.S., 6 percent of the GDP in China, and 4.5 percent of the GDP in the global economy; whereas based on the broad definition, the respective numbers were 21.6 percent in the U.S., 30 percent in China, and 15.5 percent globally (2019 Digital Economy Reprot, United Nations). Despite the differences in the definition and measurement, there is no doubt that the digital economy is impacting every aspect of our lives. In fact, if we consider the digital economy as encompassing all economic activities that use or are facilitated by digitized data, then it is essentially the entire economy.[1]

New digital technology and the Internet have drastically reduced the costs of search, entry, transportation, and reproduction, unleashing enormous potentials for enhancing economic efficiency (Goldfarb and Tucker, 2019). At the same time, these cost changes raise new challenges for the organization of markets, especially because of their profound impacts on the role of platforms, the value and protection of innovation, and the trade off between firms' data usage and consumer privacy. In this paper,

[1]The transformational impact of digitalization can also be seen from the changing composition of the top 20 companies in the world. Among them, measured in market capitalization, the percentage of technology and consumer services rose from 16% in 2009 to 56% in 2018, while the oil and gas and mining sector fell from 36% to 7% over the same period. Four of the top 10 firms in 2018 were not even among the top 100 in 2009: Amazon, Alibaba, Facebook and Tencent (2019 Digital Economy Reprot, United Nations).

I review the insights from some recent studies on the opportunities and challenges in the digital economy, especially on issues related to platforms, innovation, and consumer data, and discuss how well-designed policies can improve market performance.

One crucial feature of the digital economy is the growing importance of platforms and platform-enabled products/services. A platforms is basically an intermediary for transactions. With the reduction in consumer search cost on the Internet, one might think that there is diminished need for intermediaries. However, the Internet has also substantially lowered entry and consumer search costs, which has greatly expanded the size of markets and increased the number of firms a consumer can access. The lower entry cost may also lead to a reduction of average firm quality in the market, as entry becomes profitable also for low-quality firms. Platforms thus become especially valuable as information intermediaries in the digital economy. Recent research has shown that by coordinating and guiding consumer search, a search platform can improve market efficiency (e.g., Athey and Ellison 2011; Chen and He, 2011). However, a platform may have distorted incentives when, for instance, it is partially vertically integrated (e.g., de Cornière and Taylor, 2014; White, 2013; Chen and Zhang, 2018).A platform may also perform poorly in guiding consumer search when product quality is not (perfectly) observable. Due to network effects and other factors, platforms often possess enormous market power and may abuse their market dominance. I will discuss how instruments such as competition policy and product liability can have positive welfare impacts by aligning the interests of platforms and consumers.

Digitization has greatly increased the value of innovation and the need for intellectual property (IP) protection. This is especially true because many digital products have the distinctive property of low reproduction and transportation costs. Therefore, on the one hand, it is feasible and efficient for one firm to serve a large market with an innovative product, so that the innovation becomes more valuable; while on the other

hand, strong intellectual property rights—particularly patent protection—is needed in order to deter imitation and provide desirable innovation incentives. The literature on the economics of innovation has devoted increasingly more attention to sequential or cumulative innovation, where the effects of patent policy are very different from those for a single innovation. I will focus on two recent studies that yield new insights on how patent policy may improve an industry's performance in innovation. Chen, Pan, and Zhang (2018) analyze how patentability standard impacts the rate and direction of innovation, where the rate of industry innovation is shown to vary with patentability standard in an inverted-U shape. Chen and Sappington (2018) study the optimal rule for patent infringement damages in a sequential innovation environment. As I shall also discuss, as the values of innovation rise and the costs of imitation fall, IP protection and innovation will play vital roles for economic development in the digital age. Furthermore, the increase in IP protection and the reduction in search cost increase the efficiency of the market for technology, giving rise to more external innovation rather than internal innovation.

Equipped with digital technology to gather and store data, firms now have enormous capability to learn about consumer preferences and utilize such knowledge in their business activities. Some consumer data, such as those with information to open an account with a firm, are obviously needed to facilitate transactions. Consumer data can also be useful for firms to provide better products. For example, information about consumers and consumer demand can help firms to design and produce new or better products. Personalized information may also help firms to provide products that better match consumer needs or reduce consumer search cost, possibly through product recommendations or targeted advertising. However, consumer information collected by firms can also potentially harm consumers, for at least three reasons. First, firms may use consumer purchase history to engage in price discrimination (e.g., Chen, 1997; Fudenberg and Tirole, 2000). Second, consumers may

have an intrinsic preference for privacy and hence suffer from the collection of their personal information by firms. Third, data breaches can leak sensitive personal information and harm consumers. Recent research in economics has offered new insights on the potential trade off in protecting consumer data and on the optimal design of regulatory policies.

The enormous impact of products and services enabled by digital technology/digital data is in full display during the Covid-19 pandemic. At the time of writing, many schools and universities have gone online for teaching and learning. A vast number of business meetings and academic conferences are being held online, which has led to substantial increases in stock prices for companies that provide virtual meeting platforms such as Zoom Video Communications Inc., amidst large declines of the overall stock market. Remote working, through the Internet, is occuring in an unprecedented large scale. Online shopping for groceries and online ordering for restaurants, while having already provided much conveniences before, are a necessity for many people during the pandemic. Online provision of healthcare services and virtual doctor appointments are becoming a common practice. Clearly, the digital economy has played a crucial role in the supply of goods and services during the pandemic,[2] and it will be the driving force for economic growth in the "new normal" afterwards.

In the rest of the paper, I discuss platforms and how to improve platform markets in Section 2. The rising values for innovation, the design of optimal patent policy in the digital age, as well as issues related to external vs. internal innovaiton, are discussed in Section 3. Consumer data and privacy policy are discussed in Section 4. I conclude in Section 5.

[2] According to the National Bureau of Statistics of China, while China's GDP decreased 6.8% in the first quarter of 2020 compared to the last year, its digital economy component, the communication, software, and information technology service sector, actually *increased* 13.2% (http://www.stats.gov.cn/tjsj/zxfb/202004/t20200417_1739602.html.).

## 2. PLATFORMS AS INFORMATION INTERMEDIARIES

Consumers often need to incur search costs to find product and price information. Intermediaries have long existed to reduce such costs and facilitate transactions. For example, shopping malls have traditionally served as intermediaries for consumers who search for products from different sellers. As transactions are increasingly mediated through digital technology and the Internet, consumers can access products at lower search costs. Will the lower search costs in the digital economy reduce the need for intermediaries? To answer this, one must recognize that digitization and the Internet have also greatly expanded the market, and consumers now face a much larger set of sellers to choose from. This market size effect appears to be the dominant force, making intermediaries more valuable for facilitating transactions between sellers and products in the digital economy. This has led to the enormous commercial successes of platform companies such as Google, Amazon, Alibaba, and Tencent.

There are different ways in which platforms operate. For example, Google's search engine provides sponsored links to sellers who win keyword auctions. A seller makes a payment to Google when a consumer clicks the seller's link, regardless of whether and how much the consumer purchases from the seller. On the other hand, an online marketplace may host various sellers, each of whom could be charged a fixed hosting fee (e.g., by Yelp SeatMe to each restaurant for reservations) or a commission as a percentage of the transaction amount (e.g., by Expedia for a hotel booking). An online store like Amazon is both a multi-product retailer and a marketplace for independent sellers: it sells various products by itself while hosting independent sellers as an intermediary.

Athey and Ellison (2011) and Chen and He (2011) are early contributions that explore the role of platforms as information intermediaries guiding consumer search. In their models, a platform has a certain number of advertising positions that are

available to sellers through auctions, and the sellers are placed on the platform in the order of their bids. The sellers differ in quality, with a higher-quality seller offering a product that is more likely to meet a consumer's need. A seller's quality is its private information. Each consumer must incur a search cost to visit a seller, through which the consumer uncovers whether the seller's product is a match for her. In equilibrium, a higher-quality seller is willing to bid more for placement at a higher position on the platform, because he expects that a consumer searching his site is more likely to find a match and make a purchase. Moreover, sellers set the same price because each consumer has the same value for her matched product even if it is sold by different sellers. Anticipating the sellers' strategy and their paid placements, consumers have the incentive to visit sellers sequentially in the descending order of their positions on the platform. The platform thus effectively acts a coordination device, enabling consumers to search more efficiently—finding a match with less expected search cost—and enabling high-quality sellers to reach more customers.[3]

In Athey-Ellison and Chen-He, position auctions by the platform provide efficient sorting of sellers. Subsequent research has relaxed some of their assumptions in several directions. For instance, several authors have considered the possibility that the platform has bias when guiding consumer search, possibly because it is (partially) vertically integrated and wishes to direct consumers to its own products away from competitors' offerings (e.g., Burguet, Caminal, and Ellman, 2015; de Cornière and Taylor, 2014; White, 2013). In fact, Google was accused of having acted illegally by giving priority placement in search results to its own shopping service, while relegating results from rivals to areas where potential buyers were much less likely to click. It was fined €2.4 billion ($2.7 billion) for violation of antitrust law by the European Commission (Reuters, June 27, 2017).

[3]Bagwell and Ramey (1994) pioneered the idea of coordination economies in retail markets with consumer search.

Because of the tremendous market power that platforms possess, antitrust agencies have taken actions to prevent exclusionary practices by them in order to preserve competition. In addition to bias in displaying search results, another controversial issue is product bundling. Bundling is often a profitable business strategy, partly because it reduces the dispersion of consumer valuations, enabling firms to extract more consumer surplus (Chen and Riordan, 2013). But bundling by a dominant firm can also foreclose competition. In 2018, Google was fined a record-breaking €4.3 billion ($5 billion) by EU regulators for breaking antitrust laws. The European Commission states that Google has abused its Android market dominance in three key areas, including its bundling of the search engine and Chrome apps into the operating system (The New York Times, June 18, 2018).

Another direction to extend the analyses in Athey-Ellison and Chen-He is to relax their assumption that consumers can observe product quality when they search the firm. That is, instead of assuming products to be "inspection goods", we need to consider them as "experience goods" in many situations, especially for online purchases where the quality of a product may not be learned before purchase. As Chen, Li, and Zhang (2020) demonstrate, a decrease in consumer search cost for experience goods can then *reduce* consumer and total welfare, because the resulting low price/profit will reduce the gain from the reputation of being a high-quality seller, which in turn lowers firms' incentive to invest in product quality. For experience goods, a platform may no longer be able to perform efficient sorting of sellers, because a low-quality seller may potentially receive a higher profit from attracting a consumer. This can potentially explain why online markets tend to have, on average, lower product quality than traditional brick-and-mortar stores. For example, in a recent investigation by the U.S. Government Accountability Office (GAO), 20 of the 47 products purchased from third-party sellers on 5 popular consumer websites, including Amazon

and Walmart, were counterfeits.[4]

Apparently, in the example above the online platforms have not been effective in sorting out the counterfeit sellers. Part of the problem is how to motivate a platform to exert more effort to deter sellers of fake/low-quality products. Reputation can be a mechanism to motivate the platform to act as a responsible gatekeeper on product quality. While some of the sellers are "short-term" players that may have a low incentive to establish reputation, the platform can be the "long-term" player with a stronger reputation to establish and protect  For reputation to work well, however, consumers will need to have choices from competition, which may be limited due to the dominant market positions of some platforms. But even with competition, the reputation mechanism can be fragile and does not provide sufficient incentives, and product liability can be an effective incentive mechanism. In fact, competition and the desired product liability may possibly exhibit a non-monotonic relationship (e.g., Chen and Hua, 2017), and it could be desirable to impose product liability not just on sellers, but also on the platform.

The problem of low-quality sellers and products in the online market is also related to the low entry cost in these markets. As Chen and Zhang (2018) show in a model of search markets with both vertically and horizontally differentiated firms, the average quality of sellers in a search market becomes lower when entry cost decreases. They identify two opposing effects of an increase in entry cost: it raises the average firm quality in the market, positively impacting welfare; but it also reduces the product varieties in the market, diminishing consumers' search options. Chen and Zhang show that, under plausible conditions, the quality effect dominates when entry cost is low, so that consumer surplus and social welfare both initially rise with search cost, even

[4]All 47 items purchased were advertised as new, brand-name items sold by independent sellers with average customer ratings above 90 percent, and all items were shipped from U.S. addresses ( GAO-18-216, January 2018).

though they eventually fall. This suggests that in the digital economy, in which entry barrier is very low for many markets, regulations that impose entry restrictions could improve market performance. The increase in entry costs, possibly in the form of a licensing fee, a certification of qualifications, or a minimum quality standard. can raise product quality and boost both consumer and total welfare.

## 3. INNOVATION AND IP PROTECTION

As market expands with digitization, a new product can reach more consumers and have higher demand. This potentially increases the value of innovation, suggesting one possible reason for the apparent acceleration of worldwide innovations in recent years, measured by the number of patent applications. In 2017, innovators around the world filed 3.17 million patent applications (43% of them from China), representing an eighth consecutive year of growth. There were 13.72 million patents in force worldwide in 2017, of which around 2.98 million were in force in the U.S., 2.1 million in China, and 2 million in Japan (WIPO, 2019).

Digital products often have low reproduction cost, even though they may require substantial up-front investment. This suggests that intellectual property rights (IPRs) can be crucial for promoting innovation in the digital economy. A central issue for innovation economics in the digital economy thus concerns how to protect IP rights, especially how to design optimal patent policies when innovations are cumulative in nature, with current innovations building on past ones.

Chen, Pan, and Zhang (2018) investigate how patent policy, specifically patentability standards, may affect the rate and direction of cumulative innovation in an industry where firms can conduct R&D in multiple directions.[5] They consider a situation where there are two research directions, $A$ and $B$, for a sequence of innovations (or

[5]The study of R&D direction under comulative innovation has attracted the attention of several authors recently. See Bryan and Lemus (2017) and Hopenhayn and Squintani (2016).

new products) that deliver higher product qualities over time. An innovation in direction $B$ produces a quality improvement of stochastic sizes ranging from low to high, whereas an innovation in direction $A$ produces a more certain quality improvement with an intermediate size. They consider the range of patentability standards ($S$) under which innovations in direction $A$ are always patentable while an innovation in direction $B$ is patentable only if its realized quality improvement is sufficiently large. Thus, $A$ is the safe R&D direction and $B$ the risky direction.

If innovation were a one-time activity that ends with the successful introduction of a new product, a (marginal) increase in the patentability standard would discourage R&D in the risky direction by making it harder to obtain a patent through this direction, generating the *threshold* effect. However, if innovation is cumulative, with challengers conducting R&D that may lead to a follow-up innovation that replaces the current leader, a higher patentability standard increases the value of being a leader because it will take longer before the leader is replaced by a successful challenger. This *incumbency-prolonging* effect can potentially increase the incentive for R&D in both innovation directions, because challenges will receive higher rewards from succeeding in a patentable innovation.

Moreover, the changes in the R&D incentives in the two directions will interact with each other. In particular, an increase of R&D in one direction induces the next innovation discovery to come sooner, which lowers the profit from incumbency and thus reduces the incentive for R&D in the other direction. Conversely, a decrease of R&D in one direction has the opposite effect. As Chen, Pan, and Zhang demonstrate, this dynamic *strategic substitution* effect between the two directions, together with the incumbency-prolonging effect, leads to novel effects of patentability standards on innovation. Specifically, as patentability standards rise, the industry rate of innovation initially goes up and eventually falls down, reaching its maximum at some intermediate level; and R&D intensity in the risky direction exhibits a similar

pattern. Furthermore, industry R&D is biased towards (against) the risky direction under lower (higher) patentability standards.

The cumulative nature of innovation also raises new issues for another aspect of optimal patent policy: how to levy financial penalties ("damages") for patent infringement. The design of damages for patent infringement is particularly subtle in the presence of cumulative (or sequential) innovation. While stringent damage rules can encourage early innovators, they may discourage subsequent innovation, especially when it is uncertain about whether follow-on innovations infringe earlier patents.[6]

Chen and Sappington (2018) present a model in which innovation is not certain because of stochastic variation in the costs required for innovations. Patent protection also is uncertain in their model. Hundreds of thousands of patents are granted annually, and patent descriptions can be vague and incomplete. Therefore, in practice, it is often difficult to determine whether an innovation infringes an existing patent.[7] They use the parameter $\lambda \in (0, 1]$ to denote the probability that the patent of an initial innovator, firm 1, is infringed by the differentiated product of a follow-on innovator, firm 2. The value of $\lambda$ can be viewed as a measure of the strength of patent protection (e.g., Choi, 1998; and Farrell and Shapiro, 2008). Departing from the prior literature that has primarily analyzed individual damage rules that are employed in practice, including the *lost profit* (LP) rule and the *unjust enrichment* (UE) rule, Chen and Sappington analyze the optimal design of patent damage rules when the

[6] Today's smartphones are estimated to embody innovations protected by as many as 250,000 patents that have been developed from cumulative innovations (Sparapani, 2015).

[7] The recent protracted patent infringement ligation between Apple and Samsung provides an illustration for this point (e.g., Vascellaro, 2012). Lemley and Shapiro (2005) report that the U.S. Patent and Trademark Office issues nearly 200,000 patents annually. With rather limited time that a patent officer can devote to assessing the merits of an individual patent application, the validity of a patent. may be successfully contested in court.

initial innovator's patent may be infringed by the follow-on innovator.

The LP rule requires the infringer to compensate the patent holder for the reduction in profit the latter suffers due to the infringement, whereas the UE rule requires the infringer to deliver its realized profit to the patent holder (e.g., Choi, 2009). Chen and Sappington consider damage rules that are linear combinations of LP and UE, coupled with a lump-sum transfer between the innovators. Under a linear rule, if firm 2 is found to have infringed firm 1's patent, firm 2 is required to deliver a damage payment ($D$) to firm 1 that has three components: a lump sum monetary payment ($m$), a fraction ($d_1$) of the amount by which firm 2's operation reduces firm 1's profit, and a fraction ($d_2$) of firm 2's profit. Thus, linear rules generalize the LP rule and the UE rule, including the former (with $d_1 = 1$ and $m = d_2 = 0$) and the latter (with $d_2 = 1$ and $m = d_1 = 0$) as special cases.

Despite its simplicity, Chen and Sappington show that an optimally-designed linear rule achieves the highest welfare among all balanced damage rules (in which all payments are internal to the industry). This is the case because linear rules allow substantial control over the key determinants of welfare. Specifically, the selected values of $d_1$ and $d_2$ affect pricing decisions, and thereby influence the allocation of industry output between the suppliers. The values of $d_1$ and $d_2$ also affect total industry profit and their allocations between the suppliers to influence their innovation activities. The lump-sum payment ($m$) facilitates the desired allocation of industry profit. The optimal linear rule typically differs from both the LP and UE rules, and often results in a substantial increase in welfare relative to both of them. Furthermore, the optimal linear rule can ensure the first-best outcome, under which each firm innovates if and only if its innovation enhances welfare and industry output is also allocated efficiently. In this case, the optimal linear rule resembles more the LP rule than the UE rule (so $d_1 > d_2$) when consumers value the product of the initial innovator relatively highly, while it resembles more the UE rule (so $d_2 > d_1$) when

consumers value firm 2's product relatively highly.[8]

The discussion of optimal patent policy has largely focused on the strength of patent protection, Remarkably, the optimal linear rule maximizes welfare among all balanced rules, regardless of the strength of protection for firm 1's patent (i.e., for any given $\lambda > 0$). This suggests that the design of damages for patent infringement may play an especially important role in fostering cumulative innovations.

The optimal IP policy may differ for countries at different development stages. One prominent view among economists (e.g., Helpman, 1993) has been that strong IP protection mostly serves the interests of the developed countries (the "North")—which are the primary producers of innovations—and does not benefit developing countries (the "South"). Chen and Puttitanum (2005), however, argue that IP protection and innovation are also important for developing countries, even though technologies in the South may differ from those from the North. In Chen and Puttitanum, successful economic development is viewed itself a process to advance innovation capabilities and to establish institutions that respect property rights. Their theoretical and empirical results suggest that the optimal IP protection in developing countries, while weaker initially, will gradually increase towards the standards in the developed world. The rapid development of the Chinese economy, with its growing emphasis on innovation and IP protection in more recent years as it becomes the country with the most patent applications in the world, is an interesting case in point. In digital economy, with the rising values of innovation and the decreasing costs of imitation, IP protection and innovation will play increasingly important roles for economic development.

The digital economy also brings about significant changes to how R&D and innovation are organized. Firms can choose to pursue an innovation either internally or

[8]By inducing the firms to partially internalize each other's profit, which influences their pricing strategies, the optimal linear rule shifts equilibrium industry output toward the product that consumers value most highly.

externally. Internal innovation allows the firm to fully utilize its own R&D resources and to achieve better coordination of R&D and production, but it places (more server) limitations on innovation opportunities and successes. External innovation, through mechanisms such as acquisitions, partnerships, joint ventures, and licensing, furnishes a larger set of innovation opportunities, but may have higher transaction costs. As innovation proliferates, search frictions fall, and IP protection strengthens, the market for innovation and technology transfer becomes both more needed and more efficient in the digital economy. This has led to a shift in the pattern of innovation towards external innovation. According to a study by the Boston Consulting Group,[9] companies are increasingly using acquisitions and corporate venture capital to acquire new ideas and technologies from startups and other external sources. Cisco Systems, for example, has maintained its lead in networking technology in part by making more than 175 acquisitions betwee 1993 and 2016. Facebook paid a total of $3 billion for Instagram and Oculus VR. Gilead Sciences' $11 billion acquisition of Pharmasset was pivotal for the development of breakthrough treatments for hepatitis C. Some of the largest technology companies have fueled their growth through acquisitions. For example, between its founding in 1998 and January 2020, Google made 240 acquisitions.

The increased importance of external innovation is not without concerns and controversies, especially when the acquistion of innovation from a (potential) rival negatively impacts competition. In February 2020, the Federal Trade Commission issued special orders to five large technology firms, Alphabet (including Google), Amazon, Apple, Facebook, and Microsoft, requiring them to provide information about prior acquisitions not reported to the antitrust agencies. "The orders will help the FTC deepen its understanding of large technology firms' acquisition activity, including ...whether large tech companies are making potentially anticompetitive acquisitions

[9] "Bringing Outside Innovation Inside" (2017), https://www.bcg.com/publications/2017/growth-bringing-outside-innovation-inside.aspx

of nascent or potential competitors..."[10] While the acquisition of a potential rival may decrease competition, the issue of how strict antitrust restrictions should be on acquisitions in innovative industries is actually more complicated. Startups are driven to innovate and are able to receive VC funding, partly because there is the prospect for them to be acquired when they succeed in investing in risky innovations. Restrctions on acqusitions could adversely affect the innovation incentive by startups. The design of policies that both encourage innovation and promote competition remains a challenging task for economic researchers and policy makers.[11]

## 4. CONSUMER DATA AND PRIVACY PROTECTION

A central part of the digital economy is digital technologies to gather and store data. In recent years, we have witnessed an exponential growth in digital data over the Internet. Global Internet Protocol traffic, a proxy for data flows, has grown dramatically from 100 GB per day in 1992 to 46,600 GB per second in 2017, and is expected to grow to 150,700 GB per second in 2022 (2019 Digital Economy Reprot, United Nations). Firms have greatly expanded their use of big data analytics, artificial intelligence, and digital platforms to develop new products and serve consumers. Access to data and the capability to utilize data have become essential for the competitiveness of firms in the digital economy. The growing ability of firms to analyse and process massive amounts of data, in particular, is crucial to the developments

[10] "FTC to Examine Past Acquisitions by Large Technology Companies", https://www.ftc.gov/news-events/press-releases/2020/02/ftc-examine-past-acquisitions-large-technology-companies.

[11] As Gilbert and Newbery (1982) initially point out, an incumbent possesses a higher value for an innovation than a potential rival. Chen (2000) shows how the strategic relations between the new and existing technologies may determine whether the incumbent will find it more profitable than a new competitor to acquire the external innovation.

in artificial intelligence (AI). AI is already in use in areas such as voice recognition, automation, and robotics. Together with new technologies such as 5G and new computational power, AI will make self-driving cars a reality. It has been estimated that AI has the potential to generate additional global economic output of around $13 trillion by 2030, contributing an additional 1.2 per cent to annual GDP growth (2019 Digital Economy Reprot, United Nations).

Firms have various ways to learn about consumer preferences, possibly using information about a consumer's personal characteristics, her past purchases, her purchases of other products, and so on. Some of the consumer information, such as a consumer's name and address, is often needed for opening an account with a merchant and to facilitate transactions. Information can also be useful for firms to provide better products. For example, information about consumers and consumer demand can help firms to design and provide new or better products, such as self-driving cars. Individualized information may also help firms to offer products that better match customer needs or reduce consumer search cost, such as through product recommendations. However, consumer information collected by firms may also harm consumers, for at least three possible reasons. First, firms may use consumer purchase history to engage in price discrimination (e.g., Chen, 1997; Fudenberg and Tirole, 2000).[12] Second, consumers may have an intrinsic preference for privacy, which is infringed by firms' data collection (e.g., Acquisti, Taylor and Wagman, 2016). Third, data breaches, which nowadays occur quite frequently, can cause substantial consumer harm.[13]

[12] History-based price discrimination is a widely-observed business practice in the digital age. For example, phone companies and banks ofte offer new-customer discounts that discriminate against repeat purchasers, whereas airlines offer loyalty programs that reward repeat customers. After making a purchase from an online retailer, customers may receive a discount from the retailer for the next purchase.

[13] A recent survey found that, in 2016, 15.4 million U.S. consumers suffered from identity theft and fraud with a total loss of about $16 billion. See the survey report at Javelin Strategy & Research:

How to balance the data needs of the digital economy and consumer privacy concerns? Economic analysis can inform policy choices on this critical issue.[14] Consider first how price discrimination—or more generally differential pricing (DP)—may affect consumers and social welfare. Traditionally, economists have focused on demand-based differential pricing —classic third degree price discrimination—for different consumer groups. But in many situations, differential pricing for a product is at least partially motivated by differences in the (marginal) cost to serve different groups of consumers. As shown in Chen and Schwartz (2015), the welfare effects of cost-based DP differ markedly from those of demand-based DP. Specifically, while demand-based DP tends to raise average market price and lower consumer welfare, cost-based DP has no such tendency and will increase aggregate consumer surplus for a broad class of demand functions. Therefore, to evaluate the potential welfare effects of a firm's access to personal data for the purpose of differential pricing across consumer groups, it is imperative to distinguish between data for learning about cost of service versus about demand elasticity, with data for cost information being less likely to have detrimental effects.

Firms have been developing innovative marketing methods to learn about consumer preference. While some of these efforts enable firms to better serve consumers, the private and social incentives generally differ for marketing innovations that gather consumer information (Chen, 2006). There is thus a need for regulation on the collection and protection of consumer data. European Union's General Data Protection Regulation (GDPR), implemented on May 25, 2018, represents a major effort in this regard. Its key requirements include Pseudonymization or full anonymization where appropriate, and explicit, informed consent for the use of personal data. GDPR im-

www.javelinstrategy.com.

[14] There is an extensive literature on the economics of consumer privacy. See, for example, Acquisti, Taylor and Wagman, 2016; Taylor 2006; and Taylor and Wagman, 2014.

poses sever penalty for violations: a violator may be fined up to €20 million or up to 4% of the annual worldwide turnover of the preceding financial year in case of an enterprise, whichever is greater.

The strong regulatory protection of personal data is not without cost. In particular, it may reduce firms' incentive to serve customers. For example, immediately following the implementation of GDPR, more than 1,000 U.S. websites blocked access from European visitors. Apparently, firms are concerned with the liability from non-compliance, which may motivate them to reduce output or even exit the market. Firms will also incur additional costs for data protection in order to comply with the regulation, which can also lead to decreases in output. The difficulty for achieving optimal regulation on data protection also arises because preference for privacy differs across countries. According to a survey in 2018, about 60% of consumers in the United States and Spain are data pragmatists, who would consider whether the service is worth the information requested, but such users comprise only 40% in Germany and the Netherlands. The survey also finds that a larger percentage of consumers in the European countries surveyed are data fundamentalists, who are unwilling to provide personal information, than consumers in the United States.[15] A strong standard on data protection across countries may thus result in excessive protection in some countries but insufficient protection in others.

Consumer data protection also interacts with competition policy. For example, a major company such as Amazon sells products both by itself and by independent sellers on its platform. Amazon can obtain sales data of the independent sellers and may potentially use such information to gain an (unfair) advantage, such as placing its own wholesale orders for a product after the marketing efforts by an independent seller has made the product popular, adversely impacting competition from the independent

[15] Global Alliance of Data-driven Marketing Association: http://www.globaldma.com/wp-content/uploads/2018/05/Global-data-privacy-report-FINAL.pdf.

seller. The information may also affect competition between Amazon as a retailer with the third-party sellers it hosts. In July 2019, the European Commission opened an investigation into possible anti-competitive conduct of Amazon. As part of the investigation, the Commission will focus on whether and how the use of marketplace seller data by Amazon affects competition. Also related is the issue of potential tracations for data. For instance, data from third parties may be more valuable to small firms which, unlike their larger counterparts, may have more limited direct access to consumer information. Regulations that prohibit or limit data trading, while desirable from the perspective of protecting consumer privacy, can enlarge the asymmetry of competitive positions among competitors at the expense of smaller firms.

Another important issue concerning policies on data and privacy is how they may affect product innovation. One concern is that strong privacy protection will hinder firms' efforts to learn about consumer preferences, and to the extent that such information is often needed for product innovation, regulations on consumer privacy protection will impede innovation. However, privacy policy can also impact consumers' willingness to share information. In particular, if consumers believe that there is strong privacy protection, they are more likely to permit the use of their information by firms. Stringent privacy regulation can thus enable firms to commit to strong protection of consumer data, which leads to more information sharing from consumers and in turn is conducive to innovation. Therefore, the relationship between privacy protection and innovation is likely to be non-monotonic, and an increase in privacy protection can facilitate—rather than impede—innovation.

## 5. CONCLUSION

Digital technologies and the Internet have profoundly changed how markets function. The drastically reduced costs in search, transportation, reproduction, and entry

offer tremendous new opportunities for higher market efficiency. At the same time, the increasing importance of platforms, innovation, and consumer data poses new challenges on effective competition, IP protection, and consumer privacy in the digital economy. Drawing insights from recent research in industrial economics, this paper has shed light on these new economic forces and on the optimal design of policies to improve market performance.

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