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Digital Innovation and the Distribution of Income

Dominique Guellec

9.1 Introduction

Income inequalities have increased in most Organisation for Economic Co-operation and Development (OECD) countries over the past three decades (OECD 2015a). In the United States, the income share of the top 1 percent has soared, rising from earning on average 27 times more than the bottom 1 percent in 1980 to 81 times more in 2014. The top 1 percent income share is now almost twice as large as the bottom 50 percent share. There has been close to zero growth for working-age adults in the bottom 50 percent of the distribution since 1980 (Piketty, Saez, and Zucman 2016).

In this chapter, we argue that the increasing importance of digital innovation (which are new products and processes based on or embodied in software code and data in and beyond IT industries) is magnifying innovation-

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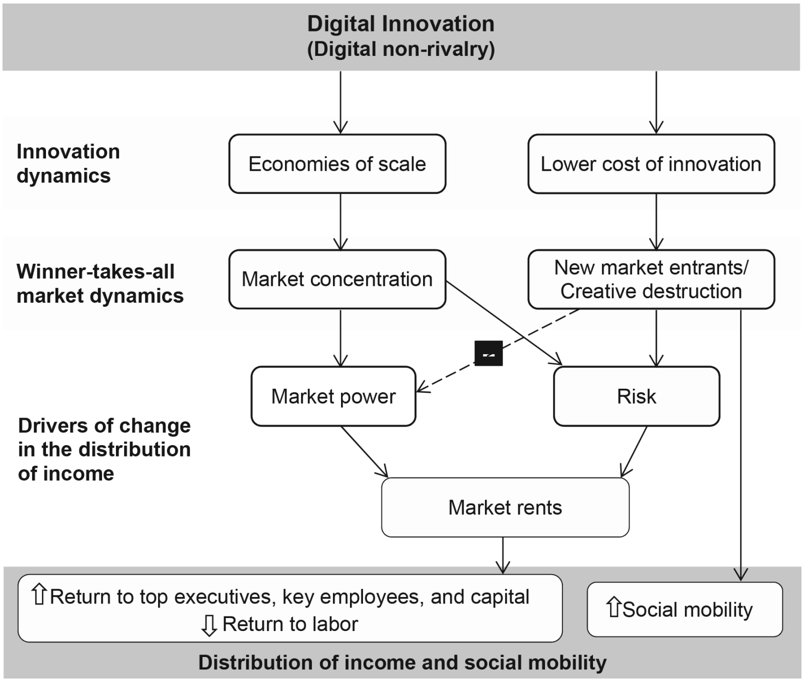


Fig. 9.1 Impacts of digital innovation on market structures and the distribution of income

based rents that contribute to increasing the income share of the top groups. Specifically, the chapter focuses on inequality coming from market rents accruing to top executives, key employees, and shareholders but little to the average employee. Figure 9.1 summarizes the mechanisms at work in my framework.

Digital innovation has received surprisingly little attention in spite of the increase in market rents—the return on productive resources, notably capital, in excess of what is needed for resources to be deployed in production—and in spite of the fact that in recent years, the evolution of top incomes owes much to increased returns to capital (CEA 2016; Piketty, Saez, and Zucman 2016). This explanation adds to others that point to globalization, the financialization of the economy, unskilled-labor-displacing technologies, and the weakening of trade unions as causes of growing income inequalities. These other changes also have to do with digitalization, which has been an enabler or a driver for globalization, financialization, and skills-biased technical change.

Viewed from the perspective of digital innovation, the increase in top income inequality partly results from the nonrival character of these intangible products, referred to as digital nonrivalry (DNR) in the remainder of the chapter. This, however, does not imply that restraining innovation would improve the well-being of the low- and medium-income categories: innovation is a major driver of economic growth and also a source of benefits to all groups in society, including the most disadvantaged.

The impact of digital innovation on income distribution is reflective of the well-known effects of innovation on market structures. It has been recognized since Schumpeter (1911) that innovation requires and generates market rents. Successful innovation endows innovators with a temporary market exclusivity based on first-mover advantage, intellectual property rights (IPR) protection, brand reputation, network externalities, and entry barriers. This exclusivity allows innovators to set prices above the marginal cost and gain rents. The nonrivalrous nature of knowledge means that the costs of new ideas come mainly from their development—typically through R&D, design, and market research—while costs of implementing and diffusing them are much lower or even nil. This gives rise to large returns to scale; the more an idea is applied, the lower the average cost. Increasing returns to scale favor large firms and concentrated market structures.

The effects of nonrivalry are magnified by intangible (digital) products that have constituted an increasing share of the US economy over the past decades (Corrado, Hulten, and Sichel 2005, 2009). With wider use of information technology (IT), software, and data, the marginal cost of production is essentially nil, and the intangible component makes most of the value of products. This applies particularly to fully intangible products such as software, as increasing returns to scale are tied essentially to the intangible component of a product. The tangible components might generate economies of scale, but not to the same extent as the intangible ones, because their variable costs are not zero (with materials, labor, and other input needed to produce additional units). Effects apply beyond the IT sector because software code and data are increasingly important across all fields of the economy.

As a consequence of digital nonrivalry, a growing number of industries are subject to "winner-take-all" dynamics—that is, markets akin to tournaments in which the best offer wins the race and captures most (if not all) of the market (Rosen 1981). Such market concentration allows winners to extract a rent by raising the price of output and/or lowering the price of inputs. Moreover, globalization has allowed successful firms to dominate not only their national market but also the larger global one, hence increasing the size of the corresponding market rent.

Digital innovation also lowers the costs of innovation, raising opportunities for "creative destruction"—the process by which new products replace current products, sometimes involving the exit of incumbent producers and entry of new ones—as it reduces barriers to entry on many markets. The capital requirement for programming software, the core of digital innovation, is much lower than for other types of innovative activities, such as those requiring special facilities to develop innovations (e.g., laboratories and experimental settings in pharmaceuticals). The intangible nature of knowledge and the opportunities for rapid scale-up facilitate creative destruction. This is exemplified by the "app economy"; individual innovators and small companies offer their products on the internet at no direct cost.

Where opportunities for creative destruction and market entry arise, the level of risk is higher than in the past: while in traditional markets, new, superior products may reduce the market share of incumbents, in a winner-take-all market, new, (even slightly) superior products can result in new firms taking over the entire market. Incumbents in such winner-take-all markets have higher market shares than firms in other markets. However, firms and investors run the risk of losing it all, as more creative destruction generates more instability in market shares and hence in income.

Higher risk leads investors to demand a risk premium, in turn increasing the average return to capital. These dynamics are most visible in the venture capital market, but they extend to other types of investment as well. This increase in risk explains in part why the average return on capital and its dispersion between firms have increased over the past two decades as digitalization was progressing (Furman and Orszag 2015).

From the perspective of innovation dynamics, market entry and creative destruction may reduce market concentration arising from the scale economies digital innovation allows for. Which of the two opposite forces dominates depends on the technology, business strategies, and of course, policy (including antitrust, entrepreneurship, and IPR). In terms of technology, radical changes in the basic technologies (e.g., the PC replacing the mainframe) reduce the advantage of incumbents and therefore favor newcomers and competition; by contrast, technology stability favors incumbents and concentrated market structures.[1]

In terms of business strategies, incumbents can identify and implement new, more powerful ways to protect their market position in the digital economy, hence mitigating the level of risk they are faced with. First are network effects—the more customers a product has, the more valuable it is to each of them—complemented by limited portability (customers cannot easily change from one product to a competitor). Technical standards are another related effect: large players encourage standards that increase entry cost and reduce customer's mobility. Third is blocking competitors from access to data. In the digital economy, data are the primary input for many innovations and services. This is reinforced in more recent technologies like artificial intelligence. Fourth, large firms can play the role of "integrators" by acquiring start-ups that have been successful in promoting new products

1. This is not systematic, however, as one can see from the example of artificial intelligence. The main players are the same as with the internet, because some of the key competitive factors are the same in both cases (notably access to large amounts of data).

and integrating them into their own offer. This has the twofold advantage of enriching their product portfolio and preempting potential competition.

Empirical evidence provided in this chapter shows that the forces tending toward more market concentration have prevailed over competition-enhancing forces of digital innovation, resulting in winner-take-all markets that are characterized by higher market concentration and more creative destruction. Market power and creative destruction are not in contradiction with each other. Competition in digital innovation is not about prices—in which case, the threat of new entry would discipline the incumbents—but about innovation, as new products are so innovative that they take over the market no matter the price charged by current incumbents.

How do the rents from digital innovation affect income distribution? They are mainly shared among shareholders and investors, top executives, and key employees of the winning firms, who are already in the top tier of the income distribution (as they own capital and skills and hold managerial and leading positions in firms), hence contributing to increased income inequalities. Shareholders have benefitted from a steady increase in dividends and share prices over the past decades. This has come with an increased dispersion in profits across firms (that many investors accommodate by pursuing portfolio diversification strategies). As a result, the share of capital (vs. labor) in national income has increased in the United States and most other OECD countries, particularly in innovation-intensive economic activities. Top executives have benefitted from increased compensation with the expansion of high-powered incentive schemes (like stock options and bonuses), which are aimed at monitoring their decisions in the riskier environment of winner-take-all dynamics (Hall and Liebman 1998).

Labor has not gained as much from rents, with the exception of the top categories. Indeed, top employees of successful firms have benefitted to a certain extent, as shown by the importance of cross-firm wage inequality in total income inequality (Song et al. 2015). Average employees, however, have been less successful in gaining from the rents for a number of reasons. They face more competition in the labor market and are increasingly employed in temporary work arrangements. Workers employed under alternative work arrangements (such as temporary help agency workers, on-call workers, contract workers, and freelancers), which represent the bulk of job creation in the United States for 2005–15 (Katz and Krueger 2016), are in a weak negotiating position when it comes to sharing rents. These effects of digital innovation and, more broadly, intangibles on labor add to the impacts that arise from how different worker occupations and skills profiles complement or substitute to these new technologies (see, e.g., Autor and Dorn 2013; Haskel and Westlake 2017).

Lower entry barriers that facilitate creative destruction also enable increased social mobility, as newcomers can displace incumbents. Turnover

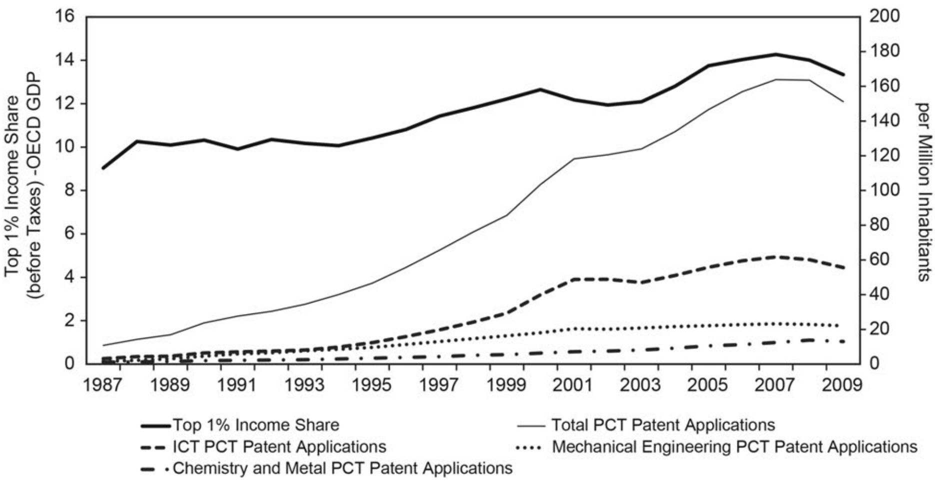


Fig. 9.2 Top 1 percent income share and PCT patent applications for selected OECD countries, 1987–2009

Source: The World Top Incomes Database, http://topincomes.g-mond.parisschoolofeconomics.eu/ (accessed July 15, 2015) for the 1 percent income share data; OECD Patents Statistics for PCT patent applications.

Note: The statistics are based on a GDP-weighted average for the following 13 OECD countries: Australia, Canada, Denmark, France, Germany, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. The selection is based on data availability over the 1987–2009 data period. The data appendix provides further information.

in the top income categories has increased in recent decades and is positively related to the intensity of innovation activity (as, e.g., across US states in Aghion et al. 2015).

The remainder of this chapter is structured as follows: section 9.1 describes global trends in innovation and the distribution of income. Section 9.2 defines DNR and explains why it is increasingly important. Sections 9.3 and 9.4 analyze the impacts of digital innovation on economies of scale and market concentration and on the costs of innovation and creative destruction. Section 9.5 discusses implications of these changing market trends on the distribution of income, while section 9.6 lists open research questions.

9.2 Digital Innovation and the Distribution of Income: Global Trends

Many OECD economies have seen an increase in income inequality. In particular, the top categories of income distribution increased their share in total income. This trend coincides with the growing importance of digital innovation. Figure 9.2 plots Patent Cooperation Treaty (PCT) applications and the income share of the top 1 percent for a group of OECD countries.

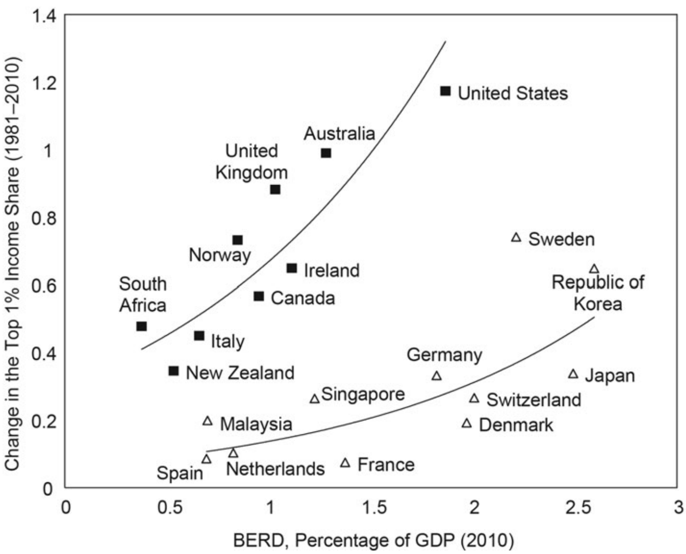


Fig. 9.3 Changes in the top 1 percent income share over 1981–2010 relative to business R&D spending as percentage of GDP in 2010

Source: The World Top Incomes Database, http://topincomes.g-mond.parisschoolofeconomics.eu (accessed July 15, 2015), for the 1 percent income share data; OECD Science and Technology Indicators for business expenditure on research and development (BERD) as percentage of GDP. The data appendix provides further information.

Note: The two lines are exponential trends for the two groups of countries.

Both series show an initially modest upward trend, followed by acceleration in the mid-1990s. Interestingly, information and communications technology (ICT) patents show the strongest upward trend of all, highlighting the growing importance of ICT in innovation.

Comparing business R&D spending (as a proxy for digital innovation) with trends in the top 1 percent income share gives a more mixed picture (figure 9.3). In a group of countries that includes the United States (jointly with Norway, the United Kingdom, and Australia), the share of the top 1 percent income owners increased more substantially than the intensity of R&D investments. In another group of countries (including Denmark, Germany, Japan, and Switzerland), strong business R&D investments coincided with positive but modest increases in the top 1 percent income shares over the past two decades. These differences may result from diverse country policy approaches to income inequality as well as from diverse industry dynamics and structures. Differences may also be driven by how economies are engaged in digital innovation and consequently in the degree to which digital innovation activities affect market structures and the distribution of income.

9.3 Digital Nonrivalry and Its Growing Importance

9.3.1 Digital Nonrivalry

Digital innovation gives knowledge (design, IPR, software code or data) a more prominent role in the value share of new products and processes than does "traditional" innovation, which is only partly intangible as the knowledge component of tangible products. Digital innovation is fully intangible and consequently allows for what we refer to here as digital nonrivalry (DNR). Hal Varian referred to the key components of digital innovations as essentially ideas, standards specifications, protocols, programming languages, and software rather than "physical devices"—consequently as innovations without physical constraints (Varian 2003).

Economists have long been familiar with the concept of nonrivalry when it comes to knowledge: one piece of knowledge can be used simultaneously by any number of users, at any scale, at low or even zero marginal cost. For instance, once assembled or designed, inventions can serve any number of users at no additional cost. This property contrasts with tangible (or physical) goods: two people can discuss fully the same idea, but they cannot eat the same apple. Nonrivalry favors "fluidity" or "ubiquity," ideas spreading instantaneously and everywhere at zero marginal cost. By contrast, the cost of producing the intangible product itself (referred to as "original" in national accounting) is sunk—that is, it is not incurred again with every additional use of the product.

The impact of nonrivalry on the real world economy has been limited until recently because ideas needed a physical carrier; they had to be embodied in a tangible good to be stored, disseminated, or commercialized: it could be a book, a new car (embodying an invention), and so on. Physical embodiment means significant production and transportation costs and favors inertia, as it requires time and resources to make the physical carrier of the idea. To diffuse the idea, you need to print and physically distribute the book and access the idea embodied in it; you need to buy the book. The price of an individual copy of the book will not reflect the total cost of producing the idea, which (in equilibrium) is shared among all copies. And this price will also include the cost of producing and diffusing physical copies of the book. The same holds with a new object—say, a car. You need to produce the new car and distribute it physically, and customers need to go to the shop and buy it. The cost of inventing the new car is split between all copies sold. Hence *when ideas are embodied in physical goods, nonrivalry is only partial, and the real-world economics of ideas is a mix of nonrival and traditional physical goods economics*.

With computers and the internet, the need for a physical carrier disappears. Ideas, once encoded in electronic bits, can be disseminated instantaneously everywhere. They really become ubiquitous and accessible at a quasi-zero

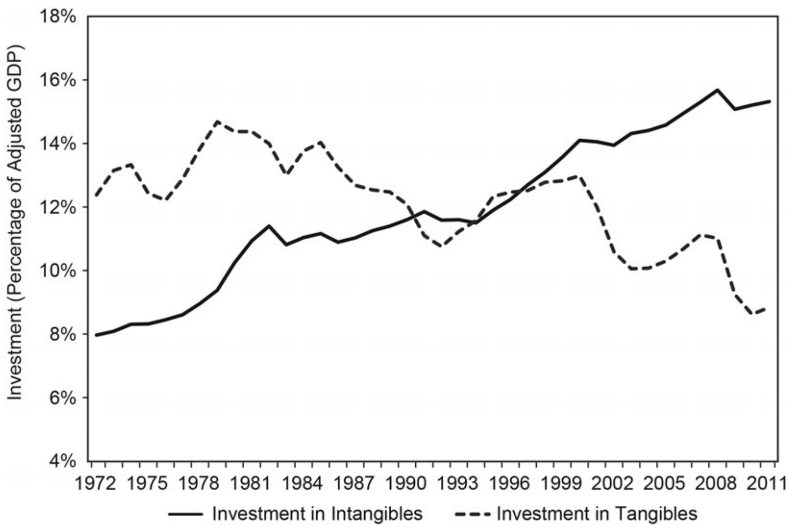


Fig. 9.4 Business investment in intangible and tangible capital, United States, 1972–2011 (percentage of adjusted GDP)

Source: OECD, based on unpublished update on C. A. Corrado and C. R. Hulten, "How Do You Measure a 'Technological Revolution?,'" *American Economic Review: Papers and Proceedings* 100 (May 2010): 99–104.

Note: Estimates are for private industries excluding real estate, health, and education.

marginal cost: we move from partial nonrivalry to total nonrivalry, which we refer to here as DNR in order to differentiate from broader-based nonrivalry and stress that its realization is tied to digitalization. With DNR, there are no more limits and delays on the diffusion of ideas: it suffices to access the site where they are presented, possibly to download a file.

9.3.2 The Growing Importance of Digital Nonrivalry

The effects of DNR have become increasingly important because of the growing importance of intangible investments over tangibles. In the United States, business investment in intangibles has risen almost continuously for the past 40 years, starting with the electronics revolution of the 1970s and increasing its pace over the past decades (Nakamura 2001). In the 2000s, intangible investments have become relatively more important than tangibles (figure 9.4). Among intangibles, computer software—a component of intangible investments—has been among the most dynamically increasing parts (Corrado, Hulten, and Sichel 2005, 2009). Until recently, official statistics have not accounted well for the large changes; Corrado, Hulten, and Sichel (2009) estimated that the omission of such investments from published macroeconomic data has consequently led to underestimates of USD 800 billion (as of 2003), excluding more than USD 3 trillion of business intangible capital stock.

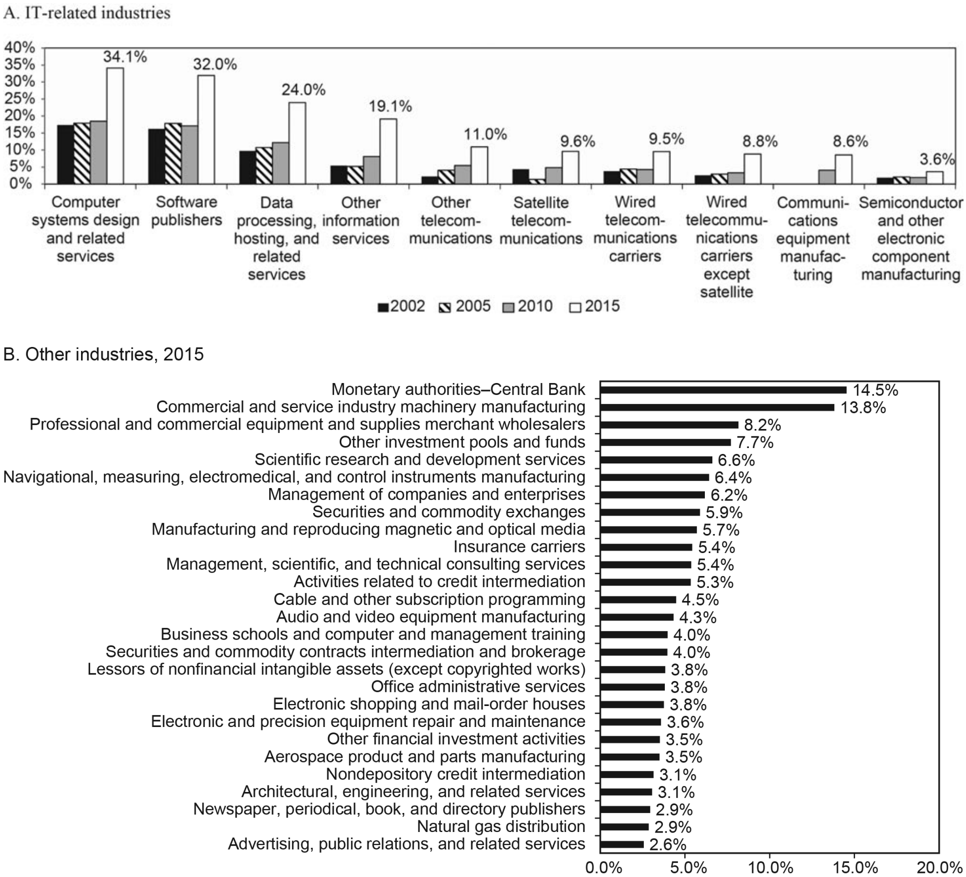


Fig. 9.5 Share of employment in software-related occupations within industries in the United States, 2002, 2005, 2010, and 2015

Source: US Bureau of Labor Statistics (2016), Occupational Employment Statistics (OES) Survey, Department of Labor.

Note: Panel B reports the share of employment in software for industries in which the share is higher than 2 percent of total employment. Industries are provided at the four-digit NAICS 2012. The data appendix describes the occupations included as software related.

The effects of DNR are also widespread across the economy because digital innovation is increasingly relevant across many other industries. Branstetter, Drev, and Kwon (2015), for instance, show that between 1981 and 2005, IT assets have become increasingly critical in production in "traditional" sectors such as automobiles, aerospace and defense, medical devices, and pharmaceuticals. Spending on software increased substantially over time, and software engineers represent an increasingly important share in employment not only in telecommunications, software, and hardware industries but also in other industries, such as finance, business services, machinery manufacturing, and other information-provider services (figure 9.5).

9.4 Impacts of Digital Innovation on the Economies of Scale and Market Concentration

9.4.1 Implications of Digital Nonrivalry for Market Concentration on Global Markets

DNR allows for massive economies of scale that favor market concentration, because with DNR, the marginal cost of diffusion is also zero for the producers: the more products sold, the lower the average cost. Once the idea has been produced and formatted, there is no need to print copies or assemble embodying objects; it is enough to upload the idea to a website, and it becomes accessible to all with a computer and an internet connection. The marginal cost of delivering it to customers is null; hence the unit cost declines linearly with the quantity sold. If a digital product succeeds on the market, the production volume can quickly adapt to demand, and sales can increase while unit costs decrease. Producers will aim to supply the entire market. Such phenomena have been observed in many industries under various names, such as "blockbusters" (pharmaceuticals, movies, aeronautics) or "superstars" (sports). In such conditions, companies with a large pool of customers have an advantage in cost over competitors, which can result in natural monopolies.

Mass production in manufacturing as developed in the Fordist model of production lowered marginal cost compared to specialized production in the previous, craftsmanship-based model. However, the marginal cost was still positive. By contrast, the marginal cost of producing knowledge-intensive products (beyond the first unit) is essentially zero. A corollary of this idea is that investments are largely used to produce "originals"—that is, to innovate, not to produce more copies of the same template. This amounts to the pure fixed costs and zero marginal costs textbook case that is an absolute exception for most production processes—except for information goods, for which it is the baseline case (Varian 2003).

On the process side, IT has lowered communication costs, hence raising the efficient size of firms whatever their industry. It is possible with IT to coordinate highly segmented and dispersed value chains of very large size. This factor is pushing toward higher market concentration in all industries. Evidence collected by Mueller, Simintzi, and Ouimet (2015) shows that the average size of the largest firms has increased significantly in 14 of the 15 countries they studied between the mid-1980s or mid-1990s and 2010. The average size of the top 50 (100) firms in the United States grew by 55.8 percent (53.0 percent) between 1986 and 2010.

Hence IT coupled with globalization have transformed both product markets and production processes in the direction of favoring large size and concentration. Brynjolfsson et al. (2007) show evidence of higher market concentration for more IT intensive industries for 1996–2006 compared to the previous period of 1987–95 (figure 9.6).

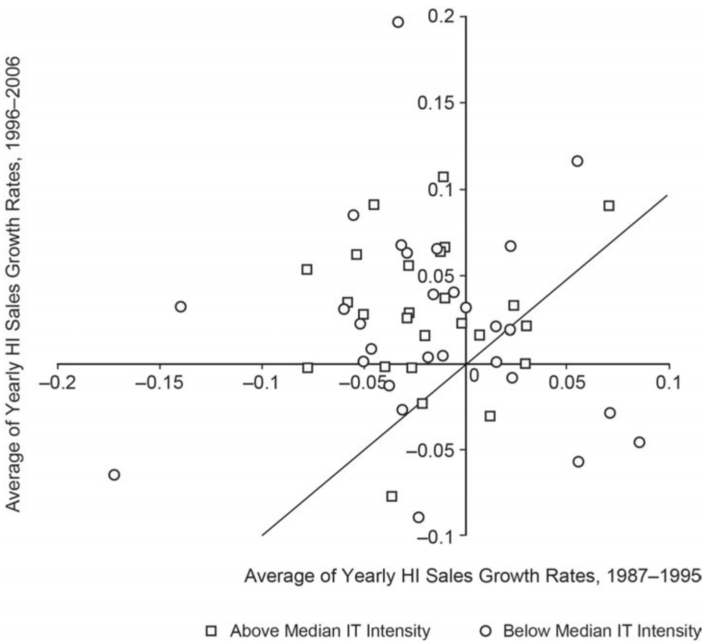


Fig. 9.6 Growth in market concentration of more and less IT-intensive industries, 1996–2006 and 1987–95

Source: Brynjolfsson et al. (2007) based on Compustat.

Note: HI refers to the Herfindahl index of firms' sales.

In markets for digital innovation, economies of scale are reinforced by several factors that foster market concentration and opportunities for smaller-scale producers to challenge incumbents: first-mover advantage, reputation effects, IPR, network effects, and product bundling, whereby different products are sold jointly, as the marginal cost is negligible. There are also opportunities for smaller-scale producers, as discussed in the next section. The expression "scale without mass" (Brynjolfsson et al. 2007) captures a closely connected idea, that it takes little time and investment for a small company (in terms of the number of employees) to become a global behemoth (in terms of turnover), as digital goods can be reproduced at the cost of a click.

A consequence of such economies of scale is the emergence of winner-take-all market structures—that is, markets with highly asymmetric market shares (Rosen 1981). The market dynamics are akin to tournaments, in which the best offer wins the race and captures most (if not all) of the market. The winner's product may only be marginally better than the alternatives, but a market with no substantial distribution costs and where up-scaling is nearly instantaneous (for instance, by distributing services on the internet) gives the winning innovation the opportunity to gain most of the market quickly. The Economic Census shows high rates of concentration for some of the markets closely associated with the digital economy and the economies of scale it allows for. For instance, among business-to-business electronic market providers, the top four providers held 34 percent of the sales 2012 (North American Industry Classification System [NAICS] code 42511). By contrast, the average share of the top four businesses in the wholesale business (NAICS code 42) was 5.6 percent.

Winner-take-all market effects are a well-known phenomenon in innovation-intensive markets. The value distribution of innovations has been shown to be very skewed. Only a few innovations are of high value, while most provide little gain: this has been measured, for instance, using the monetary evaluation given by patent holders to their titles (Harhoff, Scherer, and Vopel 2003) and in terms of the number of citations and other measures of patent quality (see, e.g., OECD 2015b). This results from a few firms dominating markets for those innovations. This tendency is accentuated by digital innovation.

Concurrent with digital innovation, globalization favors market concentration, as lower barriers to operating across borders allow for the emergence of a few global leaders (instead of a multiplicity of national ones) that benefit from the larger scale offered by global markets. This is illustrated by IT sectors with global leaders such as Google and Amazon but also across other more traditional industries in which digital innovation has become increasingly important (in product or in processes), such as pharmaceuticals, automobiles, or chemicals.

Assessing the market shares of these global actors is challenging, as national-level data only capture resident firms but not all market competitors. As an imperfect proxy, figure 9.7 computes the shares of the top 1 and 5 global companies among the 2,500 top R&D companies across different sectors; the evidence shows strong levels of concentration in some of the very dynamic sectors that are highly associated with digital innovation—notably software and computer services, financial services, and electronic and electrical equipment. Figure 9.8 plots the market shares of software and computer services against those of heavy industries.

9.4.2 Rents in Global Knowledge-Intensive Markets

Digital innovations generate higher rents than other innovations. The fact that successful innovators raise rents is not new; it was conceptualized in 1911 by Schumpeter. It is a necessary condition for innovation to occur. What is new is the scale at which this is happening, as reflected in large profit margins in sectors where digital innovation is important. Health technology, technology services, and electronic services were first, third, and fourth in the Forbes 2015 ranking of most profitable sectors, with profit margins of 20.9 percent, 16.1 percent, and 13.2 percent, respectively (finance was in second position, with margins of 17.3 percent; Forbes 2015). Aggregate

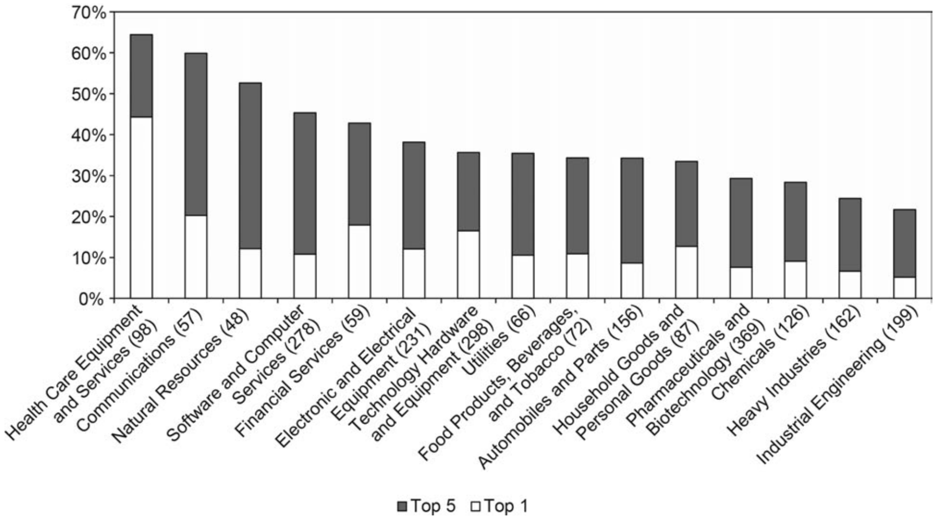


Fig. 9.7 Share of the top 1 and 5 companies in total sales of leading R&D firms in 2015

Source: EU (2016), EU R&D Scoreboard 2016. The shares are computed as the sales share of the top 1 and 5 firms within the total number of firms of the 2,500 R&D most-intensive firms of the EU R&D Scoreboard. The number of firms included in the total for each sector is included in brackets.

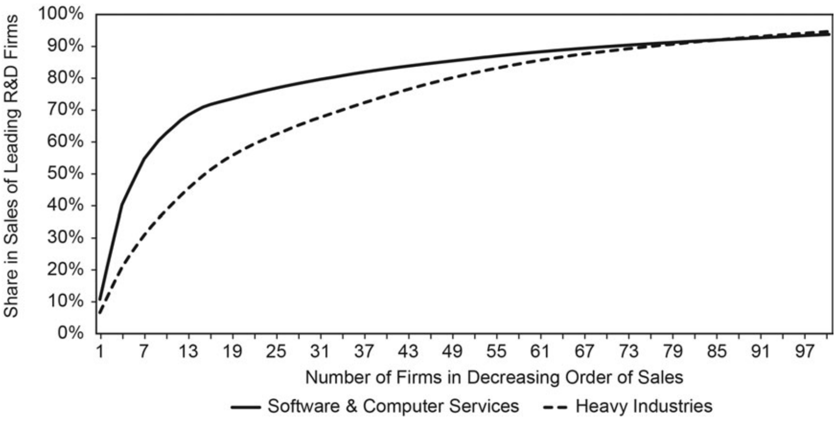


Fig. 9.8 Distribution of the 100 largest firms in terms of sales among the top R&D firms within the software and computer services and heavy industries sectors in 2015

Source: EU (2016), EU R&D Scoreboard 2016.

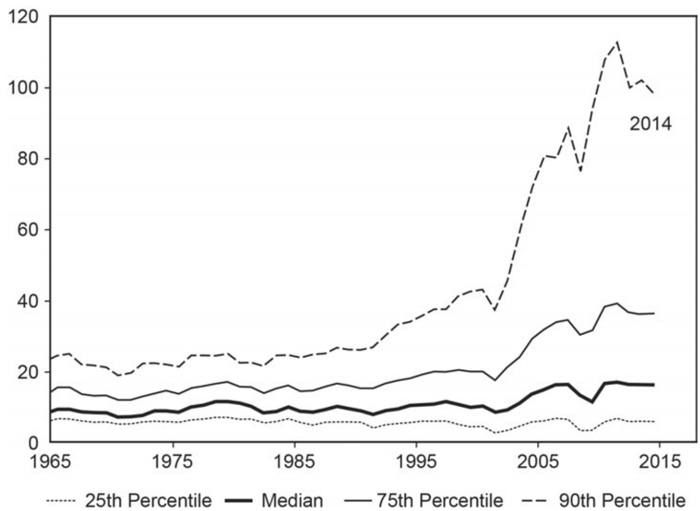


Fig. 9.9 Return on invested capital excluding goodwill, US publicly traded nonfinancial firms

Source: Furman and Orszag (2015) based on Koller, Goedhart, and Wessels (2015).

statistics also show that in the United States, the share of corporate profits in income increased (see figure 9.13 in section 9.5).

The evolution of firm profits is also consistent with increasingly winner-take-all market structures: the top percentiles of firms ranked by return on invested capital (ROIC) have grown most significantly, from less than 30 percent in the early 1990s to 100 percent in 2014 (figure 9.9). The lowest percentiles (25th) had a constant ROIC, and the median increased slightly. Data collected by McKinsey suggest that "two thirds of the non-financial firms with an average ROIC of 45% or higher between 2010 and 2014 were in either the health care or the IT sectors" (Furman and Orszag 2015). Other suggestive evidence of more winner-take-all dynamics is the rise in the share of nominal GDP of the Fortune 100 biggest American companies from 33 percent in 1994 to 46 percent in 2013 (*The Economist* 2016). Players closely associated with the digital economy have gained in importance in this ranking. Those in traditional industries in which digital innovation has become more important also rank highly.

Several supply- and demand-side characteristics favor incumbents' rents. On the supply side, economies of scale in knowledge-intensive products feed efficiency and consequently firms' market shares. One reason is that it is often not straightforward for followers to imitate a successful product immediately. Also, the advance over competitors allows first movers to hire the most skilled and creative workers (who in turn benefit from interacting with equally productive peers). Moreover, in various markets, economies of scope strengthen incumbents' market positions, as in the extreme case of platforms (e.g., Amazon, Apple, Facebook, or Google). These are best placed to launch new products or to profitably scale up existing ones (possibly invented by other firms that platforms will acquire and integrate), as they have a large consumer base that competitors cannot easily match. Owing to standards and reputation effects, products do not travel easily across platforms, and entry for competitors is restrained. Hence while technically newcomers might scale at little cost, they may not get the rewards unless they access leading platforms. These supply side conditions shape the extent to which new entrants can challenge incumbents.

On the demand side, a firm's or product's reputation often influences consumer choice in favor of incumbents; these constraints reduce entrants' opportunities to successfully penetrate markets in spite of the low product scaling costs. The market success of a product can stimulate further sales by incumbent producers, hence reducing opportunities for new entrants. Also, the technical complexity of certain knowledge products magnifies incumbents' advantage, because greater complexity increases the information asymmetry between consumers and producers; consumers prefer to buy from sellers with a specific brand with high reputations as a guarantee that the product is of good quality. Moreover, network effects—that is, product value for each user increasing with the number of users—matter in core sectors of the digital economy. Examples include software programs (the number of users of the software and its interoperability), social networks (the number of friends/colleagues/partners to communicate with), online auctions (the number of bidders and sellers), and internet search engines.[2] Ownership of big data is also an increasingly important source advantage for incumbents, as competitors can only obtain the same quality of data with difficulty. The advantage of data ownership is increasing as, for instance, machine-learning algorithms become more intelligent with larger access to data, reinforcing the advantage of incumbents with access to such data.

Regulatory and policy conditions, including with IPR and standards, are also critical. In allowing firms to protect their digital innovations, they create barriers for competition. There is, consequently, much scope for policy to influence market concentration. Standards, which may restrict entry at the same time as they may enable innovation, also apply more where production processes make intense use of digital innovations.

Certain factors may limit market concentration. One factor is the diversity

2. In the case of internet search engines, the network effects are indirect—that is, one group of users benefits from larger uptake by another group of users. Internet search engines offer users access to information to attract advertising revenues from firms, which they use to develop their services to attract the largest possible number of users. Pricing and other strategies are strongly affected by indirect network effects. For example, profit-maximizing prices may entail below-marginal cost pricing to one set of customers over the long run. In fact, many two-sided platforms charge one side prices that are below cost and sometimes even negative. Thus rents are not observed directly, as would be the case for single-client markets.

of consumers' tastes, which can lead to fragmented markets and monopolistic competition "à la Chamberlin" instead of large winner-take-all markets. However, digital innovation may make product differentiation less costly, allowing companies to extend their control beyond small niche markets by supplying different market segments, chasing potential competitors from their respective domains. Another and more important factor that limits market concentration comes from new entry and creative destruction that arises with lower costs of digital innovation, as discussed next.

9.5 Impacts of Digital Innovation on the Costs of Innovation, Market Entry, and Creative Destruction

This section discusses how digital innovation's effect on the costs of innovating may trigger a more rapid displacement of existing products, increasing the risk for firms to lose market revenue. Creative destruction and market entry may also reduce the market concentration DNR has facilitated.

9.5.1 Lower Entry Costs for Digital Innovations Allow for More Creative Destruction

The costs of innovating have been reduced in a number of ways with digital innovation. First, IT has lowered entry costs compared to many markets, including the costs of producing, managing, and communicating new knowledge (see, e.g., Paunov and Rollo 2016 for evidence of the use of the internet on firm innovation in developing countries). For instance, the emergence of "the cloud" has done away with large upfront investment, giving access to computing power at a low price. Second, the downstream costs of innovating—that is, the costs of producing and disseminating digital innovations—are reduced or even disappear with DNR. Using digital means for advertising and distributing a product (e.g., opening a web page on Amazon) also allows producers of physical goods to reduce marketing costs; they can reach the global market without having to incur large, sunk investment in branding and so on. This is even more the case for some of the most dynamic digital knowledge products, such as software and online services, which can be distributed directly on the internet (no transportation cost). Third, scaling costs are also lower for digital innovations, as they are immediately scalable and can reach an unlimited number of customers. Opportunities to "scale without mass" (i.e., the production of goods and services that require many fewer labor and capital inputs relative to traditional "tangible" products, as a large share of the product is intangible) extend beyond pure digital products (such as software or pure online services).

The lower cost of commercializing innovations allows for more market entry and creative destruction at a more rapid pace, increasing incumbents' risk to lose most if not all market revenue. Even where new products provide only minor improvements relative to existing ones, they may challenge

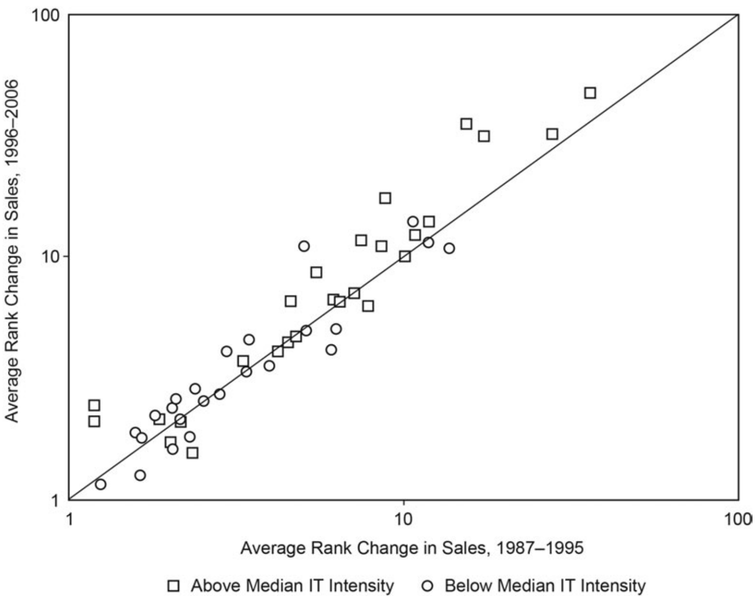


Fig. 9.10 Creative destruction in high- and low-IT-intensive sectors, 1996–2006 and 1987–95

Source: Brynjolfsson et al. (2008) based on Compustat.

incumbents. In the traditional industrial economy, even minor changes to a product would mean incurring significant costs to reach customers (retooling, marketing, etc.). With the digital economy, the main cost of introducing a new product is the cost of invention, as production and marketing costs are low or even nil. Invention costs themselves may also be low in the case of weak differentiation (technical similarity). Yet businesses facing low downstream production costs may launch marginally improved products on the market as in winner-take-all contexts; even innovations with only a marginal advantage over competing products may gain all the market. This reinforces the impact of the reduction in cost on the incentive to launch new innovations. Technical change, however, may not be more rapid overall, as it depends on total research effort. Appendix A provides a simple model of the impacts of cost reductions for digital innovations on the sequencing of innovation.

There is evidence that digital innovation has indeed increased risk that firms face in markets. Brynjolfsson et al. (2007) show that "creative destruction" (i.e., changes in firms' rank of sales in their respective industries) was more important in more IT-intensive industries following the mid-1990s (figure 9.10). Statistics on the volatility of stock market valuations of traded US companies show a similar increase over the 1990s and continued high levels from then onward (figure 9.11).

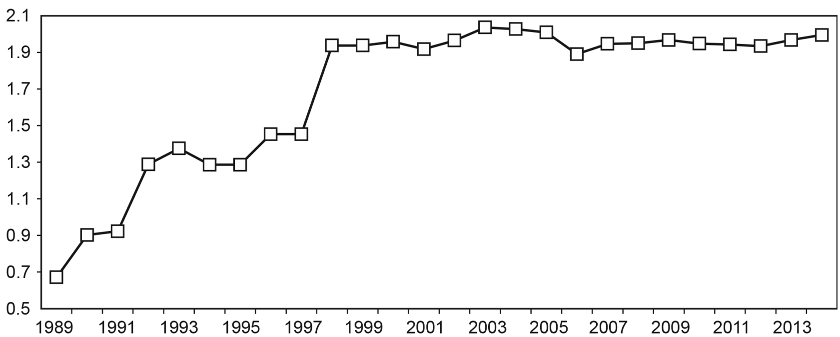


Fig. 9.11 Stock market volatility of traded US-based companies, 1989–2014

Source: Bas, Paunov, and Rodriguez-Montemayor (2017) based on Compustat.

Note: The figure plots the median standard deviation of the annual stock market price of US-based traded firms.

Volatility measures of financial investments also point to higher risk in more innovation-intensive sectors: betas (that estimate investment volatility) are higher than 1 (indicating greater risk compared to the entire market) in the biotechnology, internet, computer, and electrical equipment industries, while less knowledge-intensive industries, such as food processing and tobacco, display betas lower than 1 (figure 9.12). Also, Faurel et al. (2015) show that US firms registering more new trademarks faced higher volatility of stock market return and earnings for the 1993–2011 period.

9.5.2 Impacts of Market Entry and Creative Destruction on Market Concentration

Market concentration and creative destruction are not in contradiction with each other in markets where competition is based on digital innovation. In such markets, competition is not about prices—in which case, the threat from new entry would discipline the incumbents—but about radical product innovation, as successful new products fully displace existing ones, taking over the market no matter the price charged by incumbents. This also means that until the next innovation comes, incumbents keep their market position and do not have to bother about competition. The massive scale economies combined with business strategies that allow retention of market power allow winners to reap rents until they are replaced by successful challengers.

While the evidence shows that market concentration has increased with digital innovation—that is, that the current context is one where market concentration and creative destruction coexist—the threat of market entry and creative destruction may also reduce market concentration. The extent to which market concentration is reduced depends on technology, business strategies, and policy. Where technology brings radical change, newcomers can challenge incumbents more than where incumbents can rely on master-

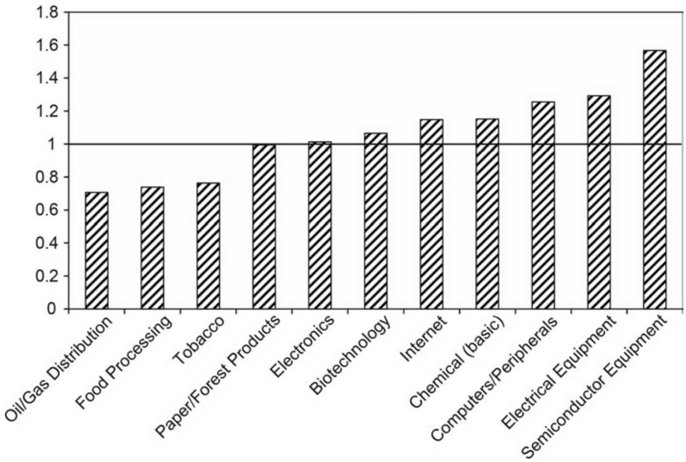


Fig. 9.12 Estimates of selected sectors' betas relative to the entire financial market for US firms in 2008–12

Source: Damodaran (2015) based on data from Bloomberg, Morningstar, Capital IQ, and Compustat.

Note: The beta of a sector is a measure of the volatility, or systematic risk, of a financial investment in a sector in comparison to the financial market as a whole. The betas are estimated by regressing weekly returns on stock of companies within a sector against a benchmark index representative of the financial market, which is the NYSE composite index. Regressions are based on data within a time window of five years previous to the reference year. The beta is unlevered by the market value debt-to-equity ratio for the sector making use of the following formula: Unlevered Beta = Beta / (1 + (1 – tax rate) (Debt/Equity Ratio)). The unlevered beta is the beta that would be obtained if the investment was on a company without any debt. The risk of an investment is, in general, higher when the ratio between debt and equity within a sector is higher. In this way, the focus is on the level of risk, which is only driven by the characteristics of the sector other than the financial structure of companies within the sector. Further details can be found at http://pages.stern.nyu.edu/~adamodar/.

ing the technology. For instance, traditional car manufacturers find themselves confronted with new business models such as the one implemented by Uber, which provides car sharing as an alternative to car ownership. Also, where incumbents have fewer opportunities to exploit network effects, platform dominance, leading technical standards, and data access,[3] more competitive market conditions may result. The latter critically depends on policy (including antitrust, entrepreneurship, and IPR).

Creative destruction may be challenged on winner-take-all markets because winning comes with advantages that allow incumbents to retain rents for at least a period of time. Particularly large market players benefit from economies of scale and scope and often from network economies. These provide them with the capital and networks needed to capitalize on

3. In the digital economy, data are the primary input for many innovations and services. This is reinforced in more recent technologies like artificial intelligence.

and upscale innovations. This includes the advantages large incumbents can reap from big data with better tools to make use of them. These may contribute to the marginalization of small players by a feedback loop, whereby better data allow better services, further enhancing their advantage. Moreover, in consolidated markets, incumbents have succeeded in establishing their products as essentials (as, for instance, is the case for different digital platforms). In this context, challengers develop new, more radical innovations but do not immediately replace winners. Anecdotal evidence shows that most of the many new entrants are quickly pushed out of the market (see, e.g., Decker et al. 2014 for evidence on the United States).

While start-up failure is not surprising in itself—as new business ideas usually have higher failure rates—the issue is that among the successful ones, most are taken over by incumbents. Examples include YouTube (acquired by Google) or Instagram and WhatsApp (both acquired by Facebook). This is also the case in other industries like biotechnology, where most successful start-ups are taken over by big pharmaceutical firms that increasingly act like platforms, which possess unique marketing and financial infrastructures and can externalize the most exploratory innovation to start-ups that they acquire when successful. While these acquisitions reduce competition and creative destruction, they may contribute to increasing the efficiency of industry ecosystems, as good radical innovations developed in small firms can create more value once deployed at larger scale.

9.6 How Do Rents Generated by Higher Market Concentration and Greater Risk Affect the Distribution of Income?

This section discusses how changes in market structures and risk brought by digital innovation have affected the distribution of income. It describes the mechanisms accounting for higher returns to the top of the income distribution—resulting in higher returns to capital, top executives, and top employees but less to average workers. The mechanisms explain aggregate findings by Forbes (2000) on the correlation between higher growth across US states and higher levels of income inequality and returns to the top 1 percent and 10 percent and by Aghion et al. (2015) on differences in innovation intensities and higher returns to the top 1 percent.

9.6.1 Effects of Digital Innovation on the Distribution of Income

The impact channel of digital innovation on the distribution of income that has been discussed in the literature is about complementarity or substitutability to different types of labor. The debate, which dates back to the industrial revolution, has aimed at identifying whether technological change is skill-biased or not (see Haskel et al. 2012). More related to digital innovation, several studies have investigated the substitution effects of automation, specifically with regards to routinized operations that machines can easily execute (see Goos and Manning 2007; Autor and Dorn 2013; Michaels, Natraj, and Van Reenen 2014). Also, Acemoglu and Restrepo (2016) show a robust negative effect of the adoption of robots on employment and wages. As to effects on pay of top income groups, Haskel and Westlake (2017) discuss how the rise of intangibles in the economy—closely related to an increase in digital innovation—may also result in superstar pay for managers and other key employees.

The channel linking digital innovation to the distribution of income we discuss herein is different and stems from digital innovations' impacts on market structures. It does not relate to how capital and labor complement or substitute for digital innovation. Winner-take-all market structures affect the distribution of income in two ways. First, market concentration results in higher market rents. This affects the distribution of income due to important differences in the negotiation power of different claimants to these rents, including investors, top executives, and different workers. Second, higher market risk as generated by more creative destruction results in higher compensation for risk takers (owners, investors, and executives). The specific implications for different input factors and the evidence are discussed below.

9.6.2 Higher Returns to Capital Invested in the Digital Economy

Winner-take-all market conditions have resulted in higher returns to the capital affecting the distribution of income as capital ownership is concentrated among the highest income groups (Atkinson 2015). The returns to capital invested in digital innovation increase because the market rents are mainly captured by the residual claimants, who are the investors and managers, while employees' wages are largely fixed in the labor market. "Efficiency wage" mechanisms ensure that some of the rent goes to employees. Rents are not necessarily "excessive"—that is, higher than required—from an incentive/efficiency perspective. Investors require a risk premium to invest, as market risk is higher with more creative destruction.

An indicative piece of evidence of more rents for investors and owners is that over the past decades, corporate profits have increased while interest rates have decreased (figure 9.13). If there were no rents, then corporate profits would follow the path of interest rates, as these reflect the returns to capital in the economy. Barkai (2016) also documents a substantial increase in the profit share of US businesses over the past 30 years. Recent work by de Loecker and Eeckhout (2017) also shows that markups and market power increased since the 1980s.

As pointed out by Kornai (2016), anecdotal evidence from the Forbes 400 richest individuals includes a number of key actors of digital innovation: Bill Gates (Microsoft), Larry Ellison (Oracle), Michael Bloomberg (Bloomberg), Mark Zuckerberg (Facebook), Larry Page and Sergey Brin (Google), and Jeffrey Bezos (Amazon).

The evolution of top income share has been a capital-driven phenomenon

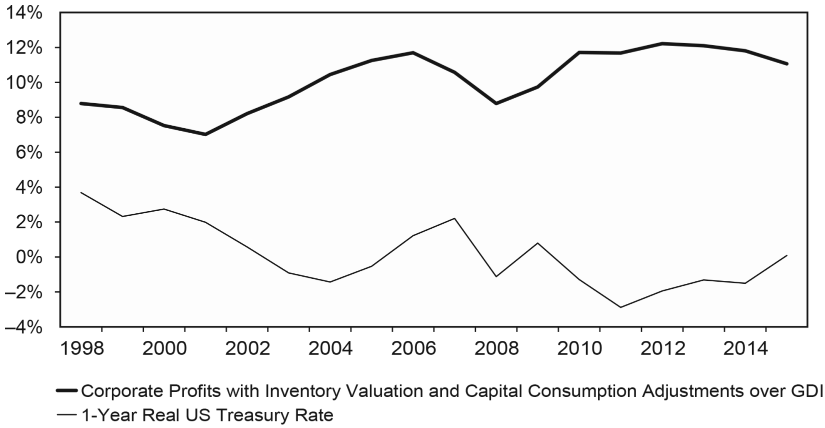


Fig. 9.13 Corporate profits and real interest rates (in percentages) for 1985–2015

Source: Based on data on corporate profits and the GDI from the Bureau of Economic Analysis, Bureau of Labor Statistics published May 27, 2016. Data on the one-year real US Treasury rate are taken from the US Treasury (http://www.multpl.com/1-year-treasury-rate/table) using the CPI for the United States from the OECD Main Economic Indicators database.

since the late 1990s (Piketty, Saez, and Zucman 2016). Data for 2000–2014 show that growth of average income per adult owed mostly to growth in capital income, which grew by 2.2 percent per year, while labor income grew by 0.1 percent per year.

Investigating the relationship between profits and the top 1 percent income, figure 9.14 shows the evolution of median and average profits of US stock-market-traded firms for 1992–2013 and pretax income for the top 1 percent and the middle 40 percent. Figure 9.15 shows a strong positive correlation between the growth rates of the top 1 percent income and profit: 0.48 (for the median) and 0.51 (for the average). By contrast, correlation between the middle 40 percent income and profits is lower (of 0.12 for the median and of 0.24 for the average). This suggests that the evolution of profits influences income inequality, as it benefits the top 1 percent but not others.

Bas, Paunov, and Rodriguez-Montemayor (2017) show that markets characterized by higher concentration and volatility (to proxy for risk) are associated with higher profits (column 1 of table 9.1). Market volatility benefits profit more than wages but less than executive pay (columns 2 and 3 of table 9.1). These results are obtained for the following specification:

$$(1) \qquad \Pi_{ijt} = \alpha + \beta_{herf} * Sh\_Top5_{jt-1} + \beta_{vol} * Volatility_{jt-1} + \Gamma * \boldsymbol{X_{ijt}} + \Lambda * \boldsymbol{J_{jt}} + \tau_{st} + \lambda_i + \lambda_t + \varepsilon_{ijt},$$

where Π_{ijt} stands for the log profits as well as the profit-to-wage and profit-to-executive-pay ratios. *Sh_Top5* and *Volatility*, respectively, refer to the

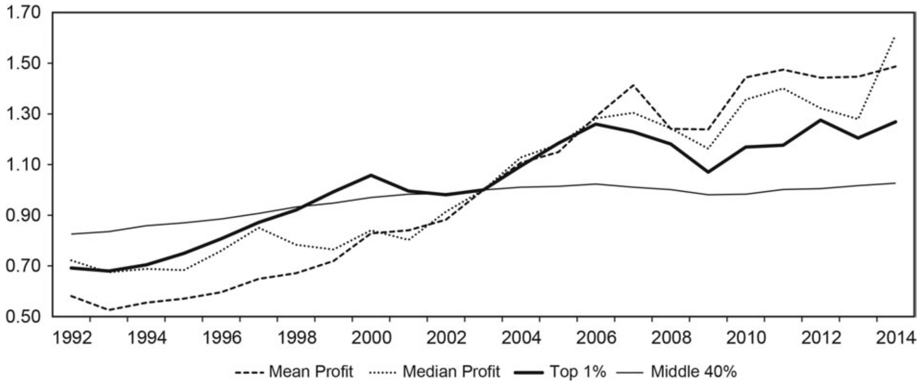


Fig. 9.14 Evolution of profits of publicly traded US-based firms and the US pretax income of the top 1 percent and middle 40 percent, 1992–2014 (2003 = 1)

Note: Profit data are computed using data for publicly traded firms in all industry and service sectors with the exception of the mining, quarrying, and oil and gas extraction sector (NAICS 21), excluding in this way the influence of the price of natural resources on the trend, and NAICS sectors 55–92.

Source: Bas, Paunov, and Rodriguez-Montemayor (2017), based on Compustat for profits, and Piketty, Saez, and Zucman (2016) for pretax income of the top 1 percent and middle 40 percent.

share of the top 5 percent of firms and the standard deviation of firms' stock market valuations for industry j at time $t - 1$. The specification includes time trends across industry sectors (τ_{st}) to control for sector-specific time trends that may affect executive pay and correlate with changing market dynamics. The authors also include firm fixed effects (λ_i) and year fixed effects (λ_t) to isolate any time-invariant unobservable differences in pay across industries, firms, and executives and year-specific shocks to executive pay from our estimates. J_{jt} is a vector of industry controls that includes industry size and capital intensity. X_{ijt} is a vector of firm observable characteristics varying over time that includes firm size, profit margins, and revenue.

9.6.3 The Declining Return to Labor

A corollary of higher returns to capital is the decreasing share of labor in value added in many OECD countries over the past three decades (figure 9.16). Official statistics from the US Bureau of Labor Statistics show a decline of the share of labor in the United States from 64 percent—a value that stayed constant from the immediate post–Second World War period—to 58 percent from the mid-1980s onward (Elsby, Hobijn, and Şahin 2013).[4] Official statistics may underestimate the decrease in the labor share because

4. Karabarbounis and Neiman (2014) also show that the share of corporate gross value added paid to labor declined by 5 percentage points for 59 economies over 1975–2012. Using industry-level data, Alvarez-Cuadrado, Van Long, and Poschke (2014) find that the income share from labor has declined in all but 3 of a set of 16 industrialized economies over the same period.

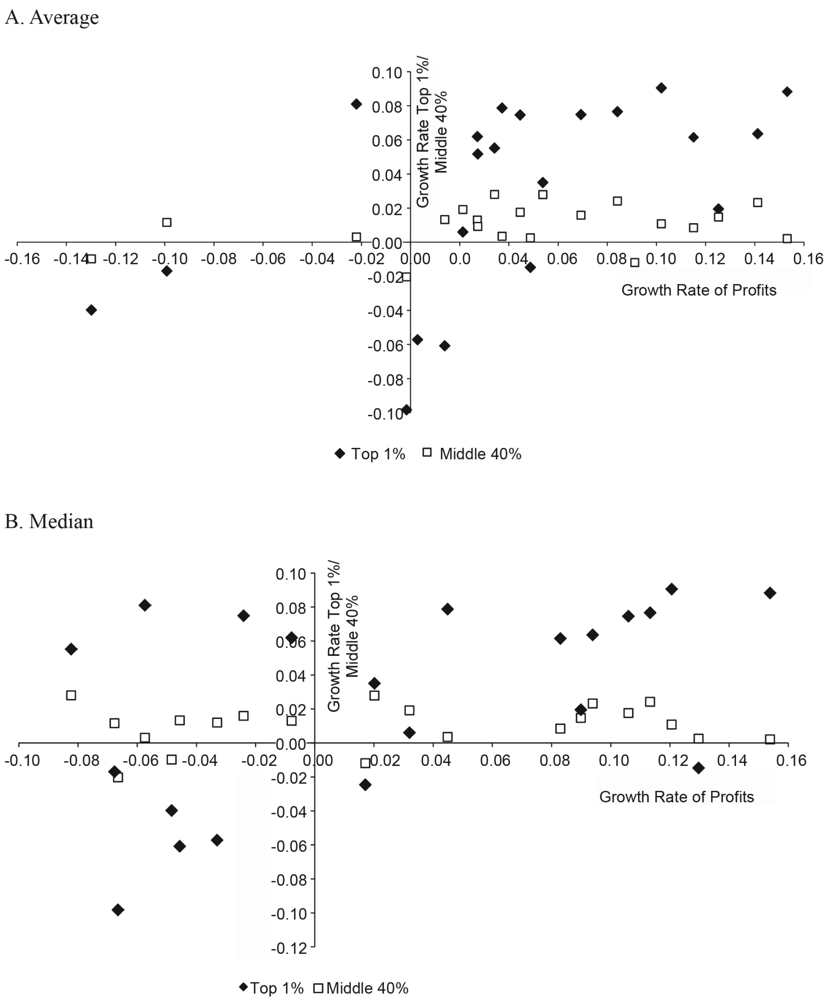


Fig. 9.15 Correlation of annual growth rates of profits and the average top 1 percent and middle 40 percent of the US pretax incomes, 1992–2014

Source: Bas, Paunov, and Rodriguez-Montemayor (2017), based on data on corporate profits from Compustat, and Piketty, Saez, and Zucman (2016) for pretax income of the top 1 percent and middle 40 percent. Growth rates are computed on real income and profits, applying the same deflator as described in Piketty, Saez, and Zucman (2016).

intangibles are not adequately accounted for in capital. Corrado, Hulten, and Sichel (2009) show that the USD 1 trillion increase in GDP (in 1999) arising from addition of intangible investment to GDP results in an equal increase in gross domestic income (GDI), all of which accrued to the owners of capital, consequently decreasing the share of labor income.

Several pieces of evidence point to a role of digital innovation in account-

Table 9.1 Impacts of market dynamics on profits

Dependent variables:	Profits$_{ft}$ (1)	Profit to wage ratio$_{ft}$ (2)	Profit to executive pay ratio$_{ft}$ (3)
Concentration (s, $t-1$)	0.181*	0.202	−0.253
	(0.103)	(0.150)	(0.222)
Volatility (s, $t-1$)	0.024	0.118***	−0.102***
	(0.018)	(0.031)	(0.036)
Firm controls	Yes	Yes	Yes
Industry controls	Yes	Yes	Yes
Industry-time trend	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	44,570	10,039	9,584
R^2	0.95	0.86	0.76

Source: Bas, Paunov, and Rodriguez-Montemayor (2017) based on ExecuComp and Compustat for 1992–2013.

Notes: Market concentration is measured using the share of the top 5 percent of firms in total industry sales while market volatility is measured as the average annual standard deviation of firms' stock market value at the 6-digit NAICS industry level. See Bas, Paunov, and Rodriguez-Montemayor (2017) for a description of the other variables used in this estimation. Robust standards errors corrected for clustering at the 6-digit-industry-year level are reported in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$.

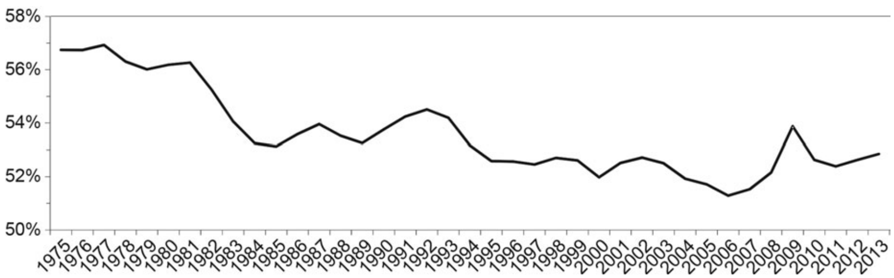


Fig. 9.16 Labor share in value added for the OECD-21 in percentages, 1975–2013

Source: OECD National Accounts Database.

Note: The figure shows statistics for the following 21 OECD countries with available data: Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Spain, Sweden, the United Kingdom, and the United States.

ing for those changes. First, figure 9.17 shows that the labor share in the United States decreased significantly in the more R&D-intensive sectors but not in the least R&D-intensive sectors. Also, Koh, Santaeulàlia-Llopis, and Zheng (2015) show that the lowering of the labor share in the United States over the past three decades stems mainly from an increase in the income share of knowledge capital—that is, IPR and software and not physical capital. Related evidence comes from Karabarbounis and Neiman (2014), who

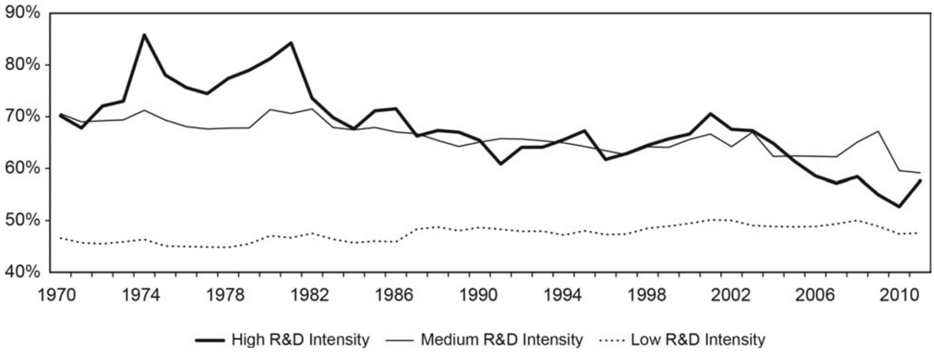


Fig. 9.17 Labor share of industry value added in the United States by sectoral R&D intensity in percentages, 1971–2011

Source: OECD STAN Database.

Note: Labor share of income is measured as labor costs (compensation of employees) over value added. Sectors are assigned to R&D intensity categories following OECD "OECD Taxonomy of Economic Activities Based on R&D Intensity," OECD Science, Technology and Industry Working Papers, No. 2016/04. (Paris OECD, 2016). The "medium R&D intensity sectors" category combines the medium-high-, medium-, and medium-low-intensity sectors.

find that countries and industries experiencing larger declines in the relative price of investment—a development mainly due to IT investments—had larger declines in labor shares.

Second, table 9.2 provides regression results for 27 OECD countries over 1995–2007 that show more direct evidence on the effects of innovation, following the methodology first proposed by Rajan and Zingales (1998). In our context, we compare the trends in labor share of income, concentration, and firms' mobility between industries that are relatively more and less dependent on R&D investments as a function of country level innovation, controlling for both industry- and country-year effects. The advantage of this approach is that it avoids cross-country comparison (which is more subject to endogeneity concerns deriving from omitted variables biases). The estimated regression is as follows:

$$(2)\quad Y_{cjt} = \beta_0 + \beta_1(Patenting_{ct} * Patent\ Int_j) + \beta_2(Graduates_{ct} * Skill\ Int_j)$$
$$+ \beta_3(Capital_{ct} * Capital\ Int_j) + \beta_4(Finance_{ct} * Intang\ Int_j)$$
$$+ \beta_5(Trade_{ct} * Transport_j) + \beta_6(Union\ Density_{ct} * Low\ Skilled\ Share_j)$$
$$+ \beta_7(GDP_{ct} * K\ Int_j) + u_{cj} + \eta_{ct} + \varepsilon_{cjt}$$

where Y_{cjt} is the labor share and β_1 is our coefficient of interest, indicating the effect of innovation—proxied for by patenting at country level and interacted with industry patent intensity—on the labor share. We also test for the effects of other factors that may be correlated with innovation and affect

Table 9.2 **Evidence on the impacts of innovation on the labor share from industry data for 1995–2011 across 27 OECD countries**

	Industry labor compensation over value added				
Dependent variable	(1)	(2)	(3)	(4)	(5)
Patents_c * $\text{Patent intensity}_{ind}$	−0.054*	−0.056*	−0.068**	−0.058**	−0.064**
	(0.032)	(0.030)	(0.028)	(0.028)	(0.027)
Graduates_c * $\text{Skill intensity}_{ind}$		−0.202*	−0.201*	−0.183*	−0.184*
		(0.115)	(0.116)	(0.110)	(0.106)
Capital_c * $\text{Capital intensity}_{ind}$		0.038	0.068	0.043	0.009
		(0.421)	(0.419)	(0.423)	(0.430)
Finance_c * $\text{Intangible assets}_{ind}$		−0.336**	−0.349**	−0.336**	−0.324**
		(0.145)	(0.143)	(0.145)	(0.145)
Trade_c * $\text{Transport equipment}_{ind}$			0.196*	0.178	0.128
			(0.115)	(0.112)	(0.113)
Union Density_c * $\text{Low-skill intensity}_{ind}$				0.007*	0.008*
				(0.004)	(0.004)
GDP_c * $\text{Capital intensity}_{ind}$					0.393
					(0.317)
Country-year fixed effects	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	4,070	4,070	4,070	4,070	4,070
R^2	0.25	0.26	0.26	0.27	0.27

Source: Regressions based on data from the OECD MSTI and STAN databases.

Notes: Regressions use data for 16 manufacturing industries in 27 countries and over a period of 17 years between 1995 and 2011. Both dependent and independent country-level variables are in logarithms. Industry-level exposure variables are normalized. As a consequence, coefficients are interpretable as difference in the elasticity of the dependent variable, to changes in the country-level variables, between industries with maximum exposure and industries with minimum exposure. Therefore, the coefficient on Patents_{ct} * $\text{Patent intensity}_{ind}$ in column (5) reads as follows: the difference in the elasticity of the labor share to an increase in country-level innovation (Patents), in industries with the highest patent intensity (1) compared to industries with the lowest patent intensity (0), is −0.064. For instance, if patenting doubled (increase by 100 percent), then the labor share in industries with high patent intensity would decrease by 6.4 percent more than in industries with low patent intensity. The identification is based on the hypothesis that industries that use patents more intensively have a lower labor share than industries that rely relatively less on patents. The data appendix provides definition of variables included. Robust standards errors are reported in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$.

the labor share. This includes controls of the availability of human capital, finance, and capital, as well as the importance of labor unions and trade. We also add country GDP as well as country-year and industry-year fixed effects to account for and control for other country and industry factors and their evolution over the period analyzed. The data appendix provides details of the variables we use.

Our findings show a negative relation between labor shares and patenting performance, even as the effects of finance, skills, capital, labor unions, trade, and GDP are controlled for. We also find a negative effect of a more skilled labor force on the labor share. This may also be related to labor-replacing effects of technological change. The evidence is coherent with evidence by Bassanini and Manfredi (2012), who find for industries across 25 OECD countries over the 1980–2007 period that 80 percent of intra-industry labor-share contraction can be attributed to total factor productivity growth and capital deepening.

Third, other evidence that supports our model on the effects of winner-take-all markets on the decrease in the labor share includes recent evidence by Barkai (2016) and Autor et al. (2017). Barkai (2016) finds that the decline in the labor share is due to an increase in markups, thus confirming the link between the labor share and rent sharing. Autor et al. (2017) show across different datasets for the United States and other countries that the fall in the labor market share is strongest in industries with stronger market concentration and that market concentration is stronger in more technology-intensive industries.

Digital innovation is of course not the only cause behind the decreasing labor share and higher rewards to capital. Other factors have contributed as well, including the weakening of unions (as also shown in our results in table 9.1). Also, decreasing labor returns do not automatically translate into higher rewards to capital invested in digital innovation. Some of the gap may be related to higher depreciation rates: modern forms of capital, such as computers, software, and other communication technologies, depreciate much faster than equipment of the past. Computer R&D has an estimated depreciation rate of 40 percent (Li and Hall 2016). Moreover, capital includes, aside from intangible assets, real estate, tangible capital, and capital stocks of the government sector. Bonnet et al. (2014), for instance, shows evidence of higher returns to real estate.

Finally, several measurement issues need to be addressed to adequately measure the labor share, especially as digital innovation rises in importance. This includes accounting for the contribution of intangibles to income. The gap between income accounts that take intangibles into account and those that do not widens (Corrado et al. 2009). In addition, Elsby, Hobijn, and Şahin (2013) show that the methods used to impute the labor and capital income earned by entrepreneurs, sole proprietors, and unincorporated businesses influenced the changing labor shares reported by the US Bureau of Labor Statistics. The downward trend, however, remains even if self-employment is not taken into account (Karabarbounis and Neiman 2014). The gross labor share may also be much higher than the net labor share once tax deductions are taken into account. Bridgman (2014) finds, however, that adjustments to taxes are modest for most countries, including the United States.

9.6.4 Higher Returns to Executives

Growing risk has increased the impact of managers' decisions on profits. Under stable market conditions, decisions made by managers make little dif-

Table 9.3 **Share of executive compensation in net sales over 1992–2014, on average and by percentile**

Sector	10th	50th	90th	Average
IT-related services	0.3%	2.0%	16.9%	6.4%
Innovation-intensive manufacturing	0.3%	1.7%	13.4%	5.4%
Finance and insurance	0.2%	1.5%	7.7%	3.5%
IT-related manufacturing	0.3%	1.3%	6.7%	2.8%
Extractive industries	0.1%	1.1%	7.6%	2.8%
Non-IT-related services	0.1%	0.5%	2.8%	1.3%
Noninnovative manufacturing	0.2%	0.6%	2.3%	1.2%
Retail and wholesale trade	0.1%	0.4%	2.0%	1.0%
Transportation	0.1%	0.4%	1.6%	0.7%

Source: Bas, Paunov, and Rodriguez-Montemayor (2017) based on ExecuComp and Compustat.
Notes: Further detail on the categorization of industries is provided in the data appendix.

ference, as market shares have some inertia and the quality of decisions can be averaged over time. In winner-take-all markets, a manager's decision that is just marginally better or worse than that of competitors can result in large gains or alternatively large losses. The mechanism operates as described by Rosen (1981) when characterizing the earnings of the most successful athletes and entertainers ("superstars"), which exceed by far the predictions of conventional models. Evidence on the rewards of executives relative to firms' net sales shows striking differences in rewards for the top 90th percentile in a few key sectors of activity: IT-related services, innovation-intensive manufacturing, and IT-related manufacturing (table 9.3). Top managers in finance and insurance and extractive industries also receive high pay; this evidence points to the role of other factors such as the financialization of the economy in explaining changes in the distribution of income.

In addition, top managers' activity is subject to information asymmetry: it is difficult to monitor their actual capacity and effort, especially where only marginal differences might make a big difference in the outcome and where market risk is high. Competition between firms to attract the best managers has consequently increased, giving top managers the ability to negotiate favorable compensation packages. For those reasons, top managers have been able to capture part of the higher rent and have seen their average pay—particularly nonwage compensation—rise much faster than other employees who have less influence on firms' performance. There is the more intensive use of high-powered incentives such as stocks and stock options that give executives a share in the company's profits, boosting the pay for the winners and, in theory, punishing losers (Lerner and Wulf 2007; Hall and Liebman 1998; Murphy 1998). More than three quarters of executive pay in 2014 were due to nonwage compensations—up from slightly more than

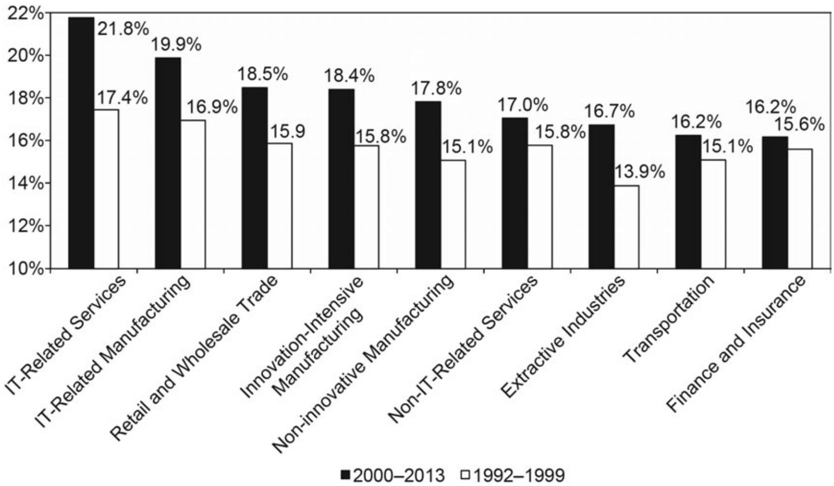


Fig. 9.18 Annual turnover rate of leading executives by sector of activity, for 1993–2013

Source: Bas, Paunov, and Rodriguez-Montemayor (2017), based on ExecuComp.
Note: Further detail on the categorization of industries is provided in the data appendix.

half in 1992. It is also these shares rather than the salary per se that explain the higher reward to top deciles during the period of the dot-com bubble.

Moreover, as is the case for investors, important nonwage compensation means that managers share in the market risks and consequently may claim higher risk compensation. One piece of evidence on risks for managers is their turnover rate. Checking the rates across sectors of activity, we find indeed that it is larger for IT and innovation-intensive activities. Over 2000–2013, top executives in IT-related services have the highest exit rate, with more than 1 in 5 leaving their position (this number may also partly reflect executives leaving for other firms as part of "poaching of the best"; figure 9.18). IT-related manufacturing is the second highest. The rate has increased relative to other sectors compared to 1993–99.

Digital innovation has evolved at the same time as top managers have seen their rewards increase, also in IT-intensive sectors. In the United States, the CEO-to-worker compensation ratio was 29.0 to 1 in 1978, grew to 122.6 to 1 in 1995, and was 272.9 to 1 in 2012 (Mishel and Sabadish 2013). An estimated 40 percent of the top 0.1 percent in the United States are managers in nonfinancial industries (Bakija et al. 2010 as quoted in CEA 2016). Top managers in sectors where digital innovation is important receive returns that are higher than expected from their industries' share in total sales (table 9.4). Executives in the IT-related services industries represented nearly one in five of the top 1 percent of executives in 2000–2014, a similar share to executives

Table 9.4 Distribution of the top 1 percent of executives across sectors of activity

	2000–2014		1992–99	
	Share of the top 1%	Industry share in sales	Share of the top 1%	Industry share in sales
Finance and insurance	24.9%	19.3%	26.5%	13.3%
IT-related services	24.1%	11.3%	21.4%	9.8%
IT-related manufacturing	12.4%	7.6%	9.8%	7.9%
Retail and wholesale trade	8.9%	13.0%	8.6%	13.7%
Innovation-intensive manufacturing	8.7%	7.1%	7.5%	7.9%
Extractive industries	7.4%	14.5%	3.5%	13.3%
Non-innovative manufacturing	6.9%	8.9%	9.5%	13.6%
Non-IT-related services	4.0%	7.9%	7.3%	8.5%
Transportation	2.7%	10.4%	5.9%	11.9%

Source: Bas, Paunov, and Rodriguez-Montemayor (2017) based on ExecuComp and Compustat.

Notes: Further detail on the categorization of industries is provided in the data appendix.

in finance and insurance. IT-related manufacturing is in third rank in terms of the share of top executives, above its rank in industry sales. Other sectors represent higher shares in sales than of top 1 percent executives.

Bas, Paunov, and Rodriguez-Montemayor (2017) show that winner-take-all market characteristics—that is, markets that are characterized by higher industry market concentration and market volatility (to proxy for risk)—are associated with higher pay of the top executive of US-based traded companies. Their evidence is based on the following specification:

$$(3)\qquad Pay_{ifjt} = \alpha + \beta_{herf} * Sh\_Top5_{jt-1} + \beta_{vol} * Volatility_{jt-1} + \Gamma * \boldsymbol{X}_{fjt} + \mathrm{K} * \boldsymbol{Z}_{ifjt} + \Lambda * \boldsymbol{J}_{jt} + \tau_{st} + \lambda_{if} + \lambda_{t} + \varepsilon_{ifjt},$$

where *Pay* stands for executive *i*'s pay of firm *f* in industry *j* at time *t*. Z_{eijt} is a vector of executive-specific controls and includes the age of the executive, their tenure in the firm, and whether they are about to leave the firm (as pay may differ prior to executives' departure). Other variables are as specified for equation (1), described above.

Columns (1) and (2) of table 9.5 show a positive association between market concentration, volatility, and executive pay at both executive and firm levels. Specifically CEOs—that is managers who decide on firms' strategies (column 3)—receive higher pay on these markets. It is not the fixed-wage component but the share that varies with firm performance that is higher on more concentrated and volatility markets (column 4). This finding points to the role of risk compensation in executive pay. The effects of market concentration on executive pay are also consistent with that of Gabaix, Landier,

Table 9.5 **The impacts of market concentration and volatility on top executive compensation in the United States, 1992–2013**

Dependent variables:	Executive pay$_{ift}$ (1)	Executive pay share$_{ft}$ (2)	Executive pay$_{ift}$ CEOs vs. others (3)	Executive wage pay$_{ift}$ (4)
Concentration (s, t − 1)	0.474***	0.006***		−0.067
	(0.165)	(0.001)		(0.099)
Volatility (s, t − 1)	0.103***	0.026***		−0.006
	(0.021)	(0.007)		(0.012)
Concentration (s, t − 1) × CEOs			0.650**	
			(0.262)	
Concentration (s, t − 1) × Other executives			0.335	
			(0.255)	
Volatility (s, t − 1) × CEOs			0.121***	
			(0.023)	
Volatility (s, t − 1) × Other executives			0.091***	
			(0.022)	
P-Value of the Difference in Coefficients for Concentration			0.00	
P-Value of the Difference in Coefficients for Volatility			0.07	
Firm controls	Yes	Yes	Yes	Yes
Executive controls	Yes	No	Yes	Yes
Industry controls	Yes	Yes	Yes	Yes
Executive-firm fixed effects	Yes	No	Yes	Yes
Firm fixed effects	No	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes
Observations	42,407	8,608	42,407	42,407
R^2	0.79	0.47	0.79	0.76

Source: Bas, Paunov, and Rodriguez-Montemayor (2017) based on ExecuComp and Compustat.

Notes: Market concentration is measured using the share of the top 5 percent of firms in total industry sales while market volatility is measured as the average annual standard deviation of firms' stock market value at the 6-digit NAICS industry level. Robust standards errors corrected for clustering at the 6-digit NAICS-year level are reported in parentheses. See Bas, Paunov, and Rodriguez-Montemayor (2017) for a description of the variables used in this estimation. Robust standards errors corrected for clustering at the 6-digit-industry-year level are reported in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$.

and Sauvagnat (2014), who show that CEOs in larger-sized firms get more pay. Although not identical, firm size and market power are correlated.

The evidence reported associates executive pay to winner-take-all market characteristics of their own industry. The rent-sharing effects should apply with regards to executives' own industry because higher pay arises from the profits generated in executives' own industry and executives' ability to negotiate shares in profits in their company. This would not be affected by market dynamics in other sectors than executives' own because rents are not transferable.

However, developments across the economy at large are also relevant to executive pay because executives may have transferable skills that can be applied in other markets. This means that the market characteristics in one sector may influence the pay in another. This is well illustrated by the Heckscher-Ohlin model that can obtain very different outcomes compared to a single-industry model (see Haskel et al. 2012). This regards executive pay compensation given in winner-take-all markets as skills that complement capital in the digital innovation economy. These effects are not adequately captured if the focus is only on developments in executives' own industry. The role of such effects is consistent with the finding in Bas, Paunov, and Rodriguez-Montemayor (2017) of strong significant effects of market dynamics across the larger industry in which executives operate. However, the effects are no longer significant if industry characteristics are also included in those regressions, suggesting that effects of market dynamics operate at the specific industry level. Evidence from the 20-year panel of executives of ExecuComp also shows that few executives switch to other industries.

Interestingly, during the "dot-com bubble" of 1999–2000, a period during which the stock market value of IT companies skyrocketed, these companies increased rewards to their executives (figure 9.19A). During the period, the total compensation of the highest-paid group increased substantially more than that of other groups. Other industries did not experience similar trends (figure 9.19B).

The trend in executive pay over 1992–2013 closely mimics the evolution of the income of the top 1 percent, similar to the evidence shown in figure 9.14 for profits. The correlation between growth rates of the top 1 percent income and executive pay is high: 0.63 (for the median) and 0.70 (for the mean). The correlation between the growth rates of the middle 40 percent and executive pay is slightly lower for both the median (0.47) and the mean (0.60; figure 9.20). This evidence suggests that executive pay influences income inequality as profits do. The stronger correlation of average compared to median executive pay suggests that the dispersion of executive pay is also related to income inequality.

Finally, evidence on the wealthiest 400 Americans is also consistent with the "superstar" explanation: Kaplan and Rauh (2013) find that in 2011 compared to 1982, the richest individuals were less likely to have grown up wealthy but had a university education and succeeded in industries—technology, finance, and mass retail—where digital innovation has driven growth. Andersson et al. (2009) show that the firms operating in the US software sector with high potential upside gains to innovation pay "star" workers, notably programmers, more than firms that operate less innovation-intensive industries.

9.6.5 Labor Compensation

Digital innovation may also be expected to increase the rewards to those employees that play a critical role in securing rents of winning firms. Emerg-

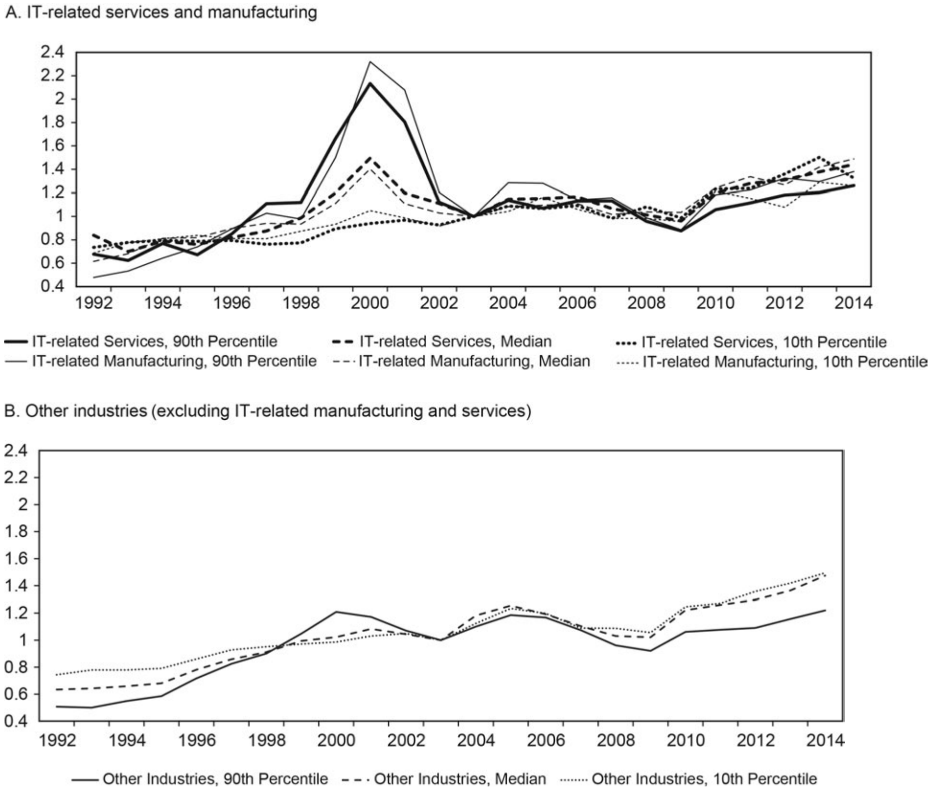
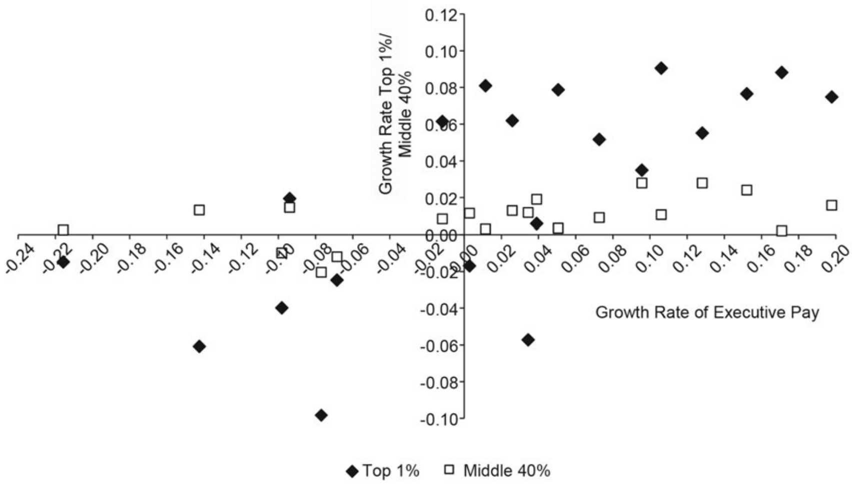


Fig. 9.19 Trends in executive income by income decile for 1992–2014 (2003 = 1)
Source: Bas, Paunov, and Rodriguez-Rodriguez-Montemayor (2017), based on Compustat.
Note: Further detail on the categorization of industries is provided in the data appendix.

ing microevidence shows rent sharing with workers. Song et al. (2015), for instance, find that over 1978–2012, inequality in US labor earnings increased across firms, within industries and US states, which is suggestive of rent sharing with employees. Evidence from the United Kingdom suggests these rents are shared with more skilled workers; Mueller, Simintzi, and Ouimet (2015) find that in this country, wage differentials between high-skilled and either medium- or low-skilled jobs increase with firm size, while differentials between medium- or low-skilled jobs are either invariant to firm size or (if anything) slightly decreasing. They also identify a link between wage inequality and the average number of employees of the largest firms in Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, the Netherlands, Spain, Sweden, the United Kingdom, and the United States over 1981–2010. Card, Heining, and Kline (2013) also find that increasing heterogeneity across firms explains over 60 percent of the growth in wage inequality across occupations and industries in West

A. Average



B. Median

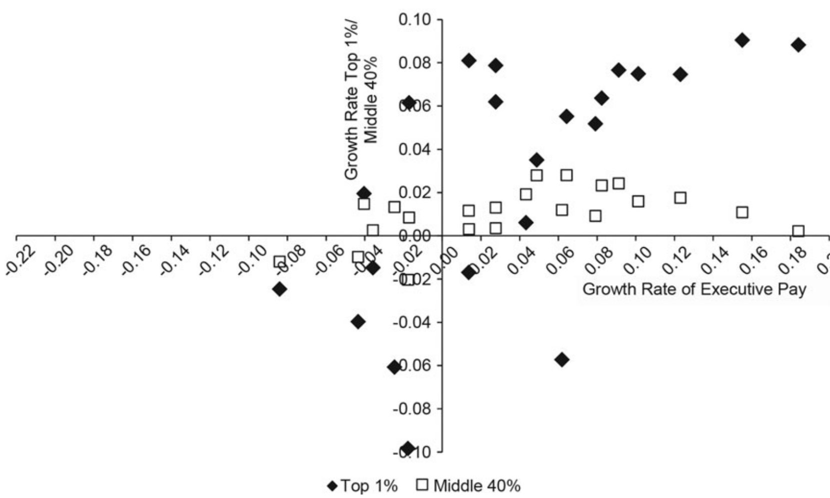


Fig. 9.20 Correlation of annual growth rates of executive pay and the average top 1 percent and middle 40 percent of the US pretax incomes, 1992–2014

Source: Bas, Paunov, and Rodriguez-Montemayor (2017), based on data on executive pay from ExecuComp and Piketty, Saez, and Zucman (2016) for pretax income of the top 1 percent and middle 40 percent. Growth rates are computed using deflated income and executive pay, applying the same deflator as described in Piketty, Saez, and Zucman (2016).

Germany over 1985–2009. The increased wage differential between highly skilled workers and others as reflected in those studies is not likely to be related to skill-biased technological change, as it depends on the size of the employer, and there is little reason why technical trends would differ across differently sized firms. An explanation in terms of rent sharing is more plausible, as rents may differ across firms.

Evidence provided by Bas, Paunov, and Rodriguez-Montemayor (2017) on publicly traded firms in the United States that report on wage payments shows no association of firms' wage pay and average wages in more concentrated and volatile markets, which is different from the findings on effects on executive pay and profits (tables 9.1 and 9.5).

The negotiation power of most workers, however, is weaker for a number of reasons. First, labor market pressure, which tends to equal the price of similar labor across firms, is stronger for employees than for managers. It is more difficult to replace managers than a number of workers. Second, another factor that reduces labor's share in rents is that information asymmetries regarding capacity and effort that allow negotiating higher pay are often less prominent for employees than for managers. Third, IT-enabled outsourcing and more temporary work arrangements weaken workers' connections to winning firms, increasing the competitive pressure on employees (Goldschmidt and Schmieder 2015). From 2005 to 2015, virtually all job creation in the United States was related to alternative work arrangements, defined as temporary help agency workers, on-call workers, contract workers, and independent contractors or freelancers (Katz and Krueger 2016). Goldschmidt and Schmieder (2015) show that reducing rent sharing was one of the motivations for German firms to outsource noncore activities, such as food, cleaning, security, and logistics services starting in the early 1990s.

9.6.6 Opportunities for Social Mobility

Inequality indicators capture the relative position of individuals at any point in time; an important question these indicators do not address is whether individuals in lower income categories have the opportunity to move upward (Jones and Kim 2014). In many countries, higher inequalities are, however, associated with lower upward social mobility (as described by the so-called Great Gatsby curve). Chetty et al. (2014), for instance, find that a child born in the 1980s to parents in the bottom 20 percent of the income distribution has only a 7.5 percent chance of moving to the top 20 percent.

Social mobility is connected to creative destruction, as this mechanism triggers a change in market winners (and losers), affecting respective incomes as new winners move up the distribution (while new losers move down). With digital innovation's impacts on the incidence and role of creative destruction, social mobility may increase in the digital innovation economy.

There is some evidence connecting social mobility and innovation: anecdotal evidence from the Forbes 400 list of the richest Americans shows that between 1982 and 2001 (as digital innovation was progressively taking off), the share of individuals who were not wealthy prior to their business success compared to that of individuals who inherited their wealth (an indicator of cross-generational social mobility) increased. However, having professional skills is a critical precondition for success: the share of people with a college education rose in the list from 77 percent in 1982 to 87 percent in 2011 (Kaplan and Rauh 2013). Recent empirical work also suggests that social mobility increases with innovation: Aghion et al. (2015) shows that US states with more innovation-led growth had higher upward social mobility over the 1995–2010 period.

9.7 An Open Research Agenda

This chapter puts forward an understudied mechanism that links digital innovation to changing market structures and, consequently, impacts on the distribution of income. It provides initial evidence pointing to the importance of this mechanism. Further evidence is important to improve our understanding of the issues and channels involved. The following areas in particular are critical.

First, the changes brought by digital innovation require continued efforts to measure the phenomenon of software-based innovations and relevant intangible investments. With continued technological progress, developing the right types of indicators is by nature a moving target that requires continued adaptation. While a decade ago indicators on computer and internet access were suitable for analysis, at present such an indicator is at best of weak interest given widespread adoption and the further development of digital innovations. It is important to know more about digital innovations across firms, industries, and countries over time to trace systematically the effects of digital innovation on market dynamics. Such evidence is particularly important to explore the wider impacts of digital innovation beyond the sectors most closely associated with the digital economy, such as software and hardware producers, search engines, and online portals. Evidence on digital innovation and intangible investments at sector and firm levels are also important.

Second, the impacts of digital innovations on market dynamics in the United States and other countries require further attention. An analysis of economic census data would allow testing of the extent of changes and in what contexts they arise. Recent work by Autor et al. (2017) and de Loecker and Eeckhout (2017) provides first evidence on the evolution of market concentration. Analyses of risk would also be important. Analyses need to address a number of conceptual challenges; accounting for "redefining" the industry associated with particular businesses is increasingly important as the digital economy changes markets. For instance, IT firms' investments in automated cars points to the company's role as competitor in a number of markets. Moreover, the absence of monetary transactions in two-sided markets such as online search engines also requires thinking about what measures of market concentration to use in addition to traditional sales-based measures.

Third, there is the large agenda on impacts of winner-take-all markets on the incomes of different groups in society and on social mobility. Matched employer-employee data allow documenting, beyond executives and investors, which workers benefit from rent sharing and which are excluded. Such data also allow an understanding of whether digital innovation creates opportunities for social mobility and, if so, how. Documenting the evidence of countries can allow an understanding of whether country-specific contexts, including differences in opportunities provided for social mobility, affect how winner-take-all markets impact the distribution of income.

Fourth, further analyses aimed at assessing the relative importance of the new channel linking innovation to the distribution of income outlined in this chapter compared to others (financialization, globalization, skill-biased technological progress, etc.) would also be an important development.

Appendix A

The Impact of Reduced Costs of Innovation on the Sequencing and Versioning of Innovation

The effects of reduced costs of innovation on the rate of innovation in the context of digital innovations can be accounted for in a simple two-period framework.

In the basic, one-period setting, the total cost of a product is

$$C = R + F + d*V,$$

where R is the investment in research (fixed cost), F is the fixed cost for producing and marketing the product (setting up a factory or retooling, setting up or reorienting a commercial network, etc.), d is the variable unit cost, and V is the volume of sales.

The turnover is

$$S = p*V,$$

where p is the unit price.

A firm will decide to engage in the research investment leading to the product if and only if the (expectancy of) profit is positive—that is, the (expected) turnover exceeds the (expected) cost:

$$\text{Condition 1: } S > C \Leftrightarrow V > (R + F)/(p—d) = V°.$$

There is a minimum volume of expected sales V° below which the company will not engage in innovation.

Digital innovation reduces the fixed cost of producing, marketing, and distributing the product, and the variable unit costs approach zero. According to Condition 1, V° is decreasing in F and in d, meaning that the lower fixed cost of production and marketing, or a lower variable unit cost, makes it profitable for a firm to innovate with a lower expected volume of sales. This implies that digital innovation reduces the threshold for triggering spending in innovation, resulting in more innovations.

The impact of digital innovation on the cost of innovation also makes it more rewarding for a firm to split its innovations into smaller parts and market those new products rather than launch more advanced new products (cumulating several rounds of innovation) at longer time intervals. This can be described by defining two periods of production.

Assuming that the research, production, and sale can be sequenced in two periods if the firm decides to, the firm can produce and sell a "partial version," or a "smaller innovation" version, of the final good. Across two periods, 1 and 2, the costs and turnover equations are as follows:[5]

$$C1 = R/2 + F + d^*V1$$

$$C2 = R/2 + F + d^*V2$$

$$S1 = p^*V1$$

$$S2 = p^*V2$$

The supplementary cost for the firm generated by sequencing its innovation is due to further production and marketing fixed costs that are incurred every time the firm issues a new product, independently of the degree of novelty and the volume of sales of the product.

By accessing the market earlier, the firm can increase total sales by stealing customers from competitors. This is reflected in the assumption that $V1 + V2 = V + V' > V$.

The condition for the firm to divide its innovation in two smaller innovations is that profit should be higher when it does so (it should also be positive, Condition 1):

$$\text{Condition 2: } (S1 + S2) - (C1 + C2) > S - C \; ? \; F < (p - d)V'$$

This condition is all the easier to satisfy with low F and d. This is exactly what happens with digital innovation. F is lower due to digital distribution,

5. We ignore discounting of period 2 because (i) the difference between the two periods is often a question of months and because (ii) interest rates have been very low for a decade. Introducing discounting would also not provide additional insights into the main mechanism we illustrate.

and d is even zero for digital products. Therefore, digital innovation tends to accelerate the pace of innovations and increase versioning by making it beneficial to split innovations over time into smaller marketable pieces. In addition, in a winner-take-all context, small innovations, with only a marginal advantage over competition, might be enough to gain all the market: this reinforces the impact of the reduction in cost on the incentive to put innovations of a small size to market rapidly.

Appendix B

Information on Data Used

9.B1 Industry Categories Used in Tables 9.3 and 9.4 and Figures 9.18 and 9.19

The SIC two-digit industries of all firms in ExecuComp and Compustat are categorized into the following groups:

- *Extractive industries* include Metal Mining (10); Coal Mining (12); Oil and Gas Extraction (13); Mining and Quarrying of Nonmetallic Minerals (14); and Petroleum Refining and Related Industries (29).
- *Construction* includes Construction—General Contractors and Operative Builders (15); Heavy Construction, Except Building Construction, Contractor (16); and Construction—Special Trade Contractors (17).
- *IT-related manufacturing* includes Industrial and Commercial Machinery and Computer Equipment (35) and Electronic and Other Electrical Equipment and Components (36).
- *Innovation-intensive manufacturing* includes Chemicals and Allied Products (28) and Measuring, Photographic, Medical, and Optical Goods, and Clocks (38).
- *Noninnovative manufacturing* includes Food and Kindred Products (20); Tobacco Products (21); Textile Mills Products (22); Apparel, Finished Products from Fabrics and Similar Materials (23); Lumber and Wood Products, Except Furniture (24); Furniture and Fixtures (25); Paper and Allied Products (26); Printing, Publishing and Allied Industries (27); Rubber and Miscellaneous Plastic Products (30); Leather and Leather Products (31); Stone, Clay, Glass, and Concrete Products (32); Primary Metal Industries (33); Fabricated Metal Products (34); and Miscellaneous Manufacturing Industries (39).
- *IT-related services* include Business Services (73); Communication (48); and Engineering, Accounting, Research, and Management Services (87).

- *Finance and insurance* includes Depository Institutions (60); Nondepository Credit Institutions (61); Security and Commodity Brokers, Dealers, Exchanges and Services (62); Insurance Carriers (63); Insurance Agents, Brokers and Service (64); and Holding and Other Investment Offices (67).
- *Retail and wholesale trade* includes Wholesale Trade—Durable Goods (50); Wholesale Trade—Nondurable Goods (51); Building Materials, Hardware, Garden Supplies and Mobile Homes (52); General Merchandise Stores (53); Food Stores (54); Automotive Dealers and Gasoline Service Stations (55); Apparel and Accessory Stores (56); Home Furniture, Furnishings and Equipment Stores (57); Eating and Drinking Places (58); and Miscellaneous Retail (59).
- *Transportation* includes Railroad Transportation (40); Local and Suburban Transit and Interurban Highway Transportation (41); Motor Freight Transportation (42); Water Transportation (44); Transportation by Air (45); Transportation Services (47); and Transportation Equipment (37).
- *Non-IT-related services* include Electric, Gas and Sanitary Services (49); Real Estate (65); Hotels, Rooming Houses, Camps, and Other Lodging Places (70); Personal Services (72); Automotive Repair, Services and Parking (75), Motion Pictures (78), Amusement and Recreation Services (79); Health Services (80); and Educational Services (82).

9.B2 Data on the Distribution of Income in Figures 9.2 and 9.3

Data on the top 1 percent income share (before taxes) are taken from the World Top Incomes Database, http://topincomes.g-mond.parisschoolofeconomics.eu/ (accessed July 15, 2015).

The following adjustments are undertaken to deal with missing values:

- For figure 9.2, missing values of the top 1 percent income share (before taxes) have been replaced by the year in parentheses for the indicated year: Germany: 1987 (1986), 1988 (1989), 1990 (1989), 1991 (1992), 1993 (1992), 1994 (1995), 1996 (1995), 1997 (1998), 1999(1998), 2000 (2001), 2009 (2008); Italy: 1996 (1995), 1997 (1998); Netherlands: 1987 (1985), 1988 (1989); Switzerland: 1988 (1987), 1990 (1989), 1992 (1991), 1994 (1993); United Kingdom: 2008(2007). The data series of the top 1 percent income share used for each country (and period) are as it follows: Australia: Main series: 1976–2010; Canada: Main series: 1986–2000; Longitudinal Administrative Data: 2001–2010; Denmark: Adults: 1986–2010; France: Main series: 1976–2012; Germany: Main series: 1976–2008; Ireland: Main series: 1986–2009; Italy: Main series: 1976–2009; Japan: Main series: 1986–2010; Netherlands: Main series: 1986–2012; New Zealand: Adults: 1986–2012; Norway: Main series:

1986–2011; Sweden: Main series: 1986–2013; Switzerland: Main series: 1986–2010; United Kingdom: Married couples and single adults: 1986–1989; Adults: 1990–2012; United States: Main series: 1986–2014.

- For figure 9.3, missing values of the top 1 percent income share (before taxes) have been replaced by the year in parentheses for the indicated year: Finland: 2010 (2009); Germany: 1981 (1980), 2010 (2008); Indonesia: 1981 (1982); Ireland: 2010 (2009); Italy: 2010 (2009); Malaysia: 1981 (1983). The data series on the top 1 percent income share used for each country (and period) are the following: Australia: Main series: 1981 and 2010; Canada: Longitudinal Administrative Data: 2010; Main series: 1981; Denmark: Adults: 1981 and 2010; France: Main series: 1981 and 2010; Germany: Main series: 1981 and 2010; Ireland: Main series: 1981 and 2010; Italy: Main series: 1981 and 2010; Japan: Main series: 1981 and 2010; Malaysia: Main series: 1981 and 2010; Netherlands: Main series: 1981 and 2010; New Zealand: Adults: 1981 and 2010; Norway: Main series: 1981 and 2010; Singapore: Main series: 1981 and 2010; South Africa: Adults: 2010; Married couples and single adults: 1981; Spain: Main series: 1981 and 2010; Sweden: Main series: 1981 and 2010; Switzerland: Main series: 1981 and 2010; United Kingdom: Adults: 2010; Married couples and single adults: 1981; United States: Main series: 1981 and 2010.

9.B3 Industry- and Country-Level Data Used for Labor Share Regressions Reported in Table 9.2

Regression results reported in table 9.2 combine several OECD industry and country data, including the OECD database for Structural Analysis (STAN) and the Main Science and Technology Indicators (MSTI). The data are complemented with data from EU KLEMS, the OECD National Accounts database, and the World Bank Enterprise Surveys. The variables are defined in table 9.A2 jointly with their sources.

The estimating sample combines data for the following 27 countries: Australia, Austria, Belgium, Canada, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Mexico, the Netherlands, New Zealand, Poland, Portugal, Korea, Slovak Republic, Slovenia, Spain, Sweden, the United Kingdom, and the United States.

The industries covered include the following 15 industries at three- and two-digit ISIC Rev. 4 level as defined in the OECD STAN database: basic metals, construction, electrical equipment, food products, beverages and tobacco, motor vehicles, trailers and semitrailers, machinery and equipment n.e.c., other nonmetallic mineral products, paper and paper products, printing and reproduction of recorded materials, rubber and plastic products,

Table 9.A1 Characteristics of the estimating sample for regression results of table 9.5

	Number of observations	Percentage share
Number of executives	7,812	
Number of firms	1,106	
Sector of activity		
Oil and gas extraction	3,008	7.1%
Chemicals and allied products	4,151	9.8%
Petroleum refining and related industries	114	0.3%
Industrial and commercial machinery and computer equipment	930	2.2%
Electronic, other electrical equipment and components	6,150	14.5%
Measuring, photographic, medical, optical goods, and clocks	3,297	7.8%
Furniture and fixtures	73	0.2%
Industry	17,723	41.8%
Communications	955	2.3%
Electric, gas, and sanitary services	2,111	5.0%
Food stores, eating and drinking places, miscellaneous retail	757	1.8%
Depository institutions	5,115	12.1%
Insurance carriers	3,382	8.0%
Holding and other investment offices	3,194	7.5%
Business services	9,170	21.6%
Services	24,684	58.2%
Time period		
1992–95	3,478	8.2%
1996–99	5,315	12.5%
2000–2003	6,154	14.5%
2004–7	10,226	24.1%
2008–11	11,809	27.8%
2012–13	5,425	12.8%

textiles, transport equipment, transportation and storage, wholesale and retail trade, and wood and products of wood and cork.

9.B4 Executive Pay Measures Used in Tables 9.3, 9.4, and 9.5 and Figures 9.19 and 9.20

Data on executive pay refer to total executive compensation (including salary, bonuses, and other annual rewards), except for results reported in column (4) of table 9.5 that refer to executives' salary only. Table 9.A1 describes the estimating sample used in regressions presented in table 9.5. More detail is provided in Bas, Paunov, and Rodriguez-Montemayor (2017).

Table 9.A2 Industry and country-level data used for results

Variables	Description	Source
Dependent variable		
Labor share	Industry labor compensation over industry value added	OECD STAN
Country-level variables		
GDP	Gross domestic product	OECD National Accounts
Patents	Ratio of triadic patent families to GDP	OECD MSTI
Graduates	Ratio of the number of tertiary educated people to GDP	OECD MSTI
Capital	GFCF as percentage of GDP	OECD National Accounts
Finance	Share of finance sector in national value added	OECD STAN
Trade	Ratio of industry import and exports to GDP	OECD National Accounts
Union density	Percentage of workers members of trade unions	OECD and J. Visser, ICTWSS database
Industry-level variables		
Patent intensity	Percentage of firms holding at least one patent	World Bank Enterprise Surveys across 50,013 firm observations from 117 countries for 2006–2011
Intangible assets	Share of intangible capital over total capital (US period average)	EU KLEMS
(Low) skill intensity	Industry share of highly (less) skilled workers (US period average)	EU KLEMS
Capital intensity	Industry ratio of capital stock over value added (US period average)	OECD STAN
Transport equipment	Transport equipment capital as ratio of total capital	EU KLEMS
R&D intensity	Ratio of industry R&D expenditure in value added	OECD (2016), "OECD Taxonomy of Economic Activities Based on R&D Intensity," OECD Science, Technology and Industry Working Papers, No. 2016/04.

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