DIGITAL INNOVATION AND THE DISTRIBUTION OF INCOME

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Contribution to the NBER CRIW Conference on Measuring and Accounting for Innovation in the 21st Century

Version: 23 February 2017

Abstract

Income inequalities have increased in most OECD countries over the past two to three decades; particularly the income share of the top 1% has soared. In this paper we argue that the increasing importance of digital innovation – new products and processes based on software code and data - has increased market rents, which benefit disproportionately the top income groups. In line with a Schumpeterian vision, innovation gives rise to rents from market power and scale economies. This is magnified with digital innovation, in which the intangible component (the source of rents) is much larger than in traditional manufacturing innovation. Highly concentrated market structures ("winner-take-all") allow rent extraction. In addition, digital innovation tends to increase risks because even only marginally superior products can take over the entire market, hence rendering market shares unstable. Instability commands risk premia, hence higher expected revenues, for investors. Market rents accrue mainly to investors and top managers and less to the average workers, hence increasing income inequality. Market rents are needed to incentivize innovation and compensate for its costs, but beyond a certain level they become detrimental as rent seeking then substitutes to innovation in business strategies. Public policy may stimulate innovation and welfare by eliminating ex ante the market conditions which allow rent extraction that comes from anti-competitive practices.

JEL Codes: O30, D24, D31, D40, L11

Keywords: Information technologies (IT), innovation, income inequality, market structure, market concentration, creative destruction, social mobility

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Stefano Baruffaldi and Akira Tachibana provided valuable research support. The authors would like to thank participants of the "Innovation and Inclusive Growth in Germany" workshop organized by the Bertelsmann Foundation, the Advisory Group Meetings of the Innovation for Inclusive Growth Project and the "Symposium on Technology, Innovation and Inclusive Growth: Future Perspectives" in Paris for their comments.

Introduction

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

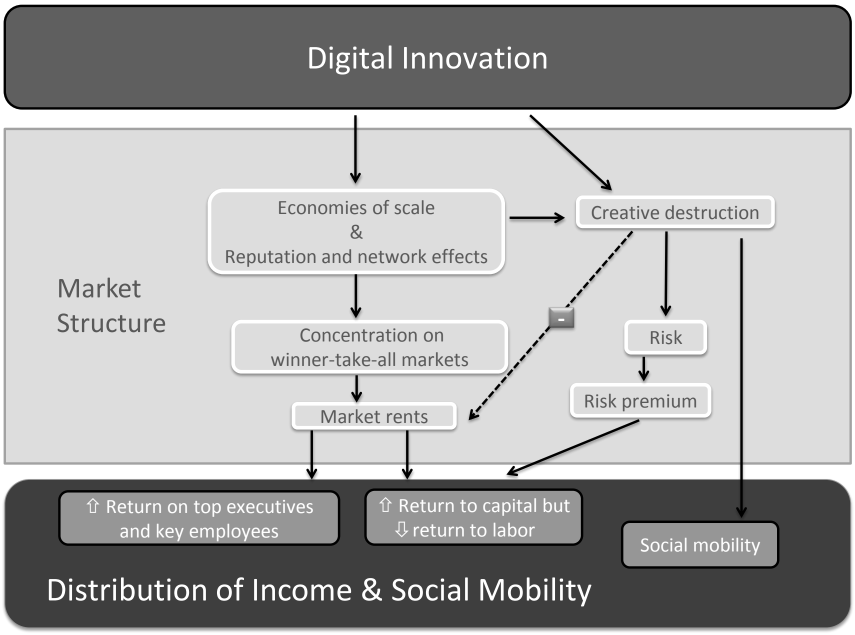
In this paper we argue that the increasing importance of digital innovation (which are new products and processes based on or embodied in software code and data, in and beyond IT industries) is magnifying innovation-based (and possibly bigger) rents that contribute to increasing the income share of the top income groups. Specifically the paper focuses on inequality coming from market rents accruing to top executives, key employees and shareholders, but little to the average worker. Figure 1 summarizes the mechanisms at work in our framework.

This issue has received surprisingly little attention in spite of mounting evidence of the increasing importance of rents (CEA, 2016) and in spite of evidence that in recent years the evolution of top incomes owes much to increased returns to capital (Piketty et al., 2016). The explanation adds to others that point to globalization, the financialisation of the economy, unskilled-labor-displacing technologies and the weakening of trade unions as causes of growing income inequalities.

Viewed from this perspective, the increase in top income inequality partly results from digital innovation. This, however, does not imply that restraining innovation would improve the wellbeing 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 issue for public policy is to preserve innovation while limiting its negative impact on income inequalities, specifically as addressing some of the sources of inequalities can stimulate innovation-based growth.

Figure 1: Impacts of digital innovation on market structures and the distribution of income



The impact of digital innovation's on the 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 exclusivity over their innovation, 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 from their innovation. The non-rivalrous nature of knowledge means that the costs of new ideas comes 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 is the average cost. Increasing returns to scale favor concentrated market structures, where in the end only a few companies supply most of the market as large quantities mean lower unit production cost.

With digitalization – i.e. 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. Increasing returns to scale and the rents that arise 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 many products and processes in traditional, tangible industries increasingly include software code and data.

As a consequence of these characteristics of digital innovations, a growing number of industries are subject to "winner-take-all" dynamics, i.e. 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 the winner 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 raises opportunities for "creative destruction" 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 arise, the level of risk is much higher than in the past: while on a traditional market, a new, superior product may reduce the market share of incumbents, on 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 a higher market share than firms in other markets, but they run the risk of losing it all. More creative destruction in winner-take-all markets implies higher risk for firms and investors as it generates more instability in market shares, hence in income: firms that dominate the market are making large profits, others are making large losses, with a low likelihood to be in-between.

Higher risk leads investors to demand a risk premium, excluding investment with lower expected returns, in turn increasing the average return to capital. These dynamics are most visible on 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).

Market concentration and creative destruction are not in contradiction with each other in markets where competition is based on digital innovation. Such competition is not about prices - in which case the threat from new entry would discipline the incumbents - but on radical product innovation, as new products are so innovative that they take over the market whatever the price charged by current incumbents.

How do the rents from digital innovation affect the 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 came with an increased dispersion in profits across firms (that 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 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 an environment of winner-take-all dynamics and higher risk (Hall and Liebman, 1998).

Labor has not gained as much from rents with the exception of those at the top. Indeed, the wages of top employees of successful firms have benefitted to a certain extent, as shown by the role of cross-firms wage inequality in total income inequality (Song et al., 2015). The average workers, however, have been less successful for a number of reasons. They face more competition in the labor market and are increasingly employed in temporary work arrangements. This is all the more so the case for the growing number of 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 2005-2015 (Katz and Krueger, 2016).

Lower entry barriers that facilitate creative destruction also enable increased social mobility, as newcomers can displace incumbents. Turnover in the top income categories has actually 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).

Drawing policy implications needs considering two factors. First, rents are needed for innovation and innovation is necessary to growth. Hence policies should avoid targeting innovation-based rents (and rents that facilitate innovation), but instead focus on the rents that do not come from innovation (e.g. leveraging market power based on regulatory monopolies, anti-competitive practices, barriers to trade, etc.). Second, many policies shaping innovation were designed for an economy in which tangible activities were dominant, hence innovation-based rents lower. They need reviewing to assess whether the balance between market rents for innovation and opportunities for innovation by new entrants is adequate.

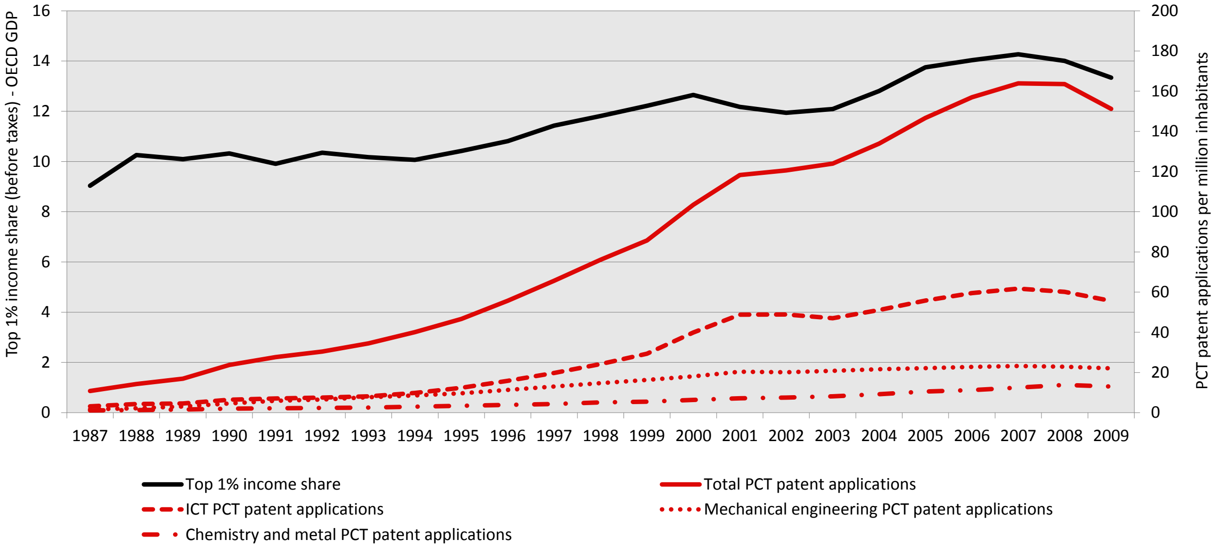
What does this mean for policies? Tax policy, the instrument of choice for dealing with income inequalities, has limitations, as it does not make the distinction between competitive and excess market rents: it may therefore have detrimental effects on the incentives to innovate. Instead of attempting to redistribute (ex post) rents, it might be more effective to eliminate them (ex ante) in the first place by strengthening market competition. Policy instruments that may be mobilized and adapted to this purpose include IPR (ensuring that they favor access to knowledge), standards, rules of access to and ownership of data, competition policy, support to innovation (favoring new, small players) and entrepreneurship (including training).

The remainder of the document is structured as follows: section 1 describes general trends in innovation and the distribution of income. Section 2 discusses the relationship between digital innovation and market structure, while section 3 focuses on the impact of digital innovation on creative destruction. Section 4 discusses the implications of these market trends for the returns to income. Finally, section 5 discusses policy implications and section 6 lists open research questions.

1. 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 2 plots Patent Cooperation Treaty (PCT) applications and the income share of the top 1% for a group of OECD countries. Both series show an initially modest upward trend, followed by acceleration in the mid-1990s. Interestingly, ICT patents show the strongest upward trend of all, highlighting the growing importance of ICT in innovation.

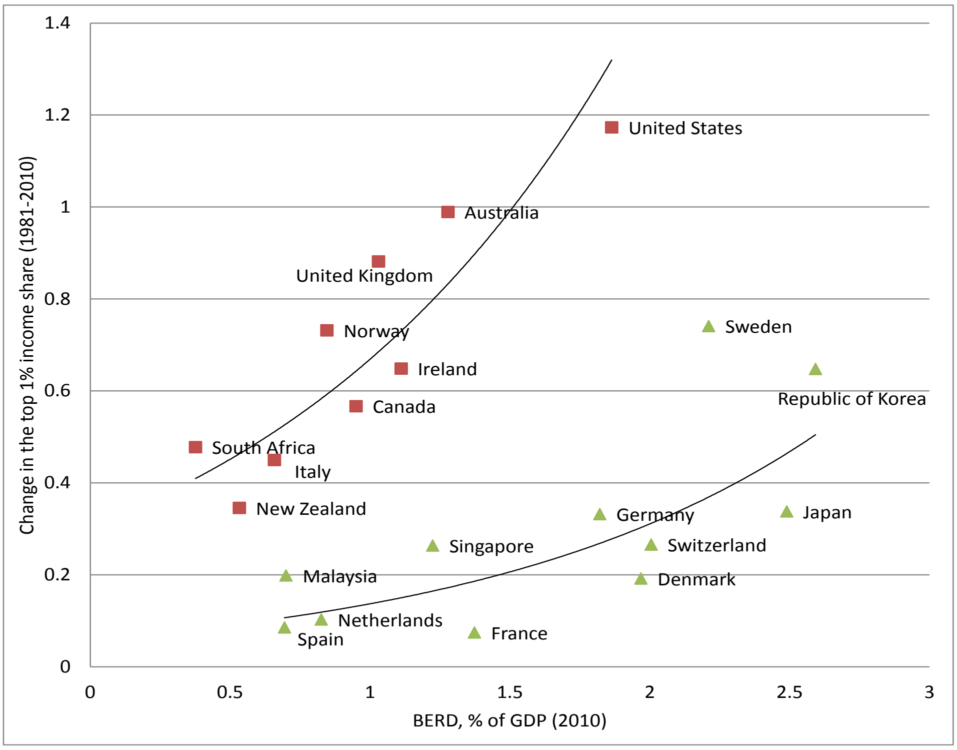
Figure 2: Top 1% income share and PCT patent applications for selected OECD countries, 1987-2009



Source: *The World Top Incomes Da*tabase, http://topincomes.g-mond.parisschoolofeconomics.eu/ (accessed on 15 July 2015) for the 1% 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 annex provides further information.

Comparing business R&D spending (as a proxy for digital innovation) with trends in the top 1% income share gives a more mixed picture (Figure 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% 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% income shares over the past two decades; the increases are larger than in countries (such as Spain and the Netherlands) with relatively weaker R&D investments, but the difference is not significant. These differences may result from different country policy approaches to income distribution, as well as from diverse industry dynamics and structures. Differences may also be driven by differences in how economies are engaged in digital innovation and consequently differences in innovation activities affect market structures and the distribution of income as discussed next.

Figure 3: Changes in the top 1% income share over 1981-2010 relative to business R&D spending as % of GDP in 2010



Source: *The World Top Incomes Database*, http://topincomes.g-mond.parisschoolofeconomics.eu (accessed on 15 July2015), for the 1% income share data; *OECD Science and Technology Indicators* for business expenditure on research and development (BERD) as % of GDP. The data annex provides further information.
Note: The two lines included are exponential trends for the two groups of countries.

2. Market concentration increases with digital innovation

Characteristics of knowledge and implications for market structures on global markets

Digital innovation gives to knowledge (design, IPR, software code or data) a more prominent role and larger value share in new products and processes than "traditional" innovation does. While "traditional innovation" is partly intangible (the knowledge component), digital innovation is fully intangible.

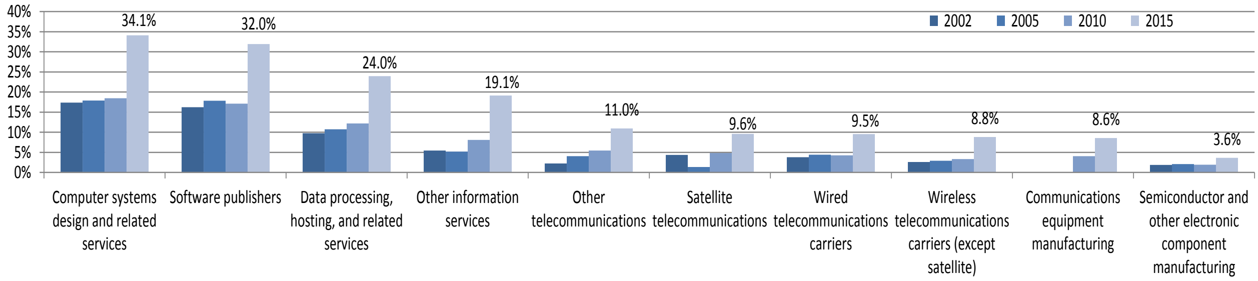
Knowledge is characterized by non-rivalry: one piece of knowledge can be used simultaneously by any number of users, at any scale, at low or even zero marginal cost. For instance, once assembled or designed, databases and inventions of all sorts can serve any number of users, at no additional cost. This property does not apply to tangible goods: a given good can be used only by a restricted number of users at the same time, and increasing the number of users entails significant marginal costs. 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 without physical constraints (Varian, 2003). By contrast, the cost of producing the intangible product itself (referred to as "original" in national accounting) is sunk, i.e. it is not re-incurred with every additional use of the product.

Non-rivalry makes the market production different from the tangible goods because non-rivalry means that knowledge production is subject to massive economies of scale in a context of digital innovation: the more products sold, the lower the average cost. If a digital product succeeds on the market, the production volume can quickly adapt to demand, and sales can increase while unit costs decrease. Such phenomena have been observed in many industries already, under various names like “blockbusters” (pharmaceuticals, movies, aeronautics) or “superstars” (sports).

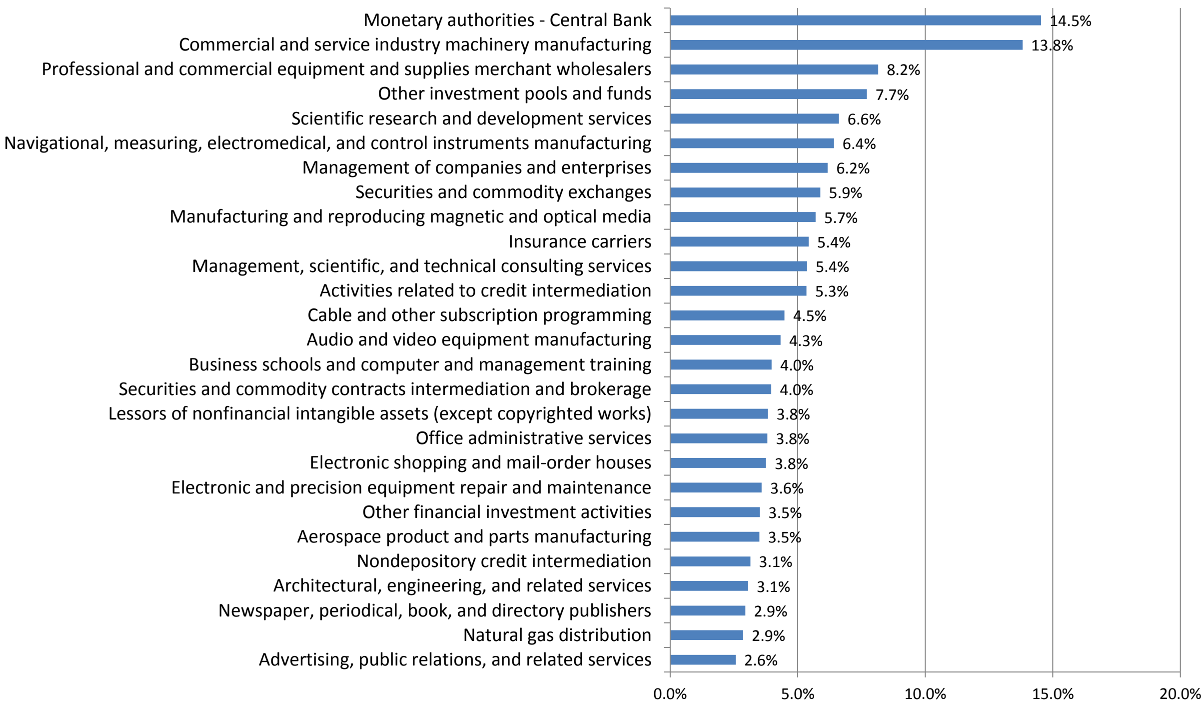
While digital industries are the most affected, digital innovation is relevant across many other industries. Branstetter et al. (2015), for instance, show that between 1981 and 2005, IT assets have become increasingly critical in production in “traditional” sectors such as automobiles, aerospace and defense, medical devices and pharmaceuticals. Spending on software in particular has increased substantially over time. Software engineers represent an increasingly important share in employment not only in telecommunications, software and hardware industries. They also have become more important in other industries such as finance, business services, machinery manufacturing and other information-provider services (Figure 4).

Figure 4: Share of employment in software-related occupations within industries in the United States, 2002, 2005, 2010 and 2015

Panel A: IT-related industries



Panel B: Other industries, 2015



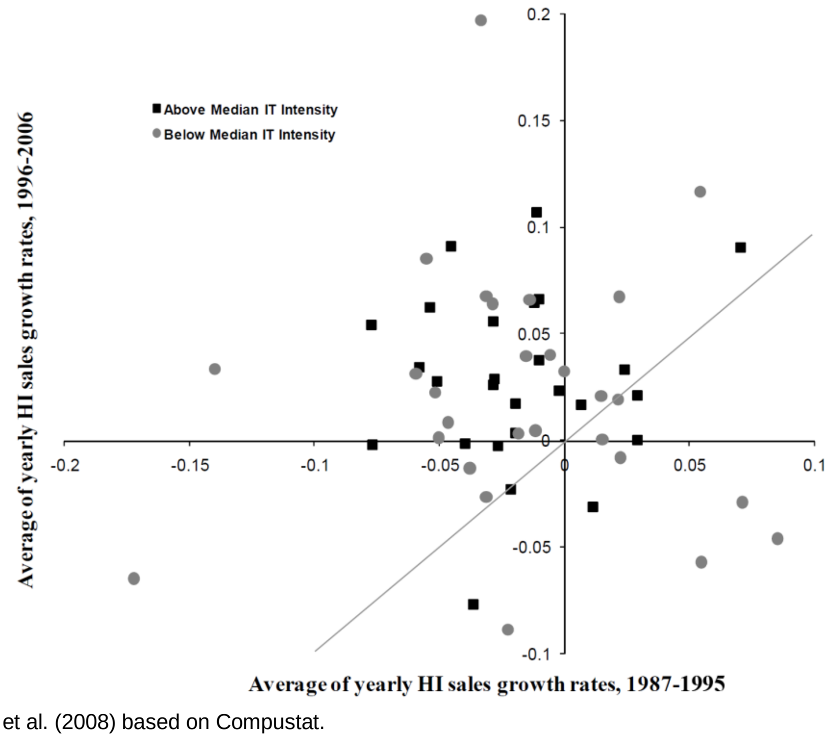
Source: US Bureau of Labor Statistics (2016), Occupational Employment Statistics (OES) Survey, Department of Labor.
Note: Panel B reports the share of employment in software for industries in which the share is higher than 2% of total employment. Industries are provided at the 4-digit NAICS 2012. The data annex describes the occupations included as software-related.

Mass production in manufacturing as developed in the Fordist model of production lowers marginal cost compared to specialized production in the previous, craftsmanship-based model. However, the marginal cost is 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 new investments are largely used to produce "originals", i.e. to innovate, not to produce more copies of the same template. This amounts to the pure fixed costs and zero marginal costs text book case that is an absolute exception for most production processes, except for information goods for which it is the baseline case (Varian, 2003). This is on the product side.

On the process side, it is recognized that 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 a very large size. This factor is clearly pushing towards higher market concentration in all industries. Evidence collected by Mueller et al. (2015) shows that the average size of the largest firms has increased very significantly in fourteen of the fifteen countries they study between the mid-1980s or mid-1990s and 2010. The average size of the top 50 (100) firms in the US grew by 55.8% (53.0%) between 1986 and 2010.

Hence IT coupled with globalization have transformed both product markets and production processes, both in the direction of favoring large size and concentration. Brynjolfsson et al. (2008) show evidence of higher market concentration for more IT intensive industries for 1996-2006 compared to the previous period of 1987-1995 (Figure 5).

Figure 5: Growth in market concentration of more and less IT-intensive industries, 1996-2006 and 1987-1995



Source: Brynjolffsson et al. (2008) 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 (see discussion on demand, supply and regulatory factors below) as well as product bundling, whereby different products are sold jointly as the marginal cost is negligible. There are also opportunities for smaller-scale producers. 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 to become a global behemoth, as digital goods can be reproduced at the cost of a click. This however, requires addressing a number of obstacles as discussed below.

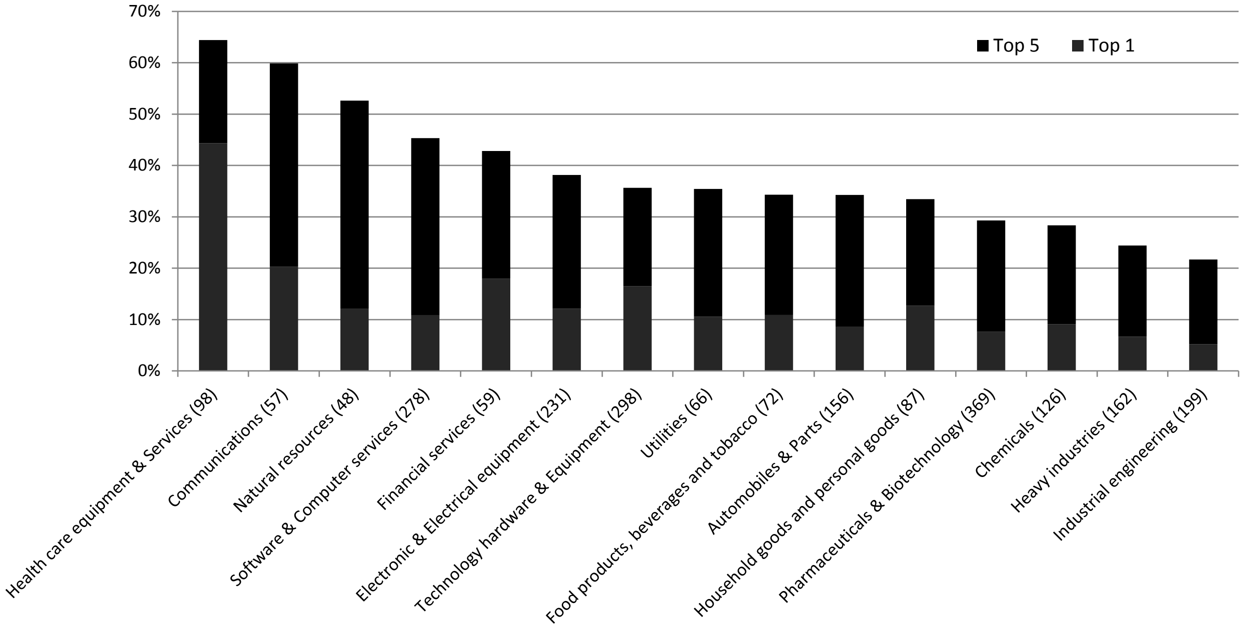
A consequence of such economies of scale is the emergence of “winner-take-all” market structures, i.e. markets with highly asymmetric market shares (Rosen, 1983). The market dynamics are akin to tournaments, in which the best offer wins the race and captures most (if not all) of the market. The winner’s 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, distributing a service on the Internet) gives the winning innovation the opportunity to gain quickly most of the market. The Economic Census shows high rates of concentration for some of the markets that are 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 4 providers held 34% of the sales 2012 (NAICS code 42511). By contrast, the average share of the top 4 businesses in the wholesale business (NAICS code 42) was of 5.6%.

“Winner-take-all market” effects are a well-known phenomenon on 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 et al.,2003) or in terms of the number of citations and in terms of other measures of patent quality (see e.g. OECD, 2015b). This results from a few firms/individuals dominating markets for those innovations, and we believe that this tendency is only accentuated with 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 a wider set of industries in which digital innovation has become increasingly important (in product or in processes) including more traditional ones like pharmaceutical, automobile or chemicals.

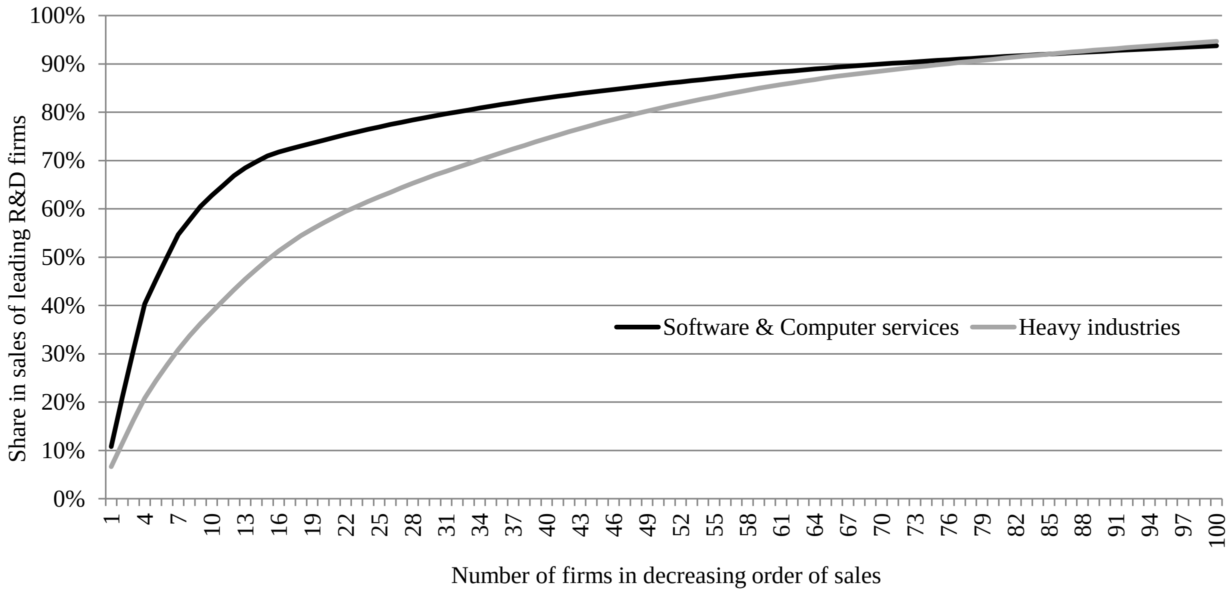
Assessing the market shares of these global actors is challenging as national-level data only capture resident firms but not all market competitors. As an imperfect proxy, Figure 6 computes the shares of the top 1 and 5 global companies among the 2 500 top R&D companies across different sectors, showing strong levels of concentration in some of the very dynamic sectors that are highly associated with digital innovation, notably software & computer services, financial services and electronic & electrical equipment. Figure 7 contrasts the market shares of software & computer services and those of heavy industries.

Figure 6: 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 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.

Figure 7: 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



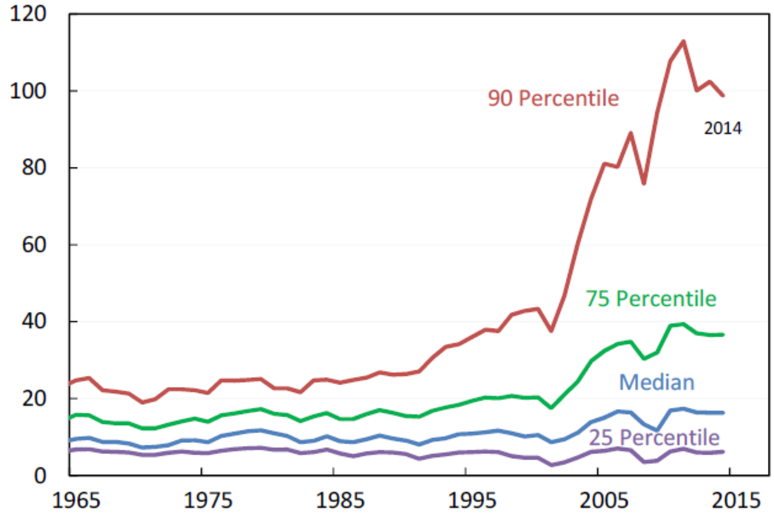
Source: EU (2016), EU R&D Scoreboard 2016.

Rents in global knowledge-intensive markets

The fact that successful innovators raise rents is not new; it is a necessary condition for innovation to occur and it was conceptualized in 1911 already by Schumpeter. What is new is the scale at which this is happening, as reflected in large profit margins in sectors where data-driven innovation is important. Health technology, technology services and electronic services were 1st, 3rd and 4th in the Forbes 2015 ranking of most profitable sectors with profit margins of 20.9%, 16.1% and 13.2% respectively (Finance was in 2nd position with margins of 17.3%) (Forbes, 2015). Aggregate statistics also show that in the United States the share of corporate profits in income increased (see Figure 11 in section 4).

The evolution of firm profits is also consistent with increasingly "winner-take-all" market structures: the top percentiles of firms ranked by the return on invested capital (ROIC) have grown most significantly, from less than 30% in the early 1990s to 100% in 2014 (Figure 8). The lowest percentiles (25th) had a constant ROIC and the median increased slightly (Figure 8). 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% in 1994 to 46% in 2013 (The Economist, 2016). Players closely associated with the digital economy have gained in importance in this ranking, aside from the growing importance of digital innovation to many of the traditional players in the ranking.

Figure 8: Return on invested capital excluding goodwill, US publicly traded nonfinancial firms



Source: Furman and Orszag (2015) based on Koller et al. (2015)

Winners can extract rents both from their higher operating efficiency or better product, but also from their market power. Hence the level of rents depends on the level of competition, actual or potential (contestable market). Incumbents might use various means in order to escape competition: They might take over prospective competitors (fast growing startups), or might spend part of their rent on lobbying, in order to create legal and regulatory barriers to entry. Hence it is important from a policy perspective to make the distinction between rents which come from innovation and are needed to keep incentivizing it, and rents which come from non-competitive behaviors, which are in fact detrimental to innovation.

Several supply- and demand-side characteristics reinforce that winner-take-all markets (that arise from the characteristics of knowledge) favor incumbents. On the supply side, economies of scale from producing knowledge-intensive products feed efficiency and consequently firms' market shares. One reason is that it is often not straightforward for followers to replicate immediately. 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, on 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 competitors cannot easily match. Also, 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 creative destruction arises for different market participants.

On the demand side, a firm's or product's reputation often influences consumer choice in favor of incumbents. The market success of a product frequently stimulates further sales by incumbent producers. What is more, the technical complexity of certain knowledge products magnifies incumbents' advantage because greater complexity magnifies the information asymmetry between consumers and producers; consumers will prefer to buy from sellers with the right brand names and reputation as a guarantee the product is of good quality. Moreover, network effects, i.e. product value increasing with the number of users, matter in some of the most innovative sectors of the digital economy. Examples include software programs (interoperability matters and consequently the number of users of the software), social networks (the number of friends/colleagues/partners to communicate with), online auctions (the number of bidders and sellers) and Internet search engines.[1] Ownership of big data is also an increasingly important source advantage for incumbents as competitors can only with difficulty obtain the same quality of data. The advantages is increasing as, for instance, machine-learning algorithms become more intelligent with larger access to data, reinforcing the advantage of incumbents. These constraints also reduce entrants' opportunities to successfully penetrate markets in spite of the low product scaling costs.

Regulatory and policy conditions, including with IPR and standards, are also critical in allowing firms to protect their digital innovations as 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 making intense use of digital innovations.

Certain factors, however, tend to limit market concentration. One is the diversity of consumers' tastes, which can lead to fragmented markets and monopolistic competition "à la Chamberlin" instead of large winner-take-all markets. The main constraining factor of market concentration, however, is the extent of creative destruction and the limitations it imposes on market incumbency as discussed next.

3. Digital innovation increases creative destruction

Digital innovations may displace existing products or at least reduce their market shares and, if produced by outsiders, may challenge incumbents more than is the case for traditional innovations. While creative destruction is by no means new, in winner-take-all markets it has higher impact: successful newcomers can very rapidly upscale to take over most if not all of the market, hence not only reducing the market share of the incumbent but fully displacing them. The reason is that smoothing factors like the time to scale up a new product have all but vanished with digital innovation.

Lower entry costs for digital innovations allow for enhanced creative destruction

The relationship between markets for digital innovation and creative destruction is different where entry barriers have been reduced. In these contexts, all competing firms have more to gain and to lose. More frequent radical innovations make markets riskier for incumbents – while not reducing market

[1] In the case of Internet search engines the network effects are indirect i.e. 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-maximising 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 they would be the case for single-client markets.

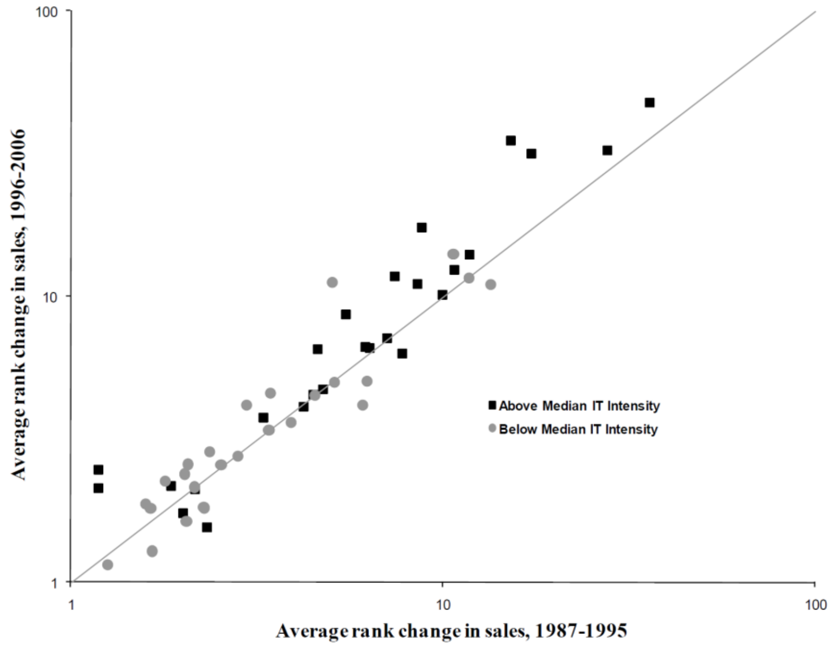
concentration that arises from the economies of scale. ITs have reduced entry costs compared to many markets – the costs of producing, managing and communicating new knowledge. For instance, the emergence of "the cloud" has done away with large upfront investment, giving access to computing power at a low price. Moreover, some of the most dynamic knowledge products, such as software and online services do not require manufacturing equipment or specific distribution networks as they can be distributed on the web. Also, Internet-based intermediaries (like Alibaba or Amazon) have opened up the global market to small companies and even self-employed individuals in many sectors.

The opportunities of reaching "scale without mass" (i.e. the production of goods and services that require much fewer labor and capital inputs as a large share of the product is intangible) extends beyond pure digital products (such as software or pure online services). For instance, the share of intangibles in the total product costs of cars has increased substantially. The profit-size ratios of successful start-ups, when acquired by large industry players, are considerably lower than those of industrial corporations. These opportunities for knowledge creation in turn create greater competitive pressure to innovate and stimulate more innovation efforts than was the case in the past.

At the macroeconomic level, the disruptive nature of digital innovations has widened threats for incumbents where products are entirely reinvented as is the case for the transportation industry; competition may come from unexpected corners. For instance, traditional car manufacturers find themselves faced by new business models such as the one implemented by Uber. Uber provides car sharing as an alternative to car ownership. The threat of competition from other industries, specifically those that have been successful digital innovators also arises, so that creative destruction operates, as it happened in the mobile phone industry (where Nokia was displaced by Apple).

There is evidence to show that digital innovation has indeed increased firms' risks. Brynjolfsson et al. (2007) find evidence of more important "creative destruction" (i.e. changes in firms' rank of sales in their respective industries) in more IT-intensive industries following the mid-1990s (Figure 9).

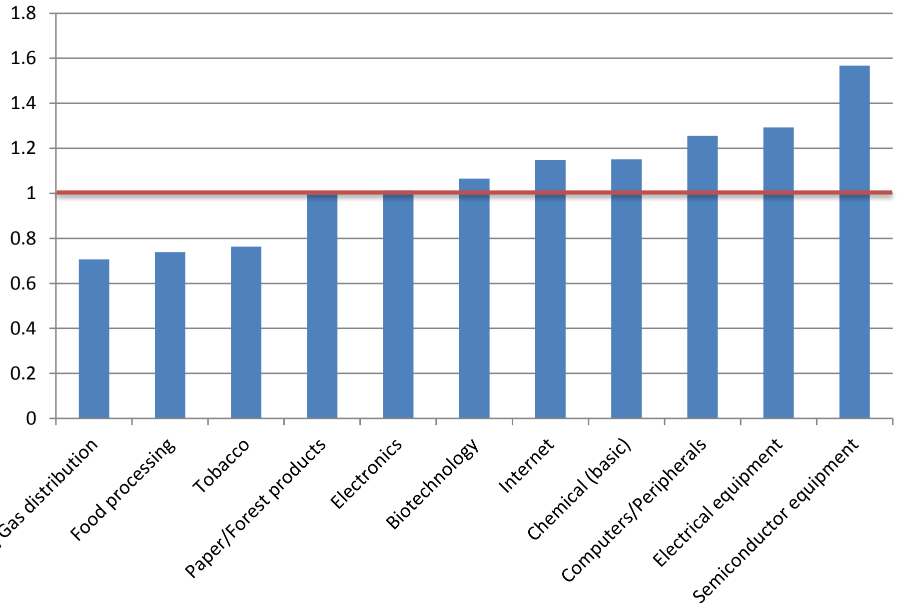
Figure 9: Creative destruction in high and low IT-intensive sectors, 1996-2006 and 1987-1995



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

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 10). 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.

Figure 10: Estimates of selected sectors' betas relative to the entire financial market for US firms over 2008-12



Source: Based on data by Aswath Damodaran (2015), computed from 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 5 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/ .

Market concentration and creative destruction are not in contradiction with each other in markets where competition is based on digital innovation. On 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 new products are so innovative that they fully replace existing ones, they take over the market whatever the price charged by current incumbents. This also means that until the next innovation comes, the incumbent keeps its market position and does not have to bother about competition.

Limitations to creative destruction and competition

However, creative destruction may be challenged on winner-take-all markets because winning comes with advantages that allow for retaining 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 and upscale innovations. In this context challengers develop new more radical innovations but do not immediately replace winners nor change the large levels of market concentration.

Large players often acquire start-ups of highest potential and threat. 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 which increasingly act like platforms, who possess unique marketing and financial infrastructures and can externalize the most exploratory innovation to start-ups that they acquire when successful. This also poses challenges for competition policies. A joint paper by the French and German competition authorities argues that the "dynamic competition may be stifled if established undertakings have a proven ability to buy out competitively significant new entrants with a turnover, asset-base or market share too low to trigger merger control."[2] These acquisitions themselves may contribute to increase the efficiency of industry ecosystems as good radical innovations developed in small firms can create more value once deployed at larger scale.

Today's large players, such as Google and Facebook may be presented as examples of newcomers of the past that demonstrate that challenging incumbents is possible, but this does not account for important changes in the current competition environment. This includes, staying with the example of these two large players, the advantages they can reap of big data with better tools to make use of them. These may continue to marginalize small players by a feedback loop whereby better data allow better services, enhancing further their advantage. In consolidated markets, incumbents have succeeded in establishing their products as essentials (as, for instance, is the case for different digital platforms) to the extent that barriers to entry block competition. Much will depend on policy responses to allow a level-playing field in a context of digital innovation. Lock-in, which arises where network effects are so important that other sellers cannot offer a price that is sufficiently low to induce consumers to switch, may then become even more likely.

4. How do increasing market rents and risk affect the distribution of income?

The changes in market structures and risk brought by innovation have impacted the distribution of income. At the aggregate level, Forbes (2000) finds that higher growth across US states correlates to higher levels of income inequality and higher returns to the top 1% and 10%. Aghion et al. (2015) show that differences in innovation intensities also account for higher returns to the top. This section discusses mechanisms behind higher returns to the top of the income distribution – as a result higher returns to capital, top executives and top employees but less for average workers - and presents relevant evidence.

Higher returns to capital

Changing market conditions – concentration and risk – have resulted in higher return to capital; higher returns to capital in turn affect the distribution of income as capital ownership is concentrated among the highest income groups (Atkinson, 2015), hence increasing inequalities. Higher return on capital from digital innovation arise because the rent accruing to market leaders is captured mainly by the residual claimants, who are the investors and managers, while employees earn wages mainly fixed by the labor market - although some "efficiency wage" mechanisms might ensure that some of the rent goes to employees.

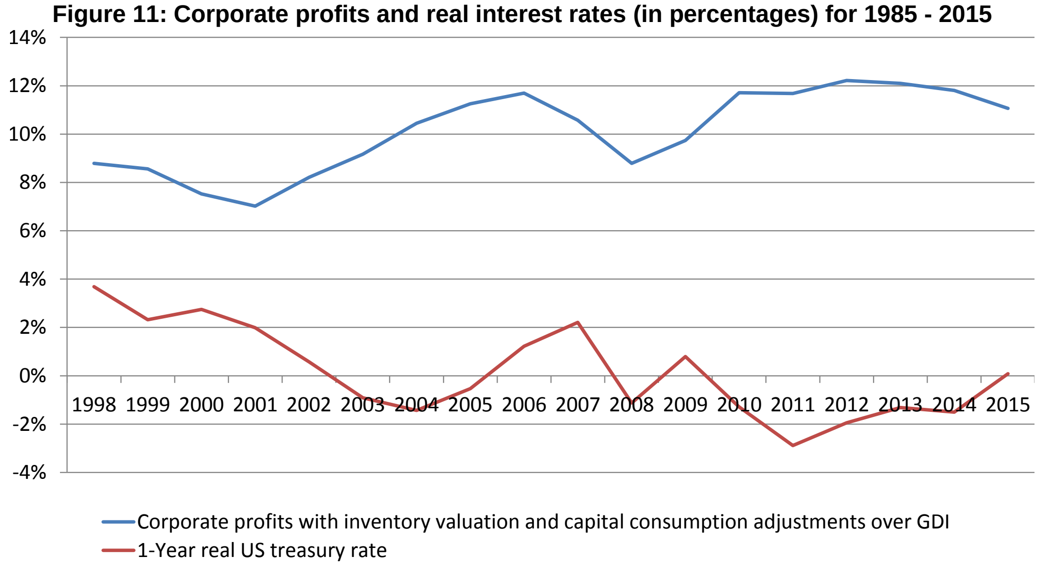
This is not to say that rents are necessarily "excessive", i.e. that the rewards are higher than required from an incentive/efficiency perspective. The higher level of risk for investors in winner-take-all markets -

[2] See footnote 4.

where products may win the whole market or fail to bring any rewards at all - requires a risk premium for them to engage in the first place. Moreover, on the side of managers, the fact that even marginally better decisions can result in market gain and/or failure, justifies higher rewards to the most effective decision-makers (see discussion below).

An indicative piece of evidence on increasing rents for investors and owners is the fact that corporate profits have increased somewhat while interest rates have decreased over the past three decades (Figure 11). If there were no rents, then it should be the case that corporate profits follow the path of interest rates as these reflect the returns to capital in the economy.

Figure 11: Corporate profits and real interest rates (in percentages) for 1985 - 2015



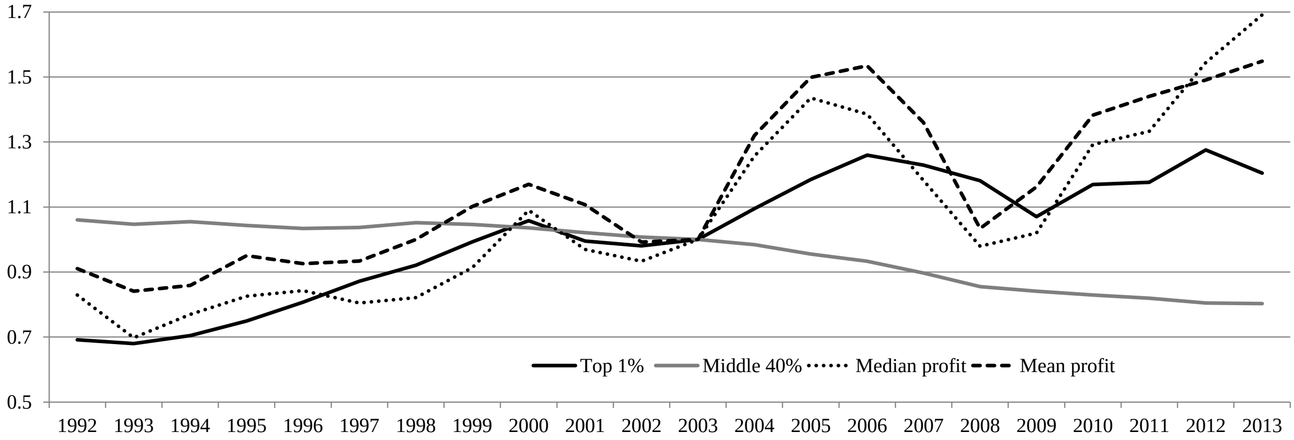
Source: Statistics based on data on corporate profits and the GDI from the Bureau of Economic Analysis, Bureau of Labor Statistics published in May 27, 2016. Data on the 1-year real US treasury rate are taken from the US Treasury (accessed at: http://www.multpl.com/1-year-treasury-rate/table) using the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

Also, anecdotal evidence from the Forbes 400 richest individuals shows a range of names of owners that coincided at some point with digital innovation, as pointed out by Kornai (2016): Bill Gates (Microsoft), Larry Ellison (Oracle), Michael Bloomberg (Bloomberg terminal), Mark Zuckerberg (Facebook), Larry Page and Sergey Brin (Google) and Jeffrey Bezos (Amazon).

Higher returns to capital and its corollary, declining returns to labor, are important to explain the evolution of top income which has been a capital-driven phenomenon since the late 1990s (Piketty et al., 2016). What is more, data for 2000-2014 show that growth of average income per adult owed mostly to growth in capital income which grew by 2.2% per year, while labor income grew at a rate of 0.1% per year. Higher returns to capital lead to increasing income inequalities because the distribution of wealth is highly unequal and concentrated at the top.

Regarding the relationship between profits and the top 1%, Figure 12 shows the trend in median and average profits over 1992-2013 comparing it to the trend of pre-tax income for the top 1% and the middle 40%. There is high correlation between the growth rates of the top 1% income and profit: 0.58 (for the median) and 0.54 (for the average) (Figure 13). By contrast, correlation between the middle 40% income and profits is lower (of 0.35 for the median and of 0.37 for the average). This evidence suggests that the evolution of profits influence the income inequality. The fact that the correlation is higher for the average profit than for median profit also suggests that the dispersion of profits also related to income inequality (as the top profit quantiles influence the average but not the median).

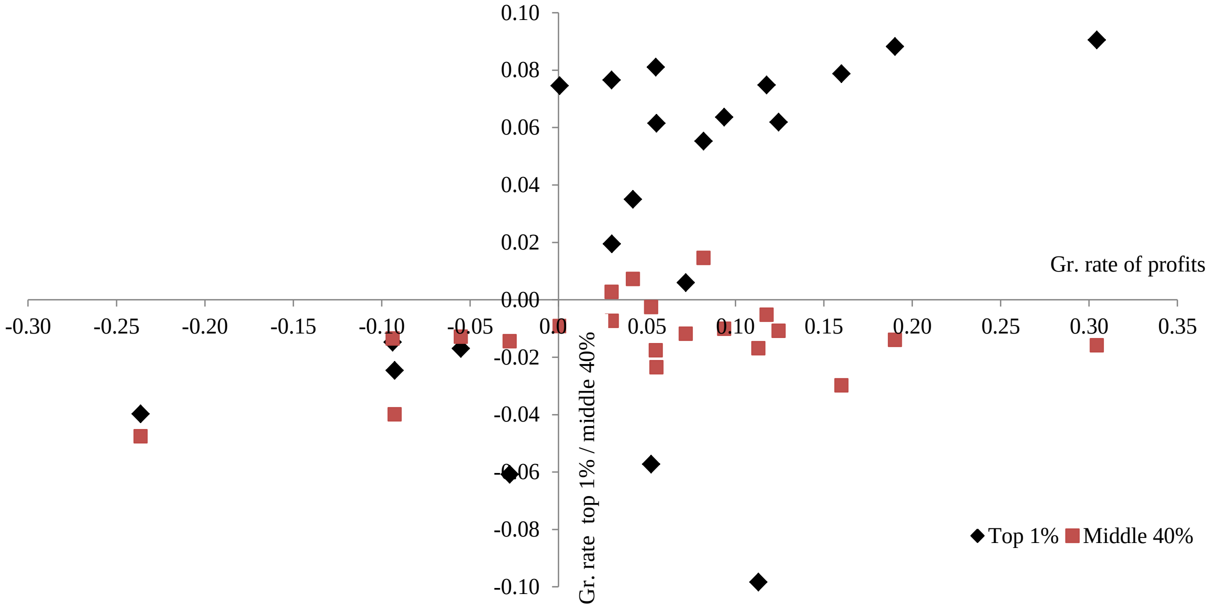
Figure 12: The evolution of profits and US pre-tax income of the top 1% and middle 40%, 1992-2013 (2013 = 1)



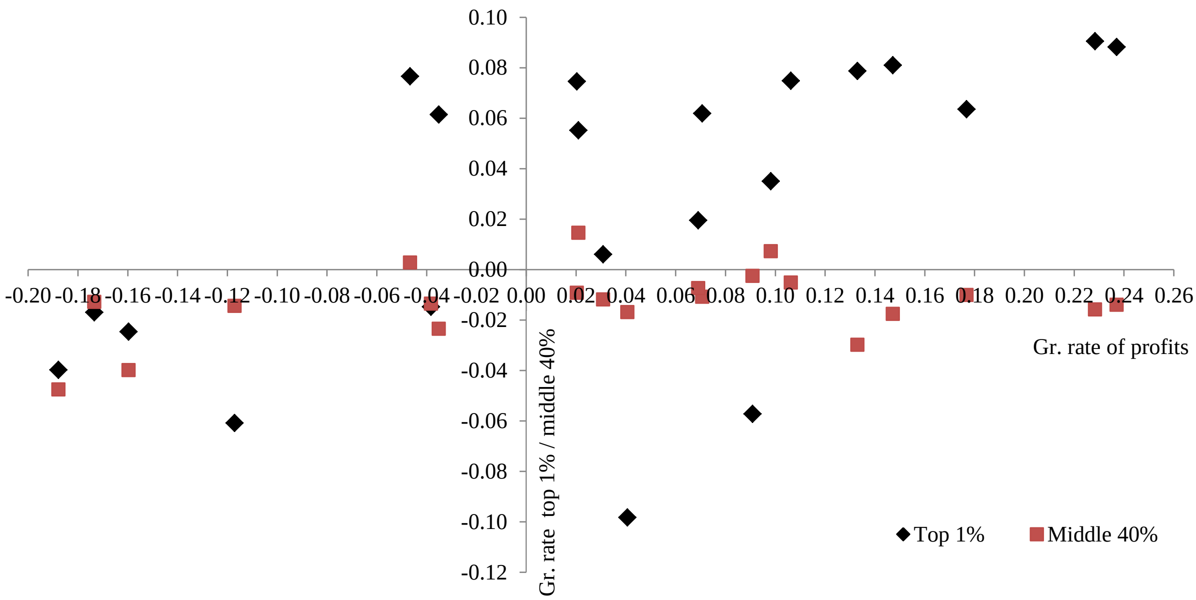
Source: Bas and Paunov (2017) based on data from the Compustat database on profits and Piketty et al. (2016) for pre-tax income of the top 1% and middle 40%.

Figure 13: Correlation of annual growth rates of profits and the top 1% and middle 40% of the US pre-tax income distribution, 1992-2013

Panel A: Average



Panel B: Median



Source: Bas and Paunov (2017) based on data from the Compustat database on profits and Piketty et al. (2016) for pre-tax income of the top 1% and middle 40%. Growth rates are computed using deflated income and executive pay, applying the same deflator as described in Piketty et al. (2016).

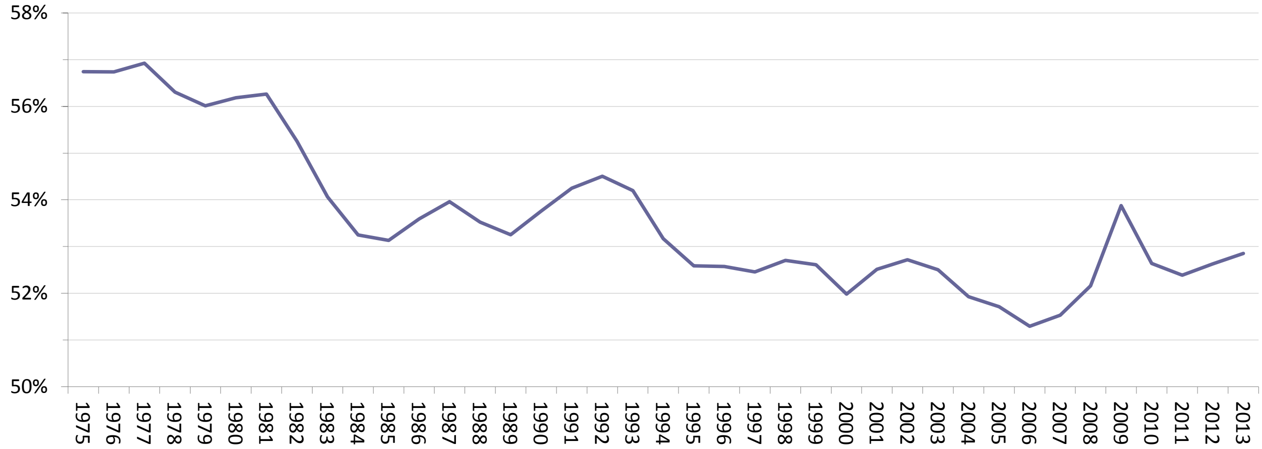
The declining return to labor

A corollary of higher returns to capital is the decreasing share of labor in value added that has taken place in many OECD countries over the past three decades (Figure 14). Karabarbounis and Neiman (2014) show that the share of corporate gross value added paid to labor declined by five percentage points for 59 economies over 1975-2012. Using industry-level data, Alvarez-Cuadrado et al. (2014) also show that the income share from labor has declined in all but 3 of a set of 16 industrialized economies. According to reports of the US Bureau of Labor Statistics, the share of labor in the United States was of 64% from the immediate post-Second World War period to the mid-1980s, when the measure subsequently declined to 58% (Elsby et al., 2013).

Several pieces of descriptive evidence point to a role of digital innovation in accounting for those changes: Figure 15 shows that in the United States the labor share has decreased significantly in the more R&D-intensive sectors but not much in the least R&D-intensive sectors. Koh et al. (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, i.e. IPR and software and not physical capital. Related indicative evidence comes from Karabarbounis and Neiman (2014) who show that countries and industries experiencing larger declines in the relative price of investment, a development mainly due to IT investments, experienced larger declines in labor shares.

Two industry-level studies provide perspectives on the impacts of digital innovation on the decreasing labor share: using industry-level data for a wider set of 25 OECD countries over 1980-2007, Bassanini and Manfredi (2012) find that 80% of intra-industry labor-share contraction could be attributed to total factor productivity growth and capital deepening. Table 1 provides regressions for 27 OECD countries over 1995-2007 that show more direct evidence on the effects of innovation. Findings show a negative relation between labor shares and patenting performance across industries in these countries, even as other factors are taken into account, including the role of finance, skills, capital, labor unions and trade. The evidence points to a negative effect of a more skilled labor force on the labor share. This may also be related to more substantial technological change with negative impacts on the demand for labor.

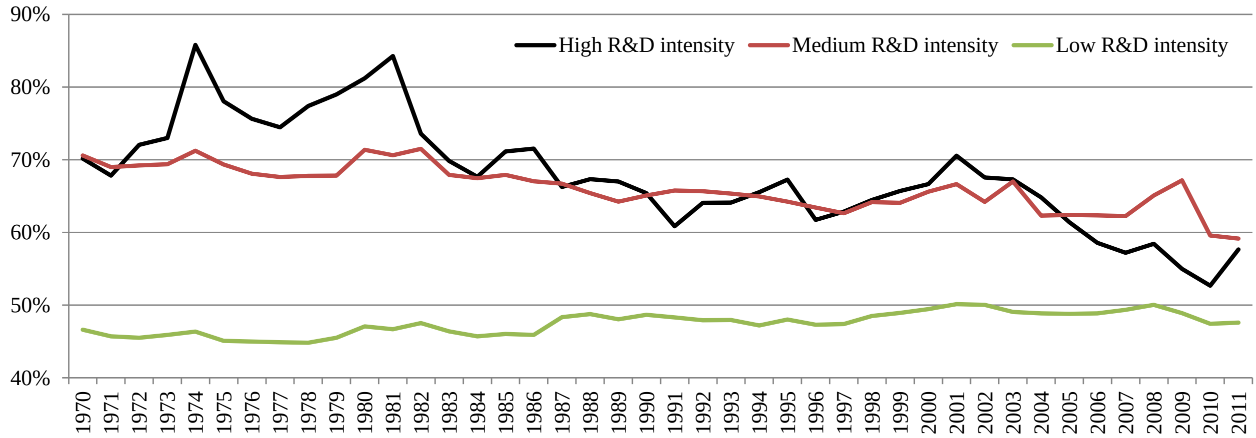
Figure 14: Labour share in value added for the OECD-21* in percentages, 1975-2013



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.

Figure 15: 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 (2016), OECD Taxonomy of Economic Activities Based on R&D Intensity", OECD Science, Technology and Industry Working Papers, No. 2016/04., OECD Publishing, Paris. The “medium R&D intensity sectors” category combines the medium-high, medium- and medium-low intensity sectors.

Table 1: Evidence on the impacts of innovation on the labor share from industry data for 1995-2011 across 27 OECD countries

Dependent variable	Industry labor compensation over value added						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$Patents_c$ * Patent $intensity_{ind}$	-0.054*	-0.049	-0.049	-0.056*	-0.068**	-0.058**	-0.064**
	(0.032)	(0.030)	(0.030)	(0.030)	(0.028)	(0.028)	(0.027)
$Graduates_c$ * Skill $intensity_{ind}$		-0.211*	-0.211*	-0.202*	-0.201*	-0.183*	-0.184*
		(0.115)	(0.116)	(0.115)	(0.116)	(0.110)	(0.106)
$Capital_c$ * Capital $intensity_{ind}$			0.049	0.038	0.068	0.043	0.009
			(0.422)	(0.421)	(0.419)	(0.423)	(0.430)
$Finance_c$ * Intangible $assets_{ind}$				-0.336**	-0.349**	-0.336**	-0.324**
				(0.145)	(0.143)	(0.145)	(0.145)
$Trade_c$ * Transport $equipment_{ind}$					0.196*	0.178	0.128
					(0.115)	(0.112)	(0.113)
Union $Density_c$ * Low-skill intens						0.007*	0.008*
						(0.004)	(0.004)
GDP_c * Capital $intensity_{ind}$							0.393
							(0.317)
Country-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,070	4,070	4,070	4,070	4,070	4,070	4,070
R-squared	0.25	0.26	0.26	0.26	0.26	0.27	0.27

Source: Baruffaldi and Paunov (2016), Regressions are based on OECD MSTI and STAN databases.
Note: 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 to range between 0 and 1. 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 $Patents_c$ * 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 country-level innovation (Patents) doubles (increases by 100%), the labor share in industries with the highest patent intensity would decrease by 6.4% more than in industries with the lowest patent intensity. The regressions apply the methodology first introduced by Rajan and Zingales (1998) that allows identifying the impacts of innovation, proxied by the country patenting relative to GDP, on the labor share while controlling for industry-year fixed effects. 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 annex provides definition of variables included. Robust standards errors corrected for are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Digital innovation is of course not the only cause behind the decreasing labor share Several other factors have contributed to the declining labor share including the weakening of unions as shown in Table 1. Moreover, capital aside from intangibles includes real estate, tangible capital and capital stocks of the government sector (see Bonnet et al., 2014). Also, decreasing labor returns do not automatically translate into higher rewards to capital. Some of the gap may be related to higher depreciation rates: modern forms of capital, such as software, depreciate faster in value than equipment of the past. Computers and other information and communication technologies have high depreciation rates. Computer R&D has an estimated depreciation rate of 40% (Li and Hall, 2016).

Finally, several measurement issues may influence the measured labor share. This includes the methods used to impute the labor and capital income earned by entrepreneurs, sole proprietors, and unincorporated businesses. Elsby et al. (2013) show that these imputations influenced the changing labor shares reported by the U.S. Bureau of Labor Statistics. Yet, the downward trend remains even if self-employment is not taken into account as in 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.

Higher returns to executives

Growing risk has increased the impact of managers' decisions on profits. In stable market conditions, mistakes by managers make little difference 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 whose relevance is just marginally better or worse than those of the competitors might mean total success or alternatively large losses for the firm. The rewards operate in the same manner as described by Rosen (1981) when characterizing the outstanding 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 as well as IT-related manufacturing (Table 2). We also identify high rewards for the best paid managers in finance and insurance and extractive industries, pointing to the role of other factors such as the financialisation of the economy in explaining changes in the distribution of income.

Table 2: Share of executive compensation in net sales over 1992-2014, on average and by percentile

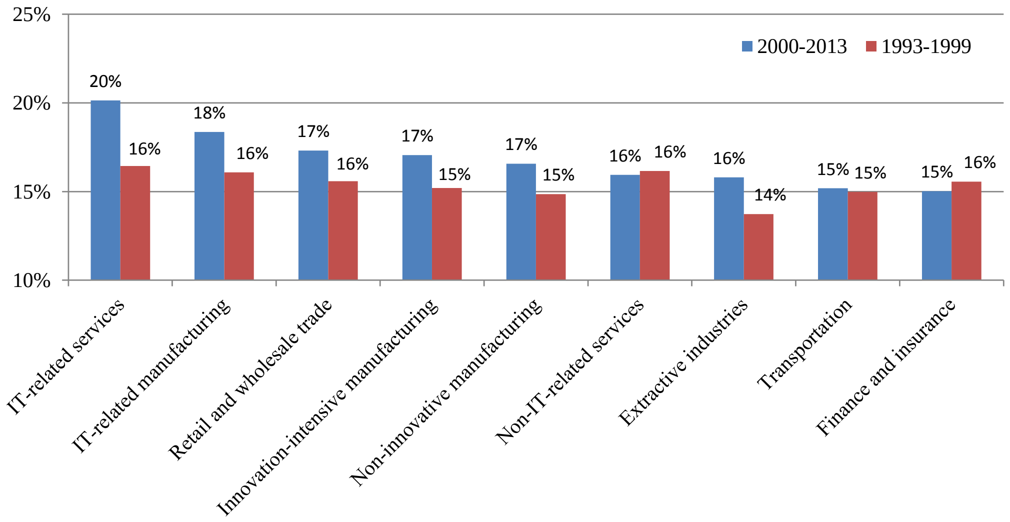
Sector	10th	50th	90th	Average
IT-related services	0.2%	1.9%	16.4%	6.2%
Innovation-intensive manufacturing	0.3%	1.7%	13.3%	5.3%
Finance and insurance	0.2%	1.4%	7.6%	3.4%
IT-related manufacturing	0.2%	1.3%	6.6%	2.8%
Extractive industries	0.1%	1.1%	7.5%	2.8%
Non-IT-related services	0.1%	0.5%	2.8%	1.2%
Non-innovative manufacturing	0.2%	0.6%	2.3%	1.2%
Retail and wholesale trade	0.1%	0.4%	2.0%	0.9%
Transportation	0.1%	0.4%	1.6%	0.7%

Source: Statistics based on the ExecuComp and Compustat databases.

Note: Further detail on the categorization of industries into IT-related services and manufacturing are provided in the data annex.

In addition, managers' activity is subject to information asymmetry, which makes it difficult to monitor their actual effort or capacity (especially as only marginal differences might make a big difference in the outcome). This has boosted competition between firms to attract the best managers, giving the ability to negotiate favorable packages including with insurance in case of failure ("golden parachutes"). For those reasons, managers have been able to capture part of the increased rent, and have seen their average pay rising much faster than other employees who have less discretion and less influence on firms' performance. One piece of evidence on risks for managers is the 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 to other firms as part of “poaching of the best”) (Figure 16). IT-related manufacturing is the second highest. The rate has increased relative to other sectors compared to 1993-1999.

Figure 16: Annual turnover rate of leading executives by sector of activity, for 1993-2013



Source: Statistics based on the ExecuComp and Compustat databases.
Note: Further detail on the categorization of industries into IT-related services and manufacturing is provided in the data annex.

Digital innovation has evolved at the same time as top executives/managers have seen their rewards increase. 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% of the top 0.1% in the United States are managers in non-financial industries (Bakija et al., 2010 as quoted in CEA, 2016).

Top executives/managers in sectors where digital innovation is critical receive particularly large returns beyond their industries' share in total sales (Table 3). Executives from the IT-related services industries represented at least around one in five of the top 1% of executives in 2000-2014, in the same level as executives from finance and insurance. IT-related manufacturing is in third rank in terms of the share of top executives, above its share in industry sales. Other sectors represent higher shares in sales than among top executives.

Table 3: Distribution of the top 1% of executives across sectors of activity

	2000-2014		1992-1999	
	Share of the top 1%	Industry share in sales	Share of the top 1%	Industry share in sales
IT-related services	24.7%	9.6%	22.5%	9.4%
Finance and insurance	24.4%	16.6%	25.8%	13.7%
IT-related manufacturing	12.4%	8.8%	9.7%	8.2%
Innovation-intensive manufacturing	8.6%	8.0%	7.0%	9.2%
Retail and wholesale trade	8.6%	20.4%	8.6%	17.0%
Extractive industries	7.6%	10.6%	2.6%	7.9%
Non-innovative manufacturing	7.0%	9.7%	9.8%	13.8%
Non-IT-related services	3.9%	6.9%	7.5%	7.7%
Transportation	2.7%	9.3%	6.4%	13.0%

Source: Statistics based on the ExecuComp and Compustat databases.
Note: Further detail on the categorization of industries into IT-related services and manufacturing is provided in the data annex.

Several pieces of evidence point to the relation of higher pay to executives with digital innovation. Importantly, 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 non-wage compensations up from slightly more than 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 DotCom bubble, as the evolution of salaries was rather stable during that period. Also, Gabaix and Landier (2014) show that CEOs have larger rewards in larger-sized firms. Although not identical, firm size and market power are correlated.

In addition, Paunov and Bas (2017) show, on US traded firms, that higher industry market concentration and creative destruction affect top executive pay positively (column 1 of Table 4). They also find that higher pay may partly compensate for more volatile pay and that the pay increase is not due to the fixed wage component but to other firm-performance-based compensations. Impacts are even stronger for CEOs as they are responsible for firms' critical strategic decisions (column 4 of Table 4). Also, consistently with the winner-take-all market hypothesis, the best executives, proxied in two alternative ways by the 90^{th} percentile in quantile regressions and the 30^{th} percentile in fixed-effects regressions, obtain largest rewards (columns 5 and 6 of Table 4).

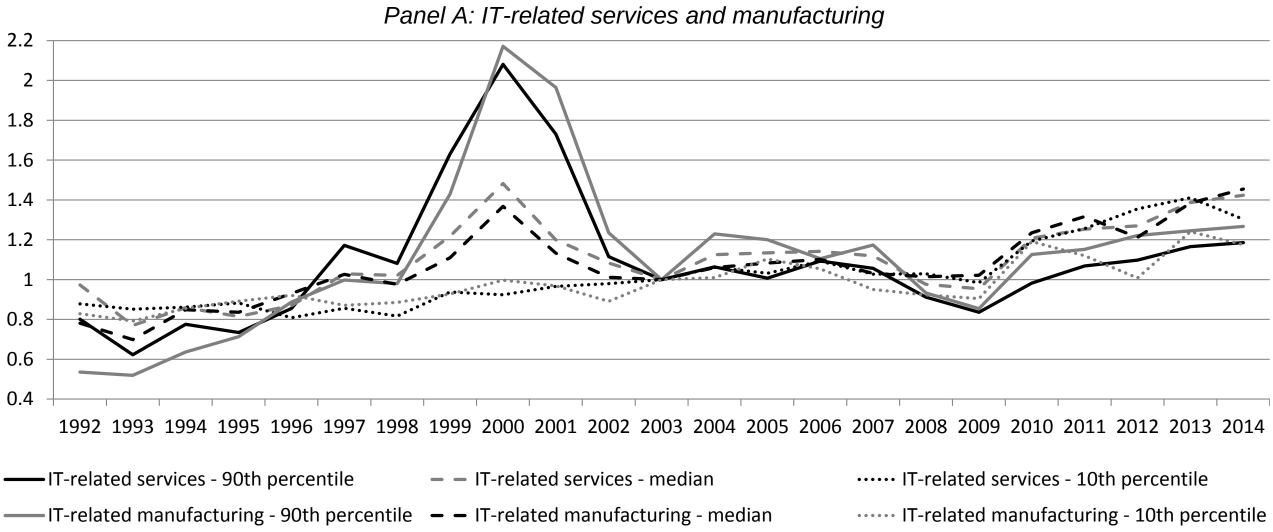
Table 4: The impacts of market concentration and creative destruction on top executive compensation in the United States, 1992- 2013

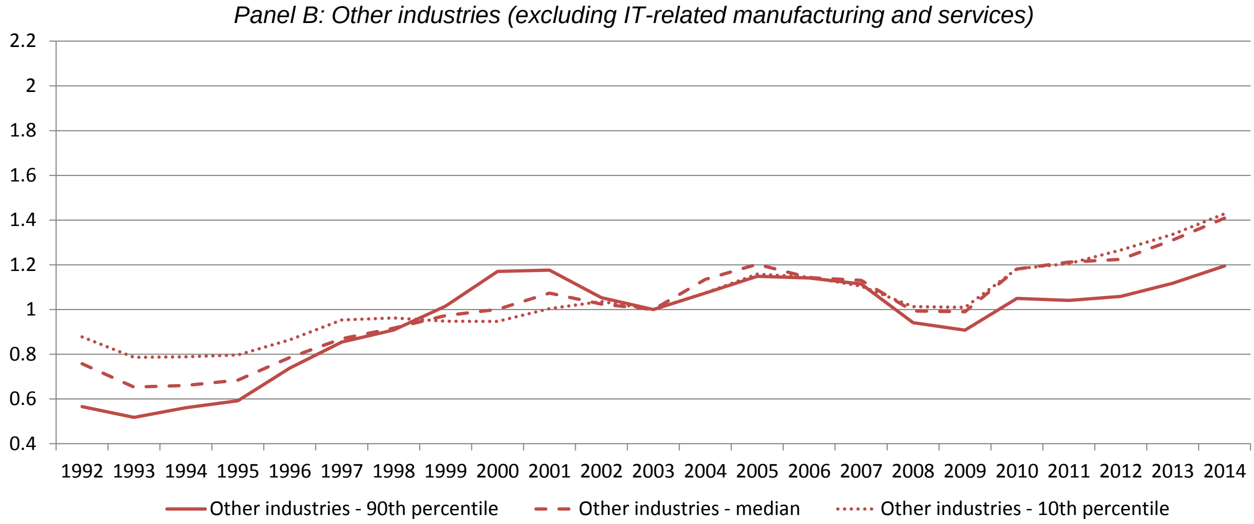
Dependent variable:	Executive compensation					
	Average effects	Volatility of pay	Wage pay	CEO vs. other executives	90^{th} percentile	Top paid executives
	(1)	(2)	(3)	(4)	(5)	(6)
Herfindahl index $_{t-1}$	0.593***	1.484***	0.009		0.930*	
	(0.170)	(0.333)	(0.136)		(0.482)	
Creative destruction $_{t-1}$	0.967*	4.085***	0.271		6.214***	
	(0.569)	(1.030)	(0.233)		(1.885)	
Herfindahl index $_{t-1}$ * CEO				0.934***		
				(0.253)		
Herfindahl index $_{t-1}$ * Other				0.496***		
				(0.184)		
Creative destruction $_{t-1}$ * CEO				3.377***		
				(1.083)		
Creative destruction $_{t-1}$ * Other				0.224		
				(0.542)		
Herfindahl index $_{t-1}$ * Top 30						0.824***
						(0.247)
Herfindahl index $_{t-1}$ * Below 70						0.381**
						(0.176)
Creative destruction $_{t-1}$ * Top 30						1.927***
						(0.655)
Creative destruction $_{t-1}$ * Below 70						-0.133
						(0.681)
P-Value of the difference in coefficients (Herfindahl index)				0.09		0.08
P-Value of the difference in coefficients (Creative destruction)				0.00		0.00
Executive controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry controls	Yes	Yes	Yes	Yes	Yes	Yes
Executive-firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	55,582	45,555	55,582	55,377	55,582	55,582
R-squared	0.20	0.04	0.18	0.20		0.20
Number of executives	12,312	9,593	12,312	12,164	12,312	12,312

Source: Paunov and Bas (2017) based on ExecuComp and Compustat data for 1992-2013.
Note: Market concentration is measured using the normalized Herfindahl index while creative destruction is measured as the reverse of the rank correlation of firms' sales from one year to the other at the 4-digit SIC industry level. See Paunov and Bas (2017) for a description of the control variables used. Robust standards errors corrected for clustering at the 4-digit-SIC level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Interestingly, during the "DotCom bubble" of 1999-2000, a period during which the stock market value of IT companies skyrocketed, experienced also a significant increase in the rewards of executives, and this increase was very differentiated by pay decile (Figure 17A). During the period, the total compensation of the highest paid group increased substantially more than that of other groups. Hence the increase in executive pay was highly skewed, pointing to a connection with the skewed distribution of businesses' performance. No such trends arose for other sectors of activity, pointing to the singularity of this sector (Figure 17B).

Figure 17: Trends in executive income by income decile for 1992-2014 (2003 = 1)



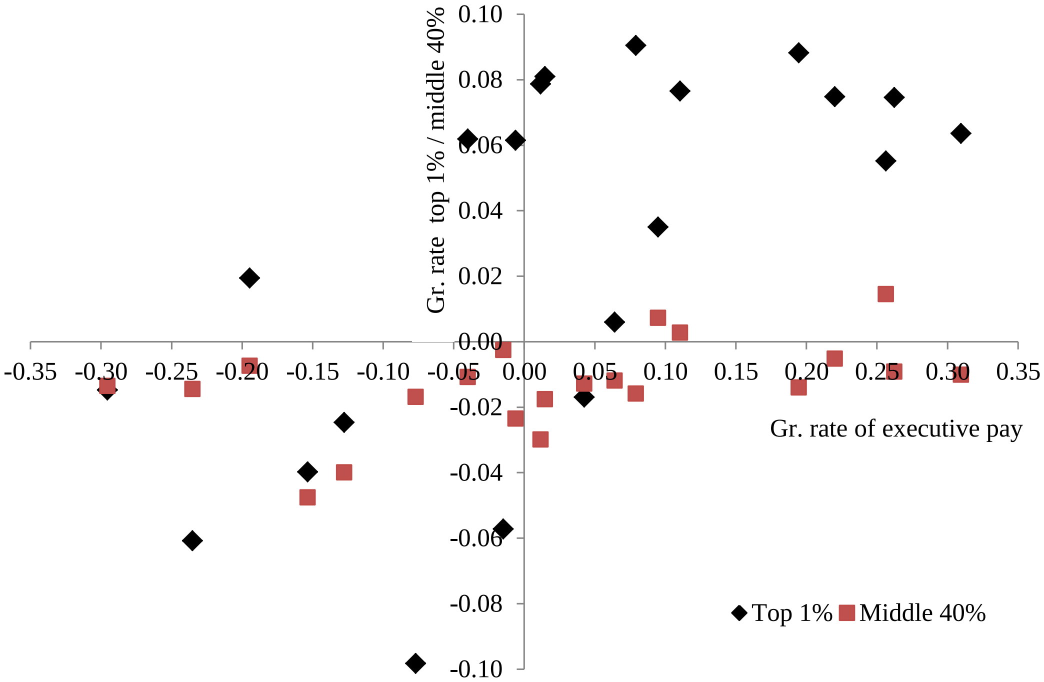


Source: Statistics based on Compustat.
Note: Further detail on the categorization of industries into IT-related services and manufacturing is provided in the data annex.

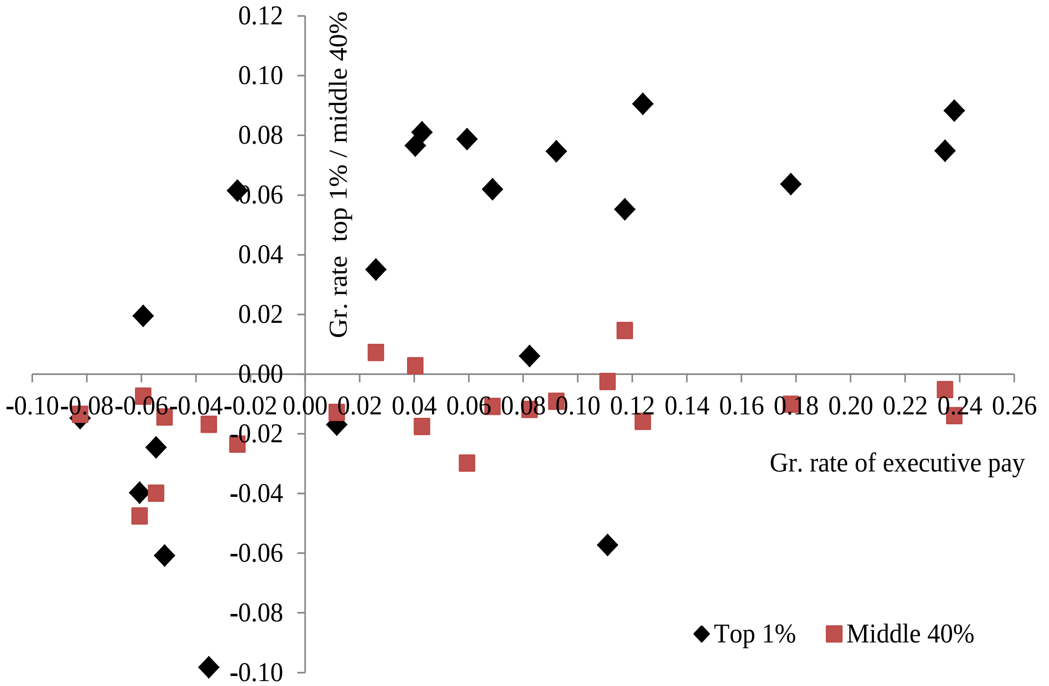
Regarding the relationship between executive pay and the top 1%, the trend in pay over 1992-2013 shown in Figure 17 mimics closely the evolution of the income increase of the top 1%, similarly to the evidence shown in Figure 12 for profits. The correlation between growth rates of the top 1% income and executive pay is high: 0.60 (for the median) and 0.64 (for the average) (Figure 18). By contrast, the time trends in middle 40% income follows are different from those of than executive pay, with correlations of 0.40 (for the median) and 0.47 (for the mean). This evidence suggests that executive pay influences the income inequality similarly to the role profits play, which is due to the fact that executive pay is one channel from profits to income of the top categories. The stronger correlation of average compared to median executive pay also suggests that the dispersion of executive pay also related to income inequality.

Figure 18: Correlation of annual growth rates of executive pay and the top 1% and middle 40% of the US pre-tax income distribution, 1992-2013

Panel A: Average



Panel B: Median



Source: Bas and Paunov (2017) based on data from the ExecuComp database on executive pay and Piketty et al. (2016) for pre-tax income of the top 1% and middle 40%. Growth rates are computed using deflated income and executive pay, applying the same deflator as described in Piketty et al. (2016)

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 innovation and KBC have 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 operating in stable and less knowledge-intensive industries.

Labor compensation

With a line of argument similar to the one applying to managers, we expect that digital innovation increases the rewards to employees having a critical role in firms which make rents. There is some micro evidence that points to workers sharing rent in winning firms. Song et al. (2015), for instance, show that over 1978-2012, inequality in US labor earnings increased across firms, within industries and US states, which is a possible indication of the existence of rent sharing with employees. Evidence for the United Kingdom suggests these rents are shared with more skilled workers; Mueller et al. (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 find 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 et al. (2013) also find that increasing heterogeneity across firms explain over 60% of the growth in wage inequality across occupations and industries in West 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 on publicly traded firms in the United States that report on wage payments suggests that while market concentration positively affects profits it does not have effects on wages benefitting investors (from higher returns to capital) to workers (Table 5) (Paunov and Bas, 2017).

Table 5: Impacts of market dynamics on profit and wages

Dependent variables:	Profits	Wages	Profit to wage ratio
	(1)	(2)	(3)
Herfindahl index $_{t-1}$	0.333***	-0.026	0.477**
	(0.112)	(0.236)	(0.216)
Creative destruction $_{t-1}$	0.345	0.453	0.152
	(0.394)	(0.597)	(0.608)
Firm controls	Yes	Yes	Yes
Industry controls	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	11,962	3,993	3,049
R-squared	0.72	0.45	0.31
Number of firms	1,404	435	381

Source: Paunov and Bas (2017) based on Compustat.
Note: Market concentration is measured using the normalized Herfindahl index while creative destruction is measured as the reverse of the rank correlation of firms' sales from one year to the other at the 4-digit SIC industry level. Robust standards errors corrected for clustering at the 4-digit-SIC level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The negotiation power of most workers, however, is weaker than the one of managers, explaining the increased returns to capital discussed above. This is for a number of reasons. First, labor market pressure, which tends to equal the price of similar labor across firms, might be stronger for employees than for managers as their labor market is thicker. 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 are often less prominent for employees than for managers, allowing for control over higher compensation. 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). Katz and Krueger (2016) find that from 2005-2015 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. Goldschmidt and Schmieder (2015) show that reducing rent sharing was one of the motivations why German firms outsourced non-core activities, such as food, cleaning, security and logistics services starting in the early 1990s.

Opportunities for social mobility

Inequality indicators capture at any point in time the relative position of individuals; a closely related question is whether individuals in the lowest income categories have the opportunity to move upwards. Social mobility is important in debates on inequalities as it is seen as an inter-temporal equalizing force across income groups (Jones and Kim, 2014). In many countries higher inequalities tend to be associated with lower upward social mobility (as described in the so-called "Great Gatsby" curve). Chetty et al. (2014) find that a child born in the 1980s to parents in the bottom 20% of the income distribution has only a 7.5% chance of moving to the top 20%.

Social mobility is connected to creative destruction, as this mechanism triggers a renewal regarding who the market winners and losers are, which impacts on their respective income: new winners should move up the income distribution while losers should move down. As innovation is amplifying creative destruction and making its impact bigger (due to winner-take-all dynamics), we expect a positive correlation between innovation and social mobility. This is confirmed in recent empirical work: Aghion et al. (2015) shows that US states with more innovation-led growth had higher upward social mobility over the 1995-2010 period. Other work by Aghion et al. (2016) for Finland shows that becoming an innovator enhances intragenerational and intergenerational social mobility, reducing the father-son income relation.

Moreover, anecdotal evidence from the Forbes 400 list of the richest Americans discussed above also 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 making it: the share of people with a college education rose in the list from 77% in 1982 to 87% in 2011 (Kaplan and Rauh, 2013).

5. Policy implications

There is a growing consensus that income inequalities in OECD countries have reached socially unacceptable levels, and that corrective policies need to be engaged. Such policies however should not hamper innovation as it is the main driver of income growth and welfare improvements for all. Current policies and institutions were developed to suit traditional activities like manufacturing, which implied very different production processes and market structures to those of the currently emerging ones. Instruments that governments can act on include fiscal policies, innovation, IPR, data access, and competition policies. These policies need to be reviewed with the view to not only encourage innovation but also to reduce income inequality, notably by containing market dominance and keeping markets open to newcomers.

Fiscal policy

The most direct instrument to reduce income inequalities is fiscal policy, which can be used to redistribute income from the richer to the poorer. However, while tax instruments are needed, they are of limited effectiveness and might sometimes be counter-productive for addressing innovation-related income inequalities:

- First, for households, progressive income tax is implemented in all countries, but it has not allowed reducing significantly inequalities and it has become weaker over time in most countries (OECD, 2011). Consequently, action is needed ex ante: it is not only about redistributing income after it has been generated, but is it mainly about affecting the conditions in which income is generated so that primary income distribution would be less unequal.

- Second, the intangible nature of many assets has facilitated their relocation in low (or no) tax countries, hence evading taxes from countries where the revenue is generated. Curbing tax evasion notably from businesses is a priority for governments also to boost income redistribution.

- Third, governments should limit taxation of innovation-based rents as this might deter investment in innovation. Moreover, even if it is efficient to tax heavily rents that do not come from productive activities but from undue market power (based on regulation, influence, strategies, etc.), distinguishing such rents from those which reflect actual productive activities can be difficult. It is therefore more efficient, when possible, to eliminate the very conditions which allow for those non-productive rents, notably barriers to competition. Providing for competitive conditions in markets is complementary to taxation policies.

Innovation policies

Certain policies which support innovation might favor incumbents, depending on their specific settings: R&D tax incentives, for instance, tend to benefit mainly large, established companies, which are more often profit-making than start-ups. Public procurement also tends to benefit incumbents, as governments are often risk-adverse and prefer to deal with established suppliers, and as bidding for public contracts is costly for newcomers. These policies should be reviewed in light of their impact on competition and new entry. Special clauses can be integrated in the design, like tax support to start-ups (like the French R&D tax credit, which reimburses in cash the amount that loss-making businesses would have made thanks to the measure if they had been profit-making), or special conditions for small firms to access public markets (like the US Small Business Innovation Research, SBIR program).

IPR and standards

The market dominance of winners in digital innovation competition is largely based on economies of scale and network effects. However, its persistence is favored by legal and technical instruments, namely IPR (notably patents and copyrights) and standards. These instruments can therefore deter entry in such markets, to the detriment of competition and innovation. IPR are needed in certain cases in order to secure adequate compensation to innovators, but when it comes to digital innovation they come on the top of other strong means to secure market exclusivity, and their strength and scope should be reviewed accordingly. First, it would be appropriate to consider a narrower scope or shorter statutory duration for IPR titles, such as patents, so as to cut the excess return they are now generating. Second, in order to improve access to IPR protected knowledge, governments might encourage the development of dedicated markets for IPR, which facilitate the use of IPR protected inventions by third parties (against payment of fees) and which have difficulties emerging by themselves due to high transaction costs (notably information costs and asymmetries).

Access to personal and public data

Personal data, which includes detailed information on individuals' characteristics, practices and interests, are core assets in a digital innovation economy; they are essential commodities (i.e. with no substitute on the market) to many customers, including businesses. Access to and ownership of these assets need to be reviewed in this new context as they impact directly on market structures and the distribution of monetary benefits from digital innovation. Personal data are produced notably when the concerned individuals are using the Internet. Such data are currently the exclusive ownership of the companies providing the infrastructure on which they are produced (such as search engines, social networks, platforms and online shop), and they are a source of revenue and of market dominance for these companies. It would be appropriate to review the legal and regulatory framework which allocate rights on these data with the view to sharing more equally the benefits from exploiting these data and facilitating competition (while respecting other conditions such as privacy rights). This is all the more important as advantages provided by data exclusivity build up over time, hence reinforcing market dominance and excluding new competitors.

Competition policies and platforms

Internet-based platforms are web sites serving as intermediaries or facilitators between users, or between service suppliers and consumers (such as Facebook, Google, Uber, Amazon and Apple's iStore). Platforms have a major influence on market competition: they are the place where supply meets demand and as we have seen they can reduce entry costs to global markets for small businesses. In turn, there are concerns regarding market competition between platforms, due to their direct reliance on digital innovation, which favors winner-take-all market structures. Competition authorities around the world have dealt with a few cases involving platforms already, but there is not yet an articulated doctrine on how to deal with them in broader cases (Rochet and Tirole, 2003). It is urgent that competition authorities start elaborating such a doctrine; recent work by the German and French competition authorities goes in this direction.[3]

6. An open research agenda

This paper 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 the mechanism. Further evidence is critical to understand the nature of impacts better. The following areas in particular are critical:

First, the changes brought by digital innovation require continued efforts to proxy well the phenomenon of software-based innovations. With continued technological progress, developing the right types of indicators is of course very much a moving target that requires continued efforts. While a decade ago indicators on computer and internet access were suitable to learn about impacts, 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 better about digital innovations across firms, industries and countries

[3] See footnote 3. This includes, for instance, Bundeskartellamt (2016), Market Power of Platforms and Networks, Working Paper Ref. B6-113/15, and, Autorité de la concurrence and Bundeskartellamt (2016), Competition Law and Data. Accessed at: http://www.autoritedelaconcurrence.fr/doc/reportcompetitionlawanddatafinal.pdf

over time to trace systematically the effects of digital innovation on market dynamics. Other measures of innovation, such as the introduction of new products, the number of intellectual property rights titles and the level of R&D, capital and/or intangible investments do not allow isolating digital innovations. 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.

Second, the impacts of digital innovations on changing market dynamics in the United States and beyond require further attention. An analysis of economic census data would allow testing the extent of changes and in what contexts they arise. This requires accounting for global competition in sectors where it has become important. Such analyses, particularly if they focus on sectors that have already undergone fundamental changes, will increasingly require dealing with new challenges in the definition of market concentration that arises in the digital economy. This includes "redefining" the industry that is associated with a particular firm. Google's investments in automated cars points to the company's role as competitor in a number of markets. Moreover, the absence of market transactions on two-sided markets that are important for a number of sectors in the digital economy, as is the case for consumers using online search engines, also renders it more difficult in some markets to measure market concentration by using 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 would allow documenting, beyond executives and investors, which workers benefit from rent-sharing and which are excluded. Such data would also allow understanding whether and, if so, how digital innovation creates opportunities for social mobility. Again, documenting diverse effects across countries can allow understanding whether country-specific contexts affect who benefits from the impacts of digital innovation on "winner-take-all" markets.

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Data annex

A. Industry categories used in Tables 2 and 3, Figures 16 and 17

The SIC 2-digit industries of all firms in the ExecuComp and Compustat dataset 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), Petroleum Refining and Related Industries (29).
- Construction includes Construction - General Contractors & Operative Builders (15), Heavy Construction, Except Building Construction, Contractor (16), Construction – Special Trade Contractors (17)
- IT-related manufacturing includes Industrial and Commercial Machinery and Computer Equipment (35) and Electronic & Other Electrical Equipment & Components (36).
- Innovation-intensive manufacturing includes Chemicals and Allied Products (28) and Measuring, Photographic, Medical, & Optical Goods, & Clocks (38).
- Non-innovative manufacturing includes Food and Kindred Products (20), Tobacco Products (21), Textile Mills Products (22), Apparel, Finished Products from Fabrics & 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), Miscellaneous Manufacturing Industries (39)
- IT-related services includes 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 & Commodity Brokers, Dealers, Exchanges & 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 & 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), Miscellaneous Retail (59).
- Transportation includes Railroad Transportation (40), Local & Suburban Transit & Interurban Highway Transportation (41), Motor Freight Transportation (42), Water Transportation (44), Transportation by Air (45), Transportation Services (47), 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), Educational Services (82)

B. Executive pay measures used in Tables 2, 3, 4 and Figures 12, 13, 17 and 18

Data on executive pay come from the ExecuComp database and refer to total executive compensation (including salary, bonuses and other annual rewards), except for results reported in column (3) of Table 4 that refer to executives' salary only. The volatility of pay variable is computed as the standard deviation of total executive pay. Table A.1. describes the estimating sample used in regressions presented in Table 4.

Table A.1. Characteristics of the estimating sample for regression results shown in Table 4

	Number of observations	Percentage share
Number of executives	11,746	
Number of firms	1,458	
Sector of activity		
Metal mining	92	0.2
Oil and gas extraction	3,162	5.7
Chemicals and allied products	4,393	7.9
Petroleum refining and related industries	91	0.2
Primary metal industries	394	0.7
Industrial and commercial machinery and computer equipment	771	1.4
Electronic, other electrical equipment and components	6,053	10.9
Transportation equipment	1,518	2.7
Measuring, photographic, medical, optical goods and clocks	3,386	6.1
Motor freight transportation	138	0.3
Communications	1,214	2.2
Electric, gas and sanitary services	5,310	9.6
Food stores, eating and drinking places, miscellaneous retail	3,495	6.3
Depository institutions	5,245	9.4
Security and commodity brokers, dealers, exchanges and services	1,940	3.5
Insurance carriers	3,463	6.2
Holding and other investment offices	3,896	7.0
Business services	10,461	18.8
Amusement and recreation services	560	1.0
Time period		
1992 - 1995	5,774	10.4
1996 - 1999	8,105	14.6
2000 - 2003	8,682	15.6
2004 - 2007	12,527	22.5
2008 - 2011	13,988	25.2
2012 - 2013	6,506	11.7

C. Data on the distribution of income in Figures 2 and 3

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

The following adjustments are undertaken to deal with missing values:

- For Figure 2 missing values of the top 1% income share (before taxes) have been replaced by the year in parenthesis 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 top1% 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: -2010; Netherlands: Main series: 1986-2012; New Zealand: Adults: 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 & single adults: 1986-1989; Adults: 1990-2012; United States: Main series: 1986-2014.

- For Figure 3 missing values of the top 1% income share (before taxes) have been replaced by the year in parenthesis 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% 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 & 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 & single adults:1981; United States: Main series:1981 and 2010.

D. Industry and country level data used for labor share regressions reported in Table 1

Regression results reported in Table 1 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 is complemented with data from EU KLEMS, the OECD National Accounts database and the World Bank Enterprise Surveys. The variables are defined in Table A.2. 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 3- and 2-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 semi-trailers, machinery and equipment n.e.c., other non-metallic mineral products, paper and paper products, printing and reproduction of recorded materials, rubber and plastic products, textiles, transport equipment, transportation and storage, wholesale and retail trade, wood and products of wood and cork.

A.2. 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 % 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	% 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	EU KLEMS
Capital intensity	Industry ratio of capital stock over value added (US period	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.