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Daniel Nepelski

How to Facilitate Digital Innovation in Europe

Digital technologies have the potential to modernise the economy. But digital innovations are disruptive. Therefore, policies need to be comprehensive and go beyond the support of the ICT sector as well as address a variety of issues: increasing returns to the use of data, heterogeneity of the digital innovation actors and ecosystem, digital skills in the non-ICT sectors, entrepreneurial culture, funding for scaling-up of new entrants, technological interoperability and intellectual property protection. At the same time, they need to counterbalance the costs of digitally driven disruptions. This paper highlights the main peculiarities of digital innovation and its implications for policies aiming at reaping the benefits of digital technologies.

In a narrow sense, digital innovation means the implementation of a new or significantly improved digital product, e.g. a semiconductor, a motion sensor or a piece of software. In a broader sense, digital innovation refers to the use of digital technologies to create a new product or improve an existing one. Digital innovation not only refers to the creation of products, but includes process, marketing method, or organisational method.¹ Digital technologies in that broader sense are increasingly embedded in non-digital products improving their performance and efficiency. As a result, the economic potential of digital technologies lies in their economy-wide application rather than in the information and communication technologies (ICT) producing sector. For example, while the European ICT sector accounts for only four percent of total value added (Figure 1), the measures of ICT contribution to innovation show that digital technologies are the driving force of innovation in Europe.² The potential of digital technologies for innovation can be fully harnessed provided that we understand their impact and design adequate policy responses. Using the full potential of digital technology to intensify innovation activities in Europe and to improve the efficiency of innovation processes requires a deep understanding of the role of ICT in production and market processes.

Digital technologies challenge the existing innovation policies by transforming the very nature of the innovation process. For example, any piece of information and knowledge in digital

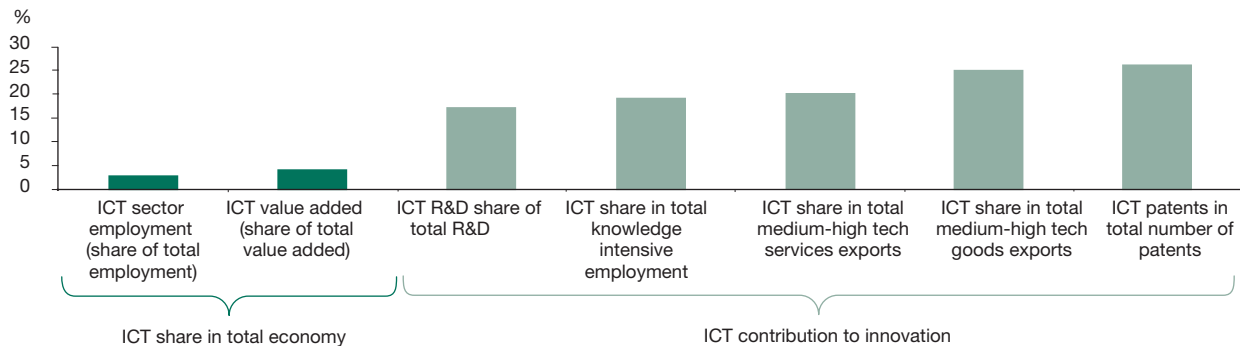
form can be easily shared and modified at very low cost. Unlike scarce material resources, information and knowledge are inputs that have increasing returns, i.e. the more people access, use and modify it, the bigger its value.³ Rather than granting exclusivity rights over knowledge and technology to individual agents to provide incentives to innovate, knowledge sharing between an increasing number of digitally connected actors is a driving factor of innovation. Another characteristic of digital innovation activities is the complexity of the ecosystem in which they take place.⁴ Multiple actors are usually involved in various stages of this process.⁵ For example, on average, there are 1.9 innovators per innovation produced within EU-funded research ICT projects.⁶ This implies that when analysing the process of digital innovation, one needs to adopt a system perspective rather than look at individual firms or organisations.⁷ Digital innovation does not only rely on collaborative and knowledge-intensive activities, rather it is a process involving a number of steps, from initial ideas and basic research to technology development and market experimentation through commercialisation. This requires a set of skills that digital entrepreneurs and start-ups must have in or-

- 1 OECD: *Stimulating Digital Innovation for Growth and Inclusiveness: The Role of Policies for the Successful Diffusion of ICT*, Paris 2016, OECD Publishing.
- 2 A. Pesole: *How much does ICT contribute to innovation output? An analysis of the ICT component in the innovation output indicator*, JRC Technical Reports, EUR 27074 EN, Luxembourg 2015, Publications Office of the European Union.

- 3 P. Romer: *Increasing Returns and Long-Run Growth*, in: *Journal of Political Economy*, Vol. 94, No. 5, 1986, pp. 1002-1037; and B. Arthur: *Increasing Returns and the Two Worlds of Business*, in: *Harvard Business Review*, Vol. 74, No. 4, 1996, pp. 100-109.
- 4 M. Fransman: *Models of innovation in Global ICT Firms: The Emerging Global Innovation Ecosystems*, JRC Scientific and Policy Reports, EUR 26774 EN, Seville 2014, JRC-IPTS; and V. Stocker, G. Smaragdakis, W. Lehr, S. Bauer: *The growing complexity of content delivery networks: Challenges and implications for the Internet ecosystem*, in: *Telecommunications Policy*, Vol. 41, No. 10, 2017, pp. 1003-1016.
- 5 F. Biagi, A. Pesole, J. Stancik: *Models of ICT Innovation: Evidence from the Community Innovation Survey*, JRC Working Paper No. 101636, 2015, Joint Research Centre.
- 6 A. Pesole, D. Nepelski: *Universities and collaborative innovation in EC-funded research projects: An analysis based on Innovation Radar data*, EUR 28355 EN, Luxembourg 2016, Publications Office of the European Union.
- 7 R. Wintjes: *Systems and Modes of ICT Innovation*, JRC Science for Policy Report, EUR 28005 EN, 2016, Joint Research Centre.

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Figure 1
Contribution of ICT to the economy and to innovation in EU28, 2014



Note: The ICT contribution to the economy is represented by the shares of the ICT sector in total employment and value added. The ICT contribution to innovation is illustrated by a set of indicators that reflect the share of R&D expenditures in ICT in total R&D expenditures.

Source: How much does ICT contribute to innovation output? An analysis of the ICT component in the innovation output indicator, JRC Technical Reports, EUR 27074 EN, Luxembourg 2015, Publications Office of the European Union; D. Nepelski, M. Bogdanowicz, F. Biagi, F. Desruelle, G. De Prato, G. Gabison, G. Piroli, A. Pesole, N. Thumm, V. Van Roy: 7 ways to boost digital innovation and entrepreneurship in Europe, JRC Science for Policy Report, EUR 28305 EN, 2017, Joint Research Centre; and M. Mas, J. Fernández de Guevara, J. Robledo, M. López-Cobo: The 2017 PREDICT Key Facts Report, in: G. De Prato, S. Samoilii, R. Righi (eds.), JRC Science for Policy Report, EUR 28594 EN, Luxembourg 2017, Joint Research Centre.

der to successfully launch a product on the market.⁸ Another distinctive feature of digital technologies is the scalability of processes of production and service provision. However, deploying digital innovations on a global scale involves substantial funding for scaling-up activities – which many European companies struggle to secure. This is not very surprising since the European policy focus is mainly on the financing of R&D and the first steps of the innovation process.⁹ Lastly, the complexity of the technologies underlying digital innovation activities require sophisticated management strategies of Intellectual Property Rights (IPR) and technological standardisation.

In order to formulate a set of policy options to facilitate digital innovation in Europe, this paper discusses the key specificities of digital innovation.

The digital innovation ecosystem

Digital innovation emerges in a complex environment of the ICT sector and is shaped by its interactions with the other economic sectors and final users. Using the concept of an innovation ecosystem,¹⁰ Fransman presents it as a set of layers (Figure 2).¹¹ The pattern of innovation behaviour is different in each layer. Layer 1 includes equipment providers and contains the capital intensive innovation process. This happens

rather slowly, because equipment providers need to secure interoperability. Layer 2 includes telecom network operators, which often have to make large infrastructure investments and rely mainly on the innovations developed by equipment providers in Layer 1. Layer 3 builds on the infrastructure provided by Layers 1 and 2 and includes content providers. In Layer 3 the pace of innovation and new firm creation is rapid. This layer has seen the largest number of fast growing companies so far, which have disrupted other traditional non-digital industries.¹² Users represent a fourth layer that includes final consumers and ICT-using companies from other sectors. This layer also contributes to innovation in the entire ecosystem. All the layers are interdependent and innovations in one layer impact innovations in another layer. For example, the apps industry (Layer 3) has grown rapidly since the introduction of the iPhone (Layer 1) in 2007. By generating and providing data, users deliver raw resources processed by the application and content providers.

Collaboration between actors of the digital innovation ecosystem is a decisive feature of digital innovation.¹³ Take for example the EC-funded ICT research projects: In this setting, 44% of all organisations producing innovations with high potential

8 R. P. Oakey: Technical entrepreneurship in high technology small firms: some observations on the implications for management, in: *Technovation*, Vol. 23, No. 8, 2003, pp. 679-688.

9 A. Hyytinen, O. Toivanen: Do financial constraints hold back innovation and growth?: Evidence on the role of public policy, in: *Research Policy*, Vol. 34, No. 9, 2005, pp. 1385-1403.

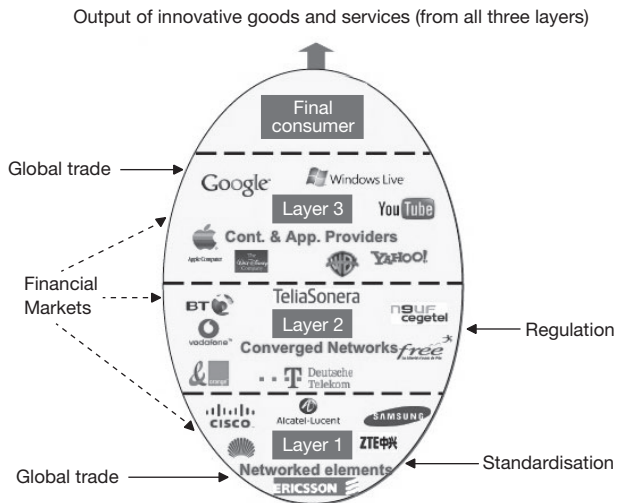
10 D.-S. Oh, F. Phillips, S. Park, E. Lee: Innovation ecosystems: A critical examination, in: *Technovation*, Vol. 54, No. 1, 2016, pp. 1-16.

11 M. Fransman, op. cit.

12 J.-P. Simon: How to Catch a Unicorn: An exploration of the universe of tech companies with high market capitalisation, JRC Technical Report, EUR 27822 EN, 2016, Institute for Prospective Technological Studies; and P.-J. Benghozi, E. Salvador, J.-P. Simon: Models of ICT Innovation: A Focus on the Cinema Sector, JRC Scientific and Policy Reports, EUR 27234 EN, Luxembourg 2015, Joint Research Centre.

13 F. Biagi et al., op. cit.; A. Pesole, D. Nepelski, op. cit.; and R. Basole, H. Park, B. Barnett: Coopetition and convergence in the ICT ecosystem, in: *Telecommunications Policy*, Vol. 39, No. 7, 2015, pp. 537-552.

Figure 2
Layers of the digital innovation ecosystem



Source: M. Fransman: Models of innovation in Global ICT Firms: The Emerging Global Innovation Ecosystems, JRC Scientific and Policy Reports, EUR 26774 EN, Seville 2014, JRC-IPTS.

are SMEs.¹⁴ The source of these technologies can be external. Innovations are frequently co-developed with universities. Large companies orchestrate these ecosystems and leverage their size to attract smaller companies. For example, manufacturing companies such as Philips and ST Microelectronics (Layer 1) have created networks of collaboration with smaller companies and start-ups to implement Open Innovation models.¹⁵ Large companies can use their financial clout to attract smaller and more innovative companies.¹⁶ SMEs and start-ups must rely on these strategic alliances if they want to grow and yet remain independent.¹⁷

All of the mentioned elements of the digital innovation ecosystem have consequences for innovation performance and dynamics, industry performance, competition, and overall welfare.¹⁸ Additionally, the cornerstones of the digital technologies must be coupled with the resulting features and existing trends in order to draw conclusions about the implications for innovation and policy.

14 A. Pesole, D. Nepelski, op. cit.

15 A. Di Minin, C. Marco, C. Marullo, A. Piccaluga, E. Casprini, M. Mahdad, A. Paraboschi: Case Studies on Open Innovation in ICT, in: G. Gabison, A. Pesole (eds.), JRC Scientific and Policy Reports, EUR 27911 EN, 2016; and M. Fransman, op. cit.

16 J.-P. Simon, op. cit.

17 A. Di Minin et al., op. cit.

18 A. Renda: Selecting and Designing European ICT Innovation Policies, in: F. Biagi, M. Bogdanowicz, P. Desruelle, N. Thumm (eds.), JRC Scientific and Policy Reports, EUR 28205 EN, Luxembourg 2016, Joint Research Centre.

Financing

Access to finance is considered one of the major hinderances to innovation commercialisation and exploitation in Europe.¹⁹ To address the issue of the “Valley of Death”, i.e. a shortfall of resources for commercialising new technologies and products, there are a number of private and public sources of funding for innovation.²⁰

During the start-up phase, companies usually try to raise funds for innovation and technology commercialisation through private means: ‘friends, family and fools’.²¹ However, most of the fast growing companies, i.e. scale-ups, depend on Venture Capital (VC) funds to grow.²²

In a global comparison of VC investments, Europe comes in third. However, in 2017, it received only 10% of global VC investments (Figure 3). VC-backed companies account for approximately 0.05% of all newly created companies or 0.005% of all active companies in Europe.²³ VC investments also exhibit strong geographical concentration patterns. In 2014, the top 20 European cities by amount of VC funding accounted for 69% of venture capital invested in Europe.²⁴ Location matters – for financing, for volume and for continuity. Start-ups based in the major European start-up hotspots have better chances of receiving (more) venture capital funding than start-ups in other locations.

Only a small fraction of companies are eligible for VC investments. This is related to several factors. For example, VC investing strategies limit the potential pool of firms that can access this source of funding. In recent years, VC funds have focused on mature companies with established technologies and market presence.²⁵ As mentioned above, companies located outside of the VC investment hotspots have lower chances of receiving VC backing. Consequently, a large share of companies, even extremely innovative ones, need to seek

19 G. De Prato, D. Nepelski, G. Piroli: Innovation Radar: Identifying Innovations and Innovators with High Potential in ICT FP7, CIP & H2020 Projects, JRC Scientific and Policy Report, EUR 27314, Luxembourg 2015, Joint Research Centre.

20 R. Gampfer, J. Mitchell, B. Stamenov, J. Zifciakova, K. Jonkers: Improving access to finance: which schemes best support the emergence of high-growth innovative enterprises? A mapping, analysis and assessment of finance instruments in selected EU Member States, JRC Science for Policy Report, EUR 28084 EN, Seville 2016, Joint Research Centre.

21 A. Puissochet: Models of ICT Innovation. Ten cases of successful innovative ICT SMEs in France, JRC Science for Policy Report, EUR 27233 EN, Seville 2015, Joint Research Centre.

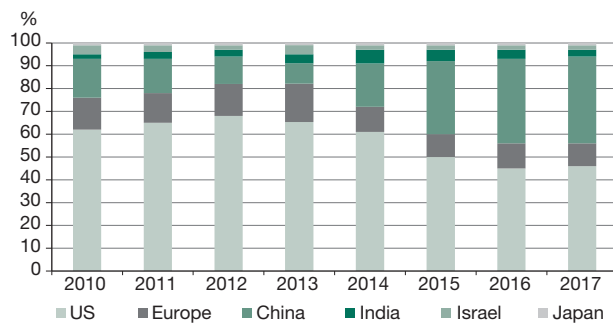
22 J.-P. Simon, op. cit.

23 Own calculations based on VentureSource by Dow Jones and Eurostat data.

24 D. Nepelski, G. Piroli, G. De Prato: European start-up hotspots: An analysis based on VC-backed companies, JRC Scientific and Policy Reports, EUR 28021 EN, 2016, Joint Research Centre.

25 Ibid.

Figure 3
Share of amount invested by VC funds by world regions, 2010-2017



Note: The graph presents the shares of the major world regions in the amount raised by VC-backed companies in billion US dollars between 2010 and 2017.

Source: VentureSource by Dow Jones.

out other funding sources to finance their innovative activity. Alternatively, companies may turn to the public sector as a source of innovation financing.

In Europe, there is direct and indirect support for innovative firms and start-ups. For example, the European Framework Programme for R&D complements private and public R&D expenditure. The 7th Framework Programme had a budget of over 50 billion euro, of which nine billion euro was allocated to ICT.²⁶ Its successor, Horizon 2020, allocated nearly 80 billion euro to support research and innovation activities.²⁷ Horizon 2020 introduced the SME instrument (SMEI). The SMEI is a novel financing mechanism targeting innovative and high-growth potential firms.²⁸ The open and disruptive innovation scheme (ODI) focuses on companies proposing disruptive ICT concepts, products and services applying new sets of rules, values and models which ultimately create new markets or disrupt existing markets.²⁹

Later stages of technology development are also supported by public instruments. For example, the European Investment Fund (EIF) is backed by the EU and other public institutions as well as private ones. It provides indirect financial investment to innovative companies mainly through loan securitisation.³⁰

In conclusion, private and public sources of innovation funding need to co-exist. The latter is said to have an important

26 More information available at https://ec.europa.eu/research/fp7/index_en.sfm.

27 European Commission: Participant Portal. H2020 Online Manual, 2018.

28 EASME: Horizon 2020's SME Instrument, 2017.

29 European Commission: Horizon 2020. Work Programme 2016 - 2017. Innovation in SMEs, 2017.

30 G. Gabison: Venture Capital Principles in the European ICT Ecosystem, JRC Scientific and Policy Reports, EUR 27651 EN, Seville 2015, Joint Research Centre.

role in supporting early-stage innovative activity by small firms given the tenuous nature of the venture capital cycle at this preliminary, yet critical, stage of firm activity.³¹ Maintaining the continuity and interplay between various sources of innovation financing appears as crucial to bridge the Valley of Death.

Intellectual property protection

The ICT industry uses patents, trademarks and copyright extensively.³² IPRs provide the edge to companies that are competing in the ICT sector. They allow innovators to transfer knowledge outside of the company and still make a profit.³³ IPR helps new entrants to access funding.³⁴ Start-ups use it as a way of signalling their innovative and growth potential to investors.

Because of short life-cycles of ICT products, they face fierce competition. A variety of IPR models and practices coexist and add to the complexity of the innovation system. This coexistence has probably become most evident in the software industry. Software can be copyrighted and in some cases machine-implemented software can also be patented. Software companies further rely on contract law and trademarks to safeguard their IP.

However, IPR are not necessarily seen as very important drivers of competitive advantage.³⁵ Secrecy and lead-time advantage are used more often than formal IPR protection mechanisms. This may be due to the fact that the complex interaction between cumulateness and innovation incentives makes the role of IPR in digital innovation unclear.³⁶ For instance, broader patent scope may provide incentives to early inventors while dissuading follow-on innovators from investing in R&D. Likewise, copyright protection can increase the cost of developing derivative works. This may reduce the incentives for follow-on creators to build upon existing works as they must obtain permission from copyright holders.

The intensive use of IPR in the digital domain has led to the emergence of patent thickets.³⁷ A patent thicket is “[...] a dense web of overlapping IPR that a company must hack its

31 P. Gompers, J. Lerner: The Venture Capital Revolution, in: Journal of Economic Perspectives, Vol. 15, No. 2, 2001, pp. 145-168; and J. Lerner: The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program, in: The Journal of Business, Vol. 72, No. 3, 1999, pp. 285-318.

32 S. Comino, F. Manenti: Intellectual Property and Innovation in Information Communication Technology, JRC Science and Policy Report, EUR 27549 EN, Luxembourg 2015, Joint Research Centre.

33 A. Di Minin et al., op. cit.

34 G. Gabison: Understanding Crowdfunding and its Regulations, JRC Science and Policy Report, EUR 26992 EN, Seville 2015, Joint Research Centre.

35 F. Biagi et al., op. cit.

36 S. Comino, F. Manenti, op. cit.

37 Ibid.

way through in order to actually commercialize new technology. With cumulative innovation and multiple blocking patents, stronger patent rights can have the perverse effect of stifling, not encouraging, innovation [...].³⁸ Patent thickets are mainly an ICT sector phenomenon concentrated in several areas within electrical engineering. Even though the practical consequences of the pervasiveness of thickets are not easy to figure out, empirical contributions suggest that SMEs in general and start-ups in need of in-license technologies are most likely to be harmed. In addition, thickets make searching for prior art difficult, thus potentially reducing the quality of patents granted by patent and trademark offices.

A market response to the slowdown of the innovation process due to the intensive use of IPR is an increase in open source practices both in software and hardware. At the beginning of the 90's, nobody believed that Fortune 500 companies would trust software that couldn't be "owned".³⁹ But the form of production of open source software (OSS) has become crucial to the emergence of the digital economy. Linux enabled Google to build cheap servers. Programming languages like Java script, Perl and Ruby have become the language of Web 2.0 applications and the free web-server software Apache powers nearly half of all websites in the world. Open source software created the foundation of the Internet age, making everyone better-off.⁴⁰ Today, the example of Arduino, a global ecosystem of hardware innovation, shows how open source hardware (OSH) communities of users are taking an active role in the development of advanced hardware technologies and products.⁴¹

In summary, the complexity of digital innovation and the IPR practices in this domain require better understanding of how to best adapt IPR protection to the needs of the digital world. Simply retrofitting old regulations to the new realities of the digital world may not be an appropriate solution.

Technology standardisation

The success of digital innovations often relies on technological interoperability facilitating the increase of network effects from a greater number of products and services. Standard setting organisations (SSOs) have attempted to create private poli-

cies to garner networking externalities using fair, reasonable and non-discriminatory licensing terms (FRAND) and licensing commitments.⁴² SSO participants must agree to FRAND licensing terms before being able to contribute.

In general, the FRAND model seems to work. The 3rd Generation Partnership Project (3GPP), i.e. the standards-setting body behind the 3G and 4G standards, is a collaboration between seven global telecommunication SSOs.⁴³ Membership is open and voluntary, and currently over 300 firms from over 43 countries are listed as members. Because some aspects of 3GPP systems are covered by essential IPR, the 3GPP IPR Policy generally requires IPR holders to make licences available to all third parties, whether or not they are 3GPP Individual Members under FRAND terms.⁴⁴

Although ICT standards are supposed to increase market development and increase product variety, they may also have a negative impact on the innovation engagement of firms.⁴⁵ One of the main critiques of the standardisation process and policy support by means of FRAND is that SMEs are often excluded from the standardisation process due to a lack of resources, expertise and absorptive capacity.⁴⁶ Another challenge of the standardisation process that may act as a bottleneck to innovation efforts is the lack of homogeneity in the interpretation of FRAND terms that can differ across jurisdictions. A final hurdle is the requirement of a long-term strategy and investment, and perhaps anticipation of future regulations. The question remains whether the coordination and economies of scale benefits of utilizing a single standard outweigh the innovation-hampering effect of requiring all players to conform to the standard.

Policy options to facilitate digital innovation in Europe

The economic and innovative potential of digital technologies lies in their capacity to modernise the economy rather than in the contribution of the ICT sector to the economy. Digital in-

38 C. Shapiro: Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting, in: A. Jaffe, J. Lerner, S. Stern (eds.): Innovation Policy and the Economy, Vol. 1, National Bureau of Economic Research, Massachusetts 2001.

39 C. Thompson: Build It. Share It. Profit. Can Open Source Hardware Work?, Wired, 2008.

40 C. Pentheroudakis: Innovation in the European Digital Single Market. The Role of Patents, JRC Science and Policy Report, EUR 27344 EN, Seville 2015, Joint Research Centre.

41 D. Cuartielles, D. Nepelski, V. Van Roy: Arduino – a global network for digital innovation, in: Open Innovation 2.0 Yearbook – Edition 2018, forthcoming; and A. Pesole, D. Nepelski, op. cit.

42 Y. Ménière: Fair, Reasonable and Non-Discriminatory (FRAND) Licensing Terms, JRC Science and Policy Report, EUR 27333 EN, Seville 2015, Joint Research Centre.

43 K. Gupta: Technology Standards and Competition in the Mobile Wireless Industry, in: George Mason Law Review, Vol. 22, No. 4, pp. 65-896.

44 For details, see <http://www.3gpp.org/>.

45 K. Blind: An economic analysis of standards competition: The example of the ISO ODF and OOXML standards, in: Telecommunications Policy, Vol. 35, No. 4, 2011, pp. 373-381; and K. Blind: The impact of standardisation and standards on innovation, in: J. Edler, P. Cunningham, A. Gök (eds.): Handbook of Innovation Policy Impact, 2016, Edward Elgar Publishing, pp. 423.

46 H. de Vries, K. Blind, A. Mangelsdorf, H. Verheul, J. van der Zwan: SME access to European standardization: Enabling small and medium-sized enterprises to achieve greater benefit from standards and from involvement in standardization, Research report, Rotterdam School of Management, Erasmus University, 2009.

novation requires a wide range of skills and capabilities in non-ICT sectors. Commercialising digital innovations on a global scale requires technical, managerial as well as financial skills. There is a disruptive character challenging the status-quo of digital innovations that requires entrepreneurial culture, the acceptance of failure, and an innovation-friendly regulatory environment to counter it. Policy actions should address and facilitate capacity building in these fields and in all economic sectors.

Disruptive innovations offer great economic potential, which often comes at a cost. These may include relocation of economic activity, changes in the composition of skills required, rebalancing the allocation of benefits and creating inequalities. Preventing digital disruption in the form of regulation or social resistance is often a response to such transformations. Status quo protection mechanisms are likely to be a short-term strategy. At the same time it is necessary to look beyond the economic impact of digital innovation: Policymakers should consider its impact on other fields, including changes in employment structure and income distribution.

Data, information and knowledge exhibit increasing returns to scale and scope. Those returns and network effects imply that the more people have access to it, use and modify it, the more value it has.⁴⁷ This challenges our thinking about the economy and the rules and organisations of economic activities. Grounded in a world of scarcity, our mental, social and economic models have difficulties in accommodating the concept of increasing returns into our life, businesses, social and economic rules and institutions.⁴⁸ As we enter into an era in which universal access and processing of the world's information is technologically possible, we still lack the legal infrastructure that will make such access and processing viable.⁴⁹

As shown before, the digital innovation ecosystem consists of various layers. The physical layer relies on large capital and R&D expenditures. Upper layers include software producers and platforms whose success depends on network effects and the size of the consumer base. Policies should address the characteristics and needs of the actors in each layer. In the physical layer, policy should promote public and private R&D and prioritize the deployment of digital infrastructures. In other layers of the ecosystem, agile instruments and demand-side innovation policy are likely to be particularly effective. Regulation plays an important role when digital platforms bring wide-ranging disruptions for businesses.

Collaboration between various players is a defining characteristic of digital innovation. Universities conduct research and produce knowledge. Many new products and services are delivered to the market through SMEs and start-ups. Large companies create ecosystems that leverage their size to attract smaller companies. The resulting open innovation models dominate the digital innovation ecosystem. To facilitate collaboration, knowledge flow and sharing needs to become a central focus of public policy. Building and linking European ecosystems would facilitate knowledge dissemination and absorption.

Digital technologies allow firms to reach customers irrespective of their location at the same cost. This creates opportunities to increase the return on innovation efforts by operating beyond physical borders as well as to build a global market presence. Substantial financing of marketing and business development – rather than R&D activities – is required to scale up a business. Public support focuses on supporting R&D activities while companies struggle to secure funding to translate technologies into commercially viable and potentially global businesses. To benefit from research results, firms depend on maintaining funding along the innovation value chain including the scaling-up phase.

Digital innovations often rely on the use of IPR. They provide incentives to pursue capital intensive innovation and entrepreneurial projects. Start-ups seeking funding use IPR as a signal about their growth potential. The intensity of IPR use also creates problems. Patent thickets, for example, make it difficult for firms in general and start-ups in particular to in-license technologies. That is why digital commons (like OSS) are on the rise. User innovations do not use intellectual property rights to extract value from their innovations but rather openly diffuse them.⁵⁰ Open Source deserves support: It is an alternative to IPR and a solution to problems related to the excessive use of IPR.

The success of many digital innovations relies on technological interoperability. It is ensured through the process of standard setting. To guarantee technological interoperability and create technology-related network effects, coordination between various players is needed, e.g. to set technological standards. Emphasis needs to be put on including SMEs and start-ups in the standardization process. It is crucial that the costs and benefits of standardisation are considered.

47 B. Arthur, *op. cit.*

48 J.K. Galbraith: *The Affluent Society*, Boston 1958, Mariner Books.

49 H. Varian: *Universal Access to Information*, in: *Communications of the ACM*, Vol. 48, No. 10, 2005, pp. 65-66.

50 E. von Hippel, J. de Jong, S. Flowers: *Comparing Business and Household Sector Innovation in Consumer Products: Findings from a Representative Study in the United Kingdom*, in: *Management Science*, Vol. 58, No. 9, 2012, pp. 1669-1681.