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7 ways to boost digital innovation and entrepreneurship in Europe

Key messages from the ***Eur****opean* ***i****nnovation* ***p****ol****i****cies for the* ***di****gital* ***s****hift project*

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Title: 7 ways to boost digital innovation and entrepreneurship in Europe. Key messages from the **Eur**opean **i**nnovation **p**ol**i**cies for the **di**gital **s**hift project

Abstract
This report attempts to summarise findings and conclusions of over 30 studies published within the EURIPIDIS project (European Innovation Policies for the Digital Shift). The objective of EURIPIDIS was to better understand how digital innovation and entrepreneurship work; to assess the EU's digital innovation and entrepreneurship performance; and to suggest how policy makers could make digital innovation and entrepreneurship in the EU work better. Because digital technologies facilitate the modernization of firms and economies, digital innovation and entrepreneurship requires a comprehensive policy response. The current report focuses on 7 issues. (1) Digital innovation and entrepreneurship require skills and capabilities ranging from technical, managerial and financial; entrepreneurial culture; failure acceptance; large funding and innovation-friendly regulatory environment. Capacity building and specific policies are needed in all those fields. (2) Resisting digital disruption and protecting the status quo is likely to be a short-term strategy. Negative social and economic effects need to be mitigated. (3) The ecosystem of digital innovation and entrepreneurship consists of a wide range of different players. Policy responses need to address this heterogeneity. (4) Digital innovation and entrepreneurship takes place through collaborative interactions between various players. To facilitate collaboration, knowledge flow and spillovers need to become a more central focus of public policies. (5) In addition to increasing funding for innovation, closer attention needs to be paid to the availability of funding for scaling-up of digital enterprises. (6) To guarantee technological interoperability and create technology-related network effects, coordination between various players to, for example, set technological standards is needed. (7) Technological complexity combined with the cumulativeness of digital innovation requires a balance between two conflicting goals: the provision of incentives to create new products and the stimulation of knowledge dissemination.

Contents

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Preface

This report was prepared in the context of the three - year research project on European Innovation Policies for the Digital Shift (EURIPIDIS), jointly launched in 2013 by JRC and DG CONNECT of the European Commission. EURIPIDIS aims to improve understanding of innovation in the ICT sector and of ICT-enabled innovation in the rest of the economy.

The project's objective is to provide evidence-based support to the policies, instruments and measurement needs of DG CONNECT for enhancing ICT Innovation in Europe, in the context of the Digital Single Market for Europe and of the ICT priority of Horizon 2020. It focuses on the improvement of the transfer of best research ideas to the market.

EURIPIDIS aims:

- to better understand how ICT innovation works, at the level of actors such as firms, and also of the ICT "innovation system" in the EU;
- to assess the EU's current ICT innovation performance, by attempting to measure ICT innovation in Europe and by measuring the impact of existing policies and instruments (such as FP7 and Horizon 2020); and
- to explore and suggest how policy makers could make ICT innovation in the EU work better.

This report attempts to provide a summary of the key messages and policy implications reported by the studies performed within the EURIPIDIS project.

List of EURIPIDIS studies[1]

ICT Innovation Policies

- Selecting and Designing European ICT Innovation Policies. Andrea Renda. Editors: Federico Biagi, Marc Bogdanowicz, Paul Desruelle, Nikolaus Thumm, 2016

Models of ICT Innovation & ICT Innovation Ecosystems

- Models of ICT Innovation: Evidence from the Community Innovation Survey. Federico Biagi, Annarosa Pesole, Juraj Stancik, 2016
- Systems and Modes of ICT Innovation. René Wintjes. Editor: Federico Biagi, 2016
- Case Studies on Open Innovation in ICT. Alberto Di Minin, et al. Eds: G. Gabison, A. Pesole 2016
- How to catch a Unicorn: An exploration of the universe of tech companies with high market capitalisation. Jean Paul Simon. Editor: Marc Bogdanowicz, 2016
- How to catch a Unicorn: Case Studies. Jean Paul Simon, Marc Bogdanowicz, 2016
- Models of ICT Innovation. Ten cases of successful innovative ICT SMEs in France. Alain Puissochet. Editor: Marc Bogdanowicz, 2015
- Models of ICT Innovation: A focus on the cinema sector. Pierre-Jean Benghozi, Elisa Salvador, Jean Paul Simon. Editor: Marc Bogdanowicz, 2015
- Models of Innovation in Global ICT Firms: The Emerging Global Innovation Ecosystems. Martin Fransman. Editor: Marc Bogdanowicz, 2014
- An Overview of Models of Distributed Innovation. Open Innovation, User Innovation and Social Innovation. Garry Gabison and Annarosa Pesole, 2014

ICT Innovation Barriers and Drivers

- Digital entrepreneurship barriers and drivers - the need for a specific measurement framework. Marc Bogdanowicz, 2015
- Assessment of framework conditions for the creation and growth of firms in Europe, Vincent Van Roy, Daniel Nepelski, 2016.
- Determinants of high-tech entrepreneurship in Europe, Vincent Van Roy, Daniel Nepelski, 2017.
- Venture Capital Principles in the European ICT Ecosystem. How can they help ICT innovation? Garry Gabison, 2015
- Understanding Crowdfunding and Its Regulations. Garry Gabison. 2015
- Incentivising innovation and adoption of ICT: ICT innovation voucher programmes. Paola Valbonesi and Federico Biagi.
- Patent Assertion Entities in Europe. Their impact on innovation and knowledge transfer in ICT markets. Europe Economics, Editors: N. Thumm, G. Gabison, 2016
- Intellectual Property and Innovation in Information Communication Technology (ICT). Stefano Comino and Fabio Maria Manenti. Editor: Nikolaus Thumm, 2015

[1] All reports can be downloaded from: https://ec.europa.eu/jrc/en/euripidis/publications

- Innovation in the European Digital Single Market. The Role of Patents. Chryssoula Pentheroudakis. Editor: Nikolaus Thumm, 2015
- Fair, Reasonable and Non-Discriminatory Licensing Terms. Y. Ménière. Editor: N. Thumm, 2015
- Licensing terms of Standard Essential Patents: A comprehensive Analysis of Cases, Chryssoula Pentheroudakis, Justus Baron. Editor: Nikolaus Thumm, 2017
- Incentivising innovation and adoption of ICT: ICT innovation voucher programmes. Paola Valbonesi and Federico Biagi, 2016

Measuring ICT Innovation

- Universities and collaborative innovation in EC-funded research projects: An analysis based on Innovation Radar data, Annarosa Pesole, Daniel Nepelski, 2016
- European startup hotspots: An analysis based on VC-backed companies, Daniel Nepelski, Giuseppe Piroli, Giudita de Prato, 2016
- Measures of ICT Contribution to Innovation Output: An Update of the ICT Innovation Output Indicator. Annarosa Pesole, 2016
- Innovation Radar: Identifying Innovations and Innovators with High Potential in ICT FP7 & H2020 Projects, Giuditta De Prato, Daniel Nepelski, Giuseppe Piroli. Editor: Eoghan O'Neill, 2015
- Birth, Growth, Survival, and Death of ICT Companies, Garry Gabison. 2015
- How much does ICT contribute to innovation output? An analysis of the ICT component in the innovation output indicator. Annarosa Pesole. 2015
- Counterfactual Impact Evaluation of Public Funding of Innovation, Investment and R&D. Daniele Bondonio, Federico Biagi and Juraj Stancik, 2015
- INNOREG: A Comprehensive Dataset on Government Policies Affecting Innovation. Giorgia Casalone and Federico Biagi, 2015
- Empirical Studies on the Impacts of ICT Usage in Europe. Martin Falk and Federico Biagi, 2015

Executive Summary

Launched in 2013 as a joint initiative of DG JRC and DG CONNECT of the European Commission, the EURIPIDIS project (European Innovation Policies for the Digital Shift) analysed innovation and entrepreneurship in the information and communication technologies (ICT) sector and digital innovation in the rest of the economy. This report attempts to summarise findings and conclusions of over 30 studies produced by EURIPIDIS.

1. Digital innovation ≠ innovation

ICT play an important role not only as a producing economic sector, but also as enabling technologies which facilitate the modernization of firms and economic performance across all economic sectors. Digitally-enabled firms are the main vehicles through which digital technology is converted into economic and social benefits. These firms are also more likely to become high-growth companies and to survive longer than traditional non-digital ones. Digital firms are also more likely than others to pursue opportunities associated with radical innovations.

2. Digital innovation disrupts the economy and society

Radical innovations transform the entire economy and society. They offer tremendous potential, but with these opportunities create new societal challenges. Disruptions triggered by digital innovations generate also negative impacts, e.g. re-location of economic activity and jobs transformation.

3. The heterogeneity of the digital innovation ecosystem

The digital innovation ecosystem consists of various layers. The physical one includes network operators and hardware manufacturers. They rely on high capital and R&D expenditures. Higher layers include software producers and platforms whose success depends on network effects and consumer base size. The diversity of digital innovations is rooted in the heterogeneity of the digital innovation ecosystem and its actors.

4. Mutual interdependencies

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 in the digital innovation ecosystem.

5. The global reach of digital innovation

Digital technologies allow firms to reach out beyond physical borders at virtually no cost. This creates opportunities to increase the return on their innovation efforts. However, building global market presence requires substantial funding for the scale-up phase. So far, however, few European digital firms succeed globally.

6. Technological interoperability

The success of many digital innovations often relies on technological interoperability and network effects. Technological interoperability is ensured through the process of standard setting. Important roles in this process play also technology markets, i.e. second-hand markets for ideas and technologies.

7. Capital intensity and technological cumulativeness

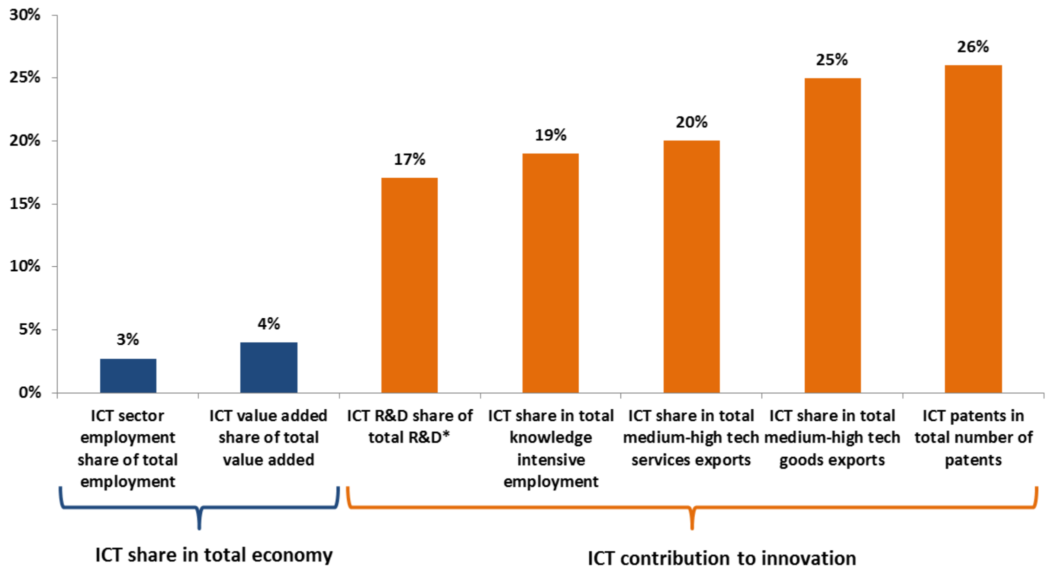
The ICT industry uses intellectual property rights (IPR) extensively. They provide incentives to pursue capital intensive innovation and entrepreneurial projects. Start-ups seeking funding, use IPR as a signal about their innovative and growth potential. However, fragmentation of IPR and the emergence of patent thickets make it difficult for firms in general and start-ups in particular to in-license technologies.

1 Introduction

A key enabler of a modern economy is the possibility to create, exploit and commercialise new technologies such as information and communication technologies (ICT) and digital technologies. ICT plays an important role not only as a producing economic sector, but also as enabling technology that facilitates the modernization of firms and improve economic performance in all sectors of the economy. ICT diffusion, i.e. digitalisation of the economy, increases the share of knowledge-intensive activities, innovativeness and the overall competitiveness of the economy (Falk & Biagi, 2015). Digital technologies also play a special role, due to their distributive nature and pervasiveness in society, the speed with which they change, their ability to enhance productivity and their capacity to offer advanced solutions for societal problems. The disruptive implications of digital innovation go beyond industries, economies, and traditional value chains and business models. Therefore, it is relevant - especially where digital technologies are concerned – to extend the innovation systems concept to the societal level (Wintjes, 2016).

When we try to assess the contribution of digital activity to innovation in Europe, we find that digitally-enabled innovation represents a much larger share of total innovative output than the share of the ICT sector in the economy (Pesole, 2015). For example, while the European ICT sector accounts for only 3% of total employment in the economy, ICT jobs in all sectors of the economy represent nearly 20% of knowledge intensive workers (see Figure 1). Digitally-related innovation shares in various innovation indicators are equally large, ranging from 17% in ICT R&D expenditures, to 25% in high-tech goods exports, to 26% in number of patents. This suggests that the ICT sector and digital technologies encourage innovation across the entire economy.

Figure 1: ICT share in the total economy and its contribution to innovation, Europe, 2014



Source: (Pesole, 2015), EC JRC

Technology-based enterprises, including start-ups, are the main vehicles through which new knowledge from science and engineering is converted into economic benefits (Acs, Audretsch, & Strom, 2009; Acs, Braunerhjelm, Audretsch, & Carlsson, 2009). These companies are more likely than others to pursue opportunities associated with radical innovations that produce positive knowledge externalities and may have transformative consequences for the entire society (Baumol, Litan, & Schramm, 2007). This is particularly true for ICT sector companies and digitally-enabled companies in the rest of the economy. In Europe, the ICT sector is increasing its share in the European economy and there are considerable differences between digital start-ups and newly-created companies in other sectors (Gabison, 2015a). For example, an ICT company is more likely to become a high-growth company than a non-ICT one and a digital start-up is more likely to survive than a traditional one. This indicates that not all innovation and entrepreneurship activity contributes equally to value creation and prosperity.

Not only does digital innovation rely on knowledge-intensive activities but it is often the result of collaborative efforts within and also between organisations. Digital innovation involves a number of steps, from initial ideas, basic research, technology development, to commercialisation. Several actors are usually actively involved in various stages of this process (Biagi, Pesole, & Stancik, 2015). For example, on average, there are 1.9 innovators per innovation produced within EU-funded research ICT projects (Pesole & Nepelski, 2016). This implies that when analysing the process of digital innovation, one needs to adopt a system perspective rather than looking at individual firms and organizations.

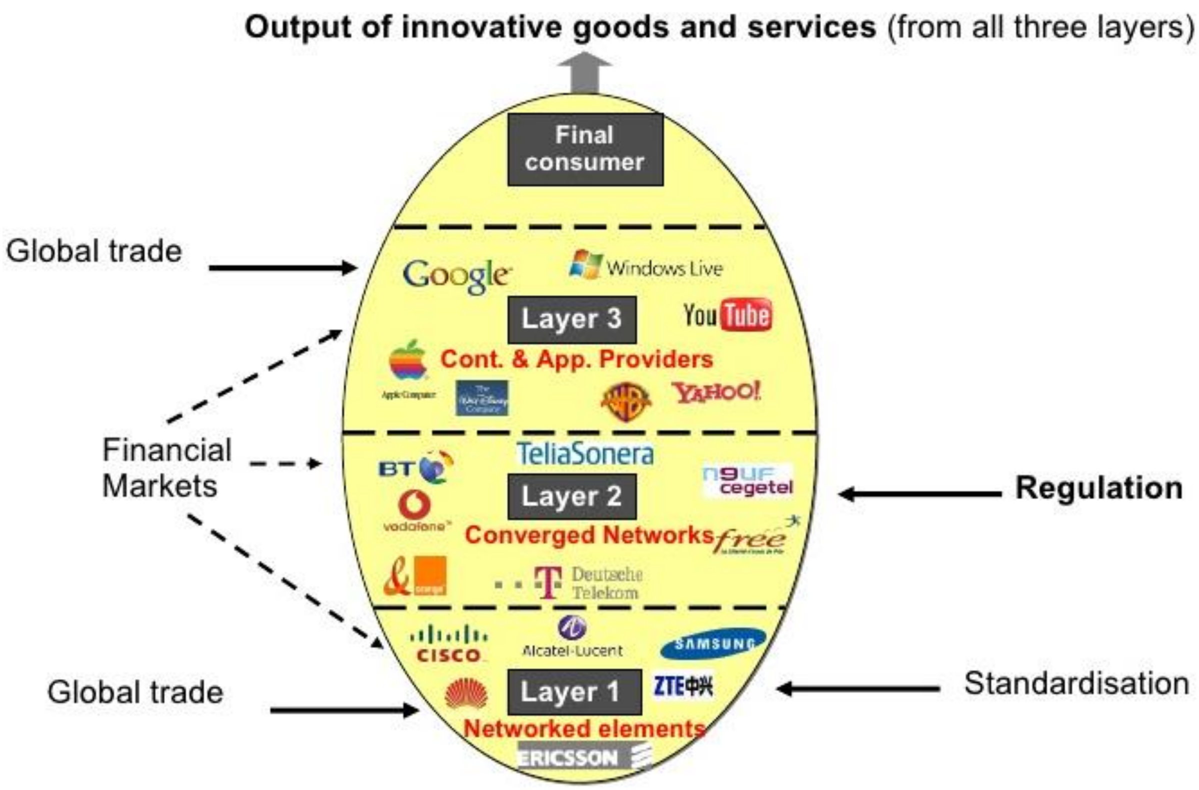
Taking into account the above-mentioned specificities of digital innovation and entrepreneurship, the current report summarises the main findings of the EURIPIDIS project, with a view to identifying relevant policy implications. The report is structured as follows: First, it reminds the reader of the main observations concerning the digital innovation ecosystem (Section 2). Then, it looks at the role of various framework conditions in the creation and growth of technology-based enterprises (Section 3). Considering that financing, IPR and technological interoperability are major factors that drive digital innovation, Section 4 reviews the key messages related to financing digital innovation and entrepreneurship in Europe, while Section 5 and 6 discuss the role of IPR and technology standardization. Finally, Section 7 presents 7 ways to boost digital innovation and entrepreneurship in Europe.

2 The digital innovation ecosystem

Digital innovation emerges out of the complex environment of the ICT economic sector and its interactions with the other economic sectors and final users, i.e. digital innovation ecosystem.

This "digital ecosystem" can be represented as a set of layers as shown in Figure 2 (Fransman, 2014). The pattern of innovation behaviour is different in each layer. In Layer 1, which includes equipment providers, the innovation process is often slower than in other layers because equipment providers need to cooperate to ensure interoperability. One way to ensure interoperability is through industry-wide standards development, which attempts to create network externalities (Ménière, 2015). 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. Some network operators have moved beyond innovation adoption to also become innovation incubators (Puissochet, 2015). Layer 3 builds on the infrastructure provided by Layers 1 and 2, and includes content providers. Here, the pace of innovation is rapid. This layer has seen the largest number of fast growing companies so far, which have also disrupted other traditional non-digital industries (Benghozi, Salvador, & Simon, 2015; Simon, 2016). All the layers are interdependent and innovations in one layer impact innovations in another layer. For example, the apps industry (Layer 3) has grown since the introduction of the iPhone (Layer 1) in 2007. The relationships between market participants appear to change more quickly in the "upper" layers of the ICT innovation ecosystem (e.g., the development of platforms) than in the "lower" layers (e.g., components) (Renda, 2016). Users represent a fourth layer that includes both final consumers and ICT-using companies from other sectors of the economy. This layer also contributes to innovation in the entire ecosystem.

Figure 2: A layered view of the digital innovation ecosystem



Source: (Fransman, 2014)

Different categories of actors in the digital ecosystem contribute to innovation according to their characteristics and capabilities, and often in collaboration. Digital innovation processes include a wide range of cooperation activities (Biagi et al., 2015; Pesole & Nepelski, 2016). Many highly innovative companies that deliver innovations are also SMEs. For example, in EC-funded ICT research projects, 44% of all organizations producing innovations with high potential are SMEs (Pesole & Nepelski, 2016). Hence, it can be assumed that SMEs are important vehicles for co-creating and commercialising innovative technologies. Universities, which are on the edge of the ICT ecosystem but often have strong links with it, are also prominent sources of new digital technologies and products. In EC-funded ICT research projects for example, 70% of innovations with high market maturity have been co-developed with universities. Here, collaboration between universities and SMEs seems to be particularly fruitful. Large companies create ecosystems that leverage their size to attract smaller companies. For example, manufacturing companies such as Philips and ST Microelectronics (Layer 1 of the ecosystem) have created networks of collaboration with smaller companies to implement Open Innovation models of innovation (Di Minin et al., 2016; Fransman, 2014). Large companies can use their financial clout to acquire smaller and more innovative companies (Simon, 2016). SMEs must rely on these strategic alliances if they want to grow and yet remain independent (Di Minin et al., 2016). In general, partnership with other companies and expanding to more markets are among the most frequent needs of organizations introducing digital innovations (De Prato, Nepelski, & Piroli, 2015).

Another important characteristic of digital innovation ecosystem is its global nature (Fransman, 2014). All highly innovative companies (must) reach out beyond their regional or national borders, and usually beyond their continent of origin, in order to access the knowledge they need to innovate. This is also how they access new markets to commercialise those innovations.

Digital technologies also have some underlying characteristics that influence the process and speed of digital innovation. These foundational elements are: strong computing power (constantly increasing, following Moore's law), modularity, the end-to-end architecture of the internet (i.e., the possibility, for every end user to engage in communication and exchange information with every other end user) and its neutrality, and the digital nature of information goods (Renda, 2016). These elements have determined the emergence of some of the features that are typically attributed to digital innovation:

- R&D intensity and innovation rates tend to be greater than in other sectors.
- Innovation is initially largely incremental, due to modular architectural design.
- Product life-cycles are becoming shorter due to the acceleration of technological change.
- Like in the case of telecom networks, the end-to-end architecture of the Internet and the digital nature of information goods have led to the emergence of network effects and large economies of scale in the ICT ecosystem. This, in turn, has led to the emergence of multi-sided platforms that are gradually changing the architecture of the network.

All the above elements have consequences for innovation performance and dynamics, industry performance, competition, and overall societal welfare. As analysed by Renda (2016), the foundational elements of the digital technologies must be coupled with their resulting features and existing trends in order to draw conclusions on the resulting impacts in terms of innovation and policy.

3 Framework conditions for digital entrepreneurship

Technology-based and innovation-intensive firms, e.g. ICT and ICT-enabled ones, are the main generators of economic growth. As such, they deserve more attention and constitute one of the main targets of public policies in developed economies (OECD, 2010). Given their peculiar characteristics, high-tech in general and digitally-enabled firms in particular may respond differently to the conditions of entrepreneurship ecosystems than firms in traditional and low-tech activity.

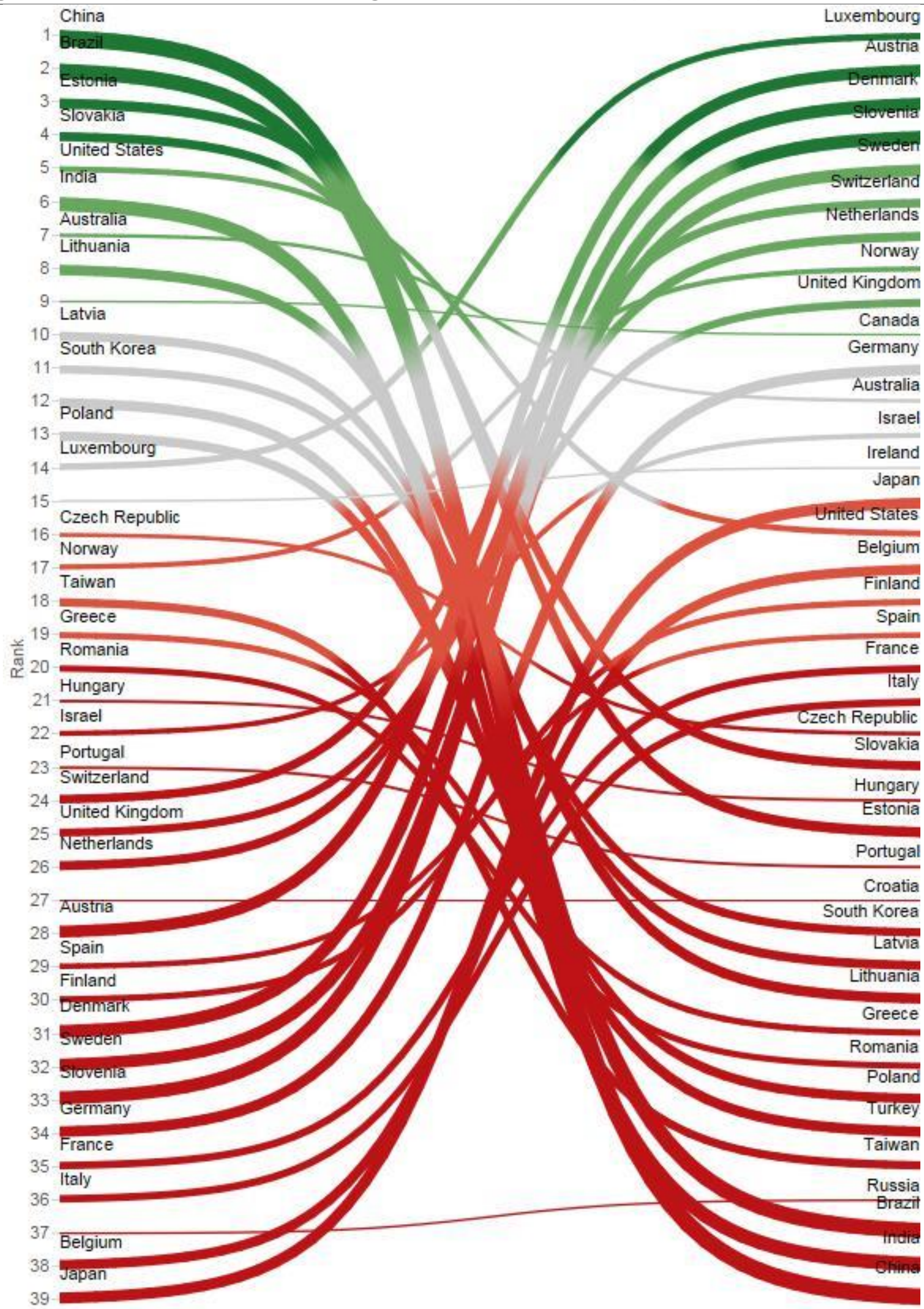
There are indeed considerable differences between overall entrepreneurial activity, which also includes, for example, opening a local shop, a bar, or a non-digital service company, and technology-enabled entrepreneurship. Countries differ widely when their overall level of entrepreneurship is compared to their level of high-tech entrepreneurship. Figure 3 shows that there is an almost inverse relationship between the levels of technology-based ventures and overall entrepreneurial activity. Countries which rank high for their rates of total entrepreneurship, e.g. China and India, rank very low for high-tech entrepreneurship. On the other hand, countries with relatively low levels of entrepreneurship have high rates of high-tech ventures in the total number of newly-created firms. Examples include Luxemburg, Austria and Denmark. This observation implies that general determinants and conditions for entrepreneurship do not necessarily affect all types of entrepreneurial activities in an economy equally.

Indeed, an analysis of framework conditions for the creation of high-tech firms reveals that technology-based ventures are driven and enabled by different factors from those that affect other types of start-ups (Van Roy & Nepelski, 2017). First of all, the existing technological base forms strong foundations for the emergence of new high-tech firms (Figure 4). Furthermore, access to finance is crucial for technology-based firms. Investment is required not only for R&D expenditures, but also for scaling-up enterprises - considerable amounts of capital may be needed to introduce and establish their products and services on the global market. Finally, IPR play a role in the development of digital technologies, their diffusion in the economy and commercial exploitation. However, their role for digital innovation is not clear-cut (Comino & Manenti, 2015) and, often, IPR are not seen as important drivers of competitive advantage (Biagi et al., 2015). Technological complexity combined with the cumulativeness of the innovation process lead to fragmentation of IPR and to the emergence of patent thickets. A patent thicket is "(…) *a dense web of overlapping IPR that a company must hack its 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* (…)" (Shapiro, 2001).

When analysing framework conditions for firm creation and growth in European countries, one can see considerable differences across Europe (see Figure 5). Scandinavian and Northern European countries have excellent framework conditions for firm growth (Van Roy & Nepelski, 2016). The top 3 countries are Finland, Sweden and the United Kingdom. The next group of countries with very good framework conditions includes the remaining Western European countries, Estonia, Malta and Cyprus.

European countries with excellent framework conditions for firm creation and growth have high levels of entrepreneurial culture, easy access to the appropriate financial instruments and outstanding access to human capital. These factors are conducive to the growth of firms (Van Roy & Nepelski, 2016). Another prerequisite for technology-based entrepreneurship is a strong digital infrastructure and broad market expansion possibilities through cross-border e-commerce and foreign direct investments.

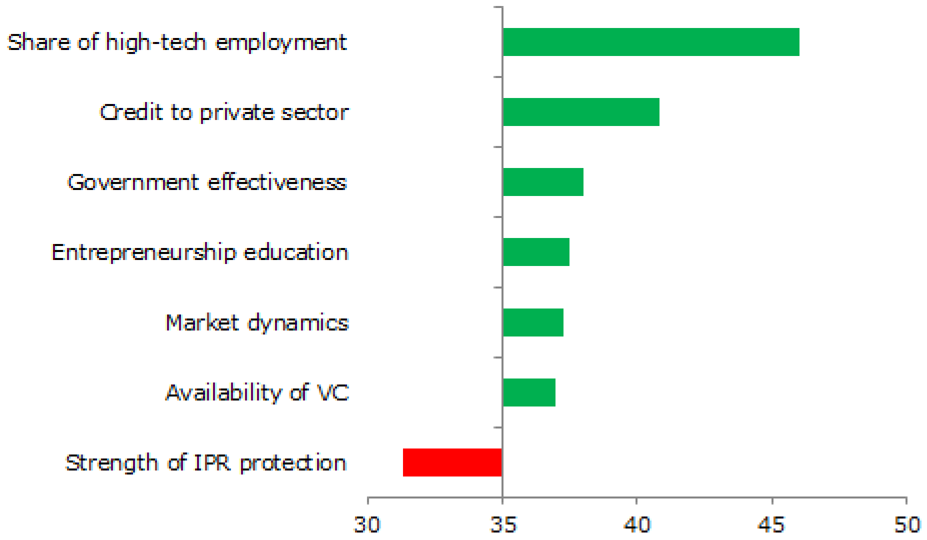
Figure 3: Comparison of total and high-tech entrepreneurship by country



Note: This figure represents a comparison of country rankings of the share of total entrepreneurship in the adult-age population and the share of high-tech entrepreneurship in total early-stage entrepreneurship. The share of total entrepreneurship and high-tech entrepreneurship are calculated as 3-year averages and averaged across the period 2002-2014.

Source: (Van Roy & Nepelski, 2017)

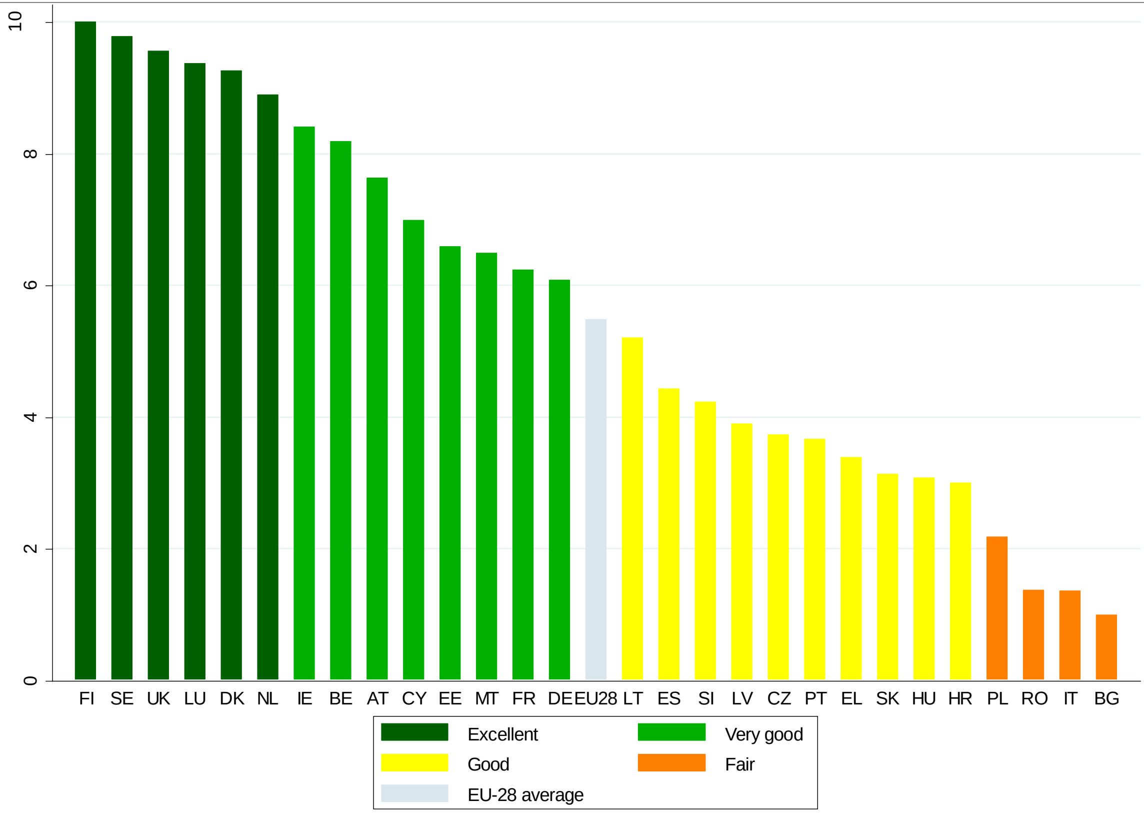
Figure 4: What impacts high-tech firm creation?



Note: This figure presents the effects on predicted shares of high-tech entrepreneurial activity due to changes in the value of determinants of entrepreneurship. Results are based on a random effect panel estimation conducted on an unbalanced panel of EU-28 countries (except Malta, Bulgaria and Cyprus) in the period 2007-2014 (total of 125 observations).

Source: (Van Roy & Nepelski, 2017)

Figure 5: Framework conditions for firm growth in European countries



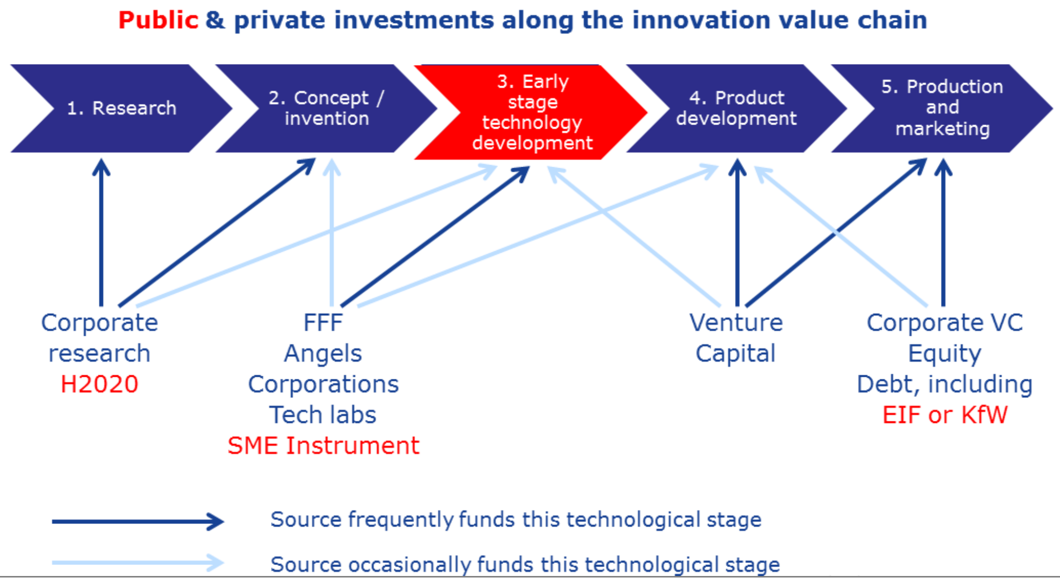
Note: The figure presents the ranking of EU Member States by their score on Scale-up index measuring framework conditions for firm growth at country level. Country groups are identified based on their scores: excellent (above 9), very good (above EU average but below 9), good (below EU average but above 3), fair (below 3).

Source: (Van Roy & Nepelski, 2016), EC JRC

4 Financing digital innovation and entrepreneurship

Access to finance is considered as the major external bottleneck to innovation commercialisation and exploitation in Europe (De Prato et al., 2015). This problem is referred to as the "Valley of Death". This term reinforces the "capital gap" perspective on early stage innovation: champions of early stage projects must overcome a shortfall of resources on the way to successfully commercialising new technologies and products (see Figure 6).

Figure 6: Stages and sources of financing of the innovation value chain



Based on: (Auerswald & Branscomb, 2003)

In Europe, a number of public sources of funding for research, innovation and entrepreneurial activities complement private money at various stages of technology development and commercialisation. For example, the EU financial instruments range from financing the initial stages of the research projects, e.g. framework programme, to the last stages of innovation commercialisation, which are backed by loans or loan securitization, e.g. the European Investment Fund (EIF)-secured loans. Also at national level, there are a number of financial instruments supporting innovative activities and firm growth (Gampfert, Mitchell, Stamenov, Zifciakova, & Jonkers, 2016).

Regarding public sources of funding for innovation and technology commercialisation, there are direct and indirect means of supporting firms and start-ups. For example, the European Framework Programme for R&D complements private and public, i.e. at national level, R&D expenditures in Europe. The 7th Framework Programme has a budget of over €50 billion, of which €9 billion was allocated to ICT (EC, 2007).[2] Generic support to firm-level investment projects of the EC funding has a positive impact on employment and value added (Bondonio, Biagi, & Stancik, 2016).

In addition to financing science and technology development, one of the main objectives of the Framework Programme is to foster international collaboration among research organizations and private firms (Nepelski & Piroli, 2016). For example, the Cooperation Programme was the core of the 7th Framework Programme and represented two thirds of its overall budget. By fostering collaborative research across Europe and other partner countries, this FP increased the capacity and connectivity of the digital innovation ecosystem. Moreover, the objective of the 7th Framework Programme was to shift from sponsoring basic research to becoming a main factor behind economic and social transformation. This transformation is made possible by scientific results being applied to solving known problems and to increasing the commercialization of technology (De Prato

[2] In comparison, the ICT sector's annual R&D expenditures in the EU was €30 billion in 2011 (JRC, 2014).

et al., 2015; Leyden & Link, 2015; Mazzucato, 2013). Public sector entrepreneurship triggers the transformation primarily by increasing the effectiveness of knowledge networks; that is, by increasing the heterogeneity of experiential ties among economic units and the ability of those same economic units to exploit this diversity (Audretsch & Link, 2016).

Mainly through loan securitization, the EIF provides indirect financial investment to innovative companies (Gabison, 2015c). The EIF is funded by the EU and public and private institutions and aims to encourage cross-border investment.

Prizes, subsidies, and vouchers are other forms of direct investments by public bodies to stimulate innovative activity. These have been shown to help R&D and innovation (Biagi et al., 2015). Though their designs vary from programme to programme, their main characteristics are the delivery process, budget, timing, eligibility, and selection procedure. The effectiveness of ICT innovation voucher programmes may depend on the granting process (Valbonesi, 2016).

Concerning private sources of funding for innovation and technology commercialisation, during the start-up phase, i.e. when a technology is developed and new products are introduced onto the market, companies usually try to raise funds through private means: ‘friends, family and fools’ (Puissochet, 2015). However, most of the fast growing companies, i.e. scale-ups, depend on venture capital funds to grow (Simon, 2016).

Venture capital funding is a Europe weak point. Although in total amount of VC, Europe comes second behind the US, it receives only 15% of global venture capital investments (Figure 7). Nearly one quarter of all European venture capital-backed companies are based in the UK (Nepelski, Piroli, & De Prato, 2016). This strong concentration pattern continues at the country level. In 2014, the top 20 European cities by amount of venture capital funding accounted for 69% of venture capital invested in Europe. One of the reasons behind the strong concentration of venture capital funding is the fact that these funds put considerable effort into monitoring their investments. Hence, venture capital funds usually prefer to invest in local companies that they can visit regularly (Gabison, 2015c). Location matters for financing, not only as regards volume but also continuity. Start-ups based in the major European start-up hotspots have better chances of receiving more venture capital money more frequently.

Also the behaviour of venture capital investors in Europe has changed over the last two decades. They have shifted their focus from seed funding to later stage funding (Nepelski et al., 2016). Venture capitalists are now investing less in companies in the earlier stages and more in older and larger companies. Contrary to perceptions, venture capitalists may not fund young, innovative and high-risk enterprises. More European companies, even innovative ones, have to find other financial sources to finance their innovative activity. One of these alternative sources of financing is crowdfunding, a form of microfinance (Gabison, 2015b; Gabison & Kleinbrink, 2016). Besides providing funds, crowdfunding benefits innovators and entrepreneurs because they receive feedback on their ideas, access the expertise of their investors.

So far however, the European crowdfunding regulation landscape resembles a mosaic. For example, Italy, the United Kingdom and France passed crowdfunding-specific regulations targeting equity crowdfunding – akin to small Initial Public Offerings (Gabison, 2015b). Each country implemented their regulations in different ways but all three tried to limit exposure of the crowd to financial risks. This variety of regulations exemplifies the lack of harmonization at the EU level.

Figure 7: Amount raised by venture capital-backed companies and number of rounds by world regions

Note: The graph presents the shares of the major world regions in the amount raised by VC-backed companies in Bln Euro and number of VC funding rounds in the years between 2006 and 2013. Original figures in US Dollars were converted to Euro. Source of historical currency conversion rates: http://www.oanda.com/
Calculations: JRC based on (EY, 2014)
Data: VentureSource by Dow Jones.
Source: (Nepelski et al., 2016)

5 The role of IPR for digital innovation

The ICT industry uses patents, trademarks, and copyright extensively in the ICT market (Comino & Manenti, 2015). For example, companies which want to access venture capital finance benefit from holding patents (Gabison, 2015b). IPR is used by companies as a way of signalling their innovative – and growth - potential to investors. Besides securing finance, patents allow their holders to cooperate. They allow innovators to transfer knowledge outside company bounds and still make a profit (Di Minin et al., 2016). IPR provides the edge to companies which are competing in the ICT sector.

Due to such characteristics of ICT products as short life-cycles, face fierce competition and complexity, different models and practices to protect IPR coexist. 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 also rely on contract law and trademarks to safeguard their IP. At the same time, open source software is making inroads into several segments of the industry. In addition, companies often adopt hybrid business models by combining open and proprietary approaches in software development and distribution. Thus, companies usually adapt their IP protection, to their needs.

However, IPR are generally not always seen as very important drivers of competitive advantage (Biagi et al., 2015). Secrecy and lead-time advantage matter more. This may be due to the fact that, because of the complex interaction between cumulativeness and innovation incentives, the role played by IPR in digital innovation is not clear-cut (Comino & Manenti, 2015). For instance, broader patent scope may provide more incentives to early innovators while dissuading follow-on inventors 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 have to obtain permission from copyright holders.

Technological complexity combined with the cumulativeness of the innovation process leads to fragmentation of IP rights and to the emergence of patent thickets (Comino & Manenti, 2015). The number of triple counts, a widely accepted measure for thickets, shows that 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 and companies needing to in-license technologies are most likely to be harmed. In addition, thickets make searching for prior art more difficult, thus potentially reducing the quality of patents granted by Patent and Trademark Offices.

Summing up, the complexity of the use of digital innovation and the IPR practices in this domain requires a better understanding of how to best adapt IPR protection to the needs of the digital world (Pentheroudakis., 2015). Simple retrofitting old regulations to new concepts may not be an appropriate solution.

6 Technology standardisation and technology markets

The success of many digital innovations and ICT products 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 policies to garner networking externalities using fair, reasonable and non-discriminatory licensing terms (FRAND) licensing commitments. For example, the 3rd Generation Partnership Project (3GPP), i.e. the standards-setting body behind the 3G and 4G standards, is a collaboration between seven global telecommunications SSOs (Gupta, 2015). Membership is open and voluntary, and currently over three hundred firms from over forty-three countries are listed as members. Because some aspects of 3GPP systems are covered by essential IPR, in general, the 3GPP IPR Policy requires IPR holders to make licences available to all third parties, whether or not they are 3GPP Individual Members, under FRAND terms.[3]

FRAND licensing terms are those to which SSO participants must agree before being able to contribute and they seem to work in practice even though innovators interpret these differently than implementers (Ménière, 2015). In spite of this, FRAND policy terms have some detractors. For example, one of the main criticisms is that SMEs rarely participate in the standard setting process. Another challenge related to FRAND is the fact that interpretation also differs greatly from jurisdiction to jurisdiction. Member States also approach issues such as when to grant an injunction differently. The Unitary Patent System will bring about some harmonization when it is implemented, but until then, implementers and patent holders alike will live with uncertainty. Finally, irrespectively of the efficiency of the application of the FRAND terms, standardisation processes take time. There is a question of whether coordination and economies of scale benefits of utilizing a single standard outweigh the innovation-retarding effect of requiring all players to conform to the standard (Weber, Haas, & Scuka, 2011).

Besides standards, another way of ensuring technological interoperability is through technology markets. In this context, one of the main concerns about the surge in patenting is the quality of the rights granted. A decline in patent quality increases transaction and litigation costs, thus endangering the functioning of the patent system as a whole.

Patent assertion entities (PAE) have emerged as important players in technology markets (EE, 2016), particularly in the USA. They serve as intermediaries between various actors which produce and use technology. PAEs are expected to be crucial in stimulating IPR negotiations. Patent assertion as a business model has had a particular impact on the ICT sector and, mainly in the US. So far, in Europe, the presence of PAEs is limited. The Unitary Patent System will harmonize enforcement across Europe. It will introduce a pan-European injunctive and damage relief. Both may trigger more PAE activity in Europe in the future. However, remedial lawyers’ fees and professional judges will probably curb their activity in Europe as compared to the US.

[3] For details, see: http://www.3gpp.org/

7 Ways to boost digital innovation and entrepreneurship

EURIPIDIS studies delivered a number of insights on digital innovation and entrepreneurship in Europe. In an attempt to synthesise this knowledge, a selection of 7 ways to boost digital innovation and entrepreneurship in Europe is presented below.

1. **Target digital innovation and entrepreneurship**

Digital innovation and entrepreneurship in particular, requires a wide range of skills and capabilities, e.g. technical, managerial and financial; entrepreneurial culture; failure acceptance; large funding and innovation-friendly regulatory environment. Capacity building and specific policies are needed in all those fields. Digital innovation is not confined to the ICT sector. Modernisation in other sectors through digital technologies needs to be addressed.

2. **Embrace disruption and mitigate its negative impacts**

Resisting digital disruption and protecting the status quo is 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 in other fields, including social impacts, e.g. changes in the employment structure and income distribution.

3. **Address the heterogeneity of digital innovation and entrepreneurship**

Various policy responses that facilitate innovation and entrepreneurship in different layers of the digital innovation and entrepreneurship ecosystem are needed. 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, more agile instruments and innovative demand-side innovation policy are likely to be particularly effective. In the layer where digital platforms bring wide-ranging business disruptions, regulation plays an important role.

4. **Reinforce collaboration**

To facilitate collaboration, knowledge flow and spillovers need to become a more central focus of public policies. Building European ecosystems and creating links between them would facilitate knowledge disseminate and absorption.

5. **Facilitate scaling-up**

In addition to increasing funding for innovation, closer attention needs to be paid to the complementarities between public and private funding for innovation. Public funding needs to focus on de-risking research and bear the costs of failures. By financing risky, early-stage projects, it needs to complement private money providing funding to mature, developed and ready-to-commercialise technologies. In addition, public funding needs to guarantee the continuity and persistence of funding to technological ventures to counteract the investment cycles of private funding.

6. **Create technology-related network effects and smooth exchange of IPR**

To guarantee technological interoperability and create technology-related network effects, coordination between various players to, for example, set technological standards is needed. Emphasis should be put on including SMEs and start-ups in the standardization process. Interoperability can be also assured through technology markets. They play a role in dealing with the fragmentation of technology and patent thickets. Their effectiveness relies on high quality of IPR.

7. **Maintain balance between openness and incentives to innovate**

Technological complexity combined with the cumulativeness of digital innovation requires a balance between two conflicting goals: the provision of incentives to create new products and the stimulation of knowledge dissemination.

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