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**INNOVATION DYNAMICS IN THE
MOBILE COMMUNICATIONS MARKET:
CURRENT TRENDS, EMPIRICAL ANALYSIS AND POLICY OPTIONS**

by

OLGA SYRAYA, M.B.A.

Resident in Düsseldorf
Matriculation Number: 0337956

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Dean: Prof. Dr. Michael Fallgatter
Faculty B - Department of Economics / Schumpeter School of Business and Economics

1st Examiner: Prof. Dr. Paul. J.J. Welfens
Faculty B - Department of Economics / Schumpeter School of Business and Economics

2nd Examiner: Prof. Dr. Kerstin Schneider
Faculty B - Department of Economics / Schumpeter School of Business and Economics

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List of Abbreviations

2.5G	2.5 generation
2G	second generation
3G	third generation
4G	fourth generation
5G	fifth generation
ADSL	Asymmetric Digital Subscriber Line
AMPS	Advanced Mobile Phone System
API	application programming interface
CDMA	Code Division Multiple Access
CEPT	Conference on European Post and Telecommunications
CTIA	Cellular Telephone Industry Association
D-AMPS	Digital Advanced Mobile Phone System
DSL	Digital Subscriber Line
EIB	European Investment Bank
EIF	European Investment Fund
ERA	European Research Area
ETSI	European Telecommunications Standards Institute
EVAC	European Private Equity and Venture Capital Association
FCC	Federal Communications Commission
FDI	foreign direct investment
GADI	gross adjusted disposable income
GDP	gross domestic product
GERD	gross domestic expenditure on R&D

LIST OF ABBREVIATIONS

GMM	generalised method of moments
GPRS	General Packet Radio Service
GRI	government research institutes
GSM	Global System for Mobile Communications
HPC	high performance computing
ICT	information and communications technology
IMT-2000	International Mobile Telecommunications-2000
IP	Internet Protocol
IPR	intellectual property rights
IS	innovation system
IT	information technology
ITPS	Institute for Growth Policy Studies (Sweden)
ITU	International Telecommunication Union
IVI	In-Vehicle Infotainment
Kbps	kilobit per second
KETs	Key Enabling Technologies
KIBS	knowledge intensive business services
LLU	local loop unbundling
LTE	Long Term Evolution
Mbps	megabit per second
MMS	Multimedia Messaging Service
MNEs	multinational enterprises
NMT	Nordic Mobile Telephony Standard
NSE	natural scientists and engineers
NSI	national system of innovation
NTBFs	new technology-based firms
NUTEK	Swedish Agency for Economic and Regional Growth
OBD-II	On-Board Diagnostics
OECD	Organisation for Economic Co-operation and Development

LIST OF ABBREVIATIONS

OEM	original equipment manufacturer
OLED	organic light emitting diode
OLS	ordinary least squares
OTT	over-the-top
PCT	Patent Cooperation Treaty
PDC	Pacific Digital Cellular
PPP	public-private partnership
PPP	purchasing power parity
PTO	public telephone operator
R&D	research and development
RFID	radio-frequency identification
RISS (Slovenia)	National Research and Innovation Strategy
S&T	science and technology
SIS	sectoral innovation system
SMEs	small and medium-sized enterprises
SMS	Short Messaging Service
SSI	sectoral system of innovation
TFP	total factor productivity
UMTS	Universal Mobile Telephony Standard
UNDP	United Nations Development Programme
VC	venture capital
VIF	variance inflation factor
VINNOVA	Swedish Agency for Innovation Systems
W-CDMA	Wireless Code Division Multiple Access
WAP	Wireless Internet Protocol
WIPO	World Intellectual Property Organization
WTO	World Trade Organisation

LIST OF ABBREVIATIONS

Chapter 1

Introduction

Information and communication technologies (ICTs) are a general purpose technology - they constitute a fundamental infrastructure supporting economic and social activities (OECD, 2013). Today, there may be no doubt about the importance of the Internet in our society, which has transformed into a ubiquitous technology supporting all sectors across the economy. The OECD (2012c, p. 20) even stresses that "*most policy makers in OECD countries now consider the Internet a fundamental infrastructure, in much of the same way as electricity, water and transportation networks*". The term *Internet economy* has become a widely used expression in the recent years - a sign of the key economic role the Internet now plays in our daily lives.

The development of mobile communications technologies, one of the youngest, most dynamic and innovative ICT markets, has no doubt contributed to the way we use the Internet today. The OECD (2012c) underlines that thanks to the development of mobile technologies, especially to the explosive growth of new smartphones and portable devices such as handheld computers and tablets, the Internet has reached its second stage of development as it evolved to a broader network reaching a wide range of new devices. Due to advances in mobile communications, in the past years there has been a significant shift in available services and ways in which people use the Internet. As more users access the Internet via mobile networks, applications such as social networking, location-based services, user-created content and blogging continue to evolve (OECD, 2012c).

The ICT firm Ericsson estimates that by 2020, there will be 50 billion mobile wireless devices connected to the Internet across the globe, and predicts that the total number of devices connected to the Internet could reach 500 billion (OECD, 2012c). An OECD estimate concluded in 2012 that a family with two teenagers may have 10 connected devices. By 2017 this number could reach 25, and by 2022 it could reach 50 (OECD, 2013). Although different projections of the number of devices connected to the Internet vary, all of them highlight the commonly held idea that the "*Internet of things*" will have significantly more connections than users (OECD, 2012c).

Obviously, both developed and developing countries benefit from the increasing role of mobile communications technologies and many more possible applications are still to be explored. The OECD (2013) stresses that policy makers that take advantage of the new communication capabilities, could make substantial gains towards policy objectives, such as promoting greater equity. In certain cases, the mobile Internet is even preferred to fixed Internet. Notably, due to the fact that the rollout of mobile infrastructure is much faster and cheaper than of fixed lines, the mobile communications sector is booming in many

developing countries that do not possess a well-developed fixed-line infrastructure. New mobile services, such as the use of mobiles for making payments and providing services to people without bank accounts in Kenya, address the large number of mobile users that do not have access to banking and online facilities. As a result, mobile communications can help overcome differences among countries and regions in the use of ICT, frequently called the digital divide (Andonova, 2006). The increased use of mobile Internet will, in turn, accelerate the diffusion of knowledge and strengthen the internationalisation of economic relations (Welfens et al., 2005).

In order to discuss in depth the topics related to Internet economy and mobile communications, we should first give definitions of the most commonly used terms related to these technologies.

The term second generation (2G) mobile technologies refers to mobile technologies based on the GSM (Global System for Mobile communication), originally designed for operation in the 900 MHz band but adapted for 1800 MHz soon after its introduction. GSM was designed principally for voice telephony (see ETSI (2014)).

Third generation (3G) mobile technologies is an umbrella term for a set of mobile standards that comply with the International Mobile Telecommunications-2000 (IMT-2000) specifications by the International Telecommunication Union. In contrast to 2G, 3G enables mobile Internet access and includes for example UMTS (Universal Mobile Telephony Standard) that is widely used in Europe and CDMA2000 (Code Division Multiple Access) that is largely used in Americas and some Asian countries.

The term fourth generation (4G) mobile technologies refers to the most recent LTE (Long Term Evolution) standard, often marketed as 4G LTE. It enables high-speed data transfer for mobile phones and data terminals.

The term 5G (fifth generation mobile networks) denotes the next major phase of mobile telecommunications standards beyond the current 4G. The European Commission as well as Korea are currently planning to invest into its development.

Today, there is no doubt about the high innovativeness of the mobile communication market as we witness the transition from third generation (3G) to fourth generation (4G) mobile technologies. 3G networks and 4G technology provide a platform for the convergence of voice, SMS/MMS and data services over a single data connection, and LTE offers even higher wireless Internet speeds. The ambitious goal is to achieve ubiquitous Internet access anytime from anywhere - that is why fifth generation (5G) mobile technologies are already a subject of attention on the EU level (e.g. as a part of Horizon 2020 programme).

Another important trend in the mobile communications market is that new entrants, for example, Free Mobile in France, made markets significantly more competitive and encouraged new innovation (OECD, 2013). In addition, high prices for international mobile roaming are increasingly recognised as a significant barrier to trade and travel in OECD economies (ibid.) and in the future we should witness more efforts to improve the situation (similar to the EU Roaming Regulation).

Furthermore, nowadays, smartphones and tablets are much more than devices to communicate and gather information. They enable home automation, smart vehicles and other connected or smart devices. The (OECD, 2013) stresses that this area has tremendous potential for OECD economies to increase efficiency and meet broader policy objectives in fields such as health and energy.

Taken into consideration the immense potential of mobile communications technologies and their crucial role for the Internet economy, it is essential to conduct a continuous

monitoring of recent trends in the international mobile communications market in combination with a detailed analysis of the achievements of and challenges faced by countries in this sector, in order to develop adequate policy measures in support of mobile technologies when needed.

This PhD thesis aims to contribute to this important task by analysing the innovation dynamics in the mobile communications market in the OECD countries. This work will consist of five major parts. The first part will be devoted to the description of most important trends in the modern mobile communications market, with a special focus on LTE deployment, smartphones' success and innovative mobile digital services.

In the second, theoretical, part, we will consider the main theories that are applicable to the mobile communications markets and our future analysis: theory of innovation systems (on both national and sectoral levels) and theory of lead markets. As regards the former approach, we will look in more detail at the history of development of the mobile sectoral system of innovation. As regards the lead market approach, we will try to find out if the conclusions based on 2G development are still valid for 3G. And in the related third part, we will attempt to revise and update the case studies on the Swedish and Korean national systems of innovation.

The fourth part is empirical and we will analyse the factors that might have contributed to the diffusion of 3G mobile technologies in selected OECD countries. In the fifth part, we will review most important EU policy measures aiming to improve the innovation activity and support the development of mobile communications market in Europe. Finally, taking into consideration the results of our analysis and existing policy measures, we will draw policy recommendations for the further promotion of an innovative European mobile communications market.

We hope that this work will contribute to a better understanding of current trends and the innovation processes in the European mobile communications market, as well as to promoting the further development of key mobile Internet technologies.

Chapter 2

Current Trends in the Mobile Communications Market

Mobile communications market comprises four major elements or sub-markets:

- Mobile network itself (e.g. GSM, UMTS, LTE),
- Handsets, most recently smartphones,
- Software innovation, for example Android OS and iOS for iPhone, so-called Apps etc.,
- Innovative services, such as mobile cloud services, mobile TV, mobile VoIP, and innovative marketing.

In this chapter we will look in more detail at the recent trends concerning these elements of the worldwide mobile communications market.

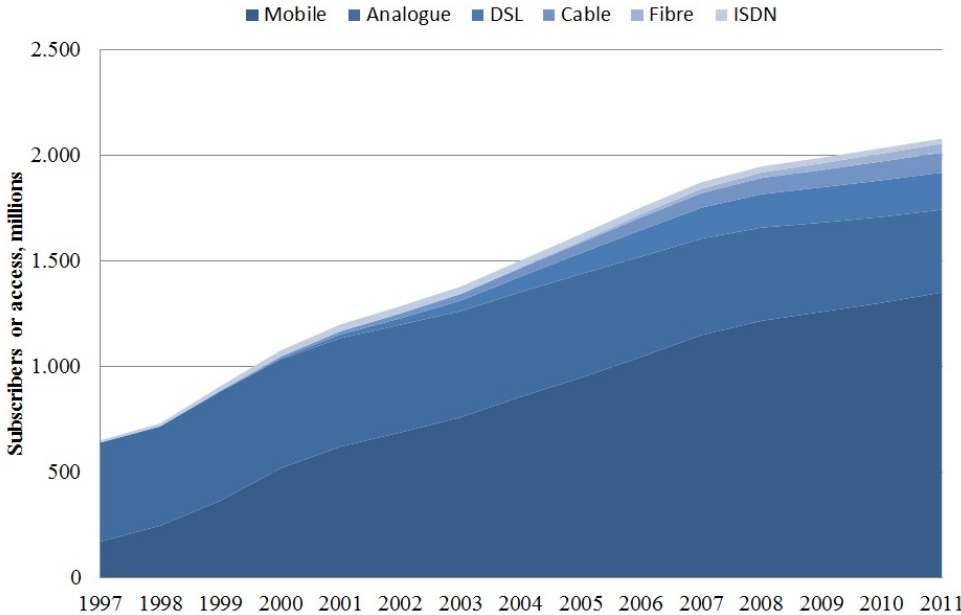
2.1 Network Development

2.1.1 Mobile Network

According to the OECD (2013), mobile access accounted for 65 per cent of the total number of communication paths in the OECD area in 2011 (see Figure 2.1). Slower growth rates - mobile subscriptions grew by 3.8 per cent in 2011 and by 3.39 per cent in 2010 - reflect maturity in mobile markets in the OECD countries. The OECD share of the number of mobile subscriptions around the world has also been decreasing - while in 1993 it was 85 per cent, in 2011 it dropped to just 23 per cent (ibid.). This reflects the success of the prepaid model for mobile services and feature phones, as well as the high growth rates of many emerging economies such as Brazil, China, India, Indonesia and South Africa, which are now aiming to replicate the success of the prepaid model for mobile devices capable of Internet access (ibid.).

Today, the bulk of growth in the wireless sector corresponds to mobile broadband services enabled by 3G and, in the future, by 4G technologies (see Figure 2.2). The OECD (2013) underlines that the uptake of 3G technologies combined with quickly growing

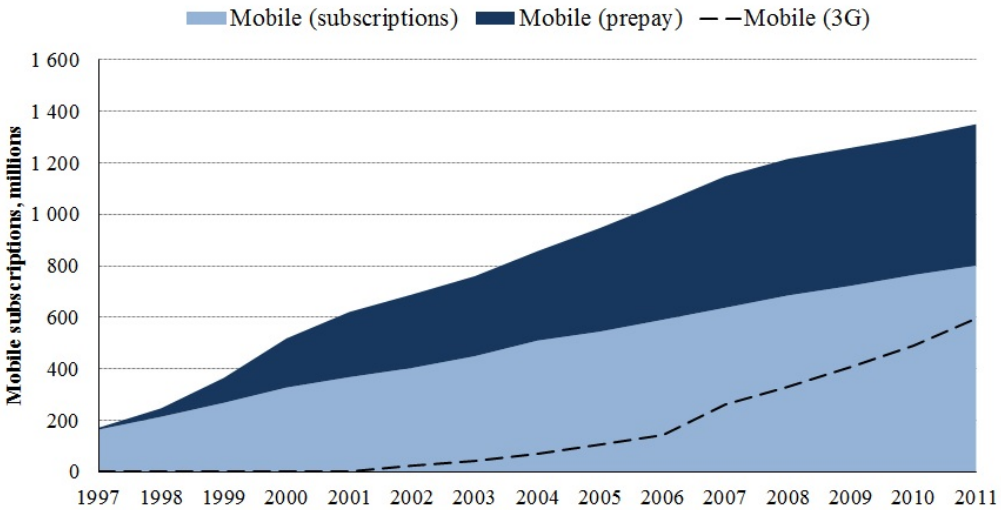
Figure 2.1: Access growth in the OECD, 1997-2011



Source: OECD, 2013.

smartphone penetration has contributed to the current increase in mobile broadband subscriptions.

Figure 2.2: Cellular mobile subscriptions in OECD countries, 1997-2011



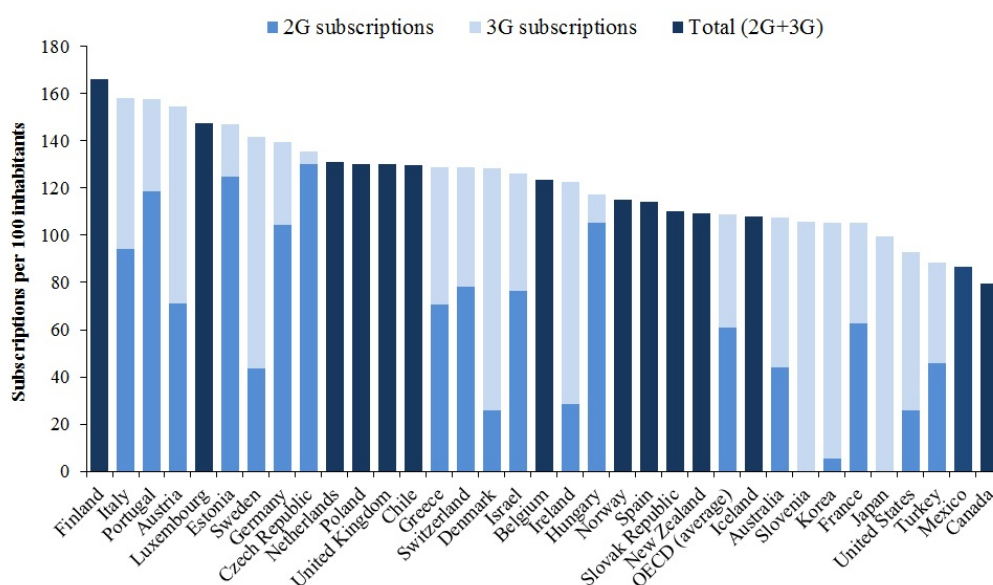
Source: OECD, 2013.

In 2011, the average mobile penetration rate in the OECD area was 109 per cent and Finland was the OECD leader with total mobile subscriptions just under 170 per cent, followed by Italy, Portugal and Austria with over 150 subscriptions per 100 inhabitants (see Figure 2.3). The OECD (2013) suggests that high subscription rates are usually present in countries where prepaid mobile services are popular, such as Italy and Portugal.

2.1. NETWORK DEVELOPMENT

According to the OECD (2013), the share of 3G-enabled mobile subscriptions has grown from 32.22 per cent in 2009 to 44.1 per cent in 2011, with a total number of just below 596 million. In 2011, for selected countries that were able to report data, 3G adoption reached 100 per cent of mobile subscribership in Slovenia and Japan, while in Korea the share of 3G subscriptions was 94.9 per cent of total mobile subscriptions (ibid.).

Figure 2.3: Cellular mobile subscriptions per 100 inhabitants, 2011, 2G and 3G



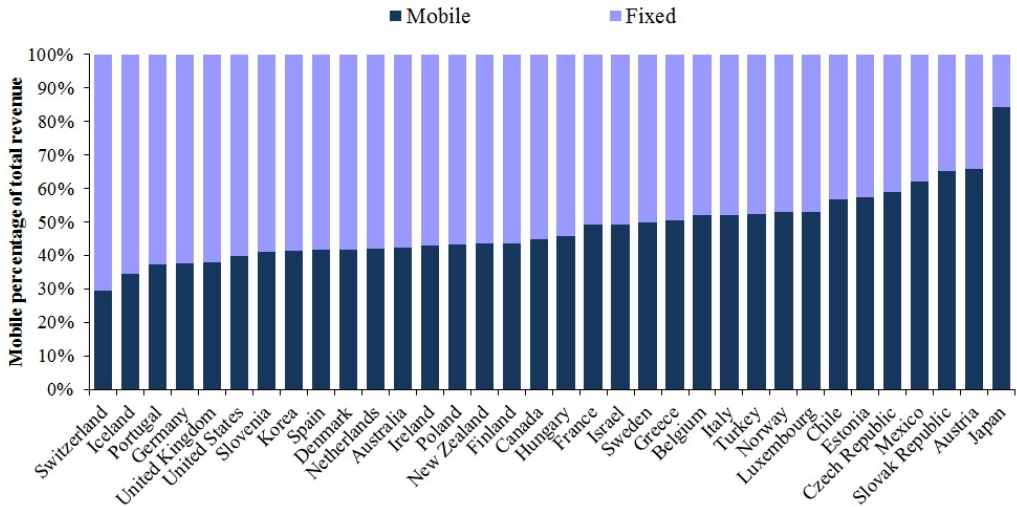
Source: OECD, 2013.

According to the OECD (2013), the share of revenue generated by mobile communications services continues to increase across the OECD area - in the 13 years between 1998 and 2011 mobile revenues increased sixfold as they reached USD 651 billion in 2011. However, while the trend toward greater shares of mobile revenues is common across the OECD area, there are some differences (see Figure 2.4). For example, in Japan the mobile revenue share is as high as 84 per cent, almost 20 percentage points above the next country, Austria. The OECD (2013) suggests that one possible factor is the pricing patterns in Japan for mobile voice and data services, because mobile operators in Japan promote flat-rate tariffs that are more competitive for customers using larger amounts of data. This promotes fixed mobile substitution, especially for the Internet usage.

In Austria, the OECD (2013) argues, the high share of mobile revenue, relative to the overall market, is also due to substitution. Because unlike most other countries, Austrian authorities consider that for regulatory purposes, mobile networks can be viewed as substitutable for fixed networks. On the other hand, the share of mobile revenues in the United Kingdom, is among the lowest as a proportion of the total market in the OECD. The OECD (2013) explains it in part by the presence of five mobile operators competing strongly in this market until 2010, which led to some of the lowest prices in the OECD area.

The use of innovative broadband services is possible thanks to the increasing deployment of faster 3G and 4G networks. According to the OECD (2013), the average mobile broadband growth rate in 2011 was 29.1 per cent. However, some countries had grown more than 100 per cent, such as the Czech Republic (324.8 per cent), Estonia (121.2 per cent), Spain (135.9 per cent) and Turkey (343.3 per cent) in Europe, and Chile (114.0 per

Figure 2.4: Share of mobile revenue in total telecommunication revenue, 2011



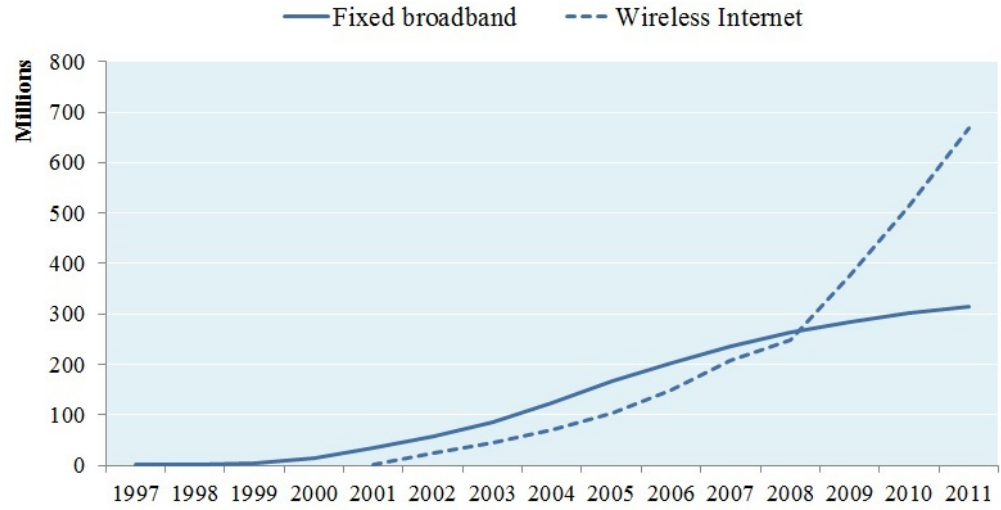
Source: OECD, 2013.

cent) and Mexico (156.8 per cent) in Latin America, while only a few had grown below 10 per cent.

2.1.2 Mobile Internet

Wireless technologies such as mobile Internet has been gaining importance in the last years and in 2008, the number of wireless Internet subscriptions in the OECD countries overtook fixed broadband subscriptions (see Figure 2.5).

Figure 2.5: Wireless Internet access overtaking fixed broadband subscriptions, 1997-2011



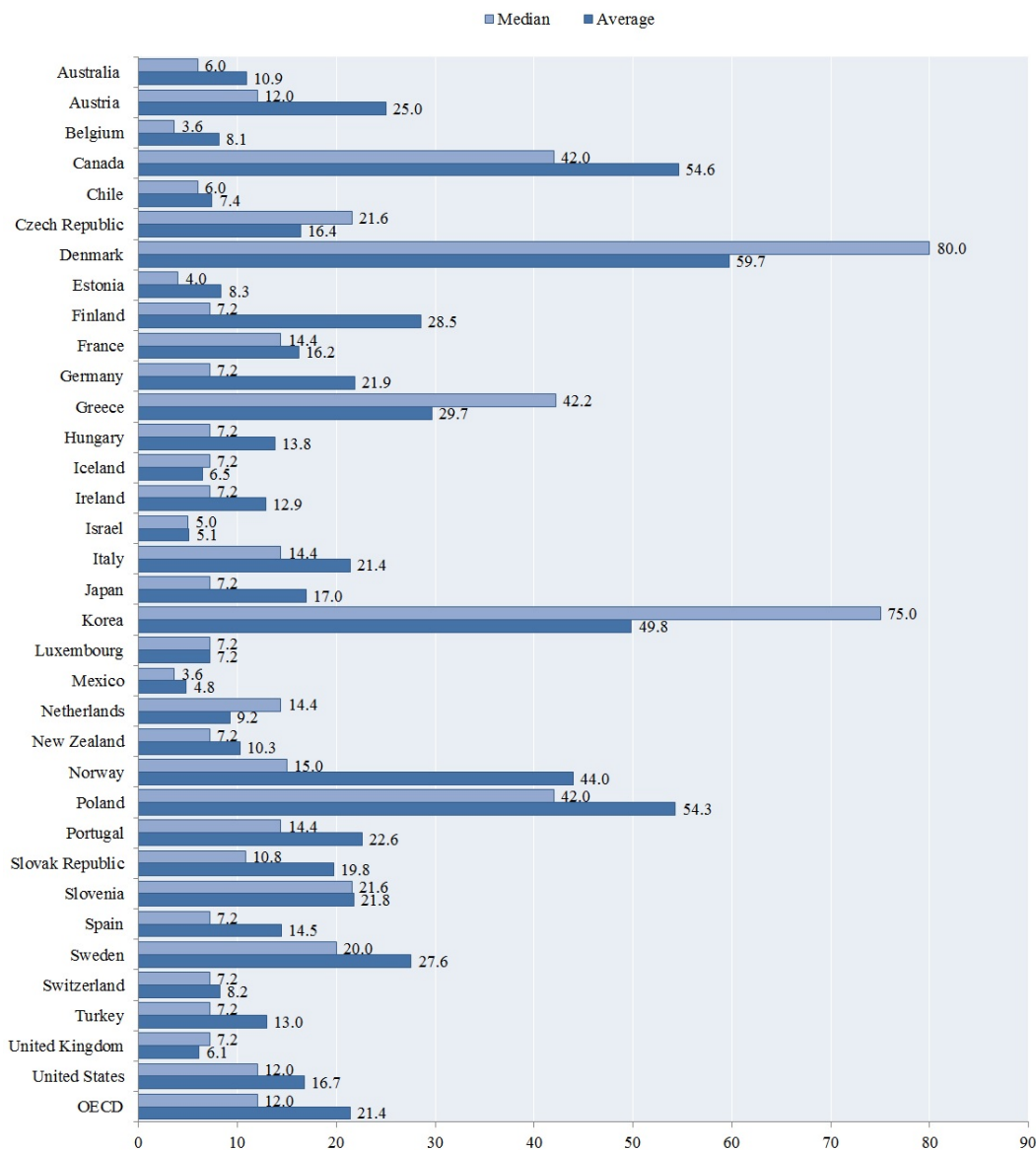
Source: OECD, 2012c.

Mobile Internet providers are increasingly advertising broadband speeds at levels much closer to those of fixed broadband offers in some countries. For example, the OECD

2.1. NETWORK DEVELOPMENT

median speed for September 2012 for mobile broadband (12 Mbps) is not far from the fixed broadband median speed in 2010 (15.4 Mbps) (OECD, 2013). In September 2012, Denmark had the fastest advertised mobile broadband speed among OECD countries (see Figure 2.5). The OECD (2013) suggests that the early adoption of LTE technology in Denmark has contributed to a sharp increase in advertised speeds. According to this OECD ranking, the second-fastest country is Korea (75 Mbps median speed), followed by Greece (42.2 Mbps), Canada and Poland (both 42.0 Mbps).

Figure 2.6: Average and median advertised mobile download speeds, September 2012



Source: OECD, 2013.

2.1.3 Commercial LTE Deployment

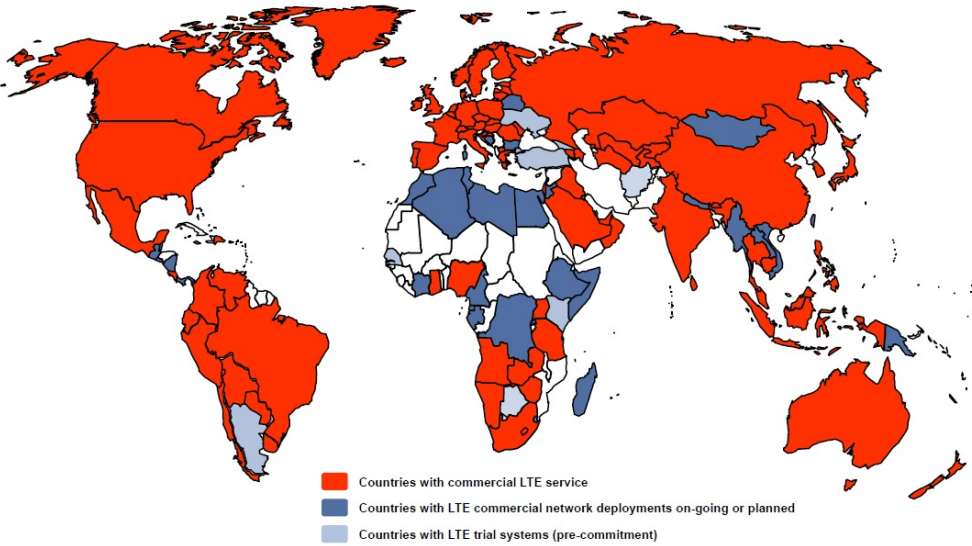
Currently, the fourth generation mobile network is being deployed all over the world and is expected to become "the next step in user experience" (GSA, 2012). Commercial

deployment of Long Term Evolution (LTE) technology has begun with the initial launch by TeliaSonera in Stockholm (Sweden) and Oslo (Norway) in December 2009.

In Korea, LG UPlus was the first player in the mobile market to introduce LTE. It launched in July 2011 and completed the first national LTE network in March 2012. These efforts by Korea's smallest operator (by number of subscriptions) saw the company gain around 5 million LTE subscriptions as of December 2011. SK Telecom, the largest mobile operator in Korea, launched LTE at the same time and has acquired 6 million LTE customers over the same period, while KT had 2 million LTE customers in August 2012. In Japan, NTT Docomo has led the market since launching its LTE service Xi in December 2010, gaining 4 million users over the first 20 months. The Verizon Wireless 4G LTE network, also launched in 2010, offers 4G LTE coverage to more than 245 million people in the United States approximately four out of five people. The company gained more than 10 million subscriptions in the first two years.

Its advertised expected download speed is up to 150 Mbps (HSPA speed can theoretically reach 42.2 Mbps). LTE has received tremendous support, for example, the European Union had funded research on LTE with 32 million USD between 2004 and 2007 and also supports further research on the enhancement of LTE with investments of 23 million USD from 2010 OECD (2010). According to GSA (2014), as of 31 March 2014, 576 operators were investing in LTE in 157 countries and 279 commercial networks were already launched in 101 countries (see Figure 2.7). The fact that as of 5 January 2012 there were only 49 networks in 29 countries shows the enormous progress of LTE in the past two years, and this rapid expansion still continues globally. GSA (2014) forecasts over 350 commercial LTE networks by the end 2014 and it has confirmed LTE as "the fastest developing mobile system technology ever" and as a "global success".

Figure 2.7: Worldwide commercial deployment of LTE networks, 2014



Source: GSA, February 2014.

The success of LTE is largely due to its technical advantages over its predecessors. This next generation of mobile broadband networks is expected to be an all-IP based, flat and simplified network, which will enable higher-speed, larger-capacity and lower-latency wireless access in a more spectrum efficient and a cost effective manner (OECD,

2.1. NETWORK DEVELOPMENT

2010). These technology advancements open three major potential benefits from mobile broad-band networks:

1. High-speed access

As already mentioned, the fourth generation of mobile broadband networks will achieve higher speed access than current mobile services. It is even expected to be comparable to the bandwidth of some entry-level fixed broadband services (OECD, 2010). This, in turn, will improve the end user experience, for example, by offering higher-quality streaming of music and higher-definition video streaming than currently possible. With the increase of download speeds, a richer variety of content, such as online gaming or movies, can become more accessible. In addition, the increased uplink data rate will enable uploading higher quality video content with lower latency. For instance, users may be able to share with friends their location in real time by using their mobile handsets. According to the OECD (2010), the new high-speed mobile network also has a great potential for business use, for example, sending and receiving large data files with smartphones can boost productivity by enabling employees to work away from their office. The possible increase in live video conferencing will help avoid high travel costs and generate environmental benefits.

2. User-friendliness

The boom of smartphones with touch screen interface shows that mobile users expect more user-friendly handsets (OECD, 2010). Not only traditional mobile phones, but also other devices may be capable of functioning as user-friendly terminals, for example tablet devices, e-book readers and even vehicles and home appliances with built-in functionality. User-friendly services may directly connect user handsets with home automation and security systems in order to manage energy control systems such as lighting and heating, or to monitor home security cameras with streaming video (*ibid.*).

3. Global and seamless mobility

The OECD (2010) suggests that global standardisation of the new mobile technology facilitates seamless mobility, interoperability and may assist in providing economies of scale. However, these features may also have a downside. For instance, in the case of international roaming switching between different access systems or networks and frequency bands may be unfavourable and confusing for users. Users may face unexpectedly high bills while roaming internationally, even when they subscribe to a flat-rate data plan in their home network. According to the OECD (2010), another challenge arises from the handover between different access technologies, such as in areas where LTE is not available yet. Although handsets with multi-mode chipset are capable of handovers from other radio access systems, chipset vendors may not supply them if the market is not large enough and they cannot benefit from economies of scale. In that case, multi-mode handsets will not be available or will be very expensive.

The OECD (2010) names five main drivers of the remarkably active and fast global development of 4G (LTE) networks:

1. Availability of "smarter" devices and applications.

With the 3G rollout, mobile communications have become available through a wide range of user devices, such as mobile handsets, PC cards, USB modems, netbooks, smartphones, e-book readers and even vehicles. Modern mobile handsets boast a large number of default applications, from calculators, stopwatches and calendars to location services, music and movie players, gaming and other entertainment. Smartphone growth in the last few years, especially due to the launch of iPhone and later Android smartphones, provides easy wireless Internet access and stimulates the use of wireless data services. However, with the increasing data traffic, new faster and more efficient mobile networks have become necessary.

2. Tariff trends for mobile data.

The introduction of new tariff plans in recent years, that include a specified amount of data a user can download, has had an increasing impact on mobile usage trends. Often such plans are advertised as "flat-rate", although they still have some sort of download cap. If users exceed their monthly data limit, they are either allowed to continue using the connection by paying an additional (usually rather high) fee, or they have a limited connection speed for the rest of the month. The OECD (2010) suggests that download caps or other forms of tariff management may help operators avoid network congestion in areas of high usage, make better use of bandwidth during peak periods, and maintain the quality of service. Flat-rate pricing is so attractive for both users and operators because of its simplicity (McKnight and Boroumand, 2000). Users often view flat monthly subscription fees as being transparent and as a way to help them avoid paying more than they expect. For operators, predictable fees reduce their administrative costs of tracking and billing for usage. Some operators have even started recently to offer unlimited data services without data caps. It must also be mentioned that the prices of data and so-called complete tariffs (including voice, SMS and mobile Internet) have decreased significantly over the last years. Users can count on even lower prices in the future if mobile operators in other countries follow the example of the French Free Mobile.

3. Traffic growth on mobile network.

Increased usage of advanced devices, applications and new services, as well as more competitive pricing, have generated significant increases in mobile network traffic over recent years. For example, it is estimated that an e-book reader creates as much traffic as two basic phones, used for voice and SMS, and a smartphone generates as much traffic as ten basic phones used only for these traditional services (OECD, 2010). Many mobile network operators in the OECD countries have experienced unprecedented traffic growth in recent years. Thus, as stated by the OECD (2010), this need to handle the high growth in data traffic is one of the key drivers for the development of mobile broadband network technology.

4. Financial pressure on network providers.

The OECD (2010) underlines that data services have become an increasingly important revenue source. Also, the proportion of revenue attributable to data is expected to increase significantly in the future. Hence the mobile network operators' desire to reduce network operating costs. Operating costs of 3G networks currently account for almost one-third of the total operating expense of network providers

(OECD, 2010). Next generation mobile broadband networks promise to be very attractive in terms of cost-efficiency and quality of service because they have simple, flat and less hierarchical network architectures requiring less cost of network operations, which results in lower cost per bit than existing mobile networks.

5. Demand side perspective.

Consumer demand for mobile broadband services increases as innovative devices and applications appear on the market. For example, geographic-based applications, including GPS capability, help users find information about restaurants, shops and so forth in the particular geographic area where they are located. The speed with which LTE networks are deployed and launched worldwide proves that mobile network providers realise their immense importance for the future of mobile communications. Although much more investments and work must be done for 4G mobile technologies to be available to everyone in the OECD countries (in Germany, for example, the LTE deployment first started in the so-called "white spots" - rural areas where there were no DSL, cable Internet or UMTS available but now covers most of its surface), one can already foresee their tremendous potential and the new user experience they will bring. However, the good coverage itself does not guarantee that the actual usage of LTE will be as intensive as expected. Thus, mobile providers should also implement adequate pricing strategies because too expansive tariffs may hinder the adoption of LTE technologies among the population.

2.2 Pricing Issues

According to the OECD (2013), offering mobile broadband services with data allowances is a common practice among mobile providers in OECD countries. When the data cap is reached, users may either be given the option of purchasing extra data for a given price (overage charge) or their speeds are "throttled", reducing it to levels such as 64 Kbps or 128 Kbps. Sometimes, the consumer's price plan may be automatically upgraded to the next higher layer, which involves a higher data allowance and a higher monthly price. In very rare cases, the mobile service could be disrupted when the maximum data allowance for a billing period is reached (*ibid.*).

There were also some exceptions to this general pricing trend - unlimited flat-rate offers without data caps sold by some operators in a few countries. For example, in 2012, KDDI au in Japan advertised an unlimited service with a maximum download speed of 40 Mbps, which utilised both 3G and WiMAX technologies. In Finland, the mobile operator Elisa offers 4G unlimited data with a maximum advertised speed of 80 Mbps. However, OECD (2013) stresses that generous data caps such as these are extremely rare in OECD countries.

After the launch of LTE, a number of operators in OECD countries have introduced 4G (LTE) plans to meet customer demand for increased data usage. The associated tariffs in some cases are similar to those offered by fixed networks (OECD, 2013). For example, some operators of LTE networks have developed tariffs based on access speeds rather than data caps, such as the tariffs of the Swiss incumbent operator Swisscom introduced in mid-2012 that all have unlimited data (see Figure 2.8). Others are offering shared data plans across multiple users. The OECD (2013) mentions that this is similar in some respects to the way in which users treat a fixed broadband connection for a single household. The

major current trend is the bundling of voice and SMS with data into a single service, billed by data usage with caps or at flat rates irrespective of the application generating the data.

Figure 2.8: Swisscom plans for mobile services

NATEL® Infinity XS	NATEL® Infinity S	NATEL® Infinity M	NATEL® Infinity L	NATEL® Infinity XL
+ Saving data via Internet				
+ Downloading HD video/photo album				
+ YouTube/Live TV/route planner/streaming radio, music				
+ SBB/Facebook/news/weather/e-mail				
E-mail without attachment				
UNLIMITED NATIONAL CALLS, SMS/MMS AND DATA				
0.2 Mbit/s/0.1 Mbit/s (down/upload)	1 Mbit/s/0.5 Mbit/s	7.2 Mbit/s/1 Mbit/s	21 Mbps/2 Mbit/s	100 Mbit/s/10 Mbit/s
USD 63 (CHF 59)	USD 80 (CHF 75)	USD 106 (CHF 99)	USD 138 (CHF 129)	USD 181 (CHF 169)

Source: OECD, 2013.

Figure 2.9 shows the OECD mobile basket with the lowest usage of data - 30 call mobile basket, complemented by 100 MB of wireless broadband data, which costs on average USD 19.74 PPP per month. Japan’s mobile basket is the most expensive offer (over USD 60) with Chile, Hungary and the United States following (around USD 30 PPP). Since mobile broadband plans in Japan focus particularly on higher usage with an overall adoption of flat-rate plans, the prices for small mobile baskets like this one are comparatively high. Three countries, Austria, Estonia and the United Kingdom, had the least expensive offers in 2012 (all under USD 10).

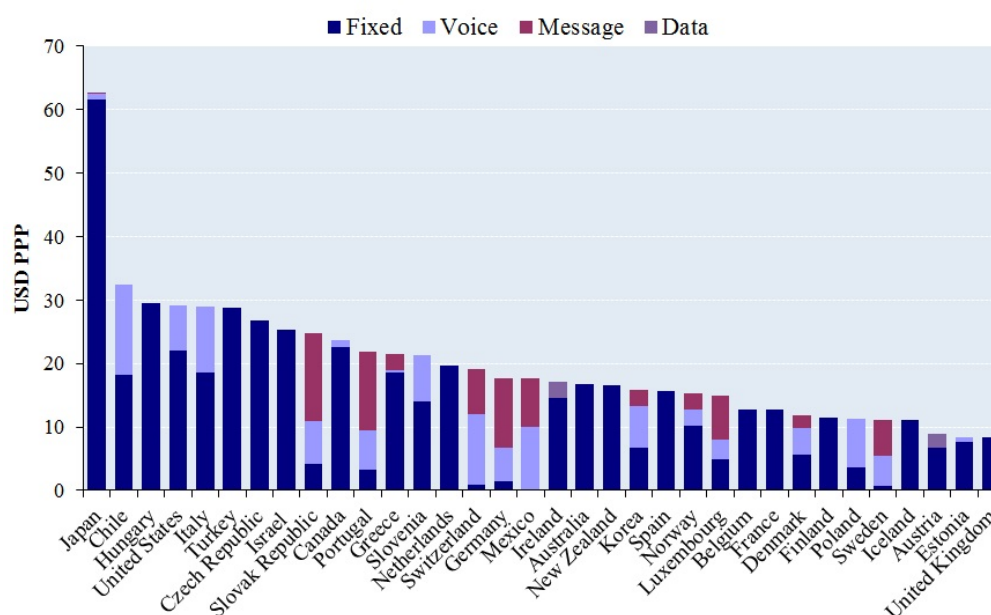
2.3 Trends in Handsets

In 2014, Apple celebrates the seventh anniversary of the launch of the iPhone. While not the first smartphone, it represented a fundamental shift in the relationship between mobile operators and customers (OECD, 2013). The success of the whole ecosystem (including “apps” and the principle of an “App Store”) pioneered around the iPhone spread quickly across the industry, first in the United States then worldwide. In 2008, at the time of launch of Apples “App Store”, approximately 20 per cent of operating systems were headquartered in the United States and 80 per cent offshore. By 2012, this figure had been reversed, primarily by Apple (IOS) and Google (Android) (ibid.).

The OECD (2013) stresses that the diffusion of smartphones has been extremely rapid - on average in the EU5 (France, Germany, Italy, Spain and the United Kingdom) their share jumped from 22 per cent in 2009 to 44 per cent at the end of 2011. The OECD (2013) suggests that the popularity of smartphones, in turn, has stimulated greater use of mobile broadband access. For example, in 2012, smartphones, which by some estimations consume 35 times more data than feature phones, were used by more than half of the population in Sweden, United Kingdom, Norway, Australia and the United States (ibid.). Also, after the Apples release of its iPad in 2010, there has also been extraordinary growth

2.3. TRENDS IN HANDSETS

Figure 2.9: OECD 30 calls + 100 MB mobile basket, August 2012, VAT included

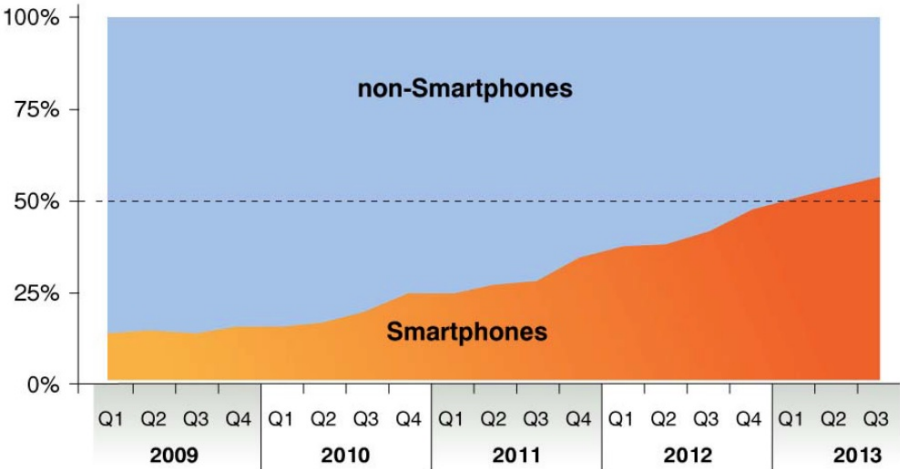


Source: OECD, 2013.

in the usage of Wi-Fi, 3G and now 4G-enabled tablets. The OECD (2013) points out that along with traditional manufacturers, such as LG, Samsung and Sony, convergence has occurred among large firms such as Amazon, Google and Microsoft, now marketing tablets under their own brands. As a result of this trend, the average subscription rate of mobile Internet access in the OECD area rose to 56.6 per cent in June 2012, up from just 30.7 per cent in 2009 (ibid.).

According to Gartner (2014), in 2013 worldwide sales of smartphones to end users totaled 968 million units, an increase of 42.3 percent from 2012. Sales of smartphones accounted for 53.6 per cent (55 per cent according to Vision Mobile (2014b)) of overall mobile phone sales in 2013, exceeding annual sales of feature phones for the first time (see Figure 2.10). Gartner (2014) stresses that the increasing contribution of smartphones was led by growth in Latin America, the Middle East and Africa, Asia/Pacific and Eastern Europe. For example, in China smartphone sales grew 86.3 percent in 2013. Moreover, as stated by Vision Mobile (2014b), in developing countries all over the world, USD 50 Android handsets are replacing feature phones and opening up new opportunities for innovation in business, commerce and education. On the other hand, according to Gartner (2014), "mature markets face limited growth potential as the markets are saturated with smartphone sales, leaving little room for growth with declining feature phone market and a longer replacement cycle". Due to "lack of compelling hardware innovation" in 2013, consumers in high-income countries do not find enough reasons to upgrade.

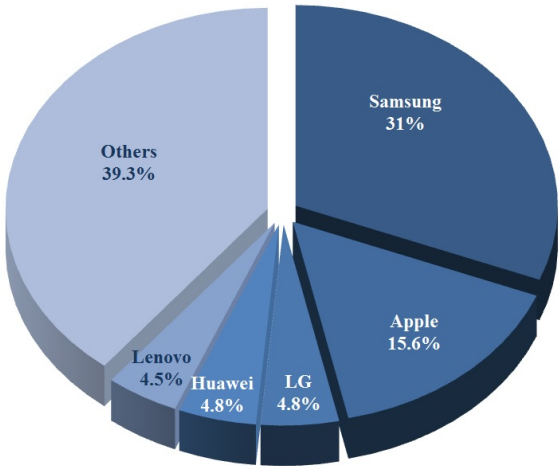
Figure 2.10: Global sales: smartphones vs. non-smartphones, 2009-2013



Source: VisionMobile, February 2014.

As Figure 2.11 shows, Samsung was the leading smartphone producer in 2013, followed by Apple. Gartner (2014) suggests that it is important for Samsung to continue to build on its technology leadership at the high end, while at the same time building a clearer value proposition around its midrange smartphones. As regards Apple’s market position, it enjoyed strong sales of the iPhone 5s and continued strong demand for the 4s in emerging markets.

Figure 2.11: Worldwide smartphone sales to end users by vendor in 2013, %



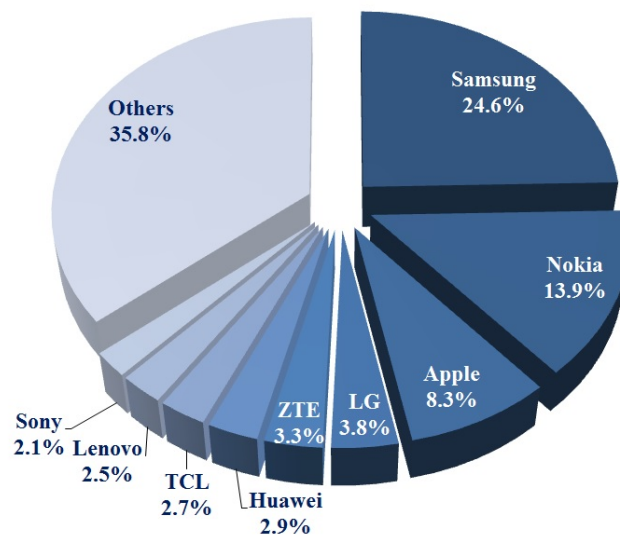
Source: Gartner, February 2014.

In 2013, worldwide mobile phone sales to end users totaled 1.8 billion units, an increase of 3.5 per cent from 2012 (Gartner, 2014), with Samsung as a leader, followed by Nokia (see Figure 2.12). However, Gartner (2014) stresses that the collective market share of the three leading mobile phone manufacturers fell in 2013 as Chinese and regional brands continue to raise their share.

In 2014, Gartner (2014) expects smartphones to continue to drive overall sales. However, it predicts that an increasing number of manufacturers will realign their portfolios

to focus on the low-cost smartphone segment, because of decreasing sales of high-end smartphones in high-income countries and increasing sales of low- and mid-price smartphones in high-growth emerging markets.

Figure 2.12: Worldwide mobile phone sales to end users by vendor in 2013, %



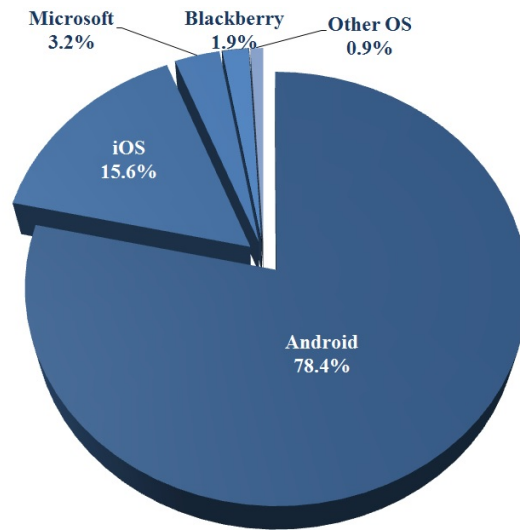
Source: Gartner, February 2014.

2.4 Software and Mobile Digital Services

2.4.1 Platform Competition

According to Gartner (2014), in the smartphone OS market, Android (originally launched by Google) remained the leader as its share grew 12 percentage points to reach 78.4 per cent in 2013 (see Figure 2.13). In 2014, Gartner (2014) expects the sales of Android phones to approach the billion mark.

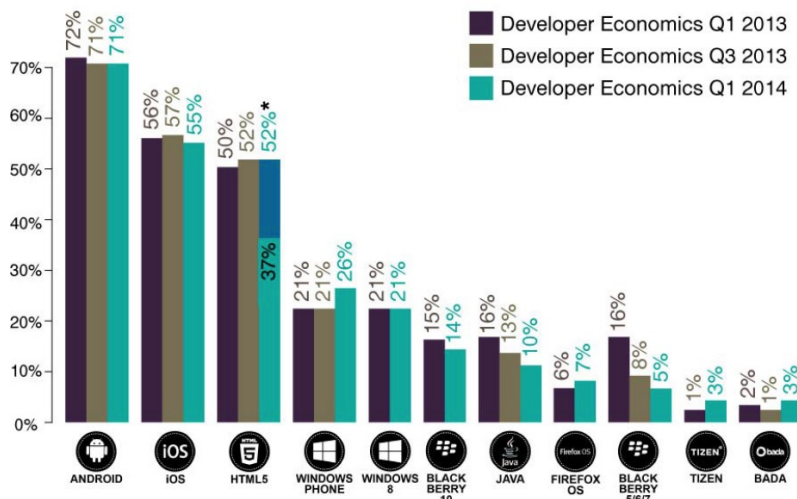
Figure 2.13: Worldwide smartphone sales to end users by operating system in 2013, %



Source: Gartner, February 2014.

Vision Mobile (2014b) states that in 2013, the Android/iOS duopoly on the mobile OS market did not leave any doubt. As Figure 2.14 shows, Android continues to dominate Developer Mindshare with 71 per cent of developers that target mobile platforms, developing for Android. For digital (but not only) businesses targeting mass markets, having a presence on Android platform is becoming a must. Even if the financial rewards from direct downloads are still lagging behind iOS, Android’s massive user base is a good enough reason to justify the investment in the platform (ibid.).

Figure 2.14: Mobile developer mindshare, Q1 2014, percentage of developers using each mobile platform



Source: VisionMobile, February 2014.

As depicted in Figure 2.15, Android and iOS dominate every single country, but while iOS leads in North America and Western Europe, Android wins in every other (less wealthy) region. The difference is most pronounced in Asia where 46 per cent of mobile developers prioritise Android against 28 per cent for iOS.

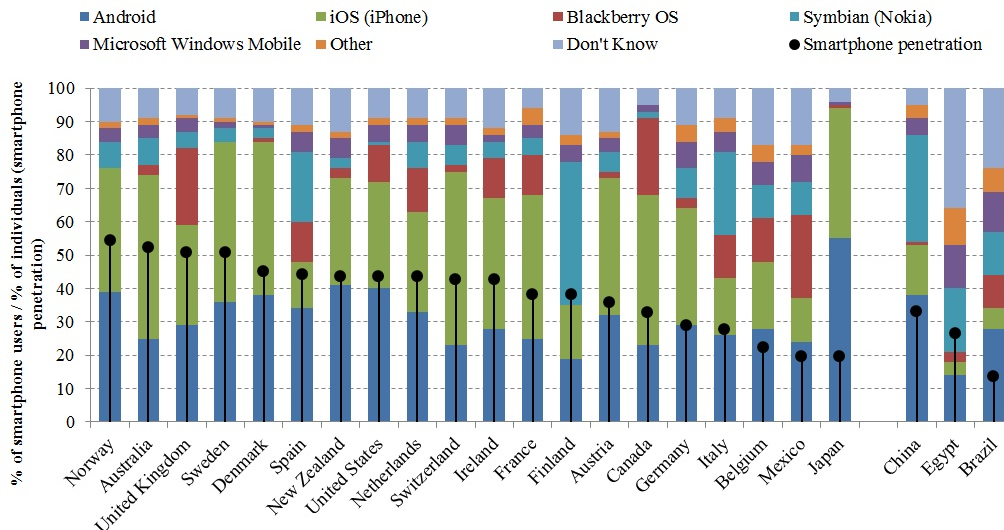
Figure 2.15: Priority platform by country



Source: VisionMobile, February 2014.

Figure 2.16 shows that in 2012, in most OECD and selected countries, operating systems were led by Apple (iOS) and Google (Android). In some countries, a third operating system held a significant market share. Symbian (Nokia) had a share of 43 per cent in Finland, 32 per cent in China, 25 per cent in Italy and 21 per cent in Spain. Meanwhile, Blackberry (RIM), had 25 per cent market share in Mexico and 23 per cent market share in Canada and the United Kingdom.

Figure 2.16: Smartphone and operating systems penetration in selected countries, Q1 2012



Source: OECD, 2013.

2.4.2 Mobile Digital Services and Apps

Development of new mobile services is driven by different factors. For example, as network operators are undertaking initiatives to meet the rapidly increasing demand for mobile data. One approach is to offload traffic from wireless networks onto fixed networks

by using Wi-Fi access points, femtocells, picocells and other microcells (OECD, 2013). The selection of appropriate "small cells" in each particular case depends on availability, reliability and costs of the different technologies. The most commonly used technique to offload mobile traffic onto fixed networks is Wi-Fi and most major mobile network operators across OECD countries have strategies in place to expand their use of Wi-Fi (ibid.). For instance, in France, at the beginning of 2012, Iliad launched "Free Mobile" as a new market entrant with a reported 5 million Wi-Fi hotspots across the country (some 25 per cent market share). The operator's fixed network subscribers share their bandwidth via Wi-Fi-enabled routers connected to DSL or fibre loops (i.e. the so-called Freebox), thus creating the hotspots. Free's Extensible Authentication Protocol Method for GSM Subscriber Identity Module (EAP-SIM) enables their mobile customers to use those five million hotspots without individually authenticating access as they enter the area served by Wi-Fi. From the customer's perspective this is seamless. Data uploaded and downloaded does not count towards fair use caps and, depending on mobile network conditions, may provide better quality of service than mobile network, therefore providing incentives to seek out hotspots. As a result, Free can offer its customers better service as well as increased flexibility in pricing.

Mobile communications market continues to impress us with its innovativeness and novel digital services. For example, in 2012, in Japan, NTT DoCoMo became the first mobile company in the world to offer real-time telephony translation (OECD, 2013). The mobile provider's customer can make a call in Japanese and be heard in English, Mandarin or Korean. The recipient can speak in any of these languages and have their words translated back to the caller in Japanese. This innovative service operates by accessing the cloud and would have obvious advantages for international roaming if it is competitive with local substitutes (ibid.).

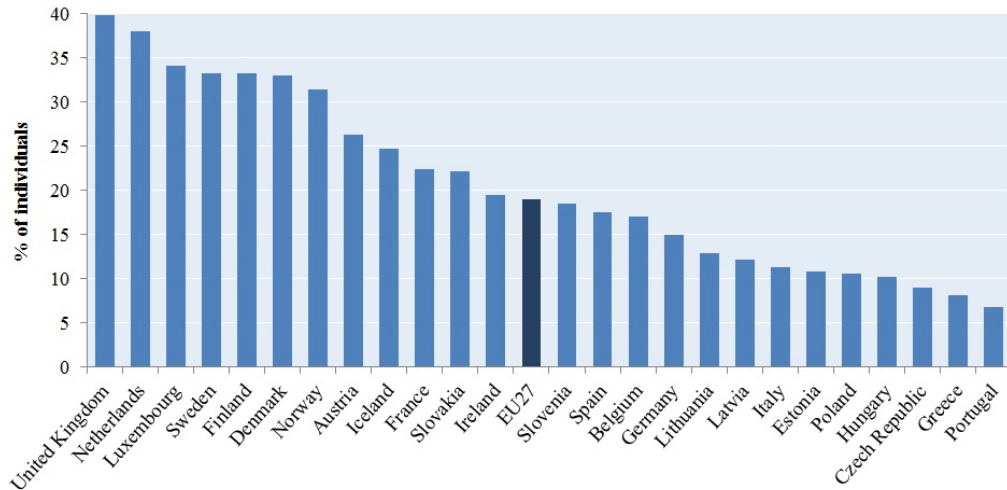
Another interesting development is the popularity of over-the-top (OTT) applications (i.e. applications and services providing a product over the Internet and bypassing traditional distribution) like Skype or WhatsApp (which offers substitutes for voice and text). These services were initially resisted and even banned by some mobile providers but survived due to high market demand. The OECD (2013) underlines that these developments were the outcome of a competitive market rather than the implementation of functional or structural separation.

Smartphone Usage

In Europe, mobile devices are increasingly used to access the Internet - more than one third of individuals in seven countries did this in 2011, with greatest use found in the Netherlands and the United Kingdom (see Figure 2.17).

2.4. SOFTWARE AND MOBILE DIGITAL SERVICES

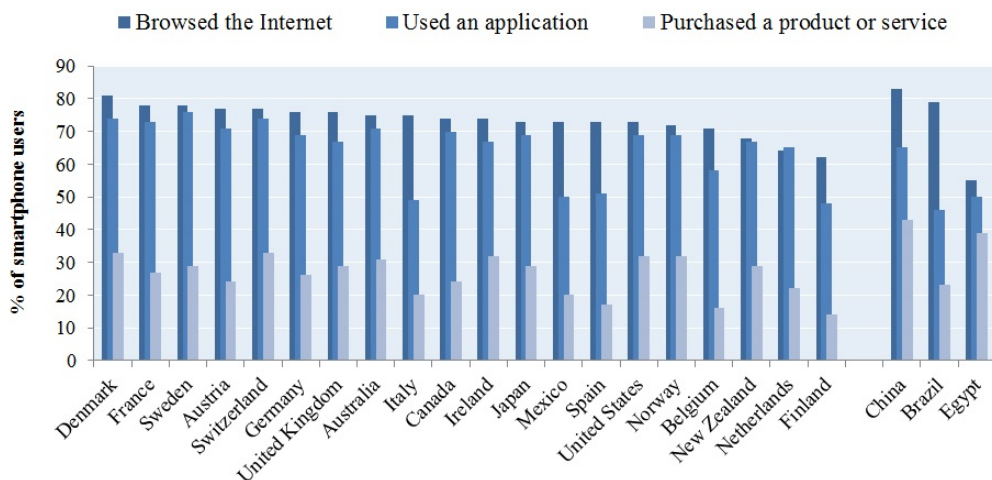
Figure 2.17: Individuals using their mobile phone (or smartphone) to access the Internet (away from home or work) in selected OECD countries, 2011



Source: OECD, 2013.

As depicted in Figure 2.18, primary use of smartphones in all analysed countries, with the possible exception of the Netherlands, was found to be browsing the Web (Google, 2012), possibly because users can download alternative Web browsers as apps. Not all smartphone users use applications equally intensively - while the use of applications is widespread for around three quarters of all smartphone users in Denmark, Sweden and Switzerland, apps are used only by half of users in Finland, Italy, Mexico or Spain. In selected countries, smartphones contained an average of 25 apps of which 9 were used during the last 30 days and 10 were purchased in apps stores (Google, 2012).

Figure 2.18: Internet browsing, apps and m-commerce with smartphones, Q1 2012



Source: OECD, 2013.

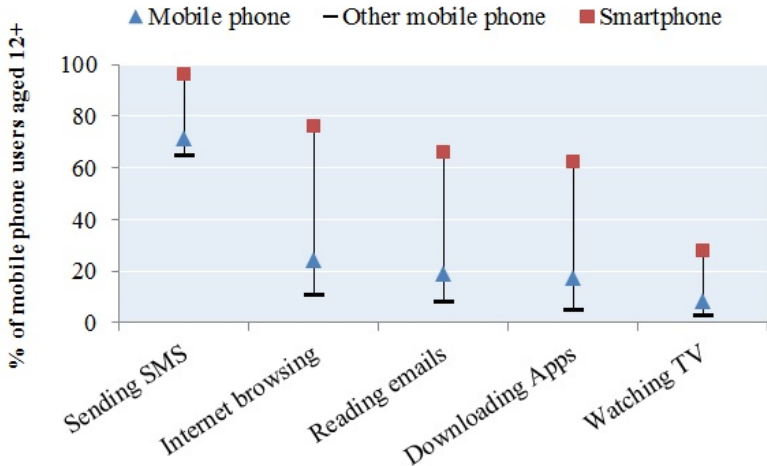
Especially m-commerce is an area where smartphones are expected to have increasing utility, as a variety of applications allow users to compare prices or complete purchases.

CHAPTER 2. CURRENT TRENDS IN THE MOBILE COMMUNICATIONS MARKET

In confirmation, eBay’s m-commerce revenue went from USD 2 billion in 2010 to USD 5 billion in 2011. In 2011, m-commerce accounted for 7 per cent of eBay’s total revenue for that year. Google (2012) has found that smartphone usage for m-commerce is already significantly high in China and to a lesser extent in Australia, the United States and in some European countries (Denmark, Ireland and Norway) (see Figure 2.18).

The comparison by the OECD (2013) shows that in France, Japan and the United States usage of smartphones and feature phones differs, especially for Internet-related activities, such as Internet access, web browsing, reading/sending email, downloading apps, using social media or viewing online videos (see Figures 2.19, 2.20, 2.21). The fact that in these three countries smartphones are preferred to classic mobile phones must be due to the better user experience they offer (such as bigger touch-screens). Notably, even for established activities pioneered on feature phones, such as SMS or taking photographs, smartphones are associated with greater use. In Japan, tablets are more widely used than smartphones for most activities.

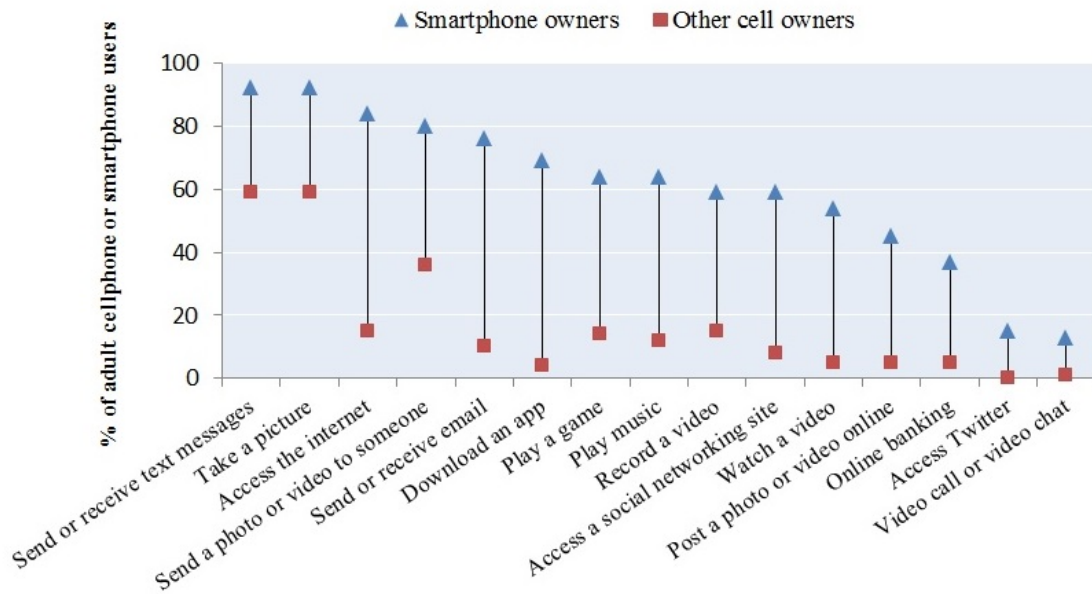
Figure 2.19: Differences between mobile phone and smartphone activities in France, 2011



Source: OECD, 2013.

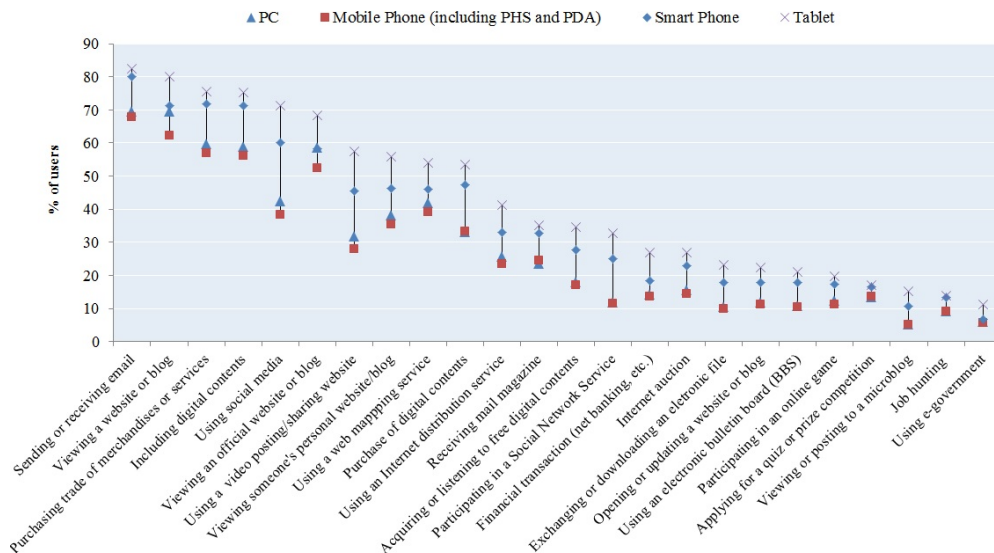
2.4. SOFTWARE AND MOBILE DIGITAL SERVICES

Figure 2.20: Differences between mobile phone and smartphone activities in the U.S., 2011



Source: OECD, 2013.

Figure 2.21: Differences between PC, mobile phone, smartphone and tablet activities in Japan, 2011



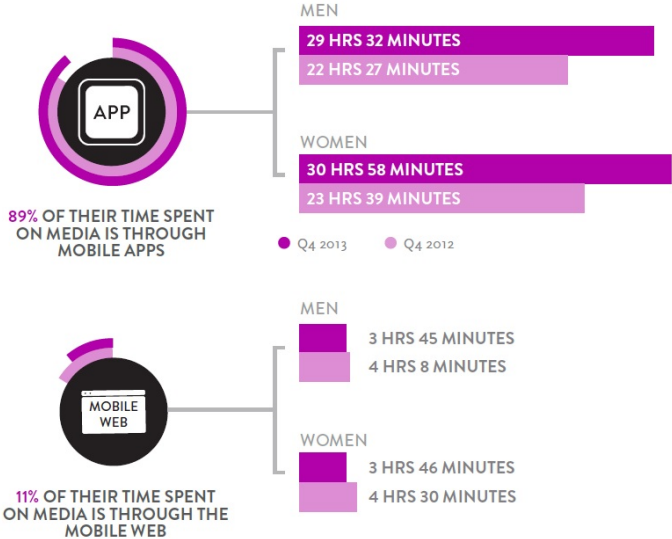
Source: OECD, 2013.

The App Economy

It is obvious that mobile apps revolutionised the way we use mobile phones and mobile Internet. Nielsen (2014) analysed the American consumers' behaviour and found out that

smartphone users use mobile apps 89 per cent of their time spent on smartphones (see Figure 2.22).

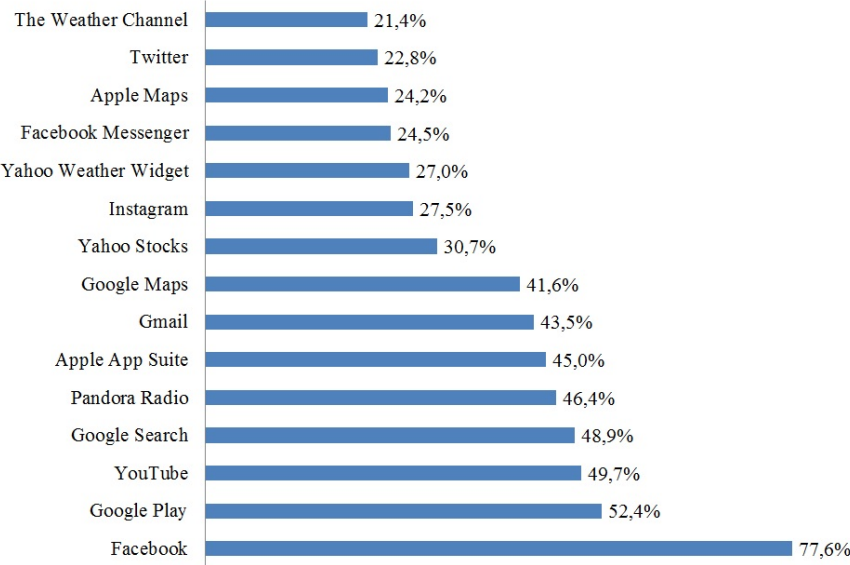
Figure 2.22: Monthly usage of app and mobile web, Q4 2013 and Q4 2012



Source: Nielsen, March 2014.

The analysis by comScore (2014) shows that Facebook ranked as the top smartphone app among U.S. users in January 2014, reaching 77.6 per cent of the app audience, followed by Google Play (52.4 per cent), YouTube (49.7 per cent) and Google Search (48.9 per cent) (see Figure 2.23).

Figure 2.23: Top 15 smartphone apps, January 2014, total U.S. smartphone mobile media users, age 18+ (iOS and Android platforms)



Source: comScore, March 2014.

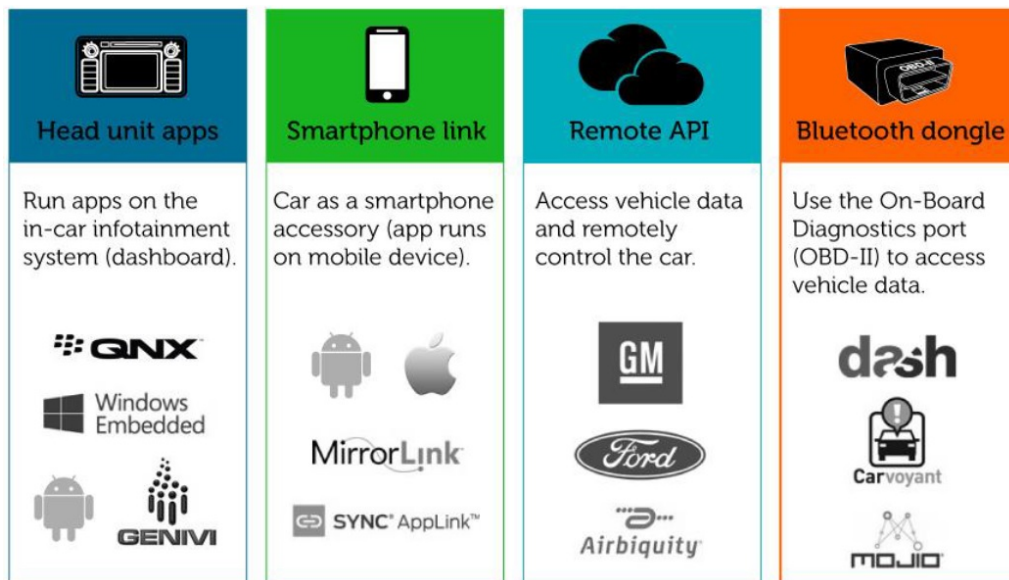
Connected Cars

A recent trend are also connected cars and the development of car app market. Especially the introduction of 4G brings about a new generation of automobiles that are constantly connected to mobile Internet at high speed. These cars are able to provide video in the back seat, stream audio in front, and up-to-the-second information on surrounding traffic conditions for the driver.

As smartphone growth rates slow down, the world’s biggest technology companies are turning their design efforts to connected cars. The market for technology that links cars and smartphones was worth 18 USD billion in 2012 and will increase more than threefold in 2018, according to GSMA. For example, Bloomberg (2014) says that BlackBerry’s QNX operating system, used to power its BlackBerry 10 phones, has become the technology of choice for mapping, communication and entertainment systems in cars from Ford Motor Co. to luxury German brands Porsche and BMW. In March 2014, Apple introduced the CarPlay platform at a car show in Geneva, where Fiat SpA’s Ferrari unit, Daimler AG’s Mercedes-Benz and Volvo Car Group showcased technology enabling hands-free use of an iPhone (ibid.). Interestingly, inside the car, Apple and BlackBerry are collaborators rather than rivals, as QNX software allows CarPlay to recreate the iPhone experience on the console’s screen, with icons familiar to iPhone users.

Apps for cars are developed in four different ways (see Figure 2.24): they are developed either on the head unit or via a smartphone link, and the user can access vehicle data and interact with the car via a remote API or using a Bluetooth OBD-II dongle.

Figure 2.24: Four ways to develop apps for cars



Source: Vision Mobile, March 2014.

First, as regards apps on the head unit, the market leader in IVI (In-Vehicle Infotainment) platforms is BlackBerry’s QNX CAR1 platform with 53 per cent market share, followed by Microsoft’s Windows Embedded Automotive with 27 per cent market share (Vision Mobile, 2014a).

As a second approach, much of the connected car activity shifted to integrating cars with smartphones in recent years. The goal of this approach is also to provide safe, valu-

able and up-to-date infotainment in the car. However, apps run primarily on the smartphone instead of in the car's IVI system. Here, smartphone apps interact with the car through a strictly defined API (application programming interface). As a result, the car becomes a smartphone accessory in a similar way as a Smart Watch would be (Vision Mobile, 2014a). The integration between the car and the smartphone might take several forms:

1. The steering wheel controls and built-in voice recognition can be used to control smartphone apps.
2. Smartphone voice recognition (e.g. Apple's Siri or Google Now) can be used to control IVI apps.
3. The built-in infotainment system becomes a second display for smartphone apps, using APIs, or by mirroring the smartphone app on the in-car display.

The innovator in this approach among car manufacturers is Ford, who recently open-sourced its AppLink system as SmartDeviceLink. It competes with Mirrorlink (roots in Nokia), a standard driven by the Car Connectivity Consortium (CCC). Recently, two main smartphone platforms have joined: Apple with CarPlay and Google with the Open Automotive Alliance (OAA).

Third, as regards the option of remote access to the vehicle through an API, modern examples of services include (see Vision Mobile (2014a)):

- Remotely lock your car by smartphone app.
- Locate your car in a parking lot by honking or flashing the lights.
- Automatically adjust your car setting (e.g. seat positions) based on driver profiles stored on a smartphone.
- Pre-heat or pre-cool the car (depending on where you live) before you leave.
- Integrations with home automation or other Internet of Things systems.

Vision Mobile (2014a) suggests that in the near future, vehicle APIs can be used to actively control the car remotely enabling a new range of use cases. Notably, vehicle remote control enables car sharing services. This might lead to an entirely new way to approach car usage and ownership, leading to a fundamental change in industry structure.

And in the fourth approach, the application typically does not run "in the car" at all, but on a smartphone, in the cloud, on a computer, or on another device entirely. On-Board Diagnostics (OBD-II) ports generally do not provide a possibility to control the car, limiting the capabilities of over-the-top systems relative to OEM-driven ones.

2.4.3 Conclusions

The data show that mobile communications is a very dynamic and innovative market, and the popularity of mobile Internet services is constantly increasing, also due to the introduction of smartphones and tablets, as well as apps. These have revolutionised the user experience, and introduced mobile communications into even more areas of our lives, for

2.4. SOFTWARE AND MOBILE DIGITAL SERVICES

example through connected cars. Wireless Internet has already overtaken fixed broadband in terms of subscriptions in OECD countries and its role will become even more important as more users benefit from high 4G (LTE) speeds. Intelligent mobile tariffs (such as pricing by mobile Internet speeds rather than data volume), when adopted by a wider number of mobile operators in more countries, should render high-speed mobile Internet even more attractive for mobile users and contribute to the development of the truly ubiquitous Internet.

Chapter 3

Innovation Theory: Traditional Approaches and New Developments

3.1 The Nature of Innovation and Innovative Process

Before starting a detailed discussion of national and international innovation policy issues in the mobile communications market, it is crucial to understand what lies behind the term of innovation, to analyse its properties as well as to outline briefly main stages of the innovation process.

3.1.1 Typology of Innovation

Edquist and Hommen (2008, p. 8), based on Schumpeter (1911), define innovations as "*new creations of economic significance, primarily carried out by firms (but not in isolation)*". They exist as product or process innovations. Product innovations are new or improved material goods as well as new intangible services - in this case *what* is produced is important (Edquist and Hommen, 2008). Process innovations are defined by Edquist and Hommen (2008) as new ways (technological or organisational) of producing goods and services - it is a matter of *how* things are produced.

Three types of innovation can be distinguished based on the degree of novelty of the product: incremental, standard and radical innovation (Grupp and Maital, 2001). This approach focuses on product features, i.e. that a product, service or process is defined as a finite collection of characteristics or attributes, all of the measurable in either physical or ordinal units. In this case any product X can be represented simply as a vector of attributes:

$$X = [x_1, x_2, \dots, x_n]. \quad (3.1)$$

In an incremental innovation a new version of an existing product has some or all of its existing attributes improved. Then the product vector would look as follows:

$$X^* = [x_1^*, x_2^*, \dots, x_n^*], \text{ all } x_i^* = c_i \cdot x_i, \text{ some } c_i \neq 1, \quad (3.2)$$

where x_i^* is the new value of attribute i and c_i is a vector of scalars, showing the proportion of change in each product feature. An example of this type of innovation can be a mobile phone for seniors with bigger keys and display signs.

A standard innovation differs from an incremental innovation in a way that one additional attribute that did not previously exist is added to the product, while existing attributes may or may not be improved. Thus, it has the following vector of attributes:

$$X' = [x'_1, x'_2, \dots, x'_n, x'_{n+1}], x'_i = c_i \cdot x_i, \quad (3.3)$$

where x_{n+1} represents a new product attribute that did not exist before. A standard innovation would be for instance the addition of a photo camera to a mobile phone.

In a radical innovation k significant new attributes which did not exist are added ($k \geq 2$), therefore creating a completely new product:

$$X^o = [x_1^o, x_2^o, \dots, x_n^o, x_{n+1}^o, x_{n+2}^o, x_{n+3}^o, \dots, x_{n+k}^o], x_i^o = c_i \cdot x_i. \quad (3.4)$$

An example for this kind of innovation would be the launch of iPhone featuring the unique design, multi-touch screen and a previously unknown system of applications. These attributes were not comparable to the existing attributes of ordinary mobile phones.

R&D programmes aiming to produce a radical innovation are usually much more costly and risky than the incremental-innovation R&D because they often require introduction of new technologies while at the same time the reaction of the market to a completely new product is hardly predictable. This reasoning will play an important role later on when we will be developing suitable innovation policy options for the mobile communications market.

Also, often a distinction is made between "*creation*" and "*diffusion*" of innovations, based on a distinction between innovations that are "*new to the market*" (globally new) and innovations that are "*new to the firm*" (being diffused to additional firms, countries or regions)(Edquist and Hommen, 2008, p. 8). According to Edquist and Hommen (2008, p. 8), these "*new-to-the-firm*" innovations are used as a measure of innovation diffusion, which for many small countries is more important than the creation of completely new innovations.

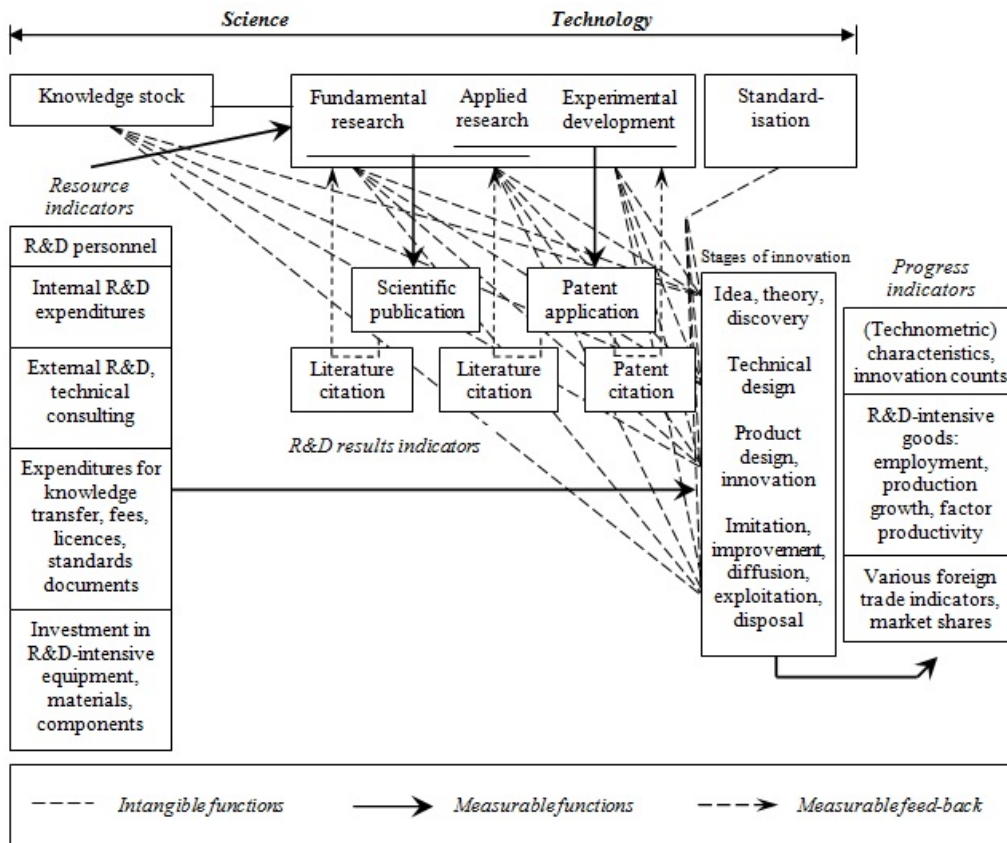
3.1.2 Innovative Process

For a deeper understanding of the innovation it is also essential to consider it as a process involving many actors and interdependences between them. This complex construction can be best represented by the "stages" model of the innovation process of Grupp and Maital (2001, p. 171), in which, first, economic inputs (e.g. R&D spending) generate science and technology outputs (such as publications, citations, and patents), and second, these science and technology outputs in turn serve as inputs generating knowledge-based exports (see Figure 3.1). This model further defines six different phases or functions of

3.1. THE NATURE OF INNOVATION AND INNOVATIVE PROCESS

the product development: theory and model development, technical realisation, industrial development, innovation and imitation, diffusion and finally utilisation. Each stage of the model is characterised by inputs and outputs. It is important to stress that the model is highly recursive because the outputs of one stage become the inputs of the following stages. Moreover, this model suggests indicators to measure the success of each stage of the process.

Figure 3.1: Stages of research, development and innovation, and corresponding science and technology indicators



Source: Grupp, 1997, p. 145; Grupp and Maital, 2001, p. 171.

The initial stage of the innovative process, theory and model development uses R&D spending as its input. This stage, which also belongs to the fundamental and partially to applied research, generates scientific outputs in the form of publications and citations of publications. The next two stages, involving the development of a technical and a product design, build on scientific expertise, as expressed in scientific publications and citations, to generate patent applications. Both publications and patent applications are widely used as R&D results indicators and data are available for different fields of science and different groups of products. As argued by Grupp and Schmoch (1999), patent data can provide a researcher with extremely useful information, for instance if a product is intended for a domestic or international market. However, the data should always be treated carefully and the aim of the analysis must be taken in to the consideration.

At the innovation and imitation stages, technology (as expressed in patents) is used to generate products, processes and services. The quality of these results can be measured by the "technometric" approach (Grupp, 1997). Finally, at the diffusion and exploitation

stage, the product and process quality is transformed into the indicators of export sales and global market share. Detailed data on exports are also usually available allowing assessment and comparison of the innovation performance of countries in different economic sectors. Grupp and Maital (2001) emphasise that this model is not necessary linear nor rigidly sequential, which means that some stages may be skipped for some products and processes while for others the sequence may differ from the one described (e.g. patents may precede publications and citations).

3.1.3 Properties of Innovation

Nowadays, the interest towards innovation and its role in the economic development is tremendous. Although we have already given several definitions of innovation, one should not forget that its properties and characteristics change over time reflecting the current knowledge base as well as the technological change in the society. Therefore, the innovation in the time of Leonardo da Vinci was in some aspects very different from the innovation at our age of information economy. Dosi (1988) defines five major properties of contemporary innovation. First, innovation always involves a fundamental element of "*uncertainty*" meaning that innovative activities must involve certain unexploited technical and economic opportunities. Of course, these opportunities can under circumstances turn into threats because when an innovation is introduced to the market it is impossible to precisely trace all consequences, positive as well as negative.

Second, modern innovation increasingly relies on advances in scientific knowledge. Indeed, 20th century technological innovation has been increasingly profiting from the advances in basic research. For example, the development of quantum physics has brought about computers, optic cables, lasers and the Internet. Moreover, scientists are now working on a quantum computer that in the case of success would mean a whole new era of data processing at currently unimaginable speeds. Third, the nature of research activities themselves has changed over the 20th century: research and innovative activities have become more complex and therefore require formal organisations, such as firms' R&D laboratories, government laboratories and universities, instead of individual innovators.

The fourth major feature of innovative activities is the fact that today a significant amount of innovations originates through "*learning-by-doing*" and "*learning-by-using*" (Rosenberg, 1976, 1982). It means that people and firms now tend to learn how to use, improve or produce things through "*informal*" activities rather than through formal search activities in R&D laboratories (OECD, 1999a). However, the ratio between formal R&D and "*learning-by-doing*" can vary from sector to sector.

Last but not least, Dosi (1988, p. 223) argues that technical change cannot be described as simple reactions to changes in market conditions, because the directions of technical change often seem to be defined by the level of technologies already in use. Besides, quite often it is the nature of technologies that defines "*the range within which products and processes can adjust to changing economic conditions*" and the probability of making technological advances in firms, organisations or countries is among other things "*a function of the technological levels already achieved by them*". All this leads to a conclusion that technical change is a "*cumulative activity*".

In addition to these five features of innovation we can define several more. The first aspect is that, as stressed by OECD (2005), innovation should not be regarded as a purely technological phenomenon because it involves both technological and non-technological changes influencing economic and social development. It is especially true if one takes

into consideration the phenomenon of "*tertiarisation*" (i.e. the increasing role of the service sector of economy) that enhances the role of non-technological innovation (Klodt et al., 1997). In the new conditions knowledge is regarded as a central resource. This approach changes the innovation process it becomes a process of knowledge acquisition allowing its economic utilisation (Hipp and Grupp, 2005). Typical feature of service innovations is for example the fact that the innovation process is very rapid. At the same time service innovations are more easily copied, which requires a continuous innovation process. This trend affects mobile communications in two ways: on the one hand the specifics of service innovations apply also to mobile digital services and should be taken into consideration when developing innovation policy options in this sector; on the other hand, mobile communications technologies themselves play an important role in the innovation process of service companies.

We can also add briefly - it will be discussed in more detail in the next chapters - that innovation is an interactive process involving both market (e.g. firms) and non-market (such as education establishments and state regulatory agencies) institutions (OECD, 2005). Even more crucial is an observation that purely market mechanisms often do not suffice for efficient innovative process because, as it was mentioned before, innovation involves an element of "*uncertainty*" and private companies might in some cases prefer not to invest in innovation if it seems too risky. In such cases incentives created in the context of the state innovation policy are especially important in promoting innovation activities.

3.2 The Role of Innovation System in the Knowledge Economy

The term "*knowledge economy*" Klodt (2003, p. 10) also refers to it as the "*new economy*") is used to describe the new economic environment in which knowledge and innovation replace capital as the primary factor of production. This leads to the increasing role of information generation, processing and distribution, and hence, augments the significance of information and communication technologies. In fact, the creation and use of knowledge is not only focused on high-technology sectors (e.g. electronics or pharmaceuticals), but also is getting increasingly important in traditional sectors such as agriculture (Goel et al., 2004). In order to stay competitive on the international level, each country should manage this transition towards the knowledge-based economy. According to Goel et al. (2004), here is where the national innovation system comes into play because knowledge is transformed into goods and services through the innovation system. Therefore, national innovation system can be regarded as an important criterion when it comes to the comparison of countries' innovative performance, and as the first policy target if the innovative performance needs to be improved. Further we will explain the concept of innovation system in more detail.

The conception of innovation system (IS) emerged in the late 1980s and started to diffuse more rapidly in the early 1990s. Its development has largely been the work of economists who adhere to an evolutionary theory of economic growth (Freeman and Perez, 1988; Lundvall, 1988, 1992; Nelson, 1988, 1993; Carlsson, 1995; Edquist, 1997b; Mowery and Nelson, 1999; Nelson and Nelson, 2002). Nelson and Nelson (2002, p. 265) stress that the innovation system idea is an "*institutional conception*", in which insti-

tutional structure plays an important role in supporting and shaping efforts to advance technology. Moreover, Freeman and Perez (1988) and Freeman and Louca (2001) have proposed that the key technologies of different eras require different sets of supporting institutions. It suggests that the successful countries of each era either already have the appropriate institutions in place when they are needed or manage to build the required new institutions quickly and well (Nelson, 2008).

Edquist (1997a) and Edquist and Hommen (1999) point out nine characteristics of innovation systems approaches:

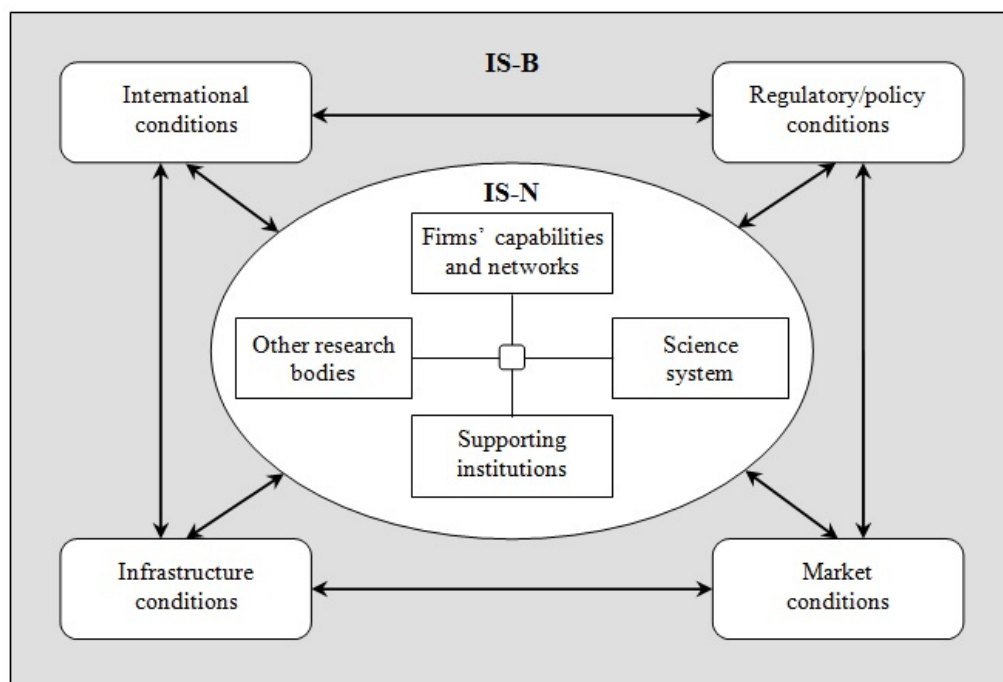
1. Innovation and learning process are placed in the middle of focus. Here technological innovation is regarded as a matter of producing new knowledge or combining existing elements of knowledge in new ways.
2. These approaches adopt a holistic (i.e. encompassing a wide array of the determinants of innovation) and interdisciplinary (i.e. besides economic, they include organisational, political and social factors) perspective.
3. They employ historical perspectives because innovation processes develop over time and include the influence of many factors and feedback processes.
4. The differences between national innovation systems rather than the optimality of these systems is stressed. This means that these approaches do not try to develop an ideal or optimal innovation system to compare the real systems with, but rather directly compare existing innovation systems of different countries.
5. Interdependence and non-linearity are stressed. This is based on the opinion that firms almost never innovate in isolation but rather interact with other organisations in the context of established institutions such as laws, rules, regulations, norms, and cultural habits (Edquist and Johnson, 1997).
6. They enclose product technologies and organisational innovations (i.e. the concept of innovation is not restricted to the conventional focus on process innovations of a technical nature).
7. The central role of institutions is emphasised.
8. These concepts are still rather diffuse and require clearer specification (Edquist, 2004).
9. They are "*conceptual framework*" rather than "*formal theories*", which means that at the current stage of development, the concepts of innovation systems are not yet capable of formal theorising and thus the empirically based "*appreciative*" theorising is accentuated (Edquist and Hommen, 1999, p. 66).

Since the concept of innovation system is quite young, there is still no one single definition of the term "innovation system" and different economists suggest different approaches. As discussed elsewhere (e.g. in Edquist, 1997b), the term "*national innovation system*" emerged first when it was first used in published form by Freeman (1987). According to his definition, national system of innovation is "*the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies*" (Freeman, 1987, p. 1). Later, Nelson and Rosenberg (1993, p. 4)

3.2. THE ROLE OF INNOVATION SYSTEM IN THE KNOWLEDGE ECONOMY

understand the concept of IS as "a set of institutional actors that, together, plays the major role in influencing innovative performance", while Lundvall (1992, p. 10) argues that "the structure of production" and "the institutional set-up" are the two most important dimensions that "jointly define a system of innovation". In this context certain authors (e.g. Edquist and Hommen, 2008; Gu and Lundvall, 2006) distinguish between "narrow" and "broad" IS approach - the "narrow" perspective including only the actors taking part in research and development and the "broad" perspective considering all the complex socio-economic system, such as infrastructure, international conditions and policy that are not directly connected to R&D (see Figure 3.2).

Figure 3.2: A scheme of innovation systems: a broad and narrow perspective



Source: Adapted from OECD, 1999, p. 23; Gu and Lundvall, 2006, p. 294.

However, this division into "narrow" and "broad" approach seems quite artificial because although Edquist and Hommen (2008, p. 5) suggest that Nelson (1993) "advanced a more narrow approach, focusing on national R&D systems and organisations supporting R&D as the main source of innovation", Nelson and Rosenberg (1993, p. 5) underline that the "broad concept of innovation" that they have adopted has forced them "to consider much more than simply the actors doing research and development". Because it is extremely important to consider all the possible actors influencing the innovation process, I prefer the "broad" concept suggested by Edquist and Johnson (1997, p. 14) where a system of innovation includes "all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion and use of innovations". This view corresponds also to the "broad" perspective depicted in Figure 3.2.

Initially, a national perspective dominated the systems of innovation approach (Lundvall, 1992; Nelson, 1993). However, already Nelson and Rosenberg (1993, p. 5) start to reflect whether the concept of "national" system is not too broad in the age of globalisation when a number of institutions are or act transnational (e.g. multinational companies, EU regulations etc.). That is why regional and sectoral innovation systems have sub-

sequently gained attention of researchers (e.g. Edquist, 2003). I adhere to the opinion of Edquist (2003, p. 2) that "*national, regional and sectoral systems of innovation co-exist and complement one another*". For future analysis it is important to understand that innovation systems may be supranational, national or subnational (regional or local), and simultaneously they may be sectoral within any of these geographical demarcations (Edquist, 2003). Indeed, on the one hand, institutions supporting innovation in one field, say in pharmaceuticals, may very little overlap with those supporting innovation in telecommunications here in certain cases a sectoral approach is required. On the other hand, regardless of the increasing internationalisation, national governments still prefer to keep control over certain domains and even if those fields are not directly connected to innovation, they still may influence the innovation process (think about the "*broad*" SI perspective).

After giving definition of innovation system, we should have a closer look at its elements. Edquist (2003, p. 2) and Edquist and Hommen (2008, p. 7) see different organisations and institutions as main "*components*" or "*elements*" of systems of innovation. Organisations are defined as formal structures that are consciously created and have an explicit purpose they are players or actors (Edquist and Johnson, 1997; Edquist, 2003; Edquist and Hommen, 2008). Organisations are for example companies, universities, R&D institutes and public innovation policy agencies. Under institutions Edquist and Johnson (1997) understand sets of common habits, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organisations. Examples of these "*rules of the game*" are patent laws and rules influencing the relations between universities and firms (Edquist, 2003, p. 2).

Organisations are strongly influenced and shaped by institutions they can be said to be "*embedded*" in an institutional environment consisting of norms, standards, etc. On the other hand, since there are firm-specific practices (e.g. bookkeeping or management structure), one can suggest that certain institutions also develop inside firms, meaning that institutions may be in turn embedded inside organisations. This leads to very complex relations between organisations and institutions that are often characterised by "*reciprocity*" (Edquist, 2003, p. 4).

Another important aspect is interactions between different organisations within the innovation system because obviously firms do not innovate in isolation but rather interact with other organisations (e.g. universities, R&D laboratories). These interactions are crucial for the development of innovations because they enable knowledge and information transfer from one actor to another. Edquist (2003) underlines that the relations between organisations may be of a market and non-market kind, which means that purely markets mechanisms often do not suffice for establishing efficient knowledge transfer. This implies the importance of stimulation of non-market collaboration as a part of national innovation policy.

The most valuable feature of the systems of innovation approach is that it has direct implications for the innovation policy on the national, sectoral or any other of the described levels. Here is the list of its general policy implications as suggested by Edquist (2001):

1. Organisational actors and/or institutional rules might need to be created, redesigned or abolished.
2. Innovation policy should focus not only on the elements of the innovation system, but also on the relations between them.

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3. Innovation policy should ensure that negative lock-in situations (i.e. when innovation process of an organisation becomes dependant on one particular actor) are avoided.
4. Changes in the production structure should be facilitated.
5. Innovation policy should support structural changes in the direction of production sectors dominated by product innovations rather than process innovations.
6. Innovation policy should be proactive, supporting emergence of new product areas and new sectoral systems of innovation.
7. Innovation policy should focus on the early stages in the development of product innovations and new sectoral IS.

The main or "*overall*" function of innovation system is to pursue innovation: to develop, diffuse and use innovations (Edquist, 2003; Edquist and Hommen, 2008). For further analysis and comparison of national innovation systems it makes sense to adapt the "*activities-based*" approach as discussed in Edquist (2004), Edquist and Chaminade (2006) and Edquist and Hommen (2008, p. 7), where under "*activities*" they understand "*factors that influence the development and diffusion of innovations*". This approach uses more dynamic perspective because it focuses strongly on what happens in the system rather than only on its constituents, and as we have already seen earlier the interactions between organisations are very important for the innovation process. A hypothetical list of ten activities is described in more detail in Edquist and Chaminade (2006):

I Provision of knowledge inputs to the innovation process

- 1 Provision of R&D and, therefore, creation of new knowledge.
- 2 Competence building through educating and training the labour force for innovation and R&D activities.

II Demand-side activities

- 3 Formation of new product markets.
- 4 Expressing quality requirements emanating from the demand side with regard to new products.

III Provision of constituents of innovation system

- 5 Creating and changing organisations needed for development of new fields of innovation (e.g. enhancing entrepreneurship, creating new research organisations and policy agencies etc.).
- 6 Networking through markets and other mechanisms, which implies integrating new knowledge elements developed in different spheres of IS.
- 7 Creating and changing institutions (e.g. patent and tax laws, environment and safety regulations, R&D investment routines)

IV Support services for innovating firms

- 8 Incubation activities such as providing access to facilities and administrative support for innovating efforts.
- 9 Financing of innovation processes and other activities facilitating commercialisation of knowledge and its adoption.
- 10 Provision of consultancy services relevant for innovation processes, for instance technology transfer, commercial information and legal advice.

It should be mentioned that these activities are not ranked in the order of importance and the list is structured in four thematic categories.

3.3 Sectoral System of Innovation for Mobile Communications

3.3.1 Definition and Framework

Sectoral innovation system (SIS) can be defined as a *"system (group) of firms active in developing and making a sectors products and in generating and utilising a sectors technologies"* (Breschi and Malerba, 1997, p. 131). According to a broader definition suggested by Malerba (2002, p. 250), a sectoral system of innovation is *"a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products"*. Edquist (2003) suggests that the boundaries of every SIS are defined by specific technologies or product areas.

According to Malerba (2002) the basic elements of a SIS are:

1. Products.
2. Agents: firms and non-firms organisations (e.g. universities, financial institutions, central government, local authorities), individuals.
3. Knowledge and learning processes it is based on the understanding that the knowledge base of innovative activities differs across sectors and greatly affects the innovative activities.
4. Basic technologies, inputs, demand and the related links and complementarities.
5. Mechanisms of interactions both within firms and outside firms there are both market and non-market interactions between actors.
6. Processes of competition and selection.
7. Institutions (i.e. standards, regulations, labour markets etc.).

In a sectoral system of innovation, the purpose of agents (organisations) is to perform certain functions in order to ensure that all the system works smoothly and efficiently. Edquist (2003b) specifies the following most important functions in the mobile communications sectoral system of innovation:

1. Developing equipment.

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2. Conducting R&D relevant for the further development of the SIS.
3. Providing relevant education and training.
4. Creating standards and other regulations that are important for the SIS.
5. Providing access (i.e. mobile telecommunications subscriptions).
6. Developing new services (e.g. mobile commerce, navigation services).
7. Providing consulting services.

As already mentioned above, these functions are carried out by organisations: certain organisations can carry out several functions but also one and the same function can be carried out by different organisations. The functions and corresponding organisations are summarised in the list suggested by Edquist (2003):

1. The development of equipment (today it is increasingly of a software kind) is done by telecommunications equipment producing firms, e.g. Motorola, Ericsson, HTC and Samsung.
2. These companies also carry out a large part of the R&D. Some R&D is carried out by universities and special research organisations.
3. Education is largely carried out by publicly controlled and funded organisations. Besides, firms also sponsor education and provide training. Additionally, learning-by-using and learning-by-doing are gaining importance.
4. There are organisations (mostly public) that create standards and regulations in order to decrease the degree of uncertainty for equipment producers and to coordinate their relations with other actors in the mobile communications SIS.
5. Access is provided by mobile system operators including incumbent mobile telecommunications operators (e.g. Telekom and Vodafone in Germany and NTT DoCoMo in Japan) and new entrant telecommunications operators (such as 1&1 or Congstar in the German market).
6. Access providers may also provide content to be transported by the systems, but there are also specialised content providers that own content but do not provide mobile Internet access (such as online magazines and newspapers, mobile games, music and video download, online shops etc.).
7. Finally, there are consultancy firms that offer various services related to the mobile telecommunications, for instance web design, development of platforms for electronic and mobile commerce etc.

Edquist (2003) stresses that that last twenty years have been characterised by increasing functional differentiation and organisational diversity in the mobile communications SIS, for example, monopolistic access providers no longer perform regulatory functions and new regulatory agencies were created. In addition, digitalisation has provided technological basis for separation between infrastructure, access and content services.

3.3.2 From NMT to LTE: The Way to Worldwide Success

NMT - Nordic Mobile Telephony Standard

The modern cellular telecommunications were born with the introduction of NMT 450, i.e. the Nordic mobile telephony standard based on the 450 MHz bandwidth (Edquist, 2003). This first generation standard began to be specified in January 1970 by the NMT group, in which the Nordic public telephone operators (PTOs), and particularly the Swedish PTO, played the leading role. NMT 450 was a fully automatic analogue standard with a roaming function within the Nordic countries.

The technical specifications were finalised between 1975 and 1978 and the implementation phase of the project began in 1977-1978 (McKelvey et al., 1998). As an instrument to initiate the development of equipment the mechanism of public technology procurement was used. It was Sweden's Ericsson who won the order to deliver switches to Sweden, Norway, Denmark and Finland. Due to the fact that NMT 450 was very specific, a network operator could buy components from different producers and put them together (Edquist, 2003). As mentioned by Edquist (2003), all in all it took ten years to specify this first mobile communications standard and get it functioning: NMT 450 was implemented in Sweden in October 1980 and in Denmark, Finland and Norway in early 1981. It is interesting to note that the very first country to implement this standard was actually Saudi Arabia in August 1980 (McKelvey et al., 1998).

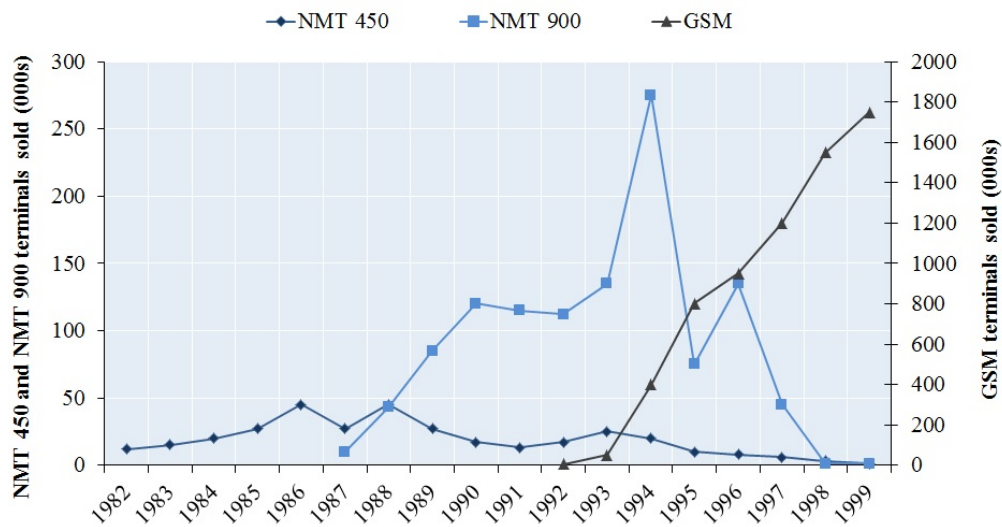
Since the NMT 450 became much more successful than expected with more subscribers joining than the standard could technically handle, the Nordic PTOs developed and added the NMT 900 (900 MHz) standard in 1986 (Edquist, 2003). This system was developed as an intermediary system between the NMT 450 and the GSM (originally from Groupe Spécial Mobile, now Global System for Mobile Communications) (McKelvey et al., 1998). The success of NMT 900 in Sweden was even bigger (see Figure 3.3) and already during the NMT era the Nordic countries had the highest mobile penetration rates 7 per cent in Sweden in 1992 against 2 per cent in the UK in 1990 despite its more extensive market liberalisation (Edquist, 2003). Edquist (2003, p. 22) suggests that the rapid penetration in Sweden was *"largely due to the consolidation of a strong market for mobile telecommunications via concerted action by the Nordic public telephone companies in defining the first-generation NMT standard and through low prices"*. For instance, the fixed subscription rates in Sweden were much lower than in the UK and Sweden's call charges were half of the call charges in the UK.

In the context of the sectoral systems of innovation approach, NMT 450 can be considered as an institution, i.e. it is a set of rules that decreased the uncertainty and risk for equipment suppliers and provided a cradle for the future development of pan-European mobile communications. Edquist (2003) underlines that when this institution was created it *"pulled"* the whole development of the new mobile communications technologies. Moreover, the development and implementation of NMT shows the importance of user-producer relation in innovation processes. According to Edquist (2003), the fact that the Nordic equipment producers Ericsson and Nokia were involved into the innovation process from the very beginning contributed greatly to their leading role in mobile communications equipment production nowadays.

It should also be mentioned that NMT was not the only mobile communications technology in 1983 the advanced mobile phone system (AMPS) developed by Illinois Bell Telephone, Bell Labs and Motorola was launched in the Americas. This standard was quite successful: it was diffused to a larger number of countries and had a larger number

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Figure 3.3: Number of terminals sold in Sweden, 1982-1999



Source: MobilTeleBranschen 1999 and 2001 (as cited in Hommen and Manninen, 2003, p 114).

of subscribers worldwide (Funk, 2002). Nevertheless, NMT in Nordic countries had the highest penetration rates in the world and was the basis for the GSM development, which became globally dominant in second-generation mobile communications (Lindmark and Granstrand, 1995; Edquist, 2003).

GSM - Global System for Mobile Communications

The GSM standard, operating in the 900 and 1800 MHz bands, was introduced in Europe in 1991 and soon became very popular all around the world. From the very beginning it was conceived as a "pan-European standard intended to cover many countries" (Edquist, 2003, p. 23). And the statistics of America's Network (1996) show that it really became a big success: first launched in 15 European countries, by 1996 GSM had over 21 million subscribers in 133 networks operating in over 105 countries in Europe, Africa, Australasia and the Middle East (as cited in Hommen and Manninen, 2003).

In the context of the sectoral system of innovation approach, the GSM standard is also an institution (Edquist, 2003). Its development occurred within the formal organisational framework provided by two European standards development organisations: CEPT (Conference on European Post and Telecommunications) and ETSI (the European Telecommunications Standards Institute). Since roaming that allows calls between the countries was one of the principal characteristics of GSM, its development required the involvement of greater number of national organisations than the NMT standard and a greater complexity in the relations among them.

Although monopolistic national PTOs had been dominant actors in the GSM development process the 1980s, by 1990s it became obvious that in order to achieve success in this complex project the cooperation of manufacturers was also of great importance (Hommen and Manninen, 2003). Hommen and Manninen (2003) suggests that this in turn leads to another important feature of the GSM standard: due to the fact that it was an "open" standard allowing producers to configure communications between the system's

components in different ways, the responsibility for system configuration shifted from network operators to equipment producers. In this development process Nordic equipment producers Ericsson (developed and tested the first prototype of a GSM system) and Nokia (produced the standard's base stations and switches) together with the Swedish PTO Televerket/Telia were very active, forming a "Nordic coalition". Edquist (2003, p. 25) states that this "contributed significantly to increasing impressive advantages already enjoyed by Ericsson, Nokia and other Nordic firms" in comparison to other equipment manufacturers.

It is interesting to note that the GSM system was actually based on technologies of non-Nordic origin - at least 82 per cent of the patents for the GSM standard belonged to non-Swedish firms (Motorola held 50 per cent, AT&T 16 per cent and Bull and Philips claimed 8 per cent each). A question arises why Motorola did not push its technology in the US. Hommen (2002) and Hommen and Manninen (2003) suggest that Motorola, first, felt unable to compete with European equipment producers in Europe and, second, perceived GSM as a European standard that would not necessarily develop into a world standard. By conditioning exclusive cross-licensing agreements with European equipment manufacturers Motorola gained significant revenue from the growth of GSM market (Bekkers et al., 2000; Hommen and Manninen, 2003). At the same time, the European cross-licensees benefited from this arrangement by becoming major suppliers for GSM (see Table 3.1).

Table 3.1: Estimated suppliers' market share of the 33 largest GSM networks in Europe (December 1996) and worldwide market share of GSM terminals in 1996

Supplier	Score switching	Market share switching	Score base stations	Market share base stations	Market share mobile terminals (worldwide)
Ericsson	10 297	48%	7 978	37%	25%
Siemens	4 426	21%	325	2%	9%
Nokia	3 086	14%	4 617	22%	24%
Alcatel	2 228	10%	2 084	10%	6%

Source: Bekkers and Liotard, 1999, Table 3 (as cited in Hommen and Manninen, 2003, p. 101).

The most important technical difference between the first and the second generation of mobile communications is that within the GSM standard digital technology was fully implemented, which created possibilities not only for voice but also for data transmission. The original data transmission rate was 9.6 Kbps but the introduction of GPRS (General Packet Radio Service) in the year 2000/2001 made possible data transmission at rates up to 115 Kbps. Data transmission within GSM was first introduced through SMS (Short Messaging Service) that became unexpectedly popular. Moreover, Internet access was also possible due to the development of WAP (Wireless Internet Protocol). The digitalisation of the second generation mobile communications also had significant impact on the development of new mobile services because it created a possibility of "decoupling services provision from transmission" (Pisjak, 1994, p. 292).

GSM had three main rival standards that have different technical specifications but

3.3. SECTORAL SYSTEM OF INNOVATION FOR MOBILE COMMUNICATIONS

similar functions: the US-based D-AMPS (Digital Advanced Mobile Phone System) and CDMA (Code Division Multiple Access) and the Japanese PDC (Pacific Digital Cellular) standard. D-AMPS was introduced by the US Cellular Telephone Industry Association (CTIA), which represented manufacturers of mobile telecommunications equipment, network operators and other users. Its compatibility with the first-generation analogue standard was supposed to facilitate the gradual shift from first- to second-generation technologies (Hommen and Manninen, 2003).

In contrast to the European telecommunications organisations, another relevant US regulatory agency, the Federal Communications Commission (FCC), decided there would be no national digital standard for the US as a whole and the operators were free to adopt any standard (Edquist, 2003). As a result, another digital standard CDMA emerged several years later attracting more operators. These two standards were not directly compatible with each other and both diffused relatively slowly in the US according to Edquist (2003), in 1997 the US mobile penetration rate was 20 per cent as opposed to 40-50 per cent in the Nordic countries. Edquist (2003, p. 26) argues that *"the slower diffusion of digital systems in the US was due to the presence of several standards and a weaker migration from the first generation to the second because of backwards compatibility"*. Additional factors slowing down the diffusion of the standards were roaming issues and the receiver pays principle adopted in the US (Hommen, 2002). For instance, the fact that the receiver has traditionally been charged in the US created an incentive for users to switch off the handsets and a disincentive to give out mobile numbers (Edquist, 2003). The diffusion of these two main US digital standards outside the country (in Latin America and Asia) was limited and they never became serious competitors to the European GSM on the international level (see Table 3.2).

Table 3.2: International competition among major second generation and other mobile communications standards: regions and market shares

	Europe	North America	Latin America	Asia	Africa
GSM	89%	4%	1%	35%	88%
D-AMPS		27%	39%	3%	
CDMA		9%	9%	14%	
Analogue	11%	60%	51%	48% ¹	12%

¹ 48% includes PDC and PHS Japanese digital cellular standards.

Source: ITU World Communications Database (as cited in Hommen and Manninen, 2003, p. 89).

The Japanese second generation digital standard PDC never diffused outside Japan and was incompatible with other standards. The PDC system was first introduced in Tokyo in 1993 by NTT DoCoMo. Due to the introduction of two further large digital cellular networks and high market competition in Japan, the prices for the PDC terminals and monthly call fees dropped considerably in 1995 (Hommen and Manninen, 2003). As a result, *"by the end of the year there were nearly nine million subscribers, with 60 per cent of them connected to digital networks"* (Garrard, 1998, p. 363).

As already mentioned before, the emergence of the GSM standard in Europe was marked by a much greater number of public actors, in contrast to the development of rival standards in the US and Japan. The biggest players were CEPT, which initiated the standard, and ETSI, which saw the standard through its completion (Hommen and Manninen,

2003). Hommen and Manninen (2003, pp. 90-91) stress that the creation of ETSI in 1988 marked *"a decisive shift from a closed to an open approach to developing standards"*. This period was also the beginning of the telecom liberalisation in Europe the formerly closed national markets were open to the international competition and the PTOs lost their monopoly privileges. As a part of the reformation process, separate regulatory authorities were created and new service providers emerged. Alliances between public- and private-sector actors became prevalent. According to Hommen and Manninen (2003), one of the important developments was the increasing role of public research organisation such as universities and research institutes, i.e. telecommunications equipment manufacturers began joint R&D with universities and research institutes rather than exclusively with PTOs. NUTEK (1997) suggests that equipment manufacturers such as Ericsson benefited from building up the competences of the universities because such cooperation allowed the recruitment of engineers (as cited in Hommen and Manninen, 2003).

In conclusion, Europe can be considered as a *"clear leader"* in the second-generation mobile telephony due to *"its success in defining standards"* (Hommen and Manninen, 2003, p. 123). However, despite the big success of the GSM standard there remained large disparities in subscriber penetration rates throughout Europe (see Figure 3.4). While the Nordic countries in 1997 attained remarkable penetration rates of 35.8 to 45.6 mobile subscribers per 100 inhabitants, some of the largest European economies, such as Germany and France, were well below the OECD average of 15.6 (OECD, 1999b). Hommen and Manninen (2003, p. 113), suggest several factors contributing to the rapid market growth in Sweden in comparison to other European countries. First, the initial penetration rate of the first-generation mobile communications (NMT) was much higher in Sweden. Second, the basic subscription rates in Sweden were much lower than in other European countries, which helped *"expand the market quickly to a size where it could "naturally" sustain lower pricing"*. And finally, the increased competition in the Swedish mobile communications market, instead of reducing already low subscription prices, helped *"reorient strategies for marketing services towards consumers and non-business users"*.

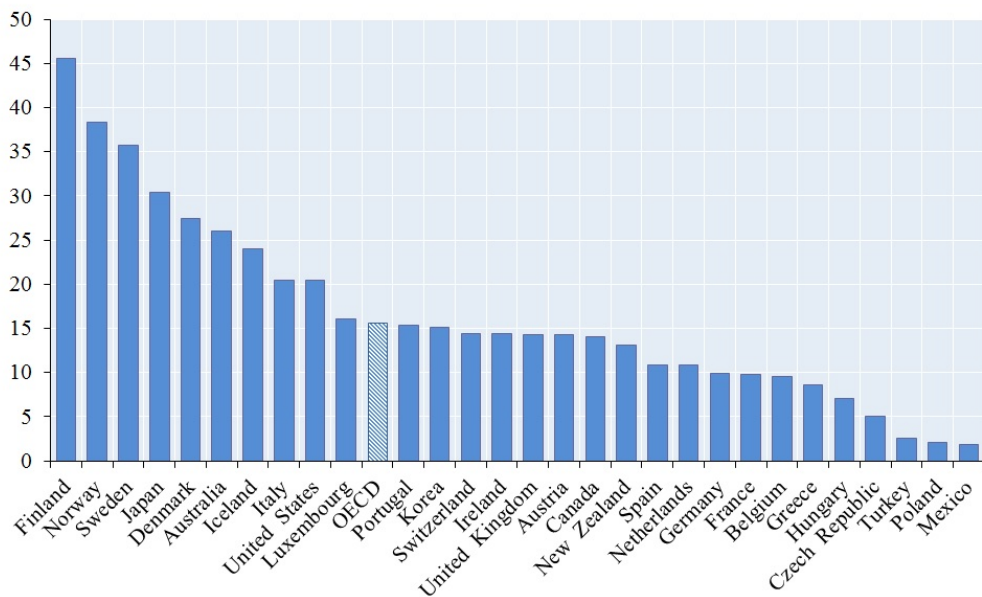
It can be stated that GSM was able to become a truly global mobile communications standard due to the close initial cooperation among numerous European and international actors. In contrast to the US with several competing technologies none of which could match the huge subscriber base of GSM, GSM was developed as a pan-European standard thereby securing a large initial market (Hommen and Manninen, 2003). In turn, the liberalisation of European telecommunications market and higher competition contributed to closer cooperation among public and private actors and to internationalisation of R&D. As suggested by Hommen and Manninen (2003), due to the complex technologies used in GSM, firms such as Ericsson started to pose much greater demand on national education systems for an adequate supply of skilled personnel. Because of their high involvement in the GSM development (it began already in the NMT era), both Nordic telecommunications equipment manufacturers Ericsson and Nokia became leading equipment producers for the GSM standard.

UMTS - Universal Mobile Telecommunications System

Although UMTS was first conceived in the late 1980s, Garrard (1998, p. 478) states that during the early 1990s *"progress on UMTS continued slowly and somewhat theoretically and was largely ignored by most of the cellular operators"*, who were more interested in growing their subscriber bases profitably within the 2G market (as cited in Hommen and

3.3. SECTORAL SYSTEM OF INNOVATION FOR MOBILE COMMUNICATIONS

Figure 3.4: Cellular mobile subscribers per 100 inhabitants, 1997



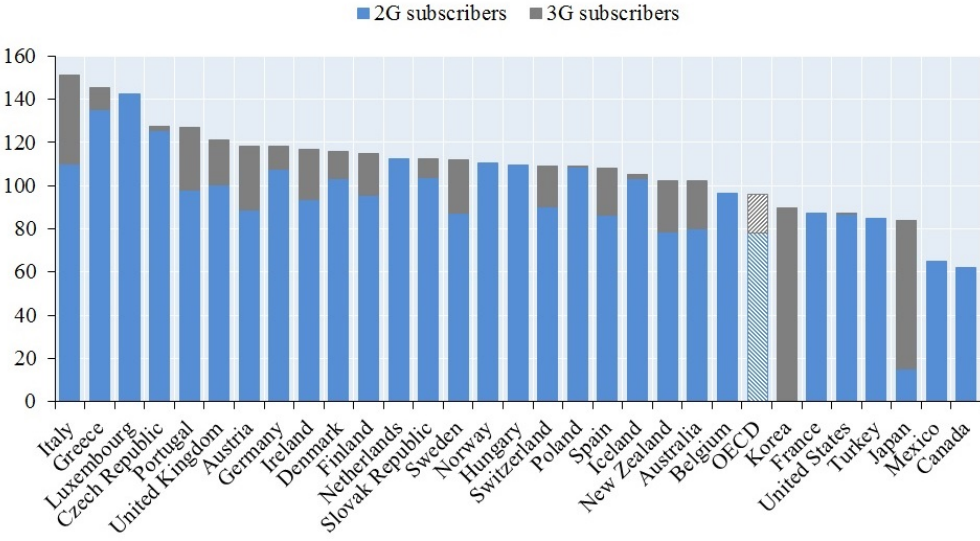
Source: OECD, 1999b, p. 68.

Manninen, 2003). The UMTS standard was officially approved by ETSI in 1998 and as its basis was taken the NTT DoCoMo's (i.e. Japanese) W-CDMA (Wireless Code Division Multiple Access) technology. According to Funk (2002), W-CDMA was chosen because the standard was believed to offer greater capabilities than an enhanced version of GSM (as cited in Hommen and Manninen, 2003). Hommen and Manninen (2003, p. 130) suggests that in contrast to GSM, the development of UMTS "was not driven primarily by the need to accommodate unexpectedly rapid growth in the number of mobile telephone subscriptions", but rather by the convergence of information and communication technologies, which created opportunities for new applications (e.g. mobile Internet) in mobile communications. Obviously, the adoption of W-CDMA as a UMTS basis was a major victory for Japanese manufacturers and its two European supporters Ericsson and Nokia. This and the official recognition by the ITU (International Telecommunications Union) made UMTS a global standard.

In comparison with the second generation technology, UMTS combines several important technical advances. First, it uses broadband instead of narrowband radio frequencies (in Europe mostly 2100 MHz); second, it fully integrates voice and data communications; third, it fully integrates fixed and mobile networks; and finally, it provides "seamless" global roaming (Hommen and Manninen, 2003; Edquist, 2003). UMTS peak downlink data rates of 384 Kbps (with low mobility even up to 2 Mbps) allow much faster data transfer in comparison to GSM and GPRS. As to the new handsets, according to Samukic(1998), they were supposed to have dual-band capabilities, enabling them to operate with both GSM and UMTS bandwidths (as cited in Hommen and Manninen, 2003). Another novelty was the evolution of SMS into MMS (Multimedia Messaging Service) allowing transfer of photos, graphics, animations etc.

A UMTS network was first put into operation by NTT DoCoMo in Japan in October 2001. In Europe, auctions for UMTS licences were held in many countries in 2000, during

Figure 3.5: Cellular mobile subscribers per 100 inhabitants, 2007



Note: Portugal's 2G data include both 2G and 3G subscriptions.

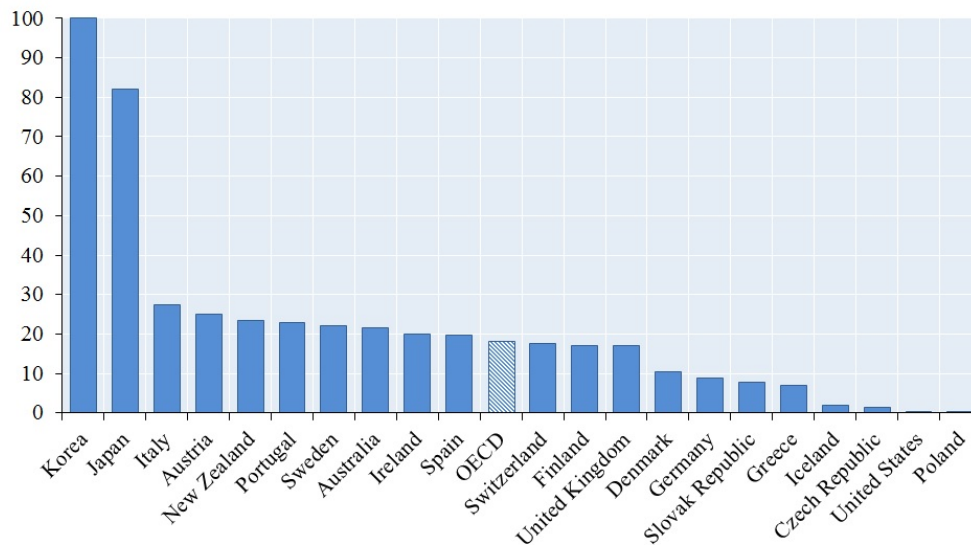
Source: OECD, 2009, p. 103.

which some operators agreed to pay enormous fees. Hommen and Manninen (2003) and OECD (2007) suggest that this has created lack of capital financing to build-out networks and was one of the obstacles to the diffusion of UMTS in Europe. The first European commercial UMTS network was launched in Norway in December 2001. However, the deployment of UMTS in Europe was not smooth compared to GSM and recent data from the OECD (2009) on penetration rates show that in the third generation mobile communications Japan and Korea (with a rival technology CDMA2000) have taken over leadership (see Figures 3.5 and 3.6). Partially, it can be explained by the fact that Japanese mobile users were familiar with mobile data services before the introduction of UMTS due to the operation of i-mode mobile Internet system (2.5G) since February 1999. Nevertheless, it does not explain why mobile data services (which were the reason for UMTS launch) per se are so much more popular in Japan than in Europe. According to Funk (2007), many Western analysts attributed the success of the Japanese mobile Internet to unique "cultural" aspects of the Japanese market such as the low PC Internet usage in Japan and the greater use of public transportation in Japan than in Europe. Funk (2007, p. 25), argues that "the early success of SMS in countries with high PC Internet usage like Scandinavia suggests that mobile Internet usage in Japan has little to do with low PC Internet usage and commuting by trains".

In order to explain the Japanese and Korean phenomenon, it might be helpful to have a closer look at the actors of mobile SSI. Interactions among the participants of the mobile communications market seem indeed to play an important role for the use of mobile technologies, as revised in detail by Syraya (2008). Indeed, Tee (2007) underlines that in this context relationships between the operator and other actors involved in the mobile telephony network (vertical network relationships) are of greatest relevance. Besides the network operator, there are two other organisations that can be part of the network: handset and equipment manufacturers (also known as vendors) and content providers. As regards the mobile telephony network structure, in Europe the number of operators

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Figure 3.6: 3G cellular mobile adoption: 3G subscribers as a percentage of total mobile subscribers, 2007



Note: Korea's 100 per cent penetration rate is due to the fact that Korea's early mobile technology, CDMA2000, was recognised as an official IMT-2000 (3G) technology by the ITU.

Source: OECD, 2009, p. 104.

greatly outnumbers the number of vendors (approximately 50 operators and about 6 vendors), whereas Japan has only three operators compared to a high number (more than 10) of handset manufacturers (Tee, 2007). In Japan, this ratio has favoured the operator in terms of bargaining power and, therefore, the Japanese operator can be thought of as a central organisation in the mobile telephony network. Firstly, it chooses the handsets to be released from the suppliers. Secondly, it can also set the technical requirements to which the phones must comply, which helps ensure that the phones' characteristics correspond to the data services provided. Thirdly, the operator has a degree of control over content providers, for instance through introduction of the micro-payment system that enables users to pay for services in a standardised, fairly secure way (Tee, 2007). Due to their central position in the mobile telephony network, "the Japanese and Korean providers were able to obtain phones that display content in a consistent manner because unlike Western service providers, they have always dictated phone specifications to the phone manufacturers" (Funk, 2007, p. 15). Besides, the Japanese operators still maintain large research and development labs and consequently, they are well aware of technical possibilities which allows them to use these more efficiently (Tee, 2007).

Tee (2007) argues that in contrast to the Japanese mobile telephony network, European vendors work very much independently from the wishes of operators and innovations done by vendor do not necessarily correspond with the interests of the operator. As the result, the take up of mobile data services has been much slower in Europe than in Japan and South Korea. Funk (2007) indicates several barriers to growth in the Western mobile Internet content market. Firstly, European manufacturers are still learning how to customise phones for the service providers and are still more likely to customise them for

large than small service providers. Secondly, while Japanese and Korean providers give more than 80 per cent of the content revenues to content providers thus creating greater incentives for content providers to develop content, few European service providers give more than 50 per cent of revenues to content providers. Third, Funk (2007, p. 26) argues that *"the high prices and profits from SMS have been a barrier to the implementation of push-based Internet mail and the promotion of access to general Internet sites"*. For example, at the end of 2003, the average price of SMS in Europe was about 15 times the price of receiving Internet mail in Japan and analysts have argued that the profit margins exceed 80 per cent on such messages even when fixed costs are included. Funk (2007, p. 18) also stresses that most European mobile service providers initially ignored low end users such as young people and their applications including SMS, entertainment content and push-based Internet mail and instead focused on high-end business users, which also leads to a slow development of mobile Internet services in Europe.

3.4 Innovation Diffusion in Mobile Communications: A Lead Market Approach

The lead market theory is quite different from the system of innovation approach as it focuses on international diffusion of innovation rather than on its generation. This will allow us to broaden our overview of innovation theories applicable for mobile communications.

3.4.1 Lead Market Advantages

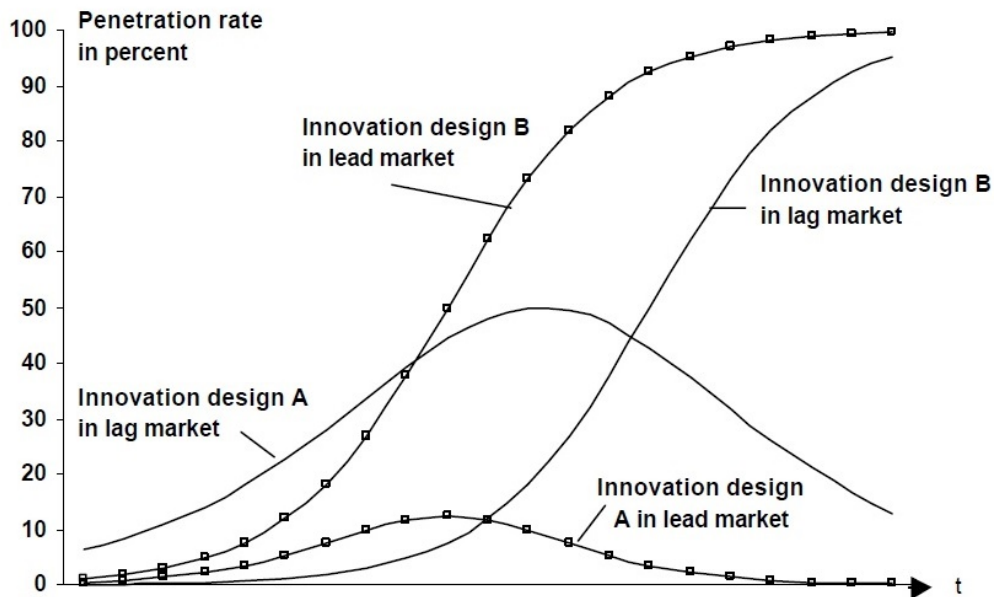
Beise (2004), Beise and Cleff (2004) and Beise (2006) define lead markets as regional markets with specific attributes that increase the probability that a locally preferred innovation design becomes internationally successful. It is also stressed that lead market is the country where a globally successful design first took off and not the country where it was invented, as one might think. For example, the principle of cellular mobile telephony was invented in the US by engineers of Bell Labs but the mass market emerged in Scandinavia. Other countries that adopt an innovation design later are defined as lag markets.

Beise (2004) and Beise and Cleff (2004) suggest the global diffusion of an innovation is usually accompanied by the competition of alternative innovations designs, each preferred by different countries (see Figure 3.7). For example before fax machine emerged in Japan, telex was adopted in many countries. Different designs are characterised as alternatives for the same need or function, and they therefore compete against each other on the world market. For instance, an IBM and an Apple computer are different designs of a personal computer.

As Figure 3.7 shows, over time, the innovation design B from the lead market pushes out the rival design A from the lag markets and becomes an internationally dominant design. Beise and Cleff (2004) stress that the lead market is not necessarily the most innovative market. Rather, a country is a lead market because its technology choice is followed by other countries. Hence, contrary to the technocentric discussion suggesting that it is the technical superiority of an innovation design that makes it successful, Beise (2006) argues that the society is one of the factors shaping the technological path through its preferences.

3.4. INNOVATION DIFFUSION IN MOBILE COMMUNICATIONS: A LEAD MARKET APPROACH

Figure 3.7: A generalised pattern of the international diffusion of innovations with competing designs



Source: Beise, 2004, p. 1000.

The lead market approach has an important implication for a company's innovation strategy because lead markets can serve as a "forecasting laboratory of the world market", as a "source of new global innovation ideas" (Beise, 2004, p. 1012). Thus, companies that develop an innovation to satisfy the demand of a lead market have more chances to succeed. And vice versa, manufacturers who have initially focused on a "wrong" innovation design will be forced to leave the market or to change to the lead market design (Beise, 2006). This leads a company to an important task - identifying lead markets for a specific product or technology.

Beise (2004), Beise and Cleff (2004) and Beise (2006) argue that lead markets can be characterised by five groups of lead market advantages, i.e. nation specific attributes that contribute to the leading role of the country. These five groups include:

1. Price and cost advantages:

Here, two possibilities exist. Either the price of the lead market design is initially lower in the lead market than in the lag market or the prices for an innovation design are the same in all markets, but still lower than the price of a rival design. Alternatively, a change in factor costs, e.g. labour, can contribute to a leading role of a country in a particular field. These advantages are expected to be one of the most important lead market drivers.

2. Demand advantages:

Countries at the forefront of an international trend anticipate demand that will later spread worldwide. Earlier, income level was an important contribution to the demand advantage. Today, complementary assets such as credit cards might play a role. However, it is often difficult to determine the general trend and demand

advantages are therefore considered to play a less important role than other lead market factors.

3. Transfer advantages:

It is the ability of a country to shape the preferences of other countries, which means that adoption of one innovation design in one country lowers the uncertainty associated with the innovation and stimulates the lag country users to adopt the same innovation. For example, the reputation and sophistication of users in one country can give a signal for the quality of an innovation design to users in other countries. Alternatively, an innovation design can be transferred from a lead market to other countries by its businessmen, tourists etc.

4. Export advantages:

Beise (2004) and Beise and Cleff (2004) suggest that certain local market conditions increase the exportability of innovation design. The three contributing factors are: first, when local market conditions are similar to those of foreign market; second, when domestic demand is sensitive to the needs of foreign countries, and, third, when local participants (e.g. institutions or users) put pressure on companies to develop exportable products.

5. Market structure advantages:

Beise (2004) stresses that more competition between domestic companies increases the likelihood that the local market will identify customers' preferences and a valuable innovation design that appeals globally because of its technical superiority, practicability or superior cost-benefit relation. Additionally, competition pushes costs down and makes a technology more price competitive against other innovation designs.

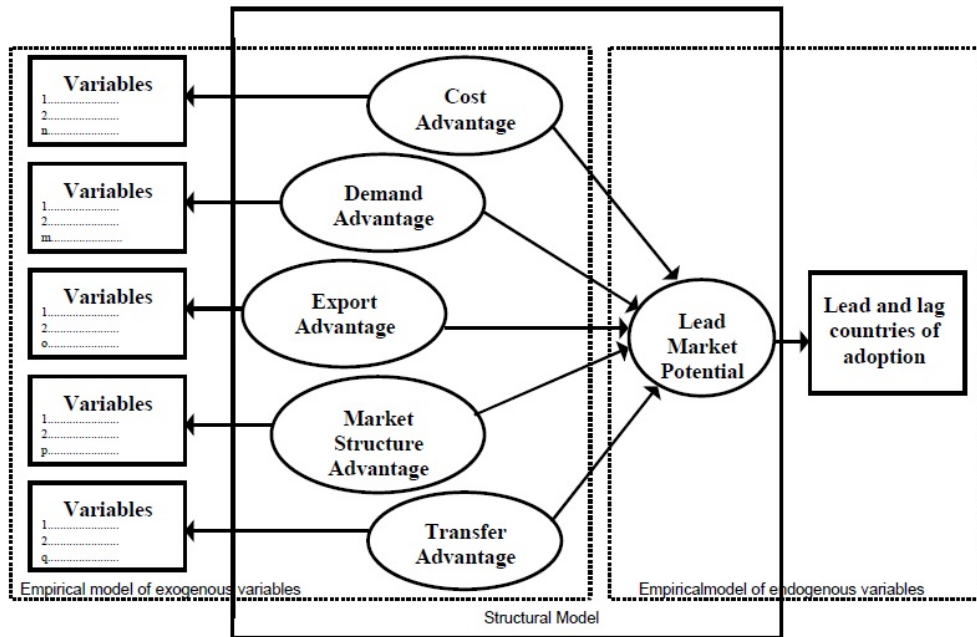
When it comes to determining lead markets for existing products, Beise (2004, p. 1013) suggests that they *"can be formally identified by gathering data on diffusion curves of an innovation in several countries"*. It is also argued that *"existing lead markets are likely to be lead markets for the next product generation as well"* (Beise, 2004, p. 1014).

For totally new innovation ideas, Beise (2004) argues, it should be established if lead markets are possible and what country (or group of countries) has the highest lead market potential. Beise (2004, p. 1014) stresses that *"lead markets can be expected in industries in which the internationalisation mechanisms are potentially large enough to overcome differences in preferences from country to country"*.

In order to assess whether lead markets exist and what countries are most likely to be lead markets, one should turn to the model of lead market analysis depicted in Figure 3.8, which is based on the five-factor scheme derived above. High values of lead market advantages would signal that lead markets are possible and the country with a much higher lead market potential than all other countries can be expected to be the lead market (Beise, 2004). Beise and Cleff (2004, p. 465) also note that *"lead market factors are all relative and not absolute variables, because the lead market potential results from the relative advantage of one country compared to other countries"*. The main task of the lead market analysis would be to find data for the exogenous variables that approximate the lead market factors for a specific innovation project (Beise, 2004; Beise and Cleff, 2004).

3.4. INNOVATION DIFFUSION IN MOBILE COMMUNICATIONS: A LEAD MARKET APPROACH

Figure 3.8: Structural and empirical model of the lead market analysis



Source: Beise, 2004, p. 1015.

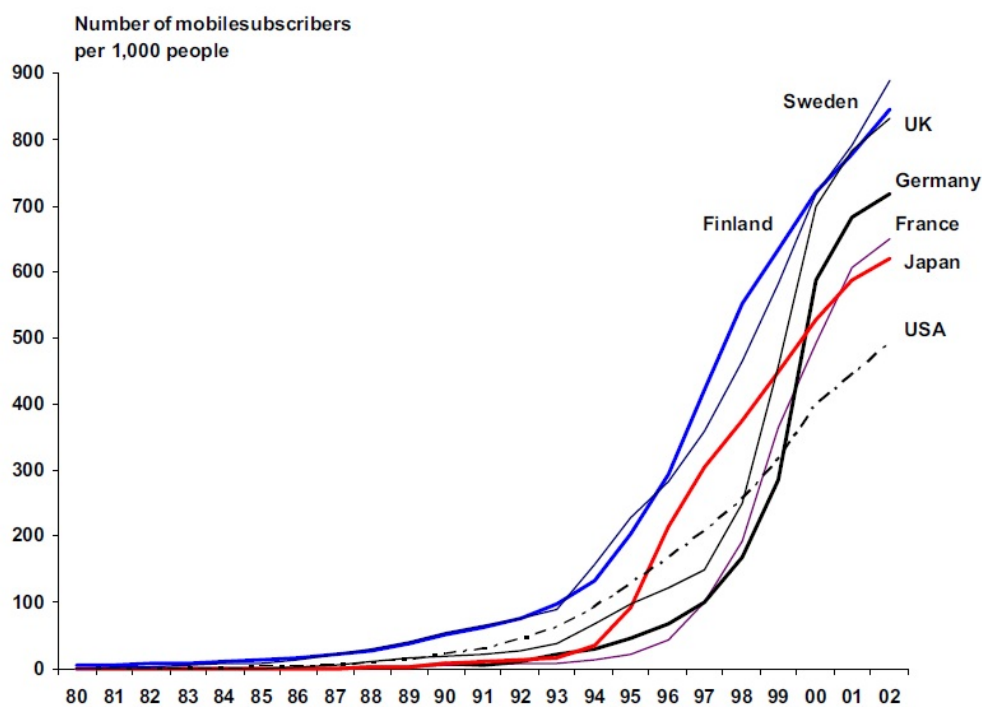
First, for the demand advantage one should identify a trend and a trend variable that can quantify how far each country is positioned within the trend. Second, the price advantage is marked by cost reduction effects, which can be approximated by market size and the anticipatory factor price effect. Beise (2004) suggests that for the latter, factor cost trends related to the innovation have to be identified, e.g. labour costs are frequently related to innovation in automation, and innovations that increase energy efficiency are related to the price of energy. In a case of a decreasing factor price trend, the country with the lowest factor price is the country with the highest lead effect (ibid.). Third, Beise (2004) argues that in order to quantify the export advantage variables, the export orientation of a country has to be found. Here, the export share of customer or supplier industries of a country can be an indicator of the pressure on companies to develop exportable innovations. Fourth, as regards the market structure effect, one can use indicators of the degree of competition such as concentration ratios or entry barriers (ibid.). Finally, Beise (2004) notes that the transfer advantage is most difficult to quantify because while the transfer effect of multinational firms can be approximated by data on direct investment, data on the reputation and attention a country receives world-wide is limited. In such cases asking experts or conducting special consumer surveys become necessary in order to estimate the factor for each country.

In order to derive a single index for the lead market potential of countries (the endogenous side of the model in Figure 3.8), the value of all indicators for each country must be aggregated. Beise (2004) stresses that there is no theoretically correct aggregation method and it is therefore advisable to use several methods and compare the resulting ranking of countries according to their lead market potential. The country that consistently obtains the largest value for lead market potential is most likely to become the lead market for a selected innovation (ibid.).

3.4.2 Defining Lead Markets in Mobile Communications

According to Beise (2004, p. 1007), "the global success of cellular mobile telephony has the typical characteristics of a lead market model". Beise (2004) and Beise (2006) suggest that Nordic countries are lead markets for cellular mobile communications. Indeed, although mobile cellular communication was invented in principle in the 1940s and realised in the 1970s by Bell Laboratories in the United States, we have already established that the first generation network (NMT) that built on this pioneering work was first launched in Sweden. It enjoyed tremendous success and penetration rates in Nordic countries were much higher than elsewhere. After the launch of the second generation mobile network (GSM) Nordic countries have also attained highest penetration rates (see Figure 3.4). Finally, the diffusion curves in Figure 3.9 clearly show the leading role of Sweden and Finland in mobile telephony adoption between 1980 and 2002.

Figure 3.9: Diffusion of cellular mobile telephony in several countries, 1980-2002



Source: Beise, 2004, p. 1007.

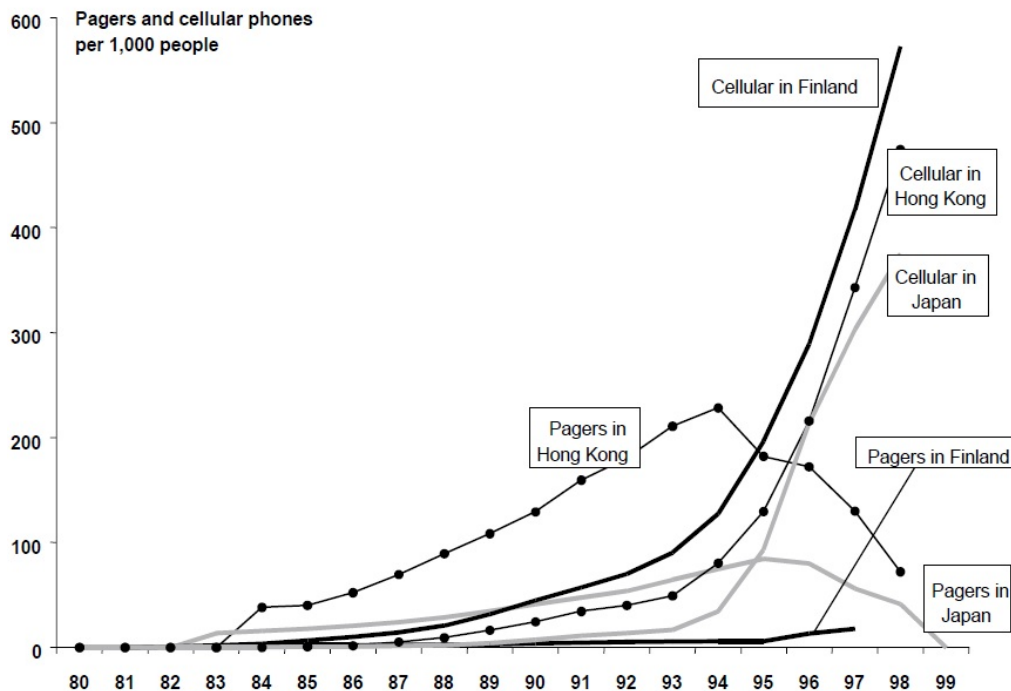
Beise (2006) argues that cellular mobile telephony did not result from a straightforward development of mobile technologies. Rather, it managed to prevail over rival innovation designs, such as pagers, satellite telephony and cordless telephones. Figure 3.10 depicts the international competition of pagers (passive receivers of messages) and mobile telephony - over time, even in Hong Kong and Japan where pagers were originally preferred to mobile phones, cellular mobile telephony managed to push out the rival technology from the market. On the other hand, in Finland, where mobile telephony was very popular from its very beginning, pagers have never managed to achieve wide adoption.

Beise (2004) suggests that the lead market role of Nordic countries in the case of mobile telephony can be explained by the following lead market advantages:

1. Price advantages:

3.4. INNOVATION DIFFUSION IN MOBILE COMMUNICATIONS: A LEAD MARKET APPROACH

Figure 3.10: Number of subscribers to pager and cellular services in Finland, Hong Kong and Japan 1980-1999



Source: Beise, 2004, p. 1008.

(Beise, 2006) stresses that competition among telecom providers in Nordic countries was high from the very beginning. This resulted (as confirmed by Edquist (2003)) in the lowest prices for mobile telephony in Nordic countries, which in turn contributed to the emergence of a mass market. In contrast, mobile network operators in other countries aimed at a more exclusive market segment with high subscription and call rates. The emergence of a mass market offered cost advantages and rapid market growth in Nordic countries and paved the way for international success of the European GSM technology.

2. Demand advantages:

Beise (2004) argues that while global trends are responsible for the internationalisation of a number of global innovations, a demand trend is not really necessary for the international success of innovations because there are other possible internationalisation mechanisms. In the case of mobile cellular technologies Beise (2004) is not sure which international trend led to their tremendous success in the 1990s and if there was such a trend at all.

3. Transfer advantages:

According to Beise (2004), in the case of cellular mobile telephony three transfer advantages can be observed: first, the maturity of a standard reduces the risk of adoption for other countries, second, domestic users transfer demand for a specific mobile service abroad and, third, a non-proprietary standard increases the benefit for telecom firms abroad. As regards the first advantage in the case of GSM technology, the fact that GSM standard was from the very beginning conceived as a

pan-European one and that GSM service was commercially available in 1992 and was accepted by a rapidly growing subscriber base has increased the reliability of the standard for other countries. The second transfer advantage of the GSM standard is its technical feature of international roaming, which facilitated the transfer of GSM technology abroad as businessmen and tourists from Europe were ready to pay more for this technical feature than the domestic subscribers. And third, as suggested by Paetsch (1993, p. 287), the non-proprietary status of GSM standard ensured higher competition in the telecom sector because several (and even small) equipment manufacturers could participate in the GSM components market (as cited in Beise, 2004).

4. Export advantages:

Beise (2004) argues that one of the export advantages of Nordic countries is their traditional export orientation: since their domestic markets are rather small, exports are necessary in industries requiring larger R&D and capital investments. Second export advantage arises from the fact that average population density is crucial for the cell size. Since population density of Nordic countries lies between the extremes of conditions in the US and densely populated Japan, the NMT and GSM technologies preferred by these "average" countries can be more easily adopted in other countries as well (Beise, 2004). Third, the fact that GSM was conceived as a pan-European standard resulted in the inclusion of a variety of features required in different European countries. Thus, from the very beginning GSM was an international standard that could be easily adopted outside Europe as well.

5. Market structure advantages:

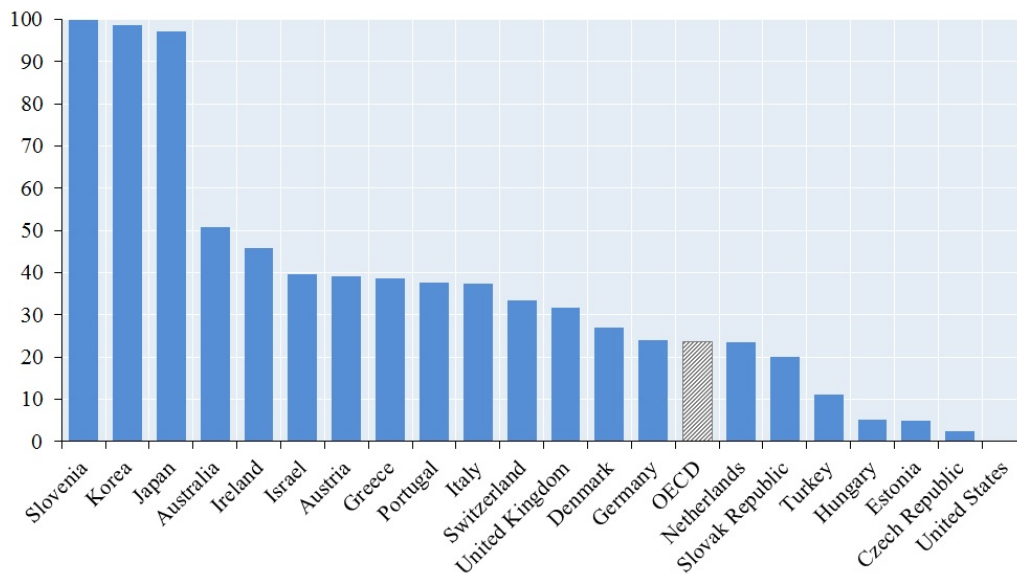
According to Beise (2004), an essential market structure advantage of Nordic countries is that competition in their mobile communications markets was originally higher than elsewhere in Europe. For instance, Sweden was the first country where two competitors (Telecom Sweden and Comvic) offered mobile telephone service. Competition drove down the prices of calls and phones and facilitated the discovery of new services and applications for mobile telephony. This, in turn, attracted new consumer segments. As a result, competition in Nordic countries enabled mass-market suitability of cellular telephony through lower prices.

3.4.3 Future Lead Markets for Mobile Communications

While there are no doubts as to the leading role of Nordic countries in the case of the first and second generation mobile technologies, third generation mobile communications (UMTS) pose a bigger challenge. Although Beise (2004) assumes that lead markets usually are likely to keep their leading role also for next generation products, more recent data on 3G penetration rates suggest otherwise. As previously discussed, the first UMTS commercial network was actually launched in Japan. In 2007, 3G cellular mobile adoption in Europe was still rather poor in comparison with Japan and Korea - 22 per cent of all mobile subscribers in Sweden against 82 per cent in Japan and 100 per cent in Korea (although the latter has adopted CDMA2000 technology instead of UMTS) (see Figure 3.6). If we look at the 3G adoption rates in 2009 in Figure 3.11, the results are even more striking: Slovenia became a clear leader, followed by Korea and Japan, with other European countries far behind.

3.4. INNOVATION DIFFUSION IN MOBILE COMMUNICATIONS: A LEAD MARKET APPROACH

Figure 3.11: 3G cellular mobile adoption, as a percentage of total subscriptions, 2009



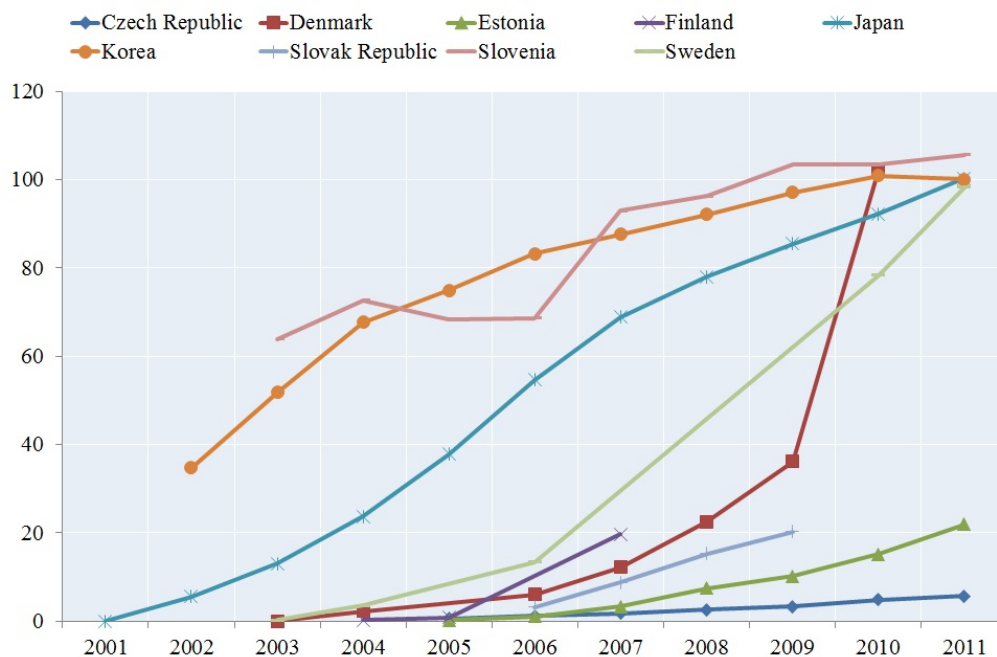
Source: OECD, 2011a, p. 132.

To establish 3G penetration rate (OECD (2013) gave only the absolute number of 3G subscriptions), I have made my own calculation based on the most recent OECD data (3G cellular mobile subscriptions divided by population in respective years) in order to determine 3G cellular mobile penetration rates from 2001 (the launch year of UMTS) till 2011 (the last year for which data were available). For this analysis were taken three Nordic countries (Sweden, Finland and Denmark), two OECD leaders Japan and South Korea as well as the new leader Slovenia along with three other Eastern European countries with relatively strong positions in mobile communications. The goal was to compare the development of third generation mobile communications in Nordic countries (supposedly lead markets) with their development in Japan and Korea that have both become actual leaders in 3G technologies, and with the development of these technologies in the emerging and most promising economies in Eastern Europe.

The results of calculations presented in Figure 3.12 are quite astonishing and unexpected, if we rely solely on reflections of Beise (2004) or Beise (2006). Judging by the data in the first years after UMTS launch, it is clear that Sweden and Finland have not only lost worldwide leadership to Japan and Korea, but they were also by far overtaken by Slovenia, a small but apparently auspicious new EU member state.

This analysis suggests that at least in the case of 3G mobile technologies there has been a shift of power: instead of Nordic countries, new players such as Korea and Slovenia have emerged. However, it is not easy to make conclusions based only on these data because it is not clear yet if these countries are true lead markets or only early adopters. Only judging by the 3G penetration curves, as Beise (2004) suggests for existing innovation designs (see Figure 3.9), we cannot assume that Slovenia, Japan and Korea have become new lead markets for 3G mobile communications. Because although Korea with its successful electronics industry (e.g. Samsung) has indeed the potential of a lead market, Slovenia was so far unremarkable in this respect. On the other hand, the fact that EION Wireless, a Canadian manufacturer of broadband wireless products, established its

Figure 3.12: 3G mobile subscriptions per 100 inhabitants in selected OECD countries, 2001-2011



Source: Own calculations based on OECD, 2013.

European subsidiary in Slovenia in November 2011 that is responsible for "developing and testing the company's next generation 4G wireless product platforms" suggests that Slovenian market is considered an important testing ground for these wireless technologies (EION Wireless, 2011).

That is why it is important to conduct detailed case studies on Korean and Slovenian mobile communications markets to find explanations for their success in 3G adoption and to establish if they are true lead markets. But even if one of them or both are merely early adopters and not lead markets as defined by Beise (2004), the results of this research which might be very useful for defining new policy measures in other countries wishing to improve their performance in mobile communications. Furthermore, additional research is required in order to establish why old lead markets (Nordic countries) have been so slow in adopting 3G. I also suggest that both approaches, sectoral systems of innovation and lead markets, are very useful in explaining such phenomena and can complement each other.

Finally, with the commercial LTE launch in 2009, a new and even more challenging task emerges - defining lead markets for this mobile technology of the future. It is too early yet and detailed international statistics on LTE penetration are available, but the launch of the first commercial LTE network in Sweden and in Norway might be a sign that Nordic countries are regaining their lead market role. Further research in this direction should help find answers to these questions and make an important contribution to the development of the lead market theory because, if there are indeed new lead markets in mobile communications, it will show that the lead market concept is much more dynamic than previously thought. If, further, it can be established which lead market characteristics are crucial and can be changed by adequate policy measures, it will help other (European) countries define key policy measures that can be undertaken in order to

improve the performance of their mobile communications market.

3.5 Conclusions

In this chapter we have mainly discussed two theories that apply to innovation in mobile communications: system of innovation approach and theory of lead markets. While the former mostly deals with generation and diffusion of innovation on the national and sectoral levels by considering the influence of ten main activities of the innovation system on the innovation process, the latter focuses on international diffusion of already existing innovation and puts forward the factors contributing to the lead market role of a particular country in a particular field.

As regards the innovation system approach, we have first conducted a detailed analysis of the sectoral system of innovation for cellular mobile communications from the begin of specification of its first generation standard (NMT 450) in 1970 to the launch of its third generation (UMTS) in the first half of 2000s. We came to a conclusion that it was the close cooperation in development of GSM standard among numerous European and international actors that has contributed to its international dominance. Furthermore, the early involvement of Nordic equipment manufacturers has ensured their leading role in the international mobile communications market. In the case of UMTS, the particularities of the Japanese sectoral system of innovation might have contributed to a much more rapid uptake of 3G mobile technologies than in Europe.

Finally, we have added an international perspective to our understanding of innovation processes in mobile communications by introducing the lead market theory. Although we have established that Nordic countries played the lead market role for GSM, transferring these conclusions to the next generations of mobile technologies (3G and 4G) presents certain difficulties because, based on 3G penetration curves, we have new (unexpected) candidates for lead markets. Further research should help to shed light on this important question contributing to the further development of the lead market theory and of adequate policy measures.

Chapter 4

Case Studies: Swedish and Korean National Systems of Innovation

In this chapter we will discuss in more detail the national systems of innovation (NSI) of Sweden and Korea. The country choice is explained by the fact that the former was a leader in the first generation mobile communications whereas the latter boasted the highest 3G penetration rates in 2007.

The structure of the case studies is based on Edquist and Hommen (2008) and will look as follows: first, after a short introduction we will outline the main trends in the history of the NSI; second, we will address the innovation intensity (propensity to innovate) of the NSI; third, we will try to identify factors (or "*activities*") that influence innovation process in the NSI; further, we will discuss the influence of globalisation on the NSI; and finally, we will consider innovation policies (those historically pursued in selected countries and those proposed for the future) that (might) influence the performance of the NSI.

4.1 The "Swedish Paradox": High R&D Input and Low Innovation

According to Bitard et al. (2008), recent innovation policy discussion in Sweden has paid much attention to the notion of a "*Swedish paradox*", meaning that despite high R&D intensity in Sweden, the share of high-tech products in its manufacturing is low as compared to other OECD countries. Or, as Andersson et al. (2002) put it, although the investments in R&D in Sweden are very large, its economic growth and competitiveness are not very impressive (as cited in Bitard et al., 2008). Similarly, already in 1993 Edquist and Lundvall (1993, p. 286, Table 8.8) pointed out "*a weak export specialisation in R&D-intensive products*", despite its very major efforts in R&D.

Edquist (2002) names three hypothesis that were suggested by different studies in order to explain this paradox (as cited in Bitard et al., 2008). One possible explanation is that the knowledge resulting from R&D remains in the R&D sphere (e.g. in universities or corporate research units) and therefore is not transformed into innovations. Another proposition is that the paradox can be explained by sectoral allocation of R&D investments in Sweden. A third hypothesis suggests that due to stronger internationalisation of

production than of R&D, R&D carried out in Sweden results in innovations elsewhere, for example in subsidiaries of Swedish multinational enterprises. We will further conduct a detailed analysis of the Swedish NSI and, among other things, will try to establish if there is any support for this paradox.

This part is largely based on the detailed analysis of the Swedish NSI conducted by Bitard et al. (2008) and the statistics in many cases turn out to be not very recent. Where possible, I have completed the analysis with more recent data but their complete update would be too time consuming (if at all possible) in the frame of this dissertation.

4.1.1 Main Historical Trends

According to Bitard et al. (2008), in the second half of the nineteenth century Sweden's exports were dominated by products from agriculture and the mining and forest industries. However, after the mid-nineteenth century new production processes allowed the export of refined products from these industries - machinery products and pulp and paper respectively. The Swedish engineering industry expanded rapidly from 3 per cent of total exports in 1880 to 10.5 per cent in 1910-1911, and reached over 20 per cent in 1950 (that year it was surpassed only by the USA among OECD countries). Edquist and Lundvall (1993, p. 272) argue that an important outcome of the process of industrialisation in Sweden was *"the combination of exports based on refined and processed raw materials on the one hand and the multinational engineering firms on the other"*. However, Jacobsson and Philipsson (1996) stress that throughout its history the Swedish economy has been strongly specialised in low-growth (low-tech) sectors, while Ohlsson and Vinell (1987) suggest that before 1990s more R&D-intensive growth sectors were relatively underdeveloped (as cited in Bitard et al., 2008).

According to NUTEK (2000, pp. 41-43) during 1980-1984 there was a general increase in service sector employment relative to manufacturing employment, but the increase in the share of employment held by the knowledge-intensive service sectors was rather modest (as cited in Bitard et al., 2008). NUTEK (2000, pp. 47-52) also suggests that in the period from 1980 to 1996 Sweden has significantly increased its export specialisation in high-technology manufacturing (as cited in Bitard et al., 2008). Moreover, NUTEK (2000, Table 3.2) points out that Swedish production of high-tech products has increased from 8.8 per cent of all manufacturing production in 1993 to 12.5 per cent in 1996 - largely due to rapid growth in telecommunications equipment and pharmaceutical products sectors, in which Sweden was already specialised (as cited in Bitard et al., 2008). In this context, Edquist and Lundvall (1993, p. 272) argue that in the Swedish NSI a decisive role is played by a *"small number of multinational firms in the engineering industry"*.

4.1.2 Innovation Intensity

In order to revisit the "Swedish paradox", Bitard et al. (2008) compare the performance of Swedish economy with other small open European economies, i.e. the other Nordic countries, the Netherlands and Ireland, from two periods - 1994-1996 and 1998-2000. As input measures they consider R&D intensity and innovation intensity; on the output side, they analyse the proportion of innovating firms, the share of all firms that have introduced new processes as well as four indicators related to product innovations.

4.1. THE "SWEDISH PARADOX": HIGH R&D INPUT AND LOW INNOVATION

As regards the input measures, Bitard et al. (2008) come to a conclusion that R&D intensity of Swedish firms is very high compared to other countries from the group - in 1994-1996 Swedish firms invested 4 per cent of their turnover in R&D, compared to the group average of 2.3 per cent. Sweden ranked first for this indicator and none of other countries invested above average. Moreover, Sweden also ranked first for innovation intensity - 6.7 per cent in 1994-1996 compared to the average of 4.1 per cent.

It is interesting to note, however, that for SMEs Sweden ranks only second with regard to innovation intensity (after Denmark): while Swedish SMEs spent 2.7 per cent of their turnover on innovation, Danish ones spent 4.9 per cent (Bitard et al., 2008). Bitard et al. (2008, p. 241) stress that *"while in most countries SMEs spend less on innovation than large firms, Sweden has the greatest difference in this respect"*.

As to the output side, the first indicator is the share of innovating firms that have introduced either a product or a process innovation. For this indicator, Swedish firms ranked only fourth for both periods (1994-1996 and 1998-2000) with a performance only slightly above average (Bitard et al., 2008). For the second indicator, the share of all firms that have introduced new processes during a three-year period, Sweden ranked fourth (out of six) in 1994-1996 and fifth (out of five) in 1998-2000 with a performance 14 per cent below the average (Bitard et al., 2008). However, on both indicators Swedish firms performed somewhat better in services than in manufacturing.

Third, Bitard et al. (2008, pp. 241-242) have analysed four indicators related to product innovations. On the indicator *"introduction of new-to-the-firm products"* (the share of firms that during a three-year period introduced products that were new to them), Sweden ranked fourth (out of six) for 1994-1996 and fourth (out of five) for 1998-2000. On the indicator *"introduction of new-to-the-market products"* (the share of firms that during a three-year period introduced products that were new to the "world"), Sweden ranked fourth (out of five). Again, Sweden's performance was better in services than in manufacturing. On the indicator *"turnover due to new-to-the-firm products"* (turnover due to the new-to-the-firm products introduced during a certain period, divided by total turnover at the end of the period), Sweden had a much better performance ranking first. Finally, on the indicator *"turnover due to new-to-the-market products"* (the ratio of turnover due to new products or significantly improved products introduced in 1998-2000, divided by the total turnover in 2000) Sweden is below the average ranking third (out of four). Bitard et al. (2008, p. 242) note that small firms performed much better on this indicator than large ones, which leads them to a conclusion that *"the overall performance of all firms [...] can be explained by the domination of large firms in the Swedish NSI"*.

As the comparison has shown, the input indicators for Swedish firms are high whereas the output indicators all indicators are quite low comparing to other small open European economies. This leads to a conclusion that the productivity (or efficiency) of the Swedish NSI is not high - it is not *"as capable as some other small industrialised countries of transforming the very large resources invested in R&D and innovation activities on the input side into correspondingly large outputs of product and process innovations on the output side"* (Bitard et al., 2008, pp. 242-243). Thus, the Swedish paradox is confirmed. Bitard et al. (2008) suggest that the underlying problem may reside with the large firms dominating the Swedish NSI, which perform poorly in innovation outputs.

4.1.3 Activities that Influence Innovation

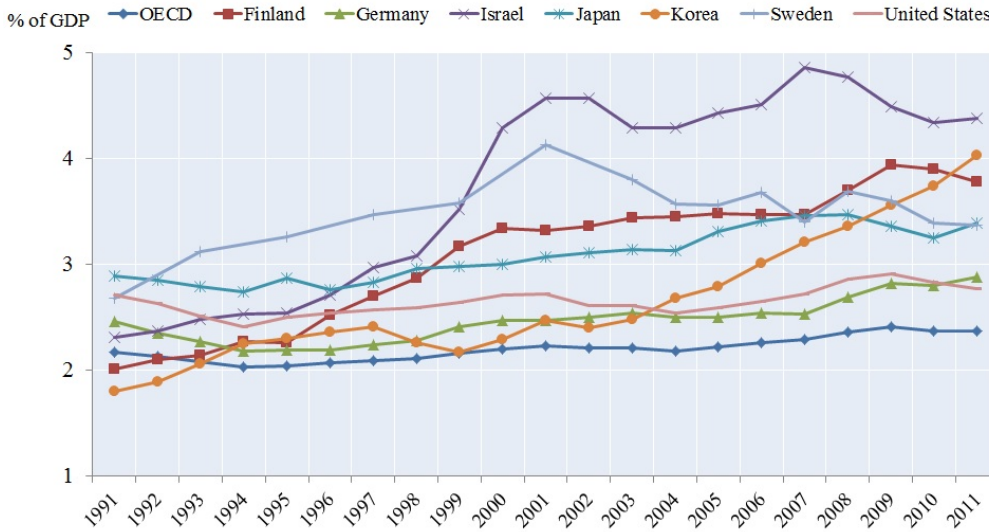
The analysis in this section is based on ten activities of IS as described by Edquist (2004) and will contribute to assessing the validity of three hypothesis (introduced at the beginning of this part) trying to explain the Swedish paradox.

I Knowledge inputs to innovation

1 R&D activities

In 2011, Sweden spent more than 1.4 times the OECD average on R&D (measured by gross domestic R&D expenditures as a proportion of GDP) figuring in the top-5 among the OECD countries (see Figure 4.1). However, Figure 4.1 also depicts that although Sweden has strongly increased its R&D spending between 1991 and 2001, from 2.7 per cent of GDP in 1991 to 4.1 per cent in 2001 (it was then surpassed only by Israel), in the last decade its performance on this indicator actually worsened. The European Commission (2003) data suggest that Sweden’s scientific output (as measured by publication) is high (it accounts for 1.75 per cent of world publications), and its technological output (as measured by patents) is well above the EU average (as citet in Bitard et al., 2008).

Figure 4.1: Gross domestic expenditure on R&D (GERD) as a percentage of GDP, 1991-2011



Source: OECD, Main Science and Technology Indicators database.

According to European Commission (2003), Sweden’s scientific specialisation lies within life sciences, food science and agriculture, environmental sciences, civil engineering and materials science. In contrast, as regards Sweden’s technological specialisation (as measured by patenting across major technology fields), its relative strengths are in pharmaceuticals, telecoms, materials and analysis control. This mismatch might be a sign of a problem in transferring scientific knowledge into industrial needs in Sweden (Bitard et al., 2008).

Bitard et al. (2008) argue that in contrast to many other OECD countries, the Swedish business sector accounts for a major share of R&D activity, and within

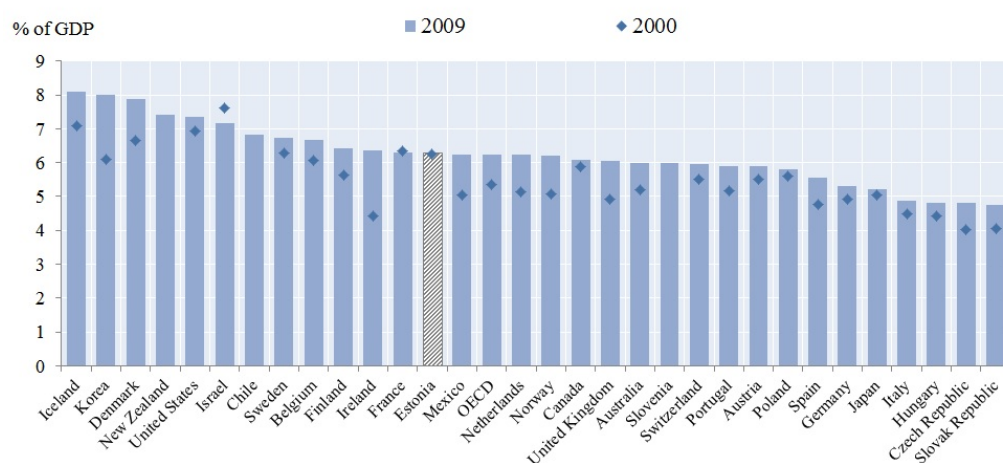
4.1. THE "SWEDISH PARADOX": HIGH R&D INPUT AND LOW INNOVATION

business sector large firms (with 500 employees or more) account for 83 per cent of R&D. In non-business R&D, the higher education sector plays a major role.

2 Competence building

As measured by the share of spending on education as a proportion of GDP, Sweden has long belonged to the world leading countries: in 1994, it ranked first in the world (OECD, 1998, p. 37); and in 1999, with the share of 6.7 per cent, it was slightly below the leader, Korea, at 6.8 per cent, and well above the OECD average of 5.8 per cent (OECD, 2002, Table B2.1a). However, as Figure 4.2 shows, more recently, other OECD countries have overtaken Sweden on this indicator - in 2009, it ranked only eighth among the OECD countries (with 6.7 per cent), again surpassed by Korea with 8 per cent.

Figure 4.2: Trends in education expenditure as a percentage of GDP, 2000 and 2009



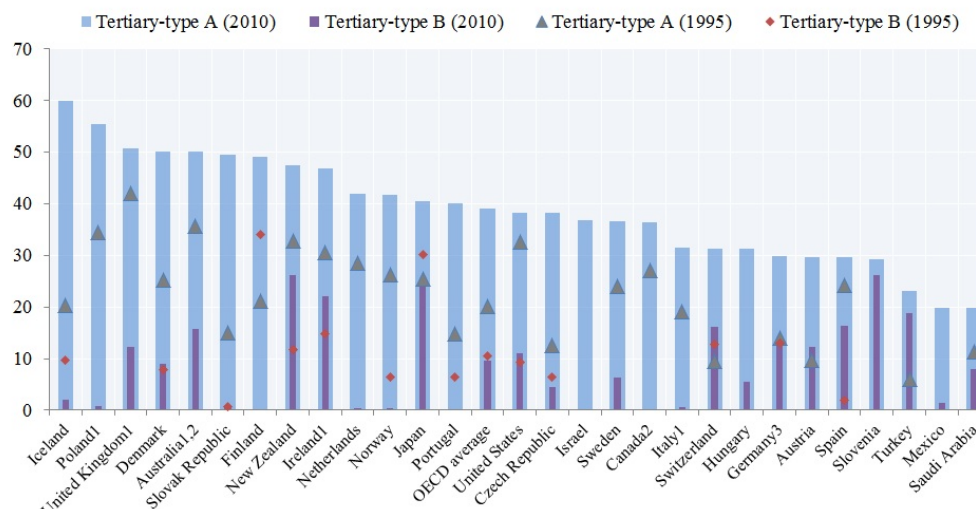
Source: OECD, 2012a, Table B2.1.

As regards the qualifications of the Swedish labour force, the situation has also worsened at the beginning of the 21st century. While in 1995 Sweden was well above the OECD average with first time graduation rate from university-level education of 24 per cent, in 2010, despite the general increase up to 37 per cent, Sweden was somewhat below the OECD average and ranked only 17th among the OECD countries (see Figure 4.3). Aspgrén (2002) and Jacobsson et al. (2001) suggest that Sweden has improved its graduation rates of natural scientists and engineers that became comparative to those of competitor countries (as cited in Bitard et al., 2008). The Swedish educational system remains under Swedish control, but after decentralisation reforms, its tertiary education has improved its flexibility and became more market-responsive (Bitard et al., 2008).

II Demand-side activities (include activities 3 and 4)

Bitard et al. (2008) suggests that Sweden's accession to the EU resulted in a shift in Swedish innovation policy: instead of utilising mainly domestic demand, it now relies more upon international demand to stimulate its industrial and technological development. While public technology procurement has been earlier an important innovation policy instrument in Sweden (Edquist and Hommen, 2000), its EU accession was accompanied by liberalisation reforms resulting in dismantling of many state

Figure 4.3: First-time graduation rates at tertiary-type A and B education, 1995 and 2010



Notes:

1. Year of reference 2000 instead of 1995.
2. Year of reference 2009 instead of 2010.
3. Break in the series between 2008 and 2009 due to a partial reallocation of vocational programmes into ISCED 2 and ISCED 5B.

Source: OECD, 2012a, p. 63.

agencies and the privatisation of many state-owned companies. More recently, the Swedish innovation policy has replaced purely demand-side measures with public-private partnerships combining demand- and supply-side measures (Bitard et al., 2008). Also, Glimstedt (2000) argues that product market regulation has shaped several important Swedish industries, such as mobile telecommunications (as cited in Bitard et al., 2008). Indeed, as discussed earlier, standard setting contributed to Ericsson's leadership in mobile communications equipment. However, standard setting has become increasingly internationalised and private actors, especially producers, are now playing a dominant role in the development of standards (Hommen and Manninen, 2003).

III Provision of constituents

5 Provision of organisations

Bitard et al. (2008, p. 249) argue that "Sweden lags in creation of new firms and their contribution to industrial renewal" - Sweden's birth rate of new firms is comparatively low, for instance, in 2001, the population of new firms was only 7.4 per cent of all companies. Moreover, according to ITPS (2002), two-thirds of the new firms are one-person companies, and few of large international companies created in Sweden were founded in the last three decades (as cited in Bitard et al., 2008). This relative lack of growth may be a partial explanation to the lack of innovation in Sweden. However, Sweden boasts rather high survival rates of new firms, for example, a study by Nås et al. (2004) showed that 63 per cent of the high-tech spin-offs established in 1996 passed the four year survival limit (as cited in Bitard et al., 2008). On the positive side, Bitard et al. (2008) suggest that Swedish

universities and large firms play an important role in creating and developing innovative technology-based spin-offs. Also, Sweden's innovative firms are now increasingly located in services rather than manufacturing.

6 Networking, interactive learning and knowledge integration

According to Bitard et al. (2008, p. 249), "*empirical data indicate that innovative collaboration and networking seem to develop organically among Swedish actors and between Swedish and foreign actors*". For example, Sandström (2002) suggests that Swedish research often involves collaborations between researchers in firms and in universities or institutes (as cited in Bitard et al., 2008). For example, 27 per cent of all Swedish publications are co-published with a national partner and 39 per cent - with a foreign partner (with preference for Nordic partners, but collaboration with US actors is also very important) (European Commission, 2003, Figure 5.4.2). As regards university-industry relations, they are also important in certain sectors, for example, according to VINNOVA (2001), in biotechnology (as cited in Bitard et al., 2008). However, Swedish companies finance fewer activities in universities or research institutes than do firms in other EU countries (European Commission, 2003, Figures 3.1.4-5). As regards partnerships among firms in Sweden, according to Bitard et al. (2008), in 1998-2000, two thirds of large Swedish firms cooperated, but only one third of SMEs. A conclusion of this analysis was that "*there is need to enhance collaboration and learning over organisational borders*" (Bitard et al., 2008, p. 251).

7 Provision of institutions

Andersson et al. (2002) and Henrekson and Rosenberg (2001) point to insufficient incentives for academic entrepreneurship, with consequently poor performance in commercialising research via new technology based firms including university-based start-ups (as cited in Bitard et al., 2008). According to OECD (1995), in 1995, Sweden had the lowest wages for experienced teachers in lower secondary education among the leading OECD countries. In 2010 the situation has not become much better - Sweden was still below the OECD average on this indicator (well behind Germany, the USA, Korea and Japan) (OECD, 2012a). Espring-Andersen (1990) argues that initially Sweden's postwar social-democratic welfare state favoured large firms and strong trade unions (as cited in Bitard et al., 2008). Thus, according to Benner (1997, p. 202), initially the "*core institution*" governing economic growth and industrial change was "*labour market regulation*"; while later, by the 1990s, public companies, investment planning and R&D policy became more important (as cited in Bitard et al., 2008). However, Andersson et al. (2002) suggest that extensive social security has been confined to large manufacturing firms and the public sector, encouraging a lock-in, which can potentially lower the impact of public investments in R&D and education (as cited in Bitard et al., 2008). Bitard et al. (2008) argues that these developments might account for the much higher innovation expenditure of large firms relative to the SMEs in Sweden, as well as Sweden's poor performance with regard to the introduction of new-to-the market products.

Researchers also argue that the "*university teachers' exemption*" granting faculty at Swedish universities complete ownership of research results (Sellenthin, 2004) along with "*anti-entrepreneurial peer pressure*" within university departments (SOU, 1996, p. 70) may have contributed to the underdevelopment of new

technology-based firms (NTBFs) in Sweden and may help to explain the low innovation expenditure of SMEs compared to large firms (as cited in Bitard et al., 2008).

As a part of EU accession preparations, Sweden liberalised domestic air travel (1992), telecommunications (1993), banking, finance, postal services (1993) and electricity (1996). These reforms aimed first of all the creation of new entrepreneurial arenas and innovation opportunities in Sweden and the EU (Bitard et al., 2008).

IV Support services for innovating firms

8 Incubating activities

Sweden's division of labour in initiating, financing and operating science parks and incubators includes government-supported non-profit units, university-driven units, public-private partnerships and private initiatives in corporate incubators (Bitard et al., 2008). Bitard et al. (2008) argue that Swedish policy makers see incubation as an important innovation policy tool, and university-related incubators have most often received public funding. According to Bengtsson (2003), Sweden's incubation activities began in 1983 with the Ideon Science Park in Lund and between 1983 and 1989 additional 15 parks were established (as cited in Bitard et al., 2008). However, as demonstrated by Ferguson (1998), Lindelöf and Löfsten (1999) and Löfsten and Lindelöf (2002), the positive results on innovation activity were not as strong or direct as expected (as cited in Bitard et al., 2008). According to VINNOVA (2002), this led to a systematic review, in which science parks were seen as only one of the instruments in an innovation environment (as cited in Bitard et al., 2008).

Bitard et al. (2008) suggest that today, most large universities in Sweden have some form of unit for handling patent and licensing issues, as well as promoting entrepreneurial and cooperative activities. Nevertheless, there is still much to be done. For example, although academic researchers own the right to their inventions, other supports for commercial activity (i.e. incentives, time, suitable career structure, financial resources, role models and experience) are often missing.

9 Financing

Bitard et al. (2008) argue that in comparison to other EU countries, Sweden is in a good situation as regards venture capital (VC) market, with growing financial options for firm formation and expansion. For example, Sweden has been often pointed out as having an impressive level of venture capital activity, and according to Eurostat (2003) data, the percentage of GDP devoted to venture capital was well above the EU average in 2003 (as cited in Bitard et al., 2008). Bitard et al. (2008) underline that between 1998 and 2002, the number of actors tripled (from 50 to 150 firms) and the funds managed quadrupled (from SEK 45 to 190 billion). In addition, Bitard et al. (2008) point out a visible internationalisation of the venture capital market in Sweden.

However, Karaömerlioglu and Jacobsson (2000) and European Commission (2003) stress that many developed EU countries have been ahead of Sweden for many years and that Sweden has yet to develop a fully competent venture capital market with experienced actors and sufficient institutional support (as cited in Bitard et al., 2008). For example, in a comparative study by EVAC (2004) analysing the regulatory environment for venture capital, Sweden was ranked below average in

Europe (as cited in Bitard et al., 2008). As positive features of the Swedish venture capital market were mentioned the fund structure, the company tax rate, the ease of registering a new company, and the regulation for reorganisation and bankruptcy of a company. On the negative side there are the strict regulation of mergers, the lack of a special tax rate for SMEs, the income and capital gain taxes for individuals, the lack of tax incentives for individuals, and the lack of fiscal incentives for interfirm cooperation.

In addition, as regards the phases of development which are VC-financed, Bitard et al. (2008) state the lack of early-stage financing, while a relatively large share of the funds has been allocated over time to late-stage development. Indeed, according to EVAC (2001) survey data, 30-50 per cent of the funds managed by the Swedish venture capital firms are invested in any of the phases from seed to expansion, and the rest in buyouts (as cited in Bitard et al., 2008). Another concern is that, according to the European Commission (2003) data, only 28 per cent of the total equity capital in Sweden is allocated to high-tech sectors - this is below both the EU average of 38 per cent and the impressive US figure of 79 per cent (as cited in Bitard et al., 2008). Bitard et al. (2008) argue that these shortcomings of the Swedish venture capital market might contribute to explaining the Swedish paradox.

10 Provision of consultancy services

As suggested by Bitard et al. (2008), almost all Sweden's private consultancies are located in the knowledge-intensive business services (KIBS) sector, which is not especially large. For example, according to Marklund et al. (2004, Figure 4.4), Sweden ranks seventh (out of nine countries, the others are Austria, Germany, Denmark, Finland, France, Italy, Norway and the USA) in the proportion of total services belonging to KIBS, and sixth in the percentage of the total labour force employed in KIBS (as cited in Bitard et al., 2008). However, recently this sector has expanded rapidly in Sweden and it also boasts a high level of innovative activity (Bitard et al., 2008). For instance, according to Nählinder and Hommen (2002, p. 11, Table 2), a high proportion of innovative firms (well above the service sector average of 36 per cent) were found in the financial intermediation (59 per cent) and KIBS (51 per cent) sectors. Another independent survey (Nählinder, 2003), suggests that 82 per cent of Swedish KIBS firms have a large level of innovation intensity in terms of the employment of qualified personnel, and some 82 per cent of this population of firms conducted some form of innovation in the period from 2000 to 2002 (as cited in Bitard et al., 2008). Bitard et al. (2008) note that these high levels of knowledge intensity of KIBS firms might help to explain why Swedish firms are currently more innovative in some service sectors, notably finance and trade, as compared to manufacturing.

4.1.4 Consequences of Innovation and Globalisation

The analysis conducted by Bitard et al. (2008) for 1994-96 and 1998-2000 periods showed that the most successful Swedish firms (as measured by turnover increases) are likely to be those investing most in innovation. These results must be interpreted with caution because the causality is not clear here - it might be that more successful firms are more likely to invest in innovation. Bitard et al. (2008) also came to a conclusion that generally the most

innovative sectors in Sweden (as measured by the share of turnover due to new products) also experience the smallest increases in value-added. However, Bitard et al. (2008, pp. 258-260, Table 7.1 and Figure 7.1) note that between 1993 and 2000, the sector with the most dramatic growth in value-added (191.83 per cent, as measured by the variation of the share of the value-added of the different sectors in the grand total) - "computer and related activities" - has also undergone the strongest growth in R&D expenditures (from index 20 in 1995 to nearly index 120 in 2001). This example illustrates positive impact of innovations on firms' value-added. Finally, Bitard et al. (2008, p. 261, Figure 7.2) also demonstrate that Sweden's labour productivity, measured as GDP per hour worked between 1979 and 2001, has not increased and remained at a high level - slightly above 80 per cent of the US level of labour productivity.

Globalisation has had a significant impact on the Swedish NSI through the extremely important role played by multinational enterprises (MNEs) that, according to Braunerhjelms (1998), accounted for as much as 70 per cent of the total private sector R&D in the late twentieth century (as cited in Bitard et al., 2008). Already in 1989, in a report to the 1989 congress of the Swedish Metal Workers Union (Solidarsk arbetspolitik, 1989, p. 93) the following account of the problems arising from increasing firms' internationalisation was given:

The problem today is that these multinationals do not any longer need Sweden, but the Swedish economy needs them. (as cited in Edquist and Lundvall, 1993, p. 292)

As discussed later by Bitard et al. (2008, p. 262), "the dominance of domestic MNEs has contributed to the Swedish paradox by diminishing commercialisation of research results and maintaining a disproportionately high allocation of R&D resources to low- and medium-technology sectors with little potential for growth". However, although the production in Sweden is now highly internationalised and the increasing share of large firms' production is located abroad, these firms, as of 2003 (based on data from ITPS (2003a)), continued to invest strongly in R&D within Sweden. Moreover, Marklund et al. (2004, pp. 13 and 32, Figure 9.3) argue that foreign subsidiaries still relied strongly upon exports from Sweden and Sweden still had a positive trade balance in high-tech products (as cited in Bitard et al., 2008). Thus, as argued by Bitard et al. (2008, p. 262), the Swedish paradox may at least in part be explained by globalisation, "in the sense that R&D carried out in Sweden increasingly bears fruit in terms of innovation in other countries".

4.1.5 Strengths and Weaknesses of NSI

The previous analysis leads to a conclusion that the Swedish NSI is generally strong on the input side (e.g. high R&D investment) but weak on the output side (i.e. it has rather low innovation performance) (Bitard et al., 2008). One exception to the overall pattern is that SMEs innovation expenditures are not especially high, which, as suggested by Bitard et al. (2008), can also be considered as a strength if it leads to a high innovation output. However, it was established that Swedish firms were more innovative in some service sectors than in manufacturing, and performance was also better for new (to the firm) products than for process innovations (ibid.).

As regards the new-to-the-market product innovations, Sweden performed very poorly, although the performance was much better for small firms than for large ones, i.e. "small

firms are much more "creative" than large ones" (Bitard et al., 2008, p. 264). Hence, Bitard et al. (2008) argue that the overall poor performance of the Swedish NSI might be due to the dominance of large firms. The fact that, according to the analysis, small firms spend considerably less than large ones on innovation, while at the same time performing well above the average with regard to turnover due to new-to-the-market products, can be considered as *"a great strength of small firms within the Swedish NSI"* (Bitard et al., 2008, p. 264). Moreover, the analysis of indicators discussed previously suggests that, in general, Swedish firms are rather good at imitating products, but are less good at new-to-the-world innovations, which suggests that *"the Swedish NSI is not creative in a profound way"* (ibid.).

Turning to the activities, the analysis by Bitard et al. (2008) suggests that Sweden is strong in R&D and competence building, but weak in support services for innovating firms, however improving more recently. On the negative side, the volume of new formation in Sweden is too low, and demand-side activities are underdeveloped, having largely been reduced to *"seeking global markets through internationalisation and restructuring domestic markets through liberalisation"* (Bitard et al., 2008, p. 264). Also, shortcomings in the institutional structure, such as rigidities in S&T employment and uncertainties related to IPR legislation, may, according to Bitard et al. (2008) have contributed to low rates of firm creation. Finally, because large firms conducting outward FDI remain central for the Swedish NSI, *"much of the return on Sweden's R&D investment is captured abroad, rather than domestically"* (Bitard et al., 2008, p. 265).

4.1.6 Innovation Policies

The analysis conducted by Bitard et al. (2008) confirmed the existence of the Swedish paradox and found support for all three hypotheses trying to explain this paradox: obstacles to technology transfer from the R&D sphere to the commercial sphere, problematic sectoral allocation of R&D, and the internationalisation of production meaning that Swedish R&D is increasingly exploited abroad. Bitard et al. (2008, p. 269) argue that a common element in all three explanations is *"the dominance of incumbent large manufacturing firms (MNEs)"* and argue that the underlying problem concerns the apparent inability of these large firms to translate innovation inputs into outputs domestically.

Thus, as a first measure, Bitard et al. (2008) suggest to address the overwhelming domination of business sector R&D by large firms. This especially makes sense because small firms have proved to be more efficient innovators than large ones, while innovation expenditures and resources available are much lower for SMEs than for large firms. Therefore, the aim of the Swedish innovation policy should be to increase R&D and innovation expenditures and efforts in SMEs in advanced sectors. In this context, Bitard et al. (2008) mention several instruments that would lead to the establishment of more new innovation based firms. One of them is to strengthen regional clusters and collaboration in strategic R&D and innovation including SMEs, another is to facilitate the spin-off of new firms from large firms when the latter do not commercialise results from R&D and innovation efforts to a sufficient extent.

Second, as regards the problematic sectoral allocation of R&D, Bitard et al. (2008) urge to stimulate the development of new knowledge-intensive industries, firstly, by encouraging large firms to diversify into them, secondly, by assisting the birth and growth of new innovation-based firms in new sectors, and, finally, by attracting foreign firms in advanced sectors. As argued by Edquist (2002, pp. 53-54) and Arvidsson et al. (2007,

pp. 9-18), contrary to the widely adopted policy, well-established ("traditional" sectors) in Sweden should receive less policy effort and fewer public resources, while radically new areas of technical development with large uncertainty need stronger, more focused interventions (as cited in Bitard et al., 2008).

Third, a solution to the Sweden's failure to capture returns on R&D investment within domestic economy that arise from the internationalisation of production is not an easy one. Bitard et al. (2008) argue that Sweden should exploit more effectively the positive effect of this trend - the development of Sweden into a global centre of R&D activities and services. Here, public policy should, among other measures, create a strong labour market for natural scientists and engineers (NSEs) and other R&D personnel. Besides, interfirm networks of innovation in Sweden, which have a strong "*vertical character*" due to the dominance of large firms, could be enhanced by measures supporting collaboration and learning over organisational borders (Bitard et al., 2008, p. 271). Also, according to Bitard et al. (2008, p. 271), increasing firms' "*collaboration with customers through diversification*" should significantly improve Sweden's poor performance in product innovations.

Fourth, because Sweden's lack of attention to the demand side was reflected by its poor performance in new-to-the-market product innovations, Bitard et al. (2008) stress that Sweden needs new initiatives in demand-side policies, such as new forms of PPPs and new combinations of supply and demand-side measures. Fifth, in order to stimulate translation of research results from universities into innovations in firms, Sweden should improve both financing and additional support services for innovating firms, especially those formed to exploit academic research results (Bitard et al., 2008). Sixth, in the light of a general need to stimulate product innovation in Sweden, Bitard et al. (2008, p. 272) suggest that, because newer and smaller firms seem to be more creative than the older and larger ones, the former should be the main focus of the Swedish innovation policy, along with "*efforts to alter the production structure towards stronger representation of high-technology sectors*". Finally, as Bitard et al. (2008) put it, the combination of many of the policy measures discussed would enable a shift towards a more knowledge-intensive structure of production leading to an increase in productivity, economic growth and employment.

4.2 Korea: Towards Knowledge Generation

South Korea has undergone a successful industrialisation process from a subsistent agricultural country exploited by Japanese colonisation and subsequently devastated by the Korean War (Kim, 1993; Lim, 2008). According to Lim (2008), Korean NSI is mid-sized and typical of a catching up country, in which it undergoes a shift from one of technology import to one of technology generation and effective use of emerging technology opportunities from abroad. Until the mid-1980s it was the government that led the industrialisation process, which was then taken over by the private sector. During this transformation, Korean firms accumulated the capabilities that allowed them not only to improve production processes, but also to develop imitative products and, later on, even some original products based on those technologies (Lim, 2008). Lim (2008) suggests that today Korea displays a mix of advanced and developing country features: its private sector includes large advanced manufacturing firms as well as small manufacturing and service firms that are still classed as laggard. On the other hand, Korea's education and financial systems

are classed as laggard by advanced country standards, and the knowledge base of Korean universities and government research institutes (GRIs) is weak (ibid.). According to Lim (2008, p. 114), there has been a growing concern that, although Korea's "*intensity of R&D investment is one of the highest in the world, it is not being matched by performance at the national level*".

The aim of this analysis largely based on Lim (2008) is to identify the features of Korean NSI facing challenges from globalisation and to suggest policy measures that Korea will have to pursue in order to become one of the advanced economies. Clearly, in many cases statistics might not be very recent, and they were updated as much as it was possible in the frame of this research project.

4.2.1 Main Historical Trends

Korea belongs to those ex-colonised countries, such as Taiwan and Finland, that showed remarkable industrial growth after the Second World War (Lim, 2008). The Japanese colonial rule in Korea has provided a capitalist institutional base and introduced such new infrastructures as railway, posts, roads and irrigation systems (ibid.). However, Korea's industrial base was mostly situated in the northern part (Kim, 1993) and was not very extensive because the Japanese wanted Korea to remain an agricultural country (Lim, 2008). The majority of industrial and infrastructure facilities were destroyed in the Korean war of 1950-1953, but the war also had a certain positive effect by "*completely transforming a traditional rigid society into a highly mobile one by forcing geographical mobility*" and also by contributing to "*the rapid formation of basic skills among the male labour force*" (Kim, 1993, p. 358).

After the period of reconstruction with US aid between 1953 and 1960, Korea enjoyed a period of rapid economic growth until 1979, when the government's export policy stimulated firms to export production from labour intensive industries, such as footwear or textiles (Lim, 2008). By contrast, already in the 1980s, the policy encouraged exports of semiconductors and automobiles (ibid.). Kim (1993) argues that the dynamic growth in Korea in this period, where FDI was less important than in Singapore or Taiwan, was facilitated by the aggressive creation and accumulation of technical capabilities by domestic firms and that Korean workers improved their skills through hard work and investment in learning.

According to Lim (2008), *chaebol* group firms created and accumulated technological capability through capital investment and R&D investment as well as organisational learning. Because large *chaebol* firms were "close", both economically and politically, to the ruling regime, they had access to financial and human resources under advantageous conditions not enjoyed by small firms (Lim, 2008). That is how the dual system of strong large firms and weak small firms emerged in Korea, becoming a chronic problem for its economy (ibid.).

In the late 1980s, first characterised by a nationwide phenomenon of asset speculation (by *chaebol* groups) and the labour and democratisation movement, Korea's economic system progressively became more open and liberalised under pressure from the USA and international organisations such as the WTO (Lim, 2008). After the financial crisis of 1997 (provoked by the instability of the economic system due to liberalisation), Korea underwent major reforms (ibid.) Nevertheless, Lim (2008, p. 117) suggests that despite the unstable environment, "*some Korean large firms emerged as world-class manufacturers whose success in the world market was based on their technological capabilities*".

4.2.2 Innovation Intensity

According to the innovation survey conducted in Korea in 2002 (modelled on the Community Innovation Survey), the share of innovative manufacturing firms with at least one successful innovation over the previous two years (2000 and 2001) was 33 per cent. The gap of over 10 per cent between Korea and European firms (for European countries this share was 44 per cent over 1998, 1999 and 2000) clearly shows that Korean firms were less likely to innovate in that period (Lim, 2008).

As measured by triadic patent families per million population, Korean firms' propensity to innovate has improved significantly in the last years - from only 7.7 in 1998, well below the OECD average of 36.2 (OECD, 2003, p. 178), to 40 in 2007-2009, above the OECD average of 38 (OECD, 2011b, p. 45). Thus, in 2007-2009, Korea was just behind the USA with 46, but still well behind Germany with 72, Sweden with 100 and Japan with 107 patents per million population (OECD, 2011b, p. 45).

Lim (2008, p. 118, Figure 4.3) also shows that, according to the innovation survey by European Commission (2004) and Um and Choi (2004), in Korea large firms in the manufacturing sector were the most innovative - 75.5 per cent of them were innovators, compared to 53.7 per cent of medium-sized and 28.8 per cent of small firms. The results of this innovation survey demonstrate that the gap between the share of "large" and "small" innovative firms is larger in Korea than in Europe - 48 percentage point in Korea against 35 in Sweden and 41 in Finland. In addition, the same survey showed that the innovativeness of service sector firms in Korea is below its manufacturing sector (22 per cent share of innovative firms in service against 33 per cent in manufacturing), which is also much lower than for the service sector in Sweden (40 per cent of innovative firms) and the EU average of 36 per cent.

As expected, the prevailing pattern of innovation in Korea is "*imitative innovation relying on foreign technology*" - among the product-innovating firms in the manufacturing sector only 6.8 per cent produced "new-to-the-world" product innovations, while most innovations were "new to the firm" or "new to Korea" (Lim, 2008, p. 119). Korean firms named "*purchasing the right to use invention or technological licensing from foreign firms*" as the most useful way of technology acquisition (out of the nine methods listed) (ibid.).

4.2.3 Activities that Influence Innovation

Here we will also revisit ten main activities that shape the Korean national system of innovation.

I Knowledge inputs to innovation

1 R&D activities

R&D intensity is high in Korea - as measured by the gross domestic expenditure on R&D as a percentage of GDP, Korea's performance has improved significantly over the last years. Figure 4.1 shows that while in 2001 Korea's GERD as percentage of GDP was 2.5 per cent, in 2011 it went up to almost 4 per cent and Korea ranked second among the OECD countries. This impressive performance is largely due to intensive R&D activity of Korea's business sector - in 2011 the R&D expenditure of Korean industry accounted for 71.8 per cent of its gross domestic expenditure on R&D (among the OECD countries, Korea was surpassed only by

Japan on this indicator) (OECD, 2012b, Table 13). Lim (2008) argues that in this respect Korea is similar to Sweden where large firms also play an important role. However, there was also an increase of small firms' share in the business sector R&D in Korea: according to Suh (2004), the share of small firms in the business sector R&D doubled from 11.4 per cent of total business R&D expenditure in 1995 to 23.6 per cent in 2001 (as citet in Lim, 2008).

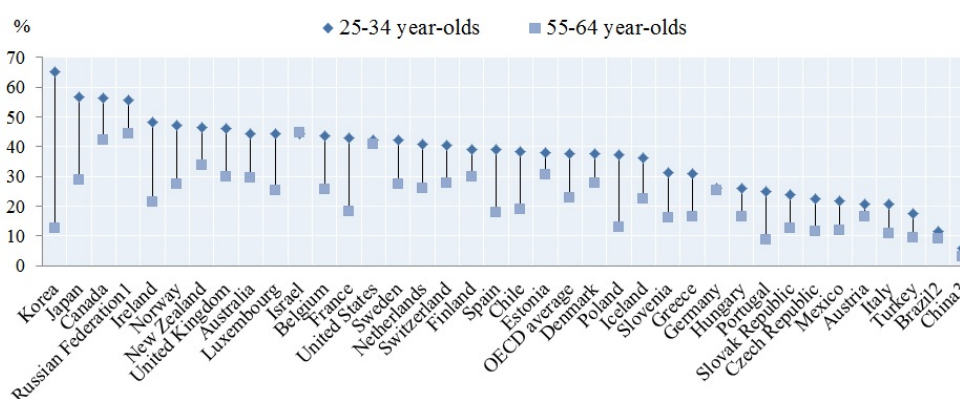
Lim (2008) stresses that university R&D is poorly developed in Korea - as measured by the percentage of gross domestic expenditure on R&D performed by the higher education sector in 2010, Korea with only 10.8 per cent was well below the OECD average of 18.7 per cent (OECD, 2012b, p. 37, Table 18).

Lim (2008) underlines that Korea's intensive R&D resulted partly from its increased specialisation in ICT - in 2007-2009 Korea ranked fourth among the OECD countries in terms of specialisation in ICT (OECD, 2011b, p. 182). Finally, Lim (2008) argues that the Korean NSI is less open globally than that of small advanced EU countries - in 2008, R&D funds from abroad (as a percentage of business enterprise R&D) were only 0.25 per cent in Korea, compared to 12.23 per cent in Sweden and 20.76 in Ireland in 2009 (OECD, 2011b, p. 92).

2 Competence building

In 2012, Korea's total spending on education (as percentage of its national income) of 8 per cent was second highest in the OECD area after Iceland (see Figure 4.2). However, while the Korean education system up to secondary level is regarded as very successful and in 2010 Korea ranked first among the OECD countries as measured by population that has attained tertiary education (see Figure 4.4), poor R&D capabilities in Korean universities lead to poorly qualified new researchers that do not satisfy the needs of large firms (Lim, 2008). Nevertheless, recent data show that Korea has undertaken serious measures in recent years in order to improve this situation - it boasted the second largest increase in expenditure per student in tertiary education between 2000 and 2009 (OECD, 2012a, Table B1.5b).

Figure 4.4: Population that has attained tertiary education, 2010



Notes:

1. Year of reference 2002.
2. Year of reference 2009.
3. Year of reference 2000.

Source: OECD, 2012a, p. 26.

In part due to their need to upgrade the quality of graduates from the Korean education system (and also because they are obliged by law to make such investments), Korean firms actively invest in training (Lim, 2008). Indeed, the OECD (2012a, Table B2.3) data show that Korea has the highest share (1.9 per cent) of private expenditure in tertiary education among the OECD countries. According to Lim (2008), reforms of Korean educational system aiming to improve the quality of its provision as well as the increase in number of overseas trained doctoral graduates who return to Korea contributed to positive changes in competence building in Korea.

II Demand-side activities (include activities 3 and 4)

As argued by Lim (2008), Korea's ICT policies is a prominent example of demand-side activities directed to market creation. For instance, government policies in the 1990s focusing on rapid diffusion of ADSL (including competition policy, policies of early commitment to the promotion of the Internet and the cyber building certificate system) were responsible for the commercial success of broadband Internet (ibid.). As a result, Korea was one of the first OECD countries (together with Belgium, Luxembourg and the Netherlands) where the DSL coverage reached 100 per cent in 2004 (OECD, 2011a, p. 165, Table 4.14).

Moreover, Lim (2008) suggests that the adoption of CDMA as the national standard for mobile communications by Korean government in the early 1990s (Korea was the first country to adopt CDMA as a national standard) led to the creation of a huge market for CDMA telecommunications equipment in Korea. As a result of intelligent policy, some of the largest Korean firms such as Samsung Electronics today have a world class "brand power" and belong to the leading telecommunications equipment manufacturers (ibid.).

III Provision of constituents

5 Provision of organisations

Lim (2008) points out that Korea has been aggressive in generating new organisations in order to capture opportunities from new technologies. For example, after the financial crisis of 1997, the Korean government encouraged venture businesses in order to revitalise the economy by offering them tax incentives and providing them with attractive environment, including the IT infrastructure. These policies contributed to an increase of newly established venture businesses from 422 in 1996 to 878 in 1999 (OECD, 2000, p. 150). Lim (2008, p. 131) argues that the influx of venture businesses, in turn, has led to increase in number of new firms, and that all in all there has been "*a positive change in the business environment and in the attitude towards launching new firms*". According to the Small and Medium Business Administration (2003), the venture business firms (i.e. excluding venture capital firms) invested heavily in R&D for innovation and contributed greatly to the dynamic growth of the Korean industry (as cited in Lim, 2008). Lim (2008) suggests that despite their sometimes poor performance, venture businesses are undoubtedly influential actors in the the new industries such as ICT and biotechnology - according to OECD (2000, p. 152), 40 per cent of the venture businesses created between 1995 and 1999 were in computer and telecommunication equipment sectors

6 Networking, interactive learning and knowledge integration

Lim (2008) argues that since historically Korean firms relied heavily on successful adoption and assimilation of foreign technology, interaction among domestic firms was generally less important for learning than interaction with firms in the advanced countries. As a result, networking among domestic firms in Korea was not very well developed, but in the last years domestic sources of knowledge has become more important.

Lim (2008) suggests that one of the key characteristics of the Korean NSI is the existence of strong *chaebol*-led networks with vertical linkages among firms in the major industry sectors. In such networks, large firms belonging to *chaebol* groups have subcontracting relationships with their affiliated firms and with other not-affiliated small firms. Further, as discussed by Lim (2008), cooperative R&D activities are becoming more common partly due to the Korea's innovation policy - when it comes to governmental funding, proposals for collaborative research projects between government research institutes, firms and universities receive priority.

As regards interactive learning, there are some barriers in Korea because, for instance, firms from different *chaebol* groups might often be reluctant to interact (Lim, 2008). Also, the traditional dual structure with weaker small firms and strong large firms impedes interactive learning between smaller and larger firms (ibid.).

7 Provision of institutions

According to Lim (2008, p. 137), "*Korean government policies in the past were based upon a bureaucratic, top-down approach*", whereas "*over the 1990s there was a trend towards a more interactive, bottom up approach*". Lim (2008) suggests that the Korean central government has always traditionally been the regulator and driver of Korean S&T policy, but while in the 1960s-70s its intervention was direct, from 1980 to 2000 (and especially after extensive deregulation conducted from 1992 to 2002) direct intervention was superseded by market mechanisms.

After the financial crisis of 1997, the Korean government became the driver of reforms in corporate governance (large firms were forced to focus on profitability and shareholders' interests rather than increased size), labour relationships (e.g. through policy for enhancing flexibility of labour markets), the financial system and the government sector (ibid.). An important policy focus was also on enhancing market competition, including trade liberalisation (e.g. abolishment of non-tariff barriers), reforms of FDI policy in order to attract foreign investors, and strengthening of fair trade policy.

Moreover, Lim (2008) argues that as the share of Korean-owned patents registered in Korea increased (from 11.4 per cent in 1980 to 32.9 per cent in 1990), the Korean government realised the importance of strengthening of IPR for protecting not only foreign investors, but also domestic inventors. As a result, in 1987, the patent law was amended to protect IPR in computer software and materials, and a product patent system was introduced.

IV Support services for innovating firms

8 Incubating activities

According to Kim and Lee (2005), the main focus of Korean policy initiatives aimed at stimulating new firms has been on providing physical facilities and facilitating the flow of investment towards new small firms (as cited in Lim, 2008). As stated by Jeong (2005), these measures included tax incentives, provision of services, relaxation of the requisites for establishing a corporation, and granting temporary leave to university and other R&D institute professors and researchers to establish venture businesses (as cited in Lim, 2008).

The first business incubator in Korea was established in 1993, and the majority of them (242 out of 291 approved in 2005 - 83.2 per cent) are located in universities (Lim, 2008). However, Kim and Lee (2005) and Yang (2004) underline that although Korea has a similar number of incubators to other advanced countries, they do not perform well in terms of providing services that satisfy the demands of firms due to the lack of experts (as cited in Lim, 2008).

9 Financing

As suggested by Lim (2008), the Korean financial system is based mainly on the banking system and banks are the most important financing source for firms. Previously, financial organisations were controlled by the government, but from the latter 1980s, regulation of financial organisation was eased and the Korean financial market was opened to foreign firms (*ibid.*). After the financial crisis of 1997, reforms of the Korean financial system were conducted including a loosening of financial sector regulation on foreign investments, which led to the increase of the share of foreign ownership in the banking sector from only 7 per cent in 1997 to 27 per cent in 2002 (*ibid.*). In addition, Lim (2008) argues that as a result of the crisis, the financial organisations in Korea tightened their conditions for lending money to firms and have been learning to build their own lending systems on the basis of credit information and estimated risks. According to Cho (2004) and Jeong (2004), this resulted in reduced monetary flows and low investment in the economy, because financial organisations have been reluctant to assume the risks involved in lending money (as cited in Lim, 2008).

After 1997, the number of venture capital firms in Korea increased dramatically - 111 firms were established between 1998 and 2002 (Lim, 2008). Korean government also contributed to the establishment of investment funds and as venture businesses began to decline, it even increased its investment in venture capital funds from 15.3 per cent in 1999 to 39 per cent in 2004 (*ibid.*). As the venture business boom in the late 1990 resulted in increasing role of financial organisations in funding NTBFs, a number of policies for supporting the financing activities for NTBFs were introduced, including, for example, a policy for supporting funds for start-up companies with less than three-year history (*ibid.*).

10 Provision of consultancy services

Lim (2008) argues that consulting services that are considered to be important for the innovation process are poorly developed in Korea. Indeed, as measured by the annual rate of increase in sales in the 1996-2000 period, traditional KIBS activities directly relevant to innovation - R&D services (8.2 per cent), business services (5.7 per cent) and technical services (-1.5 per cent) - have been growing relatively slowly, in contrast to the fast-growing (35.5 per cent) computer-related services (*ibid.*).

4.2.4 Consequences of Innovation and Globalisation

In a study by Lee and Kim (2003) on the relationship between R&D and labour productivity in Korea, a 1 per cent increase in R&D investment (stock of R&D investment) is estimated to have increased labour productivity (per labour hour) by an average of 0.13 per cent over the 1980s-90s (as cited in Lim, 2008). In addition, Lim (2008, p. 142) argues that *"patenting activity, as an approximate measure of innovation activity, has an impact on total factor productivity (TFP)"*. For example, as estimated by Youn et al. (2003) using data from 1964-2000, a 1 per cent increase in patenting application in any one year produces an increase in TFP of 0.11 per cent in the subsequent five years (as cited in Lim, 2008). Thus, as summarised by Lim (2008), over the 1980s-90s, R&D activities became increasingly important for enhancing productivity in Korea.

However, on the output side, Korea's relatively high R&D intensity is not matched by its economic performance - while its R&D intensity is high, Kaitila (2003) stresses that Korean labour productivity per hour worked in total manufacturing (as studied in the European Science Foundation project) is the lowest among the ten selected countries (as cited in Lim, 2008). In addition, as measured by GDP per hour worked in 2002, Korea was at only 37 per cent of the US level, compared to 101 per cent in Germany (Lim, 2008). This mismatch indicates *"possible problems in the Korean NSI"* (Lim, 2008, p. 142).

Globalisation has had a significant positive impact on the Korean NSI as Korean firms have enhanced their technical capabilities by accessing foreign firms via, among others, technical licensing arrangements, import of capital goods and components and, more recently, original design manufacture and own brand-name arrangements (Lim, 2008). Korea's large firms that have become multinational companies have foreign subsidiaries and branch offices for production, R&D and marketing (ibid.). Nevertheless, Lim (2008) underlines that Korea's R&D network is less well connected than its production network. Korea has a poor record in co-authorship of scientific articles and on international collaboration on innovation - in 2005-2007, only 1.3 per cent of Korea's innovative firms were involved in international collaboration, compared to 8.3 per cent in Germany and 27.1 per cent in Sweden (OECD, 2011b, p. 106).

Lim (2008, p. 144) argues that it was the financial crisis of 1997 that *"provided the momentum for opening up the Korean NSI for foreign actors"* - the Foreign Investment Act of 1998 *"provided a basis for tax exemptions and incentives for foreign investment"*. These measures led to the dramatic expansion of the FDI influx in the period from 1998 to 2002, which, in turn, resulted in increase in R&D activities of foreign firms in Korea (ibid.).

The Korea's pattern of catching up that we have described can be referred to as *"catching up by specializing in new industries"* - that is, in the ICT industries (Lim, 2008, p. 145). As discussed by Albert (1998) and Lee et al. (2005), Korean large firms in the ICT field have adopted a new pattern of innovation - development of original products by rapidly commercialising emerging technology from abroad (as we can see on the examples of CDMA mobile technologies and digital TV) (as cited in Lim, 2008).

4.2.5 Strengths and Weaknesses of NSI

As regards the strengths of the Korean NSI (based on Lim (2008)), its main advantage is its large firms that are capable of rapidly developing and producing commercial products from emerging technologies due to their access to local and international sources of

knowledge and markets. The second strength is Korea's heavy investment in IT infrastructure and high diffusion rate of IT devices that contributed to development of Internet businesses and transformation of the Korean service sector. Korea's third advantage is its capability for rapid commercialisation in fast growing new industries such as IT and electronics. And the fourth strength of the Korean NSI is its skilled and hard-working labour force.

Lim (2008) also names the following weaknesses of the Korean NSI. First, its corporate sector (the *chaebols*) have been rather reluctant to adopt the reforms and large firms affiliated to them might continue to be a major burden on the Korean economy. The second weakness is the prevalence of non-competitive small firms - while Korea, similarly to Sweden, has to face the problem of the bipolarised economy, in Korea the situation is quite the opposite, with strong large firms and weak small firms. The third disadvantage of the Korean NSI, according to Lim (2008), is its weak science base, and the fourth - the poor competitiveness and innovativeness of its service sector that is likely to be a barrier to further economic growth. Fifth, despite a large amount of highly educated labour forces, their quality of education does not satisfy the needs of large firms. Furthermore, Koreans' preference for work in closed networks (e.g. informal regional networks, networks of alumni etc.) reduces information flow and flexible work organisation required for innovation process. Another weakness is that the Korean financial system is new and banks and other organisations are reluctant to take risks in making loans to firms. Finally, Lim (2008, p. 147) suggests that the Korean business environment might not be stable enough and that "*Korean government practices are bureaucratic and follow a top-down approach to policy*".

4.2.6 Innovation Policies

Lim (2008) argues that because science and technology policies in Korea have ignored the economic and social aspects involved in the innovation process (S&T policy has been distinct from economic and industrial policies), the policies for the previously discussed activities - R&D input, competence building, the financial system, labour relations and incubation - have not worked together to encourage innovation. To correct this lack of coordination, the Korean government announced in 2004 "A Plan to Construct a National Innovation System" reflecting the country's commitment to become an innovation-based economy with S&T policy as a major national priority (ibid.).

According to Lim (2008, p. 148), the goals of this plan reflect the direction of Korea's future innovation policy in, first, "*enhancing the innovation capability of three core innovation actors (universities, firms and GRIs)*"; second, "*increasing R&D expenditure and enhancing its effectiveness*"; third, searching for and developing future strategic technologies that could become drivers of industrial growth; fourth, "*reinforcing linkages and cooperation among both domestic and foreign innovation actors (universities-industry-GRIs)*"; and finally, "*organising the system for coordination and planning of technological innovation policy, and information networks in S&T*".

In order to achieve these ambitious goals, as discussed by Lim (2008), there is a need for a system for measuring and evaluating the effectiveness of government policy programmes at the NSI level, which should be continuously revised and improved. Another measure required to facilitate innovation activities is "*removing barriers to networking among actors*" and "*removing barriers to investment by nurturing technological competences*" (Lim, 2008, p. 149). And finally, taking into consideration the increasing

vulnerability of Korean small firms to international competition, enhancing the technological capabilities of small firms and their networking with domestic and international actors will be crucially important for future innovation policy in Korea (ibid.).

4.3 Conclusions

The analysis of the Swedish and Korean systems of innovation has shown that these countries went through the industrialisation process in different ways and at different times. For example, in the 1950s, Swedish engineering industry was surpassed only by the USA in terms of percentage of total exports, while Korea still had to build its infrastructure and production facilities almost from scratch. Today, their national systems of innovation still display several differences, such as high labour productivity with hardly any growth in Sweden vs. still growing labour productivity in Korea, or strong service sector in Sweden vs. rather weak service sector in Korea.

Nevertheless, we have seen that Sweden and Korea also share many features and challenges: the lack of "new-to-the-world" products despite high R&D investment; high spending on education the quality of which does not always satisfy the needs of high-tech firms; the dominance of large firms in the NSI and the important role of multinational companies; and the fact that both countries have early recognised new technological trends and now boast very strong ICT sectors. All this implies that certain policy measures that apply to both countries, such as more support for SMEs in order to increase their competitiveness in the global economy, or enhancing collaboration and networking over institutional and country borders, might also be a solution to other countries in a similar situation.

The results of the analysis also indicate that Korea has a potential of a lead market for mobile communications. For example, compared to other OECD countries, Korean companies boast high innovation intensity (in part due to Korea's high specialisation in ICT), and Korea's total spending on education in 2012 is surpassed only by Iceland. In addition, Korea's remarkable performance in broadband Internet adoption was largely due to targeted governmental policies. Notably, it is suggested that the adoption of CDMA as a national mobile standard by Korean government in the early 1990s contributed to the success of Samsung Electronics today. All this indeed implies that Korea is a likely candidate for a 3G lead market, and not a mere early adopter.

Chapter 5

Empirical Analysis: What Affects the Diffusion of 3G Mobile Technologies?

This chapter is devoted to the analysis of factors that influenced the adoption of third generation mobile technologies in selected OECD countries. It will contribute to a better understanding of innovation diffusion processes in mobile communications and its results will hopefully serve as guidelines for policy decisions for 4G and further technologies in the mobile communications market.

5.1 Literature Review

Due to the importance of the problem, over the past years, quite a few national and international empirical studies have been devoted to the analysis of factors influencing the adoption of mobile communications technologies (and 3G in particular) from different perspectives.

On the firm level, Islam and Meade (2013) try to explain the differences in the technology diffusion of 3G mobile phones in companies, using non-linear mixed modelling on pooled multi-country data from 123 firms in 40 countries. From the national perspective, Chong et al. (2012) examine the factors that affect Chinese consumers' intention to adopt 3G and demonstrate that social influence, service quality and perceived ease of use have a direct and significant influence on perceived usefulness of 3G. The empirical analysis of factors for 3G adoption in Japan conducted by Akematsu et al. (2012) revealed that the launch of the iPhone 3G, FeliCa (a contactless RFID smart card system from Sony, primarily used in electronic money cards), data roaming, full music downloads, and the flat rate have affected the rapid diffusion of the 3G mobile in Japan. Teng et al. (2009) conducted an empirical study of the mass adoption of 3G mobile phones in Taiwan, demonstrating that perceived utility of a new mobile service (along with the perceived utility of a new handset) was a key factor of mass adoption. Also, Lin (2013) applies Grey system theory to predict the diffusion of mobile cellular broadband and fixed broadband in Taiwan and shows that mobile cellular broadband and fixed broadband have a complementary relationship. At the same time, the results of the study by Srinuan et al. (2012) suggest that in Sweden mobile broadband substitutes to fixed broadband.

On the macroeconomic level, Lee and Brown (2008) conducted both nonlinear (logistic model of technology diffusion) and linear regression analysis of factors influencing

the diffusion of fixed broadband. The results suggest that different types of local loop unbundling (LLU) policies and previous fixed broadband penetration are significant factors of fixed broadband deployment. As regards mobile broadband diffusion, econometric analysis conducted by Zaber and Sirbu (2012) over a multi-country panel dataset shows that regulatory policies regarding spectrum management have significant influence on the take-up of 3G and suggests that the presence of multiple technologies for the previous generation is associated with rollout delay of 3G. Further, an international study by Islam and Meade (2012), aiming to discover differences in technology diffusion of 3G mobile phones across countries, found a significant impact of competitive fractionalisation on the likelihood of 3G adoption, as well as a significant impact of economic globalisation on 3G market growth.

From the lead market perspective, Lehrer (2004) argued that the UK and Germany had the potential to become national "lead markets" for m-commerce and other applications of 3G despite being relative laggards in mobile telephony.

My empirical analysis can be seen to a certain extent as a follow-up of the study conducted by Lee et al. (2011), which is devoted to factors of both mobile and fixed broadband diffusion. Lee et al. (2011) adopt the logistic diffusion model to estimate the diffusion of broadband technologies because, as they argue, the logistic diffusion model is one of the most commonly used models for the estimation of new communication technologies (e.g. Botelho and Pinto (2004), Singh (2008)) and it also can capture the existence of network externalities (Gruber and Verboven, 2001). For their study they use annual data (years from 2000 to 2008) for 30 OECD countries for the fixed broadband diffusion model and annual data (years from 2003 to 2008) for 26 OECD countries for the mobile broadband diffusion model. The analysed factors of mobile broadband deployment included income (GDP per capita, PPP), population density, education (UNDP Education index), fixed broadband price (monthly fixed broadband price (Mbps) as a percentage of monthly income (USD)), standardisation policy, and mobile broadband price (monthly mobile broadband price (Mbps) as a percentage of monthly income (USD)). For the estimation of mobile broadband diffusion, Lee et al. (2011) employed the country fixed effects model. As a result of the data analysis, multiple standardisation policy, population density, and fixed broadband price were statistically significant. Thus, Lee et al. (2011, p. 14) argue that these results imply "*the importance of market-mediated, multiple standards when a new technology evolves into a different stage of development*", and that "*higher population density contributes to mobile broadband deployment*". In addition, according to the authors, the results of this mobile broadband diffusion study suggest the complementarity of mobile services and fixed broadband services in many OECD countries. However, although the logistic diffusion model proved to work well for 2G technologies, I doubt its superiority over a linear regression model in the special case of 3G adoption. To be more specific, Lee et al. (2011) used the available data from 2003-2008, but when we have a look at the diffusion curves in Figure 3.12, for most countries the penetration curve for this period (early stage of 3G adoption) is still close to a linear function. This and our methodology choice will be discussed in more detail later on.

5.2 Variables

It was decided to base our empirical model on the framework of lead market theory discussed by Beise (2004) and Beise (2006), which deals with the global diffusion of in-

novations. As discussed in Section 3.4, according to the lead market approach, certain countries or regions possess special attributes (lead market factors) that make the locally preferred innovation design successful worldwide. The lead market theory applies very well to the mobile communications market as it aims to explain the worldwide success of the cellular mobile telephony and why it prevailed over rival innovation designs, such as pagers and satellite telephony. Beise (2004) and Beise (2006) suggest that mobile telephony (and 2G in particular) became so popular worldwide because it enjoyed tremendous success in the Nordic countries from its very beginning, which possess such lead market factors as for example high competition among telecom providers and subsequently low prices, the pan-European and non-proprietary character of the GSM standard, traditional export orientation of the Nordic countries, and the average population density in these countries.

However, as already discussed in the theoretical chapter, although the approach developed by Beise (2004) and Beise (2006) works well for 2G (GSM), the adoption of 3G mobile technologies in the European countries did not follow the same pattern as that of 2G. 3G penetration curves in Figure 3.12 suggest that Nordic countries were rapidly overtaken by Korea, Japan and Slovenia. Based on this results, a decision was taken to conduct a more detailed analysis of the factors that might have contributed to the 3G adoption in the OECD countries. Hence, our dependant variable is 3G penetration rate that was calculated based on the most recent data on 3G subscriptions from OECD (2013, Table 4.9) and OECD population statistics for respective years.

As the first 3G commercial network was launched in 2001 and the latest data available were for 2011, we will be dealing with an unbalanced panel dataset with data on 23 countries (for a complete list of countries see Appendix A) over 11 years ($N = 23$, $T = 11$). The number of countries is also limited by the data on 3G subscriptions available from the OECD.

The independent variables were chosen as approximation of the lead market factors discussed by Beise (2004) and Beise (2006). Therefore, the novelty of this analysis is that it aimed to establish ex-post the influence of at least a part of suggested lead market factors on the 3G penetration rate. The data available from OECD, ITU, EUROSTAT, World Bank, UN Comtrade and EU Comext databases were classified into five lead market factors as summarised in Table 5.1 (for a complete list of data sources see Appendix A). In many cases it was not possible to find the data referring only to mobile communications technologies and therefore they were substituted with more general data on ICT.

As regards the first lead market factor - the demand advantage - we will check the influence of income, which, Beise (2004, p. 1003) argues, is "*one of the fundamental determinants that shapes the consumption pattern*". Transfer advantage - the ability of a country to shape other countries' preferences - is more difficult to quantify and we consider the 2G mobile penetration rate 10 years ago as well as the current fixed broadband penetration rate as an indicator of the sophistication of a country's users, their openness for new communication technologies. Also, the share of young population and its education level might influence the reputation of a country's users and their level of technical sophistication.

Price advantage that according to Beise (2004) is expected to be one of the most important lead market drivers, could best be quantified by the costs of mobile Internet usage. However, neither OECD nor ITU did dispose of such yearly data. The mobile cellular price of 3 minutes local call (available from ITU) did not work as a proxy because of too many missing values in the data, which made their use impossible in a statistical

Table 5.1: Independent variables

Lead market factor	Variable	Data Source
Demand advantage	Gross adjusted disposable income per capita (GADI) (USD, current prices, current PPPs)	OECD
Transfer advantage	Mobile cellular penetration rate 10 years ago (subscriptions per 100 inhabitants)	ITU
	Fixed (wired) broadband Internet subscriptions per 100 inhabitants	OECD
	Students enrolled into tertiary education per 100 population	OECD
	Young population (15-34 years) per 100 population	OECD
Market structure advantage	ICT patent applications filed under the PCT 3 years ago (inventor's country of residence, priority date, per million population)	OECD
Export advantage	Urban population (% of total)	World Bank
	Population density (people per sq. km of land area)	World Bank
	Telecommunications equipment export unit value (USD/kg)	UN Comtrade, EU Comext

Source: Own illustration based on Beise 2004 and 2006.

analysis.

Evaluation of the market structure advantage also posed a challenge because the data on the competition (i.e. the number of mobile operators for each year) in the mobile communications market in selected countries were not complete and thus not suitable for this analysis. Therefore, alternatives were required. In this case ICT patent applications filed under the PCT (Patent Cooperation Treaty) were used, which reflect the level of innovation activity in the national mobile communications and ICT market. A time lag of 3 years was taken because, according to WIPO (2013), in many cases the entire procedure from patent application to grant takes over 18 months, and the implementation of the invention also usually takes certain time, an average lag of at least 3 years is required for an invention to actually influence the market. Unfortunately, the OECD data on investment in cellular mobile infrastructure turned out to be too incomplete for the purpose of this statistical analysis.

Finally, export advantage is in this case characterised by the percentage of urban population and by the population density (allowing to compare the similarity of local market conditions), as well as by telecommunications equipment export unit value (the higher the ratio, the more high-tech telecommunications equipment the country exports).

5.3 Descriptive Statistics

Although much time and effort was invested in data collection, for many countries and variables it was impossible to find more yearly data and consequently we have to deal with an unbalanced panel with 147 observations for each variable as shown in Table 5.2.

The biggest differences across panels can be observed in variables that characterise the countries' innovation activity and exports: ICT patent applications and telecommunications equipment export unit value. Export unit value has a mean of approximately 301 USD/kg and standard deviation of just over 1804 USD/kg and ICT patent applications display a mean of approximately 35 and standard deviation of almost 39. This suggests that although significant convergence has occurred with respect to mobile penetration rates, the innovation and export performance of selected countries is still very different.

Table 5.2: Descriptive statistics

	Mean	Std. Dev.	Min.	Max.	Observations	Cross sections
3G penetration ¹	25.48513	31.37748	0	105.6542	147	23
GADI ²	21799.43	5357.022	9700.855	37809.58	147	23
Mobile penetration 10 years ago ³	23.54714	24.44652	0	89.59213	147	23
Fixed broadband ⁴	17.20923	10.9642	.0078067	39.46478	147	23
Students ⁵	4.168578	1.009632	2.530597	6.741761	147	23
Young population ⁶	26.7696	2.475253	21.91481	32.69896	147	23
ICT patent applications ⁷	34.67713	38.5611	0.0886268	172.904	147	23
Export unit value ⁸	301.3357	1804.471	13.4923	21720.13	147	23
Urban population ⁹	71.48547	10.30665	49.9294	88.7158	147	23
Population density ¹⁰	150.3553	119.8007	17.03276	512.6571	147	23

¹ 3G subscriptions per 100 inhabitants

² in USD, current prices, current PPPs

³ subscriptions per 100 inhabitants

⁴ subscriptions per 100 inhabitants

⁵ enrolled into tertiary education, per 100 population

⁶ 15-34 years, per 100 population

⁷ per million population, filed 3 years ago

⁸ in USD/kg

⁹ in % of total population

¹⁰ people per sq. km of land area

Source: Own calculations.

Further, correlation analysis was conducted and Table 5.3 displays some interesting results. For example, 3G penetration rate is highly positively correlated with mobile pen-

etration rate 10 years ago, and modestly correlated with fixed broadband penetration rate as well as with the number of students enrolled into tertiary education (per 100 population). This suggests that technical sophistication of users and their familiarity with previous mobile technologies (2G) and fixed broadband positively affects the adoption of 3G technologies (mobile broadband). On the other hand, the low Pearson's r signifies a weak positive correlation of 3G penetration with gross adjusted disposable income and with population density.

Table 5.3 also suggests that some of our independent variables are moderately to highly correlated. For example, fixed broadband is highly positively correlated with mobile penetration rate ten years ago, again suggesting that the development of mobile and fixed communication technologies goes hand in hand. Gross adjusted disposable income shows a moderate negative correlation with percentage of young population, and ICT patent applications are moderately positively correlated with percentage of urban population. Percentage of young population displays a negative correlation with most other variables - indeed, more economically developed countries tend to have an ageing population. Our correlation analysis shows that, in accordance with the 0.80 Pearson correlation criterion (see for example Lee and Brown (2008, p. 28)), no variables displayed very high correlation with other independent variables that could lead to multicollinearity problems.

Table 5.3: Correlation matrix, Pearson's r

	3G_pen	GADI	mob_pen	fix_BB	stud	young	ICT_pat	exp	pop_urb
3G_pen	1.0000								
GADI	0.2535	1.0000							
mob_pen	0.6864	0.3765	1.0000						
fix_BB	0.5629	0.4741	0.7005	1.0000					
stud	0.3839	-0.3086	0.1461	0.1511	1.0000				
young	-0.1644	-0.6224	-0.3781	-0.4138	0.2685	1.0000			
ICT_pat	0.0666	0.3763	0.1616	0.3489	0.1248	-0.4141	1.0000		
exp	-0.0298	0.1356	0.0932	0.1234	-0.0361	-0.0885	0.0046	1.0000	
pop_urb	-0.1502	0.3149	0.0823	0.3540	-0.0790	-0.4089	0.6536	0.1009	1.0000
pop_d	0.2108	0.1695	0.0461	0.2635	-0.1362	-0.1425	0.1309	-0.0342	0.2808

Source: Own calculations.

In order to further assess multicollinearity, variance inflation factors (VIF) were calculated (see Table 5.4). Although there is no formal test decision for this indicator, in applied regression analysis $VIF > 10$ is usually considered as a sign of high multicollinearity (see Kleinbaum et al. (1998)). Indeed, only two of the independent variables (mobile penetration 10 years ago and export unit value) had $VIF < 5$, while GADI, percentage of urban population and population density displayed very high multicollinearity with $VIF > 30$. High multicollinearity is a problem because it increases the standard errors of the coefficients and thus leads to imprecise estimates for highly correlated variables (see Baltagi (2011, p. 75)). Therefore, we will have to take high multicollinearity into account for future model estimation. One of the solutions would be, for instance, to drop variables with extremely high VIF. However, because multicollinearity does not

5.3. DESCRIPTIVE STATISTICS

affect the coefficients themselves and is very common in panel data models, we will only eliminate population density - the variable with the highest VIF.

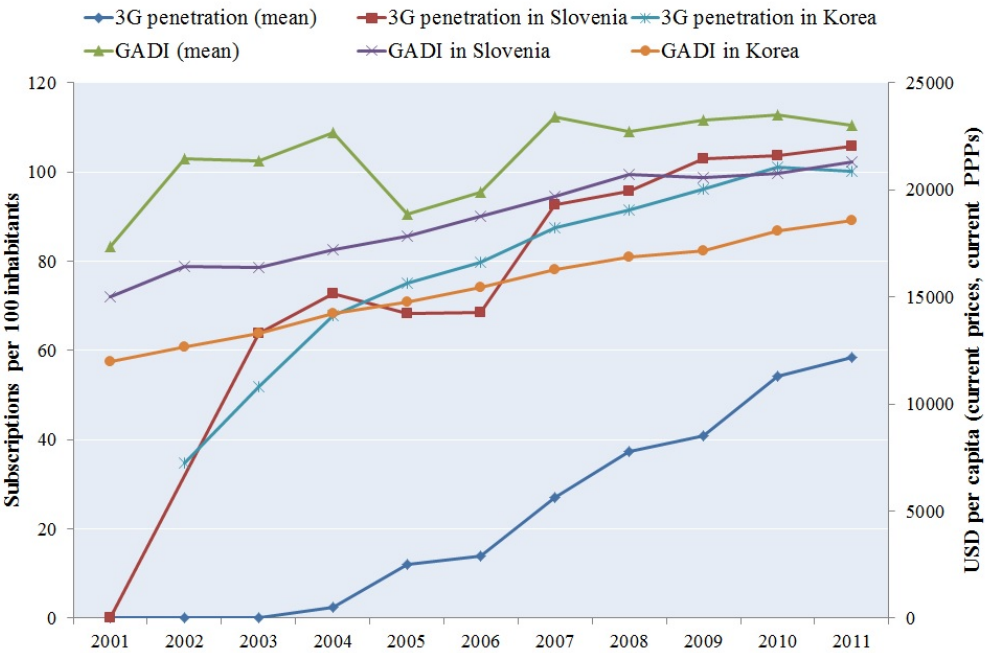
Table 5.4: Variance inflation factors

Variable	VIF
GADI	44.71
mob_pen	4.06
fix_BB	12.56
stud	20.38
young	23.40
ICT_pat	30.02
exp	1.27
pop_urb	238.93
pop_d	5435.39

Source: Own calculations.

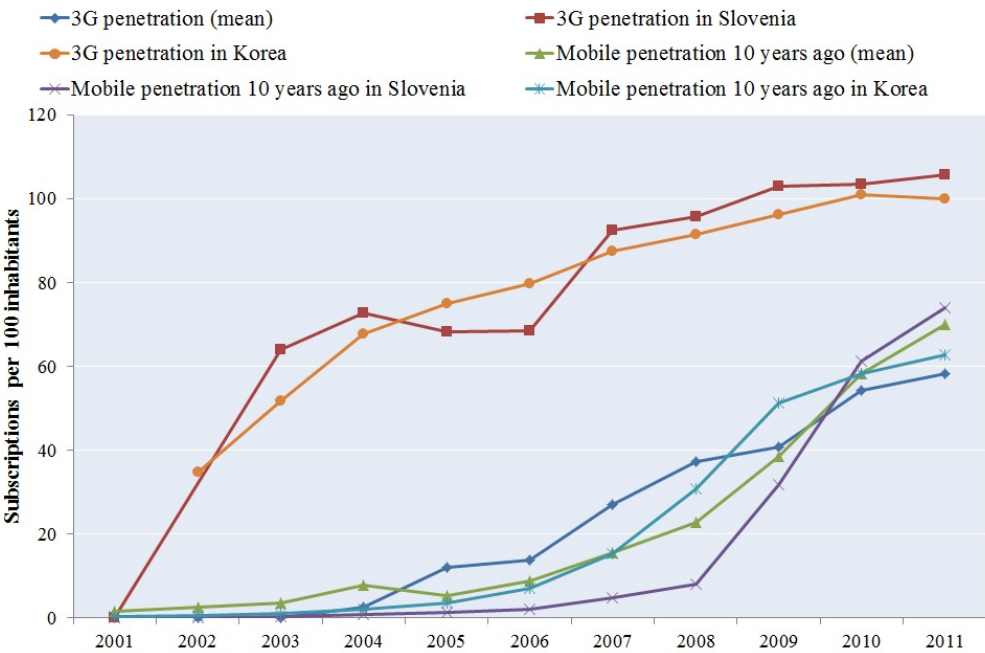
In addition, an attempt was made to establish if Slovenia and Korea (leaders in 3G adoption) displayed any similarities and interesting patterns. It turned out that although on some indicators the countries are indeed very similar, they are hardly comparable on the others. For example, Figures 5.1 and 5.7 show that Slovenia and Korea have had a very rapid 3G uptake despite their lower than average gross adjusted disposable income and telecommunications equipment export unit value. On the other hand, as measured by percentage of young population and students enrolled into tertiary education, both countries have similar higher-than-average performance (see Figures 5.4 and 5.5). At the same time, Korea has a much better than Slovenia performance in both 2G mobile and fixed broadband penetration rates (see Figures 5.2 and 5.3), as well as in ICT patent applications where Korea even exceeds the average after 2006 (Korean successful telecom producers such as Samsung have no doubt contributed to this improvement) (see Figure 5.6). These first results suggest that despite sharing some similarities, both 3G leaders seem to be very different, especially with regard to ICT development.

Figure 5.1: Relation between GADI and 3G penetration rate, 2001-2011



Source: Own calculations based on OECD.

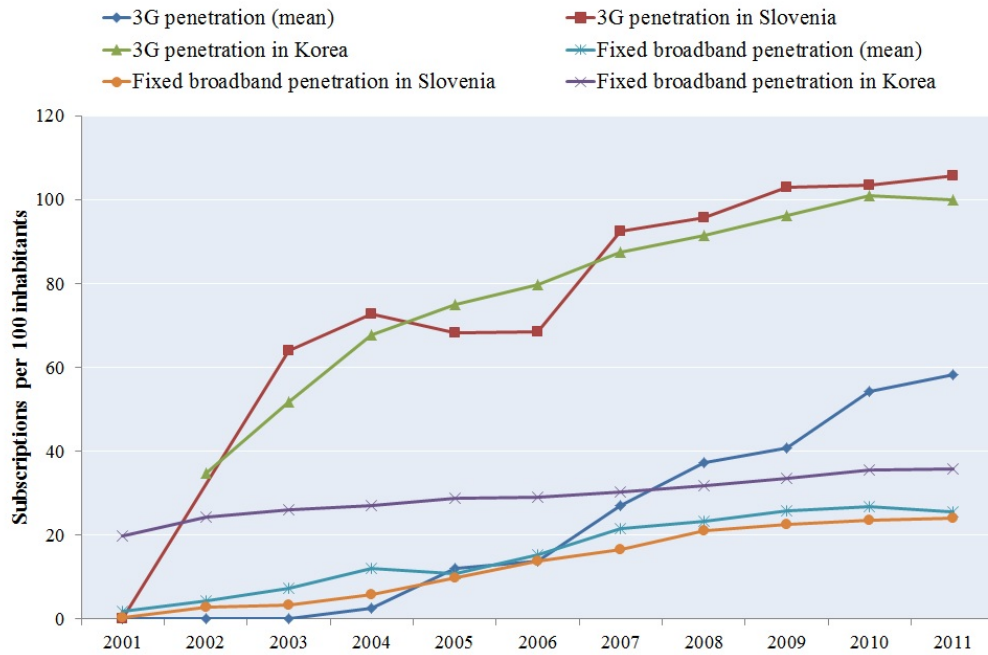
Figure 5.2: Relation between mobile penetration rate 10 years ago and 3G penetration rate, 2001-2011



Source: Own calculations based on OECD.

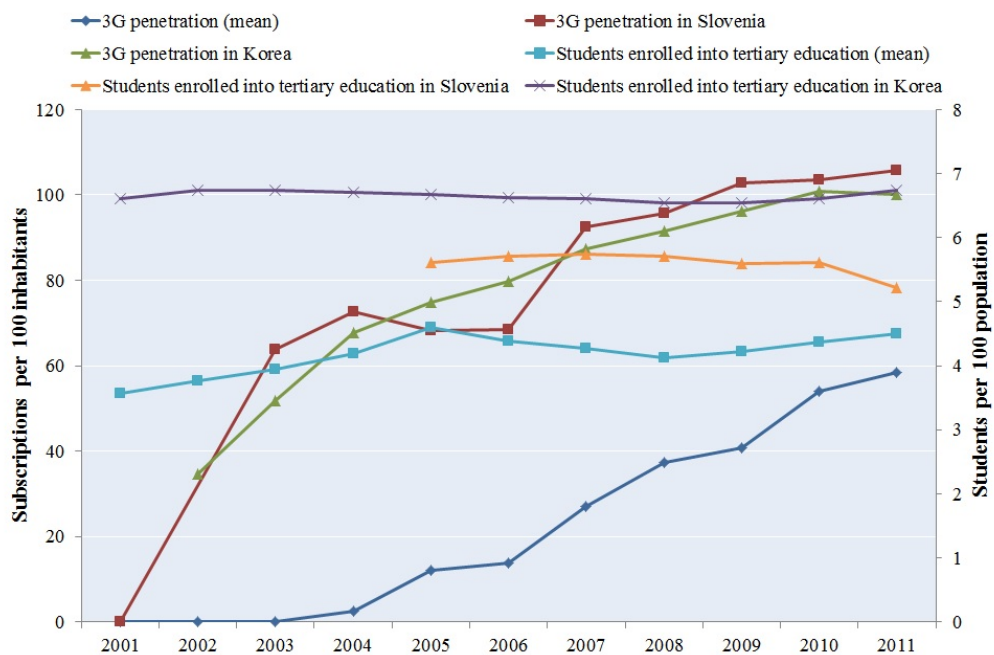
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Figure 5.3: Relation between fixed broadband penetration rate and 3G penetration rate, 2001-2011



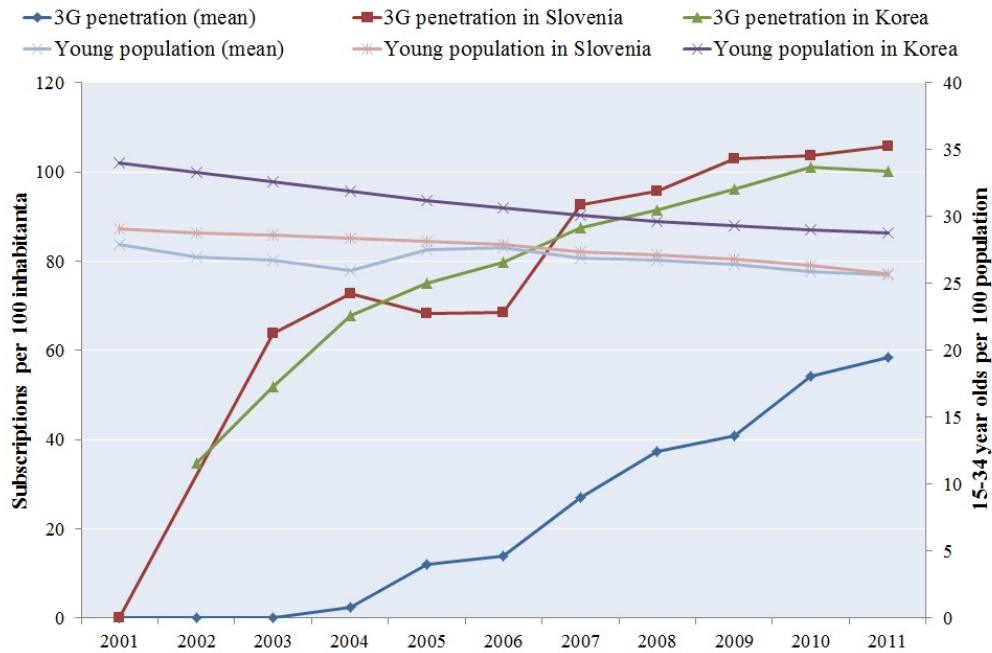
Source: Own calculations based on OECD.

Figure 5.4: Relation between students enrolled into tertiary education and 3G penetration rate, 2001-2011



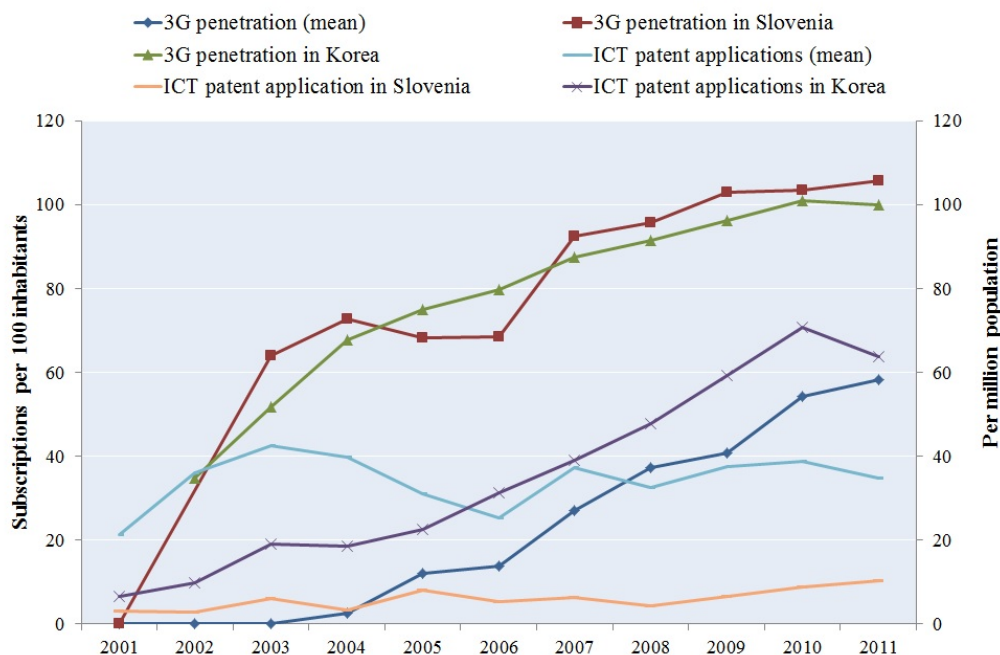
Source: Own calculations based on OECD.

Figure 5.5: Relation between young population and 3G penetration rate, 2001-2011



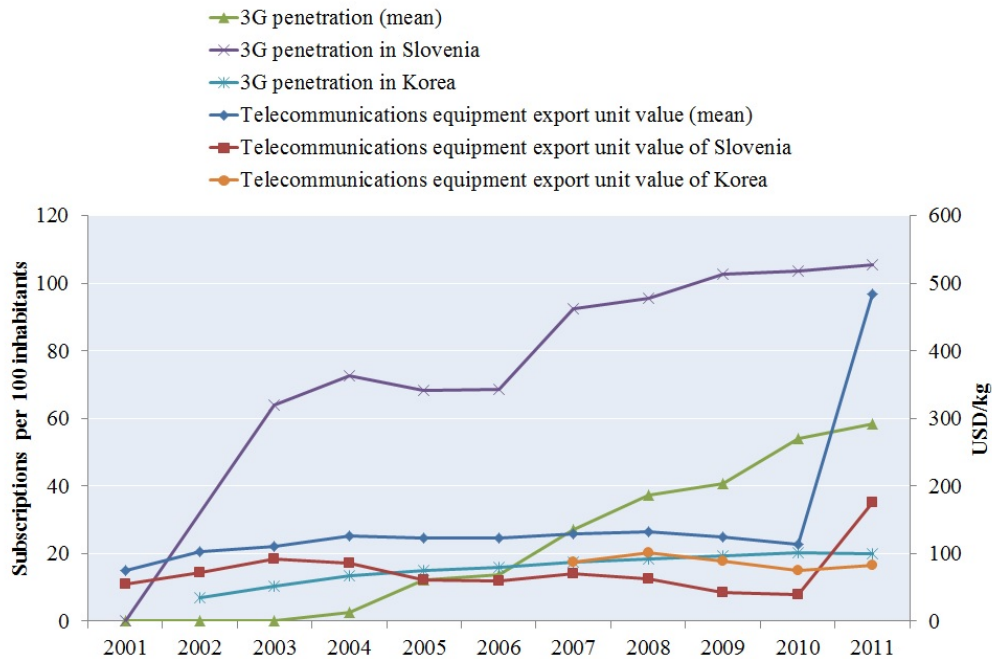
Source: Own calculations based on OECD.

Figure 5.6: Relation between the number of ICT patents and 3G penetration rate, 2001-2011



Source: Own calculations based on OECD.

Figure 5.7: Relation between telecommunications equipment export unit value and 3G penetration rate, 2001-2011



Source: Own calculations based on OECD, UN Comtrade, EU Comext.

5.4 Model and Hypotheses

The model is based on the framework of lead market theory developed by Beise (2004) and Beise (2006) and devoted to the global diffusion of innovations, and independent variables were carefully chosen in accordance with the lead market factors. After a careful analysis of the available 3G penetration curves (see Appendix B), a decision was made to step away from the commonly used logistic diffusion model employed for example by Lee et al. (2011) in their analysis of factors of fixed and mobile broadband deployment. The main reason for this choice was that by far not all available data on 3G penetration show the signs of a logistic diffusion pattern. Only eight out of 23 countries seem to be in the lower part of the logistic curve (sometimes also called S-curve), and our leaders Slovenia, Korea and Japan are already in the saturation phase (although Japan displays a very smooth S-curve close to a linear trend), while the penetration curves of 13 countries are still clearly linear (in some cases due to lack of data). Moreover, this model choice is justified by the fact that Lee and Brown (2008) also used a linear model (multiple regression analysis) in addition to the logistic model in order to examine the influences of quantifiable variables on the diffusion patterns of fixed-broadband.

At the same time, we must take into account that 3G adoption is clearly a dynamic process in which the penetration rate of every subsequent year depends on the penetration rate in the previous period. Hence, it requires a dynamic panel data model. Therefore, we act on the assumption of a dynamic linear dependence and consider that penetration rate of 3G mobile technologies is driven by eight factors: GADI, mobile penetration 10 years ago, fixed broadband Internet penetration, students, young population, ICT patent applications, telecommunications equipment export unit value and urban population (popula-

tion density was dropped because of extremely high VIF). Hence, the regression equation looks as follows:

$$\begin{aligned}
 3Gpenetration_{it} = & \delta 3Gpenetration_{i,t-1} + \beta_1 GADI_{it} + \beta_2 MobilePenetration_{it} \\
 & + \beta_3 FixedBroadband_{it} + \beta_4 Students_{it} + \beta_5 YoungPopulation_{it} \\
 & + \beta_6 ICTPatents_{it} + \beta_7 ExportUnitValue_{it} \\
 & + \beta_8 UrbanPopulation_{it} + \mu_i + \nu_{it}
 \end{aligned}
 \tag{5.1}$$

where index i denotes the country, t represents time (year in this case), μ_i is the unobservable individual specific effect (such as country-specific policy measures that are hard to quantify) and ν_{it} denotes the remainder disturbance (see Baltagi (2010)). As already mentioned, here we deal with a dynamic panel data model characterised by the presence of a lagged dependant variable $3Gpenetration$ among the regressors (ibid.). In addition, the variables fixed broadband Internet penetration and telecommunications equipment export unit value are apparently endogenous because, first, fixed broadband adoption might be influenced by 3G penetration, and, second, wide adoption of mobile technologies (and ICT in general) is likely to improve the export performance of a country in this sector.

As regards the influence of each single factor, first, it can be expected that with increasing income, the users adopt new (often more expensive) technologies more eagerly. Second, we assume a strong positive influence of penetration rate of previous mobile technologies (2G) and of fixed broadband penetration on 3G penetration rate, because more experienced and more technology-friendly users are also more likely to adopt new technologies. Moreover, we expect to show if fixed broadband Internet and mobile Internet are complementary or substitute technologies. Third, countries with higher percentage of young population and more students are expected to adopt 3G faster because younger and better educated part of population would follow mobile trends first.

In addition, it is logical to assume that 3G penetration rate should be higher in markets where more R&D in ICT (with more ICT patents) was conducted. And finally, there should also be positive correlation between the last two factors characterising export advantage and 3G penetration rate. However, the role of urban population is not entirely clear because it is also sometimes suggested that users in rural areas, on the contrary, adopt mobile technologies more eagerly if they do not have good fixed Internet access.

5.5 Methodology and Regression Results

As regards model estimation method, we stopped on Arellano-Bover/Blundell-Bond linear dynamic panel-data estimation with a system estimator that uses additional moment conditions (see Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998)). The GMM (generalised method of moments) estimation method developed by Arellano and Bond (1991) is based on the first difference of the model and eliminates the individual effects μ_i . In addition, the system GMM estimator with additional moment conditions developed by Blundell and Bond (1998) building on the work of Arellano and Bover (1995), is more efficient for panels with short T because it reduces the finite sample bias as compared to the standard first-differences estimator (see also Baltagi (2010)).

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Also, Soto (2009) was able to demonstrate through Monte Carlo simulations that a small number of individuals (which is typically the case in country growth studies) does not seem to have important effects on the properties of the system GMM estimator, which displays the best features in terms of small sample bias and precision (compared to OLS, the fixed effects and the difference GMM). Therefore, the system GMM can be seen as the best estimation method for our case - dynamic panel model with endogenous variables (fixed broadband penetration and telecommunications equipment export unit value), short T ($T = 11$) and small N ($N = 23$).

The results of postestimation specification (Sargan) test confirmed that model and overidentifying conditions are correctly specified and that there is no serial correlation in the first-differenced disturbances. The results of the regression are presented in Table 5.5.

Table 5.5: System dynamic panel-data estimation with endogenous variables

Dependent variable: <i>3G penetration</i>	One-step results
3G penetration L1.	0.7200763*** (0.0962526)
GADI per capita	0.0022808*** (0.000596)
Mobile penetration 10 years ago	0.1441716** (0.0719534)
Fixed broadband penetration	-0.0417728 (0.2427129)
Students enrolled into tertiary education	5.964504** (2.71067)
Young population (15-34 years)	2.321677** (0.9571797)
ICT patent applications filed under the PCT 3 years ago	0.0055213 (0.0626032)
Telecommunications equipment export unit value	-0.0003873 (0.0027504)
Urban population	-0.6454981** (0.3177512)
Constant	-82.07959** (41.14552)
Wald chi2(9)	713.65***
Instruments	102
Observations	109

Notes:

***, **, * denotes significant at the 1, 5 and 10 per cent level, respectively.

Standard errors are given under the coefficients.

As anticipated, these results indeed indicate positive influence of income on 3G penetration rate in selected OECD countries, confirming the role of demand advantage in the case of 3G diffusion, as suggested by the lead market theory by Beise (2004) and Beise (2006). By contrast, the income variable (as measured by GDP per capita, PPP) in the study previously conducted by Lee et al. (2011) was not statistically significant - possibly due to less data (their $T = 6$).

Further, the regression results indicate a strong positive role of mobile penetration rate 10 years ago (i.e. previous 2G adoption) on 3G adoption. Hence, our second hypothesis is also confirmed - the users' familiarity with the previous generation of mobile technolo-

gies seems indeed to have had an important positive influence on 3G diffusion. These results are similar to the findings by Lee and Brown (2008) regarding the fixed broadband penetration - the results of their study suggest that previous fixed broadband penetration is an influential factor for fixed-broadband diffusion in the 30 OECD countries that were considered.

On the other hand, we cannot say if fixed broadband and 3G (i.e. mobile broadband) are complementary or substitute technologies because the negative coefficient is not statistically significant. Thus, we are not able to confirm the findings of Lee et al. (2011, p. 15) who argue that *"in many OECD countries, mobile service is a complement to fixed broadband services"*.

As regards the percentage of students and young population, the role of these two variables is also strongly positive, suggesting that young and better educated users follow new mobile trends more eagerly. To go back to the study by Lee et al. (2011, p. 13), although their education variable (as measured by UNDP Education index) was not statistically significant for mobile broadband penetration, their results for fixed broadband penetration were similar to ours, implying that higher levels of education *"are important drivers of fixed broadband diffusion in many OECD countries"*. This indicates a similar positive role of education for both mobile and fixed broadband diffusion.

Both patent applications and telecommunications export unit value are not statistically significant, which suggests that conducting R&D in telecommunications and exporting high-tech telecommunications equipment are not among the main factors that have influenced 3G adoption. These findings are in line with the lead market theory as Beise (2006) argues that it is the society that shapes the technological path through its choices, and not technical superiority of an innovation design.

Finally, the regression results indicate a strong negative correlation between the percentage of urban population and 3G penetration rate, suggesting that in selected OECD countries rural population uses 3G technologies more intensively, maybe because fixed broadband is less accessible. These results are not directly comparable with findings by Lee et al. (2011, pp. 14-15) who take population density as an explanatory variable in their model and suggest that *"higher population density contributes to mobile broadband deployment"* and that *"less densely populated countries are indeed at a disadvantage when it comes to the deployment of mobile broadband communications"*. Hence, further research is needed to clarify this issue.

5.6 Conclusions

The results of this analysis have confirmed several of the previously formulated hypotheses and some earlier findings by Lee et al. (2011). For example, there was a positive effect of mobile penetration rates ten years ago that indicates the level of users' technical sophistication and expertise. In addition, demand advantage as expressed by gross adjusted disposable income has also positively influenced 3G adoption, as did young and better educated (and thus more technology friendly) population in selected countries. On the other hand, our results suggest that it is not urban but rather rural population that adopted 3G technologies more eagerly.

These results help to explain at least in part why Slovenia has managed to achieve such impressive 3G penetration rates despite its poor telecommunications export and R&D performance - simply because the role of these factors was not important. At the same time,

Slovenia (and Korea) have a young and well-educated population - factors that, as our results suggest, must have been among the strongest determinants of 3G success in selected countries. Detailed case studies on Slovenian and Korean mobile communications markets should help shed light on further factors that contributed to such an impressive success of 3G in these two countries.

It is clear that our sample was not very big due to lack of data on 3G penetration and other factors for many countries. Nevertheless, the results of this analysis have confirmed some suggestions of the lead market theory, such as for example an important role of users' reputation and technical sophistication. More data should be collected in the future for 3G and 4G mobile technologies in order to confirm these first findings and also to identify the measures that contribute to the development of technical sophistication and innovativeness.

Chapter 6

Policy Measures and Recommendations

In this chapter we will first get an overview of existing policy measures aiming to promote innovation activities and mobile communications development in the European Union. In the second part we will develop policy recommendations for European countries based on the results of empirical analysis.

6.1 European Union Policy

The Europe 2020 strategy, agreed by Member States at the June 2010 European Council, focuses on investments in education, research and innovation as the key to achieving smart, sustainable and inclusive growth (European Commission, 2010b). It includes seven "flagship" initiatives: Innovation Union, Digital Agenda, Industrial Policy for the Globalisation Era, Youth on the Move, the Agenda for New Skills and Jobs, Resource Efficient Europe, and the Single Market Act. In conjunction with the Innovation Union, these flagships are expected to improve conditions for innovation in the EU, including by accelerating the roll-out of high speed internet and its applications, by securing a strong industrial base, by promoting excellent education systems, modern labour markets, and the right skills mix for Europe's future labour force, and by ensuring effective competition policy and better access to third country markets (European Commission, 2010b). Moreover, in order to implement the Innovation Union, the European Commission introduced a special financial instrument - Horizon 2020 programme, which is currently the biggest EU Research and Innovation programme with nearly EUR 80 billion of funding available over 7 years (2014 to 2020). In this part we will consider the first two EU flagship initiatives concerning the promotion of innovation and ICT in the European Union, Horizon 2020 programme and its sections with ICT focus, as well as the separate Lead Market Initiative.

6.1.1 Innovation Union

The Innovation Union is the European Union strategy to create an innovation-friendly environment. As stressed by the European Commission (2013i, p. 2), its aim is "*creating a vibrant, innovation-based economy fuelled by ideas and creativity, capable of linking into global value chains, seizing opportunities, capturing new markets and creating high-quality jobs*". In order to develop even further the strengths and tackle the weaknesses of

the European economy, such as under-investment in our knowledge foundation, unsatisfactory framework conditions (e.g. poor access to finance), and too much fragmentation and costly duplication, the European Commission (2010b, p. 3) suggested ten strategic measures:

1. The EU and Member States need to continue to invest in education, R&D, innovation and ICTs, despite fiscal constraints.
2. This should go together with reforms in order to get more value for money and tackle fragmentation. EU and national research and innovation systems need to be better linked up with each other and their performance improved.
3. European education systems at all levels need to be modernised as the EU needs more world-class universities. We should raise skill levels and attract top talent from abroad.
4. Researchers and innovators must be able to work and cooperate across the European Union as easily as within national borders.
5. Access to EU programmes must be simplified and their leverage effect on private sector investment enhanced, the role of the European Research Council should be reinforced. The framework programme's contribution to nurturing fast-growing SMEs must be boosted. The European Regional Development Fund should be fully exploited to develop research and innovation capacities across Europe, based on smart regional specialisation strategies.
6. Europe needs to get more innovation out of its research, cooperation between the worlds of science and the world of business must be enhanced.
7. Remaining barriers for entrepreneurs to bring "ideas to market" must be removed, i.e. ensuring better access to finance, particularly for SMEs, affordable Intellectual Property Rights, smarter and more ambitious regulation and targets, faster setting of interoperable standards and strategic use of our massive procurement budgets.
8. European Innovation Partnerships should be launched to accelerate research, development and market deployment of innovations to tackle major societal challenges (starting with the area of healthy ageing), pool expertise and resources and boost the competitiveness of EU industry.
9. European strengths in design and creativity must be better exploited. We must champion social innovation and develop a better understanding of public sector innovation.
10. We need to work better with our international partners, which means opening access to EU R&D programmes, while ensuring comparable conditions abroad.

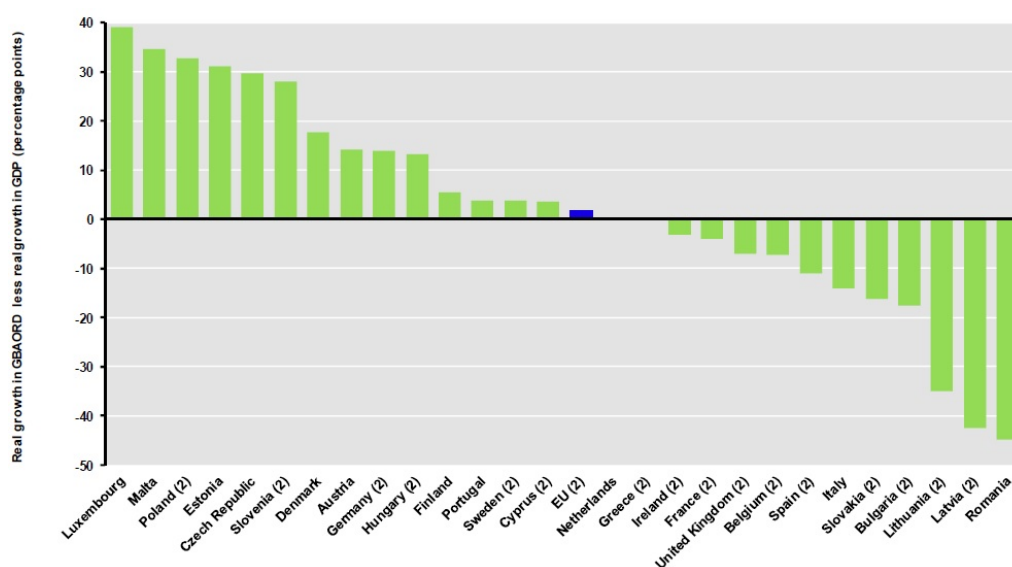
The European Commission (2010b) argues that the benefits of the Innovation Union will be significant. For example, today Europe is under-investing in its knowledge base, spending every year 0.8 per cent of GDP less than the US and 1.5 per cent less than Japan in R&D (European Commission, 2010b, p. 6). According to recent estimates by Zagamé (2010), achieving the target of spending 3 per cent of EU GDP on R&D by 2020 could create 3.7 million jobs and increase annual GDP by close to EUR 800 billion by 2025.

We will further consider in more detail the key strategic measures of the Innovation Union flagship and the progress achieved in these fields by the end of 2012.

Investing for the Future

European Commission (2013i) stresses that public and private investment in R&D is crucial to enable Europe to take advantage of any rebound in the economy. For example, the recovery in 2010 was substantially stronger in countries which had previously invested the most in R&D and innovation, such as Germany, Finland and Sweden (European Commission, 2011b). In the EU, public and private investment in R&D was growing before the economic crisis. After the outbreak of the crisis, a majority of Member States maintained or increased their R&D investments, in spite of fiscal constraints, and overall R&D spending over GDP increased from 1.85 per cent in 2007 to 2.03 per cent in 2011. However, in eleven Member States it has grown less than GDP since the beginning of the crisis (see Figure 6.1).

Figure 6.1: Government investment in the future: The difference in percentage points between real growth (1) in Government budgets for R&D (GBAORD (2)) and real growth (1) in GDP, 2008-2012 (3)



Notes:

1. Real growth was calculated from values in PPS EUR at constant 2000 prices and exchange rates.
2. Foregone tax revenues resulting from R&D tax incentives are not included.
3. EL: 2007-2008; PL: 2009-2011; BE, BG, DE, IE, ES, FR, CY, LV, LT, HU, SI, SK, SE, UK, EU: 2008-2011.
4. Data for 2012 are provisional.

Source: European Commission, 2013c, p. 4.

As regards R&D investment in private sector, according to European Commission (2013i), businesses in the EU also increased their expenditure on R&D as a share of GDP from 1.18 per cent in 2007 to 1.27 per cent in 2011. This is in part due to sustained R&D investment by European firms, but also because foreign firms consider Europe to be an attractive place to invest in R&D (ibid.). Moreover, the results of The 2012 EU

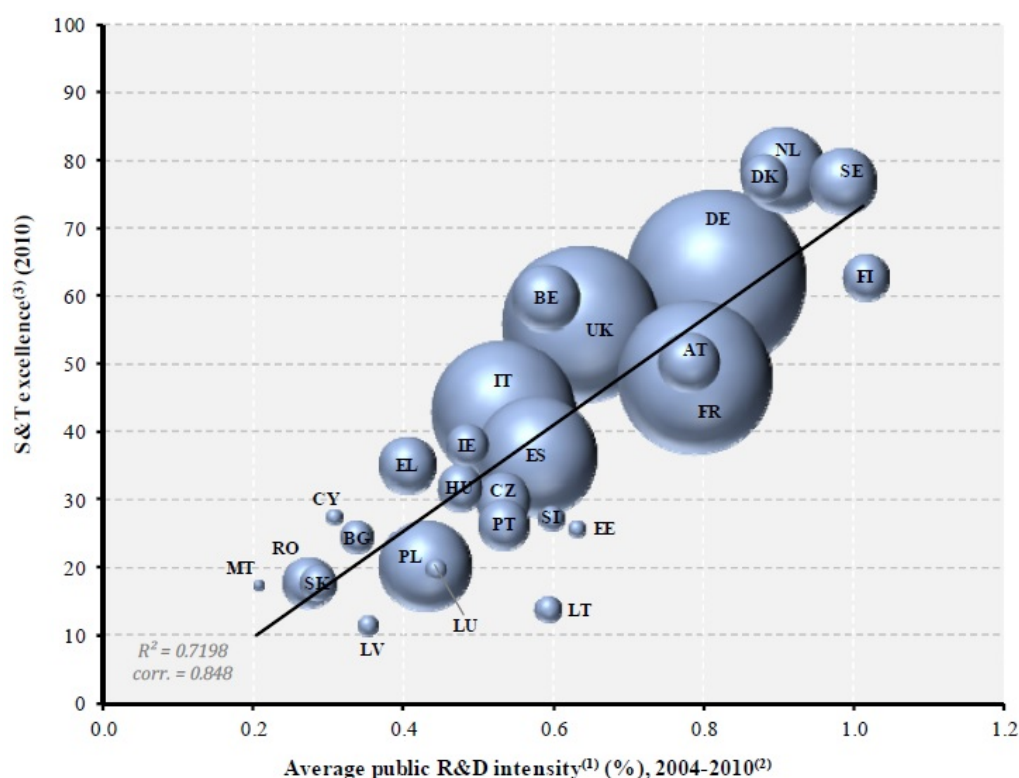
Survey on R&D Investment Business Trends suggest that in Member States where the business sector is knowledge-intensive and internationally competitive, the governments' strategy to protect R&D spending helped maintain the level of private investment (European Commission, 2012a). However, on the downside, protecting R&D investment proved more difficult for EU countries suffering from sovereign debt crisis, where liquidity constraints combined with an insufficiently innovation-friendly environment and a lower level of business demand for knowledge undermined the effectiveness of the counter-cyclic efforts to stimulate business investment (ibid.). This experience shows that investing in knowledge must be accompanied by reforms in the research and innovation system including creating innovation-friendly framework conditions for innovative businesses (European Commission, 2013i).

Reforms to Raise Efficiency and Effectiveness

As regards the goal of raising efficiency and effectiveness, European Commission (2010b) stresses that while action at the European Union level is important, the quality of national research and innovation systems remains crucial for promoting business and citizens' capacity and willingness to invest. Especially in times of fiscal constraint, significant reforms to national and regional policies are required in order to get the most out of the money invested (European Commission, 2013i). Figure 6.2 shows that there are still considerable differences between Member States in terms of their research and innovation efficiency - for a given amount of public investment, some countries achieve more excellence in science and technology than the others.

Many EU Member States have launched ambitious policy reforms in order to make their research and innovation system more efficient. For example, in Sweden, a new bill on research and research-based innovation as well as a new innovation strategy were launched in autumn 2012 (European Commission, 2013g). They increase public funding for R&D and foster the growth of firms in innovative sectors. Moreover, Sweden aims at enhancing service and product innovation by orienting innovation more closely towards global societal challenges. As this strategy is implemented, Sweden's supply-side policies (in particular to fund testing, demonstration infrastructure and reinforce incubators of new research-based products) will be matched more closely with policies enhancing the demand for innovation (i.e. introducing a new procurement law fostering innovation-friendly procurement) (ibid.). According to European Commission (2013g), over the last five years, several initiatives have been launched to enhance the effectiveness of the Swedish innovation system, with a special focus on innovation in SMEs through reinforced public-private cooperation with universities and better access to seed funding and venture capital. For example, Industrial Research Institutes have been created that would play the role of specific innovation intermediaries and act as an interface between academic research and product development in the business sector. The idea behind it is that the private business sector buys R&D services from the Institutes, while the state funds their facilities and skills development. Additionally, the bill established innovation offices to foster the commercialisation of research results. The commercialisation of research in seven Swedish universities was encouraged by additional state funding (SEK 150 million per year). Access to funding, particularly early stage seed financing, for innovative SMEs is enhanced through business incubators and venture funds (ibid.). Moreover, as part of the Europe 2020 process, Sweden received a recommendation to foster cooperation between the technology and innovation demands of larger multinational companies with the

Figure 6.2: Investment and research excellence



Notes:

1. Average public R&D intensity (public Gross Domestic Expenditure on R&D as percentage of GDP).
2. EL: 2004-2007; SE, IT: 2005-2010; DK: 2007-2010, LU: 2009-2010.
3. Composite indicator on Research excellence (feasibility study of JRC).

Source: European Commission, 2013c, p. 7.

innovative products and services produced by local firms (ibid.). The new EU Structural Funds for 2014-2020 also provide an opportunity to enhance clusters and infrastructures for the testing and demonstration of new technology-based innovation in Sweden (ibid.).

Slovenia, one of the EU leaders in public R&D investment growth (see Figure 6.1) has significantly increased its overall R&D intensity over the last decade and reached the value 2.47 per cent of GDP in 2011, which was above the EU average of 2.3 per cent (European Commission, 2013f). This suggests that Slovenia regards investment in R&D as a priority for the development of medium-high-tech, high-tech and competitive enterprises and for increased and sustainable economic growth (ibid.). European Commission (2013f) stresses that, in order to reach its R&D intensity target of 3 per cent by 2020, Slovenia is mobilising incentives and resources from its public and private sources (human, financial, infrastructural) and providing smooth paths for more technological innovation. Simultaneously, it needs to upgrade the effectiveness and efficiency of its innovation system, notably through improved governance and higher dynamics in the knowledge triangle. In order to deal with these challenges, a new National Research and Innovation Strategy 2011-2020 (RISS) was prepared and approved in 2011 (ibid.). Its aim is to create a high-performance research and innovation system which will improve the quality of life. RISS sets out the following main priorities:

1. Better integration of research and innovation;
2. Increasing scientific excellence by increasing competitiveness within S&T stakeholders and by providing necessary resources, both human and financial;
3. Promoting closer cooperation between universities, research institutions and the business sector;
4. Strengthening the capacity of research in order to contribute to economic and social development (ibid.).

Within RISS, a special section is devoted to the issue of research infrastructure - Slovenian Research Infrastructure Roadmap (2011-2020). Its key objectives are, first, a better exploitation of the existing national research infrastructure, second, upgrade and construction of new research infrastructure in priority areas, and, third, international integration based on access to large research infrastructures. In addition, the National Programme 2011-2020 for Higher Education (NHEP) in Slovenia points to improved efficiency of the system and better articulation with skills required, especially in science and engineering (ibid). Besides these two major programmes, Slovenia has several smaller programmes and instruments to support research and innovation, such as the innovation voucher, the mentorship voucher, the mentorship of young researchers, calls for basic and applied projects, financial assistance to institutions that support innovation, the strengthening of development units in the business sector and the transfer of technologies from the public sector (ibid.).

Promoting Excellence in Education and Skills Development

According to European Commission (2013i, p. 11), "*current skills mismatches and shortages of scientists and engineers present a threat to Europe's innovation capacity, precisely at a time of increasing technological needs*". In order to reach the R&D target of 3 per cent, the EU will need at least one million new research jobs (European Commission, 2010b). Taking this into consideration, European Commission (2010b, p. 8) warns that the European Union must ensure it has "*a sufficient supply of highly qualified workers, who should be offered attractive careers and easy mobility across sectors and countries; otherwise innovative investments and talent will move elsewhere*". Hence, the starting point for the Innovation Union is to create an excellent education system in all Member States (ibid.). Although Europe has a good basic education system compared to many parts of the world, science teaching remains weak in some Member States, and there are still too few girls taking science to an advanced level (ibid.). European Commission (2010b) explicitly states the urgent need for higher education reform in Europe, because most European universities do not attract enough top global talent, and relatively few of them are in leading positions in existing international rankings. In order to become more competitive, European universities should be freed from over-regulation and micro-management in return for full institutional accountability. European Commission (2010b) also suggests that universities in the EU need more diversity in their missions and outlook, with smarter specialisation across different fields.

The first steps have already been made in order to resolve these problems. For example in 2012 the Commission presented the Rethinking Education Communication that focuses on the need to develop transversal skills such as critical thinking, problem solving, team-working and entrepreneurial skills and to enhance academia-business partnerships

(European Commission, 2013i). In addition, the first Knowledge Alliances projects are under way. Their aim is to set up cross-sector partnerships between employers and educational bodies in order to address skills mismatches, for example in the audio-visual industry (CIAKL project), in manufacturing by integrating factory and classroom environments (KNOW-FACT project) and by fostering an entrepreneurial spirit in students and staff (EUN project) (ibid.). From 2014 onwards Knowledge Alliances should become part of the new Erasmus for All programme. Besides, an implementation of multi-dimensional and international ranking of higher education institutions has started in 2012 (ibid.).

Towards the European Research Area

European Commission (2013i) suggests that full deployment of the European Research Area (ERA), one of the key structural reforms to drive growth in Europe, would trigger substantial efficiency gains in knowledge and technology capacities. The essence of the reform is creating a reinforced partnership, under which the Member States, stakeholder organisations and the Commission will work together in order to enhance the effectiveness and efficiency of the European public research system. They will achieve this goal by encouraging more openness and competition, greater mobility for researchers, more cross-border cooperation and an optimal circulation of knowledge (ibid.).

The main issues of ERA framework, as suggested by the European Commission (2010b), are:

- quality of doctoral training, attractive employment conditions and gender balance in research careers in the EU;
- mobility of researchers across EU countries and sectors;
- cross-border operation of research performing organisations, funding agencies and foundations, including by ensuring simplicity and mutual coherence of funding rules and procedures;
- dissemination, transfer and use of research results in the EU, including through open access to publications and data from publicly funded research;
- opening of Member State operated research infrastructures to the full European user community;
- consistency of EU and national strategies and actions for international cooperation in science and technology.

Bringing Innovative Ideas to Market

European Commission (2013i) emphasises that the aim of Innovation Union is to remove obstacles that prevent innovators from translating ideas into new products and services that can be sold on world markets. In this context, Europe urgently needs to unleash its innovative potential by faster standard-setting, cheaper ways to obtain patent protection, smarter public procurement of innovative products and services, and better access to finance for innovators and SMEs. European Commission (2010b) and European Commission (2013i) sees three key areas where adequate policy measures are required:

1. Financing innovation

Although Europe has no shortage of innovative ideas waiting to be converted into successful business models, the first obstacle on their way is often access to finance. For example, as suggested by European Commission (2010b), innovative companies with the potential to expand into international markets have limited access to growth finance from venture capital because most venture capital funds in Europe are too small to support the continued growth of innovative companies and do not have the critical mass to specialise and operate transnationally. In order to solve these and other related problems, a number of policy instruments and programmes have been introduced in the past years. First, to remove obstacles to cross-border investment, two legislative proposals on "Social Entrepreneurship Funds" and "Venture Capital Funds" were agreed in 2012. Second, the Programme for the Competitiveness of Enterprises and SMEs (COSME) and Horizon 2020 will jointly support an equity and a debt financial instrument from 2014 onwards. Third, the Risk-Sharing Instrument (RSI) was launched as part of the Risk-Sharing Finance Facility (RSFF) in early 2012 in the form of a guarantee scheme to encourage banks to provide more loans to innovative SMEs and small midcaps. And finally, in 2013, the European Investment Bank started channelling additional EUR 10-15 billion to innovation and skills via a new Growth & Employment facility, thus generating up to EUR 65 billion of additional investment (ibid.).

2. Shaping demand for innovative products and services

European Commission (2013i) stresses that innovative companies can only be successful if there is a market for their goods and services, and consumers willing to buy them. Two key milestones towards helping innovative products and services reach the market faster are the new standardisation package, effective from 1 January 2013, and the proposal for the modernisation of the EU public procurement law. Thanks to the former, a European standard should be developed twice as fast by 2020, while the latter should enable public procurers to use a special procedure for buying innovative goods and services, to buy jointly with procurers from other Member States to share risks and costs, and to include the innovative character in the award criteria (ibid.).

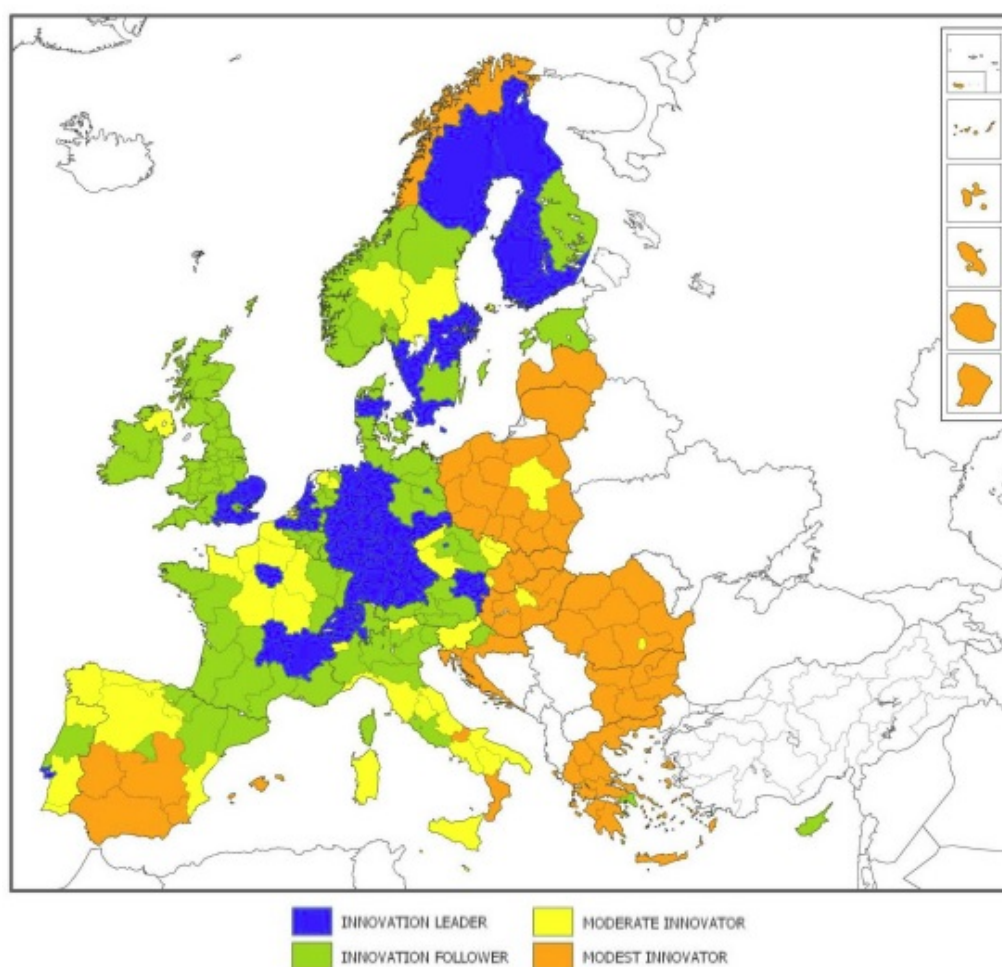
3. Capitalising on intellectual property and creativity

As underlined by European Commission (2013i), Intellectual Property Rights regimes have a crucial impact on how new knowledge and creations are owned, shared and used, and therefore constitute a key component of the framework conditions for research and innovation. To address the issue of European patent regime, the historic agreement on the unitary patent was reached in December 2012. According to European Commission (2013i), this should allow the first European patent with unitary effect to be granted and registered in spring 2014. In addition, a tool named Patent Translate, a machine translation service, is being developed by the European Patent Office in cooperation with Google. It went live in March 2012 and already offers translations from, and into, English for fourteen languages, and will gradually extend coverage to 32 languages by 2014. This free of charge service should make the content of patents and patent-related documents published anywhere in the world easily accessible for everyone (ibid.).

Spreading the Benefits of Innovation Across the Union

European Commission (2010b) emphasises that the Innovation Union must involve all regions and Europe must avoid an "innovation divide" between the strongest innovating regions and the others. So far, the country performance analysis (European Commission, 2013i) and the Regional Innovation Scoreboard 2012 (European Commission, 2012e) (see Figure 6.3) show that regional innovation divergences persist and risk to grow even more with the crisis.

Figure 6.3: Innovation performance by EU regions



Source: European Commission, 2012a, p. 6.

Due to this regional diversity, better tailoring of innovation policies to the relative strengths of individual regions is required (European Commission, 2013i). This should be encouraged under the future Cohesion Policy 2014-2020. Moreover, in the near future, Member States will have to develop research and innovation strategies for smart specialisation of their regions focused on a limited number of priorities. The Smart Specialisation Platform is already helping public authorities to design such strategies through peer-reviews, guidelines, and workshops across Europe (ibid.).

Another important priority in the European Union is social innovation. As European Commission (2010b, p. 21) puts it, social innovation is "about tapping into the ingenuity of charities, associations and social entrepreneurs to find new ways of meeting social

needs which are not adequately met by the market or the public sector". The aim of social innovation is also to bring about the behavioural changes which are needed to deal with the major societal challenges, such as climate change (ibid.). However social innovations are not yet producing the impact that they should and more support for experimentation is required. In this respect, the infrastructure for social innovation is not yet as well developed as that for business innovation.

In February 2013, the "Social Investment Package" was presented aiming, among others, to find innovative ways of financing social innovation and to support the modernisation of social protection (European Commission, 2013i). It focuses on increasing the sustainability and adequacy of budget and social policies: first, activating social policies and services; second, investing in children and youth; and, third, streamlining EU governance for social policies, monitoring and communicating with citizens. Besides, the future 2014-2020 programming period of the European Social Fund (ESF), European Regional Development Fund (ERDF) and the new Programme for Social Change and Innovation (PSCI) will reinforce such support of social innovation and social policy experimentation (ibid.). Furthermore, since 2011, through its Seventh Framework Programme for Research (FP7), the EU has supported about EUR 30 million worth research projects on social innovation and it is currently funding two networks of incubators to nurture and scale up successful social innovations (ibid.).

6.1.2 Horizon 2020 Programme

On 11 December 2013, the European Commission presented calls for projects for the first round of its Horizon 2020 programme with the total budget of over EUR 80 billion. The funding of over EUR 15 billion in the first two years (2014-2015) aims *"to help boost Europe's knowledge-driven economy, and tackle issues that will make a difference in people's lives"* (European Commission, 2013c). As communicated by the European Commission (2011a), Horizon 2020 was planned as a key tool in implementing the Innovation Union flagship initiative that brings together all existing European Union research and innovation funding. Horizon 2020 is expected to help promote growth and deal with societal challenges more efficiently than ever before because it is different from other funding programmes in several ways (see European Commission (2011a, pp. 3-4)):

- Horizon 2020 has a simplified programme architecture with a single set of rules, an easy to use cost reimbursement model, a single point of access for participants, less paperwork in preparing proposals, fewer controls and audits;
- Horizon 2020 adopts an inclusive approach open to new participants, which should ensure that excellent researchers and innovators from across Europe and beyond participate in the programme;
- Horizon 2020's goal is integration of research and innovation by providing seamless and coherent funding from idea to market;
- Horizon 2020 offers more support for innovation and activities close to the market, providing a direct economic stimulus;
- Horizon 2020 focuses strongly on creating business opportunities out of our response to the major societal challenges faced by people in Europe and beyond;

6.1. EUROPEAN UNION POLICY

- Horizon 2020 offers more possibilities for new entrants and young, promising scientists to put forward their ideas and receive funding.

Horizon 2020 programme builds on three key distinct, yet mutually reinforcing, priorities, which are especially important for the European Union (see European Commission (2011a, pp. 4-5)):

1. Excellent Science

The first goal is to *"raise the level of excellence in Europe's science base and ensure a steady stream of world-class research to secure Europe's long-term competitiveness"*. This should be achieved by supporting the best ideas, developing talent within Europe, providing researchers with access to priority research infrastructure, and turning Europe into an attractive location for the world's best researchers. In the 2014 budget alone, around EUR 3 billion of funding is available, including EUR 1.7 billion for grants from the European Research Council for top scientists and EUR 800 million for Marie Skłodowska-Curie fellowships for younger researchers.

2. Industrial Leadership

The second pillar aims at *"making Europe a more attractive location to invest in research and innovation (including eco-innovation), by promoting activities where businesses set the agenda"*. In this context, Horizon 2020 will help to provide major investment in key industrial technologies and help innovative SMEs in Europe to grow into world leading companies. For 2014, EUR 1.8 billion is available to support Europe's industrial leadership in ICT, nanotechnologies, advanced manufacturing, robotics, biotechnologies and space.

3. Societal challenges

The third target of Horizon 2020 is to address major concerns shared by citizens in Europe and elsewhere by bringing together resources and knowledge across different fields, technologies and disciplines, including social sciences and humanities. For this area, EUR 2.8 billion is planned in 2014 for innovative projects addressing seven societal challenges: health; agriculture, maritime and bioeconomy; energy; transport; climate action, environment, resource efficiency and raw materials; reflective societies; and security.

Funding opportunities under Horizon 2020 are published on the European Commission's Participant Portal for research funding. Among the current calls for proposals, at least six are directly related to Information and Communications Technologies and digital economy (for full list of calls by area see Table C.1 in Appendix C):

1. e-Infrastructures

The aim of this action is, first, to stimulate development of service-driven data e-infrastructure that responds to general and specific requirements of researchers and research organisations for open access to scientific information; second, to help develop new services in support of open science (e.g. new forms of publishing, new forms of peer review etc.); and third, to support the global interoperability of open access data e-infrastructures.

2. Digital Security, Cybersecurity, Privacy and Trust

First, this action aims to support solutions to protect individuals' privacy by default while empowering the users to set the desired level of privacy and giving them control over how their data will be used by service providers. Second, the focus of the action is also on development and testing of usable, economic and privacy preserving access control platforms based on the use of biometrics, smart cards, or other devices. Finally, the third focus is on supporting the development of state-of-the-art risk management frameworks.

3. FET Proactive - Towards Exascale High Performance Computing (HPC)

This call aims to support the implementation of a common European HPC strategy and to boost European research excellence on the key challenges towards the next generations of high-performance computing systems (such as energy efficiency, complexity etc.).

4. EU-Japan Research and Development Cooperation in Net Futures

This call includes several ICT-related topics: Technologies combining big data, internet of things in the cloud; Optical communications; Access networks for densely located users; Experimentation and development on federated Japan - EU testbeds.

5. Capitalising the Full Potential of Online Collaboration

The action aims to support the development and testing of new online services that would enable better online collaboration for innovation for SMEs in diverse sectors (such as accessing a broader range of potential innovation partners, training material available online etc.)

6. ICT

This call includes a number of important IT and communications technologies topics that will shape the future development of this sector:

- *Advanced 5G Network Infrastructure for the Future Internet*
- Smart Cyber-Physical Systems
- Smart System Integration
- Advanced Thin, Organic and Large Area Electronics (TOLAE) Technologies
- Smart Networks and Novel Internet Architectures
- *Smart Optical and Wireless Network Technologies*
- Advanced Cloud Infrastructures and Services
- Tools and Methods for Software Development
- FIRE+ (Future Internet Research and Experimentation)
- Web Entrepreneurship
- Big Data and Open Data Innovation and Take-up
- Cracking the Language Barrier
- Support the Growth of ICT Innovative Creative Industries SMEs
- Advanced Digital Gaming/Gamification Technologies

- Multimodal and Natural Computer Interaction
- Robotics
- Photonics KET
- Development of Novel Materials and Systems for OLED Lighting
- Human-centric Digital Age
- Cybersecurity, Trustworthy ICT
- Trans-national Cooperation among National Contact Points
- Innovation and Entrepreneurship Support

The ICT call for proposals includes two topics that are extremely important for the future development of mobile communications and we therefore will consider them in more detail.

Smart Optical and Wireless Network Technologies

Over the coming years, network traffic is expected to keep on showing two-digits annual growth rates in all network segments (European Commission, 2013h). While the limits of existing technological approaches for both optical and wireless technologies are about to be reached, the cost of current solutions represents a barrier on the way to the universal coverage with ultra-high speed. The European Commission (2013h) stresses that in the wireless domain, spectrum is a scarce public resource and its usage must be optimised in view of the expected exponential traffic and usage growth. Moreover, as regards the environmental impact, communication networks represented about 22 per cent of the total ICT carbon footprint in 2011, and this is expected to almost double by 2020 if underlying network technologies are not significantly improved (ibid.).

This action addresses, among others, the following challenges in the field of mobile technologies: optimised spectrum use, energy efficiency and new usages, and second, hybrid combination of terrestrial and satellite infrastructures to achieve complete coverage.

Some of the expected positive developments as a result of this call are (see European Commission (2013h)):

- Europe should maintain its state of the art industrial capability on optical network technology with at least 20 per cent of the global market share.
- The strong European capabilities in wireless systems should be diversified through emergence of novel technologies and spectrum usage patterns.
- The cost efficient emergence of novel classes of network services and applications should be supported by avoiding the "capacity crunch".
- Energy consumption of basic infrastructures should be reduced by a factor of about 10.
- Higher spectrum efficiency should be reached - the target is its 10 fold increase.
- New applications should be enabled through spectrum efficient use of higher frequency bands little used today.

- Ubiquitous access to critical/societal applications should be achieved.
- Availability of new interoperability open standards for wireless and optical communications should be ensured. Japan and Korea and the US may be considered as priority countries where international cooperation may be achieved on a win-win basis.

Advanced 5G Network Infrastructure for the Future Internet

With the increase of mobile Internet usage, communications networks face new shortcomings. First, the European Commission (2013a) emphasises that in 2020, mobile networks will have to support mobile traffic volumes 1000 times larger than today. Second, because today wireless access rates are significantly lower than those of fixed access, the emergence of ubiquitous low cost integrated access continuum with context independent operational characteristics is hindered. At the same time, communication networks energy consumption is growing rapidly, especially in the radio part of mobile networks. Fourth, the proliferation of connected devices makes maintaining similar performance characteristics over an ever larger portfolio of technologies and requirements very difficult. In addition, network infrastructure openness is still limited. These and other issues should be solved on the way to future 5G integrated, ubiquitous and ultra-high capacity networks.

European Commission (2013a) expects the following impacts of these solutions on various levels:

1. At macro level, the main aim is to keep and reinforce a strong EU industrial base in the domain of network technologies, that is seen as strategic industry worldwide. In this context, the strategic goal is to retain in Europe at least 35 per cent of the global market share for future network equipment.
2. At societal level, the goal is supporting a ubiquitous access to a wider spectrum of applications and services offered at lower cost, while reducing network energy consumption.
3. At operational level, following impacts are targeted:
 - 1000 times higher mobile data volume per geographical area;
 - 10 times to 100 times higher number of connected devices;
 - 10 times to 100 times higher typical user data rate;
 - 10 times lower energy consumption for low power Machine type communication;
 - 5 times reduced End-to-End latency (for 4G-LTE it is 5 ms);
 - Ubiquitous 5G access including in low density areas;
 - European industry driving the development of 5G standards, at least for the radio part, and retaining control of 5G standards essential patents (SEP) (20 per cent as a minimum). At the same time, international cooperation with countries having bold R&D initiatives in this field (Korea, Japan, the US, China) may be considered on a win-win basis.

- Availability of a scalable management framework enabling deployment of novel applications, including sensor based applications, as well as availability of security/authentication metrics across multi domain virtualised networks.

6.1.3 The Lead Market Initiative

By launching the Lead Market Initiative in December 2007, the European Commission (2007b) has acknowledged the importance of the lead market approach discussed in the theoretical chapter of my dissertation. The concept of lead markets used by the European Commission (2005) is based on the lead market approach discussed by Beise and Cleff (2004) and is formulated as follows:

A lead market is the market of a product or service in a given geographical area, where the diffusion process of an internationally successful innovation (technological or non-technological) first took off and is sustained and expanded through a wide range of different services.

The idea of the Lead Market Initiative for the European Union was born when it was recognised that targeting specific, innovative areas of the economy through strengthened demand side policies would lead to greater impacts not only for the sectors in question but also for society as a whole (Centre for Strategy & Evaluation Services, 2011). After consultation with stakeholders and European Technology Platforms, the following criteria for lead markets were identified by the European Commission (2005):

- Demand driven instead of technology push;
- Broad market segment (i.e. a range of interconnected products and services are offered simultaneously);
- Strategic societal and economic interest (i.e. public health, environment and climate protection, security or employment);
- Added value of prospective, concerted and targeted, but flexible policy instruments (i.e. only a combination of different public measures and incentives can make a difference);
- No "picking of the winners" (i.e. no de facto favouring of specific companies to ensure fair and open competition and to avoid dictating the technological choices)

On this basis, the European Commission (2005) has identified six markets for the Lead Market Initiative: eHealth, protective textiles, sustainable construction, recycling, bio-based products and renewable energies (see Table C.2 in Appendix B). They fulfil best the selection criteria because "they are highly innovative, respond to customers' needs, have a strong technological and industrial base in Europe and depend more than other markets on the creation of favourable framework conditions through public policy actions" (European Commission, 2005, p. 4). Although mobile communications market was not a part of this initiative (maybe, in part due to the fact that these markets are younger than mobile communications and innovators need more public support), it offers one of the key enabling technologies for these new markets.

Policy Instruments

In order to facilitate the emergence of lead markets in these six areas, the European Commission (2010b) decided upon the following set of policy instruments:

1. Standardisation, labelling and certification

The current standardisation process in the six selected markets is fragmented. This leads to competing standards that prevent interoperable solutions, and the lack of interoperability, in turn, complicates the incorporation of knowledge and various components into complex new products and services. Thus, more consistent technical, performance and product standards along the whole production chain, from raw materials to end products can facilitate the development of lead markets. In the context of the Lead Market Initiative, the choices between such standards should be made in an inclusive manner and preferably at EU level, while avoiding to exclude competing technologies. Also, standards should preferably be performance-based, but technology-neutral. One of the solutions is also development of new approaches to self-certification, building on experiences within the industry. Finally, labels can push the market through minimum requirements by banning the worst performing products, while benchmarks can provide predictability and dynamism for industry. Mandatory performance labels (e.g. Energy star and Eco-labels) to be displayed at the point of sales are essential to allow consumers make informed choices.

2. Legislation

Legislation also needs to be designed to foster innovation while at the same time it should avoid imposing burdens on innovative business and other organisations. The regulatory measures in the Lead Market Initiative action include proposals for new legislation as well as modifications, revisions or abolitions. This will help create reliable, lean and well designed legislative and jurisdictional environments, which are essential for business to invest and for consumers to take up new products and services. For example, the Recycling Lead Market Initiative action plan focuses on providing support measures in synergy with specific EU regulations, in particular the Electrical and Electronic Waste (WEEE) and End-of-life of vehicles (ELV) directives.

3. Public procurement

Public procurement accounts for some 19 per cent of GDP (as of November 2013) in the European Union and offers a big potential market for innovative products and services (European Commission, 2013e). For spending on construction this figure reaches 40 per cent and for defence, civil security and emergency operations almost 100 per cent. However, there is also "market failure" because, on the one hand, the demand is not able to encourage the market to answer to its needs (i.e. it is not giving the right signals), and on the other hand, the offer is not known. Because improved public procurement practices can help foster market uptake of innovative products and services, it is important to mobilise public authorities to act as "launching customers" by promoting the use of innovation-friendly public procurement practices.

4. Complementary actions

The European Commission (2010b) suggests that there are other actions that could accelerate and improve the interactive flow of information between suppliers and users, thus improving market transparency. In certain market areas, additional measures are required, such as, first, business and innovation support services, training and communication, and, second, financial support and incentives. As regards the former, especially young innovative enterprises in some market segments would benefit from activities to facilitate knowledge-transfer, incubation and access to finance through consultancy services or training. As regards the latter, public action can facilitate access to finance, for example by using public R&D and Innovation funds at EU or Member State level to help prove the feasibility of certain product cycles. As an example can serve JEREMIE, a joint initiative established by the Commission with the European Investment Fund (EIF) and the European Investment Bank (EIB), that can provide improved access to finance for SMEs, such as micro credit, venture capital, loans or guarantees.

Expected Results and Final Evaluation

As a result of the Lead Market Initiative, the European Commission (2007a) expected significant market and employment growth in these six sectors by 2020, especially in sustainable construction and renewable energies (see Tables 6.1 and 6.2). It remains to be seen if these ambitious goals will be reached by 2020.

Since none of the selected potential lead markets comprises the object of my current research, we will further briefly consider the overall effectiveness of the Lead Market Initiative without getting into detail on each of the six markets. Centre for Strategy & Evaluation Services (2011, p. 167) suggests in its final evaluation that although *"the Lead Market Initiative has been at the forefront of an important shift in innovation policy at a European level"*, there is a feeling that some of the rhetoric surrounding this initiative *"raised expectations of quite significant changes in policy that have not been realised"*. The degree of success of Lead Market Strategy has varied across the different markets and depended on how "busy" in policy terms the particular sector is (Centre for Strategy & Evaluation Services, 2011). For example, in the renewable energy or the recycling areas there are so many other developments taking place that there has been no room for specific lead market actions, whereas in eHealth or in sustainable construction the lead market framework offered the possibility of continuity and development.

Another important issue is the involvement of the Member States in the Lead Market Initiative. Centre for Strategy & Evaluation Services (2011, p. 168) stresses that *"in contrast to the successful involvement in a number of the sectors of the relevant industrial representative associations"*, the engagement of the Member State authorities in the Lead Market Initiative has been relatively restricted in spite of the fact that Member State involvement was seen to be "essential" from the very beginning. Despite the fact that initially some Member States expressed reservations about the whole idea and some still regard it as a low priority, there has been increasing recognition of the significance of such demand-side approaches. As a result, many Member States now make reference to similar measures in their own national innovation strategies, while some had such strategies prior to their development at a European level (ibid.). Moreover, Centre for Strategy & Evaluation Services (2011, p. 168) suggests that there is now generally a willingness to

recognise the need and usefulness of demand-orientated measures.

Table 6.1: Expected market growth of the identified emerging market areas, 2006-2020

	Volume of the new markets prod- ucts/services in the EU in 2006, EUR million	Volume of the new markets prod- ucts/services in the EU in 2020, EUR million	Growth in volume resulting from market development and policy initiatives, 2006-2020, EUR million	Growth share attributed to the Lead Market Initiative and related policies in 2020, EUR million	Cumulated growth share attributed to Lead Market Initiative and related policies, 2006-2020, EUR million
eHealth	21000	30000	9000	1800	12600
Sustainable construction	24000	87000	63000	12600	88200
Protective textiles	8800	15200	6400	1280	8960
Bio-based products	19000	57000	38000	7600	53200
Recycling	24000	36000	12000	2400	16800
Renewable energies	25000	79000	54000	38000	266000

Source: European Commission, 2007b.

It should also be mentioned that due to budget and other constraints the actual objectives set for the Initiative in the Action Plans were relatively focused and short-term, with a short duration. Consequently, as argued by Centre for Strategy & Evaluation Services (2011), in many instances the actions led to a better understanding of the problems of the market rather than their resolution. Besides, the absence of a dedicated operational budget clearly restricted the initial scope of the Initiative and thus meant that actions were not as

effective as they might have been (ibid.).

Table 6.2: Expected job creation in the identified emerging market areas, 2006-2020

	Jobs dependent on the new products/services in the EU in 2006, thousand jobs	Jobs dependent on the new products/services in the EU in 2020, thousand jobs	Growth in jobs resulting from market development and policy initiatives, 2006-2020, thousands jobs	Growth in jobs attributed to the Lead Market Initiative and related policies in 2006-2020, thousand jobs
eHealth	250	360	110	22
Sustainable construction	500	870	370	74
Protective textiles	205	228	23	5
Bio-based products	120	380	260	52
Recycling	500	535	35	7
Renewable energies	300	634	334	34

Source: European Commission, 2007b.

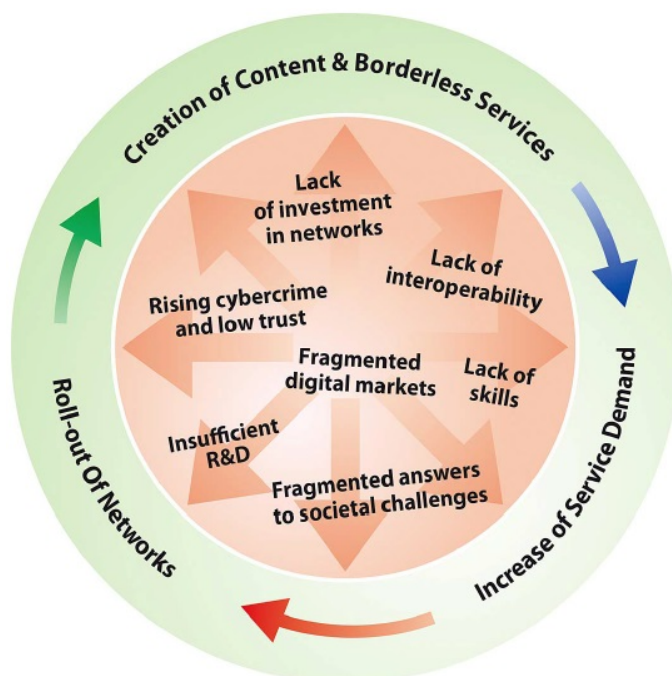
Finally, Centre for Strategy & Evaluation Services (2011) suggests in its final evaluation that where the Lead Market Initiative approach worked, it brought distinctive advantages, among others because it was able to address a targeted set of interrelated issues for the market in question. It should not be forgotten that many of the actions require follow-up to have their desired effect and much depends on future policy priorities both at the European Union and at national levels. Also, other promising potential lead markets could be supported at a national or even a regional level (ibid.).

6.1.4 Digital Agenda for Europe

Digital Agenda for Europe is the first of seven flagship initiatives under Europe 2020 strategy aiming to to reboot European economy and help EU citizens and businesses to get the most out of digital technologies (i.e. fast and ultra fast internet and interoperable applications). The ICT sector has received such a big recognition on the EU level because it is directly responsible for 5 per cent of European GDP, with a market value of around EUR 660 billion annually (European Commission, 2010a). Moreover, by delivering many of the key enabling technologies it contributes far more to overall productivity growth - 20 per cent directly from the ICT sector and 30 per cent from ICT investments (ibid.). The European Commission (2010a) suggests that the great potential of ICT can be mobilised through a well-functioning virtuous cycle of activity (the outer ring in Figure 6.4). The availability of attractive content and services in an interoperable and borderless internet

environment stimulates demand for higher speeds and capacity. This in turn creates the business case for investments in faster networks, while the deployment and take-up of faster networks opens the way for innovative services based on higher speeds.

Figure 6.4: Virtuous cycle of the digital economy



Source: European Commission, 2010a, p. 4.

The European Commission (2010a) stresses that although this flow of activity can be largely self-reinforcing, the European digital economy currently faces seven major challenges (inner circle in Figure 6.4) that prevent us from harnessing all power of ICT technologies. Thus, launched in May 2010 and revised in December 2012, the Digital Agenda for Europe now contains 132 actions (for full list see Table C.3 in Appendix C), grouped around these seven priority areas (see European Commission (2010a) and European Commission (2012b)):

1. Digital single market

"It is time for a new single market to deliver the benefits of the digital era".

2. Interoperability and standards

"We need effective interoperability between IT products and services to build a truly digital society".

3. Trust and security

"Europeans will not embrace technology they do not trust - the digital age is neither "big brother" nor "cyber wild west".

4. Fast and ultra fast internet access

"We need very fast Internet for the economy to grow strongly and to create jobs and prosperity, and to ensure citizens can access the content and services they want".

5. Research and innovation

"Europe must invest more in R&D and ensure our best ideas reach the market".

6. Enhancing digital literacy, skills and inclusion

"The digital era should be about empowerment and emancipation; background or skills should not be a barrier to accessing this potential".

7. ICT-enabled benefits for EU society

"Smart use of technology and exploitation of information will help us to address the challenges facing society like climate change and the ageing population".

The Digital Agenda for Europe sets the following 13 specific goals reflecting the future of the European digital economy (see European Commission (2014a)):

- The entire European Union should be covered by broadband by 2013;
- The entire EU should be covered by broadband above 30 Mbps by 2020;
- 50 per cent of the EU should subscribe to broadband above 100 Mbps by 2020;
- 50 per cent of the population should buy online by 2015;
- 20 per cent of the population should buy online cross-border by 2015;
- 33 per cent of SMEs should make online sales by 2015;
- The difference between roaming and national tariffs should approach zero by 2015;
- Regular internet usage should be increased from 60 per cent to 75 per cent by 2015, and from 41 per cent to 60 per cent among disadvantaged people;
- The proportion of the population that has never used the internet should drop from 30 per cent to 15 per cent by 2015;
- 50 per cent of citizens should use eGovernment by 2015, with more than half returning completed forms;
- All key cross-border public services, agreed by Member States in 2011, should be available online by 2015;
- Public investment in ICT R&D should double by 2020, reaching EUR 11 billion;
- Energy use of lighting should be reduced by 20 per cent by 2020.

The European Commission (2014c) expects that full implementation of updated Digital Agenda would increase European GDP by 5 per cent, or EUR 1500 per person, over the next eight years. By 2015, up to one million digital jobs risk going unfilled without pan-European action, while 1.2 million jobs could be created through infrastructure construction (ibid.). In the long term, this would rise to 3.8 million new jobs throughout the European economy (ibid.).

We will further obtain a more detailed overview of Digital Agenda topics and policies directly relevant for mobile communications market.

Roaming Regulation for the Single Market for Telecoms Services

The issue of high mobile roaming prices in the EU has been acute for quite a long time and its solution is essential for the establishment of the single European digital market. The European Commission (2014b) stresses that *"there is no justification in a competitive market for charging customers considerably higher prices for roaming services"*. Therefore, the aim of this regulation is to effectively eliminate all extra roaming charges by 2015 (i.e. a zero difference between national tariffs and roaming charges). According to the latest Roaming Regulation adopted in June 2012 (see European Parliament and the Council (2012)), the EUR 0.14 per minute limit for wholesale charges for the making of regulated roaming calls established on 1 July 2012 dropped to EUR 0.10 on 1 July 2013, and will decrease to EUR 0.05 on 1 July 2014. Wholesale prices for data roaming have also decreased from EUR 0.25 safeguard limit established in July 2012 to EUR 0.15 per megabyte of data transmitted on 1 July 2013, and will further drop to EUR 0.05 per megabyte of data transmitted on 1 July 2014. As regards SMS, the maximum retail charge (excluding VAT) for an euro-SMS tariff has decreased from EUR 0.09 to EUR 0.08 on 1 July 2013 and will further drop to EUR 0.06 on 1 July 2014.

Moreover, the "Connected Continent" legislation package proposed by the European Commission in September 2013 aims to ban incoming call charges while travelling in the EU from 1 July 2014 (see European Commission (2013b)). Companies would have the choice to either, first, offer phone plans that apply everywhere in the European Union ("roam like at home"), the price of which will be driven by domestic competition, or, second, allow their customers to "decouple" (i.e. opt for a separate roaming provider offering cheaper rates without having to buy a new SIM card).

Thanks to the European Roaming Regulation, data roaming became up to 91 per cent cheaper in 2013 compared to 2007. The European Union boasts retail price reductions across calls, SMS and data of over 80 per cent since 2007. The European Commission (2013d) estimates that during this period the volume of the data roaming market has grown 630 per cent and both consumers and mobile operators benefit from these EU efforts.

European Radio Spectrum Policy Programme

Radio spectrum is a very valuable but increasingly scarce resource, especially with the rise of wireless services such as mobile broadband. It was predicted that global mobile data traffic would increase by 26 per cent annually by 2015 and by that time over 7 billion phones, tablets and other mobile devices would be connectable to the Internet (European Commission, 2012c). Hence, exploding wireless data traffic requires a smarter approach to spectrum management, which must include better utilisation of spectrum bands already in use, for example through removing technology restrictions and spectrum sharing. In the past, radio spectrum policy has already enabled the development of UMTS when the paired terrestrial 2 GHz band (1920-1980 MHz paired with 2110-2170 MHz) has been allocated for UMTS communications (3G networks) as a result of the so-called UMTS Decision adopted in 1999. This launched the coordinated and progressive introduction of UMTS across the EU by 1 January 2002.

In order to solve urgent spectrum policy issues, on 14 March 2012, the European Parliament and the Council approved the first Radio Spectrum Policy Programme (RSPP), which covers all types of radio spectrum use that affect the internal European market and sets general regulatory principles, policy objectives and priorities. One of the targets of

the programme is to ensure that at least 1200 MHz spectrum are identified to address increasing demand for wireless data traffic.

On 5 November 2012, the European Commission decided to add another 120 MHz (1920-1980 MHz and 2110-2170 MHz) to the radio spectrum portfolio for 4G technologies (LTE) around the 2 GHz band, which was previously only used for UMTS (3G) wireless communications. The decision makes it mandatory for Member States to open the relevant spectrum by 30 June 2014 at the latest, and lays down harmonised technical conditions to allow coexistence between different generations of mobile technologies. The European Commission (2012c) expects that this measure will boost the take up of LTE and further advanced technologies in Europe as the EU will enjoy up to twice the amount of spectrum for high speed wireless broadband than in the United States, where it is around 1000 MHz. This Commission's decision means that mobile operators will have more opportunities to invest in improved mobile networks, and consumers will consequently enjoy faster data transfers and more broadband services at competitive prices.

As a follow-up measure, the European Commission (2012c) is also considering to deal with the unpaired terrestrial 2 GHz spectrum (1900-1920 MHz and 2010-2025 MHz) that is currently allocated to use by UMTS networks but remains unused throughout the EU.

6.2 Policy Recommendations and Future Prospects

Based on the results of the empirical analysis and taking into consideration the relevant EU policy measures, we will further give policy recommendations aiming to promote the development of new mobile technologies. We will also consider further research questions that should be answered in order to receive a better understanding of the current and future mobile communications market.

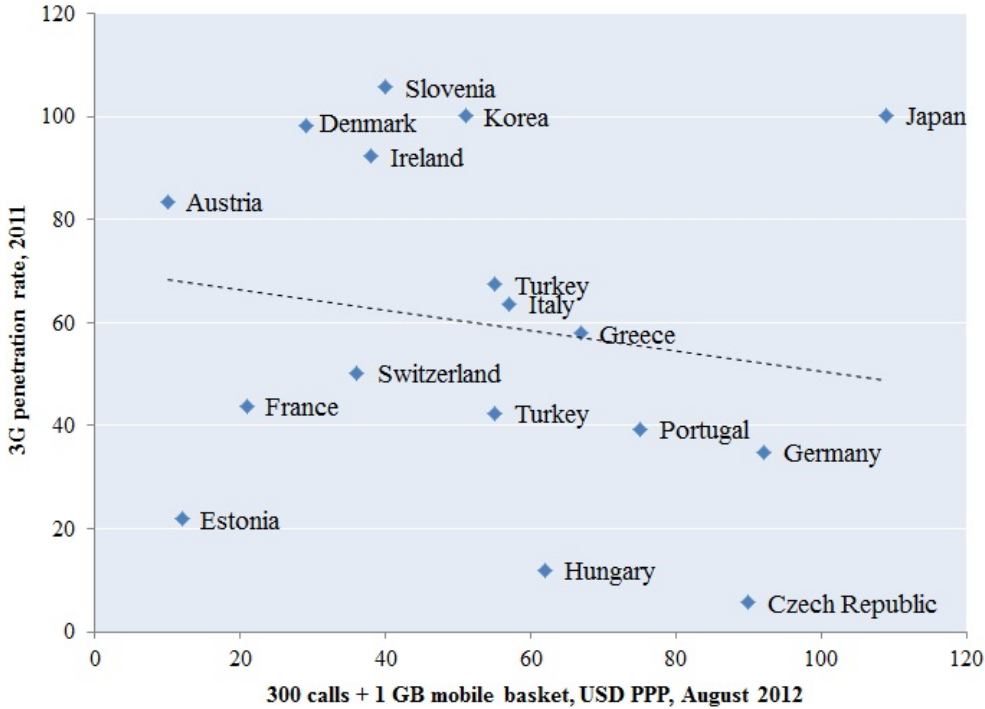
6.2.1 Policy Measures for the European Lead Market in Mobile Technologies

Revise Mobile Data Pricing

Due to the lack of data, mobile data prices could not be included into the regression model. Nevertheless, the most recent OECD data on mobile baskets including mobile Internet charges (see Figure 6.5) suggest that countries with higher mobile basket prices tend to have lower 3G penetration rates (one exception is Japan which, according to OECD (2013), focuses on delivering unlimited Internet and where "small" (in Japanese terms) 1 GB mobile baskets are relatively more expensive than unlimited plans).

This suggests the importance of price advantage from the lead market perspective - a country with too high prices cannot expect to be a lead market. Therefore, when setting mobile data tariffs, mobile operators should focus on long-term benefits from wide 3G, 4G and further generation technologies adoption for mobile operators themselves as well as for the national and European economy as a whole. Major mobile providers, like Telekom and Vodafone in Germany, should realise that by pursuing short-term profits and setting very high prices for tariffs with LTE (Telekom in Germany currently charges a monthly fee of over EUR 60 for its Complete L tariff including only 1 GB LTE, while A1 in Austria offers up to 5 GB LTE with its A1 Go! L tariff for just under EUR 55 per

Figure 6.5: Relation between mobile basket price and 3G penetration rate



Source: Own illustration based on OECD, 2013.

month, and it makes 1 GB LTE available from 35 EUR per month) they might be loosing an opportunity to acquire a broad subscriber base more quickly and to benefit from their intensive mobile internet usage. As we have discussed in the theoretical chapter, this has already happened before with GSM (2G) and UMTS (3G): the GSM uptake was much faster in Sweden due to lower prices, and the adoption of UMTS in Europe was hindered by the focus on a business-segment with higher prices instead of on young technologically advanced people. Form this perspective, the current pricing trends in Germany (which is far from being a 3G leader) are an alarming sign.

In this respect, the European Commission with its Roaming Regulation made a very important contribution to the widespread use of mobile technologies in Europe. Now it is the turn of governments to support competitive mobile markets in their countries, while mobile providers not only in Germany but Europe-wide should acknowledge the important role of intelligent pricing and to think strategically. Mobile providers should really lower the prices instead of creating even less transparent tariffs. For example, I had an impression this was the case prior to introduction of roaming pricing caps for SMS in summer 2009, when mobile provides were trying to hide from German subscribers that after the implementation of the Regulation, to send SMS within Germany would actually be more expensive than to send SMS with roaming within Europe. Lower mobile Internet prices is an important step towards a truly European digital economy - this instrument cannot be neglected.

Nurture Technically Sophisticated Users

An important result of our analysis was the significant role of technically sophisticated users that are not afraid of adopting new mobile technologies if they are familiar with their previous generations. This empirical evidence supports the importance of all the European and national policy measures to achieve the goals of Digital Agenda, especially as regards better broadband coverage and enhancing digital literacy. Europe should remember that it is never too early to think about the future Internet technologies and it is now that we should pave the way for them and nurture our own lead markets. In this respect, the launch of the first LTE network in Sweden and Norway in December 2009 might be a sign that Nordic countries (and Europe) are regaining their role of lead markets in mobile communications.

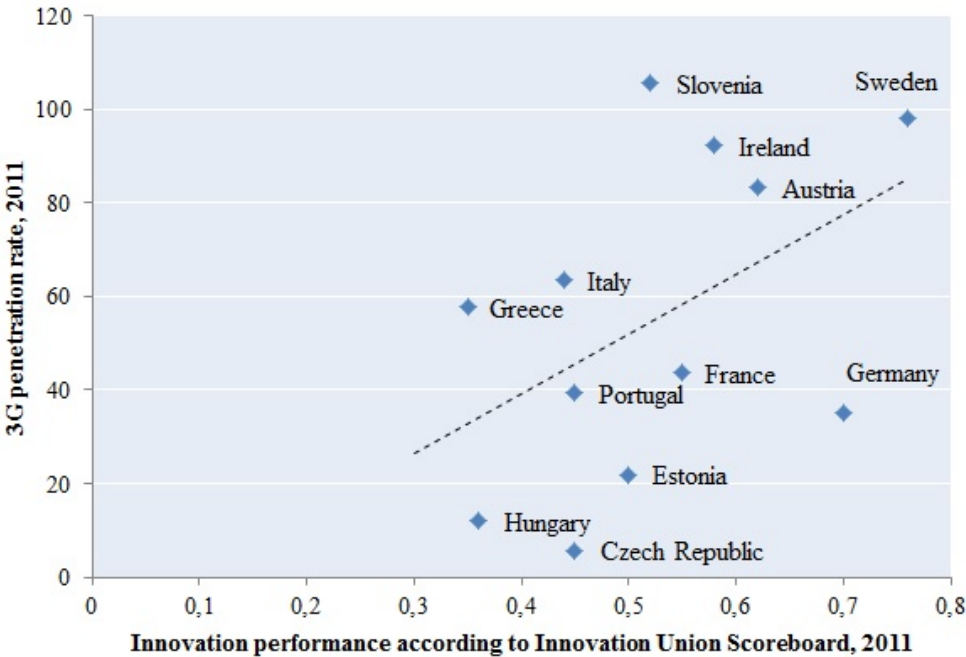
Support R&D in Future Mobile Technologies

Although our empirical analysis did not confirm the role of R&D (as measured by patent applications) in the field of mobile communications for the uptake of 3G in selected OECD countries, the development of future mobile technologies is impossible without intensive R&D in this sector. For example, we have established that Korea's performance as measured by the number of ICT patents per million population by far exceeds the average. And we have seen that according to these and other data, Korea is the best candidate for the 3G lead market. It is therefore advisable to launch more measures on the national and European levels in order to support (including financially) research and innovation in this field. The EU has already acknowledged the importance of such measures by introducing an impressive number of proposals for the ICT sector within the framework of its Horizon 2020 programme, especially concerning the development of smart wireless network technologies and 5G ubiquitous, ultra high-capacity networks. Moreover, the European Commission apparently aims at Europe becoming a lead market for 5G mobile technologies as it sets the goal for the European industry to drive the developments of 5G standards. However, these measures are still at their beginning and it should be assured that innovative European companies capable of becoming technological leaders in mobile communications do receive all the necessary support on the national and European levels.

Support Efficient System of Innovation

Despite the importance of R&D, one should not forget that not all R&D is automatically transformed into innovation that becomes successful on the market. This is where the theory of innovation system comes into play, which we have discussed earlier in much detail, especially with regard to the Swedish and Korean national systems of innovation. The problem of Sweden was, for example, that it had relatively low innovation output compared to its big investment into R&D. High general innovativeness, in turn, does not per se lead to the rapid adoption of 3G technologies, as suggested by the results of our empirical analysis. Furthermore, Figures 6.6 and 6.7 also show that not all countries that perform well in terms of innovation have an equally good performance in 3G penetration (for more detail on innovativeness assessment see European Commission (2012d) and INSEAD (2011)). For instance, Slovenia has managed to become an OECD leader in adoption of 3G mobile communications technologies despite its average innovation performance, while the European innovation leader Germany has a very poor 3G penetration rate.

Figure 6.6: Relation between innovation performance (as measured by Innovation Union Scoreboard) and 3G penetration rate, 2011



Source: Own illustration based on OECD, 2013 and European Commission, 2012e.

These results imply that, on one hand, countries should not underestimate other factors beside R&D and innovation intensity (i.e. pricing) that have contributed to faster 3G adoption in some countries and should diagnose the existing problems and remedy them. On the other hand, countries should still adopt adequate policy measures to promote more efficient transformation of R&D into innovation, especially in the ICT sector that has become the key enabling technology nowadays. This can be done, for example, through support of innovative SMEs, by facilitating knowledge transfer from universities to SMEs and creation of high-tech start-ups (e.g. the German EXIST programme supporting innovative entrepreneurs coming from universities and research organisations).

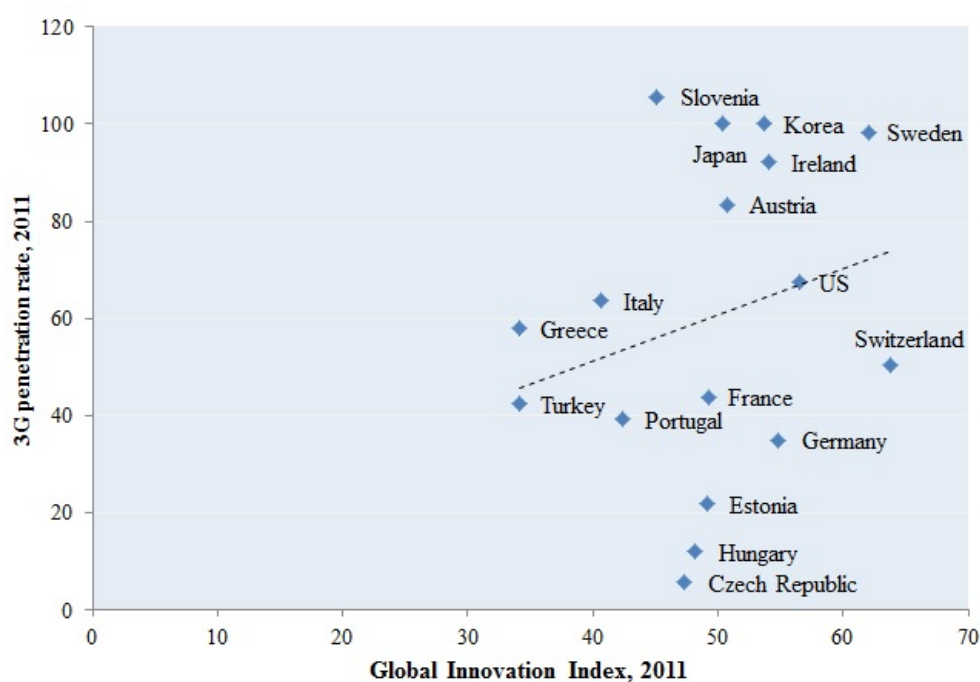
6.2.2 Further Research Tasks

This research was focused on the adoption of 3G technologies in selected OECD countries and despite its important findings, many more inspiring and important questions had to currently remain unanswered due to the lack of statistical data and to volume limitation. Here are some tasks that are considered to be very important for the future development of mobile communications market.

First, it was established that based on the penetration curves Slovenia and Korea were leaders in 3G adoption. However, while Korea possesses certain important characteristics of a lead market (e.g. high R&D intensity and export orientation in ICT), Slovenia is rather a special case as it does not boast a high innovation performance in the ICT sector. Hence, a detailed case study (including consumer preferences, government measures, price policy) would help reveal how Slovenia managed to achieve such impressive results in a such a short time and establish if it is indeed a new lead market or a mere early adopter

6.2. POLICY RECOMMENDATIONS AND FUTURE PROSPECTS

Figure 6.7: Relation between innovation performance (as measured by Global Innovation Index) and 3G penetration rate, 2011



Source: Own illustration based on OECD, 2013 and INSEAD, 2011.

of 3G mobile technologies (the same applies to Korea). This, in turn, could be used as a guidance for other countries that need to boost their mobile market development.

Second, by now, four years have already elapsed since the introduction of LTE in late 2009 and yearly data on 4G penetration rates should reveal what country or a group of countries has a potential of becoming a lead market for LTE. This market can further be used by companies as a testing ground for innovative mobile devices, services and other solutions.

Third, it is advisable to collect European data on mobile tariffs including data roaming (most of which now also include LTE) and make it available online - this should make mobile pricing more transparent for users and exercise at least some pressure on mobile providers to lower their prices.

Fourth, a Europe-wide survey among the companies from ICT sector would help assess the effectiveness of the current EU policy measures aiming to increase innovativeness and promote digital economy in Europe. The main goal of the survey would be to determine if and to which extent the companies (especially SMEs) benefit from these measures. This feedback should be used for developing policy measures that are better adopted to specific needs of companies.

Fifth, a European survey of mobile users would help shed light on their preferences and guide companies trying to bring new products and services into the mobile communications market.

Furthermore, due to the data availability, our empirical analysis was focused on the network side of 3G technologies (i.e. share of subscribers using the 3G network) and the leaders (Slovenia, Korea and Japan) were identified based on this criterion. However, as argued for example by Lehrer (2004), countries that are currently behind in terms of

3G network access could still be lead markets in other branches of the mobile communications market, such as mobile digital services (e.g. m-commerce, connected cars) and handsets. Further research should try to identify these lead markets and factors contributing to their success.

Finally, the lead market theory itself might need revision because the results of our analysis suggest that countries that were once lead markets do not necessarily stay lead markets for next generation technologies, as GSM (2G) lead markets Nordic countries have lost their leadership and Slovenia, Korea and Japan became leaders in 3G adoption. Thus, it is important not only to consider the lead market factors, but also the "ex-lead market" factors that made the country lose its leading position. This will help avoid such mistakes in the future and be prepared for the challenges of new generation technologies.

Chapter 7

Conclusions

Taking into consideration the importance of ICT (and especially of mobile communications) as a major enabling technology in the age of Internet Economy, this PhD thesis was devoted to an extensive overview of recent trends in the OECD mobile communications market.

The first part of this work dealt with the current development of the mobile network itself, especially with respect to the transition from 3G to 4G (LTE), which enables even higher mobile Internet speeds and wider range of mobile applications for ever more sophisticated mobile devices (notably smartphones and tablets). It was also established that even more devices (such as cars or even entire houses) can now be connected to the global network, thus contributing to the further development of the ubiquitous Internet society. Therefore, there can be no doubt about the innovativeness of the mobile communications market and about the crucial role it plays for the development of the European and global Digital Economy.

In the second part we have obtained an overview of the theory of innovation system and of the lead market approach. Both of them have contributed to a better understanding of innovation generation and diffusion in the mobile communications market, especially as regards transition from the first to the third generation mobile technologies. As a result, we have established the crucial role of the European cooperation in standard setting for the international success of GSM standard. This, in turn, justifies the importance of the EU effort in supporting the joint standard development for future 5G mobile technologies.

As regards the lead market theory, it suggests that Nordic countries were lead markets for 2G mobile technologies, which does not stand for 3G anymore, as we were able to show. Whether new leaders in 3G adoption (Slovenia, Korea and Japan) can be considered real lead markets should be revealed by detailed case studies in the future research. Moreover, as worldwide success of 4G continues, it will be crucial to establish leaders and potential lead markets for this mobile technology. The current and future analysis should help countries to better promote the development of their mobile communications markets.

The third part was devoted to case studies on the Swedish and Korean national systems of innovation. This analysis suggested that despite many differences, both countries share certain similarities, especially with regard to high R&D intensity, the importance of multinational companies and the strong role of ICT sector in their economy. These results support the idea that Korea has characteristics of a lead market for 3G mobile technologies and a potential of becoming a lead market for future mobile technologies.

The results of the empirical analysis conducted in the fifth part suggest that 3G adoption in selected OECD countries was positively influenced by income, familiarity with the previous generation mobile technologies, the percentage of young population and the level of education of population. At the same time, countries with higher urban population have adopted 3G less eagerly, while against expectations, the number of ICT patent applications and telecommunications export unit value did not have any statistically significant influence on 3G adoption. These results in part explain that Slovenia, which does not boast any significant ICT exports or R&D, managed to achieve high 3G penetration due to other factors.

In the sixth part of this PhD thesis, we have first obtained an overview of the most important EU policy measures aiming to improve Europe's innovation performance in general and the development of its Digital Economy in particular. It was established that mobile communications occupy an important place in the European strategy and that they are recognised as a key enabling technology. Further, we have derived policy recommendations based on the results of our empirical analysis. Intelligent pricing policy, nurturing of technically sophisticated users and support of efficient innovation system that channels its R&D into innovation are considered to be key policy measures. Finally, among future research tasks, we underline the importance of a detailed case study on Slovenian mobile communications market that should help understand how it managed to achieve such a high 3G performance and if it has the necessary characteristics of a lead market.

To conclude, this research can not only be considered an important contribution to a better understanding of current trends and drivers in the mobile communications market, but also a guideline for further more in-depth studies devoted to this innovative and ever-changing sector of ICT.

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Appendices

Appendix A

Data Sources

Table A.1: OECD countries selected for the empirical analysis

Austria	Hungary	Slovak Republic
Czech Republic	Ireland	Slovenia
Denmark	Italy	Spain
Estonia	Japan	Sweden
Finland	Korea	Switzerland
France	Netherlands	United Kingdom
Germany	Poland	United States
Greece	Portugal	

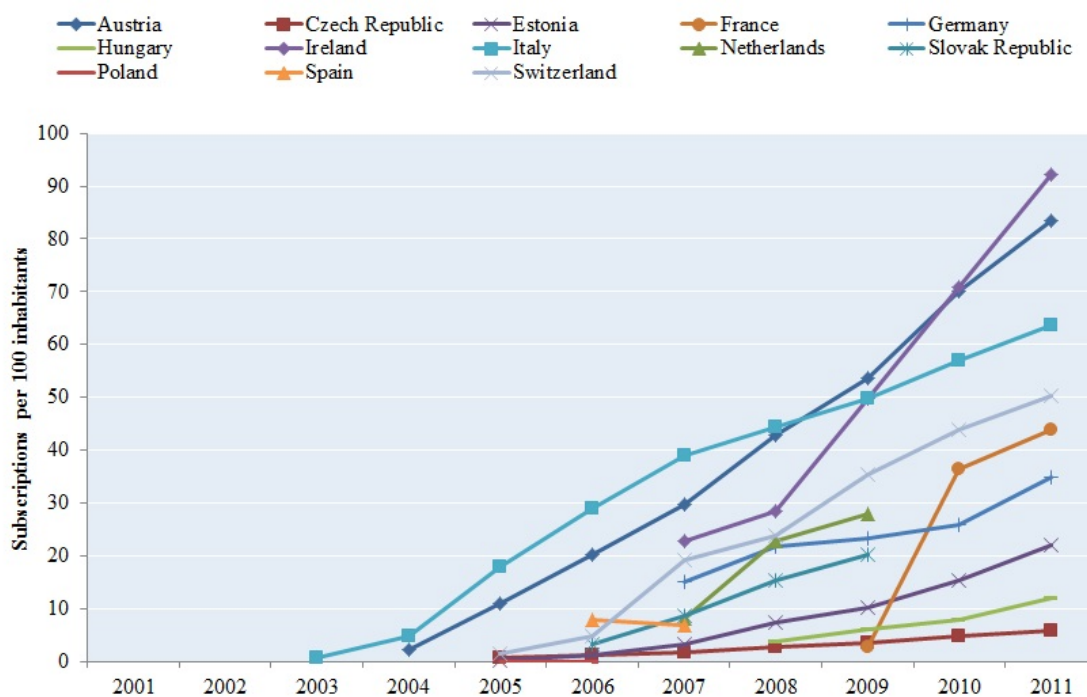
Table A.2: Data sources used in the empirical analysis

Statistics	Period	Source
3G cellular mobile subscriptions in the OECD area	2001-2011	OECD Communications Outlook 2011 and 2013
Population	2001-2011	OECD.Stat database
Gross adjusted disposable income per capita (GADI), USD, current prices, current PPPs	2001-2011	OECD.Stat database
Mobile cellular telephone subscriptions per 100 inhabitants	1991-2001	ITU Database 2011
Total fixed broadband subscriptions per 100 inhabitants	2001-2011	OECD Communications Outlook 2013
Students enrolled by type of institution, tertiary education	2001-2011	OECD.Stat database
Population, 15-34 years	2001-2011	OECD.Stat database
ICT patent applications filed under the PCT, inventor's country of residence, priority date	1998-2008	OECD.Stat database
Urban population, % of total	2001-2011	The World Bank database
Population density, people per sq. km of land area	2001-2011	The World Bank database
World telecommunications equipment exports, commodity code 764: Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76, value in EUR	2001-2011	EU Comext database
World telecommunications equipment exports, commodity code 764: Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76, quantity in 100 kg	2001-2011	EU Comext database
World telecommunications equipment exports, commodity code 764: Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76 (Japan, Korea, Switzerland, US), value in USD	2007-2011	UN Comtrade database
World telecommunications equipment exports, commodity code 764: Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76 (Japan, Korea, Switzerland, US), quantity in kg	2007-2011	UN Comtrade database
Annual foreign exchange rates	2007-2011	Federal Reserve Statistical Release

Appendix B

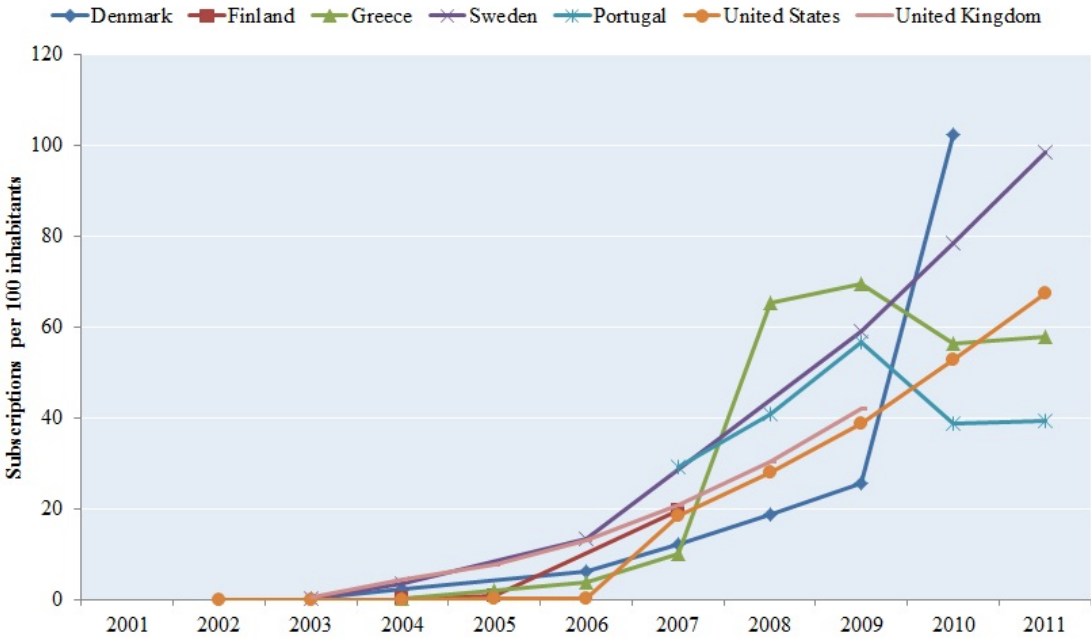
3G Penetration Curves for Selected OECD Countries, 2001-2011

Figure B.1: Linear trend



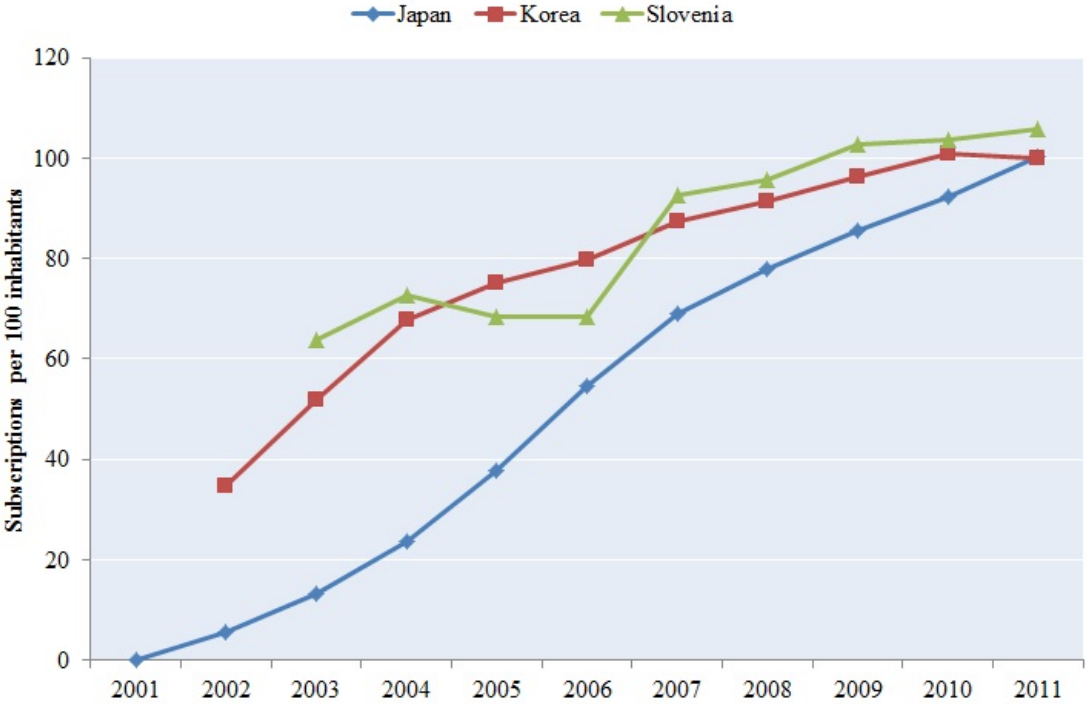
Source: Own illustration based on OECD, 2013.

Figure B.2: Exponential growth - lower part of S-curve



Source: Own illustration based on OECD, 2013.

Figure B.3: Market saturation - upper part of S-curve



Source: Own illustration based on OECD, 2013.

Appendix C

European Union Policy Measures for Innovation and ICT

Table C.1: Calls for proposals under Horizon 2020 for 2014-2015

Excellent Science	Industrial Leadership	Societal Challenges	Science with and for Society	Other Actions
<i>e-Infrastructures</i>	Applications in Satellite Navigation - Galileo	Blue Growth: Unlocking the potential of Seas and Oceans	Call for Developing Governance for the Advancement of Responsible research and Innovation	EURATOM Fission
Trans-National Cooperation among Marie Skłodowska-Curie National Contact Points (NCP)	Biotechnology	Border Security and External Security	Call for Integrating Society in Science and Innovation	Prize - Innovation SOFT
Support to Innovation, Human Resources, Policy and International Cooperation	Boosting the Investment-Readiness of SMEs and Small Midcaps	Call for Competitive Low-Carbon Energy	Call for Making Science Education and Careers Attractive for Young People	WIDESPREAD ERA Chairs

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Table C.1: Calls for proposals under Horizon 2020 for 2014-2015 - *Continuation*

Excellent Science	Industrial Leadership	Societal Challenges	Science with and for Society	Other Actions
Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)	Call for Energy-Efficient Buildings	Smart Cities and Communities	Call for Promoting Gender Equality in Research and Innovation	WIDESPREAD Transnational Network of National Contact Points (NCP)
Integrating and Opening Research Infrastructures of European Interest	Call for Factories of the Future	<i>Digital Security: Cybersecurity, Privacy and Trust</i>		WIDESPREAD TEAMING
Marie Skłodowska-Curie Action: Innovative Training Networks (ITN)	Call for Nanotechnologies, Advances Materials and Production	Disaster-Resilience: Safeguarding and Securing Society		
European Researchers' Night (NIGHT)	Call for SPIRE - Sustainable Process Industries	Energy Efficiency - Market Uptake		

...

Table C.1: Calls for proposals under Horizon 2020 for 2014-2015 - *Continuation*

Excellent Science	Industrial Leadership	Societal Challenges	Science with and for Society	Other Actions
FET Flagships - Tackling Grand Interdisciplinary Science and Technology Challenges	Capacity-Building in Technology Transfer	Energy Efficiency Research and Innovation		
FET-Open - Novel Ideas for Radically New Technologies	<i>Capitalising the Full Potential of Online Collaboration</i>	Energy Efficiency - PPP EeB and SPIRE Topics		
FET-Proactive - Emerging Themes and Communities	Cluster Facilitated Projects for New Industrial Chains	Europe as a Global Actor		
<i>FET-Proactive - Towards Exascale High Performance Computing</i>	<i>EU-Japan research and Development Cooperation in Net Futures</i>	Fight Against Crime and Terrorism		
Developing New World-Class Research Infrastructures	Earth Observation - LEIT SPACE	Green Vehicles		

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Table C.1: Calls for proposals under Horizon 2020 for 2014-2015 - *Continuation*

Excellent Science	Industrial Leadership	Societal Challenges	Science with and for Society	Other Actions
Calls for Proposals for ERC Proof of Concept Grant	Enhancing SME Innovation Capacity by Providing Better Innovation Support	Health Co-ordination Activities		
Calls for Proposals for ERC Consolidator Grant	European Intellectual Property Rights (IPR) Helpdesk	Growing a Low-Carbon, Resource Efficient Economy with a Sustainable Supply of Raw Materials		
Calls for Proposals for ERC Starting Grant	European Label for Innovation Voucher	Innovative, Sustainable and Inclusive Bioeconomy		
	H2020-LEIT-Space-Competitiveness of the European Space Sector	Mobility for Growth		
	Horizon 2020 dedicated SME Instrument	New Forms of Innovation		

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Table C.1: Calls for proposals under Horizon 2020 for 2014-2015 - *Continuation*

Excellent Science	Industrial Leadership	Societal Challenges	Science with and for Society	Other Actions
	<i>ICT - Information and Communications Technologies</i>	Overcoming the Crisis: New Ideas, Strategies and Governance Structures for Europe		
	IPorta 2	Personalising health and care		
	Peer Learning of Innovation Agencies	Reflective Societies: Cultural Heritage and European Identities		
	Protection of European Assets in and from Space - LEIT SPACE	Sustainable Food Security		
		The Young Generation in an Innovative, Inclusive and Sustainable Europe		

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Table C.1: Calls for proposals under Horizon 2020 for 2014-2015 - *Continuation*

Excellent Science	Industrial Leadership	Societal Challenges	Science with and for Society	Other Actions
		Waste: A Resource to Recycle, Reuse and Recover Raw Materials		
		Water Innovation: Boosting Its Value for Europe		

Source: European Commission.

Table C.2: Policy tools by lead market area

	Standardisation, labelling, certification	Legislation	Public procurement	Complementary actions
eHealth	EU Recommendation for interoperability	Exchange of best practices	Call for network of procurers	EU Patient Smart Open Services pilot founded
Sustainable construction	2nd generation Eurocodes	Screening of national building regulations	Network Contracting Authorities	Upgrading of skills of construction workers
Protective textiles	SME involvement in standardisation	Technical Harmonisation	Network Contracting Authorities	7 research projects selected for funding
Bio-based products	Product performance standards	Inventory of legislation affecting the sector	Encourage Green Public Procurement	Advisory Group for Bio-based Products
Recycling	CEN Packaging Standards	Waste Framework directive	Encourage Green Public Procurement	Eco-innovation observatory
Renewable energies	Minimum energy performance standards	Mandatory national targets for 2020	Improve knowledge on demand barriers	Overview of all programmes and funds

Source: European Commission.

Table C.3: Actions under Digital Agenda for Europe

I - Digital Single Market	II - Interoperability and Standards	III - Trust and Security	IV - Fast and ultra-fast Internet Access	V - Research and Innovation	VI - Enhancing digital literacy, skills and inclusion	VII - ICT-enabled benefits for EU society
Action 1: Simplifying pan-European licensing for online works	Action 21: Propose legislation on ICT interoperability	Action 28: Reinforced Network and Information Security Policy	<i>Action 42: Adopt an EU broadband communication</i>	Action 50: Leverage more private investment for ICT research and innovation	Action 57: Prioritize digital literacy and competences for the European Social Fund	Action 69: Assess whether the ICT sector has complied with common energy and emission measures
Action 2: Preserving orphan works and out of print works	Action 22: Promote standard-setting rules	Action 29: Combat cyber-attacks against information systems	<i>Action 43: Funding for high-speed broadband</i>	Action 51: Reinforce the coordination and pooling of resources	Action 58: Develop a framework to recognise ICT skills	Action 70: Support partnerships between the ICT sector and major emitting sectors

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 3: Open up public data resources for re-use	Action 23: Provide guidance on ICT standardisation and public procurement	Action 30: Establish a European cybercrime platform	<i>Action 44: European Spectrum Policy Programme</i>	Action 52: Propose measures for "light and fast" access to EU research funds in ICT	Action 59: Prioritise digital literacy and skills in the 'New skills for jobs' flagship	Action 71: Assess contribution of smart grids and define minimum functionalities to promote interoperability
Action 4: Wide stakeholder debate on further measures to stimulate a European online content market	Action 24: Adopt a European Interoperability Strategy and Framework	Action 31: Analyse the usefulness of creating a European cybercrime centre	<i>Action 45: Foster the deployment of NGA networks</i>	Action 53: Financially support joint ICT research infrastructures and innovation clusters	Action 60: Increase participation of women in the ICT workforce	Action 72: Launch Green Paper on Solid State Lighting (SSL)

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 5: Simplifying the distribution of creative content	Action 25: Identify and assess means of requesting significant market players to licence information about their products or services	Action 32: Strengthen the fight against cybercrime and cyber-attacks at international level	<i>Action 46: Member States to develop national broadband plans</i>	Action 54: Develop a new generation of web-based applications and services	Action 61: Educate consumers on the new media	Action 73: Member States to agree common additional functionalities for smart meters
Action 6: Protecting intellectual property rights online	Action 26: MS to implement European Interoperability Framework	Action 33: Support EU-wide cyber-security preparedness	<i>Action 47: Member States to facilitate broadband investment</i>	Action 55: Member States to double annual public spending on ICT research and development	Action 62: EU-wide indicators of digital competences	Action 74: Member States to include specifications for total lifetime costs for public lighting in public procurement

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 7: Fix a date for migration to Single European Payment	Action 27: Member States to implement Malmö and Granada declarations	Action 34: Explore the extension of security breach notification provisions	<i>Action 48: Use structural funds to finance the roll-out of high-speed networks</i>	Action 56: Member States to Engage in large-scale pilots financed by the Competitiveness and Innovation Programme	Action 63: Evaluate accessibility in legislation	Action 75: Give Europeans secure online access to their medical health data and achieve widespread telemedicine deployment

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 8: Revision of the eSignature directive		Action 35: Guidance on implementation of Telecoms rules on privacy	<i>Action 49: Implementing the European Radio Spectrum Policy Programme in Member States</i>	Action 120: Key Transformative Action: Establishment of the European Cloud Partnership to harness public buying power to accelerate the development of the market for cloud computing	Action 64: Ensure the accessibility of public sector websites	Action 76: Propose a recommendation to define a minimum common set of patient data

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 9: Updating the eCommerce Directive		Action 36: Support reporting of illegal content online and awareness campaigns on online safety for children	<i>Action 112: Durable regulatory measures on non-discrimination and wholesale pricing to promote investment and competition</i>	Action 121: Follow up of the European Cloud Computing Strategy	Action 65: Helping disabled people to access content	Action 77: Foster EU-wide standards, interoperability testing and certification of eHealth
Action 10: Member States to implement laws to support the digital single market		Action 37: Foster self-regulation in the use of online services	<i>Actions 113 and 114: Regulatory measures to promote competition and enhance the broadband investment environment</i>	Action 122: Launch pilot action to explore the efficiency gains from moving public services into the Cloud	Action 66: Member States to implement digital literacy policies	Action 78: Reinforce the Ambient Assisted Living (AAL) Joint Programme

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 11: Member States to transpose the VAT Directive		Action 38: Member States to establish pan-European Computer Emergency Response Teams	Action 115: Recommendation on safeguarding the open Internet for consumers	Action 127: Set up a more business-friendly environment for start-ups	Action 67: Member States to implement provisions on disability	Action 79: Propose a sustainable model for financing the Europeana digital library
Action 12: Review the EU data protection rules		Action 39: Member States to carry out cyber-attack simulations	Action 116: Update of the 2007 Recommendation on the list of markets relevant for ex ante regulation	Action 128: Web entrepreneurs action plan	Action 68: Member States to mainstream eLearning in national policies	Action 80: Propose measures to support cultural and creative industries

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 13: Complementing the Consumer Rights Directive		Action 40: Member States to implement harmful content alert hotlines	<i>Action 117: Reduction of the cost of deploying high speed electronic communications networks</i>	Action 129: Key Transformative Action/ Pooling of European public and private resources for micro- and nano-electronic behind a common industrial strategy, with a strengthened Joint Undertaking at EU level as the main vector for R&D&I support	Action 126: Grand Coalition for Digital Jobs and Skills	Action 81: Issue recommendation on digital film

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 14: Explore the possibilities for Alternative Dispute Resolution		Action 41: Member States to set up national alert platforms	<i>Action 118: Update of guidelines on state aid for broadband by end 2012</i>	Action 130: Focus and develop the photonics, robotics and Future Internet Public Private Partnership (PPP) New PPP on High Performance Computing		Action 82: Implement the Audiovisual Media Services Directive on cultural diversity
Action 15: Consult the stakeholders on collective redress		Action 123: Proposal for Directive on network and information security	Action 119: Pilot project to test project bonds for broadband deployment	Action 131: Action Plan for electronics industry in Europe, further to the 2012 strategy for Key Enabling Technologies		Action 83: Propose a Council and Parliament Decision on mutual recognition of e-ID

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 16: Code of EU online rights		Action 124: EU Cyber-security strategy	Action 132: Invest in High Performance Computing		Action 84: Support seamless cross-border eGovernment services in the single market	
Action 17: Stakeholder platform for EU online trustmarks		Action 125 Expand the Global Alliance against Child Sexual Abuse Online		Action 85: Review the Public access to Environmental Information Directive		
Action 18: Harmonisation of numbering regimes						Action 86: Implement cross-border eEnvironment services

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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<i>Action 19: Spectrum Policy plan</i>						Action 87: Issue White Paper on inter-connecting e-procurement capacity in EU
Action 20: Investigate the cost of non-Europe in the telecoms market						Action 88: Create and implement an ambitious eCommission 2011-2015 action plan
<i>Action 101: Look for durable solutions for voice and data roaming by 2012</i>						Action 89: Member States to make eGovernment services fully interoperable

Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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Action 102: Key Transformative Action 1: Copyright the way forward						Action 90: Points of Single Contact should function as fully fledged eGovernment centres
Action 103: Adopt and implement the key digital single market proposals of the Digital Agenda						Action 91: Member States to agree a common list of key cross-border public services
Action 104: Follow up on eCommerce Action Plan, Green Paper on payments						Action 92: Apply the Intelligent Transport System Directive in support of interoperability and rapid standardisation
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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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<p>Action 105: Guidelines to correctly implement EU rules on consumer information requirements</p>						<p>Action 93: Adopt the Air Traffic Management Solutions for (SESAR)</p>
<p>Action 106: VAT reform - align tax rates for digital content and similar physical goods</p>						<p>Action 94: Propose a directive for the deployment of e-Maritime services</p>

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<p>Action 107: Proposals to strengthen the data industry in Europe</p> <p>Action 108: Green paper on a converged audiovisual world</p>						<p>Action 95: Propose a directive setting out technical specifications for telematic applications for rail passenger services</p> <p>Action 96: Member States to fulfil obligations under European Rail Traffic Management System (ERTMS)</p>

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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

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						<p>Action 109: Develop and implement public service infrastructures, policy and support in the framework of the Connecting Europe Facility</p>
						<p>Action 110: Deploy and roll out digital services in key areas of public interest</p>
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Table C.3: Actions under Digital Agenda for Europe - *Continuation*

I - Digital Single Market	II - Interoperability and Standards	III - Trust and Security	IV - Fast and ultra-fast Internet Access	V - Research and Innovation	VI - Enhancing digital literacy, skills and inclusion	VII - ICT-enabled benefits for EU society
						Action 111: Focus and develop and implement, as appropriate the Smart Cities, Active and Healthy Ageing, Green Cars, Energy Efficient Buildings PPP

Source: European Commission.