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Mobile Telecommunications and Digital Innovations

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Summary: This paper describes and analyzes the most recent international trends in the development of mobile communications. The first part deals with the key sectors of the mobile communications market: mobile network, handsets and smartphone operating systems. We focus on the current deployment of Long Term Evolution networks and present the main factors of their worldwide success and their advantages over previous mobile technologies. Furthermore, special attention is given to the historical development of the mobile communications sectoral system of innovation, which contributes to a better understanding of the success of 2G (GSM) and challenges faced by 3G (UMTS) technologies. Finally, we analyze the international diffusion of mobile communications from the lead market perspective, suggest new promising directions of research and outline policy measures for the promotion of mobile communications.

Zusammenfassung: Dieser Artikel beschäftigt sich mit der Beschreibung und Analyse der aktuellsten internationalen Trends in der Entwicklung der Mobilkommunikationen. Im ersten Teil befassen wir uns mit den Kernsektoren des Mobilfunkmarktes: mobile Netzwerke, Mobiltelefone und Betriebssysteme für Smartphones. Wir konzentrieren uns auf die aktuellen Entwicklungen der Long Term Evolution Netzwerke und stellen die Hauptfaktoren ihres weltweiten Erfolgs sowie ihre Vorteile gegenüber den früheren Mobilfunktechnologien vor. Des Weiteren widmen wir uns der historischen Entwicklung des sektoralen Innovationssystems des Mobilfunkes. Dies soll einen wichtigen Beitrag zum besseren Verständnis des Erfolgs der 2G-Mobilfunktechnologien (GSM) sowie der Herausforderungen, vor denen die 3G-Mobilfunktechnologien (UMTS) stehen, leisten. Abschließend analysieren wir die internationale Ausbreitung der Mobilfunkkommunikationen aus Sicht der Lead-Markt-Theorie, schlagen neue vielversprechende Forschungsrichtungen vor und stellen Politikmaßnahmen zur Förderung der Mobilkommunikationen dar.

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Table of Contents

List of Figures

List of Tables

1. Introduction

The mobile communications market is one of the youngest and most important sectors of ICT and has been characterized by significant growth across the OECD, although its growth rates in developed countries have somewhat declined in recent years due to market saturation. The role of mobile services has also become increasingly important in Europe where mobile communications have partly become a substitute for traditional fixed line telecommunications. For example, in several EU countries, such as Austria and most new EU member states, the majority of outgoing calls is from mobile telephony.

Nowadays, thanks to the third generation (3G) and upcoming fourth generation (4G) mobile technologies allowing high data rates, one can speak of multiple play in the mobile service sector. The OECD (2006) predicts that by 2030 mobile Internet technologies will dominate the communications market because they are far more accessible then fixed line Internet such as DSL (i.e. with a mobile handset one can go online anytime, anywhere). In fact, Japan and South Korea have already set an ambitious goal to achieve a ubiquitous network society in which it is possible to connect to the network 'anytime', 'anywhere', with 'anything' and by 'anyone' (ITU, 2005). Their impressive 3G penetration rates prove that they have been successful in implementing this strategy, whereas most of the European countries, even the earlier 2G leaders Sweden and Finland, still lag behind.

Both developed and developing countries benefit from mobile communications technologies and many more possible applications are still to be explored. 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 cash payment by mobile phone introduced in India, 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 internationalization of economic relations (WELFENS et al., 2005). In developed countries, mobile communications in the context of 'green ICT' offer novel services that may help solve some of the most urgent environmental problems. For example, as a part of the automated SmartHome network proposed by RWE in Germany, users can control intelligent home appliances via smartphones with mobile Internet access in order to optimise and reduce their energy use.

Taking into consideration the big potential of mobile communications technologies for economic and social development worldwide, it is important to conduct constant 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 introduce adequate policy measures when needed. Thus, the first part of this paper is devoted to the development of major mobile communications sub-markets with a special focus on the current deployment of Long Term Evolution networks, their advantages over previous mobile technologies and factors contributing to their remarkably fast global expansion. In the second and third part we take a more

theoretical approach and aim to explain the international success and challenges faced by different generations of mobile communications from the perspectives of the innovation system (especially sectoral system of innovation) and the lead market theory respectively. Both approaches are still rather young, but they already prove to be extremely useful in the case of mobile communications and together help give a more complete picture of all the complex interdependencies in this highly internationalized market. In addition, the launch of the Lead Market Initiative by the European Commission in 2007 strongly emphasises the important implications of the lead market approach for the European innovation policy. The findings of these two parts will help us suggest areas where there is need for further research and outline policy measures that must be taken into account.

2. Main Trends in Mobile Communications

2.1 Development of Key Markets

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.

We will further look in more detail at the recent trends concerning handsets, smartphone operating systems and mobile communications networks.

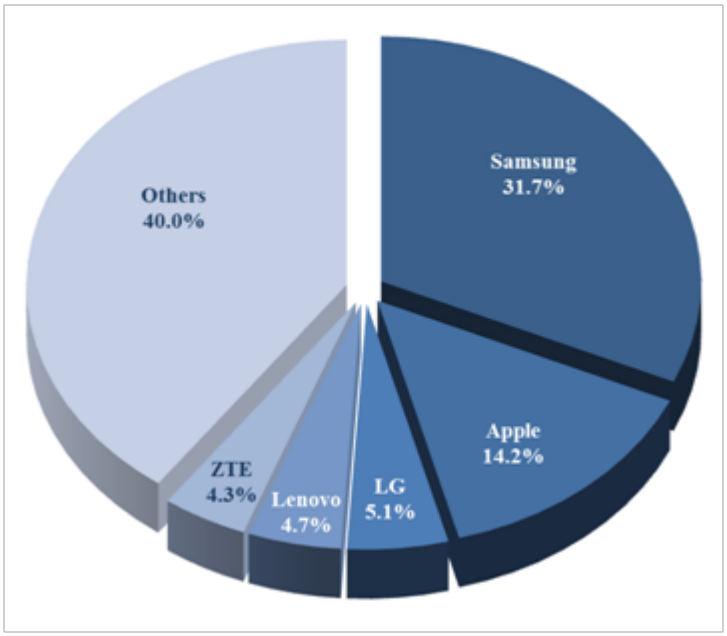
In the second quarter 2013, worldwide sales of mobile devices totalled 435 million units – a 3.6 per cent increase compared to the same period of the previous year (GARTNER, 2013). Remarkably, smartphone sales surpassed feature phone sales for the first time accounting for 51.8 per cent of mobile phone sales in the second quarter of 2013 (ibid.). According to GARTNER, smartphone sales grew in all regions, but it was the regions of Asia/Pacific, Latin America and Eastern Europe that exhibited the highest smartphone growth rates of 74.1 per cent, 55.7 per cent and 31.6 per cent respectively.

As of the second quarter 2013, Samsung's share of smartphone sales reached 31.7 per cent – it maintained the No. 1 position in the global smartphone market followed by Apple (see Figure 1).

The Android OS is a clear leader in the smartphone operating system market. According to GARTNER (2013), it accounted for 79 per cent of smartphone sales to end users in the second quarter of 2013 (see Figure 2), while Microsoft overtook BlackBerry for the first time. However, GARTNER (2013) suggests that Android should be more aggressive in

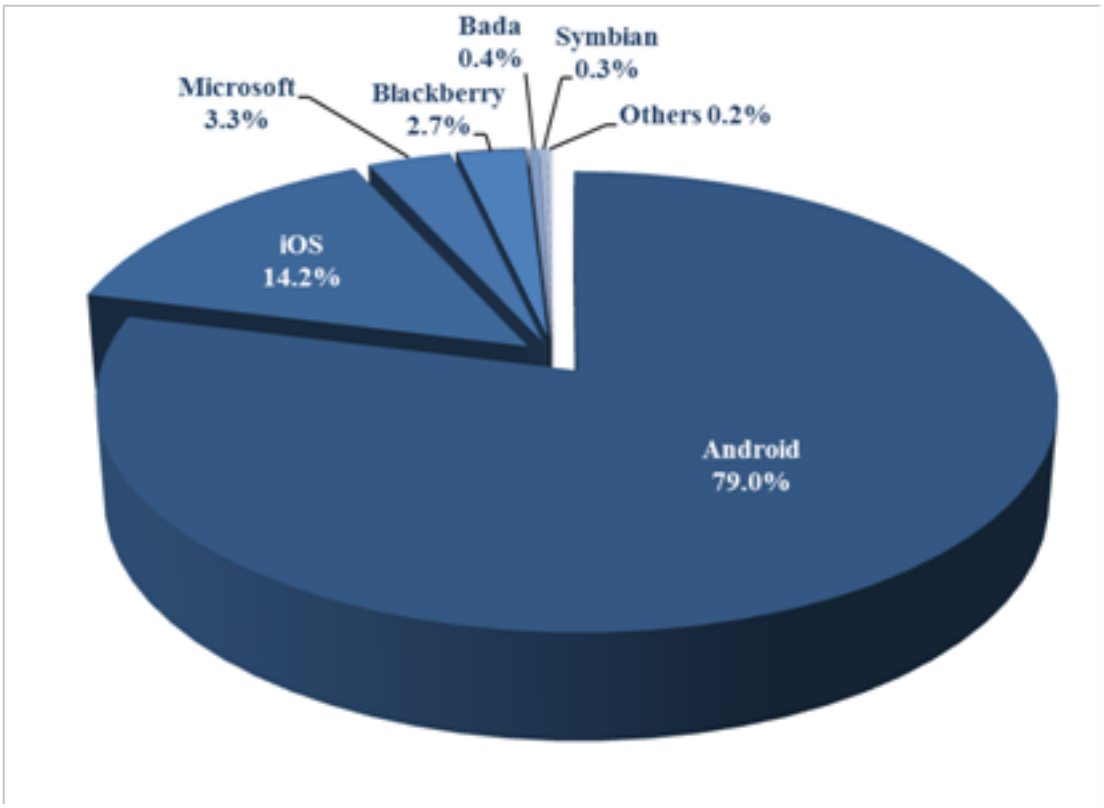
emerging markets and also pay more attention to the mid-price segment because 'innovation cannot be limited to the high end'.

Figure 1: Worldwide mobile device sales to end users by vendor, 2Q 2013



Source: GARTNER (2013)

Figure 2: Worldwide smartphone sales to end users by operating system, 2Q 2013

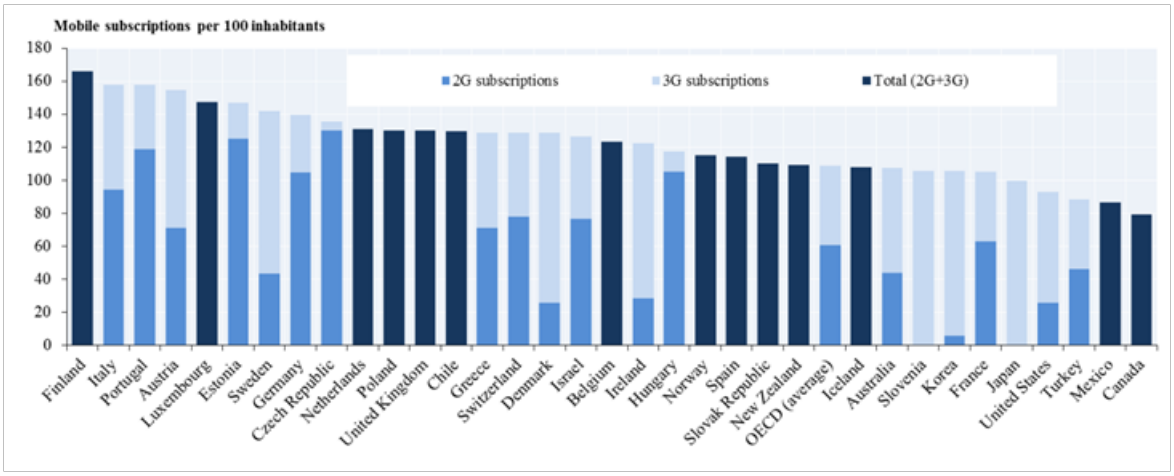


Source: GARTNER (2013)

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. Slower growth rates – mobile subscriptions grew by 3.80 per cent in 2011 and by 3.39 per cent in 2010 – reflect maturity in mobile markets in the OECD countries (ibid.). 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.).

In 2011, the average mobile penetration rate in the OECD area was 109 per cent and Finland was an OECD leader with total mobile subscriptions just under 170 per cent (see Figure 3). 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.

Figure 3: Mobile subscriptions per 100 inhabitants, 2011



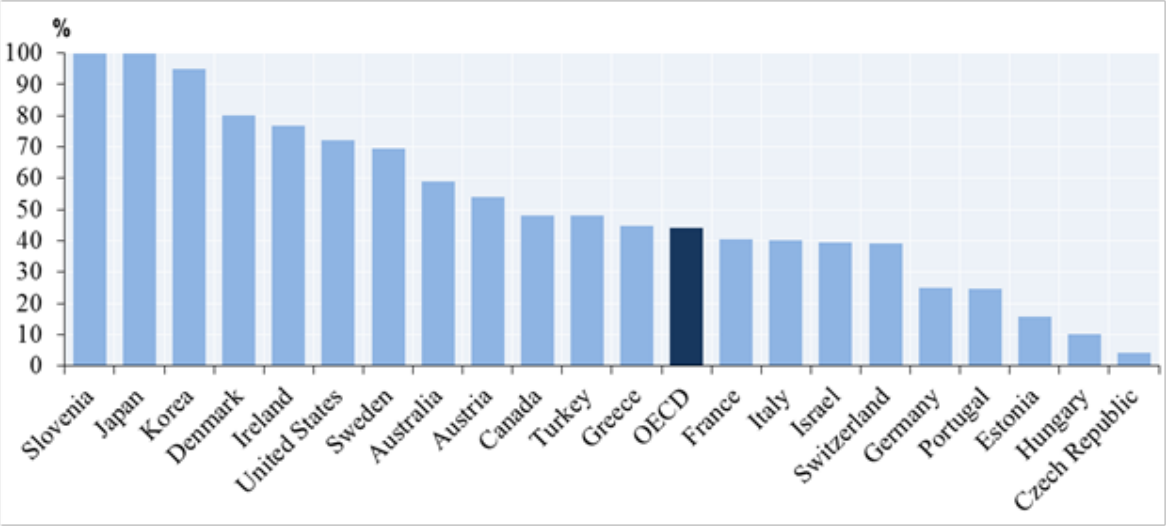
Source: OECD (2013)

The OECD (2013) suggests that the popularity of smartphones 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 Apple's release of its iPad in 2010, there has also been extraordinary growth 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.). 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 29.10 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%) and Mexico (156.8 per cent) in Latin America, while only a few had grown below 10 per cent. Nevertheless, based on 2011 data (10 years after UMTS launch), one cannot help but notice the discrepancies in 3G mobile penetration rates in the OECD countries: while Slovenia and Japan have already reached, and Korea is nearing, 100 per cent, many of the EU economies, notably Germany and France, stay even below the OECD average (see Figure 4). We will analyse this phenomenon in more detail in chapter 4.

Figure 4: 3G cellular mobile adoption, as a percentage of total subscriptions, 2011



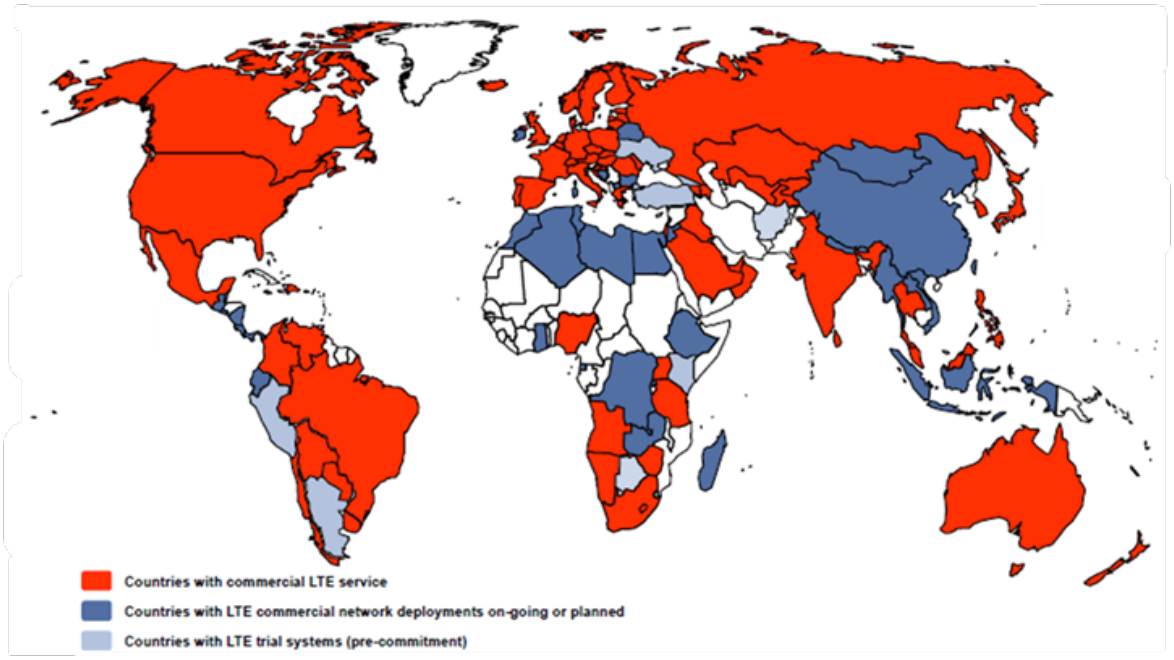
Source: OECD (2013)

2.2 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. 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 (2013a), as of 17 October 2013, 474 operators were investing in LTE in 138 countries and 222 commercial networks were already working in 83 countries (see Figure 5). 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 (2013a) forecasts 260

commercial LTE networks in 93 countries by the end 2013 and it has confirmed LTE as 'the fastest developing mobile system technology ever'.

Figure 5: Commercial deployment of LTE networks, 2013



Source: GSA (2013b)

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, 2010). These technology advancements open three major potential benefits from mobile broadband 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 recent 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 standardization 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 unfavorable 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/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 that has recently launched a new tariff offering unlimited mobile calls, unlimited fixed line calls to 40 destinations, unlimited SMS/MMS and unlimited mobile Internet within France for 19.99 EUR per month (to compare, a similar tariff from Telekom in Germany costs at least 34.95 EUR per month).

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 realize their immense importance for the future of mobile

communications. Although much more investment 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, see Figure 6), 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. For example in Germany, both Telekom and Vodafone currently offer LTE with their complete tariffs (flat-rate for data, calls and SMS) starting from 49.95 EUR and 48.99 EUR per month respectively – almost 20 EUR/month above similar tariffs with advertised HSDPA speed of 14.4 Mbps.

Figure 6: Telekom LTE coverage in Germany, October 2013

Source: TELEKOM

3. Mobile Communications Sectoral System of Innovation

3.1 Definition and Framework

A sectoral innovation system (SIS) can be defined as a 'system (group) of firms active in developing and making a sector's products and in generating and utilising a sector's technologies' (BRESCHI/MALERBA, 1997, 131). A broader definition is suggested by MALERBA (2002, 250), according to which 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) stresses that the boundaries of every SIS are defined by specific technologies or product areas.

MALERBA (2002) defines the following basic elements of a SIS:

1. Products;
2. Agents: firms and non-firms organizations (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, labor markets etc.).

In a sectoral system of innovation, the purpose of agents (organizations) is to perform certain functions in order to ensure that all the system works smoothly and efficiently. Certain organizations can carry out several functions but also one and the same function can be carried out by different organizations. The functions and corresponding organizations are summarised 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 organizations.
3. Education is largely carried out by publicly controlled and funded organizations. Besides, firms also sponsor education and provide training. Additionally, learning-by-using and learning-by-doing are gaining importance.
4. There are organizations (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 specialized 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 characterized by increasing functional differentiation and organizational diversity in the mobile communications SIS, for example, monopolistic access providers no longer perform regulatory functions and new regulatory agencies were created. In addition, digitalization has provided technological basis for separation between infrastructure, access and content services.

3.2 From NMT to LTE: Explaining the Worldwide Success

As of today, there have been four main technological standards (also called generations) in mobile communications: NMT, GSM, UMTS and LTE (see Figure 7). There have also been several so-called intermediate standards: GPRS (General Packet Radio Service, sometimes described as 2.5G) introduced in 2000, EDGE (Enhanced Data rates for Global Evolution, called 2.75 G by industry watchers) deployed in 2003 and HSPA (High-Speed Packet Access, also referred to as 3.5G) launched in 2006. In order to explain the worldwide success of GSM-based mobile technologies we will look back at the development of three key standards – NMT, GSM and UMTS – from the sectoral system of innovation perspective.

Figure 7: Evolution from NMT to LTE

3.2.1 NMT

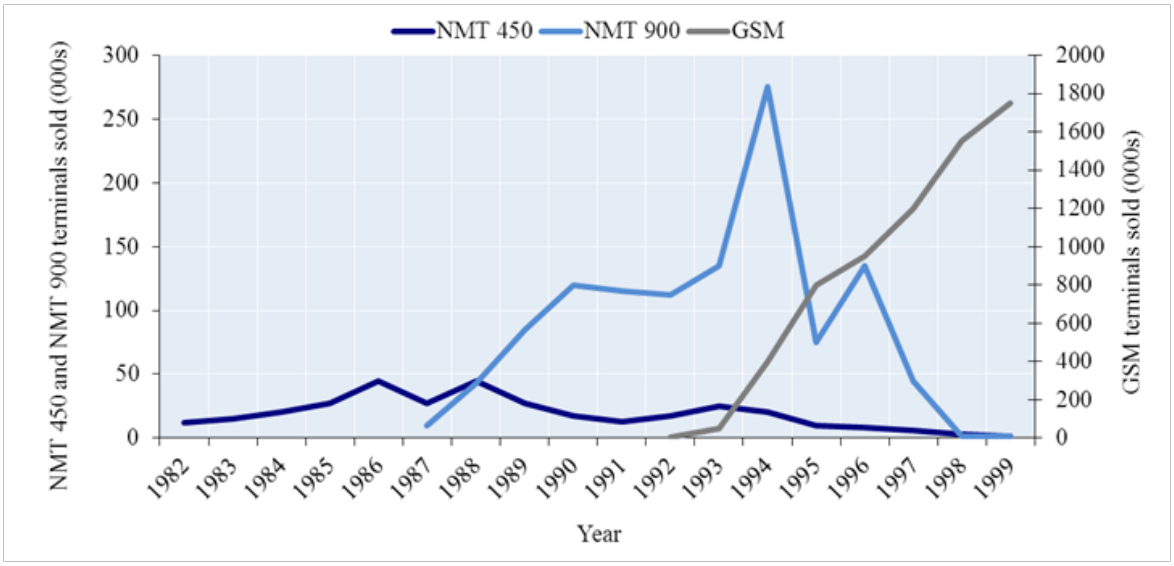
The modern cellular telecommunications were born with the introduction of NMT 450, i.e. the Nordic Mobile Telephony standard based on the 450 MHz bandwidth (EDQUIST, 2003). This first generation standard began to be specified in January 1970 by the NMT group, in which the Nordic public telephone operators (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.

According to MCKELVEY et al. (1998), the technical specifications were finalized between 1975 and 1978 and the implementation phase of the project began in 1977-78 (as cited in HOMMEN/MANNINEN, 2003). 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). 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 Demark, Finland and Norway in early 1981.

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). MCKELVEY et al. (1998) suggest that 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) (as cited in HOMMEN/MANNINEN, 2003). The success of NMT 900 in Sweden was even bigger (see Figure 8) 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 liberalization (EDQUIST, 2003). EDQUIST (2003, 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.

Figure 8: Number of terminals sold in Sweden, 1982-1999



Source: MOBILTELEBRANSCHEN (1999 and 2001), as cited in HOMMEN/MANNINEN (2003)

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 equip-ment producers Ericsson and Nokia were involved in 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 Tele-phone, 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 of sub-scribers worldwide (FUNK, 2002). Nevertheless, according to LINDMARK/ GRAN-STRAND (1995), 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.

3.2.2 GSM

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', (ED-QUIST, 2003, 23), and 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 (AMERICA'S NETWORK, 1996, as cited in HOMMEN/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 organizational framework provided by two European standards development organizations: CEPT (Conference on European Post and Telecommunications) and ETSI (the European Telecommunications Standards Institute) (ibid.). 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 the 1990s it became obvious that in order to achieve success in this complex project the cooperation of manufacturers was also of great importance (HOMMEN/MANNINEN, 2003). 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 (ibid.). 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, 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/MANNINEN (2003) suggest that Motorola, firstly, felt unable to compete with European equipment producers in Europe and, secondly, 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, as cited in HOMMEN/MANNINEN, 2003). At the same time, the European cross-licensees benefited from this arrangement by becoming major suppliers for GSM.

In contrast to the European telecommunications organizations, the 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 (Code Division Multiple Access) 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 – in 1997 the US mobile penetration rate was 20 per cent as opposed to 40-50 per cent in the Nordic countries (ibid.). EDQUIST (2003, 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'. HOMMEN (2002) suggested that additional factors slowing down the diffusion of the standards were roaming issues and the receiver pays principle adopted in the US (as cited in 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. As regards Japan, its second generation digital standard PDC (Pacific Digital Cellular) never diffused outside Japan and was incompatible with other standards.

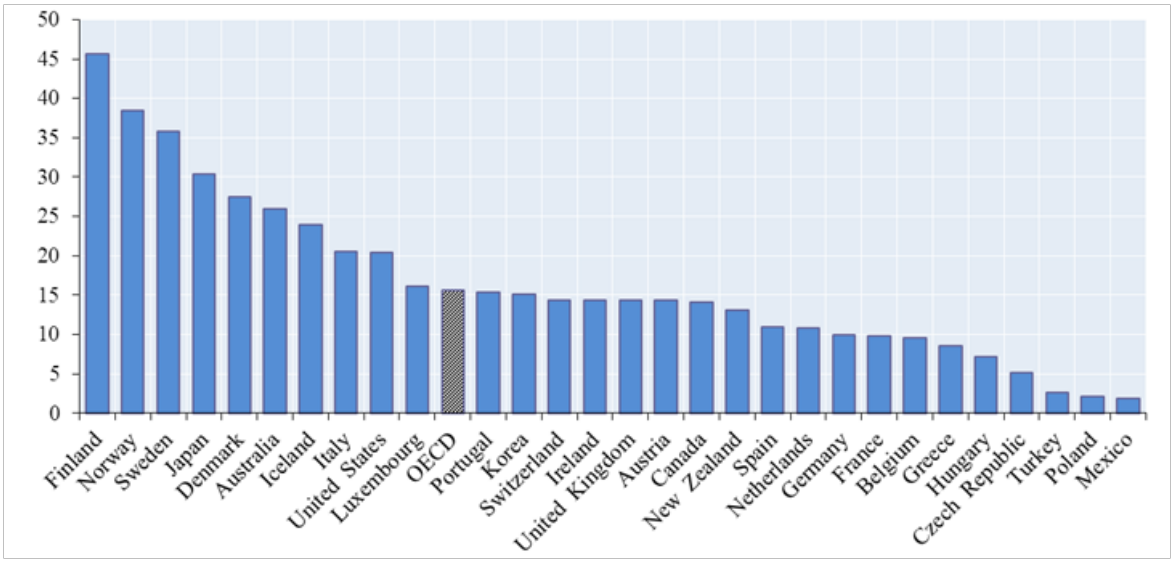
As already mentioned, the emergence of the GSM standard in Europe was marked by a much greater number of public actors, in contrast to the development of rival standards in the US and Japan. This period was also the beginning of the telecom liberalization in Europe – the formerly closed national markets 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. One of the important developments was the increasing role of public research organization 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.

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 ac-

tors. 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/MANNINEN, 2003). In turn, the liberalization of European telecommunications market and higher competition contributed to closer cooperation among public and private actors and to internationalization of R&D. 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 (ibid.). Due to their high level of 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.

In conclusion, Europe can be considered as a 'clear leader' in the second generation mobile telephony due to 'its success in defining standards' (HOMMEN/MANNINEN, 2003, 123). However, despite the big success of the GSM standard there remained large disparities in subscriber penetration rates throughout Europe (see Figure 9). 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, 1999). HOMMEN/MANNINEN (2003, 113) suggest several factors contributing to the rapid market growth in Sweden in comparison to other European countries. Firstly, the initial penetration rate of the first generation mobile communications (NMT) was much higher in Sweden. Secondly, 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'.

Figure 9: Cellular mobile subscribers per 100 inhabitants, 1997



Source: OECD (1999)

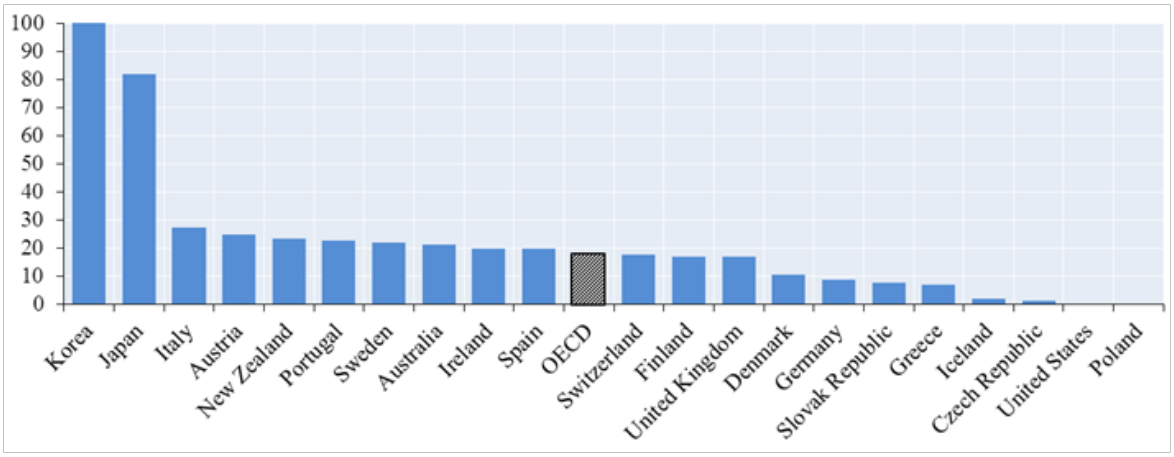
3.2.3 UMTS

Although UMTS was first conceived in the late 1980s, during the early 1990s 'progress on UMTS continued slowly and somewhat theoretically and was largely ignored by most of the cellular operators', who were, as suggested by GARRARD (1998, 478) more interested in growing their subscriber bases profitably within the 2G market (as cited in HOMMEN, 2003). The UMTS standard was officially approved by ETSI in 1998 and as its basis was 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. HOMMEN (2003, 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. Firstly, it uses broadband instead of narrowband radio frequencies (in Europe mostly 2100 MHz); secondly, it fully integrates voice and data communications; thirdly, it fully integrates fixed and mobile networks; and finally, it provides 'seamless' global roaming (HOMMEN, 2003; EDQUIST, 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 which some operators agreed to pay enormous fees. HOMMEN (2003) and the 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 data on penetration rates from year 2007 show that in the third generation mobile communications Japan and Korea (with a rival technology CDMA2000) have taken over leadership (see Figure 10). 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 the 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.

Figure 10: 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)

In order to explain the Japanese and Korean phenomenon, it may 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). For example, 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 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 (ibid.). 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 or-ganization 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 the introduction of the micro-payment system that enables users to pay for services in a standardized, fairly secure way (ibid.). 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, 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).

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 neces-

sarily 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. One of the reasons for slow mobile Internet diffusion in Europe might have been high prices and profits from SMS that have served as a barrier to the implementation of push-based Internet mail (FUNK, 2007). 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) 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 has led to a slow development of mobile Internet services in Europe.

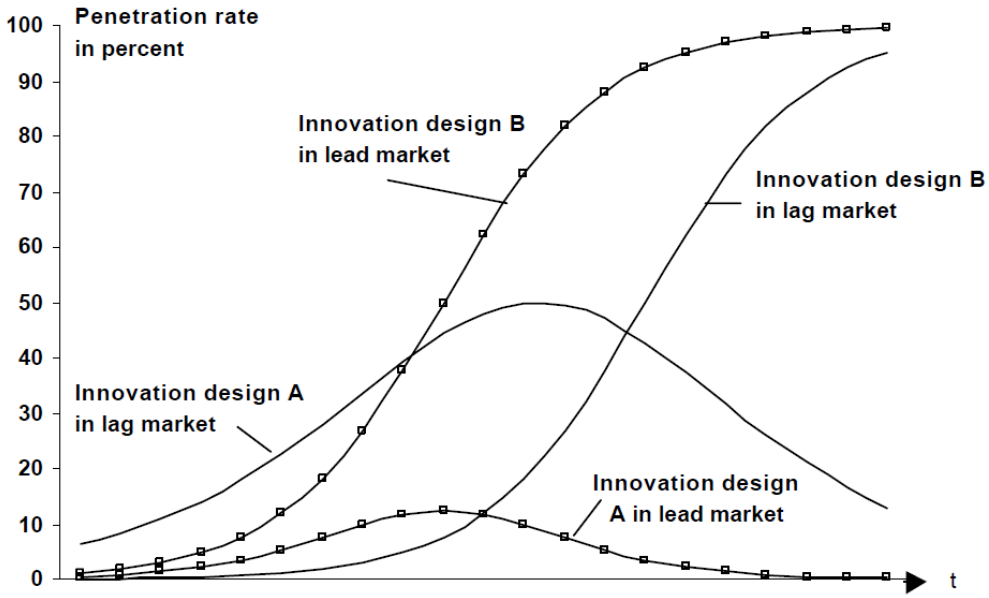
4. Innovation Diffusion in Mobile Communications: A Lead Market Aproach

4.1 Lead Market Definition and Advantages

BEISE (2004), BEISE/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 the 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/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 11). For example before fax machine emerged in Japan, telex was adopted in many countries. Different designs are characterized 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.

Figure 11: A generalized pattern of the international diffusion of innovations with competing designs



Source: BEISE (2004)

As Figure 11 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/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. 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 ', as a 'source of new global ideas' (BEISE, 2004). Thus, companies that develop an innovation to satisfy the demand of a lead market have more chances to succeed. This leads a company to an important task – identifying lead markets for a specific product or technology.

BEISE (2004), BEISE/CLEFF (2004) and BEISE (2006) argue that lead markets can be characterized 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. labor, 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:

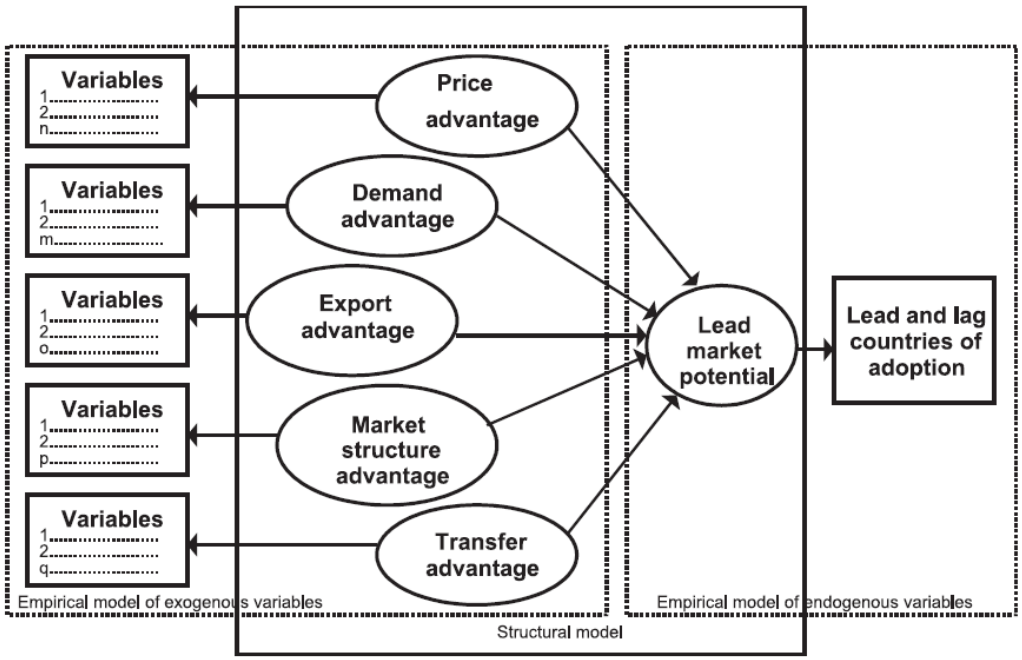
   BEISE (2004) and BEISE/CLEFF (2004) suggest that certain local market conditions increase the exportability of innovation design. The three contributing factors are: first, when local market conditions are similar to those of foreign market; second, when domestic demand is sensitive to the needs of foreign 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 identifying lead markets for existing products, BEISE (2004) suggests that data on penetration curves of a particular innovation design should give a good idea of existing lead markets. It is also argued that 'existing lead markets are likely to be lead markets for the next product generation as well' (BEISE, 2004, 1014). For totally new innovation ideas one should turn to the model of lead market analysis depicted in Figure 12. 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/CLEFF, 2004).

Figure 12: Structural and empirical model of the lead market analysis

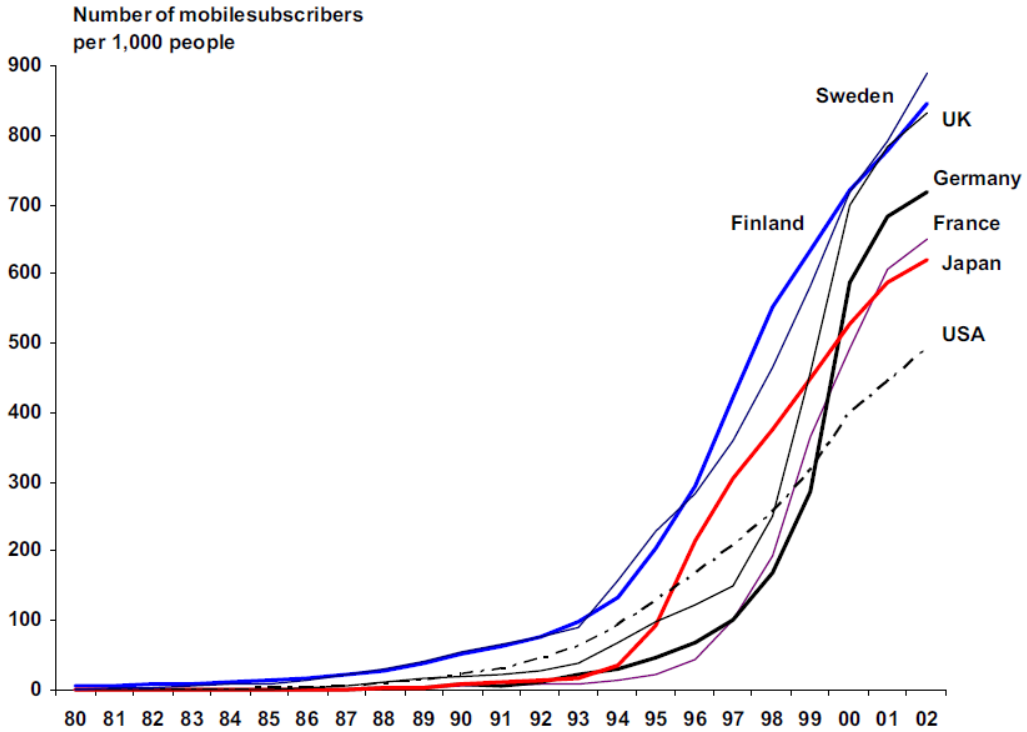


Source: BEISE (2004)

4.2 Defining Lead Markets in Mobile Communications

BEISE (2004) and BEISE (2006) suggest that Nordic countries are lead markets for cellular mobile communications. Indeed, we have already established that the first generation network (NMT) was first launched in Sweden – it enjoyed tremendous success and penetration rates in Nordic countries were much higher than elsewhere. After launch of the second generation mobile network (GSM) Nordic countries have also attained highest penetration rates (see Figure 9). Finally, the diffusion curves in Figure 13 clearly show the leading role of Sweden and Finland in mobile telephony adoption between 1980 and 2002.

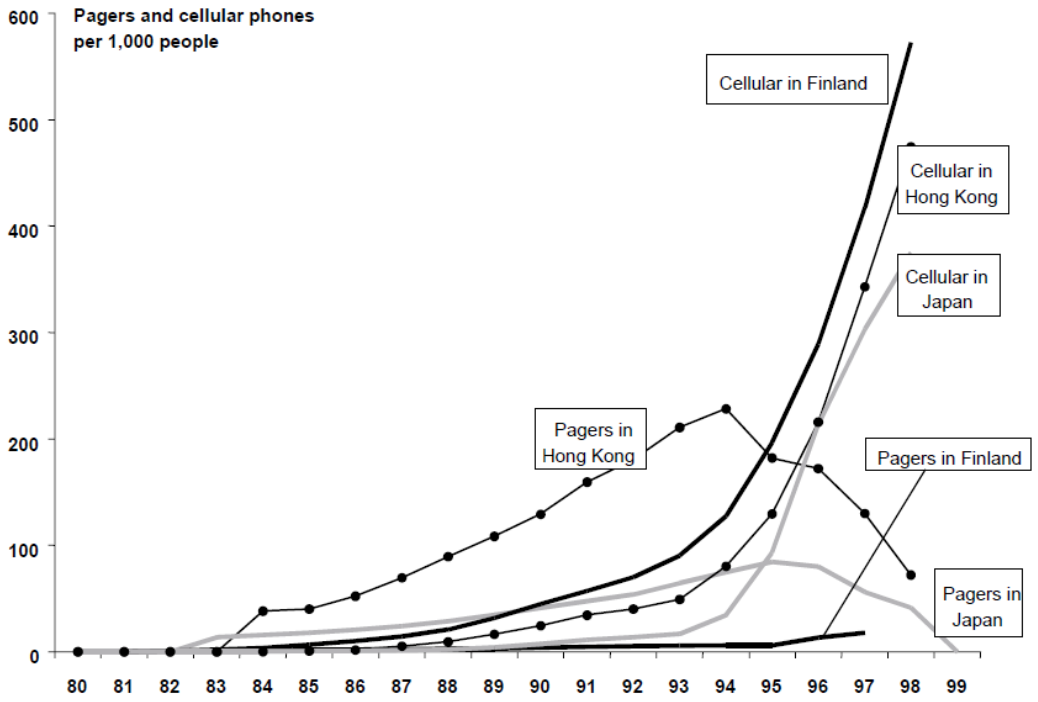
Figure 13: Diffusion of cellular mobile telephony in several countries, 1980-2002



Source: BEISE (2004)

Cellular mobile telephony was also able to prevail over rival innovation designs, such as pagers, satellite telephony and cordless telephones. Figure 14 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.

Figure 14: Number of subscribers to pager and cellular services in Finland, Hong Kong and Japan 1980–1999



Source: BEISE (2004)

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:

   As confirmed by EDQUIST (2003), Nordic countries offered the lowest prices for mobile telephony, which contributed to the emergence of a mass market, whereas 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, in turn, offered cost advantages and rapid market growth in Nordic countries and paved the way for international success of the European GSM technology.

2. Transfer advantages:

   First, 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. Second, international roaming 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, 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 (PAETSCH, 1993).

3. Export advantages:

   BEISE (2004) argues that one of the export advantages of Nordic countries is theirs traditional export orientation: since their domestic markets are rather small, exports

are necessary in industries requiring larger R&D and capital investments. Secondly, 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). Thirdly, 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.

4. 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, it facilitated the discovery of new services and applications. This, in turn, attracted new consumer segments. Therefore, competition in Nordic countries enabled mass-market suitability of cellular telephony.

As regards demand advantages, BEISE (2004) is not sure which international trend lead to the tremendous success of mobile communications in the 1990s and if there was such a trend at all. However, even if it exists, this parameter should play only a minor role in the success of mobile telephony because there are other, more important factors, as we have already seen.

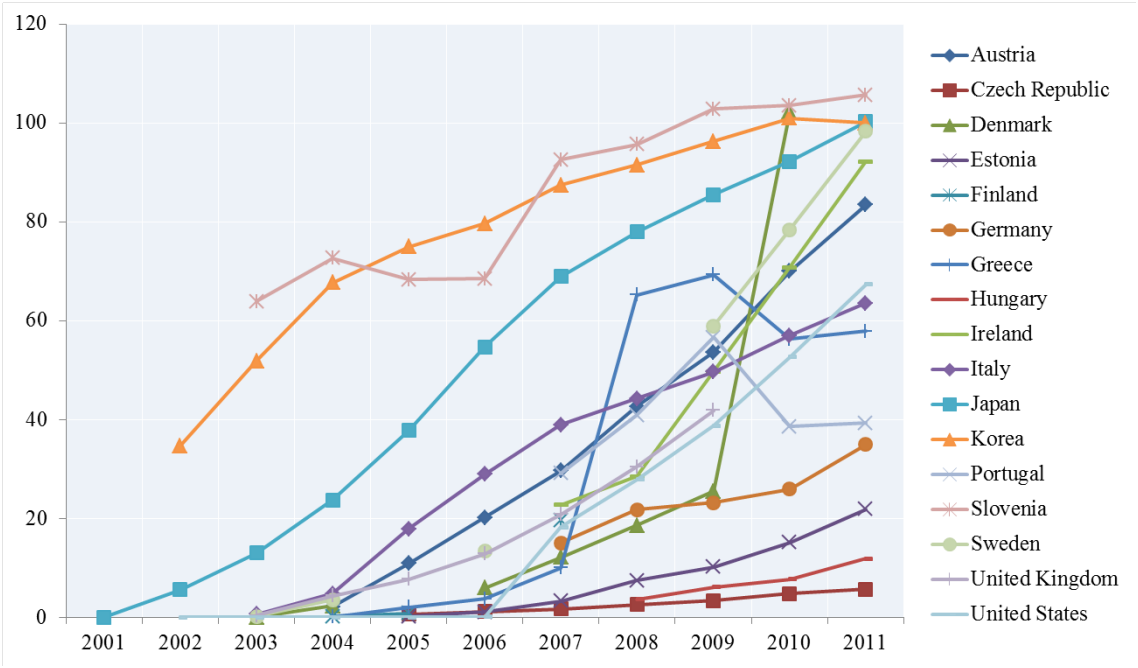
While there are no doubts as to the leading role of Nordic countries in the case of the first and second generation mobile technologies, third generation mobile communications (UMTS) pose a bigger challenge. Although BEISE (2004) assumes that lead markets usually are likely to keep their leading role also for next generation products, recent data on 3G penetration rates suggest otherwise. First, we have already seen that UMTS was actually first launched in Japan and that in Europe 3G cellular mobile adoption in 2007 was rather poor: 22 per cent in Sweden against 82 per cent in Japan (see Figure 10). Korea boasts the best results – 100 per cent of its mobile technologies belong to the third generation, although it has adopted CDMA2000 technology instead of UMTS. If we look at the 3G adoption rates in 2011 in Figure 4, the results are even more striking: Slovenia has become a leader along with Japan, closely followed by Korea, while many other European countries lag far behind.

Due to the fact that the OECD (2013) gives yearly country statistics only on 3G total subscriptions but not on 3G penetration rates, I have made my own calculation based on the available OECD data (3G cellular mobile subscriptions divided by population in respective years, see Annex) in order to determine 3G cellular mobile penetration rates from 2001 (the launch year of UMTS) to 2011 (the last year for which data were available). For my analysis I have chosen OECD countries with most complete data. Among them, three Nordic countries (Sweden, Finland and Denmark), two OECD leaders Japan and South Korea as well as the new leader Slovenia are of particular interest for our analysis. My goal was to compare the development of third generation mobile

communications in Nordic countries (supposedly lead markets) with their development in Slovenia, Japan and Korea.

The results of my calculations presented in Figure 15 are quite astonishing and unexpected, if we rely solely on reflections of BEISE (2004) or BEISE (2006). Here, we can clearly see that in the first years after UMTS launch these countries 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. Although Sweden and Denmark (unfortunately there were no OECD data on Finland after 2007) managed to catch up with the new leaders by 2011, it only shows once again that they were not lead markets in the case of 3G mobile technologies.

Figure 15: 3G mobile subscriptions per 100 inhabitants in selected OECD countries, 2001-2011



Source: Own calculations based on the OECD (2013)

This analysis suggests that, at least in the case of UMTS, there has been a shift of power: instead of Nordic countries, new players such as Japan and Slovenia have emerged. If we judge only by the penetration curves, as BEISE (2004) himself suggests for existing innovation designs, it can be assumed that Slovenia, Japan and Korea have become new lead markets for 3G mobile communications. If it is so, then we have to find explanations for this success: it might have been targeted innovation policy, market reforms etc. In chapter 3 we have already tried to explain this phenomenon from the sectoral system of innovation perspective. Now further research is needed in order to look at it from the lead market perspective and find changes in lead market advantages of old leaders and of new ones that might have contributed to the emergence of new lead markets. 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.

Moreover, 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 no official OECD 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. On the other hand, the fact that EION Wireless, a Canadian manufacturer of broadband wireless products, established its European subsidiary in Slovenia in November 2011 aiming to advance development and sales of LTE and WiMAX suggests that the Slovenian market is considered an important testing ground for these wireless technologies (EION WIRELESS, 2011). 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 and that countries can ameliorate certain lead market characteristics and become lead markets for next generation technologies. Furthermore, if 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.

5. Conclusions and Policy Implications

As we have seen, the mobile communications market boasts high dynamism and new services and application areas appear with each generation of mobile technologies. However, even OECD countries are still far from being equally successful in promoting 3G adoption: old 2G leaders, such as Nordic countries, stayed behind and new leaders, Slovenia, Japan and Korea have emerged. Nonetheless, with the worldwide expansion of LTE this trend might change again and one of the tasks of further research is to carefully monitor and analyze these developments.

Another lesson we have learned is the importance of standardization and international cooperation in combination with high competition for successful introduction and promotion of mobile technologies. In the case of NMT, it was the close collaboration between public telephone operators and equipment manufacturers combined with low prices that contributed to tremendous success of this technology in Nordic countries. For the development of GSM cooperation became pan-European, leading to the rapid uptake of 2G worldwide. This suggests that given active participation of European, Japanese, Chinese and the US telecommunications associations in the LTE standard setting, there should be no doubts about its potential and its future worldwide success. However, as we have learned in the case of UMTS in Europe, restrictive pricing and a lack of cooperation among network operators, handset manufacturers and service providers, might become an obstacle to the successful uptake of new mobile broadband services in certain countries. In this respect, one of the important tasks of European regulatory authorities is to ensure higher competition in the mobile communications market that will bring down mobile Internet prices and stimulate the launch of innovative devices and services.

The recent data on 3G mobile penetration have suggested the emergence of new leaders and, possibly, lead markets for this generation of mobile communications. The case of Slovenia is especially interesting in this respect and more detailed research is required in order to establish factors contributing to its success. The results of further investigation in this direction might help us determine key policy measures that can be undertaken by other countries aiming to promote their mobile communications. Further research in this direction may also suggest that the lead market concept is more dynamic than previously thought and will contribute to the development of the lead market theory itself. As more data become available on the worldwide expansion of LTE networks, we might witness another shift of power (the emergence of new players) or the strengthening of the role of the current ones. Alternatively, as Nordic countries have learned their lesson from the less than satisfactory results in 3G expansion, they might regain their previous leading role by intelligent policy measures. Future research will help find answers to these and other interesting and important questions.

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Annex

Table 1: 3G cellular mobile subscriptions in selected OECD countries, 2001-2011

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Austria	..	..	..	180,240	901,812	1,671,000	2,464,715	3,560,744	4,489,620	5,874,145	7,026,508
Czech Republic	..	..	..	..	65,000	119,405	182,495	276,485	354,166	510,000	600,000
Denmark	..	..	3,425	124,674	..	326, 927	666,178	1,025,000	1,408,683	5,670,165	5,725,952
Estonia	..	..	..	..	3,000	15,000	44,600	99,895	136,600	203,678	293,723
Finland	..	..	..	13,000	45,000	..	1,040,000	..	..	..	..
Germany	..	..	..	..	..	..	12,400,000	17,900,000	19,000,000	21,200,000	28,600,000
Greece	..	..	..	18,800	229,537	419,553	1,126,039	7,331,678	7,823,857	6,369,625	6,543,077
Hungary	..	..	..	..	..	..	..	365,393	614,421	777,461	1,188,086
Ireland	..	..	..	..	..	..	994,144	1,262,032	2,220,510	3,198,740	4,221,755
Italy	..	..	400,000	2,813,000	10,477,700	17,091,000	23,127,000	26,500,000	29,900,000	34,500,000	38,600,000
Japan	89,400	7,161,100	16,692,000	30,352,700	48,329,400	69,909,200	88,097,400	99,631,300	109,056,900	118,151,100	128,153,700
Korea	..	16,537,747	24,826,749	32,538,532	36,089,425	38,529,752	42,488,783	44,777,814	47,351,418	49,889,740	49,804,021
Portugal	..	..	..	..	..	..	3.074.319	4.319.850	5.984.053	4.078.377	4.153.778
Slovenia	..	..	1,276,226	1,451,905	1,367,090	1,376,044	1,868,789	1,935,216	2,100,435	2,121,950	2,168,548
Sweden	..	..	18,000	322,000	..	1,214,000	..	..	5,483,463	7,355,469	9,287,708
United Kingdom	..	..	230,000	2,567,000	4,611,000	7,714,808	12,514,000	18,444,216	25,503,490	..	..
United States	..	13,900	30,700	49,200	257,431	484,277	54,961,800	84,914,180	119,030,000	163,055,000	209,999,000

Source: OECD (2013)

Table 2: Population in selected OECD countries, 2001-2011 (hundreds)

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Austria	80,423	80,821	81,182	81,694	82,253	82,679	83,010	83,365	83,630	83,877	84,209
Czech Republic	102,242	102,008	102,017	102,069	102,341	102,667	103,227	104,297	104,915	105,173	104,967
Denmark	53,588	53759	53,906	54,045	54,194	54,373	54,614	54,936	55,231	55,477	..
Estonia	13,641	13,,586	13,536	13,493	13,461	13,435	13,417	13,407	13,403	13,402	13,399
Finland	51,880	52,006	52,130	52,282	52,461	52,663	52,887	53,134	53,389	53,634	53,883
Germany	823,499	824,885	825,342	825,163	824,694	823,765	822,664	821,101	819,023	817,769	817,977
Greece	109,500	109,875	110,235	110,617	111,040	111,485	111,928	112,371	112,828	113,075	113,000
Hungary	101,876	101,586	101,296	101,072	100,871	100,714	100,558	100,382	100,227	100,000	99,717
Ireland	38,662	39,319	39,965	40,703	41,599	42,603	43,569	44,257	44,589	45,193	45,767
Italy	569,772	571,574	576,047	581,753	586,070	589,415	593,753	598,322	601,927	604,834	607,236
Japan	1,272,910	1,274,350	1,276,190	1,276,870	1,277,680	1,277,700	1,277,710	1,276,920	1,275,100	1,280,570	1,277,990
Korea	473,574	476,222	478,593	480,394	481,381	483,719	485,977	489,487	491,820	494,104	497,794
Portugal	103,627	104,196	104,588	104,839	105,033	105,223	105,430	105,582	105,683	105,731	105,576
Slovenia	19,920	19,957	19,968	19,970	20,011	20,085	20,194	20,226	20,423	20,493	20,525
Sweden	88,960	89,250	89,582	89,935	90,296	90,805	91,481	92,196	92,985	93,781	94,490
United Kingdom	591,130	593,230	595,570	590,310	594,080	597,510	601,370	605,400	609,270	613,440	617,610
United States	2,849,690	2,876,252	2,901,079	2,928,053	2,955,166	2,983,799	3,012,312	3,040,940	3,067,715	3,093,302	3,115,919

Source: OECD Database (2013)

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

Source: Own calculatios based on the OECD (2013)

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Austria	..	..	..	2,206	10,964	20,211	29,692	42,712	53,684	70,032	83,441
Czech Republic	..	..	..	..	0,635	1,163	1,768	2,651	3,376	4,849	5,716
Denmark	..	..	0,064	2,307	..	6,013	12,198	18,658	25,505	102,208	..
Estonia	..	..	..	..	0,223	1,116	3,324	7,451	10,192	15,198	21,921
Finland	..	..	..	0,249	0,858	..	19,664	..	..	..	..
Germany	..	..	..	..	..	..	15,073	21,800	23,198	25,924	34,964
Greece	..	..	..	0,170	2,067	3,763	10,060	65,245	69,343	56,331	57,903
Hungary	..	..	..	..	..	..	..	3,640	6,130	7,775	11,915
Ireland	..	..	..	..	..	..	22,818	28,516	49,799	70,780	92,244
Italy	..	..	0,694	4,835	17,878	28,997	38,951	44,291	49,674	57,040	63,567
Japan	0,070	5,619	13,080	23,771	37,826	54,715	68,949	78,025	85,528	92,264	100,278
Korea	..	34,727	51,874	67,733	74,971	79,653	87,430	91,479	96,278	100,970	100,049
Portugal	..	..	..	..	..	..	29,160	40,915	56,623	38,573	39,344
Slovenia	..	..	63,914	72,704	68,316	68,510	92,542	95,678	102,845	103,547	105,654
Sweden	..	..	0,201	3,580	..	13,369	..	..	58,971	78,432	98,293
United Kingdom	..	..	0,386	4,349	7,762	12,912	20,809	30,466	41,859	..	..
United States	..	0,005	0,011	0,017	0,087	0,162	18,246	27,924	38,801	52,712	67,396

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