How Europe missed the mobile wave

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Abstract

Purpose – *The purpose of this paper is to provide an interpretative framework for the high market capitalisation companies (unicorns) universe, especially with the deployment of the mobile internet. The paper attempts to account for this global trend and to describe its global setting (global data), and its various components.*

Design/methodology/approach – *This paper originates from a research meant to document the phenomenon of high market capitalisation companies (unicorns) through the investigation of a qualitative sample of companies. The paper is based on desk research, a review of literature, review of the technical journals and analysis of annual reports. Going beyond the observations gathered from the sample, the research found that the transformations of the mobile communications ecosystem could provide an adequate framework to understand and put in perspective this phenomenon.*

Findings – *The paper defined unicorns as information technology (IT)-based (software mostly but hardware as well) start-ups that bridge pent-up demand and supply through innovative services and products mostly rooted in the mobile internet wave and the opportunities it brings along. The paper shows that smartphones as games changers facilitate the entry of new players in the mobile markets coming either from the IT sector or from Asia, much to the detriment of the European Union (EU) industry grappling with legacy business models. These companies derived the most from a mobile-first approach and have an outstanding number of unicorns. The paper identifies a potential telecom policy failure especially in the EU: policies have been tilted towards the supply side, without enough consideration of demand. The paper suggests that the EU, after having lead the previous wave, may have missed the last one (mobile broadband) not only from a policy but also from an industry viewpoint.*

Research limitations/implications – *More research should be done to better investigate what might have been the causes of this apparently missed mobile turn in Europe. The paper deals mostly with the cases of Asia and the USA. As the paper concentrates on the issue of unicorns and mobile technology, some other aspects of the mobile markets may not be taken into account.*

Practical implications – *The paper suggests reconsidering some policies in the field, to better take into account the role of consumers and to improve the link with other policies like innovation policies.*

Social implications – *The paper attempts at giving a better understanding of the evolution of demand and its role in the making of some new services. The paper does not deal with other societal issues like privacy or data.*

Originality/value – *The main assumption about the role of the mobile internet can shed some light not only about related developments such as the app economy but also about the business and technological environment of an array of start-ups, some of them having reached impressive market capitalisation. The paper reveals how this mobile wave is reshuffling companies, sectors, and geographies. The paper provides one of the first analysis of the unicorn phenomenon.*

Keywords *Innovation, Mobile internet, Apps, Smartphones, Asia, Unicorns*

Paper type *Research paper*

1. Introduction

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Technology companies with high-market capitalisation (often called unicorns) have been getting a lot of attention and media coverage recently. This paper originates from

a research study to document the phenomenon through the investigation of a qualitative sample of companies that have been valued above a threshold of US$1 billion in their recent history. The research identifies some of their characteristics[1].

The research was based on a review of technical journals and trade press articles, and on the analysis of annual reports of publicly traded companies. The available information is scarce and highly heterogeneous. However, the information gathered allows listing some main observations about those companies, about their dominant growth model, about the strategic role of venture capital (VC) for their initial funding, their development and their exit and the profiles of their founders characterised by the prevalence of "serial entrepreneurs" who have created other companies.

Going beyond the observations gathered from the sample, the research found that the transformations of the mobile communications ecosystem could provide an interpretative framework for the unicorn universe, especially with the deployment of the mobile Internet. Indeed, such developments are predicated upon the emergence of fully fledged and fast-evolving mobile internet networks, supported by what can be described as the mobile wave, which sees increased device capabilities combined with faster, higher bandwidth and more intelligent networks, paving the way to a wide adoption of advanced multimedia applications. The phenomenon is gaining pace with cheaper handsets and more affordable data connections, allowing access to an array of new apps on a global basis.

This paper is an attempt to account for this global trend and to describe its global setting, and its various components. The first part focuses on the sample of the unicorn companies. It illustrates how these companies have been, one way or another, riding this new mobile wave. The second part describes briefly the enabling environment of the growth of these companies: the deployment of networks and devices, focusing on smartphones. It follows the advent of apps. Then, it deals with the emergence of Asia and the role of mobile for technological leapfrogging. The paper reveals how this mobile wave is reshuffling companies, sectors and geographies and how it leaves the European Union (EU) at a competitive disadvantage.

The last section briefly explores the history of mobile communication in the EU to understand whether the EU, which was leading in the earlier generations of mobile, has not only been losing ground but may also have missed the last mobile wave. The paper concludes by questioning the role of supply side policies, on both sides of the Atlantic. Such policies may have missed the mobile turn but with more negative consequences on the EU side.

2. Are unicorns the children of the mobile internet wave?

2.1 The sample

In this study, a sample of 23[2] companies was identified (Simon, 2016a), without aiming to build a statistically representative sample. The sample was designed to capture enough diversity to explore some of the main features of the high-market capitalisation phenomenon. The sample first considered a set of companies proposed by Lee (2013), which was concentrated on US-based software companies. A report by Atomico (2015) opened up the global spread of these software companies identifying 182 such companies worldwide. The Atomico list is the most comprehensive and consistent among the various sources investigated for this study, providing a database of companies from which a sample could be selected.

In general, the sample was built around four criteria: sector, age, geographic location and financial (variations around the US$1 billion threshold). The sector categories follow the previous literature on high market capitalisation. Specifically, Lee (2013, 2015) categorises companies according to their business model. She distinguishes between:

- consumer companies, which are companies where the primary customer is a consumer; and
- enterprise companies.

Each category is further divided into two: consumer companies are split between e-commerce companies and audience business models; and enterprise companies are divided between "Software as a Service" (SaaS) companies and enterprise businesses. She defines the four resulting business model categories as follow:

1. Consumer companies:
   - *E-commerce*: Companies where a consumer pays for a good or service through the internet or mobile, including companies like Uber and Airbnb.
   - *Audience*: Free for consumers, monetisation through advertisements or leads (the freemium model is important for apps such as games).
2. Enterprise business companies:
   - *SaaS*: Users pay (often via a "freemium" model) for cloud-based software, Akamai is the leading provider of cloud.
   - *Enterprise*: Companies pay for larger-scale software, Criteo is a case in point.

According to Lee, the four business models share fairly equally in driving value in aggregate. Consumer-oriented unicorns are more numerous and created more value in aggregate. However, enterprise-oriented unicorns are fewer and have become worth more on average, and raised much less private capital, delivering a higher return on private investment.

The age category was set at above/below 10 years old to follow the previous literature. As the Atomico report (2015) revealed that China ranks second behind the USA globally, the sample attempted to rebalance with a global sample, adding companies from every region, but slightly tilting in favour of the EU. Older companies, like GAFA (Google, Apple, Facebook and Amazon) and BAT (Baidu, Alibaba and Tencent), described as "high-cap companies", were added to provide a benchmark.

The final sample, shown in Table I, comprises:

- *USA*: Ten unicorns and high-capitalisation companies.
- *Asia*: Seven unicorns and high-capitalisation companies (one each for India, Singapore and South Korea and four for China).
- *EU*: Five unicorns for the EU and high-capitalisation companies (one each for France, Germany and the UK and two for Sweden).
- *Rest of the world*: One African high-capitalisation company.

Finally, the financial criterion revolves around the US$1 billion valuation (see Table I). Without going into details about the financial performances of these companies, one should note that Asian companies seem highly profitable[3] as these companies have been betting on the expansion of demand-driven markets:

- growth of the mobile market;
- emerging economies;
- emerging middle classes[4]; and
- young customers.

Some US companies in particular appear to be burning cash as they try to establish themselves and are currently not profitable: e.g. Twitter, Zynga and Uber.

Table I The distribution of companies in the sample according to the main business models

Business model	*US companies (market capital, billion)*	*Asian companies (market capital, billion)*	*EU companies (market capital, billion)*	*ROW companies (market capital, billion)*
Consumer companies				
E-commerce	Airbnb ($10) Amazon ($198) Apple ($738) Facebook ($226) Google ($362) Uber ($41)	Alibaba (China) ($204) Baidu (China) ($72) Flipkart (India) ($3) Tencent (China) ($200) Xiaomi (China) ($46)	Rocket Internet (Germany) (€33)	Naspers Group (South Africa) (€64)
Audience	Twitter ($33) Zynga ($2)	Kakao Talk (South Korea) ($5) Garena (Singapore) ($3)	King (Sweden/ UK) ($5) Shazam (UK) €1) Spotify (Sweden) ($8)	
Enterprise business companies				
SaaS	Akamai ($13)			
Enterprise	Cloudera ($1)		Criteo (France) ($2)	

Note: Market capitalisation for 2014
Source: Compiled by author

2.2 The mobile dimension

All of the companies in our sample rely in one or another way on a mobile dimension (apps, platform, service and so on). Looking at the distribution between "mobile" and "non-mobile" unicorns yields an interesting pattern (see Table II): 20 of the total 29[5] companies may be classified as "born' or 'turned mobile". Some of the companies included under the mobile

Table II The mobile divide

Born mobile	*Turned mobile*	*Becoming mobile*
USA		
Twitter (2006) Zynga (2007) Cloudera (2008) Uber (2009)	Apple (1976–M2007) Google (1998–M2005) Facebook (2004–M2012)	Amazon (1994–M2007) Akamai (1998 - NA) Airbnb (2008- NA)
Asia		
Kakao Talk (2006) Garena (2009) Xiaomi (2010)	Tencent (1998–M2003)	Alibaba (1999–M20106)[a] Baidu (2000–M20097)[b] Flipkart (2007–NA)
EU		
King (2003)	Shazam (1999–M2007)	Criteo (2005–2013) Spotify (2006–NA) Rocket Internet (2007–NA)

Notes: Mobile unicorns are listed in the left column with their date of foundation. If not born mobile, the year they went mobile is marked M (year) when available; [a]one can tentatively dates the turn toward mobile to the launch of the Mobile Taobao App in 2010; [b]most likely the year of introduction of Baidu Mobile search as the company signed up with China Telecom and China Unicom that same year
Source: Compiled by author (Simon, 2016a)

category were not initially "mobile" companies but took the mobile turn after both Apple and Google went "mobile", having themselves reshuffled their businesses in that direction (the former opening departments, and creating new lines of products, the latter buying firms like Android, a mobile software company in 2005, and Motorola in 2011).

2.2.1 Going mobile. Indeed, the mobile dimension becomes pivotal for all the sampled companies. So as to better document the scope of the shift to mobile, this section focuses on those companies in our sample that have transformed from PC/fixed internet-based to mobile-based since 2007.

GAFA companies were all non-mobile but they all took the mobile turn in the first decade of 2000 by introducing new devices and services. Apple in a way triggered this shift to mobile with the release on the iPhone in 2007, a move that was rather unexpected by the legacy telecom players. In July 2005, Google had acquired Android Inc., a Californian start-up founded two years earlier to set up a mobile operating system (OS) based on the Linux kernel. Google created the Open Handset Alliance to create momentum with other industry players (e.g. HTC, Sony and Samsung) and telecom operators. In 2008, HTC Dream released the first commercially available smartphone running Android. In 2010, Google launched its Nexus series of devices.

In 2004, Amazon set up a laboratory in Silicon Valley that would build its first piece of consumer hardware, a device for reading digital books. In 2007, Amazon launched its first mobile device, the Kindle eBook reader (Simon, 2011). Amazon created at the same time an entire and sophisticated ecosystem around the mobile device with Amazon Publishing (created in 2009) and 13 other imprints, tools for self-publishing and giving access to hundreds of thousands of books to borrow and read (for free for Amazon Prime subscribers) on a Kindle device. Amazon has since tried to duplicate this successful ecosystem with the introduction of another mobile device in 2014, the Kindle Fire TV, for TV, movies and games, introducing tools for production, moving into content production under the flagship of Amazon Studios (created in 2011).

Facebook made its mobile turn but also enhanced its mobile profile with the acquisitions of WhatsApp and Instagram: "mobility" now accounts for 60 per cent of its revenues, according to Ezratty (2015). According to the company's annual reports, in March 2012, more than half of Facebook's 526 million users were accessing the platform through their smartphone, which had grown to 63 per cent one year later.

Mobile has become the primary driver of the Twitter business, generating significant revenue through mobile applications: approximately 85 per cent of advertising revenue was generated from mobile devices in 2014.

Regarding their Asian equivalent, BAT companies, Alibaba is leading in mobile commerce in China and its revenues are shifting more and more towards mobile: for the first time, the company announced, in August 2015, that its mobile revenues accounted for more than half of its total commerce revenues in China (Custer, 2015). In 2003, Tencent embraced mobile successfully with both the creation of WeChat/Weixin and the development of mobile games. In 2014, Tencent became the largest publisher of mobile games in China and one of the largest globally. Tencent pioneered the free-to-play[6] business model. This innovative business model now dominates the worldwide market for mobile games (Mobile Game Arch Roadmap, 2013).

Akamai claims to lead the mobile market by serving over 200 billion application programming interface calls, over 145 terabytes of mobile app data and thousands of mobile sites on its Akamai Intelligent Platform everyday. On 11 July 2013, Criteo, so as to accelerate its mobile strategy, acquired all of the shares of Ad-X Limited, a mobile analytics and attribution technology company.

On the manufacturing side, the mobile wave triggered the setting up of Xiaomi, a hardware company, founded in 2010. The company seized the technological and

market opportunities for budget iPhones initially in the fast developing Chinese mobile market. Over the past five years, Xiaomi "has accomplished a lot more than pretty much any other half-decade-old company [. . .] While all that was happening, Xiaomi has pushed HTC to the edge of the abyss, terrified the life out of Samsung, and perhaps even given Apple some food for thought" (Millward, 2015b). As of 2014, Xiaomi was the largest supplier in the Chinese market with a share of nearly 15 per cent, ahead of Samsung and Huawei. The profile of this company is interesting to stress. Initially an equipment manufacturer, manufacturing mobile phones, budget versions of the iPhone, it grew through an original business model of flash sales (online/mobile), to eventually also become a mobile operator, operating as a mobile virtual network operator, offering a suite of mobile services.

New Chinese competitors are following the mobile trail: for instance, OnePlus (founded in December 2013) or Smartisan (founded 2012). The OnePlus One phone, released in 2014 is selling out in record time, and seen as outperforming many of its competitors, including, in various tests, the iPhone 6 (Lococo, 2015). Like Xiaomi, OnePlus focuses on online, direct-to-consumer sales and delivers affordable hardware with premium specifications. Unlike Xiaomi that initially focused on the Chinese market, OnePlus is aiming at overseas markets such as the USA, the UK and especially India. For 2015, OnePlus is on track to surpass US$1 billion in sales. OnePlus went from a "bootstrap start-up to likely 'unicorn' [. . .] faster than any company in Chinese history" (Fuhrman, 2015).

2.2.2 The wave of the decade. Lee (2015) finds nine "decacorns" (companies worth over US$10 billion) in her 2015 list of unicorns, noting that five of the nine are largely mobile (Uber, Twitter, WhatsApp, SnapChat and Pinterest). She considers that mobile is the next technical wave about to bloom and likely to trigger the creation of start-ups. She notes:

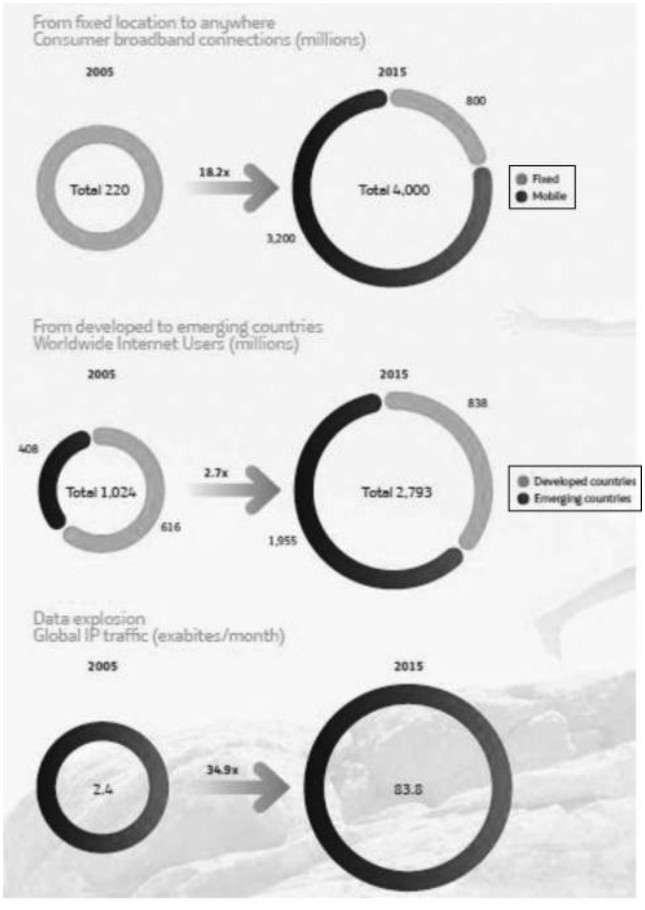
> History suggests the 2010s will give rise to a super-unicorn or two that reflect the key tech wave of the decade, the mobile web. Whichever company (or companies) comes to represent this key innovation (Uber?) will likely continue to accelerate in value as FB, Google and Amazon have over the past decade (Lee, 2015).

The mobile Internet wave appears as the technological wave "of the decade" building on two major opportunities for these companies: a fast-growing global market of consumers and room for new businesses and business models. It fostered innovative services and companies that quickly scale up to reach impressive market capitalisation succeeding in gathering large amount of private funds (VC and equity).

The major increase of start-ups and unicorns (a 115 per cent increase between the two lists established by Lee, 2013, 2015) may signal that this last technological wave (internet mobile/mobile-app economy/smartphone) could have brought down the cost of entry, typically for "apps" like games or chat. During the previous technological wave (the Internet wave), companies like Amazon invested heavily in logistics and infrastructure to enter the book market. Apps developers can enter at a much lower cost as exemplified by mobile games companies (e.g. Garena, Kakao, King and Zynga). This diversification of delivery channels brought by mobile and online video games allowed the shift from console games/packaged products and a handful of global publishers to a self-publishing model as illustrated by the Finnish company Rovio (publisher of the global hit *Angry Birds*), and also by the New Zealand game company, Sidhe. It created opportunities for companies located in smaller markets, such as Finland or New Zealand, to reach a global market. However anecdotal, the 2014 global success of the Vietnamese game *Flappy Bird*, released by an unknown developer, is one of the latest examples: he became "appillionaire" with two to three million downloads per day and daily revenues of $50,000 (Do, 2014).

As stressed by Telefonica's (2014) Digital Manifesto, the "old internet" was fixed, the new internet is mobile, data centric and led by emerging countries. Figure 1 reveals how the

Figure 1 From the old Internet to the new Internet



Source: Digital Manifesto (2014, p. 21)

reshuffling is taking place between fixed and mobile, between regions (developed and emerging countries) and between voice and data. The combination of these three shifts is having a dramatic impact on the global reorganisation of the markets.

In 2012, telecom spending amounted to US$1,574 billion, of which mobile accounted for US$925 billion (voice: US$600 billion; data: US$352 billion), and fixed for US$622 billion (voice: US$317 billion; data: US$305 billion) (Telefonica, 2014, p. 19). The former is increasing, with mobile operator revenue predicted to reach almost US$1.4 trillion in 2018 (Statista, 2016), while the latter is decreasing.

In general, unicorns seems to be IT-based (software mostly but hardware as well) start-ups that bridge pent-up demand and supply through innovative services and products mostly rooted in the mobile Internet wave and the opportunities it brings. They are global companies, offering scalable services and products, relying on connectivity (high-speed networks, mobile and fixed), new devices (smartphones, tablets, phablets and so on), often at affordable prices. Their economics are grounded in networks effects, economies of scale (demand-side economics of scale) and scope. They rely on a favourable business environment. They are dependent on VC and the competition for funding can generate impressive – some would say inflated – valuations. They are mostly developing through a strong organic growth model building on fast-expanding markets, regionally or mobile (smartphones).

Given these characteristics, it is not surprising to find that most of the unicorns in our sample originate either from the USA or from Asia, notwithstanding the fact that the sample has been tilted towards the EU. The EU picture looks even worse in the bigger sample constructed by Atomico: 182 companies (2015)[7]: USA leads with 97 companies (North America has 99) more than half of the 2015 total, Asia comes second with 54 (China has 39 of which 25 reached the bar since 2013), Europe has 22 companies[8] in the set. This is in line with the broader remarks of Curwen *et al.* (2015) in their analysis of the world's largest telecommunications, media and technology (TMT) companies. This is also in line with the continuing results of the EC JRC IPTS PREDICT reports[9] looking at the shares of value added, employment and R&D expenditures in the information and communication technologies (ICT) sector that show that the USA dominates the global landscape, that the EU follows[10], but that China is rapidly climbing.

3. An enabling ecosystem: the deployment of mobile internet, the role of smartphones

The EU, once leading in the global mobile market, has lost its position especially for this new wave of mobile. Therefore, there is no wonder that firms combining strength in IT and in mobile should now come from other regions. Before looking back at the evolution of the mobile sector in the EU, this section will first set the global trends that enable the growth of these firms. This section also illustrates the role of some of the companies in the sample: Apple, Amazon, Alibaba, Facebook, Tencent and Kakao Talk.

3.1 Smartphones as game changers

Smartphones are game changers. They were enabled by the deployment of new mobile networks. The smartphone (the iPhone and the Android family) combines the abilities of a PDA[11] with a mobile phone leading in turn to widespread demand for mobile Internet connectivity. The release of the Apple iPhone in late 2007 played a major role in triggering a migration towards new uses because it provided a convincing approximation of the familiar wired internet. In turn, data growth in mature markets accelerated (West and Mace, 2010, p. 16). Smart devices are much more than just phones:

> [. . .] for many people around the world, they are our primary tool for communicating with friends, family and business contacts, for accessing the internet, for watching content such as TV shows and movies, for playing games, and many other activities (Kemp, 2015a).

Smartphones now account for more than 40 per cent of the world's active handsets (i.e. handsets connected to an active mobile subscription) but accounted for 75 per cent of the sales for the first quarter of 2015 (Kemp, 2015a). A total of 2.6 billion smartphones were sold in 2014 (GSMA Mobile Economy, 2015, p. 6). AppAnnie (2016, p. 5) predicts that the installed base of smartphones and tablets will double from 2.6 billion in 2015 to 6.2 billion in 2020.

The phenomenon gained pace with cheaper handsets and more affordable data connections, allowing access to an array of new apps. Table III sums up this trend: as of August 2015, there were 3.7 billion unique mobile users and 7.529 billion SIM connections, which is slightly higher than the total world population of 7.357 billion (Kemp, 2015a). Cisco

Table III Global digital, social and mobile usage (August 2015, billion)

Total population	*Active internet users*	*Active social media users*	*Unique mobile users*	*Active social users*
7.357 Urbanisation: 53%	3.175 Penetration: 43%	2.206 Penetration: 30%	3.734 Penetration: 51%	1.925 Penetration: 26%

Source: Kemp (2015a)

Visual Networking Index (2014) attributes this impressive growth of mobile data traffic to a combination of trends, among which: the transition to smarter mobile devices, a move towards the Internet of Everything, video dominance and the adoption of IPv6. Faster and higher bandwidth and more intelligent networks paved the way for a wide adoption of advanced multimedia applications that contributes, in turn, to increase mobile and Wi-Fi traffic. Smarter devices and updated networks can accommodate mobile video content with much higher bit rates than other mobile content types, thereby generating much of the mobile traffic growth through 2018 according to Cisco Visual Networking Index (2014, p. 13).

Kemp (2015b) reports that mobile internet access grew exponentially in 2014, "with 39 per cent of all global mobile connections now classified as 'broadband' (i.e. 3G or 4G)"[12]. In addition to the existing 2.9 billion mobile broadband subscribers worldwide, mobile broadband subscriptions are currently growing at 30 per cent year-on-year, adding 50 million new subscribers every month. Kemp estimates at least 1.92 billion active mobile social accounts in January 2015. Figure 2 shows the penetration in different regions of the world: there is room for growth especially in the developing economies with a 48 per cent penetration in Southeast Asia, 53 per cent in East Asia and 57 per cent in South America. Mobile broadband is now widely available in less developed countries. In sub-Saharan Africa, for example, subscriptions went from 14 million in 2010 to 117 million in 2013 (OECD, 2014, p. 28, quoting the ITU). Between 2012 and 2016, the number of Internet users worldwide is expected to double to some five billion people, and most of the new arrivals will be on mobile devices in emerging markets (Quartz India, 2015).

3.2 Smartphones and apps

Smartphones and the mobile internet saw the advent of applications (or "apps") for the consumer. Apple's App Store and Google's Android Market brought two new powerful consolidated channels for app distribution. The development of apps accelerated the growth of an already rapidly expanding market for smartphones. As of 2015, there were 3.1 million apps available (1.6 million on Android, 1.5 million on iOS) (Mehra, 2015). In 2011, global mobile app revenues amounted to US$8.32 billion, reaching US$34.99 billion in

Figure 2 Mobile broadband deployment (January 2015): per cent of active 3G and 4G mobile connections to total active mobile connections

Source: Kemp (2015b)

2014 and are expected to more than double by 2017, up to US$76.57 billion (Mehra, 2015). Consumers are spending more and more time: total time spent in apps grew by 63 per cent on Android phones from 2014 to 2015 according to App Annie's Usage Intelligence (AppAnnie, 2016, p. 6). AppAnnie forecasts downloads to grow 33 per cent to 147.3 billion in 2016, from 111.2 billion in 2015 and to reach 284.3 billion in 2020 (AppAnnie, 2016, p. 8).

A 2014 study (Mulligan and Card, 2014) carried out by GIGAOM and NUI Galway for the European Commission, estimated revenues for apps of €17.5 billion in 2013 and forecasted €63 billion by 2018. The press release adds an optimistic note about the strength of the EU app economy thanks to the role of EU games app developers that lead the field:

> [. . .] 28 EU leading companies created 40 per cent of the top 100 grossing apps in the EU and USA. Three of the top-five companies are Nordic games developers (1st King.com, 2nd, Supercell, 5th Rovio) with German, French, Spanish and UK app developers also finding success outside their native markets.

The EU accounted for 19 per cent of the global app economy in 2014 (Application Developers Alliance, 2014). As noted, smartphones continue to proliferate in emerging markets; therefore, they will drive much of the growth. China accounts for one of every three downloads and India is likely to grow with the on-going development of the mobile internet. Games are the leading app by far, generating about 85 per cent of app market revenue in 2015 (AppAnnie, 2016, p. 12).

3.3 Messaging apps

Together with gaming apps, the success of messaging apps (including social and photo-sharing titles) is having a particularly significant impact. Some messaging apps, such as LINE and Kakao Talk (one of the unicorns in the sample), started to evolve into platforms[13], rather than standalone apps with the inclusion of games and sticker stores. As of March 2014, LINE claimed 100 million games downloads via its messaging app.

The strategic role of messaging apps came to the fore with the wave of exits and investments in the messaging app arena: Facebook acquired WhatsApp for $19 billion; Rakuten acquired Viber for $900 million; Alibaba invested $215 million in Tango (Wee, 2014). The trade association Application Developers Alliance (2014) claims that "New businesses don't think about the desktop environment – they think mobile first, if not mobile only. Tech start-ups today are apps".

Kemp (2015a) also notes that the growth of mobile-centric "chat apps" is overshadowing the growth of more conventional social networks (i.e. PC based). WhatsApp is the world's fastest growing "big" platform (i.e. platforms with more than 100 million active new users in the past year with 800 million active users as of August 2015, followed by Facebook with 700 million. QQ mobile, an app from Tencent, ranks third with 603 million users. Kemp (2015a) indicates that WeChat/Weixin, a Tencent app, added roughly 150 million users around the world within 12 months, which roughly translates to year-on-year growth of 39 per cent (see Box 1), allowing the chat app to reach number four with 549 million users. Kakao Talk (another company in the sample) ranks eighth with 38 million users in the list of the leading chat apps. The list does not include any EU company.

Chan (2015) attributes the success of WeChat (see Box 1), to combining numerous elements together: "WeChat reveals what's possible when we take a mobile-first approach to platforms, portals, social networks, and brands". She further stresses:

> Ultimately, however, WeChat should matter to all of us because it shows what's possible when an entire country – which currently has a smartphone penetration of 62 per cent (that's almost 1/3 of its population) – 'leapfrogs' over the PC era directly to mobile.

Box 1. WeChat, a vision of a mobile lifestyle managed entirely through smartphones

WeChat is a messaging app for sending text, voice and photos to friends and family. Initially, Tencent launched QQ, the most popular messaging app. But when Tencent realised how game changing the smartphone really was, they decided to design a mobile messaging service without the legacy of the PC.

WeChat's average revenue per user (ARPU), which is estimated to be at least US$7, i.e. seven times the ARPU of WhatsApp. In early 2015, WeChat had 549 million monthly active users among over one billion registered users, almost all of them in Asia.

Downloading the app is free. Along with its basic communication features, WeChat users in China can access an array of services. WeChat has focused on building a mobile lifestyle – its goal is to address every aspect of its users' lives, including non-social ones. The way it achieves this goal is through its pioneering model of "apps within an app". Millions of lightweight apps live inside WeChat, much like webpages live on the internet. This makes WeChat more like a browser for mobile websites, or, arguably, a mobile OS complete with its own proprietary app store. The lightweight apps on WeChat are called "official accounts".

Payments are managed through a portal that lives in a completely separate part of the app from official accounts. That portal takes the form of the WeChat "Wallet", a menu of carefully curated, pre-selected service providers that users can transact with after inputting their payment credentials.

With WeChat, mobile does not just navigate, but moves into the physical world: offering an online–offline integration. So whereas most US apps confine the smartphone camera to just taking photos of people and places, WeChat engages the camera to scan English text and translate it into Chinese, or to pay directly for a transaction.

Research from GlobalWebIndex suggests that more than six of ten Internet users in China used WeChat in the past month (Kemp, 2015c).

Sources: Chan (2015); Kemp (2015c)

3.4 The emergence of Asia: Making the best out of leapfrogging

As stressed by GSMA (Mobile Economy, 2015, p. 10), the greatest impact of the technology migration towards 3G and 4G (see Box 1 for a brief history of mobile generations) is taking place in the developing world. Asia lagged behind more developed countries in the deployment of fixed networks for decades; mobile allowed Asia to leapfrog these more developed countries (Box 2).

If the European market still leads the world in terms of penetration of unique subscribers, with a 79 per cent penetration rate compared to a global average of 49 per cent (GSMA Mobile Economy Europe, 2014, p. 9), the Asia-Pacific region accounted for over 50 per cent of the mobile connections in 2014 (3.6 billion connection, 1.8 unique mobile subscribers) and is expected to grow further (4.7 billion connections and 2.4 unique subscribers forecast by GSMA for 2020). China and India are the fastest growing mobile (data) markets in the world (De Prato and Simon, 2015).

China is the world's largest mobile market. In 2014, China Mobile was the world's largest mobile operator based on connections and annual mobile revenue (US$108.64 billion[14]) (GSMA Intelligence, 2014a). As summed up by Millward (2015a, 2015b), "China is making a huge shift to mobile". In its report on Internet development in the country, the Chinese agency, CCNIC (2014) stated that as of December 2013 the internet penetration rate was 45.8 per cent and the number of internet users in China had reached 618 million, of which the number of mobile Internet users had reached 500 million and was growing. The report stresses that "mobile phones are still the main driving force for the growth of internet users in China" as the proportion of Internet users that access the Internet via mobile is much higher than via other devices. In September 2015, the Chinese Ministry of Industry and Information Technology (MIIT)[15] reported that there were 946 million mobile web users in China. The vast majority of them, more than 900 million, access the web via mobile phones

Box 2. A brief history of mobile generations

The first generation (1G) using analogue technology, was launched commercially in the early 1980s, to be replaced by the second generation (2G) based on Global System for Mobile (GSM), a digital standard developed by the European Telecommunications Standards Institute (ETSI) created in 1988). GSM initially stood for Groupe Spécial Mobile (GSM) that was formed, in 1982, by the Confederation of European Posts and Telecommunications to design a pan-European mobile technology.

In 1987, the agreement on the technical specification (GSM History, 2016) paved the way for the signature of the GSM MoU in Copenhagen in September by 15 members from 13 EU countries that committed to deploying GSM. In 1989 Groupe Spécial Mobile was transferred to an ETSI technical committee. GSM is the dominant global second-generation digital mobile network technology standard.

The third generation (3G) was launched in 2001, based on several different digital technologies: HSPA, EV-DO, the IMT 2000 family of standards [Enhanced Data Rates for GSM Evolution (EDGE) and CDMA].

In 2008, 4G was launched: LTE, TD-LTE and WiMAX. Samsung's flagship Galaxy S3 and Apple's new iPhone 5 are LTE-enabled devices.

A debate is on-going on what 5G is exactly about. Verizon's 5G Technology Forum, said it expects 5G technology to have 50 times more data capacity compared to current 4G LTE, and have the ability to "handle exponentially more internet connected devices", as part of the Internet of Things. First commercial rollouts are expected in 2020, and Verizon predicts that widespread adoption will only occur from 2025.

Steinbock links generations and markets. He opens the technical odyssey with pre-cellular services addressing the maritime, security and FM/industrial services markets (1946-1963). Analogue cellular was designed for the business voice market. Digital cellular (2G) allowed the consumer market to be reached, multimedia cellular (3G, the smartphones markets) allowing a global reach, and broadband cellular (4G) is still adding services on a global basis.

Sources: GSMA (2016: history); gsmhistory.com (2015; 2016); Majithia (2015); Steinbock (2002)

(as opposed to tablets or other mobile devices) (Custer, 2015) soon to near one billion taking into account its growth rate. China is going through a rapid shift towards 4G, and as of September 2015, China had hit 270 million total 4G users (Custer, 2015). China is indeed surpassing the EU and USA in 4G rollout, and is well positioned to lead in 5G.

India is expected to be the world's second biggest smartphone market by 2017, overtaking the USA to be second only to China (Strategy Analytics, 2015). India had 405.5 million unique mobile subscribers in 2013 (GSMA Intelligence, 2014b, p. 5). India's web traffic is dominated by mobile devices, with phones alone accounting for 72 per cent of all web pages served in the world's second most populous nation (Kemp, 2015a). India is considered as the last big internet market. The explosion of smartphone sales has made the internet accessible to hundreds of millions of as-yet untapped customers:

> The sheer number of mobile internet users pushes retail e-commerce activities towards mobile devices in a way that is not yet seen in the USA, where desktop computers still factor quite prominently for shopping activities (M. Peart[16] quoted by Waring, 2015).

Asian companies are leading in mobile markets. The penetration of mobile commerce in East Asia outnumbers even the USA at 18 per cent: South Korea has a penetration of mobile commerce of 37 per cent, China 27 per cent, Singapore 22 per cent and Hong Kong 21 per cent (Kemp, 2015b). China is taking the lead in e-commerce (11 unicorns companies of 32 in the 2015 Atomico report).

To sum up the three main points, smartphones as games changers facilitate the entry of new players in the mobile markets coming either from the IT sector (Apple, Google and

Amazon) or from Asia (Alibaba, Kakao, Tencent and Xiaomi). These companies derived the most from a mobile-first approach.

4. The lost momentum of the EU mobile industry

Assuming the above interpretation of the technological wave and its related deployments is correct, the question may turn out to be: did the EU miss the mobile turn – not only from a policy viewpoint but also from an industrial and a manufacturing viewpoint – as illustrated by Nokia but also by EU telcos and their failed attempts to introduce the mobile internet.

4.1 Explosive growth in the EU from mid-1990s to the 2000s

In the 1980s, the EU took a leading role in the adoption and shift to the digital standard, away from the first generation of analogue technology. Therefore, the EU contributed to the creation of a mass market for the new technology that spread quickly to other continents. The creation of GSM in 1982 was a landmark decision to create the conditions for the adoption of a single unified standard body. It was followed in 1987 by an agreement on the technical specification (GSM History, 2016) and the signature of the GSM MoU. With the adoption of the standards and the deployment of the appropriate networks, the first GSM networks went into commercial service in 1992. In the early 1990s, GSM enabled roaming across European nations – for the first time a single market was formed. Up to 1995, it remained a strictly European phenomenon. The fast-growing mobile industry started moving out of its initial business target to enter into a new world of consumer electronics. It paved the way for the creation of companies like Vodafone (founded in 1982[17]), and it enabled Nokia to become a global leader for the manufacturing of devices.

The last mobile generation is enabled by the deployment of new networks (3G, 4G and soon 5G) characterised by faster higher bandwidth and more intelligent networks allowing the deployment of the mobile Internet (or mobile broadband). With the introduction of 3G, the term "mobile broadband" was introduced because of its speed and capability. Weber *et al.* (2011, p. 2) date the introduction of the mobile internet back to the launch of the iMode by NTT Docomo in 1999, which was followed shortly thereafter by the far less successful launch of Wireless Application Protocol (WAP) in Europe.

While acknowledging, in 2008, that "Our strong EU mobile industry is however at a historical tipping point", Commissioner Reding nevertheless stressed that "Europe remains the world's leader in mobile communications" (Reding, 2008). However, the pace and nature of the markets changed with the introduction on the iPhone in 2007 that revealed a massive pent-up demand for quite new services: the "apps", as accounted for in the previous section. Weber *et al.* (2011, p. 2) even claim that since 1999, the *locus* of innovation shifted away from the EU as most data-related innovations came from Japan since the late 1990s.

4.2 Missing the new 3G value chain: ill-adapted business models

Steinbock (2002, p. 9) considers that 3G brought a change in the drivers of multidimensional strategic advantages through the setting up of a new value chain. With 2G, the top-tier manufacturers (Nokia, Ericsson and Motorola) served as catalysts for the entire industry. With 3G, the migration of value to software shifted this role towards IT players.

Despite first-class marketing, Nokia missed some of the elements of the then burgeoning ecosystem, and did not foresee the introduction of new business models. At the time of the introduction of Apple's iPhone, in the third quarter of 2007, Nokia's market share was still at 48.7 per cent; by the third quarter of 2012 it had slipped to just 3.5 per cent (Statista, 2015). In 2000, Nokia had a market capitalisation of $208.1 billion; by 2012, the value of the company had plummeted to $20.4 billion (Curwen *et al.*, 2015). As of 2014, its market

capitalisation was $27.8 billion, compared with a market capitalisation of the four-year-old Xiaomi that same year of $46 billion.

As noted by Steinbock as early as 2002, what he called the "euro-Nordic leadership" in the telecom industry was aiming strategically at using the "twin drivers of Internet and mobility to attack USA-based IT leaders in the early 2000s" (Steinbock, 2002, p. 4) when reaching their own industrial climax. Ironically, it went in the opposite direction with IT companies like Apple, Amazon and Google managing their mobile shift. As Steinbock noted with some irony: "the twin drivers looked more as a double whammy". These companies, just like Motorola, failed to challenge their own mobile industry business model. Instead, they were attempting to compete with these IT leaders while maintaining their legacy approach (Box 3).

EU telecom operators, deploying 3G networks, were grappling as well with new business models especially to accommodate an emerging data consumption that did not fit their former voice-centric metered business model. Operators were reluctant to introduce flat-fee data tariffs. Commissioner Reding noted, in her 2008 Barcelona speech, that the operators' approach, "versioning of the web", was not a successful model, regretting that the:

> [. . .] the growth of Mobile Internet so far has been disappointing in Europe. We in Europe were the first to roll out 3G services, but these data services have still not really taken off.

Weber *et al.* (2011, p. 3) put the blame on an over dependency on GSM-related technologies (the ransom of success so to speak) such as SMS and MMS, and the subsequent lack of competition between technologies in contrast to the Japanese case where services were launched on the basis of proprietary technologies (Weber *et al.*, 2011,

Box 3. Nokia stumbles . . . on a success story

Nokia Communicator, released in 1996 marked, together with IBM's Simon in 1993, the beginning of the smartphone era, a smartphone being a still loosely defined category of mobile telephone with extended capabilities and some PC-like functionalities.

Later, Nokia later released the Nokia 7650 for around €600. The phone was referred to as "smart phone" in the media, and kept its supremacy with N-Series of 3G. It was notable for a number of firsts: first Nokia smartphone with the Symbian OS (version 6.1), first Series 60 [Now S60)] platform device and the first Nokia with built-in camera.

In 2008, while Google released the cross-platform OS around Android, Nokia bought the independent non-profit organisation Symbian Foundation, supporting the deployment of the Symbian OS, a royalty-free, open source software. Symbian was at that time the most diffused OS for smartphones.

Unfortunately, Nokia "botched" the launch of its new device, the smartphone, despite the fact that the Finnish company was not only a global leader with strong investments in R&D, but also an acknowledged innovator with a good marketing experience, and an impressive number of patents.

Despite the early introduction of such a new device in the 1990s (Nokia Communicator and Symbian OS), Nokia did not manage to grapple with new competitors.

Forge and Blackman (2011) added a list of failures:

- failed to develop touchscreen technology;
- use of proprietary OS (like Apple) – Symbian – which had not been taken by others to provide an industry;
- failed entry into music store field; and
- failed entry into internet services.

Sources: Updated from Wikipedia, C. Feijoo in De Prato *et al.* (2010, p. 16); Forge and Blackman (2011)

p. 9). These authors quote Brock asking whether the "coordination and economies of scale benefits of *utilizing* a single standard outweigh the innovation-retarding effect of requiring all carriers to conform to the standard" (Weber *et al.*, 2011, p. 17).

It also accounts for the failure of the introduction of WA)[18] (see Box 4), the first EU attempt to introduce some mobile equivalent to the internet, based on a common industry standard but neither customer-centric, nor user-friendly. Handsets became available in 1999 but wireless services between 2003 and 2004. However, most of the pieces of an effective ecosystem were missing: the networks were inappropriate not allowing for more bandwidth, the devices were not satisfactory, content providers and developers were not really involved, the adequate charging scheme was lacking. By contrast, Apple traditionally focuses on closed and proprietary technologies but also, as in the case of the Japanese iMode (Lindmark and Bohlin, 2003), did invest in the shaping and creation of an appropriate ecosystem based on a user-friendly device and access to a broad variety of contents. Although vendors and operators in the EU were, according to Steinbock, best positioned in the GSM path towards the next generation (multimedia cellular, i.e. 3G), they lost most of their competitive edge through misguided efforts to sell new technologies, instead of services like Apple or NTT Docomo, in what he called "the early WAP debacle" (Steinbock, 2002, p. 8).

5. Conclusion: supply side policies missing the mobile turn?

The developments following the mobile Internet wave have been largely market-led. In contrast, in the telecommunications sector most of the EU and US policies over the past 30 years have been designed for the fixed telecommunications markets whether by liberalising the sector or regulating it. On the contrary, mobile telecommunications started in a competitive environment: the need to intervene was hence less apparent. Public policies more or less took the guise of competition law when and if needed.

Box 4. The failure of WAP

As with 2G, direct phone access to the internet did not scale well for mobile. The WAP standard was developed to address these concerns. WAP was a stripped-down version of HTTP, which is the basic protocol of the World Wide Web. WAP browsers were designed to run within the memory and bandwidth constraints of the phone. The WAP solution was attractive for handset manufacturers and they left it to developers to come up with the content users wanted. They could maintain their protectionist policies regarding handset design. It was attractive for mobile operators providing a custom WAP portal directing their subscribers to the content they wanted to provide, and wallow in the high data charges associated with browsing. They could maintain their walled garden model.

The first WAP-enabled handsets to hit Europe did so in 1999. However, WAP fell short of commercial expectations, except in Japan and a few other places. Developers and content providers did not deliver, except in a limited way. Also, the user experience was poor. It was lampooned as "Worthless Application Protocol". Small handset screens were too small for surfing. Reading a sentence a fragment at a time and then waiting seconds for the next segment to download ruined the user experience, especially because every second of downloading was charged to the user. Besides, there was not much of a mobile web in place save for some basic news, sports and stocks pages, plus simple e-mail access. No wonder that derogatory phrases like "Wait And Pay" were thrown around, referring to the fact that connecting to WAP services was not included in monthly tariff costs, and because the connection speeds were snail-like.

New standards were required. WAP gave way to EDGE in the early 2000s (heralded as "2.5G"), but it was 3G that really marked a drastic change. It allowed packet switching for data transmission. It has been the *de facto* standard in mobile data since it was first tested in Japan in 2001, and its commercial launch in the UK in 2003.

Sources: Clark (2012); Vodafone (2013)

However, when looking back at the disruption that took place in 2007 after the introduction of the iPhone, one can have second thoughts about this sole policy choice – a focus on fixed rather than mobile telecoms. In the late 2000s, policies were still concentrating on the deployment of fixed networks: after the successful deployment of ADSL, policies focused on shifting from high to ultra-high broadband fixed networks. In the USA, a National Broadband Plan was adopted in 2010, following a hot debate about the USA falling into a "broadband ditch" after the release of the 2007 OECD Broadband Statistics (Simon, 2010). The EU followed track with the 2010 Digital Agenda. Some fierce debates took place, in a similar fashion, about the EU lagging behind other OECD countries with economic performance like Australia, Japan, South Korea and the USA over the broadband penetration.

5.1 Tilted towards the supply side

The policies were legitimate from that angle, but this analysis might now show how some issues were left unaddressed. These policies were supply side policies. This can be considered surprising since the deployment of these networks was supposed to generate network effects known as "demand side economies of scale" that play an important role in the economic analysis of the impacts of digital technologies.

Policies were designed to open up the market, and in the mobile sphere they were not supposed to play a more proactive role except at the beginning to set up the standard on a European basis. There was no debate about mobile broadband, or broadly speaking pro-mobile policies. The issue of the deployment of the mobile internet was noted by Commissioner Reding, but it did not trigger any specific policies[19], and the blame was put on the operators' strategies and their unwillingness to change their business models as we stressed. The issue of mobile was dealt only from a restricted angle, focusing on the issue of mobile TV. In the EU, mobile TV has benefited from strong standardisation support since 2007 (DVB-H). However, despite attempting to use major events (e.g. the Olympics and football) for commercial launches, the output remained modest with a limited response from EU markets (at about 5 million users). This dead end stems from divergent technological options (broadcasting vs. mobile communications) but also from a lack of perceived value and usefulness by users. Mobile TV may have been perceived as still belonging to the legacy broadcasting model, a push model, at a time when users were enjoying the opposite using the new capacities of their device, with the freedom to choose the content they wanted to view (pull model). This is a clear example of a supply side policy[20].

Policies designed to promote the shift from broadband to ultra-high broadband tell a similar story. The demand for ultra-fast broadband remained latent whenever the networks were deployed. This reluctance was noted in the Digital Agenda Scoreboard as early as 2011. The 2014 Digital Agenda Scoreboard still stressed this discrepancy between NGA coverage and take up of fast broadband (at least 30 Mbps): "NGA is available to 62 per cent of homes in Europe, but only an estimated 15 per cent subscribe to fast broadband" (European Commission, 2014). As Marcus and Elixman (2014) noted, in countries with an impressive deployment of ultra-fast broadband, like Japan and South Korea, usage is not notably higher. In reality, 3G access has outnumbered fixed broadband subscriptions since early 2009 (ETNO, 2015, p. 22). Pew (2016, p. 2) reports that the share of Americans with broadband at home plateaued (down to 67 per cent in 2014, from 70 per cent in 2013), and more rely only on their smartphone for online access with 68 per cent of Americans owning a smartphone.

Customers did not appear to grasp what they could get from this increased bandwidth for lack of attractive applications at a time when attractive mobile applications started blooming. In Europe, data from Vodafone showed that in the quarter to September 2013, 75 per cent of the company's data traffic in Europe was already video and browsing (GSMA,

Mobile Economy: 18). Mobile video traffic exceeded 50 per cent of total mobile data traffic for the first time in 2012 (Cisco Visual Networking Index (2014), p. 1).

Ironically, if mobile broadcast TV (the legacy push model) went nowhere, the adoption of mobile devices to watch video and TV-on-demand[21] (streamed: the new pull model) was, by and large, unexpected and reached significant levels: in 2014, 25 per cent of French consumers used a mobile device to watch TV or video on a weekly basis, 27 per cent of Germans and up to 42 per cent in Sweden, the country with the highest 4G penetration rate[22]. Besides, the distribution of films on devices such as a mobile, once seen with scepticism, "is increasingly the place where young people in particular are choosing to watch film" (Gubbins, 2014, p. 75).

The irony of such a mismatch between supply and demand is that it ignored that growth of traffic was more and more consumer-led (Cisco), and media-led with video being the driver. Customers were using their new devices to produce and exchange their own content (Simon, 2016b). For example, YouTube started with some amateur short videos. Smartphones triggered the migration to mobile[23]: YouTube announced in October 2014 that mobile devices generate 50 per cent of its traffic, up from 41 per cent in 2013 (GSMA, Mobile economy Europe, 2014, p. 20). Demand was limited for fixed traffic but demand has been overwhelming for mobile and for "attractive" apps as soon as they become available. The willingness to engage in the "apps" universe was the result of enhanced services and engaging interfaces developed for the smartphone ecosystem.

On the backdrop of the assumption that mobile is "eating the world", more research should be done to better investigate what might have been the causes of this apparently missed mobile turn in European policy and industry. Despite the similar supply-side policies followed on both sides of the Atlantic, US players, mostly IT players, benefited from the changes. First, because value has migrated to software, which, as reminded by Steinbock (2002, p. 11), has been dominated by US firms since the Second World War. Second, these IT players swiftly managed their mobile shift, successfully entering the mobile business at a time when EU mobile companies were missing their software shift.

Besides, the example of Asia shows how countries like China and India can successfully leapfrog the past technology and become world leaders. By the same token, the case of the USA where mobile companies were also lagging in the 1990s, reveals that the combination of the release of the iPhone and the deployment of new networks allowed AT&T and Verizon to climb again up the rankings. AT&T, when preparing a deal with Apple in 2005 for an unheard of concept of "app stores", was taking a serious bet on the future, making the company "nervous" (AT&T's Mobility CEO Glenn Lurie quoted by Majithi, 2015). Now Chinese and US companies are the top ranking companies in term of revenues. With 4G and 5G likely to bring some other changes in existing value chains, these countries seem also best placed to make the most out of it. With 4G now and 5G[24] also bringing new opportunities, a review of the EU policies may be timely.

Notes

1. The paper draws on a report for the European Commission's JRC Institute for Prospective Technological Studies on companies with high market capitalisation (over US$1 billion), the so-called unicorns (Simon, 2016a, 2016b). The views expressed are purely those of the author and may not in any circumstances be regarded as stating an official position of the European Commision.
2. In fact, a larger sample was built that included seven would-be unicorns: AppAnnie (USA), Buongiorno (Italy/Japan), Cyanogen (USA), Flurry (USA), Meerkat (USA), Storm8 (USA) and Yodo (China).
3. With the exception of Indian Flipkart.
4. China's middle class reached 109 million in 2015, and overtook the USA's for the first time ever, according to a Credit Suisse report released in October 13 (quoted by Huang, 2015).
5. The Naspers group is not included in this table.

6. With free basic features (free trial period and full version for a fee), which is alternatively called also free-to-play (F2P: the content is made available for free online).
7. Atomico (2016) gives 236. In 2014, Atomico released an analysis of the then 146 companies globally that have reached the billion-dollar mark over the past decade. In May 2015, the updated report documents 182 unicorns. The report is an interactive dataset, updated on a regular basis, quarterly since January 2015.
8. Atomico includes included Russia (3) and Israel (4).
9. Since 2006, the Information Society Unit at the JRC Institute for Prospective Technological Studies (JRC IPTS) has been carrying out the PREDICT research project on Prospective Insights on R&D in ICT for the Directorate General for Communications Networks (DG Connect).
The PREDICT project has become a unique source of information on the ICT sector and on ICT R&D in the EU and its global competitors. All data and reports are available at: http://is.jrc.ec.europa.eu/pages/ISG/PREDICT.html
10. However, the European ICT sector maintained its value added overall share in the European GDP around 4 per cent through the crisis years.
11. Personal digital assistant also known as a handheld PC.
12. Although with varying speeds.
13. The apps start offering a single service like messaging or games, then new functionalities are added turning the initial app into a multifunction platform.
14. Annualised revenue for the period to Q2 2014. US$90.44 billion in 2013 (Gillet, 2014).
15. The state agency of the People's Republic of China responsible for regulation and development of the postal service, internet, wireless, broadcasting, communications, production of electronic and information goods, software industry and the promotion of the national knowledge economy, established in March 2008.
16. A forecasting analyst at eMarketer.
17. Operated as Racal Millicom from 1982 to 1991. Went public in 1999.
18. Working under a push technology: delivery of content to the mobile device without previous user interaction (Openvawe, 2002).
19. One should, nevertheless, note that spectrum issues were properly taken care of and the need for more bandwidth, for instance, with the refarming of the 2G spectrum. However, this was still creating the right conditions for the market to work.
20. Interestingly, nevertheless, in the wake of this early deployment, some EU start-ups like Buongiorno managed to devise a business model moving from mobile TV to apps (De Prato and Simon, 2015; Simon, 2016a).
21. On-demand audio-visual content streamed to a mobile device.
22. According to Ericsson consumer research, quoted by GSMA Mobile Economy Europe (2014, p. 20).
23. iPhones already allow for some kind of motion pictures; manufacturers are introducing new cameras that may not be different from the camera they produced for the professional sectors, at least for the lighter ones.
24. Some initiatives are being developed at the EU level. The European Commission and Europe's tech industry (already involved in the 5G Public-Private Partnership of December 2013) presented their vision for 5G during the Barcelona 2015 Mobile World Congress. See: https://ec.europa.eu/digital-single-market/en/towards-5g. Other linked initiatives are dealing with the Internet of Things, machine-to-machine communications and Big Data.

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