

ANDROID IMPACT

HOW THE ANDROID ECOSYSTEM SUPPORTS ECONOMIC IMPACT IN SOUTH KOREA



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The amounts in this report are estimated in US dollars. Where applicable the conversion is based on the average exchange rate in 2015, sourced from X-Rates.com, which was 1 USD = 1130.69 KRW.



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South Korea's estimated economic benefits from Android*



BUSINESS BENEFITS

App developers can readily target more than **1 billion** users worldwide by developing on **Android**: not having to replicate development efforts, saves them **30%** in development time, implying between **US\$15 – 75 million** (~~₩~~17 – 85 billion) in costs saved for over **6,000** Korean apps



Telcos have benefitted from data traffic originating from **Android** devices, which has been growing at over **60%** annually in South Korea



CONSUMER BENEFITS

South Korean consumers value **Android** at more than **US\$4.0 billion** (~~₩~~4.5 trillion) annually



Apps that come included with **Android** are highly valued by users. In fact, over **5%** of **Android** users count 3 or more of these apps as their favorite. For Non-Android users, this share is even higher at more than **10%**



SOCIETAL BENEFITS

Lower smartphone prices and greater competition and innovation, linked to **Android**, may have led to more than **30 million** more South Koreans adopting smartphones since 2010, potentially adding over **US\$15 billion** (~~₩~~17 trillion) to South Korea's GDP over the last 5 years



An estimated more than **40,000** **Android** app developers are working in South Korea



* Data in exhibit is estimated by AlphaBeta using a range of original and third party sources. See Appendix for detailed methodology. Unless otherwise stated, these estimates refer to annual benefits based on the latest available figures, thus of 2015.

EXECUTIVE SUMMARY

Smart devices have changed the way millions of South Korean users interact, do business, and stay connected to the world. More than US\$111 billion (₩126 trillion), equivalent to over 27% of global smartphone sales, were made by South Korean Original Equipment Manufacturers (OEMs) in 2015.¹ While hardware improvements have been significant, much of the success of smart devices can be traced to the advancements in software, which is ultimately the way users interact with their devices. Open source software, such as the Android™ operating system, has played a key role in this software development and created significant positive economic “spillovers” in terms of enabling greater smart device adoption and innovation. However, quantifying the benefits of open source software can be difficult given that it is provided to manufacturers and software developers free of charge. To fully understand the economic impact of open source software, one needs to look further than just traditional economic measures such as Gross Domestic Product (GDP). This report aims to inform the discussion on how to measure the contribution of open source software by estimating the

economic impact that the Android operating system has on South Korea’s economy.²

The economic impact of the Android ecosystem will be underestimated if we rely solely upon traditional economic measures. For instance, being provided for free, the operating system has allowed OEMs to lower the manufacturing costs of handsets and thereby, has made a significant contribution to the fast growth of smart devices globally. This growing demand for smart devices has in turn been instrumental in the rise and spread of third-party applications (“apps”). However, GDP fails to fully take account of these contributions to local OEMs and app developers. Similarly, none of the benefits that consumers derive from their Android devices, such as communicating through email or finding places via digital maps, are reflected. Finally, the broader benefits to the South Korean society from additional mobile internet penetration and jobs supported by the Android ecosystem are also not directly reflected in economic measures.

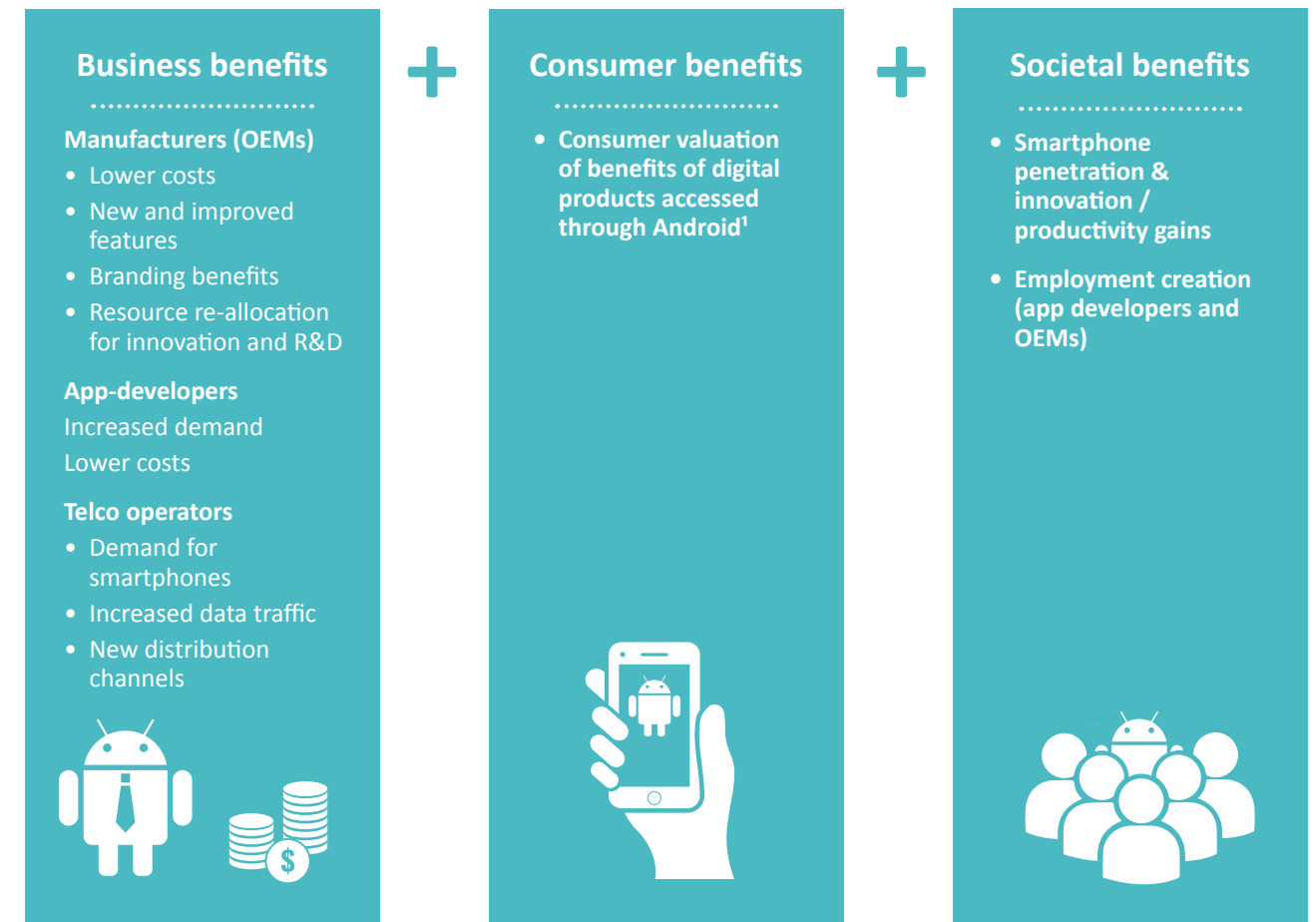
This report seeks to address these shortcomings by looking at three components of the economic impact of Android in South Korea that are not adequately captured by traditional economic measures: business benefits, consumer benefits, and societal benefits (Exhibit 1). Using third party data, consumer surveys, and interviews with OEMs, app developers, and telecommunication operators (telcos), AlphaBeta’s analysis reveals that Android supports a range of significant, yet diffuse benefits, some of which can be quantified. These benefits are measured in terms of costs saved by South Korean businesses, and the valuation of the Android user experience by South Korean consumers which are delivered through Android

devices. Furthermore, as proxies for the societal benefits of Android, the report estimates the GDP contributions from Android-induced smartphone penetration, as well as the employment generated (directly and indirectly) by Android. The benefits estimated in this report are a proxy for the ‘gross economic activity’ generated by Android, i.e. this methodology does not account for activity that

may have been displaced by Android. In many instances, particularly for the consumer and societal benefits, it is impossible to completely isolate the contribution of Android versus other factors to these benefits. As such, we describe the benefits as being supported by Android, but not solely driven by Android.

EXHIBIT 1

The economic impact of Android is broken down into benefits for businesses, consumers and society



¹ The benefits were sized through an AlphaBeta survey of South Korean consumers.
Source: AlphaBeta analysis

¹ Reported by World's Top Exports - <http://www.worldstopexports.com/cellphone-exports-by-country/>

² Android refers to an open source software stack supporting a wide range of devices, as well as a corresponding open source project led by Google and other members of the Open Handset Alliance. Android is provided free of charge and was primarily designed as an operating system for touchscreen mobile devices such as smartphones and tablets but is also used in other internet enabled devices such as video game consoles, televisions, and even appliances. In this report, we group all these devices under the collective term of “smart devices”. For more details about Android, see Box 1.

Business benefits

The free and open-source nature of Android has allowed smart device producers to drastically lower the manufacturing costs of devices. South Korean OEMs are saving one-off development costs from being able to use Android source code directly rather than having to develop bottom-up operating systems themselves.

Since Android is open source and there is a growing community of Android developers, Google and other third-party developers can contribute to debugging efforts; this enhances the software and minimizes the need for regular maintenance by OEMs themselves. Thus, OEMs also achieve additional annual savings through simplified operating system maintenance and upgrading.

App developers can reach more than 1 billion Android users globally with the help of Android and the associated “Google Play” store. The vast adoption of free-to-use open source operating systems such as Android allows app developers to cut development time and therefore costs. This is because programming a single version of an app can reach the same number of users, without having to develop different versions to function on a different operating system for each OEM. The total savings to South Korean app developers are estimated to be between US\$15 - 75 million (₩17 - 85 billion).

Furthermore, utilizing free-to-use open source operating systems has increased competition in the app development market in South Korea, giving rise to more local developers and quality apps. According to industry sources, “Any individual, even a high school student, can register as an app developer and compete against other players globally through app stores. This facilitates greater competition in the industry.”³

Android-accelerated spread of smartphones has also been beneficial for South Korean

telecommunication operators, specifically in supporting greater mobile data consumption. The contribution of data traffic originating from Android-powered smartphones to South Korean telecommunication operators has grown at rates of more than 60% annually since 2011.

Consumer benefits

South Korean consumers derive more than US\$4.0 billion (₩4.5 trillion) of annual benefits from the user experience that Android offers. While it is hard to separate the benefits related to Android from the benefits associated with the entire smart device, the operating system is integral to delivering the services and features of a smart device to the user. In fact, at least 1 in 4 South Koreans stated that the operating system was one of the main reasons they decided to purchase their smart device.

To arrive at this estimate of Android’s contribution to the overall benefits from the smart device user experience, AlphaBeta’s survey of South Korean consumers asked respondents to value their operating system directly as well as their top 3 favorite services and software features they access on their devices. The average Android user placed an annual valuation of their operating system at roughly US\$135 (₩152,000), which when scaled by the over 30 million Android users in South Korea results in the estimated consumer benefit of over US\$4.0 billion (₩4.5 trillion).⁴

Furthermore, Android provides additional benefits by fully integrating the functionality of the Google Mobile Services (GMS).⁵ Many of the GMS apps - YouTube in particular - that come pre-loaded with Android are among the favorite apps of consumers, whether they use Android or other operating systems. Amongst all survey respondents, regardless of what operating system they used, more than 35% counted at least one GMS app among their favorite apps.

Societal benefits

The societal benefits provided by open source Android are potentially vast but difficult to size. Lower costs for smartphone manufacturers and app developers have spurred innovation. The reduced barriers to entry, both in the manufacturing of smartphones and app development have created greater competition and thus broader consumer choice.

This report estimates that these benefits could have supported more than 30 million South Koreans adopting smartphones from 2010-15 than otherwise would have occurred. This increased smartphone penetration in South Korea has, in turn, boosted annual economic growth by up to 0.27 percentage points from 2010-15. The economic growth impacts of this are significant, potentially increasing GDP in South Korea by over US\$15 billion (₩17 trillion) over the last 5 years.

Furthermore, Android has facilitated job creation in the digital economy. Over 125,000 South Koreans are employed in jobs that are either directly or indirectly linked to Android. This includes more than an estimated 40,000 South Koreans who are employed directly in Android app development jobs. These estimates exclude the broader employment impacts in related sectors such as telcos, which could potentially be several times larger.

³ Interview with local app developer.
⁴ We used two methodologies to estimate the annual valuation of the Android operating system. To be conservative, we took the lower end of the range.
⁵ For a detailed explanation of Google Mobile Services, please refer to Box 5.

BOX 1

The Android Operating System



open handset alliance

Android is a device operating system developed by Google and other members of the Open Handset Alliance (OHA). The Android software was primarily designed for touchscreen mobile devices such as smartphones and tablets but is also used in devices such as video game consoles, televisions, and even appliances. In this report, we group all these devices under the collective term of “smart devices”.

The OHA, led by Google, was established in 2007 to accelerate innovation and improve industry standards in mobile as well as to provide consumers with handsets and services using the Android operating system.⁶ It currently includes 84 technology and mobile companies, consisting of all parts of the mobile ecosystem, in its network. The members represent OEMs (e.g. Samsung and HTC), telecommunication operators (e.g. Vodafone and NTT DoCoMo), semiconductor companies (e.g. Intel and MediaTek Inc.), software firms (e.g. Google and eBay), and other partner companies such as Noser Engineering Inc. and Borqs.⁷ All members of the OHA have committed to making Android a commercial success and to offer consumers an affordable and better experience.

Android was commercially launched in 2008, with the first Android phone in the world – the “HTC Dream”, and its source code is

provided free of charge and open-source to manufacturers and developers in the form of the Android Open Source Project (AOSP). This has allowed smart device manufacturers to drastically lower the production costs of handsets as they need not create a proprietary software from scratch to operate their devices but can use stock Android instead. The availability of a common set of Google applications (“apps”) has also helped ensure a consistent and familiar user experience and compatibility across smart devices. Furthermore, OEMs can freely customize stock Android to tailor their products and their customers’ preferences. As a result, low cost smartphones have become a reality worldwide and also in South Korea, with models selling well below US\$100 (₩113,000), making mobile internet available to everyone, especially low income consumers.

Free of charge and open source access to Android has also drastically reduced the up-front investment costs to software development, spurring competition, and innovation in the international and domestic market. Android has also been instrumental in the rise of third party software application developers and their distribution through Google Play (see Box 2) and alternative Android app stores.



⁶ Information obtained from Open Handset Alliance, January 25, 2017 - http://www.openhandsetalliance.com/oha_faq.html
⁷ Information obtained from Open Handset Alliance, January 25, 2017 - http://www.openhandsetalliance.com/oha_members.html



BUSINESS BENEFITS

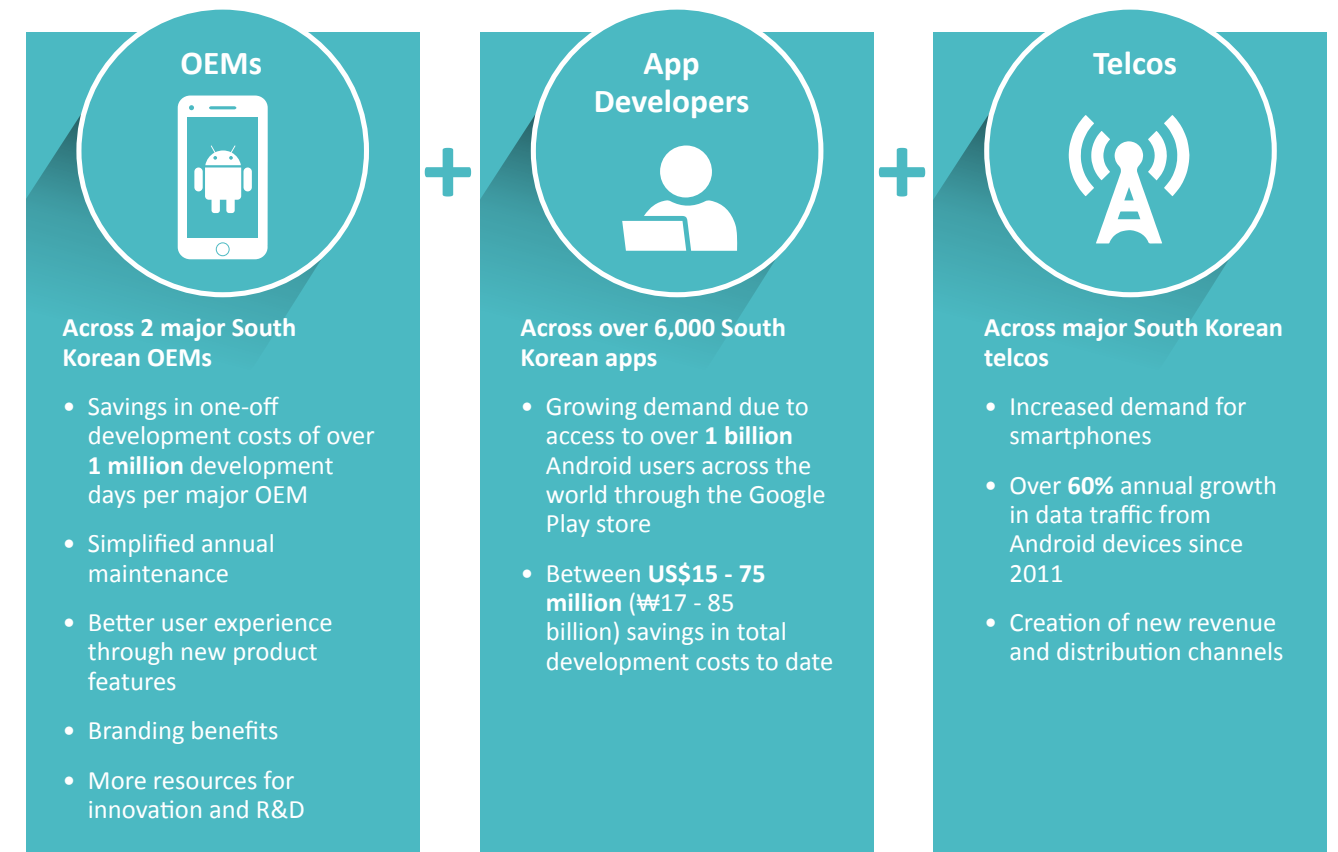


Android provides benefits to manufacturers, app developers, and telecommunications operators (Exhibit 2). The size of some benefits is estimated whereas others are discussed qualitatively. The benefits are measured in costs saved from using Android by manufacturers and app developers during product development, as well as data revenues telcos receive from traffic originating from Android devices in 2015. Because of Android, OEMs can drastically reduce one off development costs and annual software maintenance costs. It is estimated that free-to-use

open source operating systems such as Android have enabled Korean OEMs to save more than 1 million software development days each (Exhibit 3). App developers have been able to save between an estimated US\$15 - 75 million (₩17 - 85 billion) in development costs. Finally, telcos have also benefitted from growing data traffic from Android devices. These insights were gathered through a combination of third-party research as well as targeted interviews with OEMs, app developers and telcos conducted by AlphaBeta.

EXHIBIT 2

South Korea enjoys significant business benefits to OEMs, app developers and telco operators from Android



Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources. See Appendix for detailed methodology.

The commercial launch of the Android operating system in 2008 had a fundamental impact on the global smart device industry, primarily in the smartphone element. This is especially true for South Korea. South Korea is home to some of the world’s leading companies in the smart device space - Samsung and LG in particular - who utilize the Android OS in their products. Allowing these and other OEMs to use the Android code at zero cost has significantly reduced their cost base, allowing OEMs to channel funds into R&D and innovation efforts. South Korean OEMs are saving costs by not having to develop and maintain separate operating systems and using free-to-use open source operating systems such as the Android source code instead. Furthermore, being an open source platform, Android source codes are constantly being reviewed by the Android community and many third-party developers, aiding the debugging and maintenance efforts. This has helped OEMs to reduce resources on maintenance and reallocate them to development and innovation.

Likewise, the rise of Android devices and the popularity of Google Play has made it easier for South Korean app developers to reach broader audiences, at home and abroad. The early days of smartphones app development were hampered by additional obstacles such as having to port apps across different operating systems, thus raising costs for app developers. With free-to-use open source operating systems such as Android, developers can reach a larger audience by developing apps that can work across multiple manufacturer brands and devices, as well as benefit from the knowledge of the Android open source community. South Korean app developers are saving on average between US\$2,500 –11,500 (₩3 - 13.0 million) per app in development costs due to freely available open source operating systems like Android. In addition, Android lets new app developers target more than 1 billion users in 190 countries and territories worldwide.⁸

The introduction of Android phones coincided with an average 431% rate of growth of smartphone subscriptions from 2009-11 in South Korea. This, in turn, has allowed South Korean firms to become competitive powerhouses on a global scale. According to industry research, net exports of mobile technologies (including devices, accessories, mobile content, apps, and services) contributed close to US\$80 billion (₩90 trillion) to South Korea’s GDP in 2014.⁹

Original Equipment Manufacturers (OEMs)

Revenues from sales and licensing of enablement platforms (such as app stores), devices (including smartphones and tablets) and mobile operating systems in South Korea have been estimated at almost US\$11 billion (₩12.4 trillion) in 2013.¹⁰ More than 60% of domestic device sales are for products from South Korean OEMs.¹¹ Furthermore, the majority of the devices which operate on the Android system worldwide (worth more than US\$111 billion (₩126 trillion), equivalent to over 27% of global smartphone sales) were made by South Korean OEMs in 2015.¹² According to AppBrain.com, Samsung, the world’s largest smartphone manufacturer, and LG, Korea’s second largest smartphone manufacturer, account for more than 50% of the user base of Android-powered devices globally. In 2015, Samsung held a 22.5% share of the global smartphone sales.¹³

Drawing on third-party research as well as targeted interviews with OEMs, the most prominent benefits for OEMs emerging from Android are linked to (1) Cost reductions (from reduced development and maintenance costs); (2) New features and improvements to the user experience; (3) Branding benefits; and (4) Improved innovation mainly driven by enabling reallocation of OEM resources towards R&D, and increasing competition.

Reducing costs for OEMs

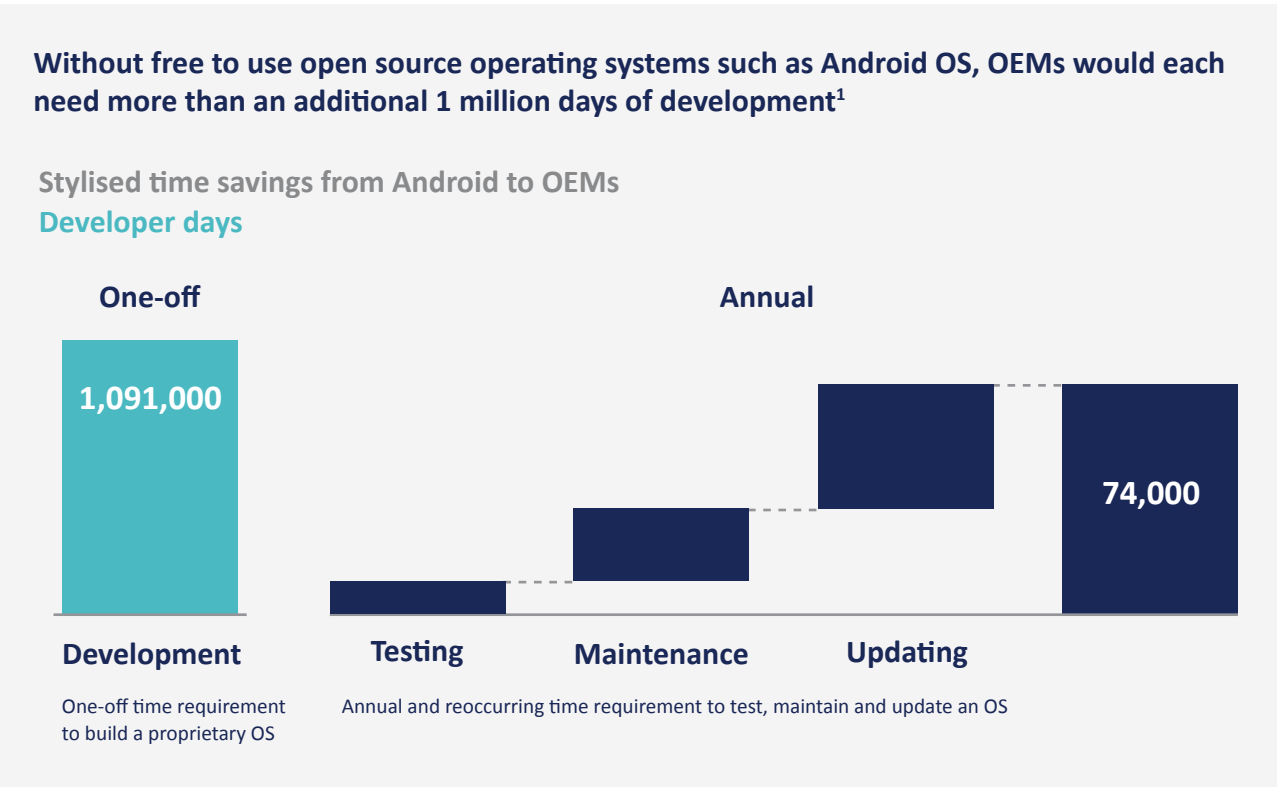
Free access to the Android operating system has played a significant role in these successes for local OEMs. The cost savings are due to “reductions in resources and development cost and time required for basic OS functionality”.¹⁴

The cost saved from being able to use free open source codes available in the market such as Android and not having to design a unique operating system is substantial. Based on analysis of operating system development and maintenance

processes, we estimate that free-to-use open source operating systems can save major OEMs more than 1 million software development days each. This consists of both one-off time saving from using the open source code directly and reoccurring annual time savings from having the open source community to collaborate on maintenance efforts (Exhibit 3). In order to estimate this, we employed the Basic Constructive Cost Model (COCOMO) which computes the required software development effort as a function of the software programs size in single lines of code (SLOC).¹⁵

EXHIBIT 3

Free to use open source operating systems such as Android produces savings of over 1 million software development days per OEM



¹ Hours saved are based on the lines of code in Android and the incremental additions of lines of code between major Linux updates as well as estimates of developer hours per line of code. Rounded to the nearest 1,000 days. Source: AlphaBeta interviews and analysis, Data in exhibit is estimated by AlphaBeta using a range of original and third party sources including OEM and app developer interviews.

¹⁴ Interview with local OEM conducted by AlphaBeta.
¹⁵ See the Appendix for details on this calculation.

⁸ Global data from Android Developers The Google Play Opportunity - <https://developer.android.com/distribute/googleplay/about.html>
⁹ Boston Consulting Group (2015), The Mobile Revolution – How Mobile Technologies drive a Trillion Dollar Impact.
¹⁰ Boston Consulting Group (2015), The Connected World – The Growth of the Global Mobile Internet Economy.
¹¹ Reported by Techno Stream - <http://techno-stream.net/iphone-6-sales-in-japan-korea-set-new-apple-records/>
¹² Reported by World’s Top Exports - <http://www.worldstopexports.com/cellphone-exports-by-country/>
¹³ Information obtained from Gartner Newsroom, February 18, 2016 - <http://www.gartner.com/newsroom/id/3215217>

To illustrate the resources required to develop a mobile operating system further, we can consider the case of Nokia's Symbian operating system. The Symbian operating system was developed in the 1980s by Psion, and was acquired by Nokia in 2008 and its source code was eventually made freely available.¹⁶ The Symbian operating system was the top-selling smartphone operating system globally throughout the early 2000s till the late 2010; millions of Nokia smartphones with this operating system have been sold worldwide in that period.¹⁷ However, by 2013, Nokia announced that it would discontinue the use of this operating system in its devices. High investment costs associated with the operating system software development and maintenance are likely to have been at least partially responsible for this. It has been estimated that Nokia had allocated roughly 6,200 software engineers to the Symbian operating system team, resulting in over US\$1.1 billion (¥1.2 trillion) in R&D spending in 2010.¹⁸ Furthermore, it was also reported in 2013 that a Symbian phone took about 22 months to be ready to hit retail stores; much longer than other smartphones which took less than a year – the delay being attributed to the operating system.¹⁹

Introducing new features and improvements to the user experience

Another major driver of benefits to OEMs is that Android provides them with various features and product improvements. For example, Android's Voice Search and translation capabilities are attractive to consumers in a country with relatively few English speakers. According to a major regional OEM, "In terms of competition against companies that do not use Android, the functions of Android provide a source of competitiveness."²⁰

Creating branding benefits

The Android brand name was also cited by OEMs as a further benefit in reaching consumers at home and abroad. According to these local OEMs, Android provides a "common public expectation" with regards to quality and user experience.

Supporting innovation

One driver of innovation is due to the substantial cost savings OEMs are able to reallocate human capital from operating system development to other critical areas such as research and development (R&D).

Android has also been a major driver of competition in the smart device industry which puts pressure on OEMs to continuously innovate. The Android operating system is used by more than 24,000 distinct devices globally, produced by a large number of OEMs, fourteen of which have a global market share larger than 1%.^{21 22} South Korea alone is home to four OEMs who produce devices that are mainly powered by Android.²³ Further, Android has made it easier for customers to switch between OEM brands. "Transferring and synchronizing personal data such as contacts, pictures or game scores is incredibly easy with Android and Google services. Before Android, people needed to port data manually, via storage devices, across closed operating systems. This means switching smartphone brands is easier with Android."²⁴

¹⁶ Reported by Computer Hope, 2017 - <http://www.computerhope.com/jargon/s/symbian-os.htm>

¹⁷ Reported by PCWorld, June 14, 2013 - <http://www.pcworld.com/article/2042071/the-end-of-symbian-nokia-ships-last-handset-with-the-mobile-os.html>

¹⁸ Reported by AllThingsD, February 3, 2011 - <http://allthingsd.com/20110203/not-seeing-much-return-on-that-massive-rd-spend-are-you-nokia/>

¹⁹ Reported by BGR, June 12, 2013 - <http://bgr.com/2013/06/12/nokia-symbian-shipments-end/>

²⁰ Interview with regional OEM conducted by AlphaBeta.

²¹ Open Signal (2015), Android Fragmentation Visualized - <http://opensignal.com/reports/2015/08/android-fragmentation/>

²² App Brain Data - <http://www.appbrain.com/stats/top-manufacturers>

²³ The four OEMs are Samsung, LG, Pantech, and KT-Tech.

²⁴ Interview with regional OEM conducted by AlphaBeta.

App Developers

South Korea is quickly becoming a hub for start-ups. The number of Android developers tripled from 2013 to 2015, placing South Korea among the top five countries in the world in terms of the number of app developers using Android.²⁵ It is also the third largest Google Play market in the world by revenue.²⁶

South Korean app developers are benefitting from the Android operating system in two ways: (1) Increasing demand for apps; and (2) Reducing the time and cost of developing apps.

Increasing demand for apps

There were 58.5 billion app downloads across the Asia Pacific region in 2015.²⁷ Not only has Android driven the global demand for apps, but through Google Play it provides a direct export channel for local developers. South Korean app developers can offer their apps to more than 30 million Android users at home and more than 1 billion users globally across 190 countries and territories.²⁸ Developers can also reach many more consumers through third party and alternative Android app stores such as F-droid and GetJar. Developing on Android allows entrepreneurs to tap into this large global market, facilitating them to be export focussed right from the start. It has been estimated that there were roughly US\$22.9 billion (₩26 trillion) in revenue realized for app developers across all platforms in 2015.²⁹ App market revenue for South Korea in 2015 is estimated at more than US\$1.3 billion (₩1.5 trillion) dollars, 95% of which was generated by mobile gaming.³⁰ In 2013, exports of mobile games stood at US\$151 million (₩171 billion).³¹

Reducing the time and cost of developing apps

Having an open source and free-to-use operating system of good quality, the associated reduced

cost savings to OEMs are likely to lead to widespread adoption of the software, such as in the case of Android. A positive side effect of this widespread adoption by OEMs is that having the same operating system ensures a baseline level of compatibility between their and competitors' devices. This compatibility, in turn, can greatly reduce the initial development and launch costs associated with apps versus a more fragmented ecosystem with several closed proprietary operating systems. According to app development industry sources, "Fragmentation is a serious problem, even within one operating system, that can occupy half of development time and testing, making fragmented systems a lot more time intensive and complicated to develop on. This problem is most impactful during first-time development."³²

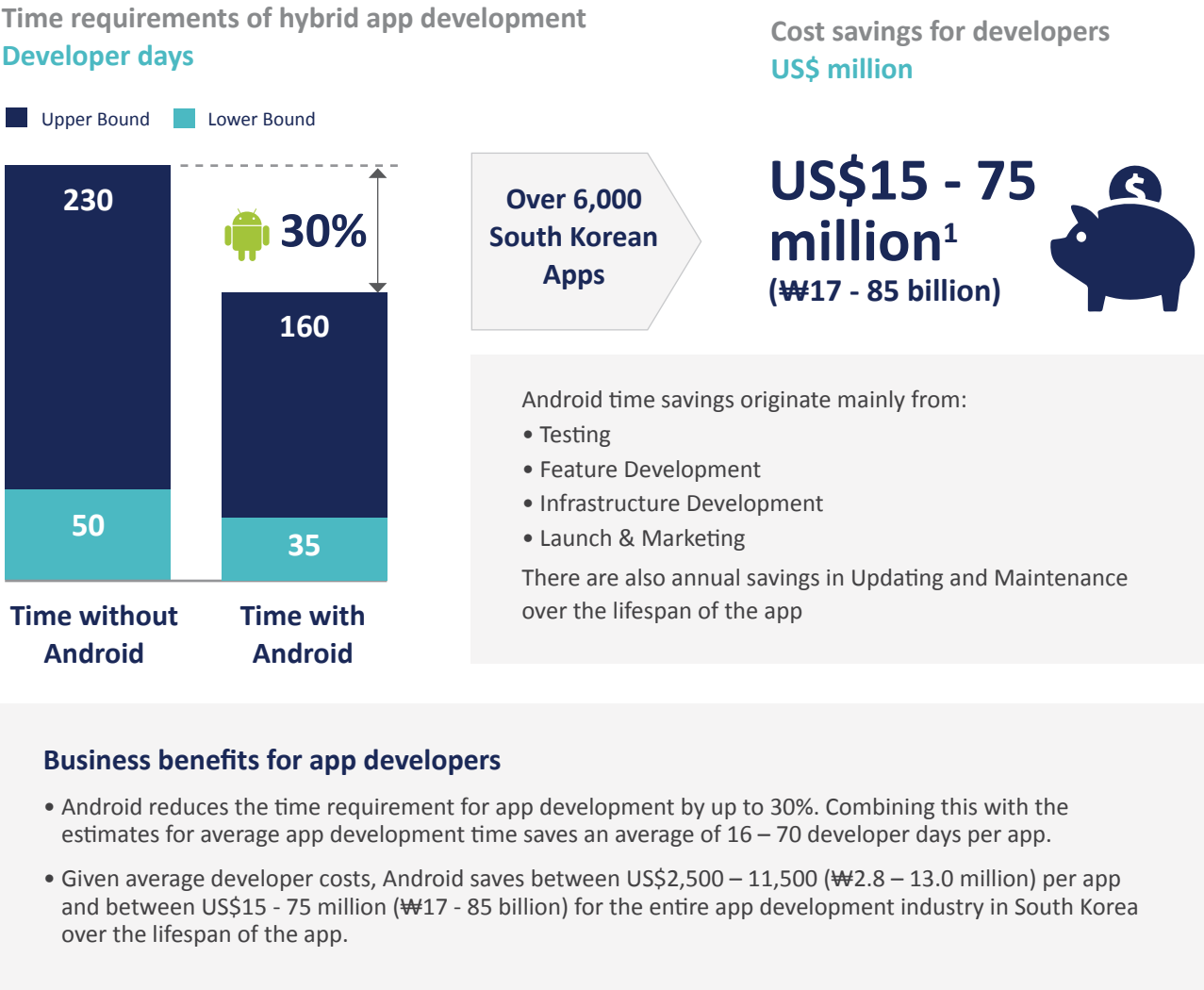
By allowing app developers to target a large audience, but without having to replicate apps for additional operating systems their costs are reduced significantly. On average, it adds 6.5% additional development time to port an app to a new operating system using the simplest and most time efficient techniques available. As a thought experiment, using the example of Android, if an app developer wanted to develop an app that would work for 14 different closed operating systems (reflecting the number of OEMs using Android with global market share larger than 1%), the initial development time plus the additional time for each operating system port would add up to 230 days. Compared to the current (high-end) estimate of roughly 160 days for native Android app development, this implies each app developer is saving a total of roughly 30% of the time per app from the spread of Android. For the more than 6,000 apps that are estimated to have been developed in South Korea to date, this implies a total saving of between US\$15 - 75 million (₩17 - 85 billion) in associated time costs (Exhibit 4).³³

The time savings are calculated using market research and interviews with app developers on the average time requirement at various stages of app development. The time saving from Android is computed as the difference between average Android app development time and the app development time of the simplest and most time efficient alternative technology available plus the

additional time required to port the alternative app to 14 additional operating systems (14 being the number of OEMs with a larger than 1% global market share). These incremental time costs are then multiplied by the average annual salary of a software developer in South Korea. See the Appendix for further details.

EXHIBIT 4

Android reduces the time-associated cost from porting apps across different operating systems (OS) by up to 30%



¹ Rounded to nearest US\$5 million.
Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources including OEM and developer interviews. See Appendix for detailed methodology.

²⁵ Boston Consulting Group (2015), *The Connected World – The Growth of the Global Mobile Internet Economy*.
²⁶ App Annie (2016), *App Annie Index: Market Q3 2016 – China Makes Revenue Records with iOS*, App Annie Insights.
²⁷ App Annie (2016), *App Annie Mobile App Forecast: The Path to US\$100 Billion*, App Annie Insights.
²⁸ Global data from Android Developers *The Google Play Opportunity* - <https://developer.android.com/distribute/googleplay/about.html>
²⁹ App Annie (2016), *App Annie Mobile App Forecast: The Path to US\$100 Billion*, App Annie Insights.
³⁰ Estimate based on SuperData Research (2016), *Asia Mobile Games Report 2016*, and App Annie (2015), *App Usage report Q1 2015*.
³¹ Korea Creative Content Agency data reported by McKinsey & Company (2015), *The virtuous circle: Putting Korea's Startup Ecosystem on a Path to Sustainable Long-run Growth*.
³² Interview with app developer, Cardinal Blue.
³³ App Brain Data - <http://www.appbrain.com/stats/top-manufacturers>

BOX 2
Google Play store



Google Play is Google’s proprietary app store native to Android. It is, in itself, an app and separate from the Android operating system. OEMs can choose to include Google Play pre-installed on their devices as part of the Google Mobile Suite (GMS).

Google Play has contributed to the rise of application development in South Korea. Apps have become the primary way digital-enabled societies engage with media, brands and ultimately with each other. Google Play allows South Korean consumers to access a diverse variety of applications and tools (both local and international apps) that improve their daily lives. In fact, Google Play offers Android users a choice of over 2 million apps to download.³⁴

There were 58.5 billion app downloads across the Asia Pacific region in 2015, and roughly US\$22.9 billion (₩26 trillion) in revenue realized for developers.³⁵ There is constant growth in South Korean developers listing their apps with Google Play. Google Play, as a marketplace, allows these local entrepreneurs to offer their apps to more than 30 million Android users at home and over 1 billion Android users globally across 190 countries.³⁶ Thus, Google Play helps to facilitate traction as it is available in multiple

countries and has in-built tools to assist app developers. According to industry sources, “Google Play enables developers to launch their apps overseas easily. Translation is often an issue for us to get our apps to the foreign markets. Google Play provides translation tools which help us to speed up the process to distribute our apps overseas.”³⁷

Apart from Google Play, there are other alternative Android app stores where Android users can access and download their apps. These include app stores such as SlideMe, Amazon Appstore, F-droid, and GetJar.³⁸ There are also numerous localized Android app stores by various South Korean stakeholders in the digital economy such as OEMs (e.g. Samsung operates its Galaxy Apps) and telcos (e.g. SK Telecom, KT, and LG Uplus launched a joint app store, One Store, in 2015).³⁹ This has resulted in strong competition for app developers and a wider range of choices of apps and app stores for South Korean consumers. These app stores can also compete with Google Play on the support they offer app developers in launching their apps. According to industry insiders, “Some app stores such as Amazon Appstore and KDDI’s AU Smart Pass in Japan lend active support and assist with testing”.⁴⁰



BOX 3
Case Studies: South Korean App Developers

There are many app developers in South Korea that benefit both from the Android ecosystem and/or the online platform that is Google Play for reaching out to the vast global market.

KakaoTalk is a prime example. A free mobile instant messaging app, launched in South Korea in 2010 by Kim Beom-Su, it gained a massive following globally by tapping into the vast consumer base that Google Play provides.⁴¹ KakaoTalk currently has more than 150 million users across the world and is available in 15 languages.⁴² Through digital platforms like Google Play, Korean developers can tap the global market and scale their businesses rapidly.

South Korea is also a major consumer and developer of mobile gaming apps in the region.^{43 44} One major Korean game development company is Com2us. It was established in 1998 and develops mobile games such as Summoners War for different operating systems. Summoners War, released in 2014, has been South Korea’s most downloaded game with over 50 million downloads. It is also available in 14 different languages and has a global community.^{45 46} Similarly, mobile gaming apps are not restricted by geography and can reach the global online population via app stores. These digital gateways create new revenue streams for developers and allow consumers to encounter diverse apps from around the world.



³⁴ Information obtained from AppBrain, March 8, 2017 - <https://www.appbrain.com/stats/number-of-android-apps>

³⁵ App Annie (2016), *App Annie Mobile App Forecast: The Path to US\$100 Billion*, App Annie Insights.

³⁶ Number of Taiwanese Android users based on data from Statista and Global StatCounter, global data from Android Developers The Google Play Opportunity - <https://developer.android.com/distribute/googleplay/about.html>

³⁷ Interviews with app developers.

³⁸ Information obtained from The App Solutions, January 24, 2017 - <http://theappsolutions.com/blog/marketing/alternative-android-app-stores/>

³⁹ Reported by The Korea Herald, June 3, 2015 - <http://www.koreaherald.com/view.php?ud=20150603000792>

⁴⁰ Interview with app developer, Cardinal Blue.

⁴¹ Reported by Forbes, March 2, 2015 - <http://www.forbes.com/sites/ryanmac/2015/03/02/kakaotalk-billionaire-brian-kim-mobile-messaging-global-competition/#11a9e2181947>

⁴² App Annie (2016), KakaoTalk App Details.

⁴³ Reported by Forbes, March 2, 2015 - <http://www.forbes.com/sites/ryanmac/2015/03/02/kakaotalk-billionaire-brian-kim-mobile-messaging-global-competition/#11a9e2181947>

⁴⁴ Reported by OneSky Blog, July 24, 2015 - <http://www.oneskyapp.com/blog/mobile-gaming-south-korea/>

⁴⁵ Reported by Soomla Blog, January 28, 2016 - <http://blog.soomla.com/2016/01/top-10-mobile-games-made-south-korea.html>

⁴⁶ Reported by Com2us.com - <https://us.com2us.com/>

Telecommunication Operators

There are three major sources of benefits for telecommunication operators linked to Android: (1) Increased demand for smartphones; (2) Growth in data traffic; and (3) The creation of new distribution and revenue channels.

Increasing demand for smartphones

Android has spurred demand for smartphones through lowering the costs of handsets and encouraging innovation globally. This increase in demand boosts revenues for telco operators on the retail side of their business.

Growing data volumes

The increased smartphone penetration, partially due to Android (see Chapter 4), has, in turn, created significant demand for mobile data. South Korean telcos are benefitting from this increase in demand. Mobile data volumes that originated from Android devices in South Korea grew by more than 60% annually from 2011-15 after Android found commercial success in 2010 (Exhibit 5).⁴⁷ This additional data traffic has driven significant data revenues for telcos.⁴⁸

These estimates were computed using average monthly data volumes per user in South Korea and multiplying them by the number of Android users in South Korea.

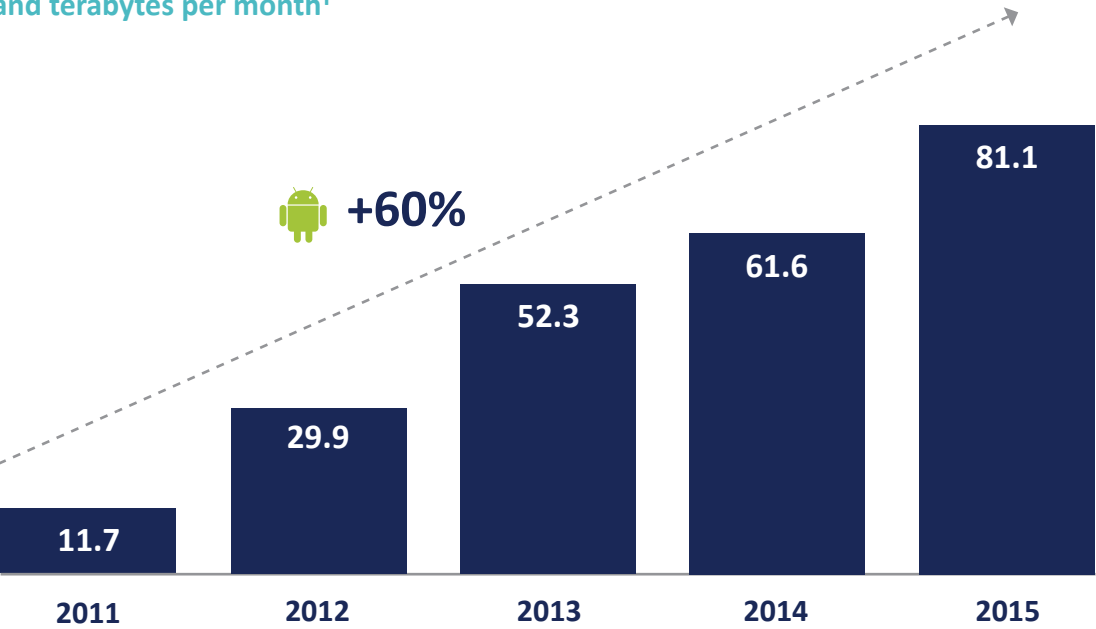
Creating new distribution and revenue channels

In addition, telcos can utilize the AOSP software to create their own distribution channel for apps; enabling them to generate new streams of revenue. For instance, SK Telecom, KT and LG Uplus (recently joined by Naver) operate their own app store, One Store. Direct carrier billing and proprietary apps are other alternative revenue streams facilitated by Android.⁴⁹

EXHIBIT 5

Data traffic contributions from Android devices for telco operators have been growing at over 60% annually since 2011

Data traffic from Android devices in South Korea
Thousand terabytes per month¹



¹ Values rounded to nearest 100 terabytes per month.
Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources including telecommunication industry data, telco operators annual reports, South Korean ICT industry reports. See Appendix for detailed methodology.

⁴⁷ Estimates based on data from the Korea Communications Commission and Tefficient - <http://media.tefficient.com/2016/06/tefficient-industry-analysis-3-2016-mobile-data-usage-and-pricing-FY-2015-final2.pdf>

⁴⁸ This is a gross benefit as increased data traffic may have led to the substitution of voice and text services.

⁴⁹ Reported by Business Korea, May 6, 2015 - <http://www.businesskorea.co.kr/english/news/ict/10425-competing-outlet-korean-mobile-carriers-open-new-application-store>



CONSUMER BENEFITS



More than 30 million South Korean consumers are running Android on their smart devices. The Android operating system allows users to access all their favorite features in one space. Through Google Play, users can install any apps they desire, from mobile games to social networks. Android further ensures

a consistent and familiar experience across different devices, allowing for a smooth transition if users switch between their phone, tablet, and TV or upgrade individual devices. The benefits consumers receive from Android aggregate to more than US\$4.0 billion (~~₩~~4.5 trillion) (Exhibit 6).

EXHIBIT 6

South Korean consumers receive more than US\$4.0 billion (~~₩~~4.5 trillion) in self-assessed benefits from Android devices

Annual valuation of
Android per consumer
US\$¹ (~~₩~~ thousands)

Number of Android users
Millions

Consumer benefits
received from Android in
South Korea
US\$ billions² (~~₩~~ trillions)

135 -138
(152 -157)

X

>30

=

>4.0
(4.5)

Average annual consumer valuation of the Android operating system

How much annual discount on your mobile bill
would you accept to forgo your operating system?

\$135
(~~₩~~152,000)

Average annual consumer valuation of the app services accessed on Android

% of respondents ranking category among top 3 services on Android



Average annual
valuation of top 3
services by consumers

=

\$138
(~~₩~~157,000)

¹ Based on survey respondents assessment of perceived benefits of product.

² Rounded down to nearest US\$100 million.

Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources.



To estimate the consumer benefits from the Android operating system, two separate “Willingness-to -Pay” approaches were employed. As part of the AlphaBeta consumer survey, respondents were first asked to value the Android experience. To do so they were offered a monetary discount on their mobile bill if they were willing to forgo Android for a month (and adopt an alternative operating system). Consumers on average placed an annual value of US\$135 (₩152,000) on Android.

In order to control for the fact that the operating system may be an abstract concept for many consumers, the survey also included questions designed as a robustness check. Respondents were asked to identify their top 3 services and software features on their smart devices from a range of 20 categories.⁵⁰ The services accessed on a smart device are a lot easier to comprehend than the

concept of an operating system user experience. The three favorite smart service categories amongst the Android user population were online search, mobile photography, and online video.

Subsequently, respondents were asked to assign a value to their individual bundle of top 3 services, regardless of categories chosen. On average, consumers placed an annual value of US\$138 (₩157,000) on their personal top 3 features. Leveraging the fact that the experience of user’s favorite apps, content, and features on smart devices is linked to the choice of operating system (see Exhibit 8 and corresponding discussion below), this valuation serves as a proxy for the software user experience provided by the operating system.

For more details on the methodology, see Box 4 and the Appendix.

⁵⁰ The sample for the consumer survey was verified to be representative of the country’s online population according to key demographic data including gender, age, income and geography. Given a smartphone user population of over 35 million in South Korea, a sample size of over 400 people was chosen so as to provide estimates which have a 95% probability of being no more than 5% away from the true value.

BOX 4 Calculating consumer benefits

In economic terms, the benefits a product or service provides to consumers is measured through consumer surplus. Consumer surplus is usually calculated by observing how customers adjust consumption levels in response to price changes. This poses several problems when trying to estimate the consumer benefits supported by Android.

For one, due to the perfect complementarity of hardware and software, Android is not consumed in isolation but as a component of a smart device. While it may be possible to size the benefit a consumer derives from the total device, it is much harder to attribute these benefits to individual components, features or even the design of a smart device. To deal with this issue, one could assign these benefits according to the costs of production associated with the individual components.

However, when the Android operating system – which is integral to the finished product – is provided free to OEMs and developers, and hence, no behavioral changes can be observed in response to changes in price, this method cannot be employed. Further, exact consumption levels of the services are difficult to observe. There are several alternative methodologies for estimating the consumer benefits of free services. This report employs a “**Willingness to Pay**” (WTP) approach to provide a robust estimate of consumer benefit.

“**Willingness to Pay**” (WTP) estimates consumer benefits by eliciting how much individuals are prepared to pay for specific products and services. The most straightforward way of obtaining this information is simply to ask consumers. However, this method has

drawbacks. For example, individuals often struggle to quantify the value a product or service holds to them. This uncertainty is increased when the product or service in question is free. Further, individuals are prone to overestimate their willingness to pay, especially in hypothetical scenarios.

Framing can amplify these uncertainties and potential biases. However, measures can be taken to improve the robustness of estimates. In AlphaBeta’s consumer survey, participants were confronted with the following scenarios: they were offered a monthly cash discount on their internet or mobile phone bill if they were willing to 1) have their operating system replaced with an alternative; and 2) forgo their top 3 favorite software features on their device. To reflect this different valuation approaches, the estimations in this report show a range as opposed to a point estimate. The framing of these questions was also designed to minimize potential biases. Specifically, rather than a willingness to pay, a willingness to accept was elicited, which research has shown to be less prone to biases induced by framing.⁵¹ To deal with potential uncertainty about the nominal size of their valuations, subjects were provided with a “discount menu” from which they could choose a valuation, as well as an outside option for them to provide their own valuation.

It should be stressed that it is impossible to isolate the specific contribution of Android to these consumer benefits. As such, we present these benefits as the total consumer benefits supported by Android, but not as solely driven by Android.

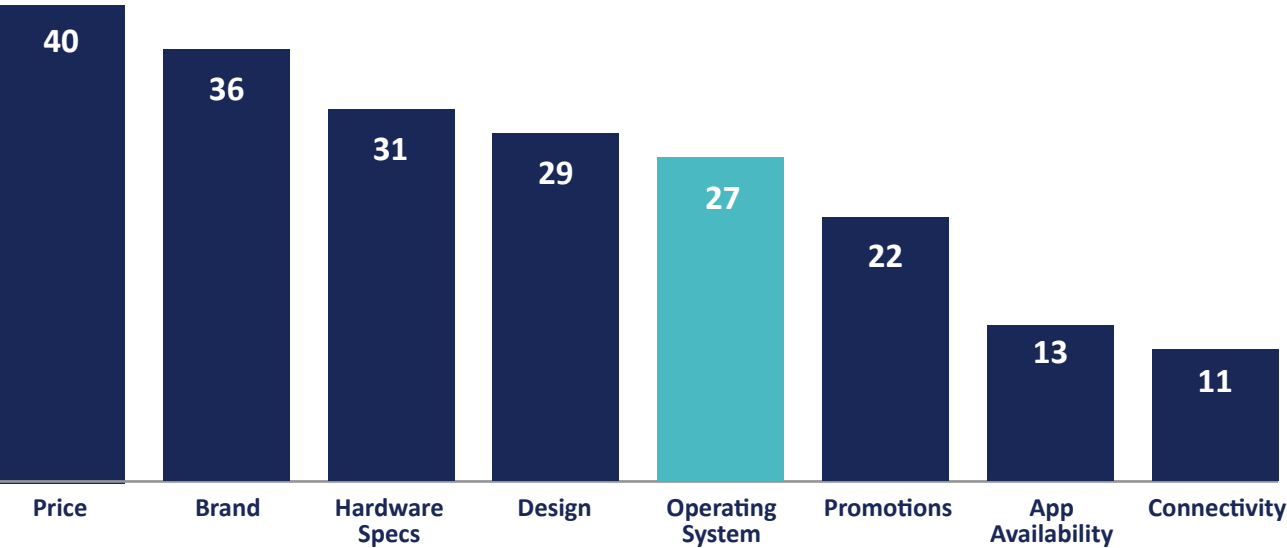
⁵¹ Yang et al. (2013), Framing Influences Willingness to Pay but Not Willingness to Accept, Journal of Marketing Research.

To obtain a better understanding of the way Android users interact with their devices, the survey delved deeper into how user engaged with their smart device operating system. The survey showed that more than 25% of South Korean Android users said that the operating system was one of their main purchase motivations (Exhibit 7). In fact, the operating system is the key software component that influenced consumers to choose their smart device. For example, South Korean Android users deem the operating system as more important than the availability of apps.

EXHIBIT 7

Over 25% of Android users see the operating system as a key driver of their smartphone purchase decisions

What are the main reasons that influenced your decision to purchase your smart device?
% share of respondents using Android who indicated factor as one of main purchase motivations



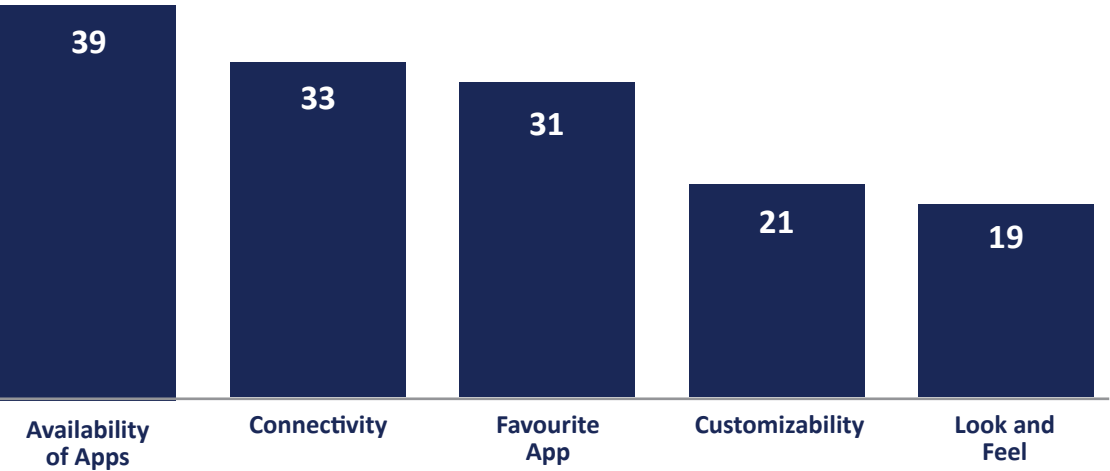
Source: AlphaBeta consumer survey

The main feature that users liked about the Android operating system was the availability of apps and content (in both the Google Play Store as well as other Android native app stores). More than 35% of respondents indicated that availability of apps was a major positive feature of Android (Exhibit 8). In addition, 33% liked the way that Android devices connected and synchronized with other devices they owned and 31% of respondents enjoyed the way their favorite apps worked on Android.

EXHIBIT 8

Users value Android mostly for the availability of apps, connectivity and the way their favorite apps works on the OS

What features do you like about your smartphone operating system?
% share of respondents using Android¹



¹Chart shows the top 5 liked operating system features only.
Source: AlphaBeta consumer survey.

The survey also looked at the apps that come pre-installed with Android devices. Google Mobile Services (GMS) is a collection of Google apps and Application Program Interfaces (API) that help support functionality across Android devices.⁵² While most of these apps are available across other Non-Android operating systems, they are deeply integrated into the Android ecosystem and hence the user experience. This allows for additional functionality of GMS apps on Android aimed at improving the device user’s experience “right out of the box”.

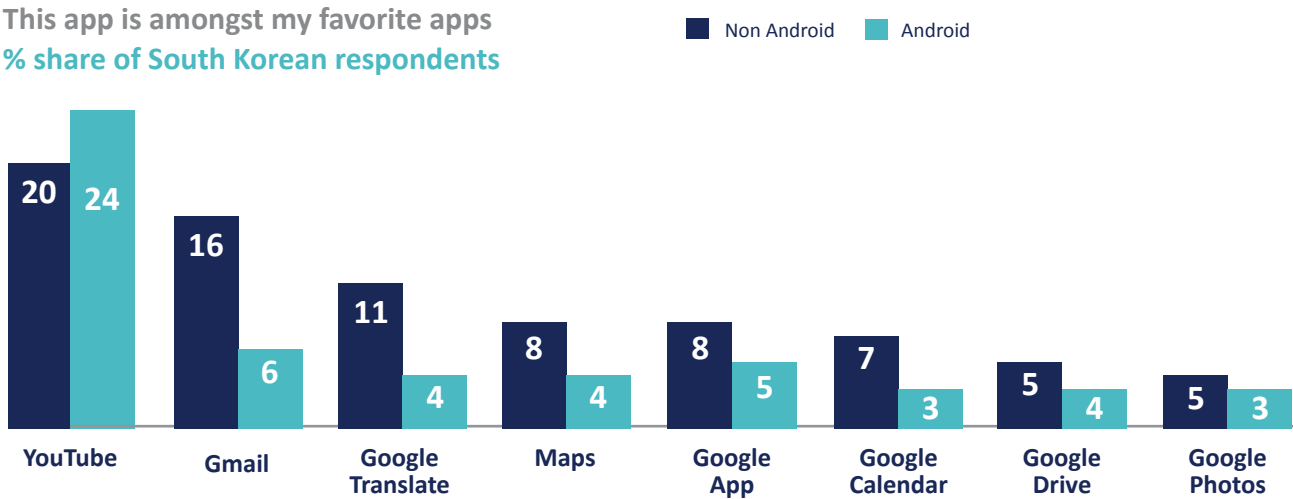
Respondents were asked to indicate how frequently they used individual apps amongst the GMS, whether they counted them among their favorite apps or whether they had deleted them from their devices. Amongst all survey respondents, regardless of what operating system they used, over 35% counted 1 or more GMS apps among their favorite apps. YouTube, in particular, is popular with South Korean smart device users. More than 20%

indicated YouTube as one of their favorite apps (Exhibit 9).

Interestingly, looking at respondents that counted 3 or more GMS apps among their favorite apps, the share of Non-Android users was more than 10%, which was larger than the share among Android users (more than 5%), despite the GMS not being pre-installed on Non-Android devices. To investigate this further, we statistically tested whether Android users were more prone to use GMS apps more frequently or more likely to count them as amongst their favorite apps. We found no statistically significant evidence that Android users use GMS services more than Non-Android users. However, there is significant evidence that Non-Android users are more likely to count GMS apps amongst their favorite apps.⁵³ This result suggests that the preference for GMS apps is not driven by the fact that they are pre-installed with the Android operating system.

EXHIBIT 9

Significant proportions of users count Google pre-installed apps among their favorite apps and these proportions are higher for Non-Android users (suggesting no bias from being pre-installed)



Source: AlphaBeta consumer survey

⁵² APIs are a set of routines, protocols, and tools for building software applications.

⁵³ In order to test this, we scored respondents indication of usage of GMS services and the number of apps amongst GMS they indicated to be their favorites. We ran t-tests on the sample means of Android users and Non-Android users for both scores. There was no significant difference for the “propensity to use” score. The sample mean for the number of favorite apps amongst GMS was larger for Non-Android users at a 5% significance level. On average Android users counted 0.8 apps out of 16 GMS apps amongst their favorites, whereas Non-Android users counted 1.2 apps amongst their favorites.

BOX 5

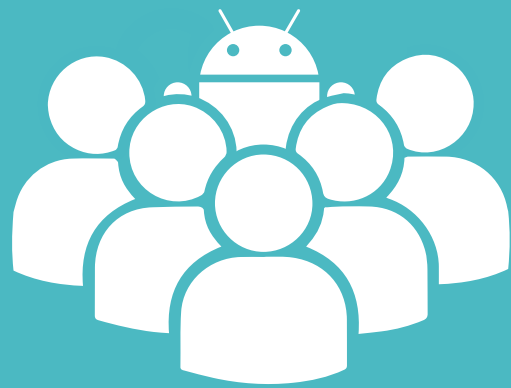
The Google Mobile Services (GMS)

Google Mobile Services (GMS) is a collection of Google apps and Application Program Interfaces (APIs). APIs are a set of routines, protocols, and tools for building software applications that help support functionality across Android devices. GMS apps include Google Search, Google Chrome, YouTube, Google Play Store, Google Drive, Google +, Gmail, Google Hangouts, Google Maps, Google Photos, Google Play Music, and Google Play Movies.⁵⁴ GMS is not obtainable or tied to the AOSP but instead available through a license from Google (there is no license fee).

Telcos, operating system operators, and OEMs can choose to bundle their own as well as third party apps with any device; for instance, if a South Korean OEM would like its customers to have the convenience of access to the GMS apps from the moment that they get their smart devices, it can pre-install these apps on the devices. By offering GMS, Android attempts to set industry standards and ensure a consistent and familiar user experience across smart devices as well as better compatibility, connectivity, and synchronization across devices.

⁵⁴ Information obtained from Android.com - <https://www.android.com/gms/>

SOCIETAL BENEFITS



Android is providing a range of benefits to South Korean society which are substantial, although difficult to quantify. This is both due to the nature of Android as one component within smart devices, as well as the inability to isolate the impact of Android from the broader impacts of innovation and technological progress over recent years. It is clear that Android has removed significant barriers to mobile device manufacturing

and software development, thereby spurring innovation - similar to the role played by Linux (which Android is built upon) for the development of servers. The reduced barriers to entry, both in the manufacturing of smartphones and app development, have created greater competition, and thus broader consumer choice. For example, there are currently more than 24,000 different Android devices in use.⁵⁵

⁵⁵ Open Signal (2015), Android Fragmentation Visualized - <http://opensignal.com/reports/2015/08/android-fragmentation/>

Android’s impact on mobile broadband penetration

South Korea is the world leader in smartphone penetration, estimated at 88% of the population.⁵⁶ Smartphones as an innovation have dramatically changed the way societies operate, do business, and communicate. Industry research has attributed the continued fast growth of mobile internet penetration to expanding coverage, increasingly sophisticated mobile-device functionality, sharply falling prices, growing consumer choice and the development of new devices.⁵⁷ The price of new services and the number of competing firms in new markets are generally regarded to be the most important determinants of the level of diffusion of innovative products. This is supported by the findings of our consumer survey, where 40% of Android users indicated that price was a driving factor for their smartphone purchase decision. Further, academic research has identified the key market drivers of mobile broadband penetration in South Korea as: price reduction; dense housing patterns; intense competition; attractive applications; and an IT-friendly culture.⁵⁸ Android has played an important role in these drivers through reducing smartphone prices, increasing competition, generating new and diverse products, as well as providing access to third party applications.

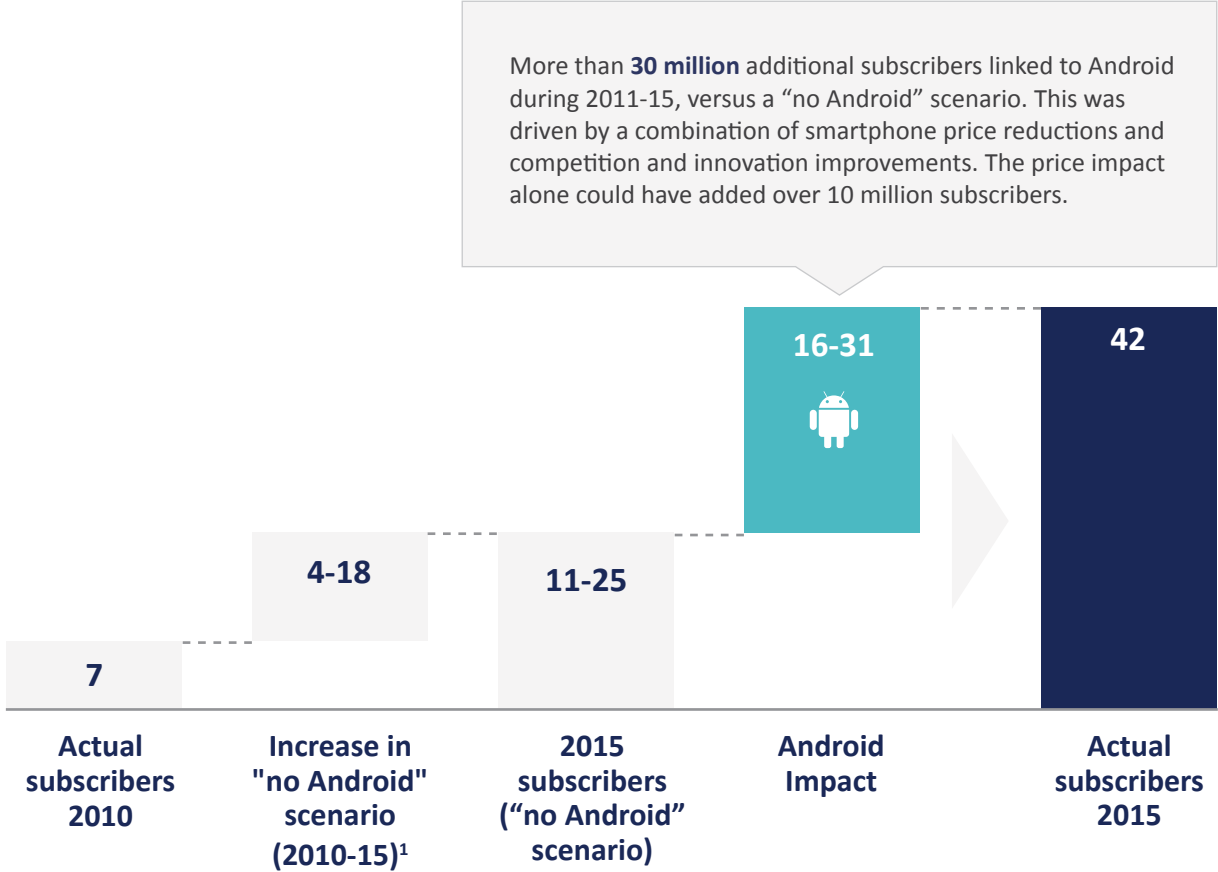
In total, we estimate that these impacts may have led to over 30 million more South Koreans adopting smartphones since 2010 than otherwise would have if the Android operating system were not available (Exhibit 10). This analysis relies on hypothetical scenarios of what would have happened to subscriber numbers in South Korea if Android did not exist, and these are by their very nature speculative. Nevertheless, they are a useful thought experiment to understand the possible impact of Android on subscriber growth. Due to the speculative nature of these scenarios, as well

as the multitude of external factors that have influenced smartphone growth over the period, we have deliberately estimated Android’s impact as a range so not to convey false precision. This range in the estimates stems from two variable factors: (1) The degree of migration between smartphone operating systems, meaning that not all additional Android users are necessarily first-time smartphone subscribers; and (2) Allowing for the counter-factual that in the absence of Android other technologies may have taken its place. In the Appendix and the sections below, we describe in further detail how these estimates were derived. In particular, there are two major drivers behind the Android-linked impact on smartphone penetration: price and competition/innovation impacts.

EXHIBIT 10

Android potentially led to over 30 million more South Korean subscribers adopting smartphones since 2010 than would have occurred otherwise

South Korean smartphone subscribers
Number in millions



¹ The range in the estimates stems from two variable factors: (1) The degree of migration between smartphone operating systems, meaning that not all additional Android users are necessarily first time smartphone subscribers; and (2) Allowing for the counter-factual that in the absence of Android other technologies may have taken its place. See the Appendix for further details on the methodology.
Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources.

⁵⁶ Pew Research Center data reported by Statista.com - <https://www.statista.com/statistics/539395/smartphone-penetration-worldwide-by-country/>
⁵⁷ Boston Consulting Group (2015), *The Connected World – The Growth of the Global Mobile Internet Economy*.
⁵⁸ Shin and Koh (2016), Analysis of Mobile Broadband Service Penetration in South Korea, Journal of Computer Information Systems, DOI: 10.1080/08874417.2016.1181491 - <http://dx.doi.org/10.1080/08874417.2016.1181491>

Price impact of Android on smartphone penetration

The average price of Android smartphones worldwide in 2015 was US\$231 (₩261,000), has decreased by a total of 28% since 2012 (equivalent to a yearly price drop of more than 10%).⁵⁹ Simultaneously, the overall average price of smartphones globally has dropped by 30% to US\$305 (₩345,000) since Android developed significant commercial traction in 2010.⁶⁰ The average Android device in 2015 was therefore 24% cheaper than the average smartphone, with many Android devices selling below US\$100 (₩113,000), some as low as US\$50 (₩57,000).⁶¹ Given the widespread adoption of Android devices, this implies that the average price of Non-Android smartphones has been increasing by more than 26% over the same time period, according to data by Gartner.⁶² While Android prices have been falling from 2012 – 2015, the average Non-Android device price increased 8% year on year to US\$633 (₩716,000) in 2015. Android is therefore primarily responsible for the average decrease in smartphone prices globally.⁶³ The price of Android devices is also forecast to decline further.⁶⁴

Measuring the precise impact of smartphone prices on mobile broadband penetration is highly complex and imprecise at best. The evidence on the relationship is also very limited. The GSMA estimates that a reduction of 1 percentage point in taxation on mobile broadband would result in up to a 1.8 percentage point increase in mobile broadband penetration.⁶⁵ Waverman et al. (2005) estimate the price elasticity of demand for mobile penetration between 1996 and 2002. Given

their results, a 10% decrease in price would have increased mobile penetration by roughly 11.6 percentage points for countries with a (for that time) average level of mobile penetration of about 8%.⁶⁶ What is interesting about their research is that the 1996 average level of mobile penetration is comparable to the level of smartphone penetration in South Korea in 2010 (14.2%) when Android found first commercial success.⁶⁷ Applying the price elasticity estimates from Waverman et al. (2005) to the almost 30% price reduction for smartphones in South Korea and globally since 2010 – driven by Android devices – implies that Android could have supported an additional up to 11 million (mainly lower income) smartphone subscribers in South Korea than otherwise would have likely occurred.⁶⁸

Innovation and competition impact of Android on smartphone penetration

Android has introduced intense competition into the smartphone market. As discussed in Chapter 2, Android has lowered the barriers to entry in both the OEM as well as the app development market through reduced costs. In 2015, there were more than 1,300 Android device brands globally, resulting in more than 24,000 distinct devices. This was more than double the number of devices in 2013.⁶⁹

Android has not only allowed OEMs and app developers to compete and innovate, but it has, in fact, enabled other operating system developers to build completely new digital products using its codes. For instance, Amazon took the Android code to develop its Fire OS for its smart devices, Cyanogen created its own Cyanogen OS from stock Android and Xiaomi with its MIUI.⁷⁰

This has effectively increased the number of operating system providers available, enhancing the competition in the smartphone industry and the options for consumers. This trend is also encouraged by the app developer community as it increases competition between platforms while conserving a baseline level of compatibility. According to industry sources, having alternative “operating systems based on Android (such as Amazon Fire) can heavily reduce development time for porting apps.”⁷¹

Given the multiple factors driving smartphone penetration, finding a precise estimate of the innovation impact of Android in South Korea is difficult. However, as rough proxies, we can identify Android’s contribution to growth in mobile internet penetration in South Korea. We then remove the maximum price component calculated earlier, to try to isolate the non-price related impact (which we link to innovation and competition). Smartphone subscriber numbers using Android devices have grown more than 49 percentage points faster per annum than for subscribers using Non-Android devices since 2010. Based on the methodology described above, we estimate that this could have resulted in an additional 5 to 20 million South Koreans (beyond the price effects estimated earlier) adopting smartphones than otherwise would have since 2010 (see the Appendix for a more detailed description of the methodology). Understanding the precise impact of this competition and product innovation on smartphone penetration in South Korea is difficult, but as mentioned earlier, industry research suggests they are significant contributing factors.

⁵⁹ IDC data reported by iCharts, February 26, 2014 - http://chartchannel.icharts.net/chartchannel/smartphone-average-selling-price-asp-os-usd-2012-2018_m3puyi9fc

⁶⁰ Consumer Technology Association data reported by Statista.com - <https://www.statista.com/statistics/510668/smartphone-average-selling-price-worldwide/>

⁶¹ Android is for everyone - <https://www.android.com/everyone/enabling-opportunity/>

⁶² Information obtained from reporting by Gartner Newsroom, February 18, 2016 - <http://www.gartner.com/newsroom/id/3215217> and Gartner Newsroom, November 17, 2016 - <http://www.gartner.com/newsroom/id/3516317>

⁶³ Some Smartphones using other operating systems have also decreased in average price, such as Windows Mobile.

⁶⁴ IDC data reported by iCharts, February 26, 2014 - http://chartchannel.icharts.net/chartchannel/smartphone-average-selling-price-asp-os-usd-2012-2018_m3puyi9fc

⁶⁵ Waverman et al. (2005), *The impact of telecoms on economic growth in developing countries*, The Vodafone policy paper series, Vol 2, Issue 03, pp. 10-24.

⁶⁶ Their estimates indicate that the price effect on mobile penetration weakens with increasing levels of countries mobile penetration.

⁶⁷ Korea Communications Commission (2015), *Annual Report 2014*.

⁶⁸ In order to estimate this, we assumed that the relation between mobile phone prices and penetration roughly holds for smartphones – a technology replacing mobile phones – and that the impact of prices on smartphone penetration linearly approaches zero as 100% penetration is reached.

⁶⁹ Open Signal (2015), *Android Fragmentation Visualized* - <http://opensignal.com/reports/2015/08/android-fragmentation/>

⁷⁰ Information obtained from reporting by CIO, July 27, 2015 - <http://www.cio.com/article/2952890/mobile/6-linux-based-mobile-operating-systems.html#slide2> and Beebom, September 29, 2016 - <http://beebom.com/android-alternative/>

⁷¹ Interview with app developer.

Android’s impact on economic growth

Smartphone and mobile broadband penetration have been linked to economic growth. According to McKinsey Global Institute (MGI), growth in internet penetration accounted for 21% of recent GDP growth in developed countries, with 75% of the benefits captured by companies in more traditional industries.⁷² In South Korea, the report estimates that the internet accounted for 4.6% of the country’s GDP in 2009 – a figure which has likely risen substantially since then – and approximately 16% of recent economic growth. This internet penetration has also been a catalyst for job creation. Among 4,800 small and medium-size enterprises surveyed, the internet created 2.6 jobs for each lost to technology-related efficiencies.

In 2013, the mobile internet generated US\$700 billion (₩791 trillion) in revenue or US\$780 (₩882,000) per person across 13 countries.⁷³ Android generated US\$370 billion (₩418 trillion) of this revenue worldwide. In South Korea, the mobile internet generated US\$28 billion (₩32 trillion) in revenue in 2013, with Android accounting for more than 70% of this revenue. As discussed above, Android has been instrumental in the fast rise of smartphone penetration globally and in South Korea.

The effects of broadband, mobile and mobile broadband penetration on economic growth have been studied rigorously in the literature. While the strength and significance of these impacts differ across different studies, there are some consistent themes:⁷⁴

- Broadband, mobile, and mobile broadband penetration increase economic growth
- The impact of mobile broadband tends to be stronger and more significant than that of fixed broadband
- There are increasing returns to broadband penetration, meaning the magnitude of the economic impact of additional broadband penetration increases with the level of broadband penetration

The positive effect of mobile phone penetration on economic development is also well documented. Evidence from Middle Eastern and North African countries show that a 10% increase in mobile penetration can generate up to 3% higher income per person.⁷⁵ There is also significant academic literature analyzing the impact of the mobile internet on productivity and economic growth. Earliest investigations of these effects, such as Thompson and Garbacz (2011), show that mobile internet penetration has significant direct effects on GDP, by allowing new and innovative markets and industries to form, as well as significant indirect effects on productivity, by reducing inefficiencies in existing economic ecosystems.⁷⁶ For example, evidence from a dataset of German companies suggests that a one percentage point increase in the share of employees with mobile internet access is associated with an approximately 0.2% higher labor productivity.⁷⁷ Evidence from South East Asia suggests every 10% increase in mobile internet penetration is correlated with a 0.3% growth in labor productivity, through spurring innovation.⁷⁸ While these effects tend to be smaller for developed countries they are still significant.⁷⁹

Based on the additional mobile internet subscriber growth numbers linked to Android (as described in the previous section of this chapter), and the academic literature on mobile internet subscriber impact on economic growth, we estimate that Android-related smartphone subscriber growth may have increased annual GDP growth in South Korea by an average of up to 0.27 percentage points

from 2010-15.⁸⁰ As a result, cumulative GDP is over US\$15 billion (₩17 trillion) higher than it otherwise would have been, and average incomes of South Koreans are up to US\$320 (₩362,000) higher per person (Exhibit 11). See the appendix for a detailed explanation of the methodology used to calculate these estimates.

EXHIBIT 11

Android may have supported over US\$15 billion (₩17 trillion) of incremental GDP growth in South Korea over the last 5 years

GDP contribution in South Korea, 2010-15
US\$ current

(x) ₩ trillions [x] ₩ thousands

Sizing Options	Approach	Incremental impact on YoY GDP growth percentage points	Cumulative Incremental GDP US\$ billion	Cumulative Incremental GDP per capita US\$
Upper Bound	Allowing for minimal migration between smartphone operating systems, meaning all Android users are first time mobile internet subscribers	0.27	16.1 (18.2)	320 [362]
Lower Bound	Most conservative estimate, assuming maximum migration from Non-Android to Android devices	0.19	11.6 (13.1)	230 [260]
Average	Using an average of the two bounds for each year over the range 2010 -15, allowing for partial migration	0.21	13.9 (15.7)	280 [317]

We compute GDP impact using evidence from the literature that 10% growth in 3G/4G penetration increases GDP per capita by 0.15% (GSMA, 2012). The range in the estimates stems from the degree of migration between smartphone operating systems. Since mobile broadband (3G/4G subscriptions) is driving economic growth we do not need to control for alternative technologies to Android as we did when estimating incremental smartphone subscribers. Please see the Appendix for more details on the methodology. Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources including OEM and developer interviews.

⁸⁰ We compute GDP impact using evidence from the literature that 10% growth in 3G/4G penetration increases GDP per capita by 0.15% (GSMA, 2012).

⁷² McKinsey Global Institute (2011), *Internet matters: The Net’s sweeping impact on growth, jobs, and prosperity*.
⁷³ Boston Consulting Group (2015), *The Connected World – The Growth of the Global Mobile Internet Economy*.
⁷⁴ The contribution to GDP growth for a 10 percentage points increase in broadband penetration varies from 0.17% - 1.5% depending on a variety of factors and study. For a review of the economic literature, see Katz (2012), *The Impact of Broadband on the Economy: Research to Date and Policy Issues*, 10th Global Symposium for Regulators.
⁷⁵ Saibal Ghosh (2016), *How important is mobile telephony for economic growth? Evidence from MENA countries*, info, Vol. 18, Issue 3, pp. 58 – 79.
⁷⁶ Thompson and Garbacz (2011), *Economic impacts of mobile versus fixed broadband*, Telecommunications Policy, Vol. 35.
⁷⁷ Bertschek and Niebel (2016), *Mobile and more productive? Firm-level evidence on the productivity effects of mobile internet use*, Telecommunications Policy, Vol. 40, Issue 9, pp. 888 – 898.
⁷⁸ Oxford Economics (2016), *One Million Opportunities: The Impact of Mobile Internet on the Economy of Southeast Asia*.
⁷⁹ Ward and Zheng (2016), *Mobile telecommunications service and economic growth: Evidence from China*, Telecommunications Policy, Vol. 40.



SOCIETAL BENEFITS

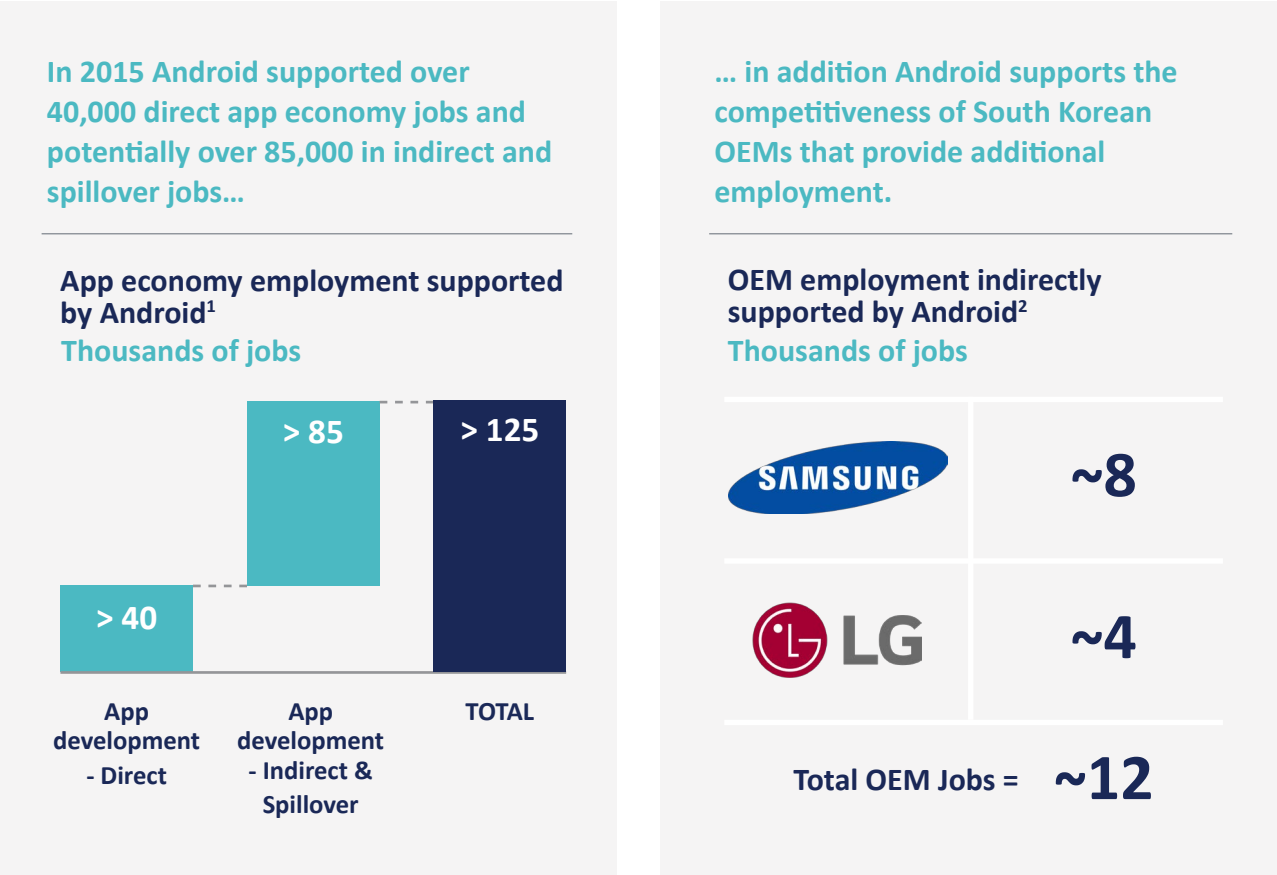
Android’s impact on South Korean employment

Android has had significant impacts on the South Korean labor market. South Korea is quickly becoming a hub for start-ups. The number of Android developers tripled from 2013 to 2015.⁸¹ Android has created entirely new fields of employment with over 40,000 Android developers estimated to be currently working in South Korea’s app economy. This number is a conservative estimate limited to the direct impact of employment. In addition to this direct employment, Android generates employment through indirect jobs (non-tech-related jobs within the app economy), as well as spillover jobs (jobs created outside of the app industry, such

as firms supplying app developers with products and services). Including these jobs could add over an additional 85,000 workers. Further, many South Koreans are employed in the production of Android-powered smartphones in the OEM market. While these jobs cannot be attributed directly to Android, the cost savings Android provides to OEMs (see Chapter 2) do no doubt support employment in the manufacturing industry. Samsung and LG alone employ an estimated 12,000 individuals in their domestic mobile divisions. Even including these numbers is still a significant underestimate of the total employment in South Korea related to Android. For example, we do not account for additional employment facilitated by internet & telecommunication services supported by the growth of Android devices.

EXHIBIT 12

There are significant numbers of jobs supported by Android across both the app economy as well as device manufacturing in South Korea



¹ International studies place the size of South Korean app economy employment in 2015 at 175,000 jobs. Android jobs account for 75% of them. Indirect and spillover jobs are estimated at 2:1 for every “core” app economy job.
² In order to obtain conservative estimates supported OEM jobs were limited to the domestic mobile divisions of the top 2 OEMs.
Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources.

⁸¹ Boston Consulting Group (2015), *The Connected World – The Growth of the Global Mobile Internet Economy*.

APPENDIX A – Detailed Methodology

This report describes the economic impact of Android in South Korea in 2015 as comprised of three components: business benefits, consumer benefits, and societal benefits. These are gross benefits, some of which can be quantified and others of which can be described in qualitative terms. While each of these benefits is additional, the concepts are distinct. The amounts were initially qualified in US dollars and then converted to local currency based on the average exchange rate in 2015.⁸²

To estimate the business benefits, we calculated how businesses saved costs and sourced revenues through Android. The industries considered in this report Android app developers and telecommunications operators (telcos).

Estimating the consumer benefits supported by Android is a tricky task. This is because Android as an operating system is but one – as integral as it may be – part of the user experience on a smart device. This study uses willingness-to-pay methods to circumvent some of the complexities. The research includes a first-of-its-kind consumer survey amongst the South Korean online population.

Finally, Android supports benefits for the broader society through job creation and stimulating faster innovation and economic growth. We used a combination of quantitative and qualitative analysis to create a snapshot of these broader benefits.

Business Benefits: Methodology and Data

The business benefits supported by Android are calculated as a combination of cost savings to app developers as well as revenues for telcos. Our methodology does not account for activity that may have been displaced by Android or attempt to estimate the incremental impact of Android on app developers and telcos beyond what would be the case if Android did not exist but other equally successful operating systems did. Such hypothetical scenarios required to calculate truly incremental benefits of Google are highly speculative and beyond the scope of this study.

Original Equipment Manufacturers (OEMs)

To estimate the time's savings from Android for OEMs we calculate the development hours required to build and maintain a proprietary software operating system. Therefore, what development time would be required to program an operating system. This time saving has a one-off component of building the operating system, as well as an annual component for maintaining and continuously updating the software.

In order to estimate this, we employed the Basic Constructive Cost Model (COCOMO) which computes the required software development effort as a function of the software programs size.^{83 84} For the one-off component of development effort, we used the Single Lines of Code (SLOC) in the latest version of the Android Open Source Project (AOSP).⁸⁵ We estimated the reoccurring annual effort component separately using the average annual incremental change in SLOC between modern Linux Kernel distributions (which Android is built upon) from version 3.0.1 to 4.5.4.⁸⁶

Table 1: Inputs and sources for calculating business benefits to OEMs

Estimation	Metric	Source
One-off and annual cost of building and maintaining a proprietary OS	Single lines of code (SLOC) required to build Android Open Source Project (AOSP)	• OpenHub
	Average incremental annual lines of code from Linux Kernel 3.0.1 to 4.5.4	• LinuxCounter.net
Basic COCOMO (Organic Project)	Model parameters (SLOC to developer time effort)	• University of Michigan-Dearborn
	Wrap Rate (Developer/labor costs to overhead costs)	• University of Michigan-Dearborn

Android App Developers

We estimated the benefit to app developers as the time cost savings from not having to port apps across operating systems and instead being able to develop one standalone Android app. In order to obtain the estimates for the parameters used in the calculation we consulted a variety of third party reports and developer surveys, as well as carried out a series of interviews with app developers.

We first estimated the development time requirement for an Android app and a Non-Android app. According to industry consensus, apps can be developed easiest and least time intensive on iOS. In order to keep our estimates conservative, we used the development time requirement for iOS as a proxy for development on all Non-Android operating systems. Further, there is also industry consensus that Android apps take significantly longer to program than iOS apps.⁸⁷ We reflect this in our calculations.

In order to compute the incremental time requirement from having to port an existing app

to a new operating system, we used the easiest and least labor intensive development technology to build apps across several operating systems, which is hybrid app development.⁸⁸ Hybrid app development (for example using HTML5 or CSS) is the most efficient way of making apps work on several operating systems and based on industry studies the incremental time cost per operating system is less than 15% of that required for native app development.

To generate an appropriate counter-factual to Android app development, we considered the number of consumers an app developer can reach through Android. We looked at the number of OEMs using Android with a greater than 1% global market share.⁸⁹ We assume that in the absence of free-to-use open source operating systems such as Android, each of these OEMs would run its own operating system. Hence, an app would need to be ported to each of them to reach the same audience, in our case, Android provides.

In summary, in order to estimate the time cost saving for free-to-use open source operating

⁸² Where expressed in quantities greater-equal to millions US\$ figures are rounded to the nearest US\$5 million.
⁸³ We use the specification outlined by the College of Engineering and Computer Science at the University of Michigan-Dearborn - http://groups.engin.umd.umich.edu/CIS/course_des/cis525/js/f00/gamel/help.html
⁸⁴ This approach has previously been used to estimate the cost of the Linux Fedora 9 distribution. McPherson et al. (2008), *Estimating the Total Cost of a Linux Distribution*, The Linux Foundation. <https://www.linux.com/publications/estimating-total-cost-linux-distribution>. In line with the literature and to obtain conservative estimates we use the "Organic Project" specification of the model.
⁸⁵ SLOC data obtained from OpenHub - <https://www.openhub.net/p/android>
⁸⁶ SLOC data obtained from LinuxCounter.net - <https://www.linuxcounter.net/statistics/kernel>

⁸⁷ Infinum.co - <https://infinum.co/the-capsized-eight/articles/android-development-is-30-percent-more-expensive-than-ios>
⁸⁸ Comentum.com - <http://www.comentum.com/mobile-app-development-cost.html>
⁸⁹ According to data from AppBrain.com, there are fourteen OEMs worldwide that satisfy this condition.

systems such as Android, we compare the developer time required to build a native Android app, to the time requirement of building an iOS app and porting it to thirteen (fourteen minus the initial operating system) additional operating systems, each time incurring the additional cost associated with hybrid development. We use an upper and lower bound on the median app development time based on third party surveys and reports. We report our result as a range as to not to give false precision.

Development time savings are multiplied with the national average monthly salary of a software

developer to obtain the average per app saving.⁹⁰ Per app savings are further multiplied by the average number of apps per publisher listed on dominant app stores, as well as an estimate of the total number of app publishers in the country to obtain the total savings in South Korea.

The estimate of app publishers in the country is based on the number of startups in 2015 and the proportion of these active in the ICT sector. We combine this with the share of the ICT startups active in the “Mobile/Internet Services” and “Game” industries.⁹¹

Table 2: Inputs and sources for calculating business benefits to app developers

Estimation	Metric	Source
Development time requirement per app	Median app development time	• Clutch.co • Crispycodes.com
	% additional app development time requirement for Android over iOS	• Infinum.co
	% additional app development time requirement per extra operating system, hybrid development	• Comentum.com • Thorn Technologies
	Number of Android OEMs with >1% global market share	• AppBrain.com
Total benefit to app developers	Monthly salary of software developer	• Robert Walters (2015)
	Apps per app publisher	• BusinessofApps.com • Android.com
	Number of app publishers	• McKinsey & Company (2015)

Telecommunications Operators (telcos)

To estimate the average total data traffic from Android devices we use data on the average per month data volumes per mobile phone subscriber. We then multiply this by the number of smartphone subscribers using Android devices.

Table 3: Inputs and sources for calculating business benefits to telcos

Estimation	Metric	Source
Telco revenue originating on Android devices	Average monthly data traffic per user	• Korea Communications Commission • Tefficient
	Number of smartphone subscribers	• Korea Communications Commission
	Android’s % share of OS in South Korea	• StatCounter Global Stats

⁹⁰ Salary data obtained from Robert Walters (2015), Salary Survey 2015.
⁹¹ Data reported by McKinsey & Company (2015), *The virtuous circle: Putting Korea’s Startup Ecosystem on a Path to Sustainable Long- run Growth*, and sources within.

Consumer Benefits: Methodology and Data

Data

An online consumer survey was conducted amongst 415 South Korean respondents with distributions of key demographic data including gender, age, income, and geography representative of the country’s online population. The survey was conducted in South Korean and consisted of 30 questions. A drop-off rate of 2% was recorded, meaning 8 respondents only partially completed the survey.

The sample size of 400+ was chosen to obtain point estimates that fall within a 95% confidence interval with a 5% margin of error, accounting for the size of South Korea’s online population. In accordance with the consensus in the economic literature, 5% constitutes a robust and acceptable margin of error.

Methodology

Consumer surplus is usually calculated by observing how customers respond to price changes. For example, if customers reduce their consumption rapidly in response to price increases, that may be

an indication that they do not value the product much higher than its current price and are not deriving much benefit from it. The consumer benefits supported by Android are challenging to measure and calculate because individuals don’t pay for Android in isolation but in conjunction with their devices, app purchases and data subscriptions. Further, Android is provided for free, making a cost-based analysis difficult. In the absence of price indicators, we employ a willingness to pay approach. This method estimates benefits by asking individuals how much they value specific products.

In AlphaBeta’s consumer survey, participants were confronted with the following scenarios: they were offered a monthly cash discount on their internet or mobile phone bill if they were willing to 1) have their operating system replaced with an alternative; and 2) forgo their top three favorite software features on their device. To reflect this different valuation approaches, the estimations in this report show a range as opposed to a point estimate.

These estimates of willingness to pay were then multiplied by the number of smartphone users in 2015 and the proportion of Android users identified in the survey.

Societal Benefits: Methodology and Data

Smartphone Penetration

This is based on isolating the contribution to growth in smartphone subscribers from Android since 2010 in South Korea. We first identify the number of Android and Non-Android smartphone subscribers and their change over time. To account for the fact that some new Android subscribers may derive from users switching between different smartphone operating systems, and therefore are not contributing to additional smartphone penetration, we estimate an upper bound and lower bound of incremental Android users per year. The upper bound is the absolute increase in Android subscribers minus any decrease in Non-Android subscribers. The lower bound assumes all existing Non-Android users switch to Android in a given year and are replaced by new smartphone users (that is, the absolute increase in Android subscribers minus the prior year’s number of Non-Android subscribers). We use both bounds to obtain a range of estimates of Android’s contribution to new smartphone subscribers. To be additionally conservative, we have allowed for the fact that non-smartphone devices (with 3G/4G access) may have grown quicker in the absence of Android. We further reduce the lower bound of the incremental number of subscribers linked to Android to account for this effect. In order to do so we assume that mobile internet penetration (3G/4G subscriptions) would have grown at the same rate if Android had not existed; however, the ratio of smartphones to non-smartphone mobile internet technologies (for example, feature phones) would have remained constant at the 2010 levels.⁹²

Smartphone Penetration: Price impact

Using data from 1996-2002 for 30+ countries, Waverman et al. (2005) estimate an inverse demand function for mobile penetration. Their estimates indicate that a 10% increase in mobile prices reduces mobile penetration by roughly 11.6 percentage points for countries with a level of mobile penetration of about 8%.

We apply their result as an estimate of the impact of smartphone prices on smartphone penetration. Further, we assume that the impact of 10% increases in mobile prices on smartphone penetration approaches 0 percentage points as smartphone penetration approaches 100%. Using data on global smartphone prices for Android and Non-Android and the domestic penetration of operating systems we compute a smartphone price index in South Korea. We then estimate the impact of price drops on smartphone penetration. Our findings suggest that price drops have stimulated an incremental ~4.4 percentage points of smartphone penetration in South Korea each year from 2010-15.

We can also deduct the price impact component from the overall impact described above, and use the remainder to proxy for “competition and innovation” related impacts of Android.

Table 4: Inputs and sources for calculating consumer benefits of Android

Estimation	Metric	Source
Consumer surplus	WTP for Operating system/ Willingness to pay for top 3 services	• AlphaBeta Consumer Survey
	Number of smartphone users	• Statista
	% share of Android users	• AlphaBeta Consumer Survey

⁹² In South Korea, in 2010 only 24% of 3G subscriptions were smartphone subscriptions as opposed to more than 80% of 3G and 4G subscriptions in 2015.

Table 5: Inputs and sources for calculating Android’s impact on economic growth

Estimation	Metric	Source
Price Impact	Global average (Android) smartphone prices	• iCharts (IDC)
Impact of Android on smartphone subscriber growth and GDP	3G/4G LTE subscribers	• Korea Communications Commission
	Mobile phone subscribers	• Korea Communications Commission
	Smartphone subscribers	• Korea Communications Commission
	Android’s % share of OS in South Korea	• StatCounter Global Stats
	GDP, Inflation, and Population Data	• World Development Indicators

Economic Impact from smartphone subscriber growth

To deliver a sense of the potential impact of Android on economic growth we combined the data above on Android impacts on smartphone subscriber growth, with estimates from the academic literature on the impact of smartphone penetration on GDP growth.

For our estimate, we take the incremental subscriber growth (excluding price impacts) linked to subscriber growth of Android versus Non-Android devices and then apply estimates from the academic literature on the 3G/4G impact on

economic growth. According to the literature, a 10% growth in 3G/4G penetration increases GDP per capita by 0.15%.⁹³ We exploit the fact that smartphones require 3G/4G connections to have full functionality, meaning we can convert additional smartphone subscriptions “one-for-one” into 3G/4G subscriptions. We provide a range of estimates based on our lower and upper bounds of additional smartphone penetration (see above). Since it is mobile broadband (3G/4G) subscriptions driving economic growth we do not need to control for the counter-factual of alternative technologies to Android as we did when estimating incremental smartphone subscribers.

⁹³ GSMA (2012), *What is the impact of mobile telephony on economic growth?*

Table 6: Sample of literature review on the economic impact of broadband/mobile and mobile broadband penetration

Impact	Study	Observed effects
Economic impact of broadband	Koutroumpis (2009)	• 10 percentage point increase in broadband penetration raises GDP growth by 0.26 percentage points for developed countries and 0.85 percentage points for developing countries
	Scott (2012)	• 10 percentage point increase in broadband penetration raises GDP per capita growth by 1.19 percentage points for developed countries and 1.35 percentage points for developing countries
	Feng and Ma (2013)	• 10 percentage point increase in broadband penetration raises GDP growth by 2.14 percentage points for subnational China
Economic impact of mobile telephony	Waverman et al. (2005)	• 10 percentage point increase in mobile penetration raises GDP per capita growth by 0.3 percentage points for high income countries and 0.59 percentage points for low income countries • 10% increases in mobile prices reduces mobile penetration by 11.6 percentage points
	Qiang et al. (2009)	• 10 percentage point increase in mobile penetration raises GDP per capita growth by 0.6 percentage points for developed countries and 0.8 percentage points for developing countries
	GSMA/Deloitte/Cisco (2012)	• 10% increase in mobile penetration increases GDP per capita growth by 0.65 percentage points
Economic impact of mobile broadband	GSMA/Deloitte/Cisco (2012)	• 10% increase in 3G penetration increases GDP per capita growth by 0.15 percentage points
	Katz et al./GSMA (2012)	• 1 percentage point reduction in mobile broadband tax rates increases mobile broadband penetration by 1.8 percentage points
	Katz and Koutroumpis (2012)	• 10 percentage point increase in mobile broadband penetration increases GDP growth by 0.32 percentage points
	Bertschek & Niebel (2016)	• 10 percentage point increase in mobile broadband penetration (amongst employees) increases sales per worker growth by 8.91 percentage points
	Oxford Economics (2016)	• 10 percentage point increase in mobile broadband penetration increases output per worker growth by 0.3 percentage points

Employment Impact

Our estimate of employment supported by Android is based on the methodology developed by Mandel (2012). Their approach employs data on job postings from indeed.com to size employment in the app economy (see reference for details).⁹⁴ The methodology distinguishes between direct, indirect and spillover jobs within the app economy, each accounting for 1/3 of total jobs in the app economy.

- **Direct jobs:** These are “tech-related” jobs dedicated to building and maintaining apps, (e.g. app developers)
- **Indirect jobs:** These are “non-tech-related” jobs such as HR, marketing, and sales within app companies
- **Spillover jobs:** These are jobs created outside of the app industry due to spillover effects such as app companies’ suppliers

Using Mandel (2012)’s methodology, previous research estimates the size of South Korean app economy employment in 2015 at 171,000 jobs.⁹⁵ We apply an estimate of the proportion of jobs supported by Android based on the US and Europe to this number to identify the app economy employment supported by Android in South Korea.⁹⁶

We further estimate OEM employment related to Android devices. We calculate the average share of employees in OEMs’ global mobile divisions as part of total employees for Samsung Electronics and LG Electronics and apply it to total employees for the two companies in South Korea.

Table 7: Inputs and sources for calculating Android’s impact on employment

Estimation	Metric	Source
App employment supported by Android	Number of jobs in the app economy	• McKinsey & Company (2015)
	Ratio of direct to indirect and spillover jobs	• Mandel (2012)
	Android Share or app economy jobs	• Mandel (2016)
OEM employment supported by Android	LG: global mobile division employment/global employment/ South Korean employment	• Korean Times • LG Electronics
	Samsung: global mobile division employment/global employment/ South Korean employment	• SamMobile.com • Samsung Electronics
	Pantech employment	• Korea Joong Ang Daily

⁹⁴ Mandel (2012), *Where the Jobs Are: The App Economy*, Progressive Policy Institute.
⁹⁵ Data reported by McKinsey & Company (2015), *The virtuous circle: Putting Korea’s Startup Ecosystem on a Path to Sustainable Long- run Growth*, and sources within.
⁹⁶ Mandel (2016), *App Economy Jobs In Europe (Part1)*, Progressive Policy Institute.



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