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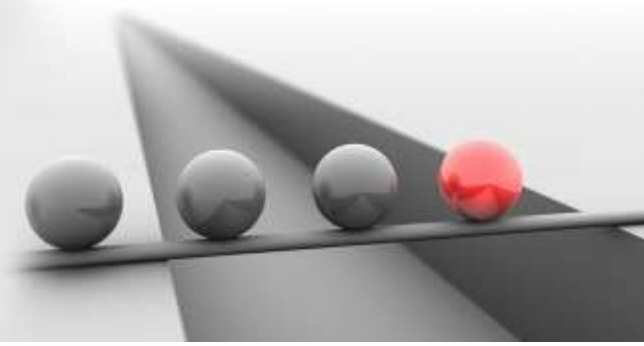

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Growing Memory Storage Capacity Adoption Trends in Smartphones

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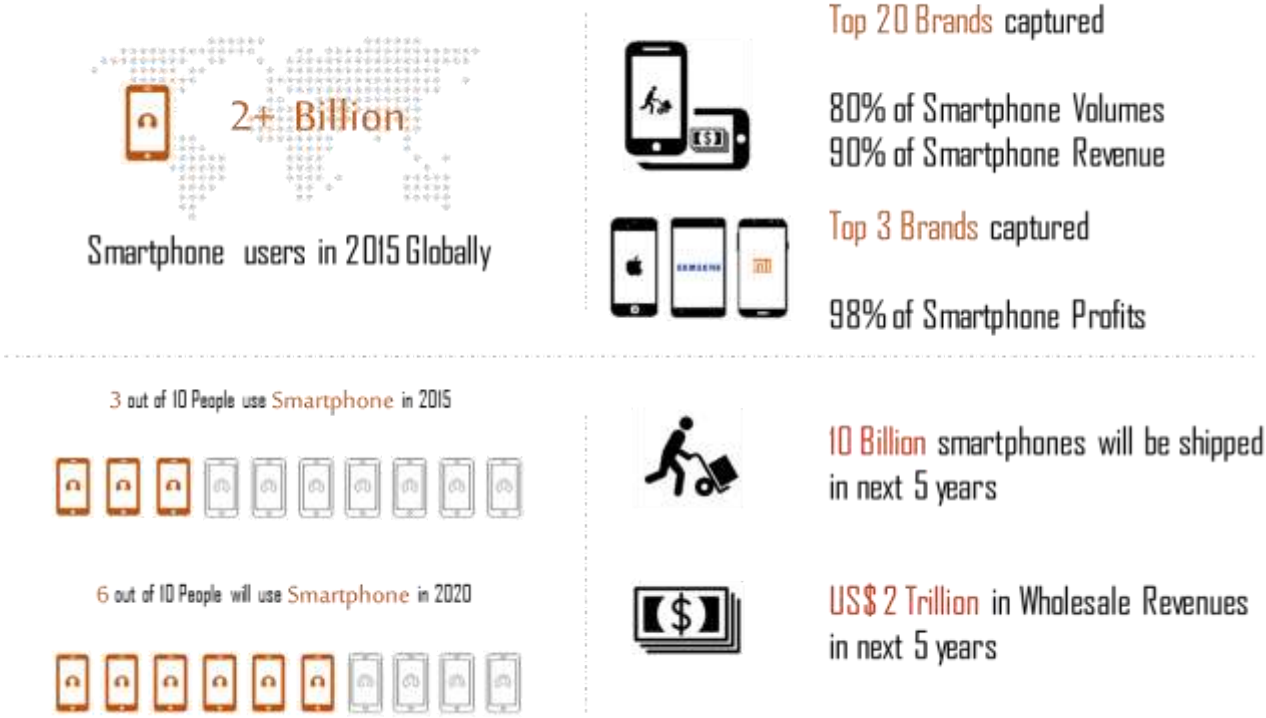
The Big Picture: Smartphones a multi-billion opportunity

At present, there are more than 2 billion people globally using their smartphones every moment of every day to enhance their digital lives by connecting and communicating, and by creating as well as consuming content. The number of people using smartphones is estimated to almost double – accounting for almost half of the global population within the next five years. The growth in smartphone adoption will be coupled with further advancement in device designs, specifications, software and services – augmenting existing and introducing new use-cases that will make our lives more and more smartphone-centric.

Counterpoint Research estimates that more than 1.5 billion smartphones will be shipped in 2015, generating more than US$ 380 billion in wholesale smartphone hardware revenues. As the smartphone adoption continues to grow, Counterpoint Research further estimates that more than 10 billion smartphones will be sold over the next five years, generating more than US$ 2 trillion in cumulative wholesale hardware revenues; a huge



opportunity for the entire smartphone supply value chain.

The major drivers for this tremendous growth and adoption of smartphones can be attributed to following factors:

- Proliferation of faster and higher capacity mobile networks.
- Mobile is becoming the de facto standard medium for almost every digital interaction – from communication, to content creation and consumption, to commerce. Applications have fundamentally changed the way people interact with internet-based content and the advent of advanced cloud architectures mean that interactions can traverse device type, but the smartphone plays an increasingly central role.
- The digital workplace is also being enhanced by the adoption of smartphones as a primary communication medium. The change is occurring more slowly than with consumers but is no less profound.
- Smartphones are key to bridging the so-called digital divide. They grant access to unprecedented levels of information into the hands of consumers, especially in emerging markets.
- Smartphones are successfully connecting users to opportunities to gain knowledge, secure employment, build commerce, and obtain health resources and much more. The result is to drive positive personal, social and economic well-being.

Smartphone revolution continues

Smartphones are a revolutionary force. We are only part way through this revolution and it will continue to grow. While the adoption is increasing among new smartphone users, existing smartphone users are contributing to the growth by changing the way they interact with their devices. The falling smartphone costs and thus the price points are lowering barriers to smartphone adoption. Every time a consumer buys smartphone, the consumer enjoy an upgraded and more capable device experience. The enhanced capabilities encourage consumers to do more with their device further entrenching and normalizing usage, and actually encouraging users to think more about spending a little more to further enhance their smartphone's capabilities. This indicates a relatively healthy development in average BOM costs with the rising demand for advanced hardware configurations.

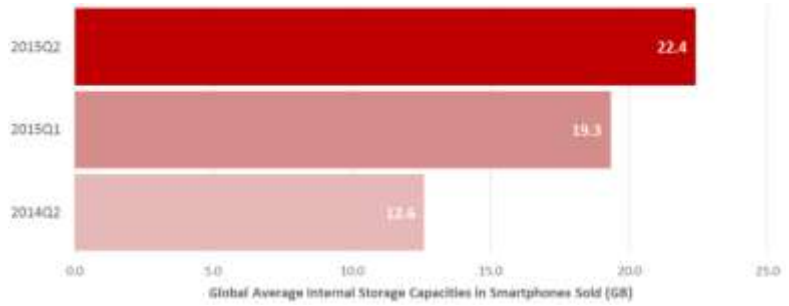
At a point in market development when consolidation might be expected to be a significant feature of the competitive landscape, there is instead a proliferation in the number of brands active in the market. Counterpoint Research regularly sees more than 400 brands actively competing for the 1.5 billion smartphones market. Of these, the top 20 brands account for more than 80% of the smartphone volume and 90% of the smartphone revenue. Furthermore, only a handful of those brands are generating positive profit margins with the top three brands capturing around 98% of the industry profits. This puts immense pressure on all other brands to manage their business carefully or innovate in how they do business. The alternative will be a forced exit.

Internal flash storage has become an essential component of the smartphone. Not only from a BOM cost perspective but also from the consumer's usage and needs perspective. The need for internal storage has continued to rise with advances in the stored software OS, rising application installs, greater content creation and consumption, the advent of mobile-first productivity suites as well as the increasing amount of corresponding user data.

Smartphone Flash Storage Capacity Trends

The average NAND Flash storage capacity in smartphones sold globally has been increasing every quarter globally. The global average NAND Flash storage capacity within the smartphones has increased by 78% in just one year to 22.4GB in Q2 2015 from an average of 12.6GB exactly a year ago.

***Exhibit 2.1**: Average Smartphone Flash Storage Capacity (in GB) of Total Global Smartphone Sales*



This increase in capacity is a combination of consumer demand for more storage, continued falling NAND Flash prices, OEM pricing strategies as well as their product portfolio SKU mix.

The proliferation of higher capacity of flash storage in smartphones is happening across different price points globally at an unprecedented rate. US$400 and above wholesale price segment, particularly, is a **leading indicator** of this trend:

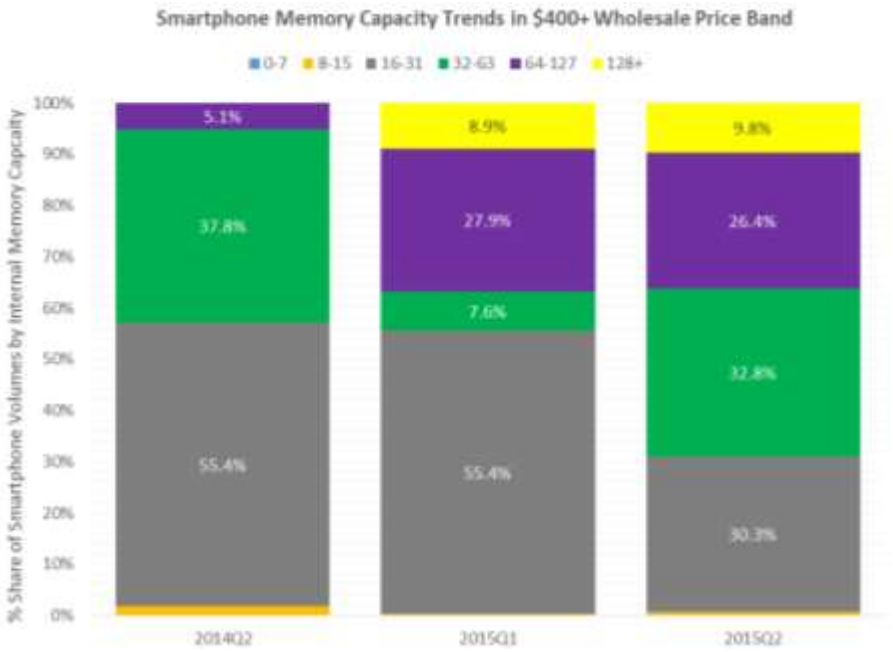
1. The $400+ wholesale price segment becomes critical as more of the mature smartphone users are upgrading to better configuration flagship devices and seeking higher memory capacity.

2. 64GB and above flash storage capacity capable smartphones contributed to more than a third of the total smartphones sold in Q2 2015 up from just 5% in the comparable quarter in 2014 $400+ price band.

3. 128GB smartphones contributed to almost 10% of the total smartphone volumes in US$400+ wholesale price-band in Q2 2015. These volumes were mostly driven by Apple iPhone 6 & Samsung Galaxy S6 series though other brands such as ZTE, Asus, and Meizu have started including the 128GB SKUs in their portfolios and next year could become similar to this year's 64GB.

4. 32GB configurations have made a strong comeback due to Samsung Galaxy S6 squeezing out 16GB which is now a mere 30% of the segment attracting mature users. While 16GB configurations have appealed the to first time users or less advanced users in premium segment, but we predict that 32GB will become the new 16GB for higher price bands as a default starting capacity to support the demanding hardware, software configurations and the consumer.

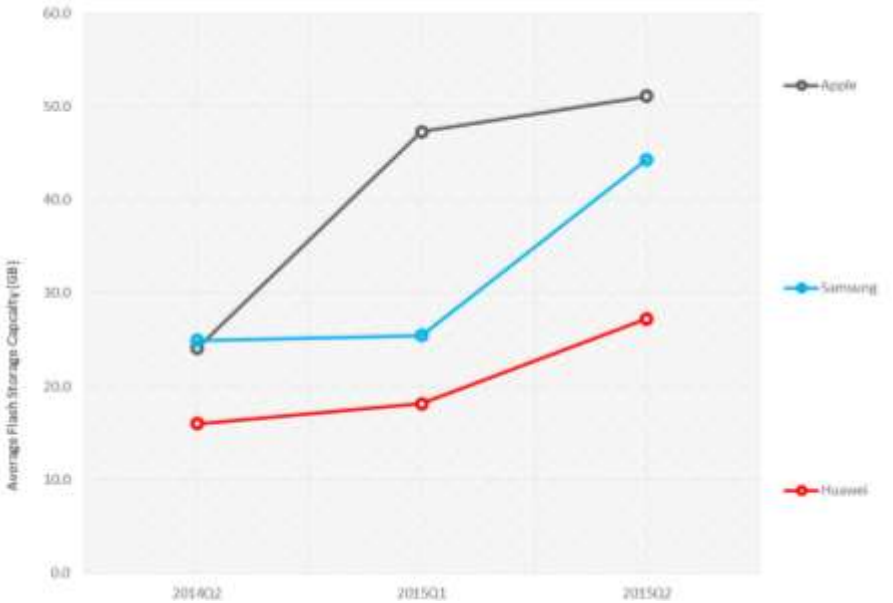
***Exhibit 2.2**: Global Smartphone Sales by Flash Storage Capacities By Wholesale Price Band*



Underlying Drivers for Rise in Smartphone Internal Storage Capacities

Brands Adopting to Consumer Demand: If we analyze the performance of the top smartphone brands over time globally we can understand which underlying brands are driving the above highlighted trends from supply side.

***Exhibit 3.1**: Global Smartphone Average Flash Storage Capacities for OEMs in $400+ Price Band*



The brands with minimal models such as Apple, Xiaomi and Motorola have been successful to at driving higher average storage capacity due to clever SKU vs pricing strategies for their flagships, which also directly translates to their volume and value growth over the last year. If we analyze the capacity trends between Apple's iPhone and Samsung Galaxy S6 series flagship sales, points towards that the consumers are buying higher memory capacity models:

- More than **55% of the total iPhone 6 sold in Q2 2015, were 64GB and above**, comparatively, only 15% of the total iPhone 5s sales were 64GB and above in Q2 2014

- Samsung's Galaxy S6 series launched in Q2 2015, which comes with multiple SKU configurations of 32GB / 64GB / 128 GB is already seeing adoption of higher memory configuration models. **One in three Galaxy S6 series phones sold were 64GB and above**, driving the average capacity for Samsung on a whole in smartphones from 25GB annually and sequentially to 45GB just in one quarter

Some of the best-selling smartphone models globally in Q2 2015 were dominated by Apple in the higher configurations (64GB and above) followed by Samsung (in 32GB) and Xiaomi in the lower configurations (8GB). The below table exhibits hero models for brands in different memory configurations. This is a good indicator of the right specs configuration, design and pricing to be the respective category leader.

Exhibit 3.3: *Best Selling Smartphone Models Globally by Flash Capacities*

Storage Capacity in Q2'15	Top-Selling Smartphone Models	Overall Smartphone Marketshare in Q2'15
4GB	Lumia 530	0.3%
8GB	Xiaomi Redmi 2	2.9%
16GB	Apple iPhone 6	2.6%
32GB	Samsung Galaxy S6	2.3%
64GB	Apple iPhone 6	2.3%
128GB	Apple iPhone 6	1.3%

Implications

- So overall, rise in sales of smartphone models with higher flash capacities among major fast growing brands have been one of the factors driving global average flash capacities in smartphones.

- The OEMs with clever SKU strategies (16/32-64-128 GB) and aggressive pricing strategies (for affordable smartphones with better specs) as adopted by Apple and Xiaomi respectively have allowed to increase the sales mix of higher storage SKUs and hence boost ASPs and realize relatively greater margins.

- OEMs are also leveraging thinner unibody form-factors to justify non-removable flash storage and in turn up-sell higher capacity SKUs.

- As the smartphone landscape continues to become more competitive, OEMs are looking to tweak their BOM costs and hence the device configurations to remain cost competitive. However, it has become imperative to include higher capacity and highly reliable flash storage to satisfy consumer expectations thus making it even more challenging for OEMs.

Other factors driving the need for higher flash storage capacities in smartphones are:

Expanding OS Software & App Installs

- With every new release of Android or iOS or Windows the size of the OS software has kept on increasing and it has been a nightmare for many consumers who have already used the bulk of their internal flash storage. So the need for higher internal storage capacity is becoming more and more important.

- Many OEMs in order to differentiate with other brands especially those using Android platform either fork the Android to develop their own android version or develop an extra layer of skin UI over the top of the base Android software. This makes the overall Android software bulkier in turn reducing the overall amount of capacity available to the users out of the box.

- Also, many OEMs partner with a number of app developers to pre-install or bundle multiple apps or games as promotional offers. This trend has also reduced the net storage available to consumers out of the box.

- Many of the applications which are installed on the primary non-removable memory by OEMs or consumers cannot be uninstalled or in some cases cannot be moved to expandable storage as it may affect the overall performance and hence the user-experience for using the application. This also reduces the amount of net storage available for the users.

- As enterprise **BYOD** (Bring Your Own Device) trend continues to rise, the overall capacity available for personal vs work applications, data reduces considerably in turn limiting the usage of device and the overall user-experience. We estimate that the total BYOD driven smartphone users to reach close to half a billion users in 2015 which is a significant number of mobile workforce in need for more storage and boost their productivity on the go

- Furthermore, scientific investigations (NEC Labs) has proven that **storage memory** is a significant **contributor to application performance** varying across basic to intensive applications.

Advancing Hardware & Connectivity

- The smartphone hardware has been advancing by leaps and bounds as under-the-hood semiconductors advancement follows the Moore's law. The **processors** have already reached 14nm manufacturing process allowing OEMs to design slimmer, lighter but powerful smartphones

- **Larger Displays:** At the same time, **smartphone screens** have gotten **larger** with the sweet spot reaching close to 5-inch displays. These larger displays are driving greater usage, content consumption and even creation on the smartphone. Thus requiring more efficient, better performance and high capacity storage solutions. **The average display size in smartphones rose to 4.93 inches at the end of Q2 2015 with sweet spot could shift to 5" display by the end of this year as more and more phablets are sold globally**

- **Thinner Devices**: Furthermore, with growing footprint of the devices, many OEMs are also racing to build **thinner devices** with **unibody closed design** which thus mostly features **non-removable flash storage**. As a result, OEMs have expanded the SKUs of those models starting from 16GB up to 128GB to satisfy users' storage needs

- **Faster Connectivity**: Additionally, these devices are not only getting faster under the hood or bigger or slimmer but also sporting **advanced wireless connectivity** solutions for e.g. **LTE** cellular access technology to proliferation of Gigabit Wi-Fi 802.11ac. For example, **one out of two smartphones sold globally in Q2 2015 was LTE capable** and this ratio will continue to increase swiftly in the future. Many advanced markets such as USA, Japan or S. Korea are seeing more than 80% of the smartphones sold are LTE capable. Scientific research (NEC Labs) showed that there is a **direct correlation between the smartphone flash storage solution and the wireless connectivity** on the performance of interactive applications that are dependent on the wireless connectivity. The faster the network, the more efficient and faster the memory solution needs to be.

- **Advanced Cameras**: The advancement in graphics processing technology as well as integration of **high resolution cameras** in the phones have resulted in a deluge of high-quality user-generated content from sharper high-quality images to high resolution HD to now even 4K videos. **The average camera sensor resolution in smartphones rose to 10.2 MP at the end of Q2 2015.**

Additionally, post processing features and software for video and images allowing to save/edit RAW images to advanced video shooting – Burst Mode Shooting, Timelapse, Slow-Motion and so forth have also spiked a need for more flash storage space in smartphones as an average size of processed or special effect files are on an average of at least 30% larger in size than the normal, compressed files.

- **High Resolution Images**: As the average image sensor resolution has gone higher with 13MP, 16MP or 21MP (4992 x 3744 pixels)

sensors becoming a feature for mid- to premium smartphones, the average size of a default image captured and stored on the smartphone has also gone up. Additionally, editing photos on the fly on the smartphone itself before sharing is becoming a big trend. Many high-end smartphone models especially from Nokia, HTC, LG and Sony have supported RAW image capture and editing which has earlier normally appealed only to photography enthusiasts but the feature is now entering into mainstream. Google with Android L (5.0) version of its OS has enabled default support for RAW photo capture independent of camera sensor resolution and when coupled with a growing developer ecosystem enabling apps to post-process those unfiltered RAW images directly on the device with ease empowers an average user to capture and edit RAW photos like being in a digital darkroom. The advantages that RAW images bring to the consumer are, images with greater detail, better in low-light conditions, less noise and so forth.

However, the RAW images use a lot of space on the smartphones. On average, **a RAW image takes three to five times the storage space compared to a high resolution but compressed JPEG file.** This trend will also factor in towards rising need for higher capacity on-board storage demand from consumers.

- **High Resolution Video**: Almost 28% of the smartphones sold in Q2 2015 are capable of recording 4K (2160p@30fps) video resolutions. According to our research, an average of a 5 minutes video in 4K could use up to as high as 3GB of storage capacity compared to 750MB of a FULL HD (1080p@30fps) video or 467MB of a 720p@30fps resolution video. That is 4K using more than four times the storage space compared to 1080p videos. As 4K becomes more accessible and popular to consumers, we will see the need for more capacity trickle down to lower price-points.

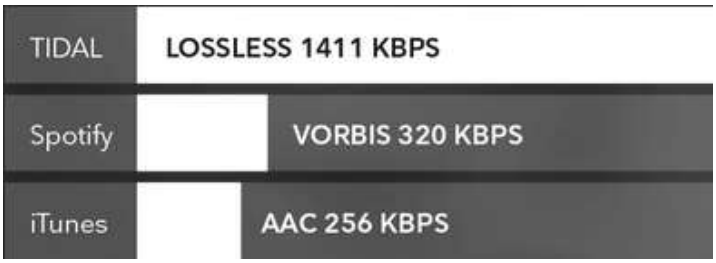
Exhibit 3.4: *Video File Size by Smartphone Camera Captured Video Resolution*

Resolution / Video File Size (MB)	1sec	1min	5min
720p	1.6	93.3	466.7
1080p	2.5	149.8	749.1
2160p	10.1	606.0	3030.0

- **High Fidelity Audio**: Even though the cloud streaming music has grown globally, rising data usage has effectively be capped by operators thus giving rise to hybrid business models for music consumption on smartphones i.e. high quality music streaming + offline download. So premium subscribers of services such as Spotify or Tidal (lossless) can use some amount of caching on the device and use up a lot of space in addition to the high quality music available for download for offline use, which will take up even more space. Also the rise of music availability in high-fidelity FLAC (Free Lossless Audio Codec) format

(1411 kbps) vs. Vorbis (320Kbps) vs. AAC (256kbps) will further multiply the need for higher storage even in the cloud streaming world.

Exhibit 3.5: *Rising Audio Fidelity for Music Consumption*



- Furthermore, with advancement in content transfer technologies and ports in form of **USB Type C** to standards such as Wireless HD has also escalated the need for an advanced, faster on-device storage to transfer the high resolution content back and forth from the device in a speedy and efficient way.

Conclusions

- Growing size of software install packages, rising number of apps installed, ever-increasing size of data created and generated by users, the continuing advancement in hardware technologies, newer form-factors and wireless connectivity are all contributing and stimulating a greater need for flash storage from consumers' point of view.

- As smartphone users continue to rise on smartphone usage curve, they will be expecting more from their mobile devices than ever before.

- More photos are now being taken annually than in the entire history of photography to date. As camera sensor sizes grow so do the resulting file sizes, further driving storage demands.

- Billions of consumers will look to upgrade to smartphones not only with advanced software capabilities, but also cutting edge hardware components from better display to faster processor to higher capacity storage. And need for higher capacity storage highly complements the other upgrades.

- The only potential contra indicator is that the growth of high speed networking can lead to more off-board storage. However networks, however advanced, are never 100% available, so the need for local storage will remain a fundamental requirement for the foreseeable future.

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