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Takshashila Discussion Document

5G, Huawei & Geopolitics: An Indian Roadmap

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Executive Summary

This report argues that the Indian government must consider the strategic implications of allowing Huawei to have a role in building and operating India's 5G network infrastructure. While there exists an economic rationale for providing Chinese telecom vendors access to the Indian market, these benefits need to be weighed against national security concerns and geopolitical objectives.

A thorough threat assessment must be conducted at two distinct levels – operational and strategic. The operational level refers to challenges such as espionage, theft, surveillance, denial of services, and disruptions. The strategic level pertains to the potential splintering of the global cyberspace and technology and innovation ecosystems into distinct spheres of influence.

Keeping this in mind, we recommend the following:

1. Decisions on new technologies have strategic dimensions. Therefore, the Cabinet Committee on Security must have the final say in these matters.

2. The Government of India should publish a whitelist of governments and vendors identifying trusted partners in the telecom and cybersecurity domains.

3. India's 5G network infrastructure must not be overly reliant on any one vendor. Being locked in to one vendor has significant economic, security, and political costs.

4. While there should be no outright ban on Chinese vendors, their participation should be restricted, conditional, and tightly regulated.

5. The size of the Indian market must be used as a key source of leverage in order to achieve strategic objectives.

Background & Context

A. Overview of India's Telecom Sector

India's telecom sector is dominated by three players - Bharti Airtel, Vodafone Idea, and Reliance Jio. All three of them have comparable market shares and spend heavily on expanding their network capacity and coverage. In general, the strategy adopted by each player is to focus on quality and cost-effective services in order to grow market share, which can eventually be monetised. As such, the sector is characterised by high levels of debt and low profitability. 5G technology, which will tap hitherto unexplored ends of the spectrum to provide services of unprecedented speed, reliability, and efficiency, will thus be a potential game-changer. The infrastructure required for 5G is, however, not the same as that required for 4G, entailing fresh cost implications. Meanwhile, the sheer size and potential of the market for new equipment creates significant opportunities for economies of scale for any hypothetical equipment provider - such as Cisco, Ericsson, Nokia, and, of course, Huawei.

See Appendix A for a detailed assessment.

B. The Nature of 5G

The fifth generation of wireless networking technology is likely to yield three major gains, i.e., extremely high speeds of connectivity, significantly higher connection density, and near-zero latency. This would enhance machine-to-machine connectivity, data analytics, and automation, resulting in the development of new products and businesses, boosting productivity and enhancing governance capacity. An Indian government study in August 2018 estimated the cumulative economic impact of 5G on the country's economy to hit $1 trillion by 2035. However, high levels of automation, greater connection density, and increased dependence on communications networks also imply a wider and more potent array of security threats.

See Appendix B for a detailed assessment.

C. Huawei: The Controversial Giant

Huawei Technologies Co., Ltd. was founded in 1987 by a former member of the Chinese People's Liberation Army, Ren Zhengfei. Over the decades, the company

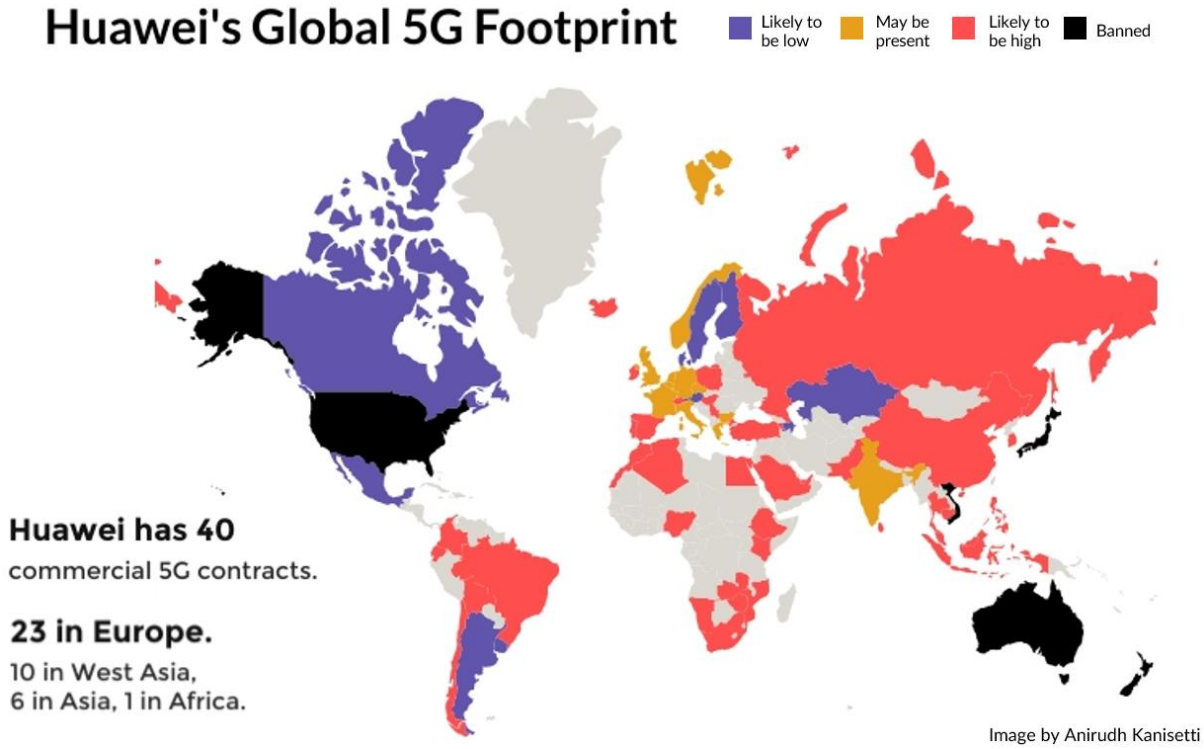
has grown to emerge as the world's largest supplier of telecommunications network equipment and the second-biggest smartphone maker. Huawei says that it is actively engaged in 1500 telecom networks in 170 countries, connecting one-third of the world's population. In 2018, it reported a revenue of $107 billion. This growth, the company claims, has been predicated on a strategy of investing in research and development in order to provide cost-effective yet high quality telecom products and solutions. Indeed, Huawei is, at present, the global leader in terms of ownership of 5G Standard Essential Patents.

However, there is sufficient evidence to indicate that Huawei's growth has been subsidised by the Chinese state. In addition, there are concerns about questionable business practices, reports of corporate and political espionage and charges of intellectual property theft. These are amplified owing to the opacity of Huawei's governance structure along with legislative changes in the PRC, which build systemic interlinkages between the Party-state and ostensibly private companies. In effect, the threat is that Huawei is increasingly likely to be comply with Chinese state security interests, even if they run contrary to its corporate interests.

See Appendix C for a detailed assessment.

The Geopolitics of 5G

Given the economic stakes associated with 5G, global telecommunications giants are locked in a race to set standards and capture markets. As of March 2019, Huawei's Rotating Chairman Ken Hu disclosed that the company had secured 40 commercial contracts to build and operate 5G telecommunications infrastructure in different parts of the world.[1]



Huawei's projected global footprint based on reporting from a variety of sources[2]. In some countries, competitors of Huawei such as Ericsson have signed deals with large telecom firms already. In others, Huawei has entered similar deals. In yet others, the regulatory environment appears favourable to Huawei's entry.

Huawei's expanding 5G R&D Budget, which far exceeds the budgets of its competitors, has led to these gains. In fact, Chinese companies began focusing on acquiring a lead in 5G intellectual property well before their global competitors. Between 2009 and 2013, Huawei claims to have invested more than $600 million into 5G research.[3] Huawei has further plans to spend nearly $800 million in 5G research and development this year.[4] Such investments have enabled Chinese companies to claim patents, which are key to setting global 5G standards. These standards are expected to be finalised by the end of 2019.[5]

A recent study examining ownership of declared 5G Standard Essential Patents (SEPs) as of 2018 found four Chinese companies - Huawei, ZTE, CATT and Oppo - among the 11 leading SEP holders.[6] Globally, in terms of SEP ownership, Huawei is leading the pack, followed by Nokia and Samsung. The report also provides data on attendance by company employees and technical contributions by companies at international meetings in order to assess the ability and influence in standard setting. In both cases, Chinese companies are significant contributors, with Huawei being the leading contributor.[7] In addition, increasing numbers of individuals from Chinese firms and government research institutes are commanding positions of authority at 5G-related standards-setting bodies.[8] This has led to increasing consternation within the US over the impact on national security and competitiveness of American companies.

All this leads to the fundamental faultline regarding Huawei, i.e., the geopolitics of 5G. The quest to dominate new technologies is at the heart of deepening frictions between China and the US. The 2017 US National Security Strategy calls for actions to protect the American National Security Innovation Base against competitors like China.[9] This, it argues, requires a domestic and international response. Concerned about potential security and economic implications, Washington has initiated steps to decouple from the Chinese technology ecosystem.[10] In response, the Chinese leadership has emphasised greater support for innovation and self-sufficiency in order to upgrade the economy and enhance global competitiveness.[11] This has serious implications for the rest of the world, given the emergence of discourse reminiscent of the Cold War,[12] with the US and China clashing over building 5G infrastructure around the world.

The USA's arguments for countries to opt against Chinese telecom companies, particularly Huawei, are rather straightforward. They draw from the National Security Strategy, which brands China as a revisionist power and a competitor that "gathers and exploits data on an unrivalled scale and spreads features of its authoritarian system."[13] In this effort, Huawei is viewed as an important tool. This underscores the significance of securing 5G network infrastructure, and the inherent strategic implications for countries deploying equipment from companies that are subject to Chinese government control.[14] "We can't forget these systems were designed by – with the express (desire to) work alongside the Chinese PLA, their military in China," argued Secretary of State Mike Pompeo in an interview in February 2019.[15] Supporting the effort to sway sovereign decisions by states, Washington is arguing that decisions by partners and allies could extend

the threat to the US. "The United States is calling on all our security partners to be vigilant and to reject any enterprise that would compromise the integrity of our communications technology or national security systems," declared Vice President Mike Pence at the 2019 Munich Security Conference.[16] Speaking at the 2019 Mobile World Congress, Robert Strayer, Deputy Assistant Secretary for Cyber and International Communications and Information Policy, added that "America is calling on all our security partners to be vigilant and avoid vendors that could compromise the integrity of global communications technology, the privacy and liberty of our citizens, and the security of our critical infrastructure and national security systems."[17] Pompeo, meanwhile, has been far more blunt, warning "If a country adopts this and puts it in some of their critical information systems, we won't be able to share information with them, we won't be able to work alongside them."[18]

Despite the rhetoric, the signals sent by the Donald Trump administration have been mixed. The National Defense Authorization Act, which was signed in 2018, effectively banned executive agencies from using or procuring Huawei and ZTE telecommunications equipment.[19] That ban has been challenged by Huawei in a US court, although it is unlikely to obtain a favourable verdict.[20] Moreover, after months of warnings, in May 2019, Trump issued an executive order effectively banning the use of Huawei equipment in US telecom networks on national security grounds.[21] That was followed by the US Commerce Department placing Huawei and 68 of its affiliates on an Entity List on May 17, 2019.[22] This decision conditions the sale or transfer of American technology to these entities unless authorised via a special license. Five days later, the Commerce Department eased some of the restrictions for a 90-day period.[23] These restrictions were imposed in the immediate aftermath of the failure of the 11th round of trade talks between China and the US, with Trump publicly suggesting that the Huawei situation could be leveraged as a bargaining chip in the broader China-US trade negotiations.[24] This implies a transactional approach,[25] which could leave partners taking action against Huawei high and dry while worsening their ties with China.

The changes in Sino-Canadian relationship are noteworthy in this context. Ties between Beijing and Ottawa have deteriorated since Meng's detention in Vancouver late last year following a US extradition request. China retaliated to that by detaining two Canadian nationals on vague charges of espionage, while also restricting the import of Canadian canola oil.[26] As tensions continue,

Canadian officials are reportedly increasingly frustrated with what they see as insufficient US support.[27]

China has responded to the US campaign with a strategy that blends propaganda, persuasion, and incentives with threats and economic coercion. Beijing has lashed out at the US for what it calls the use of "state power to discredit and crack down on specific Chinese companies."[28] In addition, its diplomats, led by Foreign Minister Wang Yi, have pledged to "take all necessary measures to resolutely defend" Huawei against "political repression" by the US.[29] Meanwhile, Huawei has engaged in a massive public relations effort, led by CEO Ren Zhengfei, to allay concerns regarding security, transparency and its links to the Chinese government.[30] This campaign has included a media blitz, reaching out to lawmakers across the political spectrum[31] in different countries, publishing open letters and newspaper adverts[32] promising transparency, and offering new investments to allay cybersecurity concerns, such as in the UK.[33] At the same time, Huawei has pointed to the controversial PRISM program, which had enabled the US National Security Agency to collect data from American internet companies.[34] In addition, it has charged the US government of acting with protectionist intent in the face of competition.[35] The broad thrust of Beijing and Huawei's argument to third parties is that Washington's campaign is simply about sustaining its geopolitical dominance at their expense.

An Indian Roadmap

From the above discussion, it is clear that the calculations involved in India permitting Huawei to play a role in the establishment of the country's 5G infrastructure are complex. There are economic, technological, security and geopolitical considerations that must be taken into account. Therefore, it is important to note that the final decision must be based on a broader assessment.

A. Strategic Assessment

From an economic point of view, the argument of engaging Huawei is rather straightforward. India imports an overwhelming majority of its telecom equipment requirement, estimated at $21,847.92 million last year.[36] In this context, Huawei is a cost-effective partner, which is active in the Indian telecom ecosystem and can offer cutting-edge technology at compelling prices. Huawei has a long history of operations in India, entering in the late 1990s. In 2016, it established a Global Service Center in Bangalore, with the aim of servicing 30-plus markets across Asia, Africa, and the Middle East.[37] In addition, it is keen to expand investments in India, announcing an additional $100 million in October last year.[38] This would support Indian telecom operators already struggling with massive capital expenditure burdens.[39] At the same time, India offers Huawei a market second only to China in size, and would be critical for its future growth. This is crucial economic leverage, which can potentially yield political dividends for New Delhi vis-a-vis Beijing. The higher the stakes of Chinese enterprises in the Indian market, the greater the potential political leverage for India. Increased investments by Chinese firms in India can lead to developing constituencies that can act as stabilisers in the bilateral relationship and even potentially influence policy in Beijing.

These benefits, however, must be weighed against security and geopolitical implications. The security risks, in this context, are largely operational, such as espionage, theft, surveillance, denial of services and disruptions. The geopolitical implications are far broader, with the possibility of the global cyberspace and technology and innovation ecosystems splintering into different spheres of influence. This makes India's decision on Huawei a strategic choice.

From a security perspective, India's import of telecom equipment makes it dependent on foreign vendors, with espionage and surveillance concerns likely to remain high. However, Huawei is different from other vendors like Nokia, Ericsson

or Samsung and the decision on it must be viewed from the prism of the broader India-China relationship, which is riddled with deep strategic mistrust. The decades old land boundary dispute between the two countries remains unresolved. Chinese capacity build-up and construction activity, not just along the LAC but also in sensitive regions such as the Doklam Plateau[40], continue despite the tense 2017 standoff and Xi-Modi informal summit at Wuhan.[41] In addition, China's engagement in Pakistan via CPEC is a repeated reminder of Beijing's disregard for India's concerns regarding the violation of its sovereignty and territorial integrity. Also, China's deep military ties with Pakistan along with the diplomatic cover it provides for Pakistan-based terrorists at multilateral fora breed further suspicion of Beijing's intentions. In this context, Huawei's history of close, if not murky, ties with the Chinese state is important to note. While as a private, commercial entity Huawei might not have the same objectives as the Chinese state, the degree of influence that the state potentially has over private Chinese companies is worrisome. This is especially so, given that Huawei's Western competitors are not legally obliged to assist their respective governments. This amplifies the threat of not just espionage and surveillance but also disruptions of systems during a bilateral crisis. The decision on what role, if at all, should Huawei play in building India's 5G network infrastructure, therefore, has to be taken after conducting a cost-benefit assessment, given the nature of the bilateral relationship.

Finally, from a geopolitics viewpoint, the US has been pressing partner countries to exclude Huawei along with other Chinese vendors from their 5G infrastructure. While most US allies appear to broadly agree on the threat assessment, there are differences in terms of the approaches to address the threat.

Australia, for instance, effectively banned Huawei from its 5G networks last year. The decision was reportedly taken after a 5G war game simulation led by the Australian Signals Directorate (ASD) revealed the serious nature of the security threat.[42] Speaking in March 2019, Mike Burgess, ASD Director-General, described Huawei as a "high-risk vendor," adding that the ban was a result of the potential threat it posed to critical infrastructure.[43] In contrast, European states like France, Germany and the UK have refrained from an outright ban on Chinese telecom operators, arguing that the risk can potentially be managed through a mix of regulation and technological solutions.[44] Their approach is a product of a mix of economic and political considerations, such as switching costs, the cost-effectiveness of Huawei products and the desire for strategic autonomy.[45] Despite

this, as a March 2019 NATO assessment concluded, there is "a growing appetite among EU member states and NATO allies on EU/NATO coordination in this matter."[46] A tangible outcome of this is the May 2019 Prague Proposals on 5G agreed upon by 32 countries, including the US, key NATO and EU members along with Israel, South Korea and Japan.[47] Although the proposals do not name any vendor or state, the references to Huawei and China are unmistakable.[48] This is indicative of deepening geopolitical competition around new technologies, with the potential of the global cyberspace splintering into different segments[49] and decoupling of technology and innovation ecosystems.

Considering all this, along with the fact that indigenisation of telecom equipment in time for 5G rollout in India is simply unviable, we recommend the following:

B. Recommendations

1. **Decisions on new technologies are acquiring strategic dimensions. Therefore, the Cabinet Committee on Security must have the final say in these matters.** The CCS is the apex body for policy decisions on matters of national security. This includes economic and political issues impinging on national security. Given the nature of the operational and strategic threats associated with 5G technologies, the CCS must guide the policies for vendor selection, security reviews, cyber audits, cybersecurity, and data protection.

2. **Government of India should publish a whitelist of governments and vendors identifying trusted partners working in the telecom and cybersecurity domains.** Such a list serves multiple purposes. First, it offers clarity to domestic network service providers in their quest for strategic partnerships. Second, it creates an incentive framework for foreign governments and vendors to meet certain defined standards if they wish to deepen their participation in the Indian market. Third, it encourages linkages with leading international actors with common threat perceptions, facilitating the sharing of knowledge, skills, and technologies to mitigate any threats.

3. **While there should be no outright ban on Chinese vendors, their participation should be restricted, conditional and tightly regulated.** In principle, it is in India's interest to create a level-playing field for all possible

equipment vendors, including Chinese manufacturers. Greater competition will only increase the quality and reduce the price of the equipment acquired.[50] There are, however, specific concerns with Chinese vendors like Huawei, such as their ties with the Chinese Party-state, which cannot be brushed aside. Therefore, Huawei and other Chinese vendors should be excluded from providing equipment for or participating in building and maintaining core and critical 5G infrastructure. On the other hand, given the affordability and competitiveness of their products, participation by Chinese vendors should be encouraged in non-critical sectors and end-user and consumer markets, fuelling the connectivity of India's economic hinterland to the digital economy.

4. **India's 5G network infrastructure must not be overly reliant on any one vendor. Being locked in to one vendor has significant economic, security and political costs.** In order to avoid this, telecom policy should expressly call on operators to work with a mix of vendors along with a focus on failsafes, redundancies, and backups of varying degrees of sophistication. Also implicit is the requirement of different standards for different kinds of networks - national security, critical national infrastructure and general connectivity. They don't all have to be equally integrated to the overall network and should have the ability to function independently in the event of a crisis.

5. **The size of the Indian market must be used as a key source of leverage in order to achieve strategic objectives.** The larger the value of a multinational corporation's investment in India, the more likely it is that it will act as a constituency of support for India in its home country. In addition, control over such investments provides the Indian state an economic tool to achieve political and strategic objectives. Recognition of this is crucial for the government in framing rules attracting foreign investment and regulating the participation of foreign firms in the telecom sector.

Appendix A: Overview of India's Telecom Sector

India's telecom sector is currently dominated by three players, though there were, at one point, nearly a dozen competing providers. The emergence of Reliance Jio in September 2016, which offered free voice calls and almost free data and SMS usage[51], was massively disruptive. The very next quarter, consumer wireless spend plummeted, falling by a total of almost 33% since[52], even as the number of mobile data consumers began to grow drastically. As of July 2018, Jio had over 225 million customers[53]. As other providers struggled to compete with its prices, data costs reduced by 94% from ₹250/GB to barely ₹15/GB over the last two years[54].

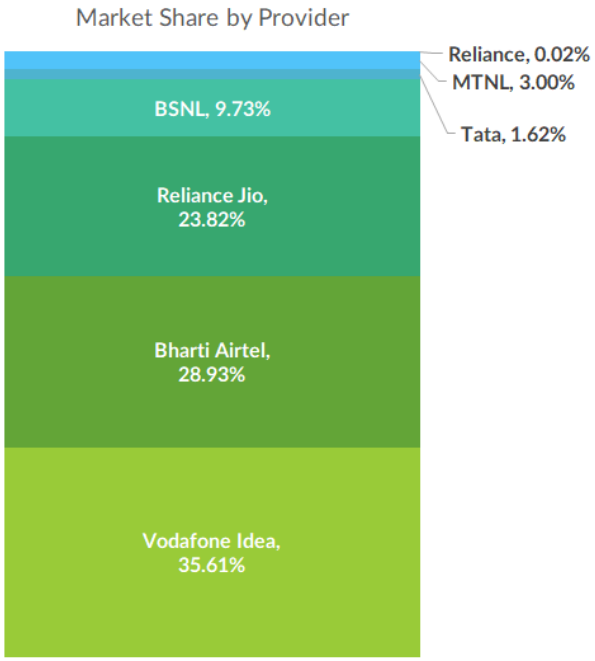


Image by Anirudh Kanisetti

Average revenue per user (ARPU) has also declined commensurately - Jio has a monthly ARPU of ₹131.7, Airtel ₹101, and Vodafone just ₹88[55]. Only the very largest players are able to sustain such low revenues: smaller providers have either been pushed out of business due to falling revenues or have merged/acquired other competitors. This has left only three major players in the sector: Reliance Jio, Bharti Airtel, and Vodafone Idea. Vodafone Idea is itself a product of a merger between Vodafone and Idea, two well-established players who now control the largest share of the market in terms of number of customers. These private providers now cater to a total of 89.98% of wireless data users, while public sector undertakings cater to the remaining 10.02%[56].

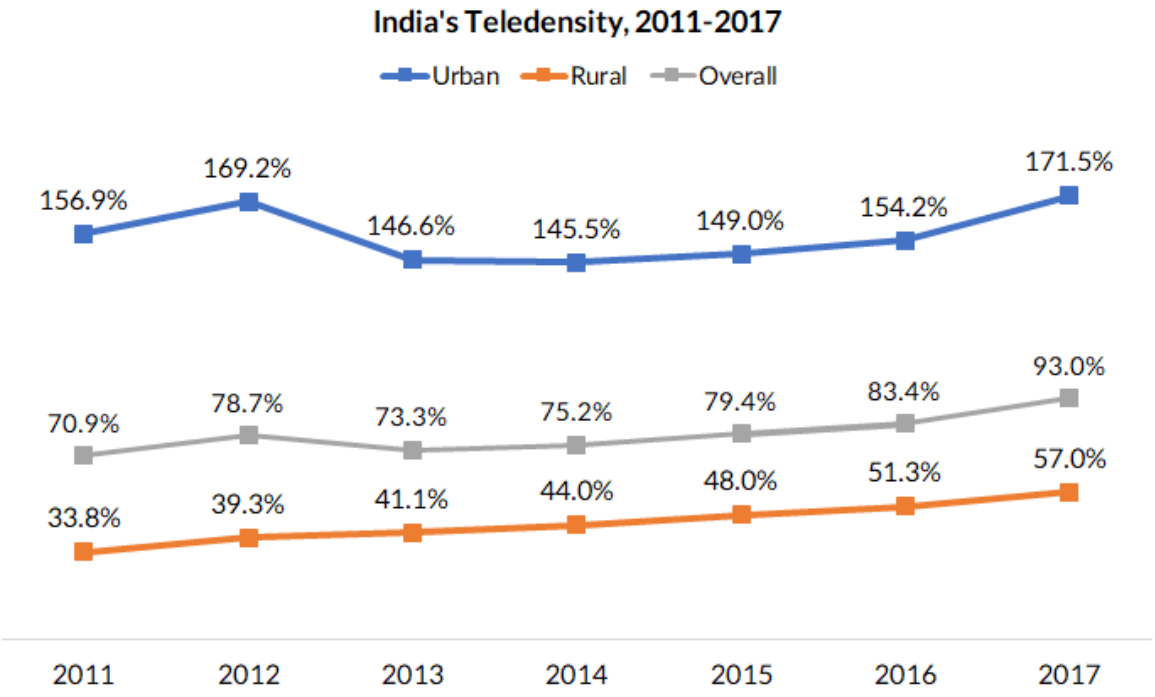


Image by Anirudh Kanisetti

With mobile phone and data penetration increasing steadily over the last decade, India has become the world's largest consumer of mobile data, at an average of 12 GB per person per month[57]. Jio has played a huge role in this, marketing low-cost Jio Phones that both urban and rural Indians have taken to with gusto - note the nearly 10% Y-o-Y increase in teledensity from 2016-2017, nearly double the average rate. More Indians than ever before are being exposed to the Internet on a regular basis, and cutthroat markets for content and apps have sprung up over the last two years, often actively encouraged by telecom companies themselves. Airtel, Vodafone and Jio all offer music and video streaming services through their apps, aiming to lock in customers and play a larger role in terms of how Indians consume content in the years to come.

These "Big Three" companies, as it were, will be critical to the future of Indian telecom. They are the only players with the financial appetite required to compete in a market where affordability of data - as Jio's success shows - is critical to growth. Airtel CEO Sunil Mittal, for example, has expressed optimism that ARPU numbers will eventually reach ₹300 a month[58], which is much more sustainable.

Investors, however, remain skittish owing to the high capital expenditure required and distant prospects of profitability. The "Big Three" have unhealthy debt-to-

earnings ratios[59], with both Jio and Vodafone's indicators in the double digits. Airtel, which the healthiest of the three, was recently downgraded to "junk" by Moody's due to "worries about weak cash flows for several quarters ahead."[60] In 2018, Airtel's biggest investor outside of the Mittal family, Singaporean Telecommunications Ltd., reduced its total share in the company's India operations, which were instead taken over by Singapore's sovereign wealth fund - possibly due to concerns regarding its own rating[61]. Concerns about ratings and long-term strategy have also led to the Big Three offloading their tower and infrastructure subsidiaries to other companies (as Jio is doing[62]) or announcing partnerships to take on the other companies (as Airtel and Vodafone are doing[63]). Airtel and Vodafone have also announced additional rounds of funding, indicating, as one analyst put it, that they are willing to continue the "brutal battle for capital and capacity"[64].

Capacity and coverage are keys to success in a game that has, essentially, become about market share (as Airtel puts it, "win the primary SIM slot and wrest back share.")[65] 2018 saw heavy competition between the Big Three to expand coverage - while Jio led the field by nearly twenty percentage points in April of that year[66], Airtel and Vodafone invested enough to close the gap to barely 5-6% by February 2019[67]. The general strategy seems to be to emphasise LTE services, providing users with more data faster, and eventually monetise the market share captured. While Jio uses 4G spectrum exclusively[68] to provide these speeds, Vodafone leverages its larger 2G and 3G footprint with technology such as dynamic spectrum reframing to achieve them[69].

Coverage and capacity battles, in turn, will be won or lost on the basis of spectrum. India's Department of Telecom auctions blocks of spectrum to telecom operators for set periods of time. Pricing remains controversial, and, as noted, not all operators are equally financially healthy. Despite the government's decision to defer payments for bids and tweak spectrum caps to allow them to consolidate[70], Vodafone remains "saddled with sizeable spectrum liabilities, of which Rs 3,000 crore is due in March 2019 and an additional Rs 12,000 crore would be due in mid-FY20."[71]

5G technology, which will tap hitherto unexplored ends of the spectrum to provide services of unprecedented speed, reliability, and efficiency, is thus a game-changer. However, implementing it will require further capital expenditure from a telecom sector already overburdened with debt incurred in the race to grow. Understandably, Vodafone wants no further spectrum auctions till 2020,

perhaps due to the risk of its competitors expanding their coverage while they themselves are too saddled with debt to do the same. Airtel prefers a 4G-only auction in FY 2019 and a 5G auction in 2020. And Jio, the most bullish of the three, is lobbying for an immediate auction[72].

Regulatory uncertainty muddies the waters. The government has officially pushed the potential auction to August 2019 at least[73] (though lobbying may change this). While the frequencies which are already being used globally for the rollout of 5G technology fall in the 3.5 GHz range, these are yet to be auctioned in India. Indeed, the Department of Telecom is reportedly averse to making spectrum temporarily available at a low cost even to conduct 5G *trials*[74]. The demand for speed is not going away, however. Jio, for example, seeks speeds approaching those that 5G can offer in order to prevent Airtel and Vodafone from expanding and perhaps monetising their 4G/LTE footprint[75].

This is where Huawei comes in. That 5G would assist in the expansion and maturation of India's digital economy is attested to by no less than the Telecom Regulatory Authority of India itself[76]. The infrastructure required for 5G is, however, not the same as that required for 4G, being more modular, requiring fibre optic cable and many smaller transmitters as opposed to a few large signal towers. The sheer size of the market creates great opportunities for economies of scale for any hypothetical equipment provider[77]. However, telecom operators have only been advised to cooperate with the following providers for equipment for 5G trials: "Cisco, Samsung, Ericsson and Nokia"[78]. Huawei and ZTE, despite the advantages they could offer in terms of affordability[79], have not been provided the green light despite increasingly serious expressions of interest (Huawei India CEO Jay Chen recently that the company was ready to roll out the technology for trials within 20 days if given approval[80]). As the Chinese giant comes under increasing international pressure, India's need for 5G infrastructure provides it with critical opportunities for growth. The causes and strategic implications of this fact will be explored in detail in subsequent sections.

Appendix B: The Nature of 5G:

An upgrade from the fourth to the fifth generation of wireless networking technology is likely to yield three major gains. First, it promises extremely high speeds of connectivity, with some estimates pegging it at 100 times faster than 4G speeds.[81] Second, 5G promises significantly higher connection density. 5G technology is expected to support up to 1 million connected devices per 0.38 square kilometre. In comparison, 4G supports around 2,000 connected devices per square kilometre.[82] Third, 5G promises near-zero latency, i.e., a drastic reduction of the time taken for a network to respond to a request.[83] This is critical to develop applications and products that rely on rapid, real-time responses. Consequently, an upgrade to 5G technology is expected to facilitate faster and deeper connectivity resulting in increased support for a larger range of applications and services.

The impact of these advances is likely to be felt in sectors as diverse as transport, healthcare, energy and manufacturing to name a few. In the long run, the expectation is that 5G networks will lead to the creation of new business and innovation ecosystems. It would enhance machine-to-machine connectivity, analytics and automation resulting in the development of new products and businesses while boosting productivity.[84] For instance, economists at IHS Markit estimate that 5G will enable 12.3 trillion of global economic output and support 22 million jobs by 2035.[85]

An Indian government study in August 2018 estimated the cumulative economic impact of 5G on the country's economy to hit $1 trillion by 2035.[86] Beyond economic gains, 5G upgrades are also expected to enhance governance capacity, such as enabling greater efficiencies in healthcare delivery, energy grid management, urban planning, etc. However, high levels of automation, greater connection density and increased dependence on communications networks also imply a wider and more potent array of security threats.[87]

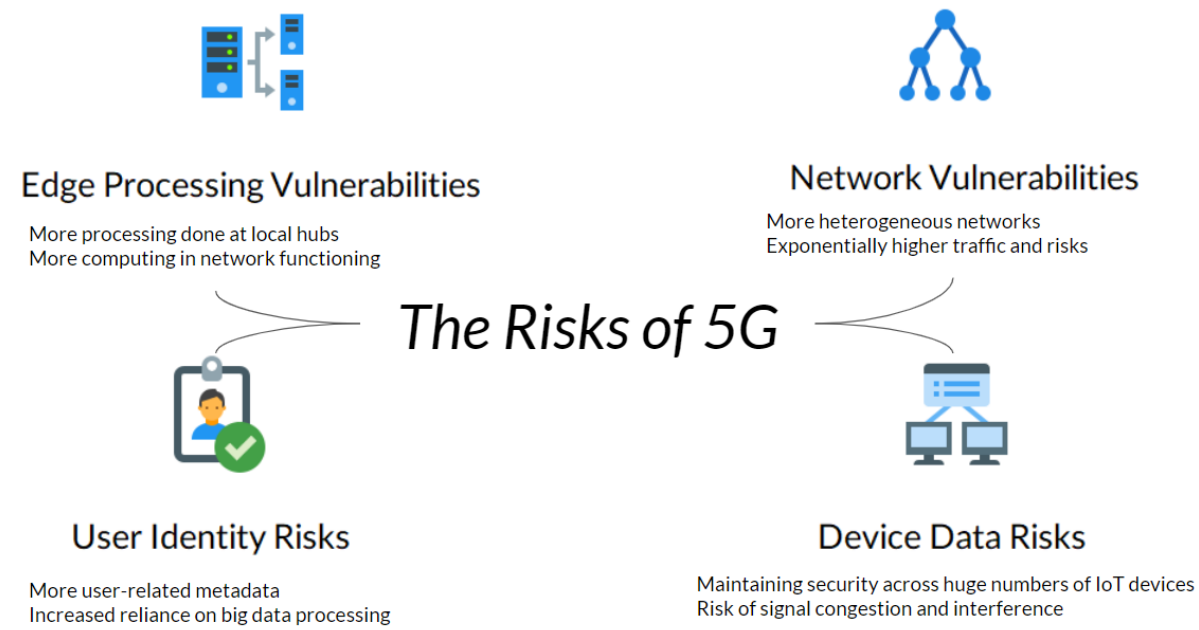


Image by Anirudh Kanisetti

The increased decentralisation, exponentially higher traffic, and heterogeneity of 5G networks will create immense challenges. More data being processed at local hubs (edge processing) and the increased use of AI to direct network traffic and monitor immense quantities of metadata both need to be taken into account by network administrators to prevent DDoS attacks, device hijacking, and identity theft.

Appendix C: Huawei: The Controversial Giant

In over three decades since its founding, Huawei Technologies Co., Ltd. has grown to emerge as the world's largest supplier of telecommunications network equipment and second-biggest smartphone maker.[88] Huawei was founded in 1987 by Ren Zhengfei, who continues to function as the company's CEO. Prior to establishing Huawei, Ren served in the Chinese People's Liberation Army, reportedly as a member of the Basic Civil Engineering Corps. His rank and the capacity in which he served in the PLA remain unclear to this day.[89]

Also murky is Huawei's corporate governance structure. Details on the company's board of directors were made public for the first time as recently as 2011.[90] That decision too was taken amid political pressure in the US for an investigation into the company following an abortive bid to acquire a start-up.[91] Officially, Huawei says that it is a private entity that is fully owned by its employees.[92] In 2014, it was revealed that Ren owned a 1.4% stake in the company, with the rest of the shares being held by a group of employees.[93] These employee-shareholders are collectively referred to as the Union. This group is represented at the Shareholders' Meeting, which is the company's key decision-making body, by a Representatives' Commission. The commission's members, the company claims, are elected by the active employee-shareholders with a term of five years.[94]

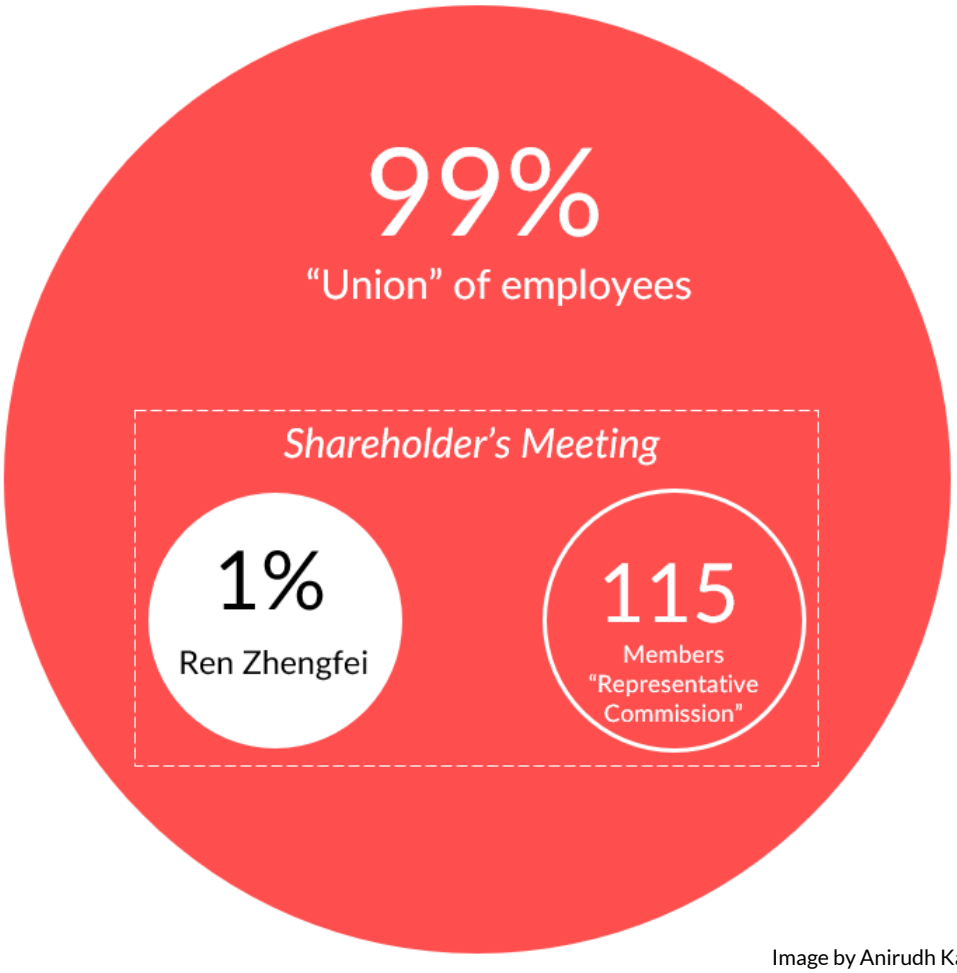


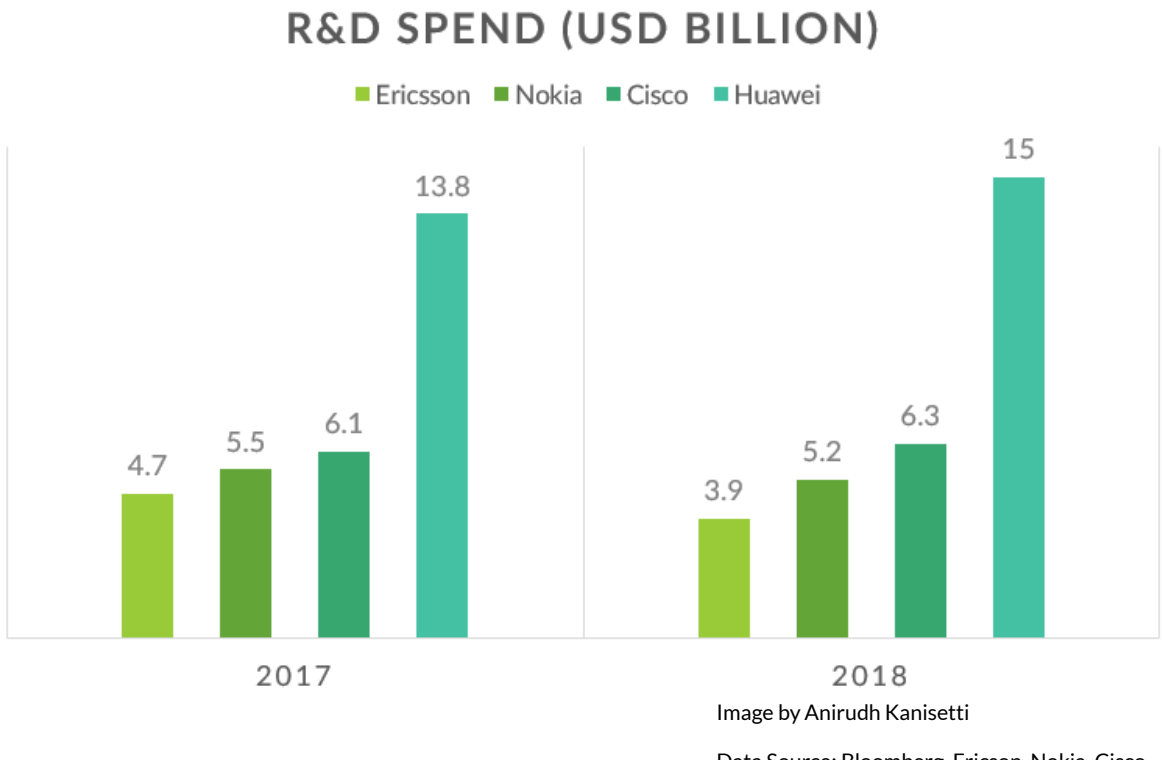
Image by Anirudh Kanisetti

The company's official website informs that its work spans four key domains - telecom networks, IT, smart devices and cloud services - across which it provides integrated solutions.[95] It reported an annual revenue of $92.5 billion in 2017. That number is expected to jump 21% to $109 billion in 2018.[96] Just under half of Huawei's revenue in 2017 was generated outside the Chinese market.[97]

Huawei says that it is actively engaged in 1500 telecom networks in 170 countries, connecting one-third of the world's population. Its global footprint is the product of the company's strategic approach towards the international marketplace, which has involved making incremental gains in emerging markets before expanding to Western Europe and North America.[98] This is reflected in the company's 2017 annual report, which shows that the European, Middle Eastern and African markets together constitute the second-largest revenue stream for Huawei.[99] Meanwhile, the company's highest value projects continue to be located

in Africa and South Asia.[100] This strategic approach is also evident in Huawei's 5G expansion.

Huawei's global growth has been possible because it has sought to provide cost-effective yet high quality products and solutions undercutting competition. The success of this approach has relied on three pillars. First, Huawei's management has ensured consistent investment in research and development. Over the past few years, Huawei's R&D expenditure has regularly surpassed those of its immediate competitors.[101] In July 2018, Huawei announced that it would expand its annual spending on research and development to between $15 billion and $20 billion.[102] That would place it in the league of tech giants like Alphabet and Amazon in terms of overall R&D expenditure.[103]



Huawei's R&D spend easily outpaces its closest competitors.

Second, there have been serious allegations against Huawei with regard to its business practices, corporate and political espionage and intellectual property theft. The earliest of such charges is perhaps the 2004 source code theft case involving Huawei and Cisco Systems.[104] Then in 2018, French daily *Le Monde*

reported that data from computers in the African Union's headquarters had been transferred nightly to Chinese servers for a period of five years.[105] Huawei was the key ICT service provider for the AU headquarters.[106] More recently, Huawei CFO Meng Wanzhou was detained in Canada in late 2018 following an extradition request by the US. The US Justice Department has formally charged Meng with "bank fraud, wire fraud, and conspiracies to commit bank and wire fraud."[107] At the same time, the US Department of Justice has also filed criminal charges against Huawei for attempting to steal T-Mobile USA's trade secrets and obstructing justice when T-Mobile threatened to sue the Chinese giant between 2012 and 2014.[108] In the same month, authorities in Poland arrested two Huawei employees on charges of espionage.[109]

Finally, in its effort to become a global leader, Huawei has received consistent state support in the form of grants, loans and contracts. A 2018 RWR Advisory Group report claims that Huawei "is treated as a state-owned enterprise and has benefited from state procurement funds, subsidized financing from state-owned policy banks and state funding for research."[110] The report estimates that in 2016, Huawei received $190 million in government grants from Chinese authorities. In addition, between 2012 and 2018, state-owned banks had lent $9.8 billion for 32 Huawei projects.

Reports also suggest that Huawei may have gained owing to the Chinese government's efforts to deepen civil-military integration. For instance, in 2013, Indian intelligence officials had reportedly pointed out the linkage between Huawei and a Chinese armed forces project called PLA-863.[111] Since then, under President Xi Jinping, civil-military integration has been upgraded to national strategy status. This essentially underscores the structural imperative for private enterprises to support the technological advancement of the PLA. What further codifies such intimate linkages between the Party-state and private enterprises is China's National Intelligence Law, which was enacted in June 2017. This legislation, as Elsa Kania notes, has created a "new legal basis that the Chinese government could use to mandate Huawei's compliance with state security interests that may be contrary to corporate imperatives."[112] Finally, threats of reprisals by Chinese diplomats against countries taking action targeting Huawei are also indicative of the Party-state's deep association with the company.[113]

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[2] This image was created primarily based on reporting from Reuters and Bloomberg, related to announcements made by specific countries. Other media reports were also used. In general, countries were assigned a colour only if the media report in question was considered credible. A detailed study of this topic can be accessed at the Australian Strategic Policy Institute's report, *Mapping China's Tech Giants*, which was released on April 18th, 2019. See https://www.aspi.org.au/report/mapping-chinas-tech-giants

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