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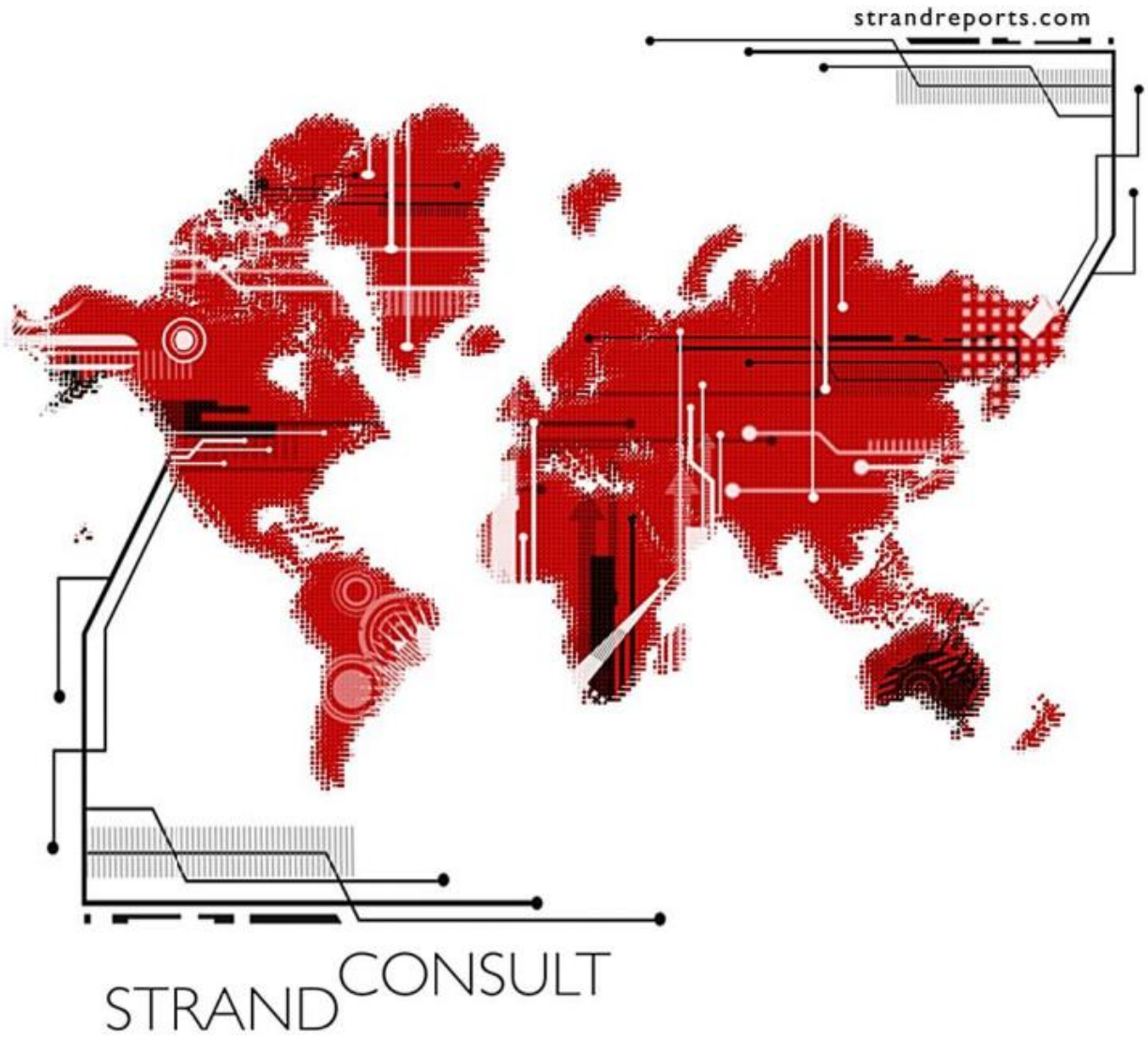

The real cost to rip and replace of Chinese equipment in telecom networks

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1. Introduction

This paper offers a critical review of the discussion of whether to replace mobile network equipment made by firms owned and / or affiliated by the Chinese government, notably Huawei and ZTE. The need for network security is not a new debate. Since 2005 many intelligence officials, militaries agencies, and security analysts have noted security risks of using such equipment, including theft of intellectual property, surveillance, espionage[1], and sabotage. Based on these reports, the United States, New Zealand[2], and Australia[3] have restricted Huawei and ZTE from networks.

The question for Europe is whether and to what degree its telecom operators can operate their networks without Chinese-made equipment and the impact of replacing the equipment for security reasons. A Huawei-funded analysis suggests that restricting Huawei from European networks will cost the region $62 billion, delay rollout for 18 months, and reduce competition in the network equipment market.[4] Such an analysis is based upon assumptions that the market for network equipment is perfectly competitive (which it is not) and that there is no security risk to using Huawei equipment (which there is). While this paper does not delve into the security discussion, suffice it to say that if there were no security risk to doing business with China, then NATO would buy Chinese fighter planes. There are categories of products and services whose supply is restricted for justifiable security reasons, and national security has long been a part of telecom policy and regulation.

Network security concerns have greater seriousness given the shift to 5G and the virtualization of networks. With increasing integration of software in network equipment, backdoors are increasingly difficult to detect, as they can be shipped in subsequent software upgrades or activated after security clearances are concluded. While US government officials may have been the most visible and vocal on the issue, many firms which have experienced hacking and IP theft have advocated for the restriction of Chinese-made

[1] China's cyber-spies make money on the side by hacking video games - MIT Technology Review; https://www.technologyreview.com/f/614088/chinese-hackers-do-double-duty-operations-for-espionage-and-profit/
[2] Where is Huawei banned from working on critical networks: https://www.theguardian.com/technology/2019/apr/19/where-huawei-is-banned
[3] ECIPE: 5G and National Security After Australia's Telecom Sector Security Re-view: https://ecipe.org/publications/5g-national-security-australias-telecom-sector/
[4] Europe's 5G to cost $62 billion more if Chinese vendors banned telcos: https://www.reuters.com/article/us-huawei-europe-gsma/europes-5g-to-cost-62-billion-more-if-chinese-vendors-banned-industry-idUSKCN1T80Y3

network elements.[5] [6] They have not done this publicly, but rather through by selecting a network provider which offers more robust security by ensuring that the network does not contain Chinese-made equipment. Indeed, the passage of China's National Intelligence Law in 2017 has prompted network providers and their corporate clients to take the threat even more seriously, as the law compels any Chinese subject to conduct espionage on behalf of the government.[7]

Strand Consult's new report ***The real cost to rip and replace Chinese equipment from telecom networks*** examines the claims about Huawei and the larger questions about restricting Chinese-made equipment including

- What factors drive investment in mobile networks?
- Would restrictions on Huawei and ZTE increase equipment prices?
- Would restrictions on Huawei and ZTE reduce competition?
- Would restrictions on Huawei and ZTE delay the role out of 5G?

It describes why operators invest in network equipment, the factors that influence the decision, and a description of the global market for network equipment. Restrictions did not result in price increases in the US or Australia and are unlikely to negatively impact Europe because Huawei and ZTE's footprint in the Europe is but 6 percent of the world's total outlay. Strand Consult estimates that the cost to replace Huawei equipment is but $3.5 billion, or €6.5 (7 dollars) per mobile subscriber. Notably mobile operators must upgrade their equipment for technological reasons, regardless of whether Huawei and ZTE is in the market or not.

Restricting Huawei and ZTE from network does not harm the economy for Europe's mobile operators nor does it meaningfully reduce competition nor does it delay rollout. However, removing Huawei and ZTE equipment from the network can greatly improve security.

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[5] China's cyber-spies make money on the side by hacking video games - MIT Technology Review: https://www.technologyreview.com/f/614088/chinese-hackers-do-double-duty-operations-for-espionage-and-profit/

[6] Stealing Thunder: Cloud, IoT and 5G will Change the Strategic Paradigm for Protecting European Commercial Interests. Will Cyber Espionage be Allowed to Hold Europe Back in the Global Race for Industrial Competitiveness? https://ecipe.org/publications/stealing-thunder/

[7] What you need to know about China's intelligence law that takes effect today: https://qz.com/1016531/what-you-need-to-know-about-chinas-intelligence-law-that-takes-effect-today/

2. Strand Consult´s key findings

- In the last two decades, Europe has fallen from being the global leader in mobile technologies to a laggard. Europe once had six manufactures of mobile phones supplying half the world's mobile users. The region no longer makes mobile phones. Europe once accounted for one-third of the world's mobile infrastructure investment, today comprises only 10-15 percent, and that number includes Russia and Turkey.

- Accumulating layers of telecom regulation have driven private investment out of Europe. Investors favor the US and Asia because they can earn better returns. Europe has an investment gap of €100 billion to reach the EU's connectivity goals.

- The Chinese infrastructure providers Huawei and ZTE spend of millions of dollars on public relations and media outreach.[8] The news has many uncritical stories about the firms which don't stand up to scrutiny.

- China poses a security threat to Europe[9], as many have experienced hacking and intellectual property theft from Chinese actors. Policymakers and the public are starting to ask questions about the risks presented by companies such as Huawei and ZTE.

- It is not logical that the Chinese government has locked down the country's telecom networks but would allow wanton cyber hacking to proliferate. The reality is that many of the cyber attacks delivered from China originate with state-supported hackers.[10]

- Those skeptical of the claims that Chinese-made telecom equipment poses a threat to security should ask themselves whether they would be okay with NATO buying a fighter plane made in China. Why is there universal agreement that military equipment from China be

[8] Huawei hires Jones Day: https://www.politico.com/newsletters/politico-influence/2019/04/08/huawei-hires-jones-day-422432
[9] In China, the government controls everything except the 100,000 hackers attacking Western targets every day: http://telecoms.com/opinion/in-china-the-government-controls-everything-except-the-100000-hackers-attacking-western-targets-every-day/
[10] China's cyber-spies make money on the side by hacking video games - MIT Technology Review: https://www.technologyreview.com/f/614088/chinese-hackers-do-double-duty-operations-for-espionage-and-profit/

restricted but not telecom networks where vital information is transported?

- A Huawei-funded industry source suggests that restricting Huawei from European networks will cost the region €55 billion and delay rollout for 18 months.[11] That claim does not stand up to scrutiny.

- The claim that Huawei is needed to create competition cannot be supported by the fact that the company increasingly has a monopoly position and it uses anti-competitive practices.

- To evaluate the impact of restricting Huawei equipment from networks, one must include the fact that operators must upgrade their networks if they want 5G, regardless of whether they use Huawei. That is to say that there is a sunk cost to network upgrades which must be subtracted from the total cost of using Huawei. Most of Europe's networks are already 3-5 years old and are ready to be replaced.

- In any case, 70–80 percent of the existing RAN equipment must be replaced, regardless of the political decision or the choice of vendor.

- In the last 3 years mobile operators have bought radio access network (RAN) equipment for $8.75 billion (about $2.9 billion annually). Forty percent of this equipment has been purchased from Huawei and ZTE. A conservative estimate suggests that replacing the Huawei and ZTE equipment purchased since 2016 (which probably can be upgraded to 5G) will cost $3.5 billion. This is equal to $8.75 billion x 40 percent. This amount compares to 14 months of total European radio access network (RAN) purchases, a small number both for Europe and the world.

- At year-end 2017, 85 percent of the population in Europe (465 million people) subscribed to mobile services.[12] The actual cost to replace the Chinese equipment is $3.5 billion for the non-upgradeable equipment. The cost is equal to a "one-time cost" of €6.5 per mobile subscriber.

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[11] Europe's 5G to cost $62 billion more if Chinese vendors banned telcos: https://www.reuters.com/article/us-huawei-europe-gsma/europes-5g-to-cost-62-billion-more-if-chinese-vendors-banned-industry-idUSKCN1T80Y3

[12] The Mobile Economy in Europe 2018: https://www.gsmaintelligence.com/research/?file=884c77f3bc0a405b2d5fd356689be340&download

- Upgrades to 5G can be achieved without using Huawei and this can be achieved without sacrificing economy or competition. Importantly, removing Huawei equipment from the network greatly improves security.

3. What factors drive investment in mobile networks?

There are two modes of network investment; the continuous upgrade or the one-time swap. In the first mode, investments in the network are not separate and discrete, rather they reflect a flow of continuous investments over time in an evolving network. However, when shifting from 2G/3G to 4G, many operators made a one-time swap, as the equipment required was significantly different than previous generations, and new antennas and base stations were required. However, Telenor Norway and TDC Denmark performed a 4G swap, replacing key hardware and software components without increasing their capital expenditure (CAPEX).

Operators face many decisions when upgrading mobile networks: which spectrum to use, which suppliers to select, which mix network strategy to employ, which devices to promote, which banks to work with, which timeframe to deliver, which locations to enable and so on. The decision can be likened to where one buys a new car or maintain an old one.

The components of a modern mobile network are neither uniform nor static. Each mobile operator will employ a slightly different strategy of spectrum, radio access network (RAN) equipment, and networks planning. Within the basic components of a RAN network, there are fluid elements which are constantly being upgraded. This applies to hardware and software.

In practical terms, hardware and software within the network are constantly being upgraded and improved as the standards evolve from 2G to 3G to 4G to 5G, and in many cases, operators may offer a blend of different standards in the same network as they upgrade. European operators are facing the upgrade of 4G networks built between 2012 to 2016.

All operators must overhaul and modernize network equipment which is more than 3-4 years old.. The upgrade is necessitated not only by the technology shift, but the need increase network capacity as traffic has exploded 20-50 percent on mobile networks.

5G upgrades will be influenced by following trends:

- Refarming of spectrum earlier used for 2G/3G to be used for LTE/5G.
- Introduction of multiple input-multiple output (MIMO) and massive MIMO technologies to increase capacity. This also includes 2x2 and

4x4 MIMO with the aim of increasing the capacity of existing and new LTE/5G bands.

- Purchase of new equipment to support the spectrum in 700 MHz, 3.5 GHz and other bands such as 26 GHz and 39 GHz.

- Upgrade and consolidation of antennas. The number of antennas an operator must deploy is party a function of the amount and type of spectrum is being used. Technologies like M-MIMO require new equipment.

- This process also includes a plan for when to shut down 3G and possibly 2G and when to start using these frequencies for LTE and 5G.

To get a network 5G ready, the operator must determine what equipment must be swapped versus what can be upgraded. The new 5G frequency bands, in combination with existing bands and new mid-band spectrum, will provide capacity and coverage. Mobile operators need hardware and software that supports flexibility as 5G begins to take hold.

An upgrade to 5G allows operators to increase network capacity and reduce operating cost (OPEX). While there are significant upfront costs to create a 5G network, all things being equal, a 5G network is more efficient to operate over time. Hence CAPEX may increase in the short run, but OPEX decreases in the long run for the given location or set of subscribers. Each mobile operator must calculate the capital expenditures (cost of investment and upgrade etc.) versus the long efficiencies from better technology. The calculation will not be the same for every operator, as it also depends on the operator's business strategy, customer base etc.

4. How mobile operators plan network investment and upgrades in 2019

Network investment decisions can be complex and take place over time. At the basic level, the mobile operator earns revenue from their customers, and operators must use that revenue to conduct the day to day business while planning future investment. There are some important economic points about the mobile operator's business which can impact the decision of when, how, and how much to invest.

- Sales account for 100 percent of the operator's revenue
- CAPEX accounts for 12-15 percent of revenue
- CAPEX fluctuates in relation to technological cycles
- Mobile infrastructure CAPEX is 30 percent of total CAPEX
- Of the CAPEX spent on equipment, 80 percent is RAN. 20 percent of that is core, backhaul, and backbone.
- Mobile operators capitalize their rollout costs, meaning they record investment in the financial statements as a capital expenditure.
- The CAPEX cost generally includes equipment but as much as 40 percent could be the installation, labor, and other costs associated with the rollout.
- While network expenditure is a significant cost for mobile operators, sales and marketing costs represent an even larger portion of the overall budget. Indeed, sales and marketing expenditures can comprise 20-25 percent of revenue, up to twice what is spent on infrastructure. This reflects that the mobile industry is highly competitive, as customers frequently change operators, and operators must win new customers.

4.1. The role of regulation in network investment

In recent years, overly strict regulation in Europe and the European Commission's unwillingness to allow mobile operators to consolidate has meant that operators must focus on alternative ways to reduce costs.[13] The strict regulatory regime in EU has both reduced operators' willingness to invest and investors' willingness to let operators use money for investment. In the last decade or so, capital has largely flowed out of Europe to regions with more growth opportunities, notably the US and Asia. The European total mobile in Europe revenues reached €143 billion in 2017 and is expected to be €144 billion by the end of 2025, a compound annual growth rate (CAGR) of 0.1%[14]. This anemic rate of growth underscores how EU regulation has hollowed the market.

In many countries, operators' lower costs through network and infrastructure sharing (meaning that two or more operators use the same mobile mast, not to be confused with reselling) and outsourcing parts of their business to actors which can operate these parts more efficiently.[15]

In the last two decades, Europe has fallen from being the global leader in mobile technologies to a laggard. Europe has an investment gap of €100 billion to reach the EU's connectivity goals. Europe once had six manufactures of mobile phones supplying half the world's mobile users. The region no longer makes mobile phones. Europe once accounted for one-third of the world's mobile infrastructure investment, today comprises only 10-15 percent, and that number includes Russia and Turkey.

The media narrative is that without Huawei and ZTE, Europe's telecommunications networks will be more expensive and take more time to deliver. However, this view does not match the European policymakers' pronouncements that there is a €100 billion telecom network investment gap in the EU. If Huawei equipment is so inexpensive and advanced, why has the EU been failing to reach its connectivity goals for years? Moreover, how can it be that the US, without any of its major operators using Huawei equipment, has a leading position in 5G? The overall role of policy and regulation has a significant impact on whether and how much an operator invests.

[13] Mergers: Commission prohibits Hutchison's proposed acquisition of Telefónica UK: https://europa.eu/rapid/press-release_IP-16-1704_en.htm
[14] https://www.gsma.com/r/mobileeconomy/europe/
[15] Mobile Network Sharing Database: http://www.coleago.com/mobile-network-sharing-managed-services/mobile-network-sharing-database/

4.2. Other features of network investment

Regulation and changing technology have driven changes in the traditional network equipment business model. The role of a network supplier is changing with new technologies. Here are the four main trends:

- Through outsourcing, CAPEX is converted to OPEX: Towers, managed service, backhaul etc. Operators can reduce large, upfront investment to lower ongoing operating costs, giving better economy to the business. This is "continuous upgrading on the go."

- Upgrades of the network are increasingly software-based versus the past when they were based largely on hardware.

- This value in the network is increasingly in software, not in the hardware.

- New players are entering the network infrastructure space, particularly software companies. This reduces the importance of the traditional network equipment provider.

The 5G network is a technological evolution based on cloud network architecture, allowing new vendors and open source solutions to enter this market with more disruptive commercial models than even Chinese vendors.[16] Huawei's strength is largely hardware, not software. This is important policy consideration as the type and number of equipment providers is less important than the role of software. It is too simple and incomplete to characterize the network equipment market as merely Huawei, ZTE, Ericsson, and Nokia.

[16] AT&T, Verizon Inch Toward Open RAN: https://www.lightreading.com/mobile/5g/atandt-verizon-inch-toward-open-ran/d/d-id/753986

5. The global infrastructure market

The market for network equipment is global and can be divided it into six regions: Europe, North America, Middle East & Africa, Asia Pacific, and Latin America.[17] There are many factors that drive the market share of network equipment providers, including the government and economic system.

Europe, while regulated, allows greater market freedom and does not require firms to fulfill predetermined market share. Huawei and ZTE has thrived in this environment, growing in part with aggressive discounting and financing from Chinese state banks. Huawei and ZTE's market share has grown from 0 to 40 percent during 2000 to 2015.[18] Huawei has fulfilled a key business objective for European companies to replace their 2G/3G equipment with new equipment that supports 4G.

European mobile operators have a total CAPEX of $30-35 billion annually. The market for RAN equipment drives 20-25 percent of a mobile operator's CAPEX, but just 12-18 percent for integrated operators. A mobile operator's spending for RAN can be categorized into three areas:

1. Radio equipment including software, hardware, antennas, cables.
2. Installation and commissioning of services
3. Labor to install, maintain and repair the physical sites and network. That includes steel and concrete constructions for RAN equipment.

The installation and commissioning market are run by sub-contractors which service all the network equipment suppliers.

The global RAN market today is roughly $29 billion.[19] China's RAN market is about than 25 percent of the world total and twice that of Europe. Notably Europe's share of the world total has fallen considerably from 2000 and is just 10-15 percent of the world total today. The European market also includes Russia, the former Russian republics and Turkey, about $4.4 billion. The EU only component is in the range of $2.9 billion.

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[17] Dell Oro Group MOBILE RAN FIVE YEAR FORECAST REPORT 2019 – 2023: https://www.delloro.com/market-research/telecommunications-infrastructure/mobile-radio-access-network/
[18] Gavekal Dragonomics: The Size Of State Subsidies: https://research.gavekal.com/gavekal-dragonomics
[19] Dell Oro Group MOBILE RAN FIVE YEAR FORECAST REPORT 2019 – 2023: https://www.delloro.com/market-research/telecommunications-infrastructure/mobile-radio-access-network/

Restrictions on Huawei and ZTE equipment for 5G would have little to no impact on European operators because most of the EU's operators have yet to deploy 5G. However, if modeling the impact where to forcibly require the upgrade of all Huawei 4G equipment in the EU, it would only impact those operators which have already contracted with Huawei and ZTE. About half of the EU's capital expenditure on RAN equipment is from Huawei and ZTE, totaling $1.8 billion. While Huawei and ZTE together have 40% market share in Europe, this translates to just 6 percent of the world market for RAN.

5.1. Would a ban on Huawei increase equipment prices?

There was concern that a ban of Chinese equipment in Australia would increase equipment prices. This did not happen, and it is worth reviewing why. Network operators have purchasing partnerships and global collaborations. For example, Telenor and Telefonica are global operators which buy together across multiple countries, allowing them to enjoy value pricing. The cost for network for a single country has limited impact on price.

The US market experienced a consolidation in 2016 in which Nokia bought Alcatel-Lucent. At that time, Ericsson controlled more than 40 percent of the US RAN market with the remainder split between Nokia, Alcatel-Lucent, and Samsung.[20] Despite moving from a market with three major suppliers to a market with two large suppliers and a small one, prices in the United States we have indications on the *fallen*, not increased. Simply put, operators use different technological strategies, and they take different amounts of "ingredients" for the recipe to make a network.

Perhaps most interesting is that the US has gained a leading position in 5G without using Huawei equipment. Ericsson and Nokia have large market shares, and Samsung is gaining rapidly. Consolidation in the US has given Samsung opportunities it would not have had otherwise.

Assume for the moment that the network security threat can be isolated by removing Huawei equipment over the next five years. Most of the equipment which would fit that bill is already at least three-years old and ready for replacement anyway.

[20] Allan L Shampine: https://www.compasslexecon.com/cases/nokia-and-alcatel-lucent-merger/

Strand Consult's conservative estimate of replacing Huawei and ZTE upgradable equipment purchased since 2016 is equivalent to $3.5 billion. This equals the 40 percent market share that Huawei and ZTE has today times $2.9 billion times 3 years. This equals about 14 months of European RAN purchases, a small number both for Europe and the world.[21] At year-end 2017, 85 percent of the population in Europe (465 million people) subscribed to mobile services.[22] Replacing Huawei and ZTE equipment can also be represented as a "one-time cost" of €6.5 per mobile subscriber.

In any case, the other 70–80 percent of the RAN equipment must be replaced anyway for 5G, regardless of the political decision or the choice of vendor. While the restriction is certainly difficult for Huawei, the impact to the market of restricting Huawei is minimal. Moreover, a major consolidation is needed with the proliferation of aging mobile masts and antennas. The network equipment provided by Huawei is a fraction of the total CAPEX a mobile operator must spend.

When considering what it would cost to replace equipment of known security risk, it is important to remember that telecommunications operators are already in process to replace and upgrade their network equipment. To estimate the impact of restricting Huawei and ZTE, it is important to identify the portion of the network equipment provided by Huawei and ZTE.

Some wrongly assume that that the upgrade or replacement cost is simply a linear function of the next mobile standard, e.g. 2G, 3G, 4G, to 5G. This is incorrect; network investment does not proceed in a linear fashion. Moreover, improvements in network capacity are logarithmic. A proper analysis would account for the following:

- Costs associated with the replacement of Huawei and ZTE radio access network (RAN) equipment that operators have purchased over the past three years and which can be upgraded to 5G.

- Cost for removing the Huawei/ZTE RAN equipment

- Cost associated with setting up the new non-Chinese RAN equipment.

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[21] Dell Oro Group MOBILE RAN FIVE YEAR FORECAST REPORT 2019 – 2023: https://www.delloro.com/market-research/telecommunications-infrastructure/mobile-radio-access-network/

[22] The Mobile Economy in Europe 2018: https://www.gsmaintelligence.com/research/?file=884c77f3bc0a405b2d5fd356689be340&download

- Price difference between Chinese and substitute providers

In practical terms, the mobile operators wanting to launch 5G face a technology change requiring that much of their equipment, including their core network, must be upgraded anyway. Therefore, the relevant figure is the incremental cost of the new network equipment less the expected cost of what was to spent anyway in the normal course of upgrade.

5.2. Would a ban on Huawei reduce competition?

Classical economics suggests that perfect competition is a function of the number of firms in the market. It also assumes that the goods being sold are the same or at least similar. Moreover, the theory requires perfect information among participants and minimal government intervention. The market for network equipment is not perfectly competitive, so the claims about restricting Huawei harming competition do not hold.

While mobile operators may offer mobile services, they use significantly different technological, network, and distribution strategies. Hence each mobile operator demands a unique set of equipment. A mobile operator's spectrum holdings will also determine the amount and type of equipment an operator will use. Simply put, technology differentiation is more important than the number of firms.

Some suggest that if Huawei is restricted from operating in Europe, then other firms would not be able to produce the needed equipment. While Huawei and ZTE are large suppliers in Europe, the region itself is but 10-15 percent of the global market, and of that, the Chinese firms only supply 7 percent. Thus, if Huawei was restricted, it would not be difficult for other global firms to fill the gap.

Limited government intervention and perfect information are also features of competitive markets. The Chinese government has one of the world's most interventionist industrial policies, in which the government designates the national champion, funds its development, sits on its board, dictates the standards, and so on. the Chinese government allocates market share in advance with a complicated formula which is weighted to Chinese providers. Huawei is assured at least 50 percent; Ericsson and Nokia, around 20 percent[23]. Moreover, Chinese government and industry are "fused" in such a way as to be interchangeable, a setup unknown in market economies, and

[23] Dell Oro Group

which affords Chinese industry a front for the Chinese military.[24] Huawei offers products with deep discounts (offers which could likely trigger predatory pricing or dumping claims) and favorable financing from Chinese state banks. This kinds of conditions and arrangements are illegal in most market economies and are not enjoyed by Huawei and ZTE's competitors.

Finally, when making a decision on network equipment vendor, some operators have the knowledge that their corporate customers have experienced theft and hacking by Chinese networks and therefore want the assurance of non-Chinese equipment. In other cases, operators do not have full information about the security threats and risks. Many mobile operators have unwittingly purchased Huawei equipment without duly being informed of the risks.

5.3. The historical experience of consolidation

In the last two decades, the network equipment market has experienced massive consolidation. This consolidation has been driven by four factors:

- Technological shift in mobile standards
- Financial pressure from mobile operators
- The evolution of hardware to software network solution
- The role of subsidies from Chinese banks to buy market share.

This section will describe each trend.

At the dawn of the mobile network there were competing standards such as Group Special Mobile (GSM), Digital Advanced Mobile Phone System (D-AMPS), Code Division Multiple Access (CDMA), and analog solutions.

The industry has consolidated from 20 top tier providers in the 2G market in 1989 to 12 top tier providers in 1999 to 5 top tier providers in 2019. Many of the first-generation enthusiasts did not make it out of the 1G analogue cellular world into the world of 2G digital cellular.

Over time the GSM standards family (GSM, WCDMA, LTE etc.) became the de factor basis for the roadmap, the standard for global economies of scale

[24] Kokas, Aynne, Cloud Control: China's 2017 Cybersecurity Law and its Role in US Data Standardization (July 26, 2019). Available at SSRN: https://ssrn.com/abstract=3427372 or http://dx.doi.org/10.2139/ssrn.3427372

and the industry benefits such as lower unit costs. Those equipment suppliers which focused on CDMA and analog exited the market.

Mobile operators have exerted tremendous pressure on network suppliers by holding back on their purchases. European mobile operators spent €110 billion for frequencies in the 3G auctions around year 2000. However, their business models to monetize the spectrum by increasing subscriber fees did not pan out. Many mobile operators folded or were acquired.

Another key trend of the information technology revolution has been the shift from hardware to software. This development allows mobile operators differentiate their network strategies. It has also allowed new kinds of software providers to emerge, supplement, partner, and compete with traditional network hardware providers.

Huawei and ZTE themselves have also benefitted from these shifts. However, they are unique in the market today as the have the backing of the Chinese government whose industrial policy favors them, along with Chinese banks which give them and their customers favorable financing. This has been crucial for the Chinese players to compete in the European market. Huawei's competitors do not enjoy the same advantages. Indeed, such European state support for European firms is illegal.

It is important to remember that in classical economic modeling of competitive markets, there is little to no government intervention. As such, to attribute Huawei's success to natural "free market" forces is incorrect. Huawei and ZTE have relied heavily on state support and promotion. The modern antitrust analysis would likely find the price erosion brought by the Chinese players as a method of unfair and discriminatory competition.

In any event, the network equipment market has become more efficient over time. Mobile operators can upgrade and replace equipment more economically than in the past.

It also bears mention that should Huawei continue in the EU, it is unlikely to use price competition as a means of differentiation going forward. While it may have relied on lower prices to deliver 3G and 4G equipment, for 5G it will try to win a premium price keeping with the pattern of established firms with large market share.[25]

The mobile market in Europe and the world has changed significantly from 5 years ago and continues to change. Technology itself, notably the

[25] Christensen, Clayton M. The innovator's dilemma: when new technologies cause great firms to fail. Harvard Business Review Press, 2013.

upgrade to new mobile standards, has been a driving force to create competition in the mobile, and increasingly mobile operators compete with wireline providers.

Some other factors also merit mention. In the mobile industry's youth, competition favored operators who were first to market with the coolest phones and those which the most generous phone subsidies could win market share. Today smartphones are a largely a commodity, and operators can no longer differentiate on this element. Market entry and new distribution models have also changed the competitive landscape. Regulation on prices, termination, and roaming has also plays a role, though in some cases, it helps established players and reduce incentives for network investment.

European mobile operators have seen their profit squeezed, and regulation has blocked measures for then to gain scale and operational efficiency. This restricts the ability of mobile operators to invest in infrastructure. In this situation, the European operators have exploited the market opportunity created by the Chinse vendors. As a result, non-Chines equipment vendors have been pressured to lower prices, and many have exited. Nokia and Ericsson subsequently purchased many of these firms. Today's Nokia is a result of six different mobile equipment vendors (Nokia, Siemens, Motorola, Panasonic, Alcatel and Lucent). Ericsson is a result of 4 different mobile equipment vendors (Ericsson, Marconi, Nortel, and parts of Qualcomm).

The claim that Huawei and ZTE is needed to create competition cannot be supported by the fact that the company increasingly has a monopoly position and it uses anti-competitive practices.

5.4. Would a ban on Huawei delay the role out of 5G?

The speed of 5G rollout in Europe will be largely be determined by regulatory policy and investors' appetite, not the choice of network equipment provider. Operators must upgrade 70–80 percent of the existing RAN equipment, regardless of the political decision or the choice of vendor. Restricting Huawei from US networks did not slow rollout in the US, which now has a leadership position in 5G. However, the speed of rollout has been a function of policy,[26] not the network equipment provider. For example, twenty US states adopted a model code of small cell deployment. Moreover, the FCC has capped the fees that cities can charge for pole attachments and the length of time a municipality can take for application review.

[26] https://www.fcc.gov/5G

6. Conclusion

The European market represents a small and diminishing part of the global radio access (RAN) infrastructure market. Despite Europe getting a lot of political attention, the European share of network equipment market is small. Many political and regulatory measures have caused the Europe's network investment gap, a delay that was already in the making before the rollout of 4G. However, the presence of Huawei equipment, for all its touted benefit of low price and advanced technology, has not given Europe a leg up in the mobile market.

Restricting Huawei and ZTE in Europe will have a minimal impact on price and competition for network equipment. Huawei's competitors are global, and the European share of the global market is very small, and European operators have the ability to negotiate global pricing for their equipment.

European operators must make upgrades anyway if they want to rollout 5G, and the restricting access to Huawei and ZTE will not necessarily raise equipment prices, reduce rollout time, or reduce competition in the market.

If Huawei is restricted, the best that Ericsson and Nokia would expect to share is 3.5 basis points each of new RAN revenue. It is not even clear that they would benefit, as European operators could choose other non-Chinese suppliers such as Samsung. Moreover, software vendors will take up a larger share.

When considering the security risk, the cost of restricting Huawei and ZTE is minor to Europe. However, the benefit in reduced risk and increased security and network resilience is tremendously high. Consider the risk calculus for the many European firms using the networks, and with new equipment would significantly reduce cyber risk. Security is worth paying for, but given improving technology, its price becomes more competitive. Upgrades to 5G can be done without sacrificing economy or competition and without Huawei.

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