

Outlook On The 5G Market

SEPTEMBER 2023



Summary

- 5G offers unprecedented transmission speeds and low latencies which will support networks of the future
- Europe's rollout has lagged the world, due to a lack of legislation and ambiguous guidelines from the European Commission, agitated geopolitics, and lack of spectrum availability
- Security concerns have also slowed the expansion of the network

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Overview of 5G

WHAT IS 5G AND WHY IS IT IMPORTANT?

5G is the 5th and latest generation of mobile network technology. Its widespread rollout commenced in 2019 and is still underway. 5G has brought an extensive range of improvements to its predecessors, paving the way for unprecedented connectivity across the globe. This erupting technology is set to have a transformative impact on the Internet of Things (IoT), enabling a new wave of innovative use cases and significantly upgrading the performance of current applications. The benefits also extend to regular consumers who benefit from higher data speeds and superior network reliability.

KEY DIFFERENCES BETWEEN 4G AND 5G

The key difference between 4G & 5G is the radio frequencies they use. Whilst 4G technology operates on a mid-band spectrum, meaning it uses a range of radio frequencies which provide good coverage and reasonable speeds, 5G offers unparalleled transmission speeds, due to its use of higher frequencies. The use of higher radio frequencies enables numerous improvements to be made to cellular network technology, including significantly lower latency (the delay between sending and receiving information), which in turn results in tremendously fast upload and download speeds. To put these differences into perspective, 4G latency ranges between 60-80ms, whereas 5G promises speeds below 5ms. (1) For mobile network operators (MNOs) to use the high frequencies they use to transmit data, they must lease the rights to use these high-band frequencies from local governments. This is referred to as spectrum leasing and is a crucial controlling factor in the rollout of 5G. Another important advantage of 5th-generation mobile network technology is its method of signal transmission. 4G transmits data using lower mid-band frequencies which have a longer range. As such, it primarily uses cell towers to do so. In contrast, 5G relies heavily upon small-cell technology to enable the transmission of data using higher frequencies. Small cells are roughly the size of pizza boxes, meaning they can be easily deployed, and at a fraction of the cost.

Small cells also provide greater cell density which enhances network capacity. Predecessor mobile network generations often encounter difficulties supporting many devices in one location. (E.g., at concerts or sporting events.) The high frequencies used to transmit signals allow much more data to be transferred at remarkable speeds, and the precision with which the network connects each device allows it to cater for a substantial number of users. This provides a cost-effective and very efficient solution for large scale, intensive IoT applications which require reliable connectivity.

LIMITATIONS OF 5G TECHNOLOGY

The main limitation of this technology is the high mm wave frequencies the network uses for signal transmission. Whilst they allow large amounts of data to be shared in much shorter timeframes, these signals can deteriorate due to external factors. Much of the networks' performance will depend on proximity to the small cell site, requiring operators to install sufficient small cells in urban areas to support adequate network coverage. This translates to significant financial investment commitments for mobile network providers, and unsurprisingly makes rural deployment unappealing, due to lower populations being spread out. On the other hand, transmission on 4G/LTE networks occurs in long-range, low-bandwidth frequencies, requiring fewer small cells and towers, but also delivering slower speeds than its 5G counterpart. One solution being adopted by governments is to mandate the implementation of 4G/LTE coverage for remote areas, requiring companies who wish to implement 5G networks in urban settings to also provide coverage for rural locations.

MAIN USE CASES

Although one might expect 5G's main consumer base to be individual customers, this demographic has been slow to make the switch to the latest generation, as they weigh the costs and benefits of faster downloads and greater bandwidth. The reality is that for the average consumer, 4G speeds are sufficient for everyday use, and the current cost of living crisis is holding many customers back from making the switch. However, there is certainly light at the end of the tunnel for carriers. 5G substantially augments the gaming experience, allowing gamers to explore virtual worlds without lag through AR and VR applications. Service providers recognize this and are using the promise of high-definition media and cloud gaming to drive 5G subscriptions. Carriers' solution to the slow uptake of 5G is to incentivize consumers to switch by offering lucrative premium bundles, offering unlimited data and complementary premium subscriptions to gaming or media services. This approach is showing promising results as regular consumer adoption of 5G steadily increases. AT&T and Verizon have both reported uplifts in the average revenue per user (ARPU) due to more customers upgrading to premium unlimited plans.

As IoT adoption expands at exponential rates, demand for wireless connectivity solutions that can power large-scale, intensive IoT applications, is rapidly rising. This high-speed, ultra-low latency, extremely high-capacity connection allows enterprises to radically improve the efficiency of their operations and provide real-time connectivity between every branch of their organization, increasing productivity, reducing costs, and facilitating communication. The three-pronged partnership between artificial intelligence, IoT and 5G will power the next wave of innovation. The latest generation of mobile technology enables AI models to process massive datasets in minimal time, enhancing these systems' productivity and expanding their capabilities. Real-world applications set to benefit from this partnership include autonomous vehicles and smart cities. Governments have begun leasing spectrum directly to companies, allowing enterprises to integrate private 5G networks into their businesses and power organization-wide connectivity. Logistic companies and factories are just some of the enterprise use cases for whom this will be transformative. The potential for innovation in the IoT space that 5G presents is also tremendous. 5G's capabilities have increased the utility of data-intensive applications such as "digital twins," a cloud simulation of real-world environments and situations. Other concepts previously deemed too costly and data-intensive are now feasible options to explore. 4G's successor is likely to enable a new wave of innovative IoT inventions such as performing highly technical and complex activities from a distance.

5G in Europe

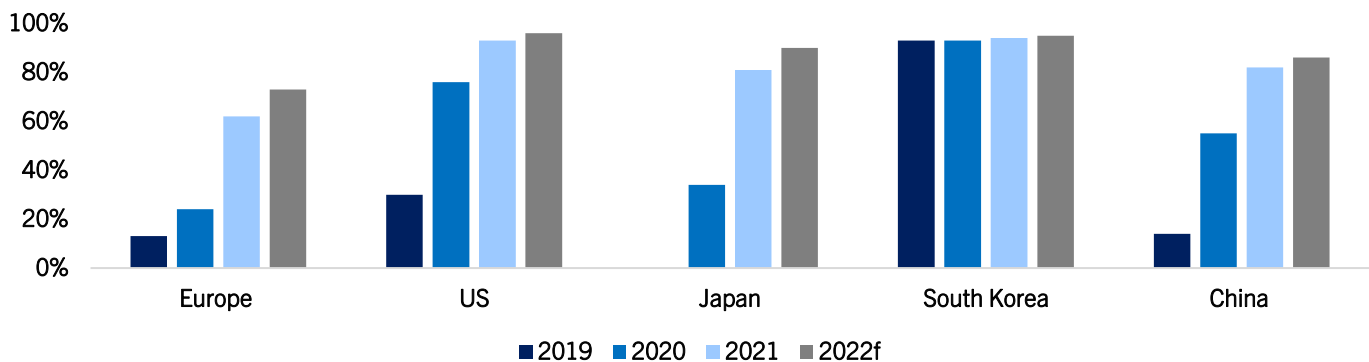
COVERAGE AND UNDERLYING ECONOMICS

The EU has set a 'gigabit for all by 2030' target. Despite having made some progress in the area, a recent report from the European Telecommunications Network Operators' Association (ENTO) signaled that the EU may fall short of its target by about 10%. (2)

As of April 2023, 5G connection was available to 81% of the European population, up from 73% at the end of 2022. (3) Such availability is significantly lower compared to peers such as the United States and South Korea, where coverage had reached 96% and 95%, respectively, by the end of 2022. (4) The underlying cause for this discrepancy could be the lower relative investment per capita of €104.4 in Europe, compared to €149.6 in the United States, and €259 in Japan. (5) As of 2022, Europe has four standalone services (SA) which enable flexibility and applicability; this is essential in accelerating the digital transformation of organizations and the greater society. The projected CAGR of the European 5G infrastructure market is 9.8% from 2023 to 2030. (6) This growth can be greatly accredited to the

expected increase of SA (standalone) services from key players in the industry which have roll-out plans in 2023. (6) In Q4 of 2022, 5G uptake in Europe accounted for 11% of total mobile connections. With subscriptions reaching 150 million by the end of 2023, uptake is expected to increase to 87% by 2030. (7) All EU countries have deployed 5G as of April 2023, but availability only exceeds 40% in three countries. (8) Availability concerns only the proportion of users with 5G compatible devices who predominantly use 5G networks. Cyprus was at the forefront of 5G availability with around 50%, which was close to the United States’ level of almost 56%. (9) Other areas of relatively high availability include Switzerland, Denmark and Greece.

Figure 1: Percentage of Population Covered by 5G by at Least One Operator



Key Players

DEUTSCHE TELEKOM

Deutsche Telekom’s network reaches 95% of the German population with an aim to reach 99% by 2025. The company has stated that 5G SA is now available in the 2.1 GHz band and that commercial use will start as soon as the relevant applications are provided. The European segment, which includes 10 countries has a lower coverage of 47% with a target of 65% by the end of 2023. (10) The company is pursuing a spectrum strategy, having implemented 5G in the 700 MHz low band and the 3.6 GHz high band in almost all of the 10 countries of the European segment, and is developing 5G services in a range of areas including health care, mobility, and entertainment.

ORANGE ESPAÑA

In 2020, Orange originally launched commercial 5G networks in Spain, using non-standalone (NSA) infrastructure. At the start of this year, Orange launched its 5G SA in Spain which covered parts of Madrid, Barcelona, Valencia, and Seville and is expected to cover 90% of these cities and set to reach 11 Spanish cities in total by the end of 2023. (11) As of March 2023, Orange’s 5G network reached 80% of the Spanish population. Orange uses 700 MHz and 3.5 GHz bands but has expressed that it may move to the 26 GHz band, which it has already acquired, subject to its future business needs. (12)

VODAFONE UK

Vodafone UK has made heavy investments in 5G, having recently begun its upgrade to standalone which is set to go commercial next year. As of July 2023, their 5G network (3.4 GHz band) has gone live in at least 161 towns and cities across the UK. (13) At the same time, Ericsson and Vodafone have started deploying a compact active-passive antenna which will bring greater 5G coverage. (14) The company has also announced a collaboration with Samsung Networks Europe which aims to put in

place open RAN network infrastructure in over 2,500 sites which underscores 5G objectives. (15) Generally, Vodafone UK has expressed interest in playing a key role in smart wireless factories in the UK as well as helping homes, transport, and healthcare to operate safer and smarter in realizing “Industry 4.0.”

Key Economic and Political Developments

BANNING OF HUAWEI AND OTHER CHINESE COMPANIES

Since 2019, there have been national security concerns among countries over the use of Chinese components in their 5G networks. Several countries, most notably the UK and US have banned the use of Huawei equipment in providers’ 5G networks, while many other countries such as France have introduced new legislation that restrict the use of ‘high risk’ equipment in 5G networks.

Due to Russian president Vladimir Putin cutting gas supplies to Germany, their reliance on other countries has been brought under scrutiny. While other companies have become less dependent on these Chinese companies, Huawei now accounts for 59% of 5G RAN in Germany. Germany is especially concerned about links between Deutsche Telekom and Huawei, as two thirds of the equipment in their 5G network is supplied by Huawei. (16) If a ban was to be put in place, Deutsche Telekom would incur huge costs. While this ban may delay the rollout of 5G in Europe, it has increased the market share of European core network equipment providers, Ericsson and Nokia. As a result of the ban in the UK, Nokia announced that they had signed a deal with BT to become their largest infrastructure partner. (17) The ban on Huawei also resulted in its other main competitor, Ericsson becoming the leading player in open RAN. (18)

Presence of Chinese Equipment in European Countries' 5G RAN Infrastructure

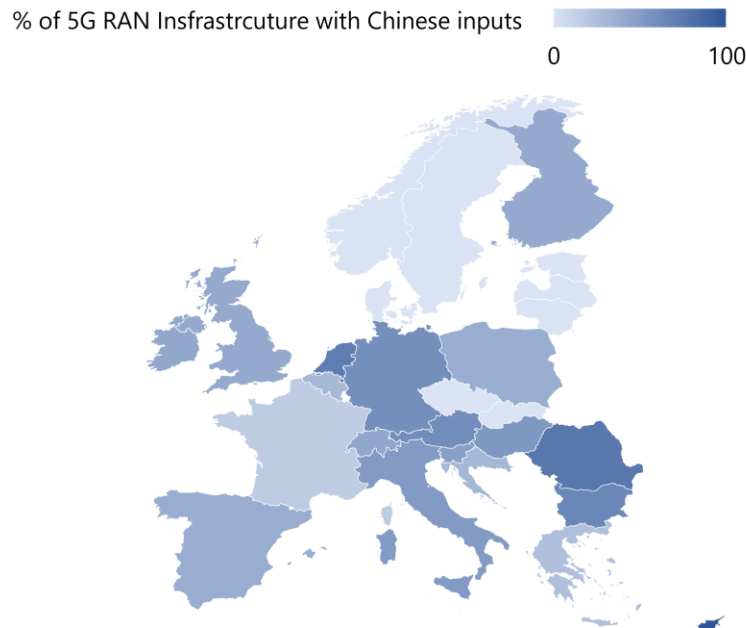


Figure 2:

CONSOLIDATION OF TELECOMS

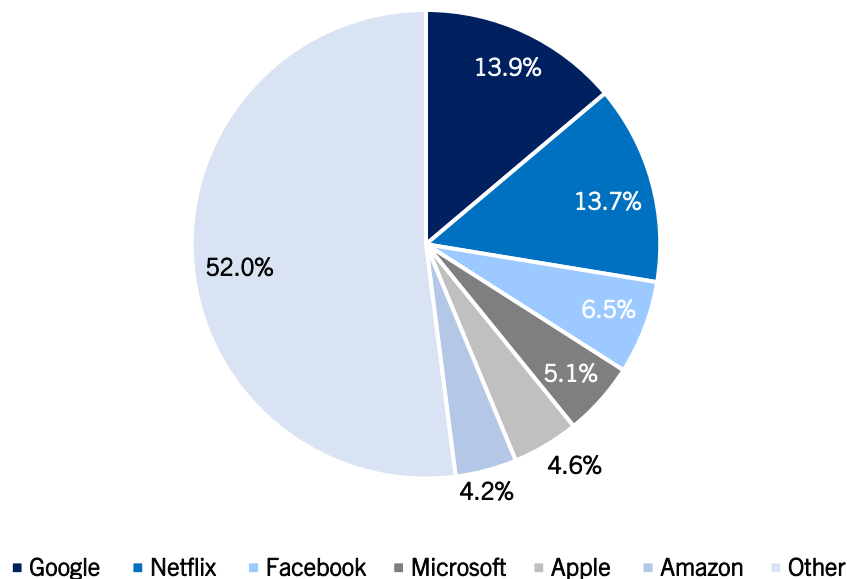
For years, telecommunications companies in Europe have lobbied for regulators to allow mergers between European telecoms operators. The costly roll out of 5G could finally trigger the consolidation of such companies across Europe. A combination of price wars and high levels of debt in the highly competitive market leaves operators reluctant to upgrade to 5G. Germany, Spain, France, the UK, and Italy each have four main telecom operators competing against each other in their own countries. (19) This is compared with three competitors in the US and China, respectively.

Despite large increases in data demand, telecoms operators have not seen an increase in average revenue per customer, due to high competition in the market. For years in Europe mergers have been blocked. However, regulators may now look at consolidation more favorably as it becomes clear that a less fragmented market would accelerate the roll out of 5G, a key part of infrastructure that will play a significant role in the economy and is expected to add billions to Europe’s GDP between 2021 and 2025. (21)

ONGOING BATTLE BETWEEN BIG TECH AND CARRIERS

Data traffic has increased over the last five years and the largest Big Tech companies account for a huge portion of this growth. Meta, Amazon, Alphabet, Apple, Netflix, and Microsoft accounted for almost 48% of global traffic in the first half of 2022. (21) This increase has put pressure on operators to upgrade infrastructure at a rapid pace, yet it is Big Tech that enjoy most of the profits. Artificial intelligence and other developments will only increase the strain on infrastructure. Many telecom companies insist they will not be able to make these critical investments without a contribution from Big Tech. These companies feel they already make a significant contribution by investing large sums in data centres. High band 5G will allow for ultra-fast speeds and low latency which will allow data to be transmitted in near real time and will be central for the tech sector in developing both the IoT and the metaverse.

Figure 3: Contribution to Data Traffic H1 2022

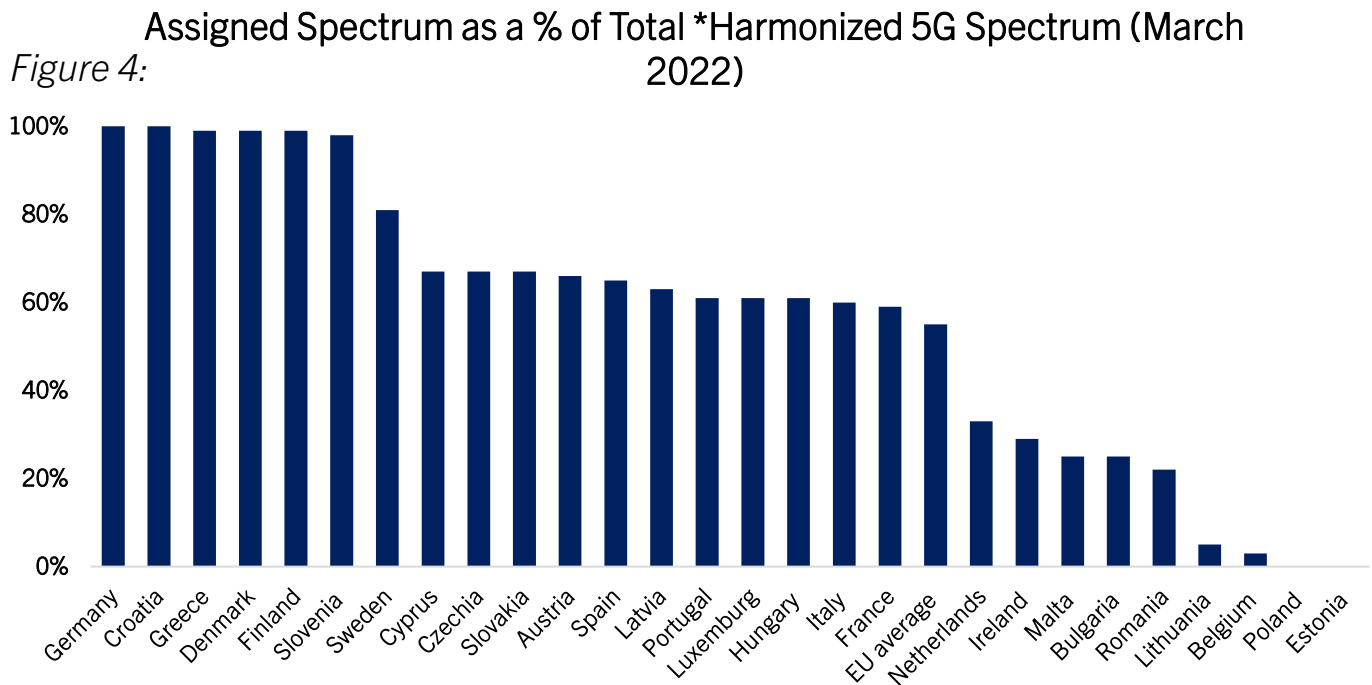


Outlook

While the latest generation of mobile networks has brought ground-breaking improvements to cellular networks, the technology has yet to become mainstream. Very few European MNOs have deployed the most advanced iteration of 5G, referred to as “5G standalone,” where the network core uses the latest technology. Without the most up-to-date advancements, 5G has little advantage over Wi-Fi services or its predecessor 4G. This slow rollout is due to a lack of legislation and ambiguous guidelines from the European Commission, agitated geopolitics, and lack of spectrum availability. The following points are some of the key factors that will determine the future of 5G in Europe.

DELAYED SPECTRUM DISTRIBUTION

A delayed and slow distribution of spectrum licenses by EU member states is strongly to blame for the EU's 5G rollout's stalled progress. Many member states have only caught up with their neighbors or made reasonable spectrum allocation progress in recent months. A lack of sufficient legislation and guidelines from the European Commission has seen each nation adopt its own unique approach to carrying out the auctions, resulting in disjoint pricing across European countries. Most US and APAC spectrum auctions were carried out earlier and in a more structured and transparent manner than in Europe, allowing providers to develop 5G infrastructure at a lower cost and quicker pace. The key difference between Europe and the rest of the world's approach was the role which regulators played. Regulating bodies in the US and APAC prioritized a rapid rollout of 5G networks over extracting the maximum value from their spectrum licenses, while EU regulators limited their involvement in the process and left the management of the auctions to member states. As demonstrated in Figure 4, the distribution of spectrum across the bloc by September 2022 was universally disjoint.



* Harmonized 5G spectrum refers to the alignment of spectrum allocation across nations, a crucial factor for the 5G ecosystem. In Europe, the harmonized 5G spectrum is known as the "pioneer bands."

Another key aspect of spectrum auctions is ensuring that, prior to the auctions, agreements have been made with bordering nations to prevent signal transmission interference. This negotiation process created many issues in Europe, as certain nations failed to reach an agreement on terms, with no independent EU body in place to mediate discussions. Fortunately for the EU, it has now auctioned off most of its C-band (the base layer spectrum for 5G) with only the Netherlands left to commence the allocation of its mid-band, as its government battles legal opposition to the auction. Poland, previously Europe's last remaining nation without dedicated 5G spectrum, recently commenced its auction of its 3.5GHz spectrum band, with all four of its national MNOs placing bids. The EU's regulatory shortcomings have been widely scrutinized and it is expected that as demand arises for higher bands, the same mistakes will not be repeated. With c-band licensing nearly complete, operators can now focus on the physical 5G infrastructure and strengthen the quality of their networks, which will result in the reliable use of 5G in every European country's mobile network market.

CONSUMER ADOPTION

While 5G has brought upgrades that have the potential to revolutionize industries and provide unprecedented connectivity for enterprises, the technology also boasts many advancements that carriers expected would impress consumers. Early consumer adoption of the latest generation mobile network would suggest this is not the case, but there are still reasons for MNOs to remain positive about future 5G demand. The network's rollout in Europe has been slow and plagued with complications, but it is important to acknowledge that 5G rollout has stabilized, and uptake is growing. The premium bundles approach to convert mobile customers being adopted by carriers has proved successful in its early stages. Deloitte's mobile trends survey revealed the percentage of consumers with a 5G device rose from 56% in 2021 to 68% in 2022. (22) This is unsurprising, considering all major smartphones have been supporting 5G since 2020. Furthermore, the firm has estimated the first \$100 5G smartphone could reach markets by the end of 2023. (23) As more people upgrade to 5G-compliant devices, more consumers will be incentivized to upgrade networks, particularly when offered a lucrative premium bundle. GSMA Intelligence reported Q4 2022 5G uptake in Europe accounted for 7.4% of total mobile connections, a drastic increase over the Q4 2021 level of 2.5%. (24) It is expected this pace will continue through to Q4 2023. Over a five-year timeframe, 5G adoption is anticipated to be widespread, with high percentages of the population expected to use the technology, as predecessor generations become outdated and lose functionality, forcing consumers to make the upgrade. Widespread adoption will likely be achieved after the US and APAC markets, due to Europe's trailing uptake.

M&A OUTLOOK IN THE EUROPEAN TELECOMS MARKET

Mergers could have a huge impact on the speed of the 5G rollout over the coming decade as larger operators would mean increased economies of scale resulting in increased investment in infrastructure. While decreased competition may lead to higher prices for consumers, operators would be more profitable, encouraging them to invest more into deploying 5G infrastructure. Telecom operators will wait in anticipation for the ruling on the merger between Orange and MasMovil, however, the impact of this decision is more likely to change outlook in the longer term.

In 2022, MasMovil and Orange reached an agreement to merge their operations in Spain. The European Commission has since opened an antitrust investigation to assess the merger. In the past, the EU Commission has blocked mergers that reduce the number of main competitors from four to three, as seen when CK Hutchinson's attempt to buy O2 was blocked in 2016. Now, however, telecommunications executives are hopeful that the need to accelerate the rollout of 5G will force the EU Commission to be more accommodating when it comes to consolidation. The EC's

verdict was initially due on the 21st of August however this has since been pushed back. If this merger is successful, it could potentially open the door to a wave of consolidation in the market over the next 5-10 years. If this merger is blocked, it would significantly dampen the outlook regarding potential consolidation and indicate that the EU's ambitious targets for 5G by 2030 will not change their competition policy regarding mergers between EU telecom operators.

SECURITY

As Europe embraces its digital sovereignty mission and imposes strict rules against foreign technologies, many European nations are faced with looming security concerns regarding the presence of foreign – particularly Chinese – components in their 5G networks. As geopolitical tensions rise around the globe, distrust between China and the West is at an all-time high. To combat these threats, the EU introduced a “5G Toolbox” risk mitigation framework aimed at identifying and restricting high-risk vendors. Since its adoption, progress has been made to reinforce the security of 5G networks in the EU with many states applying restrictions on high-risk vendors. One problem, however, is that most countries have applied divergent approaches regarding the use of equipment from high-risk vendors or the scope of the restrictions, due to the Toolbox's non-binding measures and its ambiguous definitions of high-risk vendors. Six of the eight main 5G tech providers to the EU are based outside the EU, and the extent of member states' use of high-risk components is likely to be significant. Not only does this pose a worrying security threat, but it also represents a major future expense for carriers. A third of EU nations have already banned Huawei from their 5G infrastructure, but the European Commission is still unsatisfied and has been considering a bloc-wide ban on the use of high-risk companies in the development of 5G networks. The process of removing these products can be very lengthy, and a two-to-four-year grace period is commonplace, due to the complex nature of these networks. If, as anticipated, the use of high-risk components is widespread across 5G networks, the consequences could be severe for the European market. Europe could experience a substantial national security breach if these vendors' ties to foreign governments prove to be true. Furthermore, the task of replacing these components will not only be a logistical nightmare and significantly impact the expansion of 5G in Europe but will also result in substantial financial losses for the providers and states most exposed. It is in Europe's interest to cease using these vendors to mitigate any risk of a security breach.

DEPLOYMENT OF CELL TOWERS

Telecom operators made their initial 5G deployments through traditional cell towers. One factor that can speed up the deployment of cell towers in Europe by reducing duplication of resources is the increasing presence of independent tower companies in the market. According to an EY report, since 2018, independent tower companies' market share has increased from 17% to 35%. The same report details that there are currently 440,000 towers in Europe which is expected to expand at a CAGR of 1-3%. (25) In their 2022 annual report, Cellnex claimed that they are aiming to add just under 20,000 sites by 2030. (26)

DEPLOYMENT OF SMALL CELLS

The 26 GHz frequency 5G band offers the largest capacity and highest broadband speed, which – as mentioned earlier in the report – will allow new types of applications that were not previously possible. Due to the use of higher frequencies that have much shorter ranges, the rollout of high band 5G is reliant on the deployment of a dense network of small cells in urban areas. The European Commission has adopted regulations which aim to accelerate the rollout of these small cells

in the coming year. This regulation sets standards regarding exposure levels, which will continue to inspire confidence and ease health concerns that have slowed the rollout of 5G in European countries such as Switzerland in the past. (27) According to the commission, the regulation aims to help simplify and accelerate 5G network installations, which should be facilitated through a permit-exempt deployment regime while ensuring that national authorities keep oversight. (28)

THE INTERNET OF THINGS

The coupling of advanced cellular network technology and IoT applications has the potential to revolutionize industries in the coming decades. The tangible success of these technologies will be evident over a five-to-ten-year timespan. A PwC study of the economic impact of 5G-enabled use cases across industries forecasts these technologies will contribute \$350 billion to global GDP by 2025, rising to \$1.3 trillion by 2030. (29) The number of IoT devices worldwide is forecast to almost triple from 9.7 billion in 2020 to more than 29 billion IoT devices in 2030. (30) 5G and other technological advancements have helped market the use cases for IoT devices, playing a part in this projected growth. The sectors powered by IoT appliances that are set to yield the highest portion of the economic benefit are manufacturing and healthcare. The enterprise market is also poised to experience considerable growth, according to Ericsson, at a 25% CAGR from 2022-2030. (31) This development is fueled by high-performance mobile connectivity for IoT applications, including connected vehicles, real-time automation and autonomous robotics.

Conclusion

This technology is an exciting prospect for both consumers and network operators, and customers are willing to pay more for the benefits it promises. However, the reality is that its rollout is still in early stages and there are several obstacles that are hindering 5G's success. The current use cases for 5G are promising but many of the services and benefits are not known by mundane consumers. Network coverage must be improved both indoors and rurally too, to guarantee an up-to-standard service for customers. A notable knowledge gap exists in the market, and the advantages of 5G must be better explained and marketed to consumers. None of these challenges pose a long-term risk to its adoption, teasing an exciting future for the technology. We believe that the market for 5G presents significant opportunities for investment and growth over the coming decade. Its early adoption stage and potential security threats, however, pose risk for immediate investment in the sector. Although its growth is accelerating rapidly, we are quite far from widespread 5G adoption. Consequentially, we recommend closely monitoring the sector for any developments. Adoption milestones reached should also be carefully watched. As more and more consumers make the switch to 5G, opportunities for investment will become much clearer and bring lower risk.

About the Contributing Team

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Miguel is a third-year Global Business student and is the Head of Research and an Investment Officer in the Trinity Student Managed Fund for the 2023/24 session. Last year, he was the Industrials Sector Manager and began in the fund as a Junior Analyst in the Real Estate sector. After a successful summer, Miguel will be returning to DigitalBridge as a Private Equity Summer Analyst. Additionally, he has also held internships at Charlesbank Capital Partners, Glasswing Ventures, and built an app to combat food waste. His hobbies include surfing, playing poker, and listening to podcasts.

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Jonathan is a second-year Joint Honors Economics and Mathematics student and is a Senior Research Analyst for the 2023/2024 session. He held the role of Junior Analyst in the Software sector last year and has previously completed an internship at Coalface Capital. Jonathan loves travelling and spent the last summer working in the South of France, before travelling Europe. He also loves rugby and sailing.

LARA WOLF - Senior Research Analyst

Contributing Author

Lara is a third-year Law and Business student and is one of the Senior Research Analysts this year. Last year, she was a Junior Analyst in the Real Estate Sector. This summer, Lara completed internships at A&L Goodbody and Arthur Cox and then traveled in Africa before coming to Australia for her semester abroad.

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