ERIA Discussion Paper Series
No.552

Indonesian Service Sector Review: Telecommunications

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August 2025

Abstract: *This paper aims to assess ongoing advancements in the telecommunications sector in Indonesia, elucidating strengths and weaknesses and offering policy recommendations. The telecommunications industry continues to grapple with challenges such as heavy reliance on imported equipment; pricing issues, particularly at the wholesale level; spectrum management concerns; and ensuring equitable access in addressing the digital divide. To address these challenges, it is imperative to formulate policies that guarantee equitable access and utilisation at affordable pricing, requiring enhanced market conduct and pricing mechanisms. Furthermore, incentivising operators to extend coverage to underserved areas is crucial, given the existing supply constraints in such regions.*

***Keywords*:** Telecommunications, ICT for development, digital divide

***JEL Classification*:** L96, N75, O14

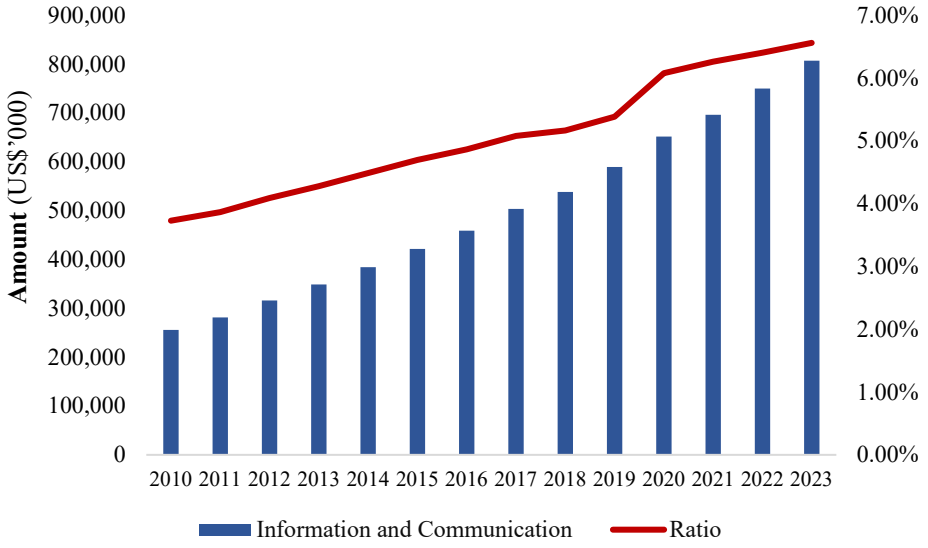
Introduction

The telecommunications sector, a crucial subset of Indonesia's information and communication technology (ICT) industry, plays a fundamental role in economic growth and digital transformation by driving innovation and supporting development. However, challenges such as unequal access, high costs, and limited competition continue to hinder its contribution. These issues restrict its ability to contribute to inclusive and sustainable progress. This paper examines these challenges and proposes strategic policies to enhance accessibility, affordability, and competitiveness within Indonesia's telecommunications landscape. While this discussion focuses on ICT services, such as telecommunications infrastructure, internet services, and digital connectivity, ICT goods like smartphones, network equipment, and electronic components also play a crucial role in supporting the sector's growth and overall development.

Macro landscape

The ICT sector's contribution to Indonesia's gross domestic product (GDP) has steadily increased since 2010, with a significant jump during the coronavirus disease (COVID-19) pandemic as digital services became essential (Figure 1). The share of sectoral value added has consistently increased since 2010. The COVID-19 pandemic was a turning point, leading to a more significant contribution. Figure 1 shows significant growth in the ICT share from 2019 to 2023. The main contribution comes from the increase in ICT use during the pandemic period, as daily activities such as work and school moved online.

Figure 1: ICT Sector Contributions to GDP
(value (US$'000) and share (%))



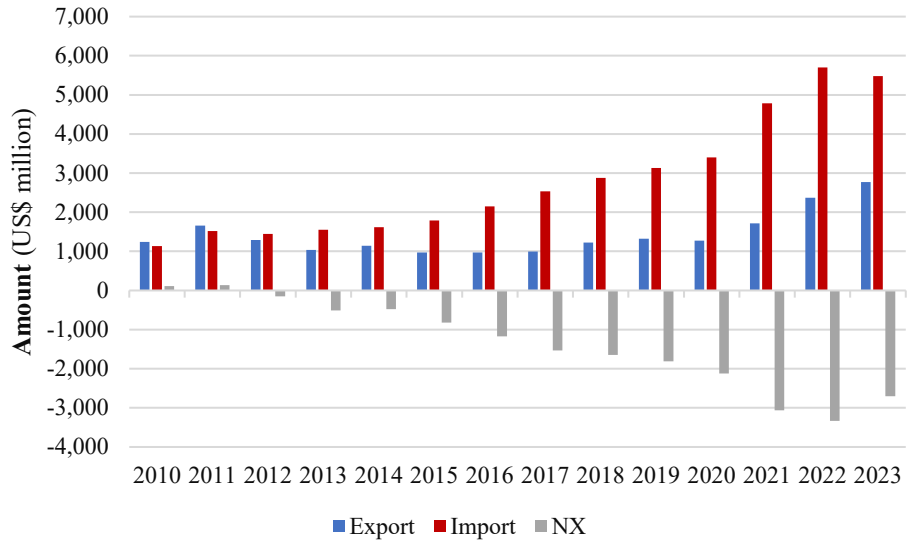
GDP = gross domestic product, ICT = information and communication technology.

Source: Bank Indonesia (2023).

The development of Indonesia's telecommunications industry relies heavily on digital infrastructure. To achieve inclusivity and affordability, significant resources are needed for infrastructure development, which is crucial for meeting market demands. Limited hardware resources often hinder performance in the national economy and at the regional level. However, advancing internet and telecommunications is vital, as ICT forms the foundation of the digital economy (OECD, 2020) that is driving the Fourth Industrial Revolution (4IR) (RIS, 2020).

Indonesia has experienced a persistent current account deficit in ICT services, primarily due to a higher volume of imported ICT services compared with exports. Since 2012, Indonesia's net exports (NX) of ICT services have remained in deficit, with the gap widening significantly from 2010 to 2023. As shown in Figure 2, while ICT service exports gradually increased from $1.24 billion in 2010 to $2.77 billion in 2023, the value of ICT service imports has grown at a much faster rate, reaching $5.48 billion in 2023. The negative NX trend shows a growing dependency on imported ICT services, which widened from –$150 million in 2012 to –$3.33 billion in 2022. Although exports increased in 2023, the deficit slightly improved to –$2.7 billion.

Figure 2: Net Exports of ICT Services Indonesia



ICT = information and communication technology, NX = net exports.
Source: Bank Indonesia (2023).

This rising deficit in ICT services is driven by Indonesia's reliance on foreign digital services, including software development, information technology (IT) consultancy, data processing, and cloud computing services, which are predominantly provided by multinational

firms. The persistent ICT services trade deficit highlights structural challenges in Indonesia's digital economy, including a lack of domestic ICT service providers, limited high-value digital exports, and dependency on foreign technology firms. However, Indonesia remains a competitive producer in certain ICT-related sectors, particularly digital financial services, business process outsourcing, and creative industries. To reduce this deficit, strategic policies are needed to enhance domestic ICT service capabilities, encourage investment in local digital firms, and develop policies that strengthen Indonesia's digital infrastructure.

The current account deficit is also caused by the dependence of domestic mobile network operators (MNOs) and internet service providers (ISPs) in Indonesia on foreign telecommunications service providers. MNOs have yet to be able to provide all the services needed to run the telecommunications ecosystem, especially those related to roaming, international calls, and cross-border internet of things. Domestic MNOs still import General Packet Radio Service (GPRS) Roaming exchange (GRX) and Internet Protocol (IP) exchange (IPX) services from international IPX service providers. Table 1 shows the services provided by Indonesian mobile operators.

Table 1: Services Provided by Indonesian Mobile Operators

<table>
<tr><th>Services</th><th>2G, 2.5G, 3G</th><th>4G, 5G</th><th>Revenue share</th></tr>
<tr><td>Roaming for own customers abroad</td><td rowspan="4">Using GRX partner</td><td rowspan="4">Using IPX partner</td><td rowspan="4">5%</td></tr>
<tr><td>Roaming for customers of other MNOs on their own network</td></tr>
<tr><td>International calls and SMS termination</td></tr>
<tr><td>Cross-border internet of things</td></tr>
<tr><td>National roaming</td><td colspan="2">• Using the mobile network of mobile operators
• Permanent arrangements that are cheaper and more effectively implemented through direct IP links</td><td rowspan="5">95%</td></tr>
<tr><td>Domestic interconnection</td><td colspan="2">• Using the mobile network of MNOs
• TDM and IP links at points of interconnection</td></tr>
<tr><td>Internet/broadband access</td><td colspan="2">• Using the mobile network of MNOs
• Using IXPs and direct IP links to Tier 1 ISPs</td></tr>
<tr><td>Domestic calling and SMS services</td><td colspan="2" rowspan="2">• Using the mobile network of MNOs</td></tr>
<tr><td>Domestic internet of things</td></tr>
</table>

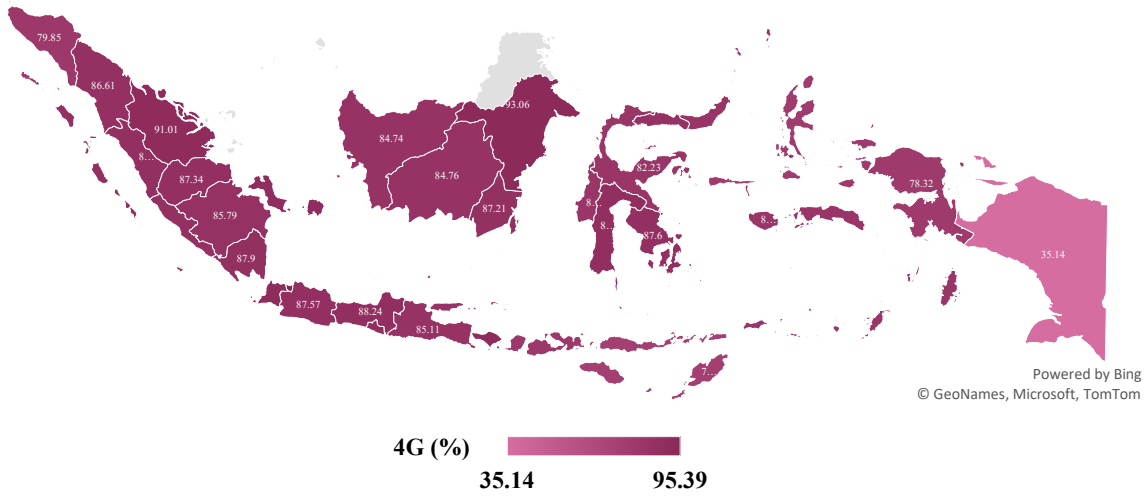
GPRS = General Packet Radio Service, GRX = GPRS Roaming Exchange, IP = Internet Protocol, IPX = IP exchange, ISP = Internet Service Provider, IXP = Internet Exchange Point, MNO = Mobile Network Operator, SMS = Short Messaging Service, TDM = Time Division Multiplexing.
Notes: GRX is a specialised network for mobile data roaming in older networks. IRX is a more advanced, versatile system designed to handle a wider range of services including voice and data for modern telecommunications networks.
Source: RIS (2020).

Indonesian MNOs, except Telkomsel, outsource the international segment of the provisioning of roaming services to global IPX service providers such as Syniverse and PCCW. Outsourcing allows operators to avoid high up-front capital expenditures (CAPEX) for building their own IPX hubs, instead treating these costs as operating expenses (OPEX). This reduces financial risk and improves cash flow, as operators can scale their IPX needs based on usage rather than committing to large, fixed investments. As a result, operators can maintain cost flexibility while generating revenue from IPX services, making them more financially viable. Based on these conditions, domestic MNOs are more interested in continuing to use international IPX service providers, which then continues to burden the current account for ICT services.

The COVID-19 pandemic highlighted the importance of digital infrastructure but also exposed inequalities in internet access across Indonesia. It caused a slowdown in world economic growth but also demonstrated the importance of digitalisation and telecommunications in daily activities. Using the internet during a pandemic to suppress the spread of a virus is a viable solution when people's mobility is limited. However, Indonesia faces the challenge of unequal internet access, as shown by the distribution of 4G internet penetration during the pandemic in Indonesia in Figure 3. We expect to find a significant relationship between 4G access and economic activity, as greater connectivity can facilitate remote work, enable digital transactions, and sustain business operations during mobility restrictions, particularly in areas with robust internet infrastructure. Solutions to this problem are discussed in more detail in the next section.

The pandemic highlighted the importance of digital infrastructure but also exposed inequalities in internet access across Indonesia. The COVID-19 pandemic caused a slowdown in global economic growth but also demonstrated the critical role of digitalisation and telecommunications in sustaining daily activities. Internet access during mobility restrictions proved essential for sustaining economic participation, education, and communication. However, Indonesia faces a challenge in achieving equitable internet access, as shown by the distribution of 4G penetration across regions during the pandemic in Figure 3.

Figure 3: 4G Penetration in Indonesia, 2020



Source: Statistics Indonesia (2020).

Recent studies have suggested that mobile broadband expansion significantly contributes to economic development and poverty alleviation. Ariansyah et al. (2024) found that increased 3G and 4G coverage in underdeveloped regions of Indonesia is associated with a reduction in poverty rates and the poverty gap. This highlights the role of mobile broadband as a key driver of economic inclusion, allowing individuals in impoverished areas to access job opportunities, financial services, and educational resources.

Furthermore, Ariansyah et al. (2024) indicated that 3G expansion has had a more substantial impact on poverty alleviation than 4G, potentially due to broader existing adoption and utilisation. While 4G offers superior speed and efficiency, its impact may be constrained by factors such as infrastructure costs, service affordability, and network coverage limitations in rural areas. Therefore, policymakers should ensure that mobile broadband infrastructure expansion strategies focus not only on increasing 4G penetration but also considering how to use the existing 3G network for economic development.

The economic benefits of mobile broadband are also linked to indirect effects, such as promoting entrepreneurship through e-commerce, improving access to financial services via mobile banking, and fostering new employment models like digital gig work. These factors suggest that enhancing mobile broadband accessibility should be a priority in Indonesia's digital inclusion policies. Given this evidence, we expect a significant relationship between 4G access and economic activity, as evident in Figure 3. Solutions to address disparities in mobile

broadband access include measures such as investment in rural telecommunications, policy incentives for private sector participation, and infrastructure sharing agreements.

Supply side

Universal Service Obligation

The problem of uneven geographical distribution of telecommunications infrastructure and accessibility in Indonesia encourages the government to innovate and find the best solution to overcome the problem. The Telecommunications and Information Accessibility Agency (BAKTI) under the Ministry of Communication and Informatics (Kominfo) is a non-profit public service institution responsible for addressing Indonesia's digital divide. It plays a key role in implementing the Palapa Ring project under the National Strategic Projects (PSN) scheme (see Box), expanding base transceiver station (BTS) infrastructure, providing internet access in 3T (*terdepan* (frontier), *terluar* (outermost), and *tertinggal* (underdeveloped)) regions, and developing digital ecosystems to enhance telecommunications accessibility across Indonesia.

BAKTI invests in telecommunications infrastructure across Indonesia by utilising funds collected from telecommunications operators through the Telecommunications Operation Fee (BHP) and Universal Service Obligation (USO) fees. The BHP is a regulatory fee imposed on telecoms operators for the right to operate networks and services in Indonesia. This fee is set at 1% of gross annual revenue, not based on profit, and is deposited as a source of Non-Tax State Revenue (PNBP). Payments can be made quarterly, semi-annually, or annually, with a 31 March deadline for the previous year, and the calculations must be based on audited financial statements or other valid financial records.

Similarly, the BHP and USO fees are mandatory universal service contributions required from telecommunications operators to support digital inclusion in underserved areas. The BHP fee is set at 1% of gross operator revenue and contributes to Non-Tax State Revenue (PNBP), while the USO fee is set at 0.5% of total operator revenue and is managed by BAKTI. Funds collected through the BHP and USO fee are used to finance the expansion of telecommunications infrastructure, subsidise interconnection costs, implement free access programmes, and reduce tariffs for disadvantaged communities. In 2018, The BHP and USO fee collection reached Rp2.5 trillion, financing the construction of 1,630 BTS towers and 12,148 kilometres of Palapa Ring optical fibre, which connected 90 districts and cities across Indonesia (Rohman et al., 2022).

Nugroho and Nafi'ah (2019) explained that the BAKTI Ministry of Communication and Informatics USO programme has successfully expanded telecommunications access across Indonesia. However, the next challenge lies in maximising the impact of this expanded access by ensuring it effectively supports key sectors such as education, healthcare, and manufacturing. While USO funds have primarily been used for network expansion, there is an opportunity to allocate these funds strategically to support local socio-economic development. For instance, funding could be directed towards digital infrastructure in schools and hospitals, subsidising broadband access for small businesses and fostering digital literacy programmes. By integrating telecommunications expansion with targeted economic and social initiatives, the impact of ICT development in Indonesia could be significantly enhanced, leading to broader economic growth and improved digital inclusion.

Haryadi (2018) explained that in other countries, MNOs and ISPs build networks throughout the country, including in the USO area. This policy sets equal rates between USO and non-USO areas for internet use, based on cross-subsidies to MNOs and ISPs as a mechanism to finance internet access for people in USO areas. For example, the United States requires MNOs and ISPs to build free Wi-Fi in specific locations that can be used by underprivileged people in USO areas. The goal of this approach is to reduce the digital divide by ensuring equitable access to telecommunications services.

Compared with other economies, Indonesia's fees to fund USO projects are relatively low. For instance, India funds its USO infrastructure through a 5% Universal Service Levy on telecoms operators' adjusted gross revenue, which is part of their licence fee. This levy is collected to support telecommunications infrastructure in rural and underserved areas, supplemented by central government grants. Similarly, Malaysia imposes a 6% Universal Service Provision levy on the weighted net revenue of telecommunications operators. This levy is separate from spectrum fees, and contributions are directed to the Universal Service Provision fund to support network expansion, essential telecommunications services, and infrastructure development in underserved areas. Given these international benchmarks, Indonesia could consider adjusting its USO contributions or adopting alternative funding mechanisms, such as higher USO fees, cross-subsidies, or targeted public–private partnerships, to accelerate digital inclusion and expand telecommunications infrastructure.

Based on benchmarking from other countries, the Indonesian government could increase the USO levy to a higher rate than what currently applies, potentially up to 5%–6%,

as seen in India or Malaysia. The increase in BHP is focused on accelerating infrastructure development in the USO area, most of which is in 3T regions of the country. Moreover, public demand is quite low, and prices are higher in 3T areas, so the government has to rely on subsidies to incentivise local people to use the network that has been built.

Apart from USO fees, other mechanisms such as free internet programmes, cross-subsidies, loss compensation for unprofitable service areas, and network sharing can serve as complementary strategies to enhance USO optimisation and digital inclusion. Providing free internet access encourages greater telecommunications use, which in turn stimulates local economic activity. Cross-subsidies can help reduce the financial burden on the government by incentivising private sector investment in USO-designated regions.

As seen in China, loss compensation mechanisms ensure that MNOs and ISPs receive financial support when delivering services in commercially unviable or high-cost rural areas. Network sharing agreements, discussed in the next section, could further lower operational costs by allowing operators to jointly use infrastructure, thereby expanding coverage without duplicating investment costs.

Box: Palappa Ring Project

The Palapa Ring project is a telecommunications infrastructure initiative in Indonesia, designed to provide high-speed internet access across the archipelago. It was completed in 2019 and involved the construction of a fibre optic network of about 35,000 kilometres, including both undersea and land-based cables. The project connects Indonesia's seven major island groups: Sumatra, Java, Kalimantan, Nusa Tenggara, Sulawesi, Maluku, and Papua. It aimed for speeds of 10 megabits per second (Mbps) in rural areas and 20 Mbps in urban areas.

The project was funded through a combination of public and private financing mechanisms, utilising a public–private partnership model. The total cost of the project was estimated at Rp7.63 trillion (about US$1.5 billion). The Palapa Ring project was divided into three packages: western, central, and eastern. Private sector consortiums were formed for each package.

The project utilised the Availability Payment scheme, where the government pays private partners based on the infrastructure's availability and performance, using funds raised in the USO fund. Additionally, the state-owned Indonesia Infrastructure Guarantee Fund provided guarantees to cover political risks and enhance private sector confidence. The challenge is now to promote utilisation of the infrastructure made available.

Source: Authors.

Role of network sharing

Several operators sharing the same network experience significant effects on their infrastructure ownership and operational costs. For example, Grijpink et al. (2018) found that network sharing arrangements can reduce total infrastructure ownership costs by about 30%. Network sharing lowers CAPEX by minimising the need for individual operators to invest in separate infrastructure, making it particularly beneficial for the deployment of cost-intensive 5G technology. The financial advantages of network sharing are even more significant in emerging markets, where high infrastructure costs and affordability constraints often limit digital expansion and connectivity growth. However, network sharing in the telecommunications industry can have complex and sometimes counterintuitive effects on competition and market dynamics. Competitive and network effects should also be considered.

The competitive effect refers to the increase in competition that occurs when network sharing allows more operators to enter or expand in a market. This increased competition typically leads to lower prices for consumers, improved service quality, greater innovation, and reduced monopoly profits for existing operators. As more competitors enter the market due to lower barriers to entry (facilitated by network sharing), the market becomes more fragmented and individual operators' market power diminishes.

The network effect, in this context, refers to the increased value and efficiency that comes from having a larger, shared network. This can lead to expanded coverage areas, improved service quality, lower operational costs for operators, and potentially higher profits due to increased efficiency and larger customer base. The net effect of network sharing depends on which of these two forces – competitive effect or network effect – is stronger in each market. If the competitive effect is stronger, network sharing may lead to significantly lower prices, reduced profitability for operators, and potential disincentives for network investment. In a network effect-dominated scenario, network sharing may result in moderately lower prices, maintained or increased profitability for operators, and increased investment in network infrastructure.

The balance between these effects often depends on the maturity of the telecommunications market. In less developed or less competitive markets, network sharing is more likely to have positive outcomes, such as increased market entry, expanded coverage to underserved areas, lower prices and increased accessibility, and a reduction in the digital divide. In highly developed and already competitive markets, the benefits of network sharing may be

less pronounced. There is also a possibility that in developed and competitive markets, the outcome could be a reduction in competition, if sharing leads to consolidation, and subsequently, a risk of collusion amongst operators.

Regulators must carefully consider market conditions when implementing network sharing policies. This involves thorough market analysis to assess the current state of competition and network development; a targeted approach to implement sharing policies selectively, focusing on areas where benefits are most likely to outweigh drawbacks; continuous monitoring to evaluate the effects of sharing agreements on competition, investment, and consumer welfare; and flexibility to adjust policies as market conditions evolve.

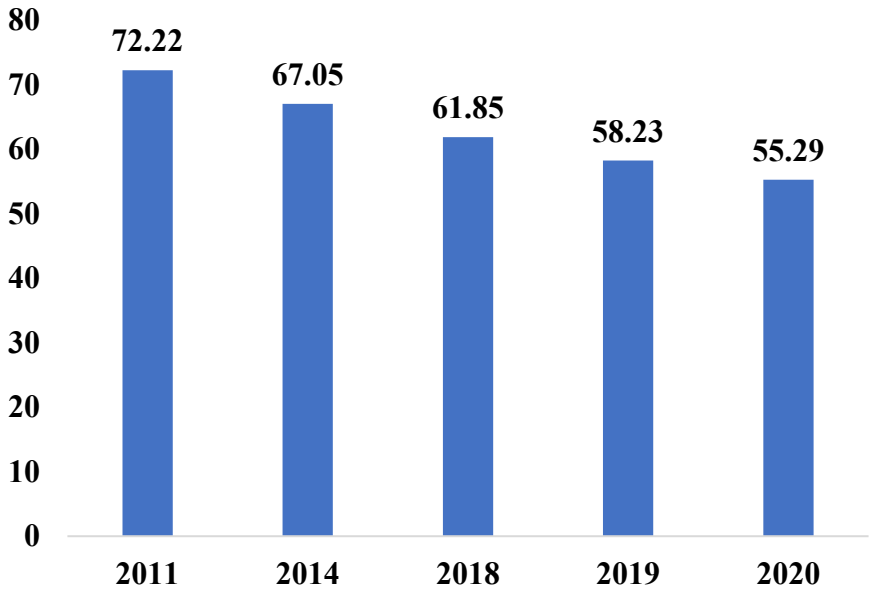
Public telecommunications operators can be involved in passive and active network sharing (Cano et al., 2017). Passive network sharing refers to sharing non-active infrastructure, such as physical site space, cabinets, shelters, and towers, while active network sharing involves sharing core network elements like antennae and BTSs across multiple operators. Houngbonon et al. (2023) highlighted that independent tower operators play a crucial role in enhancing network availability, affordability, and mobile connectivity by facilitating passive network sharing. This model allows multiple operators to use the same infrastructure, eliminating the need for each company to build duplicate tower networks, thus improving cost efficiency and coverage expansion.

Our assessment is that network sharing has benefits in Indonesia, where it will help overcome accessibility problems and reduce high levels of concentration in an MNO in an area that leads to monopoly (market concentration is discussed again below). Each MNO can expand its coverage without the need to incur high capital costs. Indeed, several MNOs have carried out the implementation of network sharing in Indonesia. Hidayat (2020) explained the benefits that arose when XL and Indosat decided to carry out active network sharing in the form of Radio Access Networks (RAN) sharing on one of XL's BTSs. This study explains that the collaboration of XL and Indosat since 2012 can cut the cost of Capital Expenditures (CAPEX) by 36.73% and Operating Expenditures (OPEX) by 44.71% annually. This study also estimates that CAPEX and OPEX will be even lower if three MNOs in Indonesia carry out network sharing.

Deployment of BTS and internet access

There is a case for increased BTS development (BTS towers enable wireless communication and extend mobile network coverage), especially in remote areas. Reducing the cost of BTS construction will also add to the affordability of internet access. The construction of BTSs, especially in villages, is being accelerated. In 2011, 77.22% of villages in Indonesia were without a BTS (Figure 5). As digitalisation and infrastructure development projects are pushed forward, the number of villages without a BTS continues to decline. In 2020, 55.29% villages did not have a BTS. Over the 9-year period between 2011 and 2020, around 17% of villages in Indonesia enjoyed internet access due to the construction of a local BTS.

Figure 5: Villages Without a BTS, 2011–2020



BTS = base transceiver station.
Source: Statistics Indonesia (various), Village Potential Statistics (PODES), 2011–2020. https://www.bps.go.id (accessed 31 December 2023).

In 2011, the number of 4G BTS towers established and on air totalled 109,615, spread throughout Indonesia. This number has grown significantly due to both private sector investments and government-led initiatives aimed at expanding digital infrastructure. The Indonesian government has supported this expansion through the USO fund, infrastructure sharing policies, and regulatory incentives that facilitate investment in underserved areas. However, most BTS towers are financed and owned by private tower companies and MNOs, which lease infrastructure to telecommunications providers. By 2019, the total number of BTS

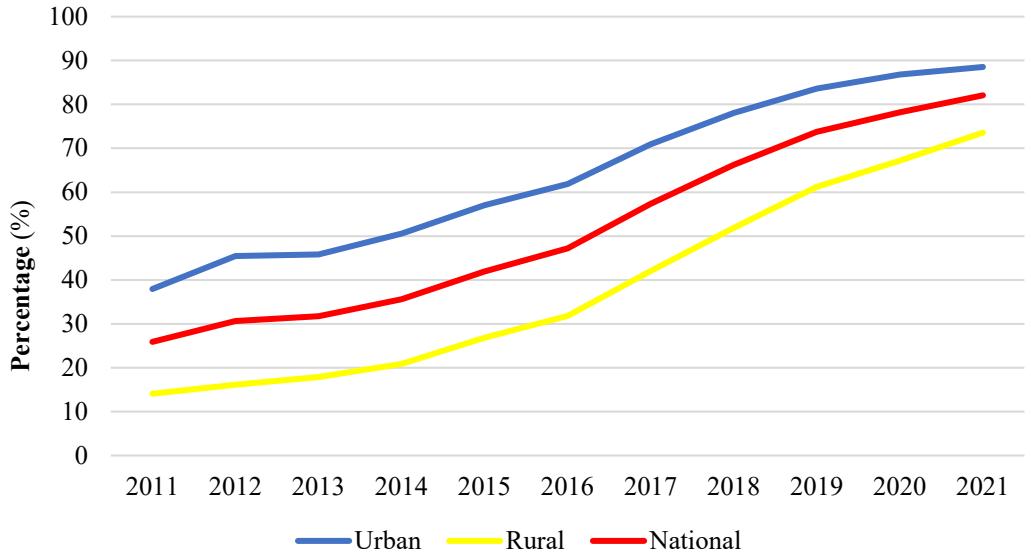
towers had increased to 539,586, reflecting a surge of 96,198 towers between 2018 and 2019, or a 21.7% increase. This growth highlights the combined role of government policies and private sector investment in accelerating digital connectivity across Indonesia, particularly in rural and remote areas where commercial viability is lower.

The distribution of BTS towers in Indonesia is more concentrated in the western regions (e.g. Java, Sumatra, and Kalimantan) than in the eastern regions (including Sulawesi, Maluku, Nusa Tenggara, and Papua). More specifically, telecommunications infrastructure in Indonesia is highly concentrated on the island of Java, with 68,126 BTS towers transmitting 2G signals, 101,132 towers transmitting 3G signals, and 141,911 towers transmitting 4G signals. The concentration of telecommunications infrastructure development in Java is inseparable from the population and GDP, of which the majority are in Java.[1]

This sizeable gap indicates that the disparity between Indonesia's western and eastern regions remains substantial and requires collective attention from both the government and the private sector to support inclusive digital development. The distribution of BTSs is a driver of internet access. Figure 6 shows the percentage of households accessing the internet in Indonesia from 2011 to 2021. A gap persists between rural and urban areas, although it is narrowing. Even though urban areas do not have access problems, they still have several problems related to quality which will be discussed in the use section.

[1] Papua and Maluku have the fewest BTS towers. In 2020, 3,143 towers were transmitting 2G signals, 3,103 towers were transmitting 3G signals, and 4,721 towers were transmitting 4G signals in Papua and Maluku. The share of infrastructure in Papua and Maluku is only 3.52% of the total BTSs on Java island and 1.94% of the total BTSs throughout Indonesia.

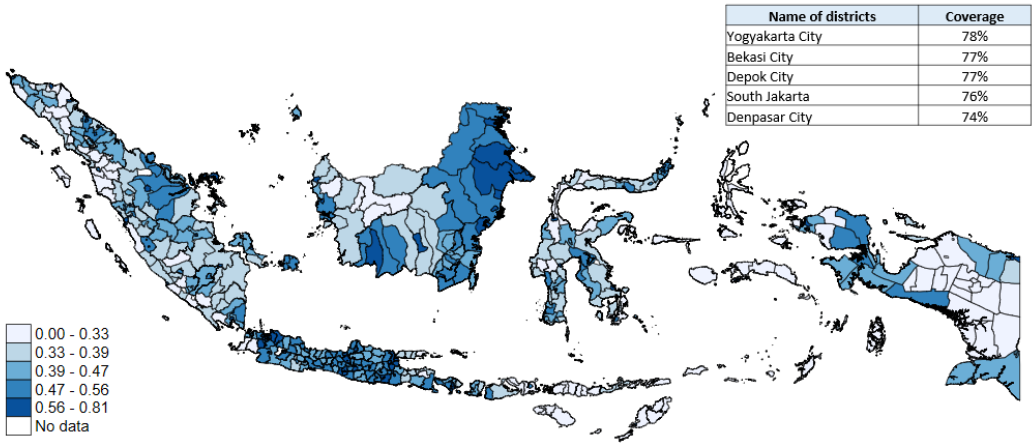
Figure 6: Percentage of Households with Access to the Internet in Indonesia



Source: Statistics Indonesia (2023).

The proportion of people accessing the internet in Indonesia is still concentrated on Java island (Figure 7), with four cities having the highest coverage in Indonesia: Yogyakarta City, Bekasi City, Depok City, and South Jakarta City. Apart from that, cities on the island of Bali and in the eastern region of Kalimantan Island also have good coverage. However, many cities or districts still have low access, especially in the provinces of Nusa Tenggara Timur and Highland Papua.

Figure 7: Share of the Population Accessing the Internet in Indonesia



Sources: Statistics Indonesia (2023), National Socio-Economic Survey (SUSENAS), https://www.bps.go.id (accessed 31 December 2023).

Demand side

Internet access, as discussed above, is related to supply-side factors. But it is important to consider demand-side factors, such as poor ICT awareness in rural communities, low education levels, low ICT skills, and low levels of community welfare. This is the topic of this part of the paper.

Internet usage

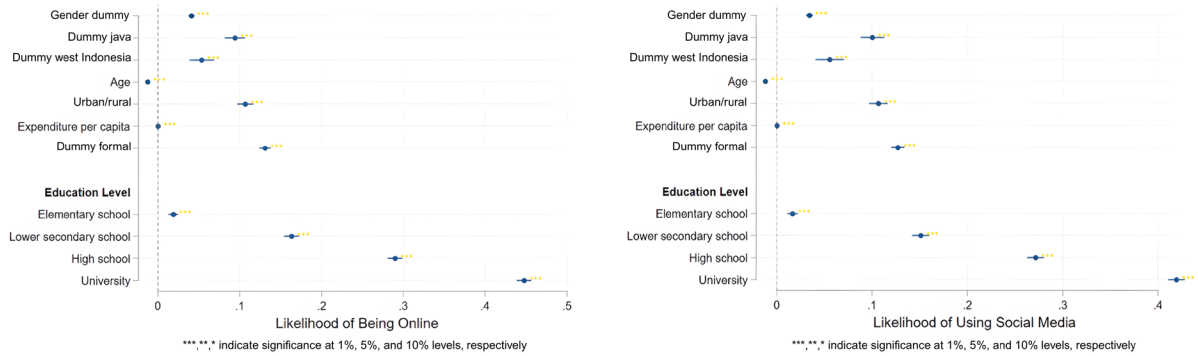
The largest use of the internet in Indonesia is for social media, entertainment, and getting information/news via mobile phones (Figure 8). In 2020, almost 50% of internet use in Indonesia was via mobile phone, 6.1% via laptop, 2.2% via computer, and 0.1% via other ICT devices. Apart from that, 43.8% of internet usage is to access social media, 34.2% for entertainment, 34.1% for getting information/news, 12.3% for educational activities, 8.0% for shopping, 6.1% for communicating via email, 3.5% for financial facilities, and 2.0% for other activities.

Figure 8: Internet Usage in Indonesia, 2020

Source: Statistics Indonesia (2020), National Socio-Economic Survey (SUSENAS), https://www.bps.go.id (accessed 31 December 2023).

We identify the determinants (other than price) of being online and using social media in Indonesia. We found that gender, Java, West Indonesia, population age, urban/rural, expenditure per capita, formal sector, and education level statistically affect the likelihood of being online. The results below (Figure 9) show that people with a university education have the highest likelihood of being online and using social media, with more than a 40% chance of being online. The expenditure per capita is the determinant with the lowest likelihood of being online and using social media, with around 0% chance of being online. Apart from the two determinants outlined above, the others have a probability of less than 20% chance of being online.

Figure 9: What Explains the Likelihood of Being Online and Using Social Media



Source: Statistics Indonesia (2020), National Socio-Economic Survey (SUSENAS), https://www.bps.go.id (accessed 31 December 2023).

Broadband price in Indonesia

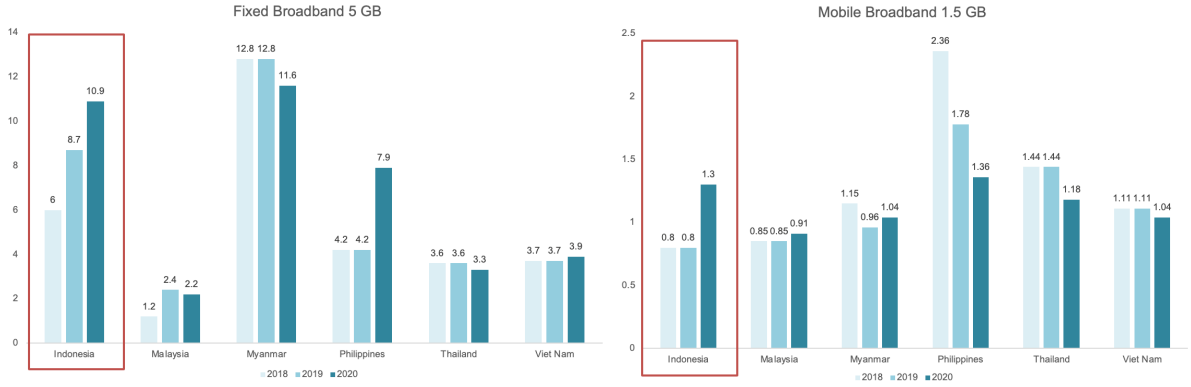
Price is another determinant of internet use. We compare the broadband prices of Association of Southeast Asian Nations (ASEAN) Member States between 2018 and 2020. Indonesia is affordable (has similar prices to the benchmark economies) for mobile broadband prices but not for fixed broadband prices (Figure 10). For a fixed broadband 5-gigabyte (GB) price, Myanmar has had the most expensive fixed broadband price in ASEAN since 2018, followed by Indonesia, the Philippines, Viet Nam, Thailand, and Malaysia. Although Myanmar's fixed broadband price started to decline in 2020, it is still slightly above that of Indonesia.

In mobile broadband prices, the Philippines had the highest price in 2018, followed by Thailand, Myanmar, Viet Nam, Malaysia, and Indonesia. Interestingly, we found that a downward trend in mobile broadband prices in the Philippines, Thailand, and Viet Nam occurred over 2018–2020. However, this trend differs from that of Indonesia, Malaysia, and Myanmar, where mobile broadband prices have been rising.

One possible explanation for these rising prices is the level of competition in the telecommunications market. Countries experiencing price increases may have limited competition, barriers to foreign participation, a lack of market competition due to consolidation, or regulatory changes that have allowed dominant operators to raise prices. Factors such as spectrum allocation policies, infrastructure investment costs, and demand fluctuations could also influence pricing trends. This situation raises concerns about long-term affordability and digital inclusion, particularly in emerging markets like Indonesia and Myanmar, where expanding mobile broadband access is a key policy priority. If prices continue

to rise, broadband adoption could slow, potentially impacting economic growth and digital transformation efforts. Therefore, ensuring a competitive and well-regulated telecoms market will be essential to maintaining affordable mobile broadband services across ASEAN Member States.

Figure 10: Broadband Price in Indonesia and ASEAN, 2018–2020



ASEAN = Association of Southeast Asian Nations, GB = gigabyte.
Source: ITU Publications (2020).

Market Concentration and Conduct

Telkom Indonesia holds a near-monopoly in the fixed-line market, while other providers account for about one-third of fixed broadband subscriptions through their own fibre optic networks. The mobile market is more competitive, but it remains concentrated amongst a few key players. According to 2022 data from Statista (2023), Telkom Indonesia dominates the market with a 62.8% revenue share, followed by Indosat Ooredoo Hutchison (19.9%), XL Axiata (12.4%), and Smartfren (4.8%). The top three firms account for over 90% of the market.

The Lerner Index is commonly used to estimate market power by comparing price margins relative to marginal costs.[2] Figure 11 presents the Lerner Index for Indonesia and selected Asian countries from 2009 to 2022. In the mobile telecommunications sector, Indonesia shows the highest Lerner Index value in 2022 amongst selected countries, following a notable decline in Malaysia's score.

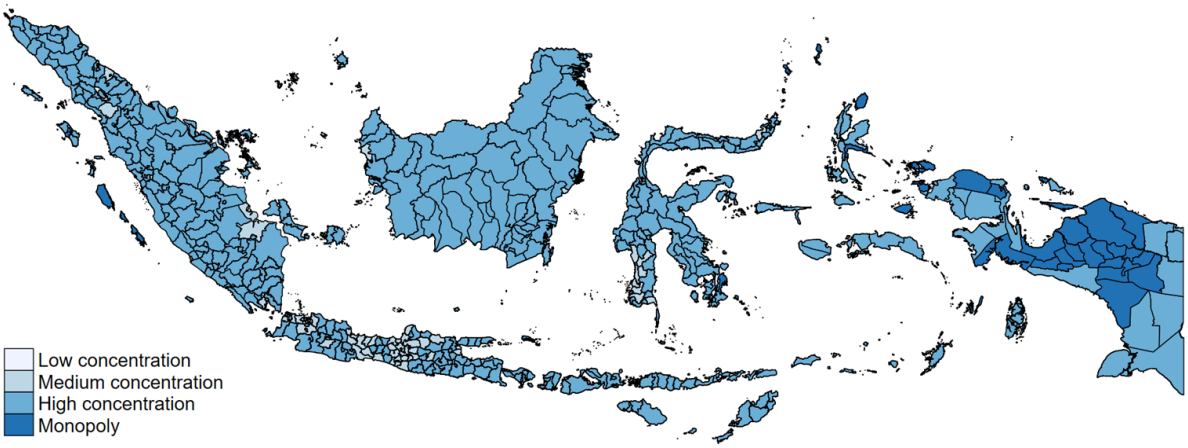
[2] The relevance of the index to telecommunications may be limited, as the industry is characterised by high fixed costs and low marginal costs. This means high price-cost margins do not necessarily indicate strong market power, as they could result from cost structures rather than anti-competitive behavior.

Figure 11: Telecommunications Sector Lerner Index, Various Economies, 2009 and 2022

Source: Bloomberg (2023).

The previous data referred to the national level; however, there is variation in Indonesia in levels of concentration by location. Rohman et al. (2022) explained that 78.6% of cities in Indonesia exhibit high market concentration in the mobile telecommunications sector, with 6.61% classified as monopolies and 14.79% as medium-concentration markets. The distribution of MNO market concentration levels in Indonesia is shown in Figure 12. Several regions in Indonesia are categorised as high-concentration or monopolies, indicating a lack of competition between MNOs in certain areas. This pattern aligns with the national-level findings from the Lerner Index, reinforcing concerns about limited competition in Indonesia's mobile telecommunications sector.

Figure 12: Distribution of Mobile Network Operator Concentration Level in Indonesia



Source: Rohman et al. (2022).

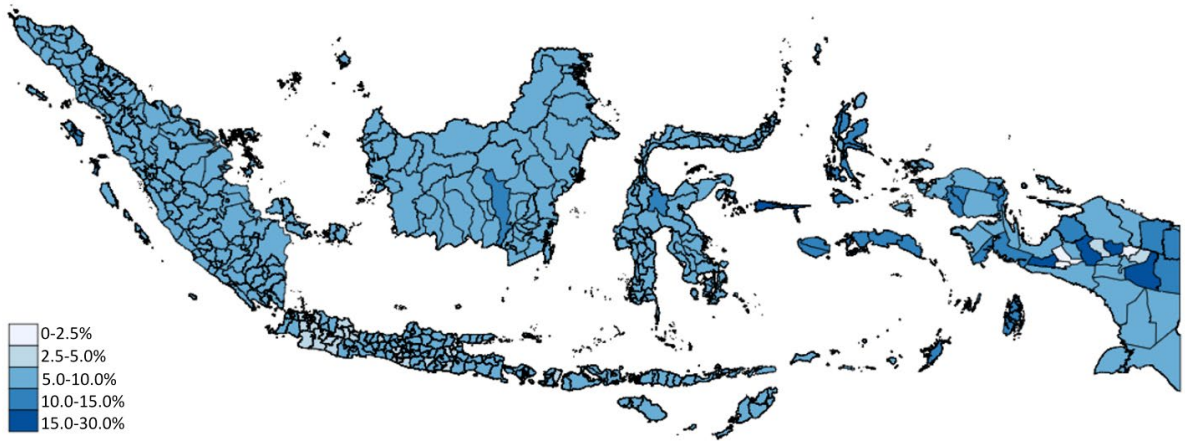
There is a link between high market concentration in the telecommunications sector and Indonesia's geography. As an archipelagic nation, Indonesia requires substantial CAPEX for infrastructure development, particularly in remote areas with low population density. This high CAPEX requirement creates a significant barrier to entry for smaller operators, limiting competition, especially in these regions.

Telkom Indonesia has consistently maintained the largest CAPEX investment in the market since 2009. On average, Telkom Indonesia's CAPEX accounted for 64.1% of the total annual industry CAPEX, reaching a peak of 77.6% (Rp29.2 trillion) in 2016. This substantial investment has allowed Telkom to achieve the widest network coverage in the country. However, despite this extensive infrastructure, concerns remain over service quality, as some areas continue to experience low signal strength. In addition to mobile network expansion, a significant portion of CAPEX is allocated to fibre optic infrastructure. While precise figures on fibre optic CAPEX are not easily found, reports from BAKTI and Telkom Indonesia suggest that a large share of investment has been directed towards expanding fibre optic networks for fixed broadband and backbone connectivity. Further research into official investment reports could provide a more detailed breakdown of CAPEX distribution.

In summary, the high market concentration in Indonesia's telecoms sector is largely driven by infrastructure investment requirements and the geographic challenges of network deployment. This dynamic inherently favours larger operators, particularly Telkom Indonesia and Telkomsel, which can afford substantial CAPEX investments to expand their networks and maintain market dominance. Consequently, the Indonesian telecoms market remains highly concentrated, limiting competition from smaller firms.

As indicated by the Lerner Index result, the existence of a barrier to entry and low competition amongst operators in several regions of Indonesia tends to result in reduced consumer welfare because operators have the market power to mark up the price of telecommunications services in the market. Conditions like this are unfavourable for consumers and indicate that telecommunications services in several locations in Indonesia are unaffordable for the public. The lack of affordability continues to be a key barrier to internet access (Rohman et al., 2022), hindering ICT development in Indonesia. Figure 13 shows the distribution of affordability levels (the percentage of ICT expenditure to total expenditure) in Indonesia.

Figure 13: Distribution of Affordability Levels in Indonesia



Source: Rohman et al. (2022).

On average, the affordability level in Indonesia is 7% but can range up to shares that are more than twice that amount. Most regions in western Indonesia tend to have better access to telecommunications because the price is affordable and the infrastructure is quite good compared with eastern Indonesia. Papua has the highest index in Indonesia (high prices making it unaffordable for the community), with a range of ICT expenditure to total expenditure of 15%–30%.

Policy Recommendations

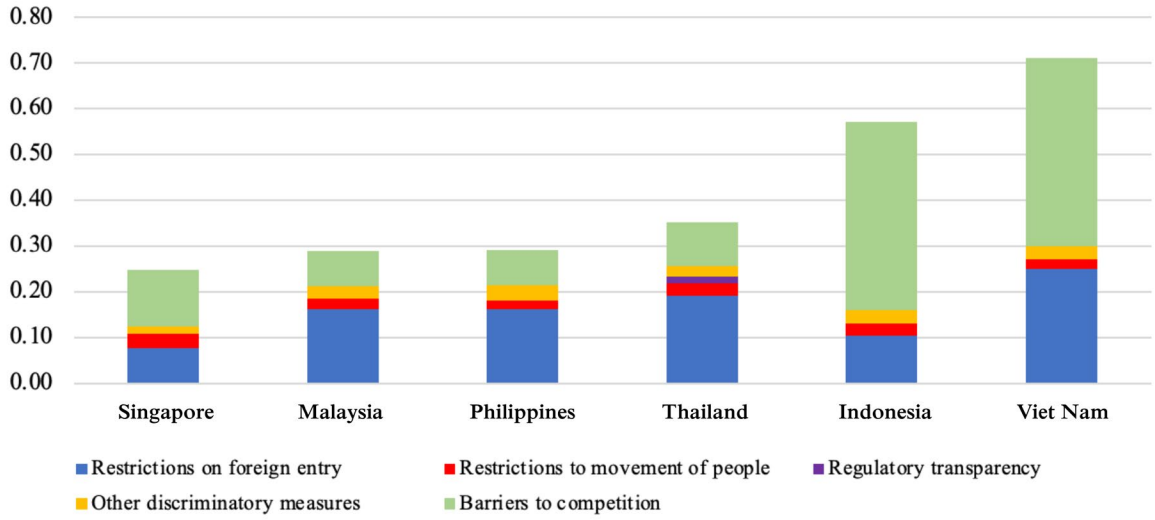
Openness

Review regulations to reduce barriers and restrictions

The Indonesian government plays a crucial role in shaping telecommunications regulations, which directly affect market openness and competition. Figure 14 highlights how Indonesia's telecommunications regulations remain a major obstacle to increased market

competition. According to OECD (2023) data, Indonesia has the second lowest level of openness in ASEAN, after Viet Nam.

Figure 14: OECD Services Trade Restrictiveness Index Policy Indicator



OECD = Organisation for Economic Co-operation and Development.
Source: OECD (2023).

The largest contributor to Indonesia's barriers to competition (accounting for 70% of the score) is the dominance of state-owned enterprises, particularly Telkom Indonesia and its subsidiary Telkomsel, which collectively control a significant portion of the market. Other challenges include the limited independence of the Indonesian Telecommunications Regulatory Body (BRTI) and the presence of dominant service providers across multiple segments of the industry.

While recent regulatory changes have eased foreign investment restrictions, barriers still exist. The New Investment List, introduced through Presidential Regulation No. 10 of 2021 and amended by Presidential Regulation No. 49 of 2021, removed restrictions on foreign ownership in many telecommunications business lines. As a result, foreign investors can now own 100% of telecommunications network operators and service providers. However, other OECD Policy Simulator findings indicate that some foreign entry barriers remain, including:

- Limits on foreign investment in publicly controlled firms, restricting foreign share acquisition in government-linked companies.
- Management requirements, requiring key managers to be Indonesian nationals.
- Investment screening mechanisms, ensuring that foreign investments do not pose economic security risks.

- Land ownership restrictions, preventing foreign entities from owning land for infrastructure deployment.
- Capital transfer conditions, imposing restrictions on the movement of foreign capital.
- Performance requirements, mandating a physical commercial presence for both fixed and mobile services.

These regulatory challenges continue to limit competition and openness in Indonesia's telecoms sector, making it less accessible to foreign players. As a result, Indonesia maintains a relatively high score for barriers to competition compared with other ASEAN economies. Moving forward, further regulatory improvements – especially in competition policy and foreign entry conditions – could help foster a more dynamic and competitive telecommunications market.

Implement mobile number portability

Mobile number portability (MNP) allows the public to change telecommunications service providers without changing their phone numbers. Switching costs are very important because their presence can increase the market power of an MNO by allowing them to charge their customer base higher prices (Beggs and Klemperer, 1992). MNP exists as a solution to reduce switching costs and encourage competition (Buehler, Dewenter, and Haucap, 2006).

Sánchez and Asimakopoulos (2012) explained that two important factors influence MNP: porting time and customer fees. When the porting period increases, people do not have access to the internet for a longer period. Indirectly, the increase in the porting period causes an increase in switching costs, preventing people from moving and reducing competition in the market. The government's role in formulating regulations related to MNP is very important, considering there needs to be a limit on porting time and consumer fees to reduce switching costs. The lower the switching cost, the better the competition amongst MNOs in Indonesia. Therefore, it is necessary to have a regulation that pays attention to time limits for porting time and consumer fees supported by a clear roadmap to see the effectiveness of the MNP policy in Indonesia.

Enforce local content requirements

While not captured in the restrictiveness index, other aspects of openness should be considered. These relate to imports of complementary products. Indonesia is an importer of smartphones. In January 2024, the Indonesian Minister of Communication and Informatics reaffirmed the government's commitment to enforcing local content requirements (LCRs) for telecommunications devices sold in Indonesia. The regulation, in effect since 2017, mandates

that 40% of each 4G and 5G telecommunications device (smartphones and tablets) sold in Indonesia must be produced locally. The Ministry of Trade continues to strictly enforce this regulation, denying import licences to companies that fail to meet the 40% LCR.

Major tech companies have responded differently to these requirements. Some, like Samsung Electronics, have established local manufacturing facilities in Indonesia to comply with the regulations. Others, like Apple, have been in ongoing negotiations with the government regarding investments and compliance strategies.

The regulation has seen several updates and expansions since its initial implementation:

- The LCR for 4G telecommunications devices remains at 30%, while 'base stations' such as wireless modems using 4G and 5G networks must meet a 40% LCR.
- The LCR now encompasses both hardware and software components, including phone applications, as part of the localisation efforts.
- The Indonesian Ministry of Industry has introduced additional schemes related to the localisation requirement, providing companies with more options to fulfil their obligations.

Recent developments have highlighted the government's continued commitment to enforcing these regulations:

- On 28 October 2024, the Indonesian government temporarily banned the import of the iPhone 16 to Indonesia, citing non-compliance with LCRs.
- On 31 October 2024, a similar ban was imposed on the import of Google Pixel phones to Indonesia, also due to failure to meet the LCR.

While these actions demonstrate Indonesia's determination to enforce its local content policies, with a focus on promoting investment in local manufacturing, they also add to the costs of access to the telecommunications system and the services it offers (Aswicahyono et al., 2023).

Human capital

Digital literacy is a critical determinant in bridging the digital divide, particularly in rural and underserved areas. Effective interventions in these regions should prioritise equipping individuals with the requisite knowledge and skills to utilise ICT tools for educational, entrepreneurial, and employment-related purposes. This study highlights the necessity of addressing disparities in ICT awareness and proficiency, particularly in rural communities,

where lower educational attainment and limited exposure to technology present significant barriers to effective ICT adoption. By enhancing digital competencies, such initiatives can expand access to economic and educational opportunities, thereby contributing to broader socio-economic development.

Preparing the workforce for the digital economy requires substantial investment in digital skills training and education. Equipping individuals with the necessary technical and professional skills to leverage ICT for employment and entrepreneurship is important. By integrating digital literacy programmes into formal and informal education systems, Indonesia can create a digitally competent workforce capable of driving innovation and supporting the country's economic transformation.

Local digital content and services play a vital role in driving ICT adoption and stimulating economic growth. The development of digital platforms, applications, and content tailored to Indonesia's unique cultural and socio-economic context is valuable. By promoting local innovation, these initiatives can create new markets, enhance user engagement, and reduce dependency on foreign technology and solutions. This approach supports a sustainable digital ecosystem while fostering economic resilience and cultural preservation.

Regulation and competition

Pricing policy

The limited availability of telecommunications infrastructure in the 3T regions, which has implications for unaffordable internet prices for the community, requires the government to intervene in the market. The main problem in the telecommunications industry is the opportunity for a large operator to carry out monopoly activities. Boylaud and Nicoletti (2001) noted that the government could intervene in this context, including by promoting technical progress, changing the market structure, and undertaking regulatory changes to improve the quantity, reach, quality, and price of telecommunications services.

Rohman et al. (2022) specified criteria for government intervention in the telecommunications market through two variables – the Herfindahl-Hirschman Index (HHI) or market share of telecommunications operators, and affordability – which vary by region (Table 2). As discussed, Indonesia's telecommunications sector faces significant challenges, particularly in the 3T regions, where limited infrastructure leads to unaffordable internet prices. The market structure is highly concentrated, with large operators often engaging in monopolistic practices.

Table 2: Proposed Clustering of Government Intervention at the District Level in Indonesia

Indicators		HHI			
		Low	Medium	High	Monopoly
Affordability	<5 %	No intervention	No Intervention	Light intervention	Light intervention
	>5 %	No Intervention	No intervention	Light intervention	Strong intervention

HHI = Herfindahl-Hirschman Index
Source: Rohman et al. (2022).

There has been discussion between policymakers and academia in Indonesia about the case for price controls (Rohman et al., 2022). The primary argument for price controls – price ceilings – is to combat the high market concentration and low competition. The legislative authority for this intervention does exist. The Omnibus Law, passed in October 2020, introduced the concept of upper and lower limit pricing for telecommunications networks and services. This law grants the central government the authority to determine price limits, aiming to prevent tariff wars amongst operators and foster healthy competition. However, the measures have not been implemented, and specific formula for these price limits have not been set out in regulations.

Setting a maximum price below the equilibrium price could reduce the application of market power. This approach is expected to benefit consumers through more affordable prices and may encourage the search for efficiencies by operators. Its effect on investment is uncertain because of its impact on profits. In other jurisdictions, the focus of price control has shifted to the wholesale level, including terms of access to share infrastructure (e.g. ACCC (2024)). However, floor price policies are generally not recommended. While they might be considered in cases of predatory pricing, they can harm consumers and connectivity by making services unaffordable for low-income individuals and potentially decreasing overall telecommunications usage.

Spectrum management

Indonesia's past approach to spectrum auctions, particularly for 3G licences, has shown signs of underpricing and inefficiency. The 2006 3G auction in Indonesia resulted in significantly lower bids compared with other countries, suggesting that the full market value of the licences was not captured. This underpricing likely contributed to suboptimal outcomes

in the telecommunications market. To address these issues, several recommendations for redesigning spectrum auctions are proposed:

1. Implement higher reserve prices that better reflect market valuations. This would help maximise government revenue and encourage more efficient spectrum use.
2. Conduct thorough market assessments to determine appropriate pricing strategies. This should consider local demand and resource availability to maximise revenue and spectrum utilisation.
3. Ensure transparency in the bidding process to foster a more competitive and dynamic market environment.
4. Design auctions to prevent excessively high final prices, which can hinder investment in mobile broadband and 5G deployment.
5. Focus on maintaining spectrum fee stability, with the goal of keeping fees below 10% of operator revenue to ensure industry sustainability.
6. Consider the economies of scale and scope in wireless spectrum valuations, adjusting prices based on factors such as population density and geographical size.
7. Implement pro-competition regulations to reduce prices without compromising service quality or investments.

By redesigning spectrum auctions with these principles in mind, Indonesia could create a more robust framework that not only ensures financial success but also contributes to the long-term growth and efficiency of the telecommunications sector. This approach aims to balance the government's revenue goals with the need for affordable services and broader coverage, ultimately fostering digital inclusion and economic development.

The focus in initiatives related to innovation in telecommunications is on the distribution of 5G technology. To put this focus into context, the rapid development of the telecommunications industry began in 1980 (Forge and Vu, 2020), and Table 3 shows the evolution of mobile technologies.

Table 3: Evolution of Mobile Technologies

Gen	1G	2G (GSM)	3G (UMTS)	4G (LTE)	5G (NR)
Year	1980	1990	2000	2010	2019
Key feature	Analogue voice	Digital voice and message	Internet connection	Fast connectivity	eMBB, mMCC, uRLLC
Theoretical download speed	2 kbit/s	9.6 kbit/s – 384 kbit/s	384 kbit/s – 56 Mbit/s	5 Mbps – 1 Gbit/s	2 – 20 Gbit/s
Latency (ms)	N/A	629	212	60 – 98	< 1
Theoretical main contribution	Access to mobile telephony for some citizens	Access to mobile telephony for the masses	High-quality mobile telephony; mobile access to the internet, introduction of mobile services	Significant enhancement of broadband web access performance; rapid development of mobile-based business and social networks	Substantial enhancement of broadband performance for radio replacement of fixed-line broadband; potential development of wireless services/products and business models

eMBB = enhanced Mobile Broadband, Gbit/s = Gigabits per second, GSM = Global System for Mobile Communications, kbit/s = kilobits per second, LTE = Long-Term Evolution, mMCC = massive Machine-Type Communications, ms = millisecond, N/A = not applicable, NR = New Radio, UMTS = Universal Mobile Telecommunications System, uRLLC = ultra-Reliable Low-Latency Communications.
Source: Forge and Vu (2020).

Faster internet speeds enable people to access digital content more easily. This has an impact on increasing internet and telecommunications use. In addition, 5G adoption can encourage innovation in the service sector, enabling the implementation of more digital services. Forge and Vu (2020) detailed the types of activities that may be carried out when 5G adoption has been implemented in an area that can encourage innovation to grow and increase economic output, as illustrated in Table 4.

Table 4: Potential 5G Use Cases

Use cases	Key 5G modes	Most benefited areas
Telepresence (next-generation videoconferencing); videochat, etc.	eMBB	Streaming video on demand, video conferences, smart field operations, education, media and entertainment, VR/AR games, sport, tourism, retails, and real estate
Tactile internet; haptic capabilities, humanoid robots; human–machine interaction	uRLLC and eMBB	Smart manufacturing, smart services
High-quality video surveillance and analytics	eMBB, uRLLC, and mMTC	Public safety, health monitoring of older persons, smart agriculture, electricity
Massive internet of things, low-power sensor networks	mMTC	Smart city, smart energy
Mission-critical solutions	uRLLC and eMBB	eHealth (remote surgery), smart energy grids, smart manufacturing and smart agriculture
Connected cars, autonomous vehicles; drones	uRLLC and eMBB	Cars, transport and logistics (smart ports, smart airports, e-commerce)
Cloud-hosted gaming services	eMBB, uRLLC, and mMTC	Games, media and entertainment
3D imaging files	eMBB, uRLLC, and mMTC	eHealth
Private networks	eMBB, uRLLC, and mMTC	Mining, smart manufacturing

AR = augmented reality, eMBB = enhanced Mobile Broadband, eMTC = enhanced Machine Type Communications, mMTC = massive Machine Type Communications, uRLLC = ultra-Reliable Low-Latency Communications, VR = virtual reality.
Source: Forge and Vu (2020).

Current adoption of 5G technology in Indonesia is low. Only 15% of the population have access, and this is limited to major cities. This is relatively low compared with other ASEAN economies. However, 5G infrastructure in Indonesia is a costly undertaking, in part due once again to its geography but also the distribution of existing base stations. Spectrum prices also matter.

Costs may be lowered by a network sharing scheme. Grijpink et al. (2018) showed that RAN sharing while building 5G networks can reduce CAPEX by up to 40%. GSMA (2023)

noted that network sharing on the 5G network can also increase the efficiency of the spectrum used, improve the quality of 5G services from the user perspective, and reduce the carbon emissions of base stations.

Indonesia's 5G deployment strategy is evolving to align with real-world use cases and economic growth opportunities. While the initial focus has been on tourism areas, there is growing recognition of the need for a more comprehensive approach that leverages 5G technology across various sectors, including manufacturing and services. As 5G technology drives rapid research and innovation, it is projected to expand market opportunities in areas such as eHealth services, autonomous vehicles, virtual reality, and machine remote control.

Indonesia is developing its 5G ecosystem by promoting domestic innovation in 5G-based platforms, content, and services. Key components of Indonesia's strategy include encouraging research and development investment in telecoms technologies, developing local expertise to tackle unique challenges, and promoting the establishment of innovation hubs and technology parks. These initiatives aim to foster collaboration amongst academia, industry, and start-ups – accelerating the development of cutting-edge solutions. To support this ecosystem, Indonesia is implementing training programmes in digital content creation, software engineering, and hardware engineering. These efforts are designed to build a skilled workforce capable of driving innovation in the 5G era.

Infrastructure

Expanding BTS coverage is crucial for addressing connectivity gaps in underserved regions, especially in rural and remote areas. Greater BTS deployment ensures that more communities can access reliable mobile and internet services, which are foundational for education, healthcare, and local businesses. By improving connectivity, these efforts also create opportunities for technological innovation, allowing underserved regions to participate more actively in the digital economy.

The Palapa Ring project is a transformative initiative designed to connect remote and eastern regions of Indonesia through an extensive fibre optic network. Fully utilising this infrastructure can significantly enhance internet penetration in areas with historically low access levels. This expanded connectivity not only fosters digital inclusion but also supports the growth of innovation in these regions, enabling local businesses, start-ups, and institutions to leverage digital tools for economic and social advancement.

Raising the USO fee to 5%–6% of operator revenues provides a sustainable funding mechanism for accelerating infrastructure development in underserved areas. This increase could enable faster deployment of essential telecommunications infrastructure, such as BTS towers, in rural and economically disadvantaged regions. By ensuring sufficient resources for these projects, the government could address connectivity gaps more effectively and create a foundation for broader socio-economic development.

While USO funds are critical for building telecommunications infrastructure, their impact could be amplified by investing in local socio-economic development. Beyond connectivity, these funds could support initiatives such as digital skills training, local entrepreneurship programmes, and access to online markets for small businesses. By aligning infrastructure investments with broader socio-economic goals, the government could ensure that digital inclusion translates into meaningful improvements in livelihoods and community well-being.

Implementation

The policy recommendations on openness, human capital, regulation, innovation, and infrastructure are complex, involving many components and several interactions. To implement these recommendations effectively, there is value in considering a number of strategies, including the following:

1. Develop a comprehensive national digital strategy that addresses all aspects of the telecommunications industry, including infrastructure development, market competition, and digital inclusion.
2. Establish a cross-ministerial task force to coordinate efforts in implementing telecommunications policies and ensure alignment with broader economic and social development goals.
3. Create a transparent and predictable regulatory environment that encourages long-term investment in telecommunications infrastructure and services.
4. Engage in public–private partnerships to accelerate the deployment of telecommunications infrastructure, particularly in underserved areas.
5. Regularly review and update telecommunications policies to ensure they remain relevant and effective in a rapidly evolving technological landscape.
6. Invest in data collection and analysis to inform evidence-based policymaking and monitor the impact of implemented policies.

7. Collaborate with international organisations and other countries to share best practices and learn from successful telecommunications policies implemented elsewhere.
8. Develop targeted initiatives to address specific challenges faced by different regions and demographic groups in accessing and using telecommunications services.
9. Encourage the development of local content and applications to drive demand for telecommunications services and support the growth of the digital economy.
10. Implement regular stakeholder consultations to ensure that policies and regulations address the needs and concerns of all industry participants, including operators, consumers, and technology providers.

By implementing these recommendations and strategies, Indonesia could work towards a more competitive, affordable, and inclusive telecommunications industry. This would support the country's digital transformation, drive economic growth, and improve the quality of life of its citizens. However, careful consideration must be given to balancing the needs of consumers, operators, and the government to ensure sustainable development of the sector.

The success of these policies will depend on strong coordination amongst government agencies, industry stakeholders, and civil society organisations. Regular monitoring and evaluation of policy outcomes will be crucial to identify areas for improvement and ensure that the telecommunications industry continues to evolve in line with technological advancements and changing consumer needs. As Indonesia continues to develop its telecommunications sector, it should remain flexible and adaptable in its approach, ready to embrace new technologies and innovative business models that can enhance connectivity and digital inclusion across the archipelago.

References

ACCC (2024), 'Communications Market Report, 2023–2024', Canberra: Australian Competition & Consumer Commission.

APEC (2023), APEC Index Policy Simulator. https://sim.oecd.org/Default.ashx?lang=En&ds=STRI_APEC

Ariansyah, K. et al. (2024), 'The Role of Mobile Broadband in Poverty Alleviation: A Comparison of the Effects of 3G and 4G Network Expansion in Underdeveloped Regions of Indonesia', *Information Technology for Development*, 31(1), pp.206–31.

Aswicahyono, H. et al. (2023), 'Economic Impacts of Local Content Requirements in Indonesia', Jakarta: Centre for Strategic and International Studies.

BAKTI Kominfo (2021), 'PALAPA RING Broadband di 57 Kabupaten/Kota melalui Pola Kerjasama Pemerintah dengan Badan Usaha dalam Penyediaan Infrastruktur (KPBU)' [PALAPA RING Broadband in 57 Regencies/Cities Through Government and Business Entity Cooperation Scheme in Providing Infrastructure (KPBU)]. https://www.baktikominfo.id/assets/uploads/ar_palapa_ring_sept_2021-min.pdf

Bank Indonesia (2023), *Statistik Ekonomi dan Keuangan Indonesia* [Indonesian Economic and Financial Statistics]. https://www.bi.go.id/id/statistik/ekonomi-keuangan/seki/Default.aspx#headingFour

Beggs, A. and P. Klemperer (1992), 'Multi-Period Competition with Switching Costs', *Econometrica*, 60(3), pp.651–66.

Buehler, S., R. Dewenter, and J. Haucap (2006), 'Mobile Number Portability in Europe', *Telecommunications Policy*, 30(7), pp.385–99.

Bloomberg (2023), Bloomberg Professional Services – Bloomberg Intelligence Data. https://www.bloomberg.com/professional/products/bloomberg-terminal/research/bloomberg-intelligence/ (accessed 30 December 2023).

Boylaud, O. and G. Nicoletti (2001), 'Regulation, Market Structure and Performance in Telecommunications', *OECD Economics Department Working Papers*, No. 237, Paris: Organisation for Economic Co-operation and Development.

Cano, L., A. Capone, G. Carello, M. Cesana, and M. Passacantando (2017), 'On Optimal Infrastructure Sharing Strategies in Mobile Radio Networks', *IEEE Transactions on Wireless Communications*, 16(5), pp.3003–16.

CEIC (2023), Indonesia Telkomsel: Network Data: Base Transceiver Station. https://www.ceicdata.com/en/indonesia/telecommunication-statistics-network-data/telkomsel-network-data-base-transceiver-station

Coleago Consulting (2019), *Sustainable Spectrum Pricing: Fostering the Deployment of 5G Through Appropriate Spectrum Pricing*. https://www.coleago.com/app/uploads/2023/03/Sustainable-Spectrum-Pricing-Coleago-2019.pdf

Economides, N. (1996), 'The Economics of Networks', *International Journal of Industrial Organization,* 14(6), pp.673–99.

Faccio, M. and L. Zingales (2018), 'Political Determinants of Competition in the Mobile Telecommunication Industry', *ECGI Working Paper Series in Finance*, No. 494/2017, Brussels: European Corporate Governance Institute.

Forge, S. and K. Vu (2020), 'Forming a 5G Strategy for Developing Countries: A Note for Policy Makers', *Telecommunications Policy*, 44(7), 10975.

Grijpink, F., A. Ménard, H. Sigurdsson, and N. Vucevic (2018), 'Network Sharing and 5G: A Turning Point for Lone Riders', McKinsey & Company, 23 February. https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/network-sharing-and-5g-a-turning-point-for-lone-riders#/

Gruber, H. and P. Koutroumpis (2011), 'Mobile Telecommunications and the Impact on Economic Development', *Economic Policy*, 26(67), pp.387–426.

GSMA (2017), *Introducing Spectrum Management*. https://www.gsma.com/spectrum/wp-content/uploads/2017/04/Introducing-Spectrum-Management.pdf

——— (2018), *Study on Socio-Economic Benefits of 5G Services Provided in mm Wave Bands.* https://www.gsma.com/spectrum/wp-content/uploads/2019/01/5G-mmWave-benefits.pdf

——— (2023), *5G Network Co-Construction and Sharing Guide Whitepaper.* https://www.gsma.com/futurenetworks/resources/5g-network-co-construction-and-sharing-guide-whitepaper/

Guha, A. and M. Mukerji (2021), 'Determinants of Digital Divide Using Demand–Supply Framework: Evidence from India', *Australasian Journal of Information Systems*, 25. https://ajis.aaisnet.org/index.php/ajis/article/view/3029/1033

Hakom (2016), 'The HRK 5 Monthly Fee for Radio Frequency Use Will No Longer Be Charged to Subscribers Starting Today', Press release, 1 September. https://www.hakom.hr/en/the-hrk-5-monthly-fee-for-radio-frequency-use-will-no-longer-be-charged-to-subscribers-starting-today/7837

Haryadi, S. (2018), 'Telecommunication Universal Access and Services: Theory and Practice'. osf.io/preprints/inarxiv/d8egp

Hidayat, M.U. (2020), 'Analisa Efektifitas Ran Sharing Pada Perusahaan Telekomunikasi (Studi Kasus RAN Sharing XL-Indosat)' [Effectiveness Analysis of RAN Sharing in Telecommunication Companies (Case Study of RAN Sharing between XL and Indosat)], *Jurnal Telekomunikasi dan Komputer,* 10(1).

Houngbonon, G.V., M. Ivaldi, E. Palikot, and D. Strusani (2023), 'The Impact of Shared Telecom Infrastructure on Digital Connectivity and Inclusion', 32nd European Conference of the International Telecommunications Society on 'Realising the Digital Decade in the European Union – Easier Said Than Done?', Madrid, 19–20 June.

Irawan, E. (2014), 'BHP Frekuensi Radio Antara Filosofi Dan Target PNBP' [Radio Frequency Usage Fees: Between Philosophy and Non-Tax State Revenue Targets]. http://jdih.kominfo.go.id/artikel_hukum/artikel-hukum/unduh/15

ITU (2015), 'Guidelines for the Review of Spectrum Pricing Methodologies and the Preparation of Spectrum Fees Schedules'. https://www.itu.int/en/ITU-D/Spectrum-Broadcasting/Documents/Publications/Guidelines_SpectrumFees_Final_E.pdf

——— (2020), *Measuring Digital Development: ICT Price Trends 2020*. https://www.itu.int/pub/D-IND-ICT_PRICES.01-2020

——— (2023), The ICT Development Index (IDI): Conceptual Framework and Methodology. https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2016/methodology.aspx

Khatri, H. (2020), 'Indonesian Users Enjoy Faster Download Speeds with 4G than on Wifi', Opensignal, 28 October. https://www.opensignal.com/2021/10/26/indonesian-users-enjoy-faster-download-speeds-with-4g-than-on-wifi

Madden, G. and R. Cooper, eds. (2009), *The Economics of Digital Markets*, Cheltenham, UK: Edward Elgar.

Middleton, C. (2013), 'Beyond Broadband Access: What Do We Need to Measure and How Do We Measure It?' in R.D. Taylor and A.M. Schejter (eds.), *Beyond Broadband Access: Developing Data-Based Information Policy Strategies*, New York, NY: Fordham University Press, pp.9–22.

Ministry of Trade (2023), 'Realisasi Ekspor-Impor Perangkat Teknologi Informasi Dan Komunikasi Indonesia: Periode 2018–2023 (Januari–Juni)' [Realization of Export-Import of Information and Communication Technology Devices in Indonesia: Period 2018–2023 (January–June)]. https://satudata.kemendag.go.id/ringkasan/produk/realisasi-ekspor-impor-perangkat-teknologi-informasi-dan-komunikasi-indonesia-periode-2018-2023-januari-juni

Niyato, D. and E. Hossain (2008), 'Spectrum Trading in Cognitive Radio Networks: A Market-Equilibrium-Based Approach', *IEEE Wireless Communications*, 15(6), pp.71–80.

Nugroho, R.A. and B.A. Nafi'ah (2019), 'Internet Access Equity Policy Is the Internet Access Equity Policy Through USO Funds Effective', *International Journal on Informatics for Development*, 8(1), pp.8–15.

OECD (2020), *OECD Digital Economy Outlook 2020*, Paris: Organisation for Econonmic Co-operation and Development.

——— (2023), 'Measuring the Regulatory Environment of Services Trade in the APEC Region'.https://www.oecd.org/en/topics/sub-issues/services-trade-restrictiveness-index/measuring-the-regulatory-environment-for-services-trade-in-the-asean-region.html

RIS (2020), IPX Regulatory Trends and Business Models [Unpublished report], Ministry of Communication and Informatics.

Rohman, I.K. (2021), Valuation Study on Radio Spectrum Bands 700 Mhz, 2.6 Ghz & 3.5 Ghz [Unpublished report], Ministry of Communication and Informatics.

Rohman, I.K., M. Zaber, N. Jasmintia, and R.R. Fadilla (2022), Study of Spectrum Fee/Price Reduction of Band 700 Mhz in Indonesia, [Unpublished report], Ministry of Communication and Informatics.

Röller, L.-H. and L. Waverman (2001), 'Telecommunications Infrastructure and Economic Development: A Simultaneous Approach', *American Economic Review*, 91(4), pp.909–23. 5

Sánchez, B.U. and G. Asimakopoulos (2012), 'Regulation and Competition in the European Mobile Communications Industry: An Examination of the Implementation of Mobile Number Portability', *Telecommunications Policy*, 36(3), pp.187–96.

Statista (2023), Indonesia: Mobile Subscriber Market Share 2020. https://www.statista.com/statistics/946022/indonesia-mobile-subscriber-market-share/ (accessed 31 December 2023).

Statistics Indonesia (2020), *Statistik Telekomunikasi Indonesia 2020* [Telecommunication Statistics in Indonesia 2020], Jakarta: BPS.

——— (2023), Persentase Rumah Tangga yang Pernah Mengakses Internet dalam 3 Bulan Terakhir Menurut Provinsi dan Klasifikasi Daerah 2020–2022 [Percentage of Households that Accessed the Internet in the Last 3 Months by Province and Regional Classification, 2020–2022]. https://www.bps.go.id/indicator/2/398/1/persentase-rumah-tangga-yang-pernah-mengakses-internet-dalam-3-bulan-terakhir-menurut-provinsi-dan-klasifikasi-daerah.html (accessed 31 December 2023).

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