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Expanding broadband connectivity in Northeast Asia with the Asia-Pacific Information Superhighway (AP-IS)

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Abstract

This article aims to identify key characteristics of broadband development in Northeast Asia. Broadband networks have become essential infrastructure in digital economy and society, enabling digital trade, e-commerce, e-government services, to name a few. Together with the expansion of social media, frontier technologies, such as artificial intelligence, have emerged to drive the so-called Industry 4.0. These applications and technologies heavily depend on the existence of reliable and affordable broadband networks. In this background, this article examines various aspects of broadband networks in the subregion, such as access, speed, affordability and usage, using the framework of the Asia-Pacific Information Superhighway to identify possible areas of further development, regional cooperation and investment.

Keyword

broadband, information and communication technology, Internet, artificial intelligence, infrastructure

1 Background

Social and economic benefits of broadband connectivity have been studied by not only researchers but also information and communications technology (ICT) practitioners. In addition to the hardware and software side of ICT development, an emphasis has been placed on the development of individual and institutional capacity, online content and services which are considered conducive to sustainable development. Capitalizing on its unique ca-

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pabilities of reaching remote and rural areas instantly and delivering information and services digitally and cost-efficiently, ICT has been playing critical roles in economy and society across the globe.

More specifically, ICT is considered as a meta-infrastructure as well as a sustainable development enabler. The former is characterized by ICT's support to other infrastructure, such as intelligent transport systems, smart grids and digital trade (UNESCAP 2018a). The latter manifests in the form of e-commerce/e-business, mobile payments, e-government, smart cities, e-resilience, e-health, e-education and e-agriculture just to name a few (Rossotto, Gelvanovska, Hohlov et al 2015, Heeks 2017). E-commerce and e-business have become a fast-growing sector with global reach (UNCTAD 2017), supported partly by FinTech innovations, such as mobile payments (Kim et al. 2018). Efforts to make governments more efficient and responsive have taken the form of e-government, which enables people to obtain public information, submit forms, request for public services, and report grievances (Heeks & Bailur 2007, Lee 2010). The use of ICT in disaster risk reduction, or e-resilience, has also gained global traction as a means to reduce and manage natural disaster risks (UN 2018), while the introduction of ICT in education (Internet Society 2018) and agriculture (Narmilan 2017) have produced noticeable impacts.

At the same time, ICT, broadband technologies, contributes to regional economic cooperation, acting as a key driver to facilitate movements of money, people, information, innovations, goods and services across national borders. Broadband connectivity development also benefits from regional cooperation and integration, as the Internet is by default regional and global in nature, and thus, would require countries to connect to one another for communication and data transmission.

These ICT-enabled applications and services are delivered on ICT infrastructure, such as broadband networks. However, not all countries equally enjoy the benefits of the applications and services, due partly to multi-facetted gaps between the "haves" and "have nots", or more widely known as the digital divide. It is defined as "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities" (OECD 2001 p.5). Despite the significant efforts made in narrowing the digital divide globally, the gap is widening, as the countries with better connectivity, capacity, investment and policy have now moved on to develop and roll out bandwidth-intensive frontier technologies, such as artificial intelligence, Internet of Things (IoT), Big Data and blockchain (UNESCAP 2017a), which are driving the phenomena called Industry 4.0.

What is particularly worrying is the gap in broadband connectivity between countries and that within a country. Broadband connectivity is a prerequisite of frontier technologies as well as the aforementioned foundational ICT applications. Limited broadband connectivity will constrain economic activities, integration into the global value chain and efforts towards regional economic cooperation in this connected digital age (UNESCAP 2018f). As such, addressing the broadband divide is an urgent and strategic policy imperative to accelerate efforts towards sustainable development.

With this background, this article examines the current status of broadband development and its characteristics in Northeast Asia, in particular how the sub-region fares vis-à-

vis other subregions in Asia and the Pacific[2]. It is expected that the findings would help prioritize areas of policy intervention and investment to materialize inclusive sustainable development and regional economic cooperation in Northeast Asia.

2 Literature Review

The existing literature on socioeconomic impact of broadband is relatively new, considering the fact the technology has been rolled out on a large scale in the past 20 years. In this section, key highlights from existing research are summarized into 1) broadband impact on economic growth, trade and financial flows and 2) investment needs, with focus on aspects related to regional economic cooperation.

The telecommunication infrastructure is evidenced to have positive impacts on economic growth. Using a dynamic fixed-effect estimation method, Datta and Agarwal (2004) analyzed the data of 22 OECD countries and showed that the telecommunication infrastructure (access line per 100 inhabitants) is positively correlated with growth in GDP per capita. A similar finding is reported by Röller and Waverman (2001) who studied the data of 21 OECD countries over 20 years and found a significant causal link between telecommunication infrastructure and economic growth especially when the infrastructure availability reaches a level of universal service.

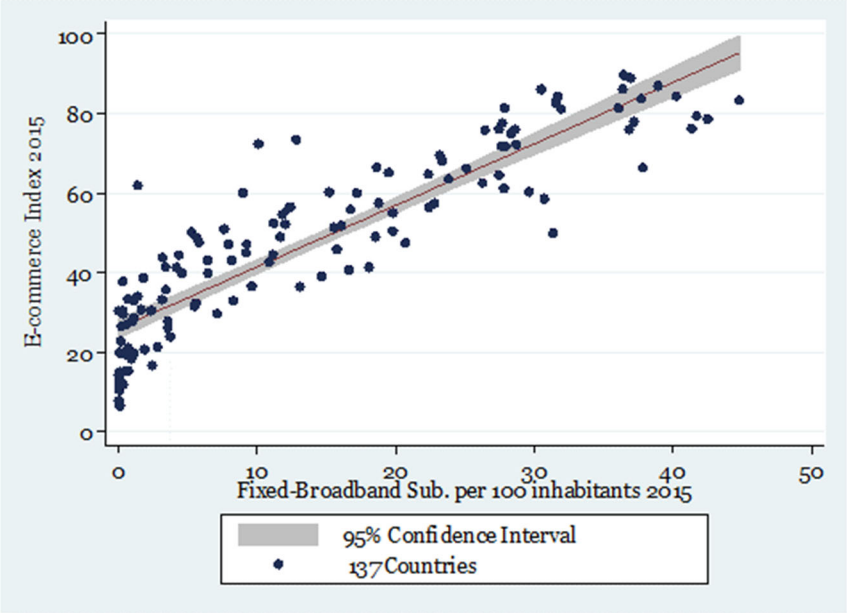
Specific to broadband infrastructure, a report by Columbia University (ITU 2012) identified two main channels of broadband impact on economy. The impact from investment in infrastructure development creates jobs and business expansion, while direct effects on enterprises and households are expected through improved broadband penetration, total factor productivity (in case of enterprise) and household income and consumer surpluses (in case of residential). The authors concluded that the higher broadband development level corresponds to the higher contributions to economic growth. The report also compared 6 studies conducted on the United States, OECD countries and various income groups of countries and concluded that all studies, except one, found varying levels of positive economic impact of broadband connectivity. In the five studies, a 10% increase in broadband penetration was found to have

1) 3.6% increase in efficiency in a study conducted with data of 46 US states between 2001 and 2005 (Thompson & Garbacz 2008),
2) per-capita GDP growth by 0.9 – 1.5 percentage points in a study on 25 OECD countries between 1996 and 2007 (Czernich et al. 2011),
3) 0.25% increase in GDP growth in a study on 22 OECD countries between 2002 and 2007 (Koutroumpis 2009),
4) additional 1.21 percentage points of GDP growth in a study conducted on 66 high income countries between 1980 and 2002 (Qiang 2009),

[2] In this article, Asia and the Pacific is defined according to the classification of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), comprised of 62 member countries, out of which 53 are geographical member countries.

5) additional 1.38 percentage points in GDP growth among 120 low-and middle- income countries between 1980 and 2002 (Qiang 2009).

There could be many factors to explain the relationships between broadband infrastructure and economic growth. One such factor is e-commerce. Broadband, in particular fixed broadband, is demonstrated to be associated with the level of e-commerce development (UNESCAP 2016c), as illustrated in Figure 1 below.



Sources: UNESCAP estimates; UNCTAD B2C E-Commerce Index 2016; and fixed broadband per 100 sourced from ITU. UNESCAP (2016c), p. 24. From "State of ICT in Asia and the Pacific 2016: Uncovering the Widening Broadband Divide", by UNESCAP, ©2016 United Nations. Reprinted with the permission of the United Nations.

Previous empirical work also found statistically significant correlations between fixed broadband subscriptions per 100 inhabitants and 1) quality of regulation and 2) investment in fixed broadband infrastructure among other factors (UNESCAP 2016c).Another group of scholars has examined the role of ICT, in particular the Internet, in regional and global trade. Barbero and Rodriguez-Crespo (2018), for example, analyzed the effects of ICT on regional trade in Europe, using the data of 232 regions in Europe in 2007 and 2010. According to the authors, ICT performs several functions in facilitating trade, namely information generation and diffusion across territories and lowering transaction, coordination and interaction costs. ICT is also regarded as a driver for innovations which increase product differentiation, reduce the cost of production and lead to a comparative advantage in the global value chain. The authors found that the estimated effects of the Internet on trade was positive and significant for both exporters and importers. The positive coefficients were found greater for the exporter regions than the importers, while the broadband coefficients were always positive

and significant. In previous studies, other scholars also evidenced positive and significant influences of the Internet on trade. Freund and Weinhold (2004) concluded that a 10 percentage point increase in website growth led to a 0.2 percentage point increase in export growth and the Internet contributed to a 1 percentage point increase in annual export growth between 1997 and 1999. Clarke and Wallsten (2007) studied a direction of causation between the Internet and trade and determined that Internet access improves export performance in developing countries. Using the gravity equation with the Internet, Lin (2015) estimated that a 10% increase in Internet users resulted in a 0.2% - 0.4% increase in international trade.

In addition, broadband networks like submarine cables enable instantaneous financial transactions across the globe. According to a report of the International Cable Protection Committee (2016), the Society for Worldwide Interbank Financial Telecommunications (SWIFT) sends 15 million messages over broadband cables to 8,300 banks and financial institutions every day. The US Clearing House Interbank Payment System (CHIPS) is another financial infrastructure which processes $1 trillion daily over 22 countries. In the case of the US, only 7% of the total data traffic could be carried by satellites, which signifies how vital submarine and terrestrial cables are to the functioning of the financial sector globally. To echo the critical role that broadband infrastructure plays in the financial sector, a US Federal Reserve official is quoted as saying that "when the communication networks go down, the financial sector does not grind to a halt, it snaps to a halt" in the report of the International Cable Protection Committee (p.5). In addition to the macro-level effect of broadband on the financial sector, the use of ICT, in particular mobile phones, for processing international remittances has garnered international attention (Jenkins 2008). According to a 2017 report of the Global System for Mobile Communication Association (GSMA), mobile money processed $1 billion daily, generating $ 2.4 billion revenues and 690 million user accounts.

Despite the critical importance of broadband infrastructure and Internet on economic growth, trade and financial flows, the development of broadband infrastructure in Asia and the Pacific has been slow. One of the key constraints is an insufficient level of investment in the telecommunications sector. According to one estimate, an average of $3.3 trillion, or 3.8% of GDP, needs to be invested in economic infrastructure annually between 2016 and 2030. It is also projected that 60% of the demands originate from emerging economies (Woetzel, Garemo, Mischke et al. 2016). Asian Development Bank estimates that the telecommunication sector alone would require $2.26 billion investment between 2016 to 2030 in Asia and the Pacific (ADB 2017). The economic benefits from infrastructure in the form of total net income gains is estimated to be $ 12.98 trillion. The benefits are expected to be significant among countries which rely on trade. The improved communication and transport infrastructure in particular is expected to lower barriers to market access (ADB 2009).

At the national level, the universal access or service fund is one of the main financing instruments in many countries, which aims to accelerate the rollout of ICT infrastructure, access and capacity development. The effectiveness of universal access and service funds was empirically examined based on the existence of the funds and broadband growth rates in a study. It concluded that among comparable income countries, broadband growth is found slower in countries with the funds than in those without (UNESCAP 2017b). These

findings could lead to a discussion on effective and efficient financing mechanisms, including revisiting focus and operation modality of the funds, preferential taxation, import duty exemption, among other means.

3 Objectives

In this context, the present paper aims to examine the state of broadband development and identify distinctive characteristics of broadband development as a key driver of economic growth, trade, financial flows, investment and regional economic cooperation in Northeast Asia[3]. The findings are expected to elucidate challenges and opportunities in developing broadband networks in the subregion and support their contributions to regional economic cooperation and sustainable development. While economic benefits of broadband infrastructure are well documented, the findings of this study would be of particular relevance to the context of dynamic technological development. Social media, e-commerce/e-business and frontier technologies such as Artificial Intelligence, are helping create innovative products, services and business opportunities where broadband infrastructure is available. In this context, it is of importance to identify the state of broadband development, its characteristics and challenges and opportunities in Northeast Asia. It is hoped that the identified gaps, challenges and opportunities will inform those tasked with leading future pre-feasibility and feasibility studies, the design of network topology and/or (the) planning and construction of fiber-optic networks in Northeast Asia.

To achieve the objective, this study uses the framework and concept of the Asia-Pacific Information Superhighway (AP-IS)[4] initiative due to its extensive geographic coverage, intergovernmental mandates, focus on physical as well as non-physical aspects of infrastructure development and existing research and analyses conducted on all subregions which enable comparisons. The initiative was developed and launched by the 62 member countries of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) in its resolution 73/6 in 2017 as a response to the growing concern over the widening digital divide as described later in this article. The implementation of the initiative is detailed in the AP-IS Master Plan 2019-2022[5] and Regional Cooperation Framework Document 2019-2022[6] which was endorsed by the 62 member countries in ESCAP resolution 75/7 in May 2019. The initiative is being implemented with the assistance of governments, international and regional organizations, academia, private sector and civil society organizations. The current study is guided by the four pillars of AP-IS (physical broadband infrastructure, Internet traffic management, e-resilience and broadband for all) and methodologies used in pre-feasibility and technical studies conducted in other subregions.]

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[3] The UNESCAP subregional classification includes China, Democratic People's Republic of Korea, Japan, Mongolia, Republic of Korea and Russian Federation, and two associate members, Hong Kong and Macau. More at https://www.unescap.org/subregional-office/east-north-east-asia/about. However, the data and information on the Democratic People's Republic of Korea are not readily available.

[4] https://www.unescap.org/our-work/ict-disaster-risk-reduction/asia-pacific-information-superhighway

[5] https://www.unescap.org/commission/75/document/E75_INF5E.pdf

[6] https://www.unescap.org/commission/75/document/E75_INF6E.pdf

The characteristics will be demonstrated through the number of fixed and mobile broadband subscriptions per 100 inhabitants, network speeds, affordability and existing cross-border broadband infrastructure and facilities including fiber-optic cables and international gateway and Internet Exchange Point (IXP). By comparing with other subregions and understanding the characteristics, the gaps (broadband divide), challenges and opportunities are expected to emerge.

As ICT is expected to serve as a critical meta-infrastructure in regional economic cooperation, this article aims to target at researchers and policy and decision makers in the ICT and non-ICT sectors alike to facilitate policy dialogues at regional, subregional and national levels. This article focuses on fixed broadband development, while it refers to mobile broadband for a comparison. The reasons include the following: 1) mobile broadband speed is still limited and not comparable with fixed broadband, 2) fixed broadband networks may have direct impact on the development of AI (Okuda and Ofa 2018) and 3) 60% of mobile data traffic is offloaded to fixed broadband networks through WIFI and femtocell (UNESCAP 2017a). In this context, a gap in fixed broadband connectivity is expected to have more significant impacts on regional economic cooperation and sustainable development.

In order to fulfil the above-mentioned research objectives, this explanatory study summarizes key findings from existing research and analysis, some of which were developed for the AP-IS implementation. The data used in the analysis include ITU World Telecommunications Indicators (ITU 2018) and World Bank (2018), among others.

4 Concepts and Definitions

This section presents some of the key concepts and definitions associated with broadband technology. A more elaborate list of terminology is available online for further reference (UNESCAP 2016b).

This article focuses on two types of broadband technology: fixed and mobile. Fixed broadband is defined as "Fixed (wired) broadband network: refers to technologies at advertised download speeds of at least 256kbit/s, such as DSL[7], cable modem, high speed leased lines, fiber-to-the-home/building, powerline and other fixed (wired) broadband" while mobile, or terrestrial wireless broadband, is defined as "technologies at advertised download speeds of at least 256 kbit/s, such as WiMAX[8], fixed CDMA[9]" (ITU 2014). The substitution or complementarity effects between fixed and mobile access and offloading of mobile traffic to fixed networks have been briefly discussed in one of the afore-mentioned reports (UNESCAP 2017a), and due to the page limitation, it will not be expanded in this article.

A building block of the broadband network is an international gateway, meaning "any facility through which electronic communications (voice, data, and video) can be sent between the domestic networks of one country and another" according to ITU[10]. The networks also

[7] Digital Subscriber Line

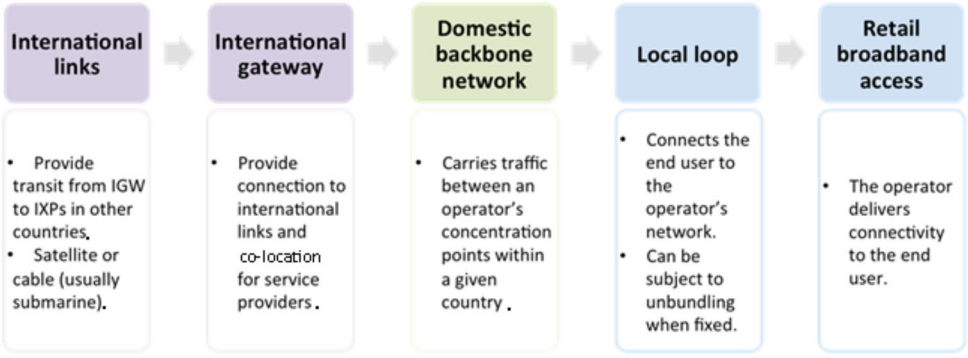
[8] Worldwide Interoperability for Microwave Access

[9] Code Division Multiple Access

[10] https://www.itu.int/itunews/manager/display.asp?lang=en&year=2009&issue=01&ipage=26&ext=html

consist of international links, a national backbone network and a local loop, the combination of which allow for retail level activities (UNESCAP 2017c) as illustrated below in Figure 2.

Figure 2: Components of broadband networks



Source: UNESCAP (2017c), p. 5. From "Effect of Open International Gateways on the Broadband Connectivity Market", by UNESCAP, ©2017 United Nations. Reprinted with the permission of the United Nations.

Internet Exchange Points (IXPs or IXs) are defined as "a physical networking location and a logical networking strategy, which facilitates interconnection between Internet-based networks" (Jensen 2012, p. 18). This switching infrastructure typically includes switches, routers, cablings and interfaces. IXPs are set up to facilitate local Internet traffic to be locally exchanged and avoid the tromboning effects mentioned below. When local Internet traffic is exchanged locally, and does not travel through international links, it reduces transit costs and subsequently Internet access costs to users (UNESCAP 2017c).

Another concept prominent in the broadband development witnessed in Asia and the Pacific is e-resilience. The term is defined as "the use of ICTs during all phases of disaster risk management —prevention, reduction, preparedness, response and recovery — towards reducing risk and impact and maintaining the gains made towards sustainable development" (UN 2018, p.53). More specifically, it aims to integrate disaster risk mitigation and management into the planning and implementation of broadband networks and ensure that online applications and services are provided for disaster response operations at a time of natural disaster. One of the major ICT connectivity initiatives in the subregion which considers e-resilience is the Belt and Road Initiative (BRI) (UNESCAP 2017d, Kunavut, Okuda & Lee 2018).

5 Drivers of broadband growth

While analyses and research have been conducted based on existing technologies and data, ICT is a dynamically evolving sector with often disruptive innovations and capabilities. Thus, estimating future demands and requirements for broadband networks based on past technological trends may not present a comprehensive picture. Cognizant of this limitation,

this section intends to shed light on prominent trends and ICT usage which are expected to drive the demand for broadband at the global, regional and national levels.

First, the growth in broadband demand is partly driven by a rapid increase in the number of social media users. According to a Statista estimate[11], there were 2.46 billion social media users globally in 2017, which is estimated to grow to 3.02 billion in 2021. As of January 2019, the most popular social media platforms worldwide were Facebook (2,271 million active users), YouTube (1,900), WhatsApp (1,500), Facebook Messenger (1,300) and WeChat (1,083). According to the Global Web Index survey during Q3 of 2017 among 77,814 Internet users aged 16-64, the most prominent motivations of social media usage were to stay connected with friends (42%), stay current with news and events (41%), fill up spare time (39%) and entertainment (37%)[12]. In Northeast Asia, 85% of Internet users in the Republic of Korea visited social networking sites as of January 2019, ranking third globally, followed by Hong Kong (SAR) (78%), China (71%), Japan (61%) and Russian (49%)[13].

The growth in e-business and e-commerce worldwide also contributes to broadband access and service demands. According to a study by UNCTAD (2017), worldwide e-commerce sales in 2015 was $25.3 trillion, out of which 90% of transactions originated from business-to-business (B2B) and 10% from business-to-consumer (B2C) sales. Cross-border B2C transactions are estimated to have reached $189 billion in 2015. The report, however, cautions that these e-commerce transactions are concentrated in developed economies, determined partly by the availability of reliable and affordable broadband networks as a prerequisite.

Another driver of broadband growth is the exponential growth in demand for bandwidth-intensive content such as video and audio, mainly through mobile broadband services. One study concluded that the total mobile data traffic in 2017 was 15 exabytes per month, which is expected to increase to 107 exabytes per month in 2023, driven mainly by access to video content (Eriksson 2018).

Broadband technologies have been instrumental in not only developing new businesses but also advancing the development and adoption of frontier technologies such as artificial intelligence, blockchain and 3D printing. They are increasingly shaping the competitiveness of companies and countries and are drivers of the so-called Industry 4.0. Industry 4.0 is driven by digital transformations, such as intelligent logistics and supply chain, software-defined universal factory and intelligent manufacturing. Furthermore, AI and its digital technology components, such as Internet of Things (IoT), cloud computing, Big Data and data analytics, have been integrated into other social and environmental sectors, improving the accuracy of forecasts and diagnostics and providing unparalleled insights. The Internet of Things (IoT) has revolutionized the way data is collected and transmitted for analysis. IoT devises are now permeating into an ever-growing sphere of our lives. They are attached to

[11] https://www.statista.com/statistics/278414/number-of-worldwide-social-network-users/, accessed on 16 February 2019

[12] https://wersm.com/the-10-top-reasons-why-we-use-social-networks/, accessed on 16 February 2019

[13] https://www.statista.com/statistics/282846/regular-social-networking-usage-penetration-worldwide-by-country/, accessed on 17 February 2019.

buildings and bridges to monitor wear and tear and calculate maintenance needs, while constantly collecting data on traffic, weather, soil conditions, pollution level, among others. The vast amount of data is accumulated using cloud computing technology, which is now widely called Big Data. Using such data, image and voice recognitions, natural language capabilities, machine learning, case-based reasoning and predictive analytics have become possible. Supported by the ubiquitous broadband networks, they form part and parcel of artificial intelligence (UNESCAP 2017a).

While the advancement of mobile broadband technologies, such as 5G, is anticipated to exponentially increase data transmission capacity, a study (Okuda & Ofa 2018) evidenced that growth in AI research and development is correlated with fixed broadband development, whilst its linkage to mobile broadband couldn't be established with statistical significance. This may point to the importance of fixed broadband development especially among countries lagging behind in fixed broadband expansion in anticipation of the increasing prominence of frontier technologies.

In this background, how to lower the costs of expanding broadband infrastructure and increase affordability become essential. One way to reduce fiber-optic cable construction costs was identified as co-deployment along passive infrastructure, such as railways, highways, power grids and oil and gas pipelines. A study on co-deployment of fiber optic cables along Asian Highways in Myanmar evidenced that the cost savings could be 56.8%, or $7,379 per kilometer, based on the calculations done for an actual project and triangulated with a comparable project in Cambodia (UNESCAP 2018d). Another way of reducing costs is efficient Internet traffic management. In Southeast Asia, a pre-feasibility study identified physical infrastructure gaps as well as possible improvements in Internet traffic management to reduce tromboning effects[14](UNESCAP 2016b).

6 State of broadband development in Northeast Asia

6.1 Overview

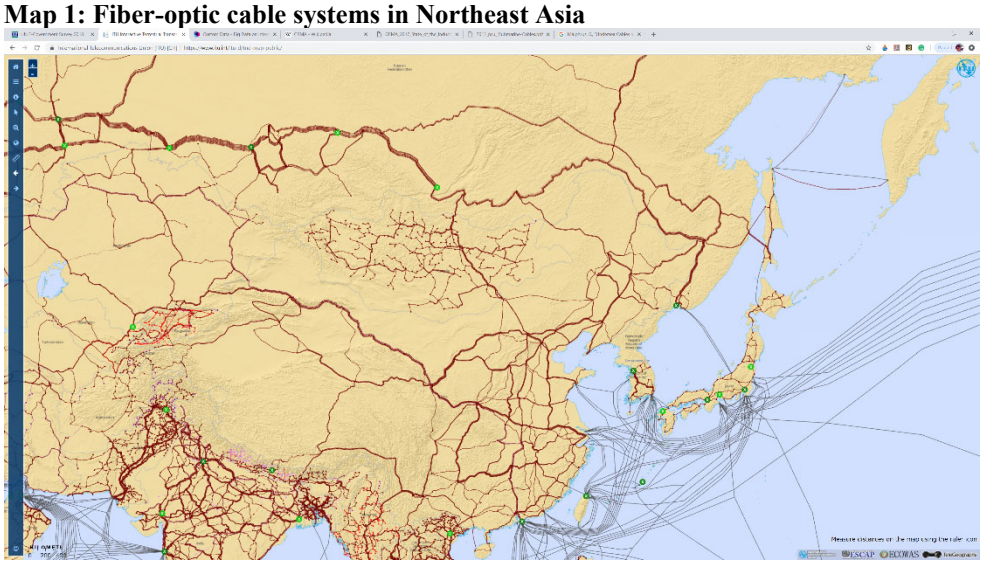
This section aims to present the state of broadband development and some of the distinctive characteristics in Northeast Asia vis-à-vis other subregions. China, Japan and the Republic of Korea have been leading the development of physical broadband infrastructure, applications and emerging technologies such as artificial intelligence and blockchain globally (UNESCAP 2018e, UN 2018). While coastal areas of these countries enjoy the advantages of submarine cables, their inland territories are far less integrated into the regional broadband networks, as referenced later in this paper.

Map 1 presents the AP-IS Transmission Map to illustrate the existing fiber-optic cable systems in the subregion. It is characterized by dense submarine cable systems landing on

[14] Tromboning index calculates "Internet routing distance/straight line distance from the source to the destination of a packet". (UNESCAP 2016, p. 12). The higher the tromboning index is, the more inefficient Internet traffic is, as the Internet traffic is routed via more locations. In some cases, e-mail sent from one country in Asia and the Pacific to a neighboring country was routed via the United States, causing delays and higher costs.

coastal areas of China, Japan and Republic of Korea, bringing affordable Internet bandwidth evidenced by the high level of Internet usage among the three countries.

Map 1: Fiber-optic cable systems in Northeast Asia



Source: ITU-ESCAP AP-IS Transmission Map at www.itu.int/itu-d/tnd-map-public/ (accessed on 16/02/2019). Green dots are IXPs; dark red is the transmission links.

While the developed countries in the region have resilient, mesh networks, broadband networks in developing Asia, on the other hand, are typically characterized as a river system, compared with mesh networks. Constrained by limited access to international transit, the developing countries' broadband networks spread from submarine landing stations to inland areas like a river (Inderst 2016). From a resilience point of view, this topology poses a risk of single point of failure in case of cable disruptions due to natural disasters. When countries are connected to the "river system", any disruption could affect other connected countries as well. This is one of the areas where regional cooperation in developing broadband infrastructure is needed with a holistic overview.

Some of the data related to broadband development in Northeast Asia is presented below in Table 1 to help obtain such a holistic overview.

Table 1: Broadband development related data: Northeast Asia

	World	East Asia/ Pacific[15]	China	DPRK	Japan	Mongolia	ROK	RF
Population (millions)	7.442	2,297	1,379	25	127	3	51	144
GNI per capita ($)	10,299	9,868	8,260		38,000	3,550	27,600	9,720
Telecom revenue (% of GDP)	2.3	2.1	1.7			3.4	3.7	1.8
Telecom investment (% of revenue)	20.7		38.8			25.7	6.9	19
Mobile subscrip-tions/100 ppl	101.6	109.6	96.9	14.3	129.8	113.6	122.7	163.3
Fixed BB subscrip-tions/100 ppl	12.5	18.8	22.9		31.5	7.6	41.1	19.5
Individuals using the Internet (%)	45.9	52.8	53.2		92	22.3	92.7	76.4
Population covered by 3G+ (%)	85	95	97	95	100	95	99	75
Int. Internet band-width (bits/user)	78,795	71,118	14,699		83,010	166,056	54,252	51,888
Mobile service fee ($ a month)	9.5	7.3	4.2		32.8	2.7	28.3	3.9
Fixed BB service fee ($ a month)	20.1	20.5	16		20.1	6.7	34.1	6
Online service index (0-1, 1=highest)	0.46	0.35	0.77	0.02	0.88	0.51	0.94	0.73

Source: Extracted from World Bank (2018) "The Little Data Book on Information and Communication Technology 2018"

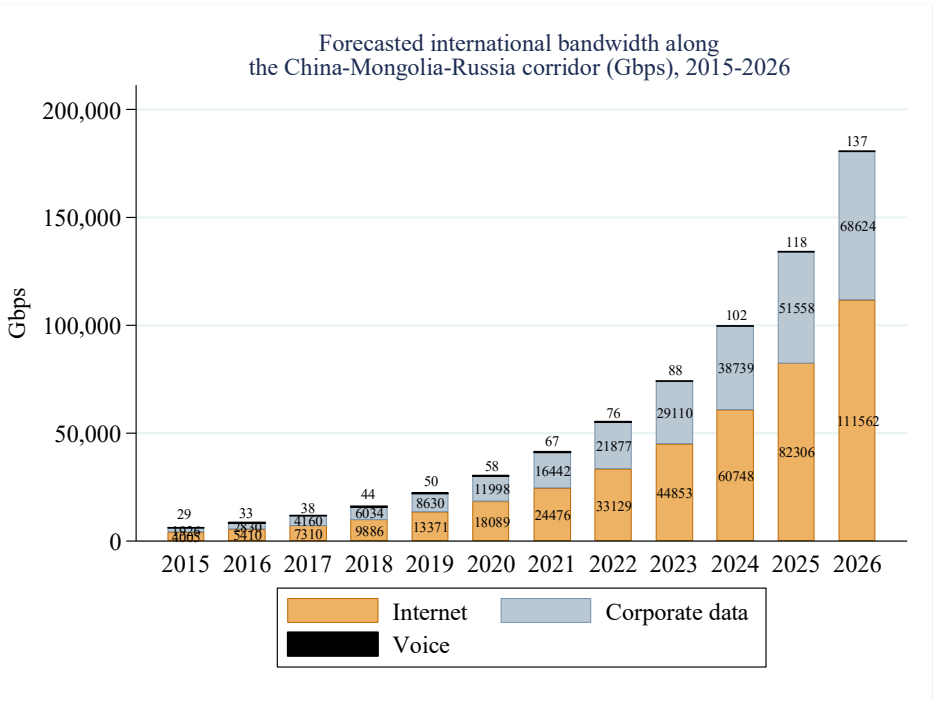
Distinctive characteristics of the subregion taken from Table 1 include the following:

- Significant levels of telecommunications investment are observed in China and Mongolia: in the case of China, the share of investment in revenue is almost twice the world average.
- Across the subregion, mobile broadband subscriptions per 100 inhabitants are close to or above the world average, except in DPRK.
- Mongolia registered far fewer fixed broadband subscriptions and a lower number of Internet users than the world average despite a very high level of international Internet bandwidth per user.
- In terms of international Internet bandwidth per user, only Japan and Mongolia exceed the world average, suggesting a greater need for cross-border broadband networks.

[15] Russian Federation is not included in this group.

As for the future demand for international bandwidth, China, Mongolia and Russia are expected to experience an exponential growth between 2015 and 2026 (Figure 4), based on an estimate calculated by Terabit Consulting (UNESCAP 2016a and UNESCAP 2017d). The growth is estimated to be driven by increased demand for bandwidth for Internet use.

Figure 4: Forecasted international bandwidth along the China-Mongolia-Russia corridor (Gbps), 2015-2026



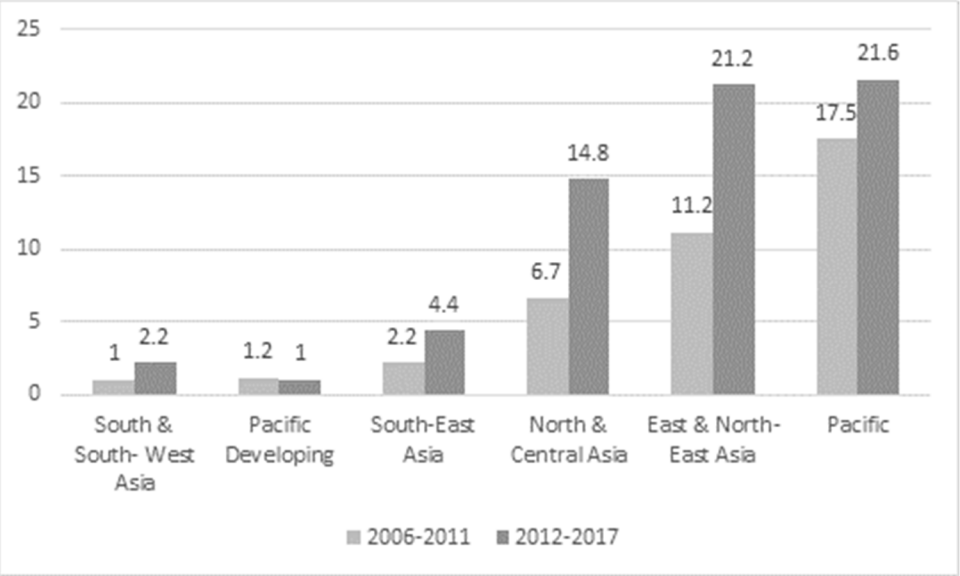
Source: UNESCAP (2017d) p. 20. From "A Study of ICT Connectivity for the Belt and Road Initiative (BRI): Enhancing the Collaboration in China-Central Asia Corridor", by UNESCAP, ©2017 United Nations. Reprinted with the permission of the United Nations.

6.2 Fixed broadband development in Northeast Asia

An important indicator of broadband development is fixed and mobile broadband subscriptions per 100 inhabitants. Due to its rapid broadband expansion and size of the population and economies, Northeast Asia registered over 77% of the total subscriptions in Asia and the Pacific, mainly driven by China, followed by South and South-West Asia (9%), North and Central Asia (7%), South-East Asia (6%) and the Pacific (2%). The concentration of broadband subscriptions in Northeast Asia has been increasing over the years (UNESCAP 2019a).

Figure 5 illustrates the differential growth patterns per subregion (UNESCAP 2019a). In addition to the concentration of fixed broadband subscriptions in Northeast Asia, the growth rate is one of the fastest among all the subregions in Asia and the Pacific.

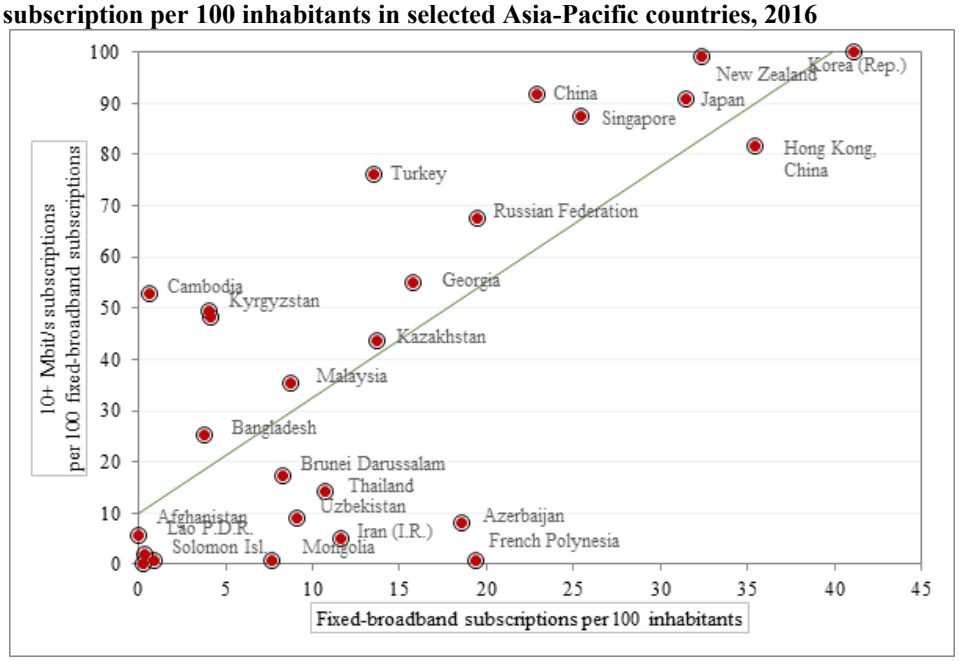
Figure 5: Average fixed-broadband subscriptions per 100 habitants, by UNESCAP subregion, 2006-2011 and 2012-2017



Source: UNESCAP calculations based on data from International Telecommunication Union (ITU), World Telecommunication/ICT Indicators database 2018, available at www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx (accessed December 2018). UNESCAP (2019a), p.3. From "Report on the Digital Connectivity and Digital Economy in Asia and the Pacific", by UNESCAP, ©2019 United Nations. Reprinted with the permission of the United Nations.
Note: The category entitled "Pacific developing countries" excludes Australia and New Zealand.

In addition to the number of subscriptions, the quality of networks matters for meaningful use of broadband services. Figure 6 illustrates fixed broadband subscriptions per 100 inhabitants and network speed of 10 Mbits/s using the 2017 ITU data (UNESCAP 2017a). This Figure illustrates a divergence among countries in the subregion, beyond subscriptions.

Figure 6: Network quality improvement between 10+Mbits/s and fixed-broadband subscription per 100 inhabitants in selected Asia-Pacific countries, 2016



Source: Produced by UNESCAP, based on data from ITU World Telecommunication/ICT Indicators Database (accessed July 2017). UNESCAP (2018g). p.5. From "Report on the challenges and opportunities in the implementation of regional broadband connectivity for all in Asia and the Pacific", by UNESCAP, ©2018 United Nations. Reprinted with the permission of the United Nations.

Table 2 shows a more granular picture of average network speeds among countries in Northeast Asia and growth in speed between June and December 2019. Some countries continued enhancing the speed, but the disparity between the top performer of Hong Kong (SAR) and Mongolia is stark; Mongolia has only 15.2% of the fixed broadband speed of Hong Kong (SAR).

A historical broadband development path also offers an additional insight as shown in Figure 7 (UNESCAP 2016c). Between 2005 and 2015, countries with red dots made less progress than those represented by blue dots. The countries in the upper right-hand corner have been enjoying higher broadband expansion in both years, and the countries in the lower right-hand corners are the ones experiencing recent expansions.

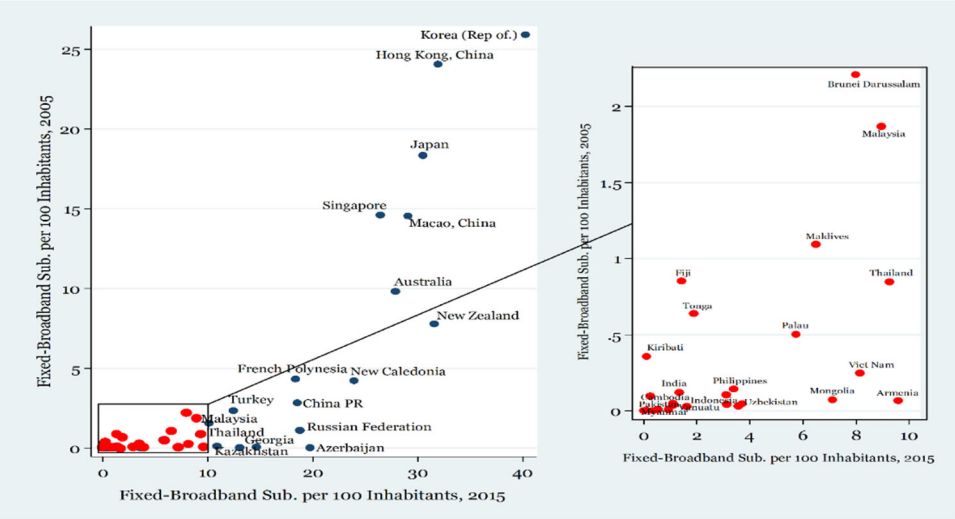
Another driver of broadband development is affordability. The Broadband Commission defines broadband affordability as 2% or less of GNI per capita (Broadband Commission 2018). Figure 8 shows countries dotted according to fixed broadband prices as a percentage of GNI per capita and fixed broadband subscription per 100 inhabitants, indicating a trajectory from unaffordable and unavailable broadband to inclusive and affordable broadband. Northeast Asia generally fares well, compared with countries in other subregions.

Table 2: Global ranking in fixed broadband speed tests conducted in June and December 2018[16]

Country	Fixed-broadband download speed Mbps	
	Jun-18	Dec-18
Singapore	180.57	190.94
Hong Kong (SAR)	150.7	161.39
Iceland	148.95	156.16
South Korea	114.07	119.61
Romania	108.42	124.54
United States	93.98	109.48
Macau (SAR)	90.14	97.79
Japan	79.37	91.94
China	78.24	89.17
Russia	38.42	45.01
Mongolia	23.13	24.66
DPRK	NA	NA

Source: http://www.speedtest.net/global-index, by Ookla

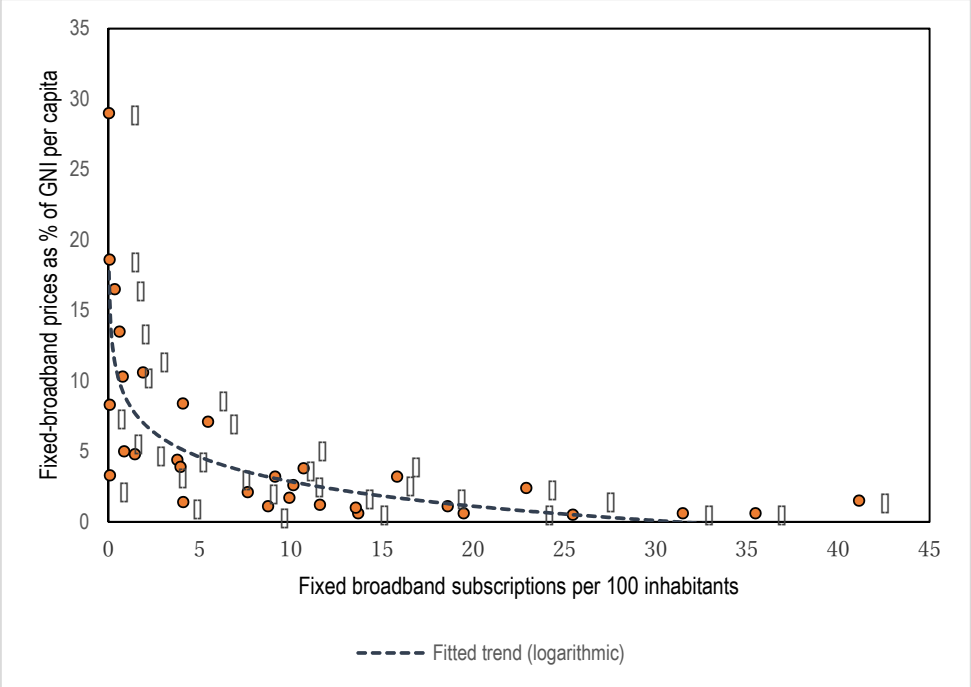
Figure 7: Comparison between fixed broadband subscriptions per 100 inhabitants between 2005 and 2015 in Asia and the Pacific



Source: Produced by UNESCAP, based on data sourced from ITU World Telecommunications/ICT Indicators Database (accessed July 2016). UNESCAP (2016c), p. 20. From "State of ICT in Asia and the Pacific 2016: Uncovering the Widening Broadband Divide", by UNESCAP, ©2016 United Nations. Reprinted with the permission of the United Nations.

[16] Results are updated at the beginning of the month for the previous month. To be ranked in each category, countries must have at least 3.333 unique user results for fixed broadband.

Figure 8: Fixed-broadband subscriptions per 100 inhabitants and prices (% of GNI per capita) in 2016

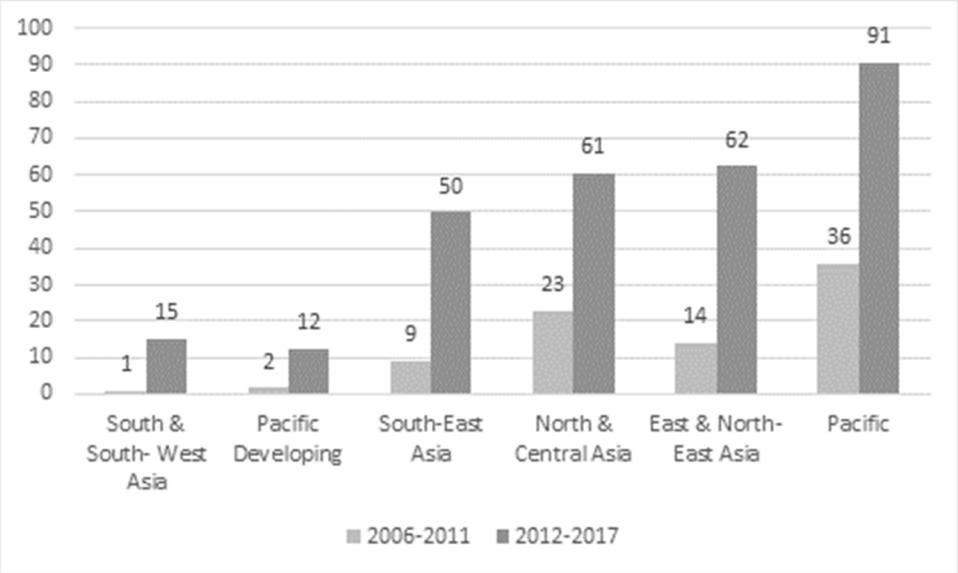


Sources: Produced by UNESCAP, based on data for fixed broadband subscriptions per 100 inhabitants sourced from ITU World Telecommunications/ICT Indicators Database (accessed July 2017). The data on fixed-broadband prices as a percentage of GNI per capita is sourced from the 2017 Measuring the Information Society Report, available from http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume2.pdf. By UNESCAP, ©2019 United Nations. Reprinted with the permission of the United Nations.

6.3 Mobile broadband development in Asia and the Pacific

When it comes to mobile broadband development in Asia and the Pacific, the landscape looks significantly different. Figure 9 shows private sector-driven rapid growth across all subregions (UNESCAP 2019a). As mentioned earlier, mobile broadband is expected to gain popularity, driven by audio and video content and social media usage on mobile phones among end users. This will require matching supportive fixed broadband infrastructure development as well as development of applications and services which capture opportunities for business, employment, education and health etc.

Figure 9: Average mobile-broadband subscriptions per 100 inhabitants, by subregion, 2006-2011 and 2012-2017



Source: ITU, World Telecommunication/ICT Indicators database 2018 (see figure I). UNESCAP (2019a) p. 4. From "Report on the Digital Connectivity and Digital Economy in Asia and the Pacific", by UNESCAP, ©2019 United Nations. Reprinted with the permission of the United Nations.
Note: The category entitled "Pacific developing countries" excludes Australia and New Zealand.

In terms of mobile broadband speed, there is a less obvious divergent trend in the sub-region. The gap between China, Japan and the Republic of Korea on the one hand and the rest of the group on the other hand is more obvious in fixed broadband network speed than in mobile network speed, as illustrated in Table 3.

Table 3: Mobile broadband network speed test results among countries of Northeast Asia, June and December 2018

Country	Mobile Download Mbps	
	Jun-18	Dec-18
Singapore	53.53	60.95
Republic of Korea	42.03	50.98
China	30.09	29.36
Hong Kong (SAR)	29.35	32.03
Japan	24.77	30.86
Russia	17.48	19.04
Mongolia	16.02	17.38
DPRK	NA	NA

Source: http://www.speedtest.net/global-index, by Ookla

6.4 International Gateways and Internet Traffic Management

In addition to the above-mentioned factors that are found correlating to broadband growth, one policy and regulatory measure examined as a potential driver is the role of an international gateway. The effects of liberalization of international gateways on broadband development are found positive, but due possibly to various information security reasons, the region has seen a reversal in trend and less countries have now liberalized the market (UNESCAP 2017c).

Data and information on some aspects of broadband development, including international gateways and IXPs in the subregion, are not readily available. However, this/such information would be useful in planning and developing broadband connectivity initiatives to improve the coverage, affordability and resilience of broadband networks in Northeast Asia.

China has three international gateways (i.e. Beijing, Shanghai and Guangzhou) which are also the carrier-neutral Internet Exchange Points (IXPs) that link together these six Chinese major backbone networks. Furthermore, China also implemented multiple small border international gateways in Alashankou, Dongguan, Fuyuan, Shenzhen, and Suifenhe for international services (mainly on voice services) between China and its neighboring countries.[17]

Considering the number of international gateways in other countries, such as Thailand (having ten), there could be opportunities to increase the presence of international gateways and IXPs in Northeast Asia.

6.5 Broadband divide within a country and policy responses

As mentioned earlier, one of the features of gaps, challenges and opportunities in the subregion is that the level of broadband network expansion and Internet usage become slower and lower when they expand to inland areas and provinces. Against this background, this section focuses briefly on gaps, challenges and opportunities, followed by other characteristics found at the national levels.

According to analysis on China's ICT infrastructure and e-resilience (UNESCAP 2016d), there are significant regional differences across China in its deployment of ICT infrastructure, and the availability and affordability of ICT services.

In 2015, the Government of China announced the Belt and Road initiative (BRI), based on six economic corridors corresponding to the Silk Road. These economic corridors (China-Mongolia-Russia Corridor; New Eurasia Land Bridge; China-Central Asia-West Asia; China-Pakistan; Bangladesh-China-India-Myanmar; and China-Indochina Economic Corridor) aim to promote connectivity of these economies with China through infrastructure, trade and investment based on the original Silk Road's pathways. (NDRC 2015).

Russia's Far East territories cover an extremely large area and are characterized by a low population density. Traditionally, the region has depended on satellite communications and pays ten times more for broadband access than major cities around the country, where prices have decreased steadily (Rossotto, Carlo Gelvanovska et al. 2015).

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[17] The details of international gateway in China can be found from "Introduction of Chinese Telecommunication: International Interconnection Projects" at https://www.itu.int/net4/wsis/forum/2015/Agenda/Session/192.

A notable initiative that could support the availability of broadband services and increase their affordability is the Okha-Ust-Bolsheretsk cable in the Russian Far East. The first stage of the network went live in May 2016 and involved the deployment of 930km of fiber-optic cabling between Ola in Magadan and Okha (Sakhalin) in the Russian Federation. The whole system spans 2,000km and has a total capacity of 400Gbps, with the option to expand to up to 8Tbps in the future[18].

In the case of Mongolia, the primary and secondary cables connect from Russia and China. As mentioned in the above sections, its international Internet bandwidth per user seems twice the world average, but it may not have expanded to provide increased access among a wider segment of the population and/or enhanced use. Mongolia's ICT development initiatives have been put in place to expand its geographical coverage and deepen the applications, such as e-government (CITA 2017).

Source:

Another salient feature of broadband development in Northeast Asia is the exposure to natural disasters and possible network vulnerabilities. The detrimental impacts of natural disasters on broadband infrastructure and delayed emergency operations in Northeast Asia have been well documented. One of the recent reports documented the fiber-optic cable disruptions in the 2011 Great East Japan Earthquake and the 2004 Wenchuan Earthquake in China, among other natural disasters (UNESCAP 2018e). Subsequent to the lessons learned, various measures and initiatives have been implemented in China, Japan and the Republic of Korea, which are chronicled and detailed in the same report. These and other lessons learned (UNESCAP 2016d, UNESCAP 2016e) are critical building blocks in planning and implementing broadband networks in the subregion.

The broadband development will be guided by national, subregional and regional initiatives. In this regard the policies and initiatives developed at the national level in each country represent another building block, as elaborated in their white papers and other documents. In addition to the emphasis on the resilient infrastructure and promoting the use of ICT, especially mobile phones, for social and economic purposes, Japan aims to deepen the use of Big Data and other emerging technologies in the near future (MIC 2017). The Republic of Korea emphasized in its Internet White Paper the deepened use of electronic applications, such as e-payment, e-commerce, and e-government, while exploring further into the convergence of AI, Internet of Things (IoT) and cloud computing (KISA 2017). In China, massive investment in broadband networks has resulted in a rapid increase in the number of Internet users (772 million), mobile Internet users (753 million) and the benefits are permeating into rural areas (CNNIC 2018). One noticeable development in China is the significant level of investment in AI (CNNIC 2018, UNESCAP 2017a).

[18] TeleGeography (2016, June). Available from: https://www.telegeography.com/products/commsupdate/articles/2016/06/10/cable-compendium-a-guide-to-the-weeks-submarine-and-terrestrial-developments/

7 Conclusion

This article aimed to present the state of broadband development and identify the characteristics, gaps and opportunities in Northeast Asia within the framework of the Asia-Pacific Information Superhighway (AP-IS). Such elements will help guide the development of technical studies, pre-feasibility and feasibility studies towards building affordable, resilient and reliable broadband networks in the subregion. This article benefitted from data and findings of technical studies, research and analyses conducted for the implementation of AP-IS.

One of the most salient characteristics emanating from this text is that there is a high concentration of fixed broadband subscriptions in Northeast Asia, and this may help accelerate the uptake and development of frontier technologies, such as AI and blockchain. However, even within the subregion, there appear to be divergent trends in affordability, speed and geographical coverage. Mobile broadband subscriptions, on the other hand, are catching up across Northeast Asia, but speed and usage might not yet correspond to the pace of access expansion.

Deepening ICT usage outside urban centers is equally critical. ICT applications benefit those in remote and rural areas most as it lowers transaction and information costs. Awareness raising and capacity development should be scaled up among provincial cities and universities to increase usage and take advantage of the increasing speeds and bandwidths being made available in national and regional broadband initiatives.

As highlighted in the section on literature review, broadband development may be associated with economic growth, increased trade and financial flows, among others, and be effective in supporting regional economic cooperation in other sectors, such as the transport, trade, energy and financial sectors. Considering the increasing connectivity among countries in the subregion, more emphasis could be placed on how to capitalize on newly developed broadband networks to enhance regional economic cooperation. It is hoped that future research will deepen empirical analysis on broadband contributions to these sectors in the context of Northeast Asia.

Future broadband development is also expected to benefit from regional economic cooperation. One of the most promising opportunities could be to connect the Far East District of the Russian Federation with submarine and terrestrial cables from neighboring countries, considering the growing oil and natural gas industry in the district and its communication needs. In addition to the physical cables and networks, efficient and effective Internet traffic management could lower costs and increase network resilience. In this regard, the importance of international gateways and IXPs cannot be overstated, considering the increasing traffic and network routes in addition to natural disaster risks.

An additional dimension specific to this subregion is the natural disaster. Northeast Asia has experienced major natural disasters, such as the 2004 Wenchuan earthquake and the 2011 Great East Japan Earthquake, both of which severely affected fiber-optic cable networks. Since then, governments have implemented various remedial measures. The need for strengthened e-resilience and the potential for enhanced co-deployment may be further challenges and opportunities in planning and deploying broadband networks in Northeast Asia, especially considering the critical role broadband networks have come to play in the financial sector, among others.

Overall, Northeast Asia is characterized by densely populated coastal areas which are well connected with submarine cables, affordable broadband services and close to universal access with active use. These are some of the prerequisites for developing and applying frontier technologies, such as AI and blockchain. On the other hand, there are still challenges in extending affordable and resilient broadband connectivity to areas deeper inland. The Far East district of the Russian Federation has far fewer broadband subscriptions than other parts of the country. In some countries, available international Internet bandwidth has not been translated into more rapid growth in broadband access, especially when fixed broadband is concerned, or deepened and widened use.

Investment in the telecommunications sector is predominantly private sector driven. For the expansion of broadband networks in the subregion, it would be essential to create an enabling environment for private sector operators to invest and compete in strategic initiatives. It would be equally important to create a virtuous circle of expanding broadband access which leads to increased usage for regional economic cooperation, such as e-commerce, trade and financial flows, and sustainable development. This, in turn, would create greater demand for broadband networks and services, and both sustain and develop the vibrant ICT industry.

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