The Research of Telecommunications Tariff Regulation and Leased Line Cost Model

—Final Report—

(English Brief Version)

RESEARCH AGENCY：

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March, 2023

Abstract

Key words: Leased Data Circuit Service, Wholesale leased line, Total Element Long-Run Incremental Cost (TELRIC), Next Generation Network (NGN), Retail price, Peering, telecommunication service tariff regulation, Price adjustments

Leased data circuit service (LDCS), or called wholesale leased line, refer to the cost incurred, when a fixed telephony operator shares or rents the leased line or infrastructure to another operator for operating voice and broadband services. In order to avoid unfair competition in the telecommunication market by price squeeze, Nation Communication Committee (NCC) would ensure the standardization of related cost and implement asymmetric regulation to the significant market power (SMP). By limit the price of wholesale market like leased line and local loop unbundling, it would promote the continuous progress of operators, and also achieve the goal of universal service obligation.

This study researched the telecommunications development plan of the European Union, as well as the telecommunications supervision policies of countries with mature markets such as the United Kingdom, Norway, France, South Korea, Japan and Australia. The researches could be the references of promoting the NGN and NGA service for our government. Simultaneously, to assist the Nation Communication Committee on ensuring the standardization of the policies of core network and access network, this study would refer the experience of building the fixed access charge (FAC) model and Mobile Access Charge (MAC) model to set up the part of wholesale leased line cost model. Also this study would build a cost model of the access network for the last mile of wholesale leased line.

The model will be renewed the calculation logic and parameters setting with references to benchmark countries such as UK, Norway, and France. Also the reseach team would use the sampling method to build the access network which was refered to Korea. The research team will subsequently consult via public discussion inviting telecom operators for their practical perspectives on parameter settings and take on advice after careful consideration.

This study recommends the implementation of Pure TELRIC model for the cost of wholesale leased line calculation. This study will conduct research on the current NGN and NGA development in various benchmark countries and will calculate cost of wholesale leased line comprised of the cost from network elements implemented in a

NGN and NGA architecture, enabling the cost of wholesale leased line to reflect the advancement of telecom technology.

In addition, the research team will also conduct international research on the actual situation of telecom tariffs in various countries, and collect relevant information on retail tariffs for comparing and analyzing the situation in our country through the OECD evaluation method. At the same time, the research team will also analyze the price profiles of Internet service interconnection in multiple cities of the Asia-Pacific region, which will be regarded as a reference for our country's supervisory authorities to develop policies in the future.

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1. Introduction

1.1 Research Background

Since the Telecommunications Management Act came into effect on July 1, 2020, the regulation of the upper limit of telecommunications tariffs in our country is based on Article 33 of the Telecommunications Tariff Management Measures for Significant Market Players, which regulates the prices of main tariffs of significant market players. However, during the period from the enforcement of the Telecommunications Management Act to the completion of the identification of significant market players by the competent authority, in accordance with Article 85 of the Telecommunications Management Act, regulatory measures similar to those under the previous Telecommunications Act will be applied. This involves setting a maximum price adjustment limit for the main tariffs of dominant players in the first category of telecommunications businesses, by calculating the reasonable adjustment range of telecommunications tariffs in the context of the overall inflation environment in our country through setting the price adjustment factor X value and adopting the LRIC (Long Run Incremental Cost) - X price index formula. The National Communications Commission will set the X values for the sixth adjustment of the upper limit of prices at 7.48% (wholesale price) and 2.15% (retail price) respectively, during the period from April 1, 2020 to March 31, 2023. Considering the vigorous development of innovative information and communication technologies in recent years, which continuously brings forth various digital services, the impact on our country's leased circuit market should also be re-evaluated. Consequently, reasonable adjustment factors for the upper limit of price adjustments should be effectively formulated to maintain a fair competitive environment in the overall telecommunications market.

1.2 Research Scope

The purpose of this project is to assist the National Communications Commission (NCC) in establishing a comprehensive regulatory system for the seventh adjustment of the upper limit of telecommunications tariffs in our country, and to propose relevant telecommunications tariff regulatory policy suggestions and directions for implementation. Additionally, in response to the rapid evolution of telecommunications technology, this project aims to re-examine and construct a next-generation leased circuit wholesale service cost model that aligns with the development trends in our market. This will be achieved by collecting historical data from telecommunications operators from Taiwan, referencing benchmark countries' trends in leased circuit regulation and their cost model designs, to serve as the basis for setting the X value for wholesale leased circuit prices from April 1, 2024 to March 31, 2027.

Furthermore, this project will also gather an overview of benchmark countries' retail telecommunications services and Internet Interconnection Bandwidth (Peering) prices, and subsequently analyze and compare the price levels between our country and benchmark cases. This not only helps in understanding international trends in telecommunications services and technology but also serves as a reference for the development of our country's telecommunications services and technology promotion, thus proposing more competitive market prices to retail end-users.

To achieve these goals, it is necessary to be familiar with telecommunications network cost measurement models and theories, as well as to grasp international trends in overall fixed communication business and telecommunications technology development through benchmark cases. Additionally, understanding key trends in recent years' telecommunications tariff service price regulation in benchmark countries and grasping the dynamics of our country's industry development through interviews and exchange meetings will be crucial in proposing recommendations that meet the development needs.

2. Worldwide Telecommunications Price Regulation and Leased Line policy

As of the end of 2021, the average broadband penetration rate among OECD member countries was 34.38%. The top three countries in terms of broadband penetration rate were Switzerland with 48.42%, France with 46.13%, and Norway with 44.91%. Among these, France and Norway have a higher proportion of fiber-optic technology in their broadband infrastructure compared to Switzerland. Additionally, France and Norway began implementing the Bottom-up Long Run Incremental Cost (LRIC) methodology for calculating the access costs of leased circuits in 2021 and 2019 respectively. Therefore, this project chooses these two countries as research targets to serve as references for the development of a leased circuit cost model in Taiwan.

2-1 European Union

In 2016, the European Union proposed the "Connectivity for a European Gigabit Society" project, which views Europe as a single framework for the digital market. The aim is to promote high levels of digitization across European countries by enhancing communication infrastructure and developing 5G applications. This initiative seeks to drive overall digital economic development and has set the broadband penetration rate as one of the key development priorities for 2025.

To facilitate the development of broadband networks across European countries, two out of the three major network connectivity goals for 2025 are related to broadband penetration issues. Firstly, regardless of urban or rural areas, each country aims to achieve a minimum download speed of 100 Mbps by 2025, with a target of reaching 1 Gbps by 2030. Additionally, for socio-economic drivers such as academic institutions or business parks, there is a goal to directly achieve a speed of 1 Gbps to enhance network speed and promote economic development.

The Body of European Regulators for Electronic Communications (BEREC) was established in 2010 against the backdrop of the EU's telecommunications reform program. Operating under the telecommunications regulatory framework set by the European Union, BEREC oversees telecommunications across EU member states. In 2013, the EU issued a recommendation on the telecommunications services market, stating that to provide innovative, faster, and higher-quality broadband services, appropriate cost calculation methods should be provided during the deployment of next-generation access networks. This ensures effective market entry for operators while striking a balance in enhancing investment incentives for operators. The BU-LRIC+

(Bottom-Up Long Run Incremental Cost Plus) calculation method is deemed most suitable to meet these objectives by setting reasonable prices for regulated wholesale access services. BU-LRIC+ establishes a model based on the costs (including sunk costs) and operational costs borne by a hypothetical telecommunications operator providing all access services with high efficiency, while also adding relevant markup ratios to recover shared service costs. Thus, the BU-LRIC+ method allows for the effective recovery of total costs incurred and provides a correct pricing reference basis.

In the "Recommendation on Relevant Markets for Products and Services" (2003/311/EC), the European Union stipulates that if certain conditions are met, including the presence of persistent barriers to market entry (structural and regulatory), lack of effective competition, and difficulty for competition law to correct market failures, asymmetric regulation should be applied to Significant Market Power (SMP) entities in those markets. The telecommunications service market is divided into five service categories: fixed telephony (including residential and business, merged in 2003), broadband, leased lines, mobile telephony, and broadcasting transmission (no longer regulated after 2007). Each service type is further divided into wholesale and retail segments.

From 2003, when there were 18 regulated items in the telecommunications service market, the number decreased to 7 by 2007. Starting from 2014, price regulation recommendations were no longer implemented in the retail market. In 2020, the recommendation for regulated markets was further reduced to only two wholesale markets: broadband and leased lines. This reduction aimed to encourage operators to increase investment in related technologies. However, national regulatory authorities can still define markets requiring regulation based on local development conditions and in compliance with the aforementioned criteria.

2-2 The United Kingdom

In the "Wholesale Fixed Telecoms Market Review 2021-26 (WFTMR)" released in March 2021, Ofcom outlines how regulation of fixed telecommunications access services will be conducted over the next five years. It also extensively solicited input from various telecommunications operators and relevant entities in the preceding year to ultimately propose strategies and implementation policies to promote competition and nationwide fiber coverage.In the WFTMR, Ofcom identifies product markets with SMP in the Wholesale Local Access (WLA) service, including Physical Infrastructure Access (PIA), Copper Pair, Fiber-to-the-x (FTTx), and leased lines. These markets are categorized into two geographical areas: Area 2 and Area 3. Area 2 refers to regions

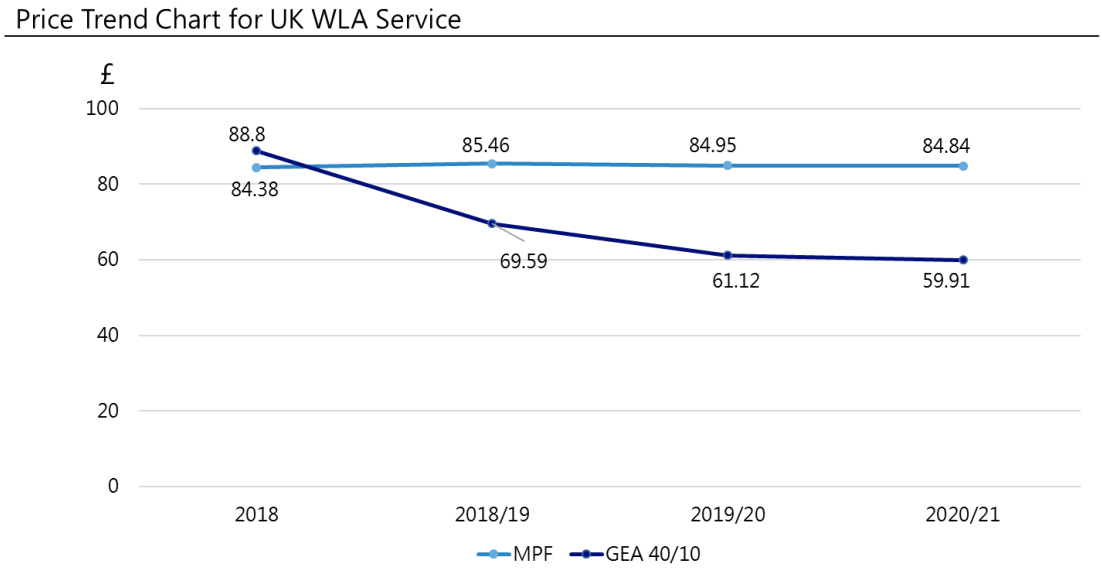
where competitors exist alongside BT, accounting for about 70%, while Area 3 refers to regions where no competitors can effectively compete with BT, making up approximately 30%. In Area 2, the expectation is to further promote investment by operators in gigabit-level fiber networks through regulatory measures. In Area 3, BT subsidiary Openreach is required to provide access to its infrastructure to other operators to promote local competition. Additionally, a cost calculation method called Regulatory Asset Base (RAB) is provided, which allows for cost recovery and serves as an incentive for Openreach investment.

Ofcom sets cost calculation bases for different service types, such as fiber networks and copper wire services, and geographical areas, such as Area 2 and Area 3, as the basis for price regulation. In Area 2, costs are mainly calculated using a Bottom-up fiber cost model, which estimates future equipment needs, network capacity, and traffic for fiber networks. In Area 3, the RAB method is used as a tool to achieve policy goals. However, Ofcom also plans to gradually phase out copper wire services, including regulatory control, as it aims to replace BT's existing copper wire services with full fiber-optic connections to ensure all households have access to ultra-fast internet services.

Ofcom sets the price control for FTTP 40/10 higher than copper wire 40/10 services (with an adjusted premium of £1.7) to reflect the value of fiber services to consumers and service providers. This regulation will apply in areas where there is no copper wire 40/10 service and Openreach has deployed FTTP 40/10 services to over 75% of the area, serving as a means to phase out copper wire services.

Ofcom's "Wholesale Local Access Review: Statement - Volume 2" announced in 2018 primarily focused on maintaining stable price fluctuations for copper pair lines. However, following a cost analysis of the Generic Ethernet Access (GEA) 40/10 service, it was discovered that the wholesale rental prices for this service were excessively high at the time. Consequently, Ofcom implemented price regulation for this service for the first time, aiming to reduce the upper limit of its price while proposing the use of the Long Run Incremental Cost Plus (LRIC+) method for cost prediction for both services.

According to Ofcom's announcement data, by 2021, there was a noticeable downward trend in the price of the GEA 40/10 service, indicating the effectiveness of the price regulation measures implemented by Ofcom.



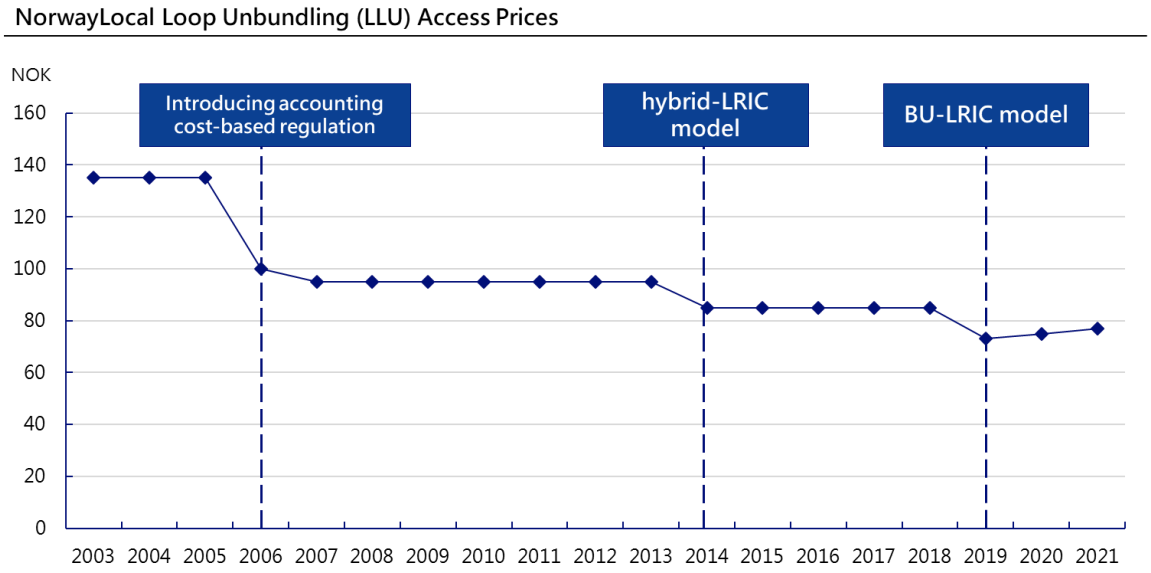
When setting price caps, Ofcom adopts the ΔCPI-X approach, and since 2019, the determination of the X value has decreased annually. In the WFTMR report, Ofcom took the step of setting the X value for the five-year period from 2021 to 2026 at 0, with the expectation that through this five-year-long regulatory policy, it can encourage operators to stably invest in fiber optic networks, ultimately safeguarding and enhancing consumer rights.

2-3 Norway

Nkom conducts surveys and analyses of the fixed-line telecommunications market every three years to examine whether there is dominance by a single operator and pricing pressure in the market. Following recent analysis reports, it is still deemed necessary to implement asymmetric regulation on Telenor's wholesale prices for copper lines in the fixed-line market. However, in the retail market, there is considered to be sufficient competitiveness, and regulation is deemed unnecessary. The regulatory approach for wholesale fixed-line services adopts a price cap method, and reasonable cost prices are calculated through a Bottom-up approach using LRIC models.

With the gradual popularization of fiber optic networks, the usage rate of copper line networks has been decreasing year by year. Therefore, Nkom has requested Telenor to completely stop providing services related to copper line networks in 2022. Instead, Telenor is required to install fiber optic lines or provide alternative products based on mobile broadband in areas where fiber optic coverage is lacking. Through this decision, Nkom aims to promote the goal of nationwide fiber optic coverage by encouraging all operators to improve their fiber optic infrastructure. Additionally, Nkom will begin evaluating whether to regulate the market for fiber broadband access in the future.

Nkom implements price cap regulation on Local Loop Unbundling (LLU) copper lines. The following graph illustrates the changes in prices over time. It can be observed that after Nkom introduced accounting cost-based regulation in 2006, there was a significant decrease in prices. Subsequently, in 2014, the introduction of model-based pricing, referencing the hybrid-LRIC calculation method, led to another price reduction. It wasn't until recently, in 2019, when the BU-LRIC model was proposed, fully incorporating the Bottom-up concept, resulting in a further reduction in overall costs. This progression in Norway's regulatory approach indicates that the gradual introduction of the Bottom-up concept has led to a gradual decrease in estimated costs.



2-4 France

The Autorité de régulation des communications électroniques et des postes (Arcep), the regulatory authority for telecommunications and postal services in France, conducts investigations and analyses of the fixed-line telecommunications market every three years. These assessments aim to examine whether there is dominance by major operators and whether there is price squeezing in the market. Based on the findings, Arcep adjusts its regulatory policies to maintain fair competition and promote the healthy development of the telecommunications market. Therefore, Arcep believes it is necessary to implement asymmetrical regulation of wholesale prices for copper and fiber optic lines by Orange, the largest telecom operator in France, in the fixed-line market, while considering the retail market competitive enough not to require regulation.

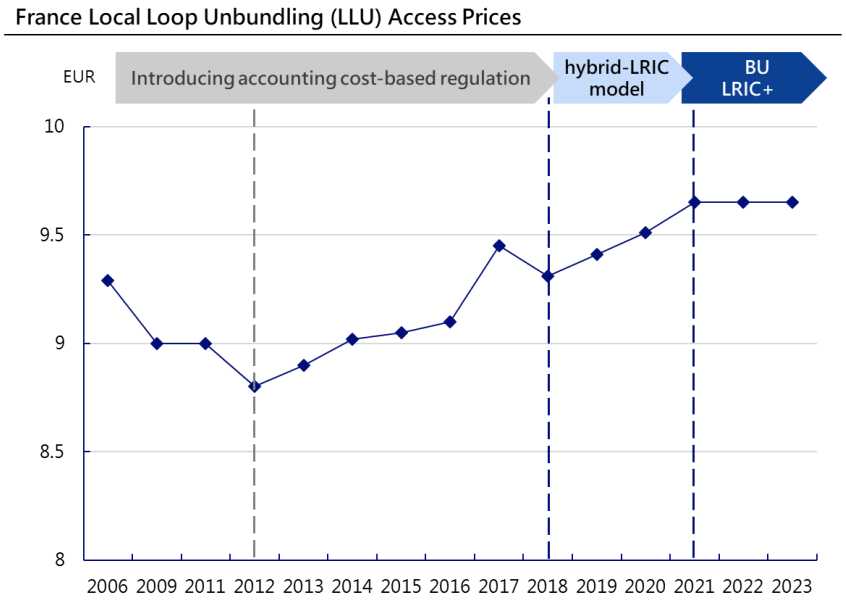
Regarding the regulation of fixed-line fiber and copper networks, Arcep employs a price cap mechanism and, starting in 2021, fully adopts the Bottom-up LRIC+ approach. Unlike the previous practice of reviewing regulations every three years, the

new regulatory period will last for five years, from 2023 to 2028. In addition to regulating wholesale prices for fixed-line fiber and copper lines, Arcep regulates fixed-line fiber according to the competitiveness of markets in various regions of France. For regions with low competitiveness, Arcep applies asymmetrical price regulation to Orange, while in highly competitive areas, prices are left unregulated.

In terms of regulatory issues, France proposed the French high-speed internet plan in 2013, with a financing amount of 3.57 billion euros. The goal was to provide 30Mbps internet service to every French consumer by 2022 and to have fiber coverage in 80% of all locations in France, aiming to achieve 100% fiber coverage throughout France by 2025. However, as of the third quarter of 2021, fiber network coverage in France reached approximately 67% of all locations. While it is expected to reach around 87% coverage by the end of 2022, the French government has reduced the target for fiber coverage by 2025 from 100% to 98% and postponed the target for complete coverage to 2030.

Arcep used accounting cost-based regulation from 2006 to 2012. Due to cost reductions resulting from regulatory policies and technological advancements, the cost of Local Loop Unbundling (LLU) decreased from 9.29 euros to 8.8 euros during this period. However, starting in 2012, Arcep accelerated the phasing out of copper lines and their replacement with newer fiber technology by reducing the depreciation period for copper lines from 25 to 13 years. The reduced 12-year period was calculated into the LLU pricing annually, resulting in an increase in copper line costs from 8.8 euros in 2012 to 9.5 euros in 2020. The increase halted when Arcep announced that the cost of copper lines would be maintained at 9.65 euros from 2021 to 2023.

In summary, prior to 2005, Arcep used the Long Run Average Incremental Cost (LRAIC) method for LLU cost calculations, estimating asset prices using the Reset Cost method. To stimulate investment in copper line networks, Arcep shifted to accounting cost-based regulation after 2006. In 2012, Arcep accelerated the phasing out of copper lines by shortening the depreciation period from 25 to 13 years. Starting in 2018, Arcep introduced a hybrid calculation method combining the BU-LRIC+ model with accounting costs, setting the line costs based on the proportion of fiber optic and copper line users (55% fiber and 45% copper). Finally, from 2021 onwards, Arcep fully adopted the BU-LRIC+ model.



2-5 South Korea

South Korea's telecommunications regulation is primarily governed by the Telecommunications Business Act, which covers various regulatory aspects including fiber optics, copper lines, infrastructure for accommodating equipment, and the installation of telecommunications facilities. The Ministry of Science and ICT (MSIT) is the main regulatory authority responsible for evaluation, market maintenance, price supervision, and other related duties under this law. The objective is to maintain fair competition, promote healthy development in the telecommunications market, and ensure convenience for users through regulatory measures outlined in the law.

Furthermore, to achieve nationwide high-speed internet coverage, the South Korean government announced plans in 2018 to provide nationwide 100Mbps high-speed internet starting from 2020. South Korea successfully achieved this goal in 2020, becoming the eighth country globally to offer high-speed internet services to all its citizens.

Regarding the cost of circuit leasing, South Korea's current calculation method is based on the business data provided by telecommunications companies to the MSIT annually. The relevant costs are calculated using a top-down accounting cost method. Unlike wholesale tariff regulation through the establishment of price caps, South Korea primarily relies on negotiations between operators. MSIT retains supervisory authority but generally does not intervene in the pricing process of wholesale tariffs. However, operators reaching a certain scale and market share are obligated to provide circuit leasing to fellow telecom operators.

In contrast to the wholesale market, regarding retail tariff regulation, telecommunications companies are required to report their cost calculation basis to MSIT in addition to business data. This illustrates that regulatory authorities adopt a more laissez-faire approach in the fixed-line wholesale market compared to the retail market, using the calculated fixed-line leasing costs as a reference. Additionally, South Korea started planning for bottom-up cost calculations in 2021, but relevant model data has not been made public yet.

Although South Korea has begun to calculate network deployment costs through the Bottom-up approach, relevant model data has not been publicly disclosed. Therefore, this study references a paper published in the May 2021 issue of the Telecommunications Policy journal titled "Estimating the deployment costs of broadband universal service via fiber networks in Korea." The paper utilizes the Bottom-up approach to estimate the costs required for South Korea's national network-wide 100Mbps universal service policy proposed in 2018 to be implemented by 2020. The study calculates that the policy would require approximately 1.1 trillion Korean won in costs. Furthermore, it indicates that there is little difference in coverage costs between 50Mbps and 100Mbps. Below is an overview of the model calculation.

2-6 Japan

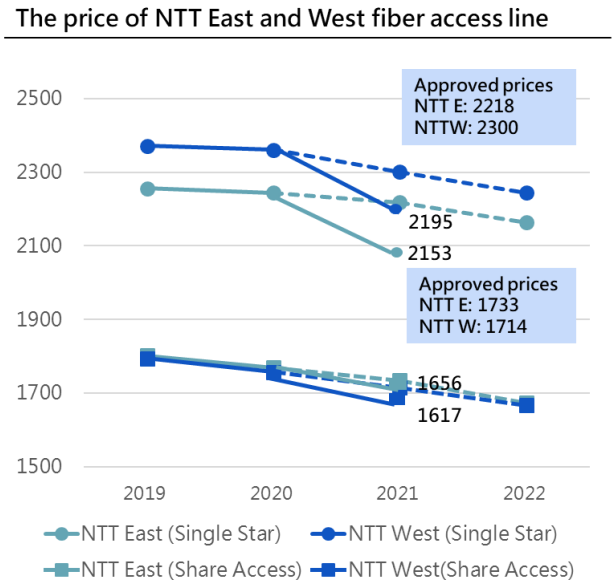
The telecommunications regulatory system in Japan is overseen and established by the Ministry of Internal Affairs and Communications. According to the Telecommunications Business Act, asymmetric regulation is applied to operators with monopolistic characteristics in the telecommunications market, targeting the pricing regulation of relevant telecommunications equipment based on its necessity, monopolistic nature, or capacity to accommodate the majority of users. In the wholesale fixed-line market, costs are primarily calculated using the Top-down approach, where regulated operators submit costs to the Ministry of Internal Affairs and Communications for review after the fact, while in the retail market, costs must be submitted before their determination.

In terms of regulating the fixed-line market, according to the Telecommunications Business Act, if the number of user loops deployed by a single telecommunications operator exceeds 50% of all user loops within each prefecture, the related equipment will be considered bottleneck equipment. The regulatory authority, the Ministry of Internal Affairs and Communications (MIC), will designate such equipment as "Type I Designated Telecommunications Facilities" and subject them to regulation. Currently,

the regulated telecommunications operators are NTT East Japan and NTT West Japan.

The regulatory approach for fixed-line market services requires the establishment of relevant safeguard contracts, which must be reported to the Minister of Internal Affairs and Communications. Services that have a significant impact on user rights, such as subscriber telephones, ISDN, or public telephones provided by NTT East and West, are classified as "specific telecommunications services." They are regulated using a price cap regime, which is adjusted every three years.

The fiber optic network architecture in Japan is divided into two modes, with different access methods available for different types of residences, namely Share Access and Single Star. Additionally, the price of fiber optic cores has been gradually decreasing in recent years due to technological advancements. This trend can be observed in the price changes of fiber optic cores offered by NTT East and West in recent years, all of which were below the price ceilings approved by the Ministry of Internal Affairs and Communications in 2021.



2-7 Australia

Unlike other countries, the telecommunications regulatory authority in Australia is the Australian Competition and Consumer Commission (ACCC), similar to the role of the Fair Trade Commission in our country. Its regulatory framework for fixed-line services can be traced back to the amended Competition and Consumer Act 2010 (CCA) in 2010. Under the CCA, the ACCC can issue Final Access Determinations (FADs) for specific services in the telecommunications market. An FAD is an administrative order used to regulate the prices of declared services and non-service obligations.

Wholesale fixed-line services in Australia are regulated using a benchmarking cost allocation framework called the Building Block Model (BBM). Therefore, the principle of cost allocation mainly follows the accounting cost allocation, with each period typically lasting five years (the most recent period being from 2019 to 2024). On the retail side, the ACCC revoked most retail price controls in 2015, and price cap regulation now only applies to Telstra's fixed-line voice services. Regarding the cost allocation framework for wholesale copper network services, the ACCC announced in 2021 that it would no longer be used. Future pricing models will be reconsidered, and the ACCC will continue to monitor whether there is a need for regulation in the fiber access market.

ACCC relies on these three objectives to establish the Fixed Line Service Model (FLSM) to determine the prices of declared fixed-line services and propose FAD, including the following seven items: Unconditioned Local Loop Service (ULLS), Line Sharing Service (LSS), Wholesale Line Rental Service (WLR), Local Carriage Service (LCS), Fixed Originating Access Service (FOAS), Fixed Terminating Access Service (FTAS), and Wholesale Asymmetric Digital Subscriber Line (ADSL). In the current regulatory period from 2019 to 2024, the pricing of these seven fixed-line services continues to be based on the prices formulated in the previous period. ACCC aims to encourage telecommunication providers to migrate their services from the PSTN network to the NBN. In the future, it will reassess the regulatory methods of price control, but the FLSM calculation method is currently maintained.

FLSM sets price caps for the seven defined fixed-line services in FAD, and its model uses the Building Block Model (BBM) for pricing. BBM is a principle commonly used by ACCC to calculate the pricing of public resources, employing a benchmarking method to refer to the tariff content of other countries implementing the LRIC benchmarking, aiming to achieve the principle of LRIC pricing. Therefore, the calculation principle of benchmarking is also based on the incurred costs, intending to allow telecommunication providers to recover their investment costs in pricing while obtaining reasonable returns on their investments. This pricing principle promotes competition among telecommunication providers and encourages them to invest in efficiency.

ACCC has defined, in addition to the original seven fixed-line services, a Domestic Transmission Capacity Service (DTCS) similar to circuit leasing. Unlike Wholesale Line Rental (WLR) in fixed-line services, which specifically refers to narrowband and voice transmission line rental services, DTCS is a general service mode for fixed lines. It broadly refers to the use of broadband to transmit voice, data, or other communication

methods, and the following conditions must be met for a transmission service type to be classified as DTCS:

- Symmetry: Bidirectional transmission must have the same data transmission rate.
- Dedicated: Dedicated to a single user and not shared with others.
- Point-to-point: Provides transmission from one point to another.
- High capacity: Requires a rate of 2Mbps or higher.
- This service must be a wholesale service and must be integrated with the requester's infrastructure to provide other services.

ACCC began price regulation for DTCS in 2020 by implementing a price cap adjustment (minus-x) to lower prices. Unlike the seven fixed-line services originally defined by ACCC, which use an international benchmarking cost allocation framework for cost calculation, the cost calculation method for DTCS involves adjusting cost prices downwards based on the costs calculated using a regression model established in 2016 through a domestic benchmarking approach. n the decision made in 2020, it was found that after adopting the price cap calculation based on the 2016 regression model, the prices of relevant services decreased by 53% during the regulatory period. In fact, the prices of some services decreased even more significantly. ACCC considered this as an effective response to the regulatory effectiveness of the regression model. Based on this situation, ACCC referred to the magnitude of price decreases during the previous period, consulted with experts, scholars, and telecommunications industry stakeholders. In 2020, ACCC adjusted the price caps for different traffic volumes accordingly. The adjustments specified for the three traffic segments designated by DTCS are as follows:

- Low traffic (2Mbps - 10Mbps): 35%
- Medium traffic (10Mbps - 1Gbps): 55%
- High traffic (1Gbps and above): 60%

3. International Comparison of Telecommunication Service Fee

The study collected data from seven benchmark countries, including Australia, France, Japan, South Korea, Norway, the United Kingdom, and Taiwan. Additionally, it included major operators from OECD countries with NRI rankings superior to Taiwan. The collected tariff items covered retail services including mobile broadband, fixed broadband, and leased lines.

Due to irregular promotional offers by operators and the sourcing of tariff data directly from the official websites of telecommunication companies without comprehensive historical data, the study ensured stability in tariff comparisons by collecting data from the same year and the latest available information at the time of comparison. For benchmark countries and reference countries, the data for mobile broadband and fixed broadband plans were collected in the first quarter of 2022, while the data for leased line plans was collected up to May 2022. The tariff data for Taiwan was collected in August and September 2022.

Moreover, the study adhered to OECD comparison principles and made adjustments according to the telecommunications market conditions, developing a comparison method suitable for current market demands. The benchmark countries for comparison were determined based on the telecommunication operators defined by each service basket, as well as the top two market-leading representatives in Taiwan.

3-1 Mobile Broadband Fee Comparison

According to the OECD's Mobile Broadband Data Only service basket evaluation method, broadband is categorized into seven usage tiers based on monthly available data usage (at least greater than 0.5GB, 1GB, 2GB, 5GB, 10GB, 20GB, 50GB). This research evaluates mobile broadband plans covering 3G, 4G, and 5G schemes. The leading mobile broadband service provider in our country, Chunghwa Telecom, offers various plans segmented by monthly data usage, along with multiple bundles and promotional offers for consumers to choose from. Considering the similarity between the service plans offered by telecom operators and the OECD Mobile Broadband Evaluation settings, which categorize charges and evaluations based on monthly available data usage, the research team will follow OECD guidelines in evaluating retail mobile broadband tariffs. This entails amortizing non-recurring expenses over three years, such as connection fees and setup fees. The comparison of mobile broadband service tariffs used by households in various countries will be based on monthly prices, inclusive of

taxes, with comparisons made based on exchange rates, PPP, and the proportion of each country's GNI. To accommodate the trend of increasing broadband data usage and our country's relatively high data usage levels, this research's mobile broadband tariff evaluation will not adopt the OECD 0.5GB, 1GB, 2GB service baskets. Instead, it will categorize data usage into four tiers based on monthly usage levels (at least greater than 5GB, 10GB, 20GB, 50GB).

Traffic	Number of countries	Measure-ment	Taiwan	Lowest Fee	High Fee
Low (≧5GB)	18	Currency (NTD)	398	122 (Switzerland)	1,300 (Canada)
		PPP (NTD)	398	55 (Switzerland)	696 (Japan)
		GNI	0.51%	0.06% (Switzerland)	1.17% (Japan)
Medium (≧10GB)	18	Currency (NTD)	399	122 (Switzerland)	1,898 (Canada)
		PPP (NTD)	399	55 (Switzerland)	1,000 (Canada)
		GNI	0.51%	0.06% (Switzerland)	1.60% (Canada)
High (≧20GB)	18	Currency (NTD)	399	122 (Switzerland)	2,277 (Canada)
		PPP (NTD)	399	55 (Switzerland)	1,199 (Canada)
		GNI	0.51%	0.06% (Switzerland)	1.92% (Canada)
Super High (≧50GB)	18	Currency (NTD)	499	122 (Switzerland)	16,971 (New Zea-land)
		PPP (NTD)	499	55 (Switzerland)	8,993 (New Zea-land)
		GNI	0.63%	0.06% (Switzerland)	15.99% (New Zea-land)

3-2 Fixed Broadband Fee Comparison

The research team, referencing the OECD's methodology for fixed broadband comparison, focuses solely on plans commonly subscribed to by households for comparison purposes. They incorporate one-time fees such as installation and construction costs over a three-year period to reflect the actual monthly cost paid by the public for using fixed broadband services. The comparison is conducted based on a unit rate of 1Mbps. The results of the comparison are based on the price per Mbps and calculated inclusive of taxes, taking into account exchange rates, PPP, and the proportion

of each country's GNI. Currently, many fixed broadband services in the telecommunications market do not impose data usage limits. Therefore, the research divides the fixed broadband service basket into categories: Low (greater than 10Mbps, less than 25Mbps), Medium (greater than 25Mbps, less than 100Mbps), High (greater than 100Mbps, less than 1000Mbps), and Ultra-High Speed (greater than 1000Mbps).

Traffic	Number of countries	Measure-ment	Taiwan	Lowest Fee	High Fee
Low (10M≦Traf-fic≦25M)	18	Currency (NTD)	29.0	29.0 (Taiwan)	162.8 (Iceland)
		PPP (NTD)	29.0	19.9 (Denmark)	85.4 (Sweden)
		GNI	0.04%	0.02% (Denmark)	0.11% (Sweden)
Medium (25M≦Traf-fic≦100M)	18	Currency (NTD)	6.5	5.2 (South Korea)	17.4 (USA)
		PPP (NTD)	6.5	3.1 (Switzerland)	9.0 (USA)
		GNI	0.008%	0.003% (Switzerland)	0.012% (Canada)
High (100M≦Traf-fic≦1G)	18	Currency (NTD)	1.8	1.0 (Denmark)	4.9 (Australia)
		PPP (NTD)	1.8	0.5 (Denmark)	2.4 (Japan)
		GNI	0.002%	0.0007% (Denmark)	0.004% (Japan)
Super High (1G≦Traffic)	18	Currency (NTD)	1.0	0.1 (Switzerland)	2.2 (Norway)
		PPP (NTD)	1.0	0.05 (Switzerland)	1.2 (U.K.)
		GNI	0.001%	0.0001% (Switzerland)	0.002% (U.K.)

3-3 Leased Line Fee Comparison

Among the dominant providers of leased lines in our country, Chunghwa Telecom offers data leased line services with transmission rates covering 64Kbps, 512Kbps, T1 (1.5Mbps), E1 (2Mbps), T3 (45Mbps), STM-1 (155Mbps), STM-4 (622Mbps), STM-16 (2.5Gbps), STM-64 (10Gbps), and others. Considering the service offerings of benchmark countries and existing providers in our country, as well as the OECD's leased line comparison settings, which include 2Mbps dedicated line services, the research team, in evaluating retail leased line tariffs, will adhere to the OECD's settings. They will exclude non-recurring charges and ensure that at least one endpoint is located in a major city. The comparison will focus on E1 (2Mbps) and E3 (34Mbps) leased lines across different countries, calculating the total price weighted by distance for different

line lengths for comparison purposes. The comparison results will be based on monthly prices, and since the target customers for applying for leased data lines should be corporate entities, the comparison will only consider exchange rates and PPP.

Traffic	Number of countries	Measure-ment	Taiwan	Lowest Fee	High Fee
2M	13	Currency (NTD)	14,375	12,617 (Iceland)	101,921 (U.K.)
		PPP (NTD)	14,375	5,426 (Iceland)	62,338 (South Korea)
34M	9	Currency (NTD)	42,545	28,400 (Iceland)	529,387 (Canada)
		PPP (NTD)	42,545	12,214 (Iceland)	338,856 (South Korea)

4. Leased Line Cost Model

4-1 Theory Concept

The basic concept of Long-run Incremental Cost (LRIC) theory posits that when a new telecom operator enters the fixed network services market, it constructs the most efficient telecommunications network using optimal technology and equipment. In long-term cost estimation, fixed costs are assumed to become variable costs for updates, thereby calculating incremental costs. The aim is to maintain market competitiveness and efficiency through this forward-looking cost calculation method. LRIC theory is developed based on the Average Incremental Cost (AIC) method and evaluates future reasonable costs based on current technological standards when calculating the constituent factors of various networks. This calculation method determines the minimum cost through the most efficient production methods, assuming all production factors are variable long-term costs.

The advantages of LRIC theory lie in incorporating operational efficiency and cost minimization in design. The primary way it encourages operators to minimize costs is through network and technological efficiency. For instance, in a competitive market, new entrants may employ the latest equipment to access the market, leading to lower cost structures or the most efficient production methods. Through the concept of long-term costs, assuming that all production factors can change due to the development of new technologies, operators can provide services more efficiently.

There are three important concepts in LRIC theory. Firstly, the Incremental Cost concept follows the principle of welfare economics, suggesting that pricing based on marginal cost maximizes efficiency (social welfare). Therefore, when calculating costs,

only the additional cost required to add one unit of service (marginal cost) is considered, without accounting for costs that exist when the telecom service is not in use (such as shared equipment, management costs, etc., which are calculated under the concept of common costs). Secondly, the Forward Looking Cost concept assumes that in a competitive market, new telecom operators can enter with the latest equipment, obtaining the most efficient cost structure. Costs are calculated based on the most efficient method derived from the current technological level, with the total demand for services as the expected assumption for each cost. Thirdly, the Long Run concept involves cost calculation from a long-term perspective. Under the long-term (beyond the maximum service life) concept, initial fixed costs are converted into variable costs, and marginal costs are calculated using the concept of variable costs. There are three main concepts in LRIC model：

1. Incremental Cost：

According to the welfare economics, the price decided by marginal cost would most benefit to the whole society. The incremental cost is defined as the cost needs to pay when tried to increase the service capacity by one unit.

2. Forward Looking Cost：

Assuming the new telecom operator could have cost competence by adopting the latest equipment, the efficient cost should be calculated based on the current technique capability.

3. Long Run Cost ：

The time period of the model should be set long enough to turn fix cost investment into incremental cost.

Following the concepts of LRIC above, we could derive a formula to calculate the access charge rate. The rate is decided assuming total long-run access revenue would equal to total incremental expense. And the time depreciation effect is also considered in the formula to reflect opportunity cost in different time. Since we adopted the TELRIC method, we would calculate the cost of every network element then sum up

each cost by routing factor. The formula used in model is listed below.

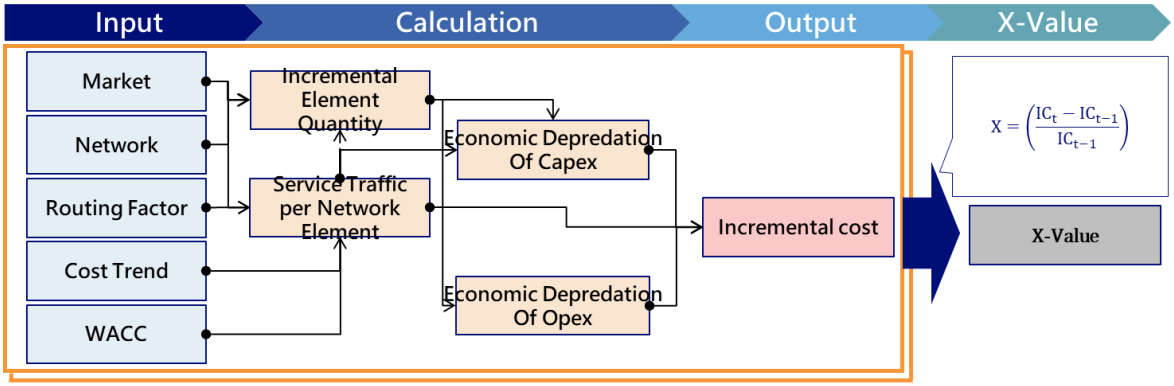
$$\sum_t \frac{1}{(1+r)^t} E_t = \sum_t \frac{1}{(1+r)^t} x_t a_t \quad \Rightarrow \quad a_i = p_i \cdot \frac{\sum_t \frac{1}{(1+r)^t} \cdot E_t}{\sum_t \frac{1}{(1+r)^t} \cdot x_t \cdot p_t}$$

Parameter Definition

E : Expense (CAPEX/OPEX)
X : Total Service Traffic
a : Access Charge Rate
P : Equipment CAPEX Index
r : Depreciation Rate (WACC)
i : Year
t : Model Period (t = 1998 - 2060)

3-2 Model Algorithm

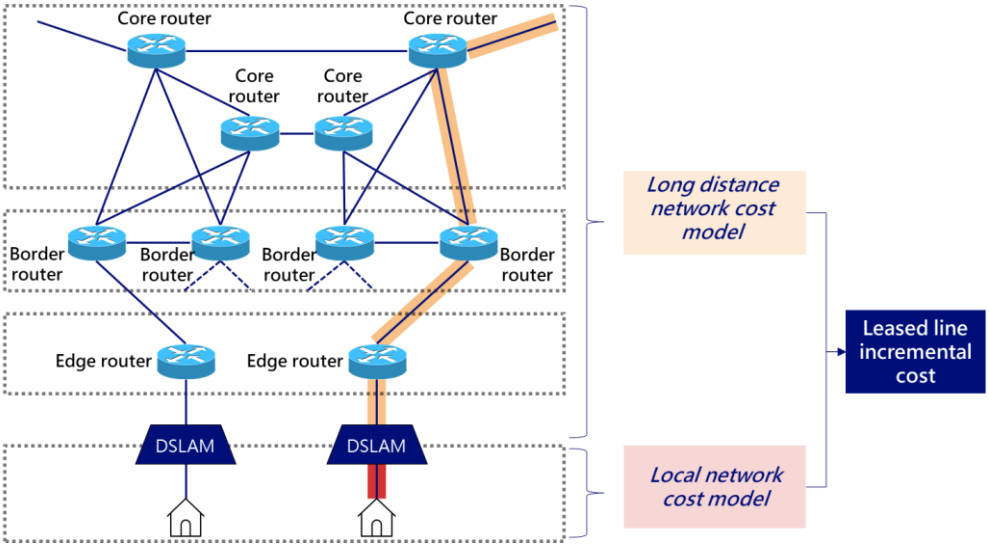
The model could be divided into three parts：input, calculation, output. The key parameters(input)of leased line cost model are market situation, network design(technical parameter), routing factor, cost trend of equipment and WACC. Market situation is used to estimate the amount of access service. According to the network design, we could then come out the incremental need of different elements. Routing factor, cost trend and WACC are used to turn the incremental network element amount into incremental cost of providing the access service. The whole algorithm picture is listed below.



The cost model is based on the Pure LRIC methodology, which means cost that could be avoided if the telecom operator chooses not to provide such service, namely avoidable cost, would not be taken into account. As the environment changed, adoption of mark-up doesn't seem to be common anymore. European Commission (EC) suggested to adopt Pure LRIC model since 2009. In Pure LRIC model, no mark-up is adopted. To calculate an efficient cost of access service, only the cost of elements which involve providing related service should be count. In recent years, most of the European countries have changed to use the pure LRIC model.

The telecommunications circuit leasing service market in our country covers the access network from telecom operator facilities to end-users, including the fixed network backbone and core network. Therefore, it is anticipated that separate cost

measurement models will be developed for local circuit leasing and long-distance circuit leasing. The circuit leasing cost model for this instance is expected to be based on the network models for wholesale access products announced by Norway's Nkom in 2018 (EU Commission defined Market 3a, Market 3b, and Market 4 by 2020) as the primary benchmark case. Additionally, other benchmark countries' circuit leasing service models and the design of the research team's previously developed fixed network core network cost model will be referenced to establish an ideal network model tailored to the operating environment of our country's circuit leasing market.



The network technologies covered by this model include Time Division Multiplexing (TDM), Next Generation Networks (NGN), and Next Generation Access (NGA). According to the recommendations of the European Commission, the network technology to be used in the cost measurement model for fixed telecommunications services should be NGN. However, considering the different national contexts, regulatory authorities may also include TDM technology from PSTN in the model design.

The research team believes that when selecting network technologies, it is necessary to consider the current situation of the telecommunications market in our country and the substitutability of various technologies. Since many voice and narrowband telecommunications services in TDM networks have not yet been replaced, such as landline services, call forwarding, enterprise telephone networks, etc., although NGN has established relevant standards for these services, it will still take some time to complete the transition plan. Therefore, the team proposes that in this circuit leasing model, the current development status of our country's fixed network should be considered, and the TDM model should be used as the initial technology before gradually transitioning to the NGN model.

On the access network side, according to reports from the Body of European Regulators for Electronic Communications (BEREC), in line with the EU's Digital Agenda goals to promote the widespread adoption and coverage of broadband services and other overall digital development plans, the construction of Next Generation Access (NGA) network cost models should consider gradually transitioning copper wire products to next-generation access products such as fiber optics.

Reflecting on the telecommunications network development process in our country, given the long-standing efforts to enhance the widespread availability and coverage of broadband services in rural areas under forward-looking initiatives, the research team also suggests incorporating the European Union's recommended approach by including scenarios of optical transformation in the model to address access network modernization.

3-3 Adjustment Algorithm

The results of this model are calculated based on various product service baskets, and X values for price adjustment upper limits are proposed according to cost variations. The model is divided into two types of circuit leasing: long-distance dedicated circuits and local dedicated circuits. The final product service baskets are designed based on the main product categories of current telecom operators, categorized according to line distance and speed. For long-distance dedicated circuits, distances are classified into three categories (0-100 kilometers, 100-200 kilometers, >200 kilometers) and two speed categories (200 Mbps - 1 Gbps, >1 Gbps), totaling six product categories. For local dedicated circuits, distances are classified into two categories (0-3 kilometers, >3 kilometers) and three speed categories (20-30 Mbps, 30-100 Mbps, 100-200 Mbps), totaling six product categories.

In order to reduce the impact of the market, there might be some adjustments made to the rates calculated by the model. Taking European countries as examples, they would make adjustments in terms of macroeconomics and smoothing introduction.

1. Macroeconomics Adjustment

This adjustment is set to include the potential effects generated by macroeconomics change. Thus the leased line cost should be adjusted according to the inflation rates each year.

In implementing the X-value for circuit leasing in this instance, we draw from our past experiences with introducing the LRIC model for calculating core network costs in both fixed and mobile networks. In the current circuit leasing cost model calculation

process, we only include the relevant costs incurred by providing leasing services to other operators. Additionally, within the model, we calculate the suggested X-value using the Pure TELRIC approach. This section will address adjustments and suggestions regarding the implementation of the Pure TELRIC-based suggested X-value.

Firstly, based on the discussions surrounding the current X-value settings for circuit leasing and our past experiences, we have also referred to the calculation methods of related models abroad. We adjust the calculated rates in the model based on predictions of the consumer price index (CPI) and inflation rate. According to the annual CPI published by the Directorate-General of Budget, Accounting and Statistics, the annual CPI growth rates have ranged between -0.87% and 3.52% from the year 1998 to 2022. After calculating the geometric mean of the growth rates over the years, the average annual CPI growth rate is approximately 1.04%.

In Taiwan, we adopt the annual increase rate of CPI(Customer Purchase Index)as the inflation rates in the model. Since the government does not predict the CPI index, we take the long-term historical data as reference. The average inflation rate between 1998-2022 is 1.04%. We assume the inflation rates would remain the same in 2024-2028. Therefore the access rate should be adjusted according to the following formula:

Rate 2024(post adjustment)＝ Rates 2024(before adjustment)*(1.0104)^ 1
Rate 2025(post adjustment)＝ Rates 2025(before adjustment)*(1.0104)^ 2
…

When considering the introduction of price adjustment factors (X values), the research team plans to calculate the cost change range from the 113th to the 117th year using the concept of geometric mean based on the unit usage cost calculated by the model. This will serve as the suggested X value result for the model calculation. The actual calculation formula is as follows:

$$X\text{-}Value_{2024\text{-}2028} = \{ 1+ [(\text{leased line incremental cost}_{2028}) - (\text{eased line incremental cost}_{2024})] / (\text{eased line incremental cost}_{113}) \} \text{ ^1/4 } -1$$

2. Access Network Fiberization Adjustment

In the cost calculation and corresponding X value section for broadband circuits in the model results, the logic for calculating the X value is the same as for dedicated circuits, averaging from the 2024 to the 2028 year. Additionally, in the calculation, the cost assumption for the 113th year is taken as the baseline point, assuming that the annual incremental cost for achieving 100% fiberization by the 2029 year serves as the

reference point. The cost changes are separately calculated for different scenarios: maintaining the current state or achieving only 50% fiberization by the 2029 year in the access network. This is to estimate the variations in X values that can be set under different policy goals and levels of completion by operators, providing adjustment recommendations for regulations and policies. Moreover, it can also serve as a policy mark-up for regulatory agencies in coordinating the fiberization process with operators.

For example, in the calculation of monthly rental fees for broadband internet circuits (excluding those above 300 Mbps and below 12 Mbps), assuming 100% fiberization completion as the baseline, the X value is set at 2.10%. This means that if operators can achieve 100% fiberization of access lines by the 118th year, the model calculates an X value of 2.10%. Similarly, if only 50% fiberization is achieved, the X value calculated by the model for the cost change relative to the baseline (100%) is 3.32%. For the scenario of maintaining the current state, the X value is calculated as 4.46%. These values can serve as policy mark-ups in negotiations with operators.

3-4 The Suggestion for Fixed Access Charge in Taiwan

The current circuit leasing model includes both core and access networks, covering both dedicated and broadband circuit components. Within the dedicated circuit portion of the model, corresponding to the main tariff items, there are long-distance dedicated circuits (core network) and local dedicated circuits (access network). Since the model calculates all dedicated circuit services, the suggested X value for both long-distance and local dedicated circuits in the main tariff items is 5.09%. However, for the Internet Interconnection Bandwidth Fee (Private Peering) in the main tariff items, it follows the convention of past practices set by the Telecommunications Association, adopting the same suggested X value as for dedicated circuit services.

In the broadband circuit section, the model calculates the cost of broadband internet circuits and separately evaluates the costs associated with copper twisted pair local loop circuits for urban users. Regarding the speed range of broadband internet circuits, services above 300 Mbps are still not mainstream; therefore, the team suggests continuing with the previous exclusion criteria.After discussions with telecommunications operators, the target for fiberization has been set to achieve 50% by 2029, serving as the basis for the X value calculation in this study.

The main tariff items	Suggested X-Value
The monthly rental fee for telecommunications operators providing internet access services, including both local and long-distance dedicated circuits.	5.09%
The monthly rental fee for telecommunications operators for interconnection circuits between internet access services, including both local and long-distance dedicated circuits.	5.09%
The monthly rental fee for interconnection circuits between telecommunications operators providing voice reselling services and E.164 User Number Network Telephony Services, including both local and long-distance dedicated circuits.	5.09%
The monthly rental fee for other local and long-distance data circuits.	5.09%
Private Peering Fee	5.09%
The monthly rental fee for broadband internet circuits (excluding speeds above 300 Mbps and below 12 Mbps).	3.32%

4. Case Study of Internet Exchange Point (IXP) Interconnection Service Overview

The research team conducted an analysis of peak traffic (Gbps) for individual IXPs in the Asia-Pacific region. Among the top fifteen IXPs in the entire APAC region, six IXPs have interconnection peak values reaching the Tbps level, with three of them located in Japan alone. Taiwan Internet Exchange (TWIX), which has the highest peak traffic in Taiwan, currently ranks fourteenth. When considering individual cities, peak traffic is even higher in ten cities, including Tokyo, Hong Kong, Osaka, Singapore, Jakarta, Mumbai, New Delhi, Hangzhou, Seoul, and Sydney.

Given this, the research team plans to conduct a total of 9 IXP rate analyses, including Japan's Japan Network Access Point (JPNAP) Tokyo, Hong Kong Internet Exchange (HKIX), Singapore Internet Exchange (SGIX), Indonesia's OpenIXP, India's Extreme IX Mumbai, China's National Hangzhou New-Type Internet Exchange Point (NNIX), Korea Internet Neutral Exchange (KINX), Australia's IX Australia (Sydney NSW), and Malaysia Internet Exchange (MyIX).

Packet Clearing House (PCH), as the organizing body, categorizes IXPs into Associations, Commercial, Governmental, Municipal, and University types, each being operated and managed by participating members, independent third-party organizations, national government agencies, local governments, and academic institutions, respectively. TWIX and SGIX in our country fall under the Commercial category operated by third-party organizations. On the other hand, Extreme IX Mumbai in India, NNIX in Hangzhou, China, and MyIX in Malaysia are all government-operated and managed. HKIX in Hong Kong and IX Australia in Sydney NSW are led by universities and participating members within the IXP, respectively.

Apart from comparing network interconnection performance and ecosystem scale, pricing is also a significant indicator of IXP competitiveness. Since IXPs in different cities do not always require users to pay Non-Recurring Charges (NRC) and One-Time Charges (OTC), for example, SGIX in Singapore completely omits these fees; therefore, the research team focuses solely on the Monthly Recurring Charges (MRC) for subscribing members. After gathering and consolidating the monthly rental rates for each IXP, except for IX Australia (Sydney NSW) and Extreme IX Mumbai in India, which lack monthly fees for 1G and 100G ports, respectively, most benchmark information can be obtained from publicly available sources.

As shown in the figure, the monthly usage fee for a 1G port at TWIX is much higher compared to all selected benchmarks, with participants having to pay a high fee of $670 per month (approximately NT$18,675). However, if the capacity limit is increased to 10G, TWIX does not raise the usage fee and remains at the same rate. This feature may attract more members to directly adopt higher-capacity 10G ports. As for higher-capacity 100G ports, TWIX adopts project-based pricing, calculating service fees on a case-by-case basis based on individual network requirements.

It is worth noting that, apart from the 1G port, in the case of 10G and 100G, the pricing of National Hangzhou New-Type Internet Exchange Point (NNIX) in mainland China is the highest, at $1,262 and $6,309, respectively, while IX Australia (Sydney NSW) is the lowest, at $251 and $895, respectively.

City or Area		Taipei	Hong Kong	Singapore	Mumbai	Hangzhou	Sydney	Kuala Lumpur
IX Name		TWIX	Hong Kong Internet eXchange (HKIX)	Singapore Internet Exchange (SGIX)	Extreme IX Mumbai	NNIX	IX Australia (Sydney NSW)	Malaysia Internet Exchange (MyIX)
Members		26	293	166	204	67	243	126
Traffic	Peak	331 Gbps	2.13 Tbps	1.29 Tbps	712 Gbps	512 Gbps	353 Gbps	249 Gbps
	Aver age	111 Gbps	852 Gbps	288 Gbps	438 Gbps	287 Gbps	70.3 Gbps	-
Mont hly fee	1 G	$670	$120	$145	$133 (10,000 INR)	$237 (1,500 RMB)	-	$179 (750 MYR)
	10 G	$670	$1,000	$555	$665 (50,000 INR)	$1,262 (8,000 RMB)	$251 (350 AUD)	$717 (3,000 MYR)
	100 G	*	$4,000	$2,700	-	$6,309 (40,000 RMB)	$895 (1,250 AUD)	$2,866 (12,000 MYR)

The interconnection rates for Internet peers in our country have decreased from 119 yuan/Mbps in 2018 to 61 yuan/Mbps in 2021, with an average annual reduction of about 20%. This reduction rate exceeds the price adjustment upper limit regulated by the current CPI-X mechanism, bringing it closer to the average price reduction in major cities across the Asia-Pacific region. The aim is to accommodate the trend of bandwidth growth in the Asia-Pacific region, allowing telecom or ICT companies to lease more affordable circuits and interconnection bandwidth. This, in turn, increases bandwidth utilization rates and enhances the overall competitiveness of our country's Internet services.

5. Conclusion

Referring to the experiences of most benchmark countries in the fixed communication network market and related business of circuit leasing, this project proposes the adoption of the Forward Looking, Bottom Up, and TELRIC principles to introduce a circuit leasing cost model as the basis for calculating the price adjustment coefficient (X-value) of the main tariff items announced during the regulatory period from the year 2025 to 2028. Furthermore, continuous reviews and updates of the circuit leasing cost model will be conducted every four years. The Private Peering fee, one of the main tariff items, can be incorporated into the regulations using the method of international city IP-transit averages, as recommended in Chapter 10, Section 5. The framework and parameter settings of this model primarily refer to the principles of LRIC models in the EU and South Korea, while also taking into account the actual conditions of our country's fixed network market. The background of our country's telecommunications operating environment has been appropriately incorporated into the model's scenario settings.

The circuit leasing cost model in this project adopts the Full Component Long Run Incremental Cost (LRIC) method, which estimates the number of network components required to build an efficient network architecture based on market service demands. The total investment cost required for network construction is then calculated based on the quantity and unit price of equipment, considering the impact of technological advancement rates and inflation rates on equipment investment and operating costs. Economic depreciation is also factored in, deriving the reasonable incremental cost of wholesale business for circuit leasing in the overall efficient fixed communication network, serving as the basis for regulation.

In the derivation process of this model, both TDM and NGN backbone network architectures and transmission network architectures are calculated in the core network. The NGN conversion schedule is considered based on our country's network development plan. For the access network, a geographical sampling method is employed to estimate the construction situation of the last mile in our country, and the opticalization schedule and targets are introduced into the model to incorporate the future fiber-opticization process into the cost calculation of the model, deriving prospective construction costs. The price adjustment coefficients for circuit leasing lines and broadband internet circuits are calculated by combining the two network models.

Currently, the regulation of related businesses of circuit leasing in our country is based on Article 33 of the Telecommunications Management Act and Articles 2 and 3

of the Regulations on Tariff Management for Significant Market Players. Among the main tariff items defined in the wholesale service market for fixed communication networks, the interpretation of circuit leasing services by telecom operators still follows the interpretation of the Fixed Communication Service Management Regulations, which includes only network transmission equipment without exchange functionality and its ancillary equipment, as well as physical circuit lines under TDM network architecture. Therefore, newer and more efficient NGN Ethernet network architectures are not included in wholesale services, and there are no data-related services about Ethernet networks in the fixed wholesale market.

However, the model proposed by the research team in this project can calculate the relevant Ethernet network equipment and estimate the associated reasonable incremental costs by introducing cost changes from future investments in newer technologies, providing regulatory authorities with reference for market analysis. Therefore, the research team recommends that in the next market determination, relevant circuit leasing services of Ethernet networks can be included in the statistics of the fixed communication network market. This should be done using a technology-neutral principle to calculate the market share of main tariff items and define significant market players, fully reflecting the actual competitive situation in the market under different network architectures of TDM and NGN. Additionally, continuous use of the model for calculation is suggested as a reference basis to determine reasonable circuit leasing costs and price adjustment coefficients among operators, aiming to maintain market mechanisms and promote fair competition.