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**Conference Paper**

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30th European Conference of the International Telecommunications Society (ITS):  
"Towards a Connected and Automated Society", Helsinki, Finland, 16th-19th June, 2019

**Provided in Cooperation with:**

International Telecommunications Society (ITS)

*Suggested Citation:* Li, Shu-Hua; Chen, Jen-Chieh (2019) : Critical development factors in infrastructure for the communications industry based on wholesale leased line services in Taiwan, 30th European Conference of the International Telecommunications Society (ITS): "Towards a Connected and Automated Society", Helsinki, Finland, 16th-19th June, 2019, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/205194>

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# **Critical development factors in infrastructure for the communications industry—based on wholesale leased line services in Taiwan**

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## **ABSTRACT**

To address the demand for 5G ultra-high transmission rate and high connection density and to provide high quality service in the area, the future mobile telecommunications network will consist of an overlay of millimeter wave capable small cells, marking a strong need for private leased line transmission capacity. First, this study will use UK, Germany, Japan and Australia as benchmark objects: UK and Germany review their leased line market periodically and frequently, having obtained significant progress in the service over the years, with relevant policies and institutions maturely developed; Japan has frequent technical exchange and interaction with Taiwan as the telecommunication development environments in both countries are quite similar due to geographical proximity; and Australia's WEF ranking and GDP are similar to those of Taiwan. With studies on these countries, we may suggest a benchmarking paths for Taiwan's industrial development. As there is a wide development gap among the countries, and no consensus is achieved, consequently all the conditions are not completed. For this reason, primarily the purpose of this study is to analyze the current development situation of leased line in Taiwan's telecommunications industry and explore its competitive profile and, secondly, to examine the national competitive advantage factor combination for the development of local leased line service. Based on the Diamond model, this study is intended to provide a comprehensive understanding of the characteristics of the telecommunication market, identifying the resources and conditions required for developing the industry for a nation. If we simply duplicate approaches while ignoring the characteristics of the industry, we may miss the best timing of growth and lose the effects. Based on the Diamond model by Porter (1990), this study employs a fuzzy analytic hierarchy process (Fuzzy AHP) approach, together with expert questionnaire survey, to examine the weight for each dimension and factor, identifying the most critical dimension for the development of fixed line and private line in Taiwan and factors with less influence on the industrial growth to avoid excessive unnecessary resource. According to the research result, government is identified as the most important critical factor, followed by related and supporting industries, and then the demand. The final weight analysis shows that the national policy, in the "government" dimension, is a significant critical factor, and the pull-through effect of leased line related

industries is also great, followed by the market size. Thus, during the growth of the leased line industry, these three conditions serve as supporting factors and are deemed the decisive factor of whether the leased line wholesale service can be successfully incubated and developed.

## **1. Introduction**

### *1.1 Background*

In view of the future 5G ultra-high-speed transmission rate, high device connection density and the ability to provide high service quality in the region, there will be a large number of small mmWave base station deployments in the future mobile communication network architecture, which will place high demands on the transmission capacity of the connected dedicated leased lines. In recent years, the National Communications Commission (NCC; Taiwan's competent authority for this issue) has attached great importance to the regulation of key intermediate input factors required for the provision of telecommunications services, wholesale leased line services are one of the key points. The network deployment cost of telecommunication industry in Taiwan is rather high, and the deployment is difficult (such as the problems of right of way and channels), thus making it difficult for other competitors to compete with CHT. So it appears that the development is rather limited. However, this industry cannot replicate the past experience models and cultivate it. In addition to certain characteristics in the internal and external environment, it is difficult to improve the development of the non-dumping state. However, the current development performance is obviously backward, coupled with government policies and regulations, and enterprises. Business strategy, infrastructure conditions and even the needs of end consumers have failed to achieve complementary synergies, that is, the lack of a comprehensive and systematic integration structure. All parties have different views and practices. Industry faces great difficulties in its development.

Given the slow development of the industry and quick change in external conditions, plus much dissension on the development direction among the industry, government and scholars, the industry is facing problems with growth. As there is a wide development gap among the countries, and no consensus is achieved, consequently all the conditions are not completed. For this reason, primarily the purpose of this study is to analyze the current development situation of leased line in Taiwan's telecommunications industry and explore its competitive profile and, secondly, to examine the national competitive advantage factor combination for the development of local leased line service. Based on the Diamond model, this study is intended to provide a comprehensive understanding of the characteristics of the telecommunication market, identifying the resources and conditions required for developing the industry for a nation. If we simply duplicate approaches while ignoring the characteristics of the industry, we may miss the best timing of growth and lose the effects. Based on the Diamond model by Porter (1990), this study employs a fuzzy analytic hierarchy process (Fuzzy AHP) approach, together with expert questionnaire survey, to examine the weight for each dimension and factor, identifying the most critical dimension for the development of fixed line and private line in Taiwan and factors with less influence on the industrial growth to avoid excessive unnecessary resource. In terms of a further analysis of an

individual dimension's sub-factor, this study is to find out the most important factor and the least important one. Since Taiwan's telecommunications industry lacks comprehensive and systematic strategies for promotion as mentioned above, this study is also intended to examine the current development profile of the industry, by taking leased line for example, explore Taiwan's competitive advantage in developing the leased line industry, identify the critical factor combination using the fuzzy AHP, and propose feasible strategies by referring to the approaches by the benchmark countries and opinions from experts, and thereby suggest the strategies for Taiwan to develop the industry.

## *1.2 Research Questions*

### I. Analysis of leased line status and competition situation

Due to the very slow growth of the industry, the external environment currently undergoes great changes. In addition, the industry and academia have expressed their respective directions for the development of the industry. The current situation of the industry is also facing bottlenecks in development. The development of each country is quite large, and there is a lack of development consensus in the industry. As a result, various development conditions are still incomplete. Therefore, the primary purpose of this study is to analyze the current development of wholesale leased line services, to study their competitive situation, and to analyze possible advantages and disadvantages, as well as opportunities and threats, and to suggest more reasonable and feasible countermeasures by deepening the perception of the industry itself.

### II. Exploring the key elements of the country's competitive advantage conditions for the development of leased line services

Taking the communication industry under the wholesale leased line services as an example to explore the development of its industry, as well as the country's competitive advantage conditions in the development of wholesale leased line services, and use Fuzzy AHP to find out which key elements are combined to propose feasible strategies for the country's practices and expert opinions, and then summarize the national strategic plan for developing the industry.

### III. Standardizing successful national practices and propose strategic applications linked to quantitative results

If industry development can make a country more successful, it may be more efficient and effective. This study is based on the United Kingdom, Germany, Australia, and South Korea. The main reason is that the UK, Germany, and Australia regularly review their leased line markets. In recent years, the development of this service has also made great progress, and the development of relevant policies and institutions has also matured. South Korea is the geographical location nearest to Taiwan, and it's also the closest in terms of technical exchanges and interactions. They are also similar to Taiwan's communication development environment. Therefore, reference and application in all aspects can help the government to provide directions for standards in industrial development.

#### IV. Proposing a feasible strategy for developing wholesale leased line service industry

This study uses Michael E. Porter's "National Competitive Advantage Diamond System" facet proposed in 1990 to analyze the competitive advantage conditions of wholesale leased line services, and combine these with successful national practices and propose strategic recommendations. It can propose a systematic and comprehensive improvement strategy for the development of wholesale leased line service related industries, and enhance Taiwan's international competitiveness in the development of communication industry.

## 2. Literature review

### 2.1 *Analysis of Leased line Industry Environment in Different Countries*

Networked Readiness Index, which has been used in the calculation of the Global Competitiveness Index by the World Economic Forum (WEF) since 2001, refers to a key tool in assessing a country's preparedness to reap the benefits of emerging technologies and capitalize on the opportunities presented by the digital transformation and beyond. More particularly, the Report assesses the factors, policies, and institutions that enable a country to fully leverage information and communication technologies for increased prosperity and crystallizes them into a global ranking of networked readiness at the country level. According to the Global Competitiveness Report published by the WEF 2018 (shown in Table 1), more efficiency and effects will be gained if we use successful countries as benchmarks. This study uses UK, Germany, Japan and Australia as benchmark objects, mainly because UK and Germany periodically reviews the leased line market more frequently and have seen significant progress in the kind of service over the years; Japan maintains technical exchange and interaction with Taiwan due to geographical proximity and its telecommunication development environment is also similar to that of Taiwan; and Australia's WEF ranking and GDP are similar to those of Taiwan. With studies on these countries, we may suggest a benchmarking paths for Taiwan's industrial development. Therefore, Germany, Japan, UK and Australia are selected as objects for our analysis of the leased line industry.

**Table 1**

Global Competitiveness Index Ranking 2018

Rank	Economy	Score	Diff. from 2017	
			Rank	Score
1	United States	85.6	—	0.8
2	Singapore	83.5	—	0.5
3	Germany	82.8	—	0.2
4	Switzerland	82.6	—	0.2
5	Japan	82.5	3	0.9
6	Netherlands	82.4	-1	0.2
7	Hong Kong SAR	82.3	—	0.3
8	United Kingdom	82	-2	-0.1

9	Sweden	81.7	—	0.1
10	Denmark	80.6	1	0.7
11	Finland	80.3	1	0.5
12	Canada	79.9	-2	-0.1
13	Taiwan	79.3	—	0.1
14	Australia	78.9	1	0.7
15	Korea,Rep.	78.8	2	0.8

Source: World Economic Forum(2018) .

**Table 2**

Macroeconomics Data of Selected Countries

Rank	Economy	Population (millions)	world GDP	GDP per capita(US\$)	Unemployment rate(%)	10-year average annual GDP growth(%)
			GDP (PPP) %			
3	Germany	82.7	3.28	44,549.70	3.8	1.2
5	Japan	126.8	4.27	38,439.50	2.8	0.5
8	United Kingdom	66.1	2.29	39,734.60	4.3	1.1
13	Taiwan	23.6	0.93	24,576.70	0.8	2.6
14	Australia	24.8	0.98	55,707.30	5.6	2.5

Source: World Economic Forum(2018) .

(1) Germany

The Federal Network Agency of Germany (Bundesnetzagentur or BNetzA), in terms of the capital of factor conditions, has set Telecom WACC for its regulation of wholesale Telecom service rate. According to the BNetzA webpage, the rate for fixed network service is 4.87% and for mobile network service, 4.91%, as of June 30, 2018. (BNetzA 2019a) In terms of annual changes in consumer price index, Germany is increased by an average of 1.3% in March 2019 and decreased by 0.5% for telecommunication service users. (Country Economy 2019). In terms of infrastructures, the Deutsche Telekom (DT), with the introduction of IP technologies to enhance network speed and capacity, is capable of providing a bandwidth of 2.5Mbps-10Gbps. (BNetzA 2012) A maximum downlink rate of 1Mbps for cable broadband service is available in German remote areas, and the 50Mbps coverage reaches 75% now. (BMVI 2019)

In terms of demand, Germany divides leased line wholesale services into long-distance and local loop by the characteristics of its domestic market; the long-distance market is exempt from ex-ante regulation as it has been recognized as effectively competitive, while the local loop market is still

under ex-ante regulation. Starting from 2012, Germany has no longer regulated the local loop with circuits of 2Mbps below, because it was recognized failing to meet the requirement of telecommunication business. Based on the surging need for high bandwidth, the BNetzA focuses on the development of 4G mobile backhaul. (BNetzA 2012) However, the BNetzA did not release data on the mainstream rate of local loop. For cable broadband users, most households choose a cable broadband of 30Mbps above, while most business users choose a broadband of 100Mbps above. (BNetzA 2018) In terms of consumer maturity, after search of the BNetzA webpage, no regulation on service quality is found. In terms of market share, most traditional technology SDH users consider transferring to Ethernet (similar price); and most Ethernet (1Gbps above) users consider transferring to optical fiber. The turnover and sales ratios of Ethernet circuits to the whole local leased lines are listed in Tables 3 and 4, showing an increasing trend year by year. (BNetzA 2012)

**Table 3**

Turnover Ratios of Ethernet to Local Leased line Service in Germany

	2006	2007	2008	2009	1.Hj. 2010
2Mbit/s bis 10Mbit/s	1	1,6%	2,4%	10,3%	12,5%
>10 bis 155Mbit/s	4,7%	6,2%	8,4%	19,6%	24,0%
>155Mbit/s	22,7%	30,6%	37,7%	57,2%	55,9%

Source: BNetzA (2012) °

**Table 4**

Sales Ratios of Ethernet to Local Leased line Service in Germany

	2006	2007	2008	2009	1.Hj. 2010
2Mbit/s bis 10Mbit/s	0,5%	0,8%	1,5%	8%	8%
>10 bis 155Mbit/s	0,5%	5,7%	8%	21%	24%
>155Mbit/s	37%	49%	50%	68%	67%

Source: BNetzA (2012) °

In terms of the situation of up-, mid- and down-stream firms in related and supporting industry, the purpose of leasing the wholesale circuits, according to the BNetzA, is to link the circuits of the user site, build their fixed network, and release as end-user circuits and other wholesale products (e.g. linking to other networks, Internet). With the increasing demand for down-stream bandwidth, for example, 4G mobile network operators demand more backhaul bandwidth, the transmission capacity should be increased to accommodate the workload, which shall be delivered via optical fiber (BNetzA 2012).

In terms of firm strategies, firm structure and rivalry, the German government owns 14.5% of the Deutsche Telekom (DT) and has an indirect shareholding of 17.4% through the state-owned bank KfW. That is 31.9% in total (DT 2019). In terms of rivalry, the DT gains a larger market share,

because entry barriers are very high (essential facilities or high construction cost), and no one but the DT can provide whole-area service, while only half of the local leased lines are owned by competitors, with market size and scalability limited. Thus, the trading capacity and turnovers for competitors are declining. In addition, the DT shows advantages in economics of scale and economies of scope: the DT holds 57% of broadband flow in Germany market, enabling various network services and reducing leased line cost; moreover, most essential facilities (e.g. local loop, passive infrastructures) are owned by the DT. (BNetzA 2012)

In terms of government policy and regulations, the BNetzA, under EU directives for telecommunications network and services, has conducted market definition and market analysis for its telecommunication policy and confirms that the local leased line market is not effectively competitive. Besides, the DT is an SMP (significant market power) and therefore should be imposed ex-ante regulation (BNetzA 2012). In terms of legal development maturity, Germany's Telecommunication Act principally follows the EU directives for telecommunications network and services, and no EU directives can be directly applied to market definition and market analysis. No discrepancy with EU directives is found for the control over local leased lines.

## (2) Japan

In terms of capital of factor elements, the WACC was 7.22 (FCC, 2006), announced by the Nippon Telegraph and Telephone Corporation (NTT) in 2006, and the CPI in 2019 is 101.8 (2015=100). In terms of market size of demand, the number of Japan's DSL and FTTH fixed network users has increasingly grown since 2000 and steadily gone up in recent years. Following the change of time, it is a period of transition from DSL to FTTH, where we may expect a significant increase in telecommunication rate; on the other hand, the number of mobile phone subscribers has exceeded 5 million per year. Particularly, for the 3.9-4G mobile phone (LTE) (service available since 2010), the number of mobile network users has skyrocketed to 120 million currently, three times as much as fixed network service subscribers in 2018. With rapid prevalence of smart phones since 2010, the importance of mobile telecommunication becomes more clearer (MIC, 2017). In Japan's leased line market, the number of leased line (3.4kHz), digital access line (64kbps) has shown a decline trend since 2010. The number of leased lines in NTT-East and NTT-West does not exceed 69,675, and the number of digital access lines does not exceed 36,155.

In terms of related and supporting industry, according to report of "2018 Future Investment Strategy: Transformation into 'Society 5.0' and 'Digital Driven Society'" by the Ministry of Internal Affairs and Communications ("MIC"), the industry should strengthen investment in infrastructures and technology and accelerate the promotion and improvement in 5G and optical fiber, Wi-Fi environment, cable, and IoT. Related and supporting industry includes Rakuten Mobile Network, cable TV and broadcast network operators, Telecom associations, cable engineering companies, Panasonic System Solutions, and BWA Japan., Ltd, etc.



In terms of firm strategies, structure and rivalry, Japan has 737 telecom and broadcast network operators (consisting of 144 Telecom service providers) and 39 leased line operators (MIC, 2019). In 2001, there was literature on the competition of leased line wholesale reporting that dark fiber was mainly provided by utilities or local government such as NTT-East and NTT-West, power companies, Bureau of Sewerage Tokyo, metro, natural gas companies, with charge slightly lower than the sewage treatment fee or metro. It is expected that the price reduction measure may accelerate Telecom service providers to use NTT dark fiber for network access. From the information, the NTT-East and NTT-West is not the only company that owns optical fiber (MIC, 2018).

In terms of government, the MIC has stipulated regulations on leased line service since 2000. In May 2013, the report of the Leased line Review mentioned the calculation of copper wire, the calculation of circuit lease connection fee, and the reevaluation of copper wire and optical fiber facilities, cost allocation methods for maintenance, etc. Thus, in 2014 and 2015, the leased line connection fee was reduced again. However, the connection fee increased in 2016 and 2017 due to decreasing demand, increasing return on equity and adjustment. In Japan, leased line is divided into two segments: wholesale and retail. For retail, NTT-East and NTT-West use “Type 1 Designated Telecom Facility”, namely, retail service for bottleneck facilities. However, by the service characteristics, service is categorized as the average leased line, ATM dedicated line, wireless line, and video line. Although the designated telecom service, exclusively used by NTT-East and NTT-West as given above, is exempt from retail price regulation now, the price and service conditions should be stated in the protection contract and reported to the MIC. When a consumer expresses his/her demand for the service, NTT-East and NTT-West are obligated to provide such service, which is called “mandatory obligation”. Besides, they are also obligated to follow the accounting system and accounting standards. For those leased line services not included in the “designated telecom business”, they are exempt from the asymmetric regulation.

In terms of wholesale, circuits lease is a leasing or access service of “Type 1 Designated Telecom Facility”; therefore, asymmetric regulation should be applied to it. Under Article 33 of the Telecommunication Act, the regulated operators are required to practice cost-based pricing, and are obligated to lease unbundled network devices. As a result, if a competitor wishes to lease copper wire or optical fiber from NTT-East and NTT-West, it may lease required devices for the fee approved by the MIC. If the competitor wishes to access the circuit from NTT East and West with the approach of “unbundled non-network device”. NTT-East and NTT-West separately provides wholesale leased line service, which is also perceived as access service of “Type 1 Designated Telecom Facility”, and the price is also regulated asymmetrically. The price regulation (current cost-based pricing) is divided into local, prefecture-level and terminal networks, while the regulated products refer to the leased line (3.4 kHz), digital access (64kbps) and Ethernet (100Mbps, 1Gbps, 10Gbps).

### (3) UK

In terms of factor conditions, in the Mobile Call Termination (MCT) Market Appraisal Report 2015 by Ofcom, it is stated that the actual WACC, before tax, would lie between 5.9% and 7.6% for general high efficiency mobile service providers. In March 2018, Ofcom announced the final declaration of the MCT market review, in which the WACC is a reasonable value of 7.0% (UKRM, 2018), the WACC for WBA is 9%, and for LLU WLA, 7.2%. Regarding CPI, 2017-2018 was 2.2% (2.3% in 2013 and 1.1% in 2014). On June 12, 2015, Ofcom used a WACC of 10.1% as a calculation basis for regulation of leased line pricing (BT, 2015).

In terms of demand conditions, the British Telecom (BT) is the largest fixed-network operator in the United Kingdom, mainly providing retail clients with telecom products and service. The BT also delivers wholesale voice, broadband and digital communication products and service (including backhaul) to fixed or mobile telecom operators. Everything Everywhere (EE) is a British mobile network operator with the largest market share. It is a joint venture between Deutsche Telekom and France Télécom (now Orange S.A.), mainly providing retail users with mobile or fixed network communication service and also providing other communication providers (CPs) with wholesale mobile service. According to the report of "Communications Market Report Published 2" by Ofcom (2018), the revenue from telecom, TV, broadcasting and post service totaled 54,700 million pounds in 2017, decreased by 20% in comparison with that in 2016. 5.2% of the family expenditure was used for communication service (124.62 pounds per month); of which 70% was used for telecom service. In 2017, ADSL (copper) fixed line broadband connection was replaced by optical fiber connection. The telecom revenue 2017 dropped to 35,600 million pounds (by 1%), while the revenue from retail fixed phone and data remained the same, and the revenue from retail mobile service showed decline. However, data used by British consumers on average is increasing. In June 2017, each fixed broadband line had a bandwidth of about 190 GB (132 GB in June 2016).

In terms of related and supporting industries, the main business of both the BT and EE was to provide retail customers with mobile or fixed network communication service. Besides, EE delivers wholesale mobile network service to the BT; alternatively, the BT also delivers backhaul and wholesale broadband network service to EE. Furthermore, Openreach, functionally separated from the BT group, delivers local loop, local loop access network, regulated backhaul and leased line services to EE. In February, the BT announced that it has merged EE by 12,500 million pounds, and submitted the merger application ("the Merger") to the Competition and Markets Authority (CMA). The reason the BT submitted to the CMA for approval of the merger includes: to accelerate the deployment of infrastructures in the mobile phone market, to provide better end-to-end control for investment and product innovation, to combine EE's 4G mobile network and BT's existing fixed network infrastructures, and to provide cost and revenue synergies.

In terms of firm strategies, structure, and rivalry, the BT, in 2006, separated its access network and backhaul products from its wholesale business division and named the new division "Openreach". Based on BT's undertakings, the function separation includes separation of organizational functions (asset separation and business items separation), employee separation, and information separation. It

further made an announcement in 2017, making Openreach more independent. For compliance with its undertakings, the BT established the Equality of Access Board (EAB) in 2005, as part of the undertakings offered by the BT and report to Ofcom on a regular basis for following review.

In terms of government element, Ofcom is a British regulator for the communications services and has started reviewing retail and wholesale leased line since 2004. Ofcom conducted three business connectivity market surveys in 2008; leased line price regulation in 2009; reviewed LLCC (Leased Lines Charge Control) appeal and PPCs (Partial Private Circuits) path overhead (POH) pricing and revised the draft of SMP conditions, conducted business connectivity market review, and called for investment among the operators in 2011; conducted business connectivity market review and further consultation in 2012; conducted business connectivity market review, reviewed retail, broadband wholesale and naked optical fiber wholesale market in 2013; conducted business connectivity market review, called for investment among the operators, and undertook relevant data analysis consultation including preliminary consultation on passive remedies, leased line charging control and dark fiber pricing, update of the drafted leased line charge mechanism, and discussion on extremely low bandwidth leased line in 2014; conducted business connectivity market review, mainly discussing regulations on leased line and dark fiber pricing in 2015; Ofcom proposed strict rules to enhance BT's performance in establishing high-speed business leases line in 2016. Based on BT's undertakings, and considering input element equality, Openreach should provide competitors with local-exchange based regulated products; and other divisions of the BT group should use the wholesale products and service, including price conditions and service quality, which Openreach delivers to competitors (as below).

1. Wholesale Line Rental (WLR): mainly providing voice and narrowband network service.
2. Local Loop Unbundling (LLU), including the following two types:
  - I. Shared metallic path facility (SMPF): mainly providing broadband network service.
  - II. Metallic Path Facilities (MPF): mainly providing voice and broadband network service.

Ofcom will consult on market assessment and remedies proposals for fixed telecoms services in 2019. This will cover wholesale voice/broadband connections and wholesale leased lines. Any remedies would come into effect in April 2021 (Ofcom, 2019).

#### (4) Australia

In terms of the capital of factor conditions, the Australian Competition and Consumer Commission (ACCC) has not clearly stipulated that the "Weighted Average Costs of Capital" (WACC) should be used for regulation in recent years. According to data, the WACC of Telstra, an existing service provider, is 6.38%. In terms of annual changes in consumer price index, according to the Australia Bureau of Statistics (ABS), the index is 1.3% during 2018/3~2019/3, while the index for telecommunication service users is -4.6% (ABS 2019). In terms of infrastructures, the Telstra webpage shows the downlink rate of 10Mbps for average Internet users, and there are differences depending on the region where users are located. (Telstra 2019)

In terms of characteristics of domestic market, the ACCC, by the competition intensity, divides the services into regulated domestic transmission capacity services and commercial (unregulated) domestic transmission capacity services. The ACCC first defines the domestic transmission capacity services (DTCS) and then identifies the market competition intensity based on different geographic markets to determine whether ex-ante regulation should be applied. (ACCC 2019a) In terms of consumer maturity, although users demand Internet backup, the ACCC, after collecting opinions from related sectors, doesn't propose to define DTCS as protected services, in path protection or equipment protection. The ACCC suggests that service users should determine their demand on their own and they should establish protection in their own way. (ACCC 2019a) In terms of market share, Australia's leased line has transformed from past SDH into digital Ethernet. Regarding market structure, we may refer to the ratio of lines accessed by Internet service providers given by the National Broadband Network (NBN), despite no number of users or market share released. As of the end of 2018, Telstra accounts for 49.6%, TPG 21.6%, Optus 13.6%, Vocus 8.6%, and others, 6.6% (ACCC 2019 b).

In terms of the situation of up- and down-stream firms, the ACCC regards DTCS as a critical input factors for down-stream telecommunication services and requires open access to lower entry barrier or cost disadvantages, increase competitiveness, and optimize effective investment and utilization of infrastructures, and thereby enhance end-user benefits. For leasers, the demand for high capacity network increases, especially the network service of 1Gbps above, because of the increasing NBN data volume, the growing demand for mobile backhaul, and the significant increase of business service data volume. The high-capacity network is mainly applied to Internet exchange points, data center and NBN point of interconnection (PoI). Also, the ACCC estimates that the demand for high-capacity network will be increasing after 5G mobile service deployment, which will have impact on the transmission market (ACCC 2019 a). In terms of the pull-through effect of related industries, Australian cable broadband operators, except Telstra, have developed strategies of cooperation or merger, e.g. TPG and Vocus group. Australia has four major vertical integrated transmission service providers now, including Telstra, Optus, TPG and Vocus. (ACCC 2019 a)

In terms of firm strategies, firm structure and rivalry, Australia government has sold its shares in Telstra in August 2011, making Telstra a completely private company. Australia government also established the National Broadband Network (NBN) in April 2009 for design, implementation and maintenance of the national wholesale broadband access network, and its access conditions are under ex-ante regulation by the ACCC. In terms of rivalry, the model cannot be duplicated economically because the DTCS feature capital-intensive business and a very high sunk-cost investment. Despite a gradual increase of prevalence, NBN networks still cannot replace the existed DTCS. As a result, other districts, particularly remote areas, shall rely on Telstra networks. Among other operators, after the previous DTCS regulation in 2014, TPG has been awarded a contract providing Dark Fiber and network services to more than 3,000 sites; Vocus, TPG and Optus have been connected to link NBN POIs directly; and small operators in metropolitans have optical fiber implementation. (ACCC 2019

a)

In terms of government policy and regulations, the ACCC has declared DTCS to be under control since 1997, preventing leading operators from blocking access, limiting traffic, charging excessively high prices or reducing service quality, because of their high market share. From the DTCS final report 2019, in addition to continuous ex-ante regulation, DTCS should be investigated independently as it provides mobile backhaul in remote areas. (ACCC 2019 a) Besides, to maintain the competition of Australia's telecommunication market, the ACCC, in addition to establishing the NBN in charge of wholesale network implementation and operation, has applied a series of asymmetric regulatory measures on Telstra, including release of dark fiber, exchange, and channel for the NBN to use and transfer of their copper wire and HFC users to the NBN network. (it news 2014) Regarding the legal development maturity, the ACCC has developed a competition assessment approach to determine whether DTCS should be exempt from ex-ante regulation. ACCC 2019 a)

Step 1: Are there at least three fiber network providers (including Telstra)?

Step 2: Is the point of interconnection at the Telstra exchange or nearby?

Step 3: Does the fiber of the network provider link the center business district in the urban area?

Step 4: Is there at least a non-Telstra operator providing service in the exchange area?

Step 5: Is there any reason for deregulation, including the development extent, terrain in the urban area, or is there any major transmission loop in the exchange area?

(5) Taiwan

In terms of the capital of the factor conditions, according to the Directorate General of Budget, Accounting and Statistics (DGBAS) of Executive Yuan Taiwan 2019/3, the CPI is increased by 0.58% annually, in which the annual telecommunication fee is raised by -4.69%. (National Statistics 2019) In terms of WACC, according to Guru focus, the Chunghwa Telecom (CHT) has a WACC of 2.41%. Regarding infrastructures, the communication market report by the National Communications Commission (NCC) Taiwan 2018, for households, the fixed network rate of 60~100Mbps accounts for the largest ratio, 12.9% (excluding 100Mbps), followed by 20~60Mbps, which accounts for 12.6% (excluding 60Mbps).(NCC 2019)

In terms of domestic market characteristics of the demand condition, Taiwan, since the telecommunication liberalization in 1996, has implemented ex-ante regulation on the leased line market, and divided it into two markets: long-distance and local loop. In both markets the CHT is the leading providers. The NCC has applied price cap regulation on the CHT. In terms of consumer maturity, after the search of NCC webpage, no regulation on service quality is found. In terms of market share, according to the CHT annual report, as of the end of December 2017, there were 4,467 thousand broadband users, accounting for 72.5% of total users in Taiwan, in which 1,282 thousand users are 100Mbps (or above) users. (CHT 2018) According to the NCC, the total number of domestic circuits had grown by 3.5% during the period between June 2016 and March 2017, and the total

bandwidth (excluding voice communication service) of the four local fixed network operators had been increased by 20% during the same period (shown in Figure 1 below). From the observation of different bandwidth rate, the bandwidth of 2Mbps or below still accounts for a larger ratio of the whole leased line service in Taiwan; however the ratio had declined by 5% from June 2016 to March 2017. The moderate speed (from 2Mbps to 200Mbps) and high speed (200Mbps above) circuits had also shown growth, by 10% and 14% respectively (TTC, 2017)

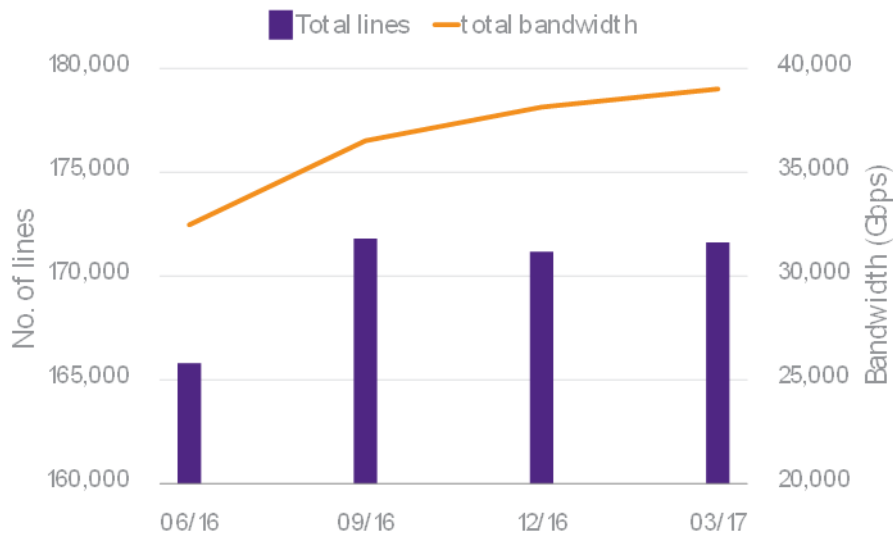


Figure 1. Number of Leased lines and Total Bandwidth, Taiwan (2016/6~2017/3)

Source: TTC (2017)

In terms of the situation of up-, mid- and down-stream firms in the supporting industry, according to the CHT annual report, the CHT has constructed FTTx network since 2003, and the coverage of FTTx 100Mbps or above reached 89.81% as of the end of 2017, while the mobile network has covered the whole nation. The CHT has gradually updated FTTx access network to FTTH, aiming to extend the coverage of FTTx 1Gbps to 90% by 2020. (CHT, 2018) Besides, from the interview with mobile network operators by the Telecom Technology Center (TTC), demand for mobile backhaul has been significantly stronger since Taiwan mobile broadband operators started providing services in 2014. In the years to come, mobile broadband operators will keep investing in network density and the implementation of small-scale sites to address the rapid increase in mobile data volume. If 5G service becomes commercially available as expected in 2020, the demand for bandwidth will be higher to meet various requirements for mobile broadband applications. The Internet of things (IoT) and Fintech application will also drive the need for reliable and high-quality network connection. (TTC, 2017) In terms of the pull-through effect of relevant industry, the CHT has formed a business alliance or partnership with content providers, media service platforms, user facility providers, network operators and ICT solution providers. Two other major mobile

network operators, the Taiwan Mobile (TWM) and the FarEasTone (FET Net), also have similar alliance or partnership.

In terms of business operating model of firm strategies, firm structure and rivalry, the government holds a nearly 40% stake in the CHT, including 35.29% directly (by the Ministry of Transportation) and 5.05% indirectly (by Chunghwa Post company, Labor Pension Fund, and Labor Insurance Fund ). (CHT 2019) Regarding rivalry, the CHT provides other mobile or fixed network service operators with leased lines. In 2017, the total bandwidth of the leased local loop or long-distance line reached 2025.2Gbps, representing a growth of 20%, in comparison with 1678.8Gbps in 2016. The main reason is the increasing backbone bandwidth required for the 4G mobile broadband service. The CHT also provides frame relay, asynchronous transfer mode, Ethernet, and wavelength division multiplexing technology, with major technologies including TDM, E1, T1 and STM1, etc. In urban area, Ethernet is used mostly and traditional TDM circuits are still in use. (CHT 2018) Regarding domestic leased line market, in addition to the CHT, there are several fixed network service operators providing leased line service, including the TWN, FET Net and the Asia Pacific Telecom Group (APTG). Although cable TV operators are technically capable of providing leased line service; however, the service scope is limited because of restrictions on operating regions. Regarding the competition on the leased line service market, service price and bandwidth rate are two major competitive elements(TTC, 2017).

In terms of national policy, Taiwan government proactively promotes the implementation of broadband network. According to the government's Digital Nation and Innovative Economic Development Plan (Known as DIGI+), the coverage of high speed broadband of 1Gbps will be as high as 90% by 2020. (DIGI+ Office 2018) In terms of regulation policy, the authority, NCC, considers that, with evolution of the Next Generation Network (NGN), the major target for the current stage will be driving the competition of the down-stream telecommunication service market through reasonable regulatory measures, while highlighting the incentives for investment in the NGN by telecom network operators, to upgrade technology facilitating a network environment required by various information and communication service in the future. For the down-stream telecommunication service market, the required intermediate input element will be leased line wholesale service. All Fixed telecommunication (e.g. local loop or long-distance digital circuit), mobile telecommunication (e.g. mobile backhaul) and Internet access service (e.g. Internet Service Provider or ISP, Internet connection with users or different ISPs) should rely on the implementation and connection of physical circuits; therefore, the leased line wholesale service is still important in the down-stream telecommunication service market. (TTC 2017)

In terms of legal maturity, the NCC, based on Article 26 of the Telecommunication Act and article 6 of the Administrative Regulation Governing Tariffs of Type I Telecommunications Enterprises, has applied tariff regulation on Type 1 telecommunication firms, and the targets of the regulation have been changed from all the market participants in the past to leading operators now when the market competition is taken into account. Under the Administrative Regulation Governing

Tariffs of Type I Telecommunications Enterprises, the NCC promulgates six major wholesale items, four of which are leased line wholesale services that have been regulated by price cap. To address the need for the development of future network's digital convergence, the NCC has taken EU telecommunication regulatory approaches as reference to draft the Telecommunication Administration Act and send it to the Legislative Yuan for review.

## 2.2 Michael Porter's Diamond Model

In *The Competitive Advantage of Nations*, which was published in 1990, Michael Porter developed the Diamond model illustrating how a given business can develop a competitive advantage in a certain country and trying to offer a theoretical framework with interpretability. Although the Diamond model is used as a tool for analysis of a nation's competitiveness, Porter stressed that we might provide effective data, by referring to the nation's specific resources and advantages, for the government to stipulate, perform, control and plan policy that is most favorable for industrial development. Therefore, the Diamond model not only is applied to analysis of competitiveness of nations but also develops to be a framework for analysis of an industry's competitiveness. According to Porter, the Diamond model is comprised of four main elements that contribute to the competitive advantage of countries in a given industrial sector: Factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry. All of these elements may be influenced by two exogenous elements simultaneously: government and opportunity. The interaction between these six elements may accelerate a nation's competitive edge or become the main reason for the lag of economic development:

- I. Factor Conditions: Factor conditions have critical important influences on competitiveness and may be different in various literatures; however their coverage scopes are similar. According to Porter, factor conditions can be divided into 5 categories : (1) Human resources: including workload, technical capability, and labor cost, while considering standard labor hours and labor ethics. (2) Capital resources: the total capital and capital cost of the national financial system. (3) Knowledge resources: knowledge on science, technology and market of products owned by the country. (4) Natural resources: including the adequacy and quality of the natural resources, price, water and electricity resources, materials, minerals, geographical location, climate, and other tangible resources. (5) Infrastructures: including the transportation system, telecommunication facilities, post and courier, health insurance, and any infrastructures in relation to industrial efficiency. These factor conditions are perceived as innately determined. Some of the conditions require long-term development and cultivation, which, in Porter's argument, are even more important and become the sources that form the industrial competitiveness of the country.
- II. Demand Factors: Demand conditions refer to the size and model of the customer base for products or services of a given industry. From Porter's study on various industries, demand factors show comprehensive influences. The factors include : (1) Characteristics of domestic market: the demand types and characteristics of domestic customers, including variables such



as segmentation structure, complexity and demand conditions of domestic customers, and whether there is any buyer with demands.(2)Demand size and pattern of growth: including variables such as the Size of home demand, number of individual buyers, growth rate of home demand, early home demand and early saturation.(3)Internationalization of domestic demand: mobile and multinational local buyers and influences of foreign need. Therefore, the demand conditions drive the production efficiency of the industry through scale economy; on the other hand, if there's home demand for higher quality in domestic demand market, firms in the industry will have an insight into the market situation and more motives for innovation and development.

- III. Related and supporting industries: Referring to the complementary activities existing between local related industries and supporting ones. When up-, mid- and down-stream industries for a given industry are developed in a robust and competitive way, the given industry will gain more competitive edge in the international market. Besides, the interactive relation among the industries, particularly coordination, and cooperation between firms and spillover and diffusion between research results, are essential reasons that will influence industrial competitiveness. (Narula, 1993)
- IV. Firm strategy, structure and rivalry: Including the foundation, organization and management pattern of a firm, and the performance of its home rivalry. A firm's strategies and structure will be influenced by social, cultural and historical elements and show different profiles, forming various competitive patterns in the industry. More intensive competition means more pressure from domestic rivalry, and an inefficient firm will be eliminated by competition. As a result, a firm will be more motivated to develop its advantage in international market, which in turn helps enhance the industry's international competitiveness. A nation's competitive edge is gained based on the optimal portfolio of different conditions. Essential consideration includes : ( 1) Strategies, management pattern and organizational structure of a firm in the given industry. (2)Business target of the firm. (3)Competition profile of the industry. (4)Individual target of the employees in the firm.
- V. Government: The system comprising the aforementioned innate elements will feature competitive only after internal canalization and positive interaction. According to Porter 's thinking, the role of government is to supply interactive energy for these four innate elements. Generally, there are six ways the government affects the interaction among the four elements:(1)Direct fund subsidy;(2) Capital market policy;(3)Education policy;(4)Changing demand conditions or affecting buyers, particularly key buyers;(5) Establishing product standards and regulations;(6) Setting the competition rules, and even participating in the competition. Porter proposes that the role of government exerts a subtle influence on the four innate elements, which will drive them positively or negatively, and an idealistic government should obtain the balance between interference and noninterference.

### *2.3 Analytic Hierarchy Process*

The Analytic Hierarchy Process (AHP), introduced by Saaty in 1980, is an effective tool for dealing with decision making by simplifying complex problems through systemization. It uses hierarchical structure to solve a problem and makes appraisal based on the quantification result for decision makers to make the best option and reduce the risk of decision errors. In short, it is a systematic, hierarchical analysis approach combining both qualitative and quantitative aspects. The AHP can be used to decide priority order, resource planning and distribution, and investment portfolios. As the AHP shows practicality and effectiveness when solving complex decision-making problems, it has been widely applied to various sectors rapidly for selection of multi-criteria options and weights distribution of resource allocation (Saaty, 1980). Mainly applied to setting priorities, choosing a best policy alternatives, generating set of alternatives, determining requirements, allocating resources, predicting outcomes – risk assessment, measuring performance, designing a system, ensuring system stability, optimizing, planning, conflict resolution.

### *2.4 Fuzzy Theory*

Fuzzy Sets Theory was introduced by Prof. Zadeh in 1965, who argued that fuzziness could be found in many aspects of daily life such as thinking, inference and perception. There should be fuzzy logic concept used to describe the difference between things to complement classical two-valued logic. The fuzzy set is defined by assigning to each element a number between 0 and 1, suggesting the degree or grade of membership in the set. The assignment of 0 to a particular element means that this element definitely does not belong to the set; the assignment of 1 means that the element does belong to the set. In short, during the definition of semantic scale, we collect expert opinions and induced the maximum, mean and minimum values.

This study employs the triangular fuzzy number (TFN) to express the scale scope of semantic variables and uses five fuzzy semantic terms: “Equally important”, “Slightly important”, “Relatively important”, “Very important” and “Extremely important”, for question measurement, with the rating scale defined as 1-9; and for the relative importance rating scale, we use the study by Chen & Hwang (1992), as shown in the Table below. The rating scale is also the most commonly used in various studies. The fuzzy nominal scale and the trig function table used in this study are given in the figure below:

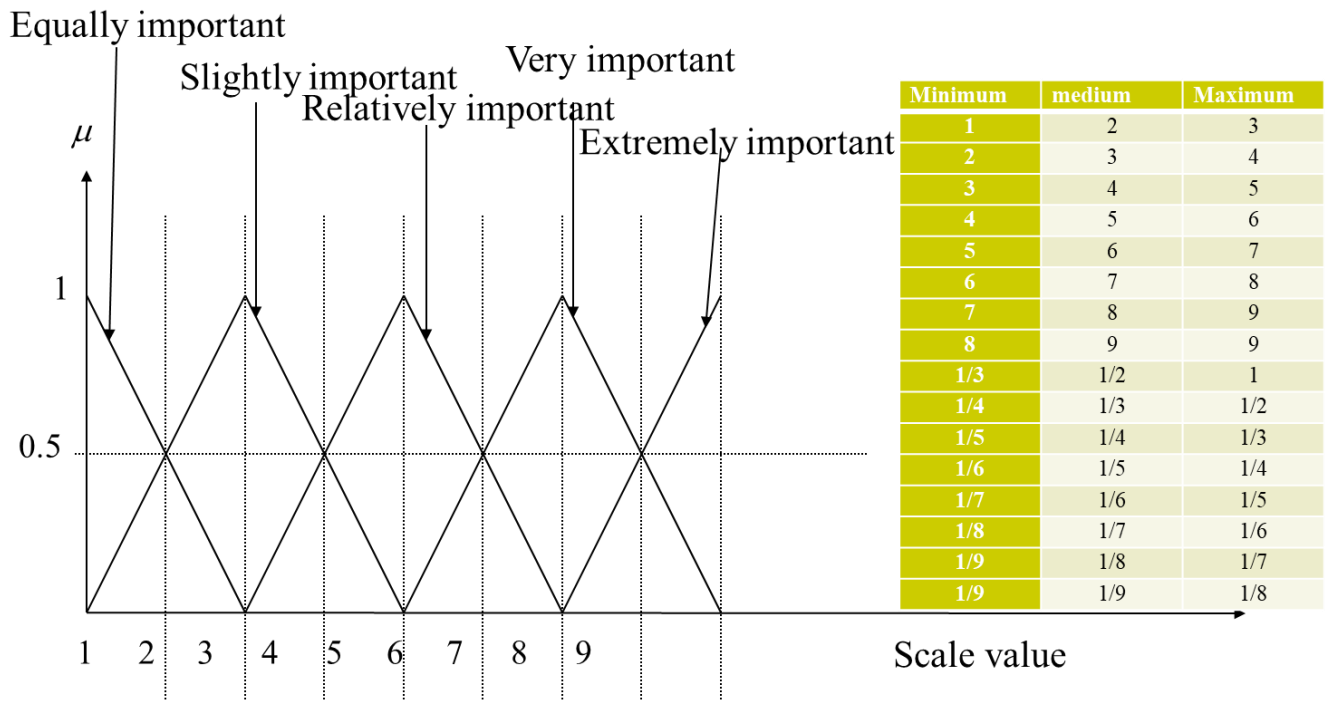


Figure 2. The fuzzy nominal scale and the trig function table

Source: Revised from Chen & Hwang (1992)

### 2.5 Fuzzy AHP

Although the AHP is a tool widely used for decision making, it has some disadvantages; for example, if a decision maker's appraisal is not a precise value, subjective perception and judgement of the appraisal members cannot be exhibited properly, while the average of the weight also lacks distribution information. Besides, many traditional quantitative methods cannot solve human-oriented and more complex problems (Csutora & Buckley, 2001). Thus, since there are some disadvantages in the AHP, Van & Pedrycz (1983) evolved the AHP into the Fuzzy Analytic Hierarchy Process (FAHP), to reflect problems the decision making analysis should address in a real environment. The implementation procedure of the FAHP is roughly the same as the one of the traditional AHP; the difference is that the FAHP is required to set fuzziness and normalization. The FAHP has advantages as followed:

- I. It addresses study problems that are difficult in quantification: For example, business strategic problems of immature emerging industry; problems with the priority in resource distribution.
- II. It reduces uncertainty for expert's appraisal of the elements.
- III. Expert perception of fuzziness is demonstrated, no unique opinion is eliminated.
- IV. Fuzzy interval in expert group decision making is demonstrated and is used as an elastic space for a decision maker's judgement by his/her individual experience.

With the operating process, researchers may correct the traditional AHP to solve disadvantages, and the decision making result obtained may be closer to facts.

### 3. Methodologies

The study analyses the wholesale leased line services with “diamond model” proposed by Michael Porter in 1990. The Competitive Advantage of Nations mentions factor conditions, demand conditions, related and supporting industries, firm strategy, structure and rivalry, government support to the country’s economy to provide a research structure for Fuzzy AHP, and the hierarchical weight distribution of individual facets and factors is discussed with expert questionnaires. A survey by expert questionnaires was used to collect the key development factors of the wholesale leased line service industry. Weight assignment situation. The research is divided into the following categories: industry experts, government unit experts and research scholars in related fields. The fuzzy analysis was carried out on 10 questionnaires that met the validity and reliability, and the five major facets of the national diamond system and its eighteen elements were compared in pairs, and the individual weights and the overall weights of the targets were calculated. It was then sorted down to the importance level and explained at those levels. Through literature collection and expert interviews, this study first adds important or eliminates less important measurement dimensions, to reduce questionnaire errors and increase questionnaire effectiveness, as the given items on the hierarchical questionnaire in Phase II. At first, we distribute 20 questionnaires to related industries, government organizations, and academic or research institutes, with 10 questionnaires reclaimed (a response rate of 50%), in which 8 questionnaires are effective (2 questionnaires are eliminated, after the consistency ratio test); therefore the effective questionnaire recovery rate is 80%.

Of the questionnaires reclaimed, over a half of questionnaire respondents have expert background with ten years or above of background experience, suggesting that these respondents have expertise with RD capability regarding this issue and are responsible for decision making in their organization, and should be recognized as “experts” in this study. The dimension, definition and scope are listed in Table 5. At last experts complete the appraisal by “extremely important”, “very important”, “relatively important”, “slightly important”, and “equally important”.

**Table 5**  
Element, Definition and Scope

Level 1	Level 2	Definition and Scope
Factor element	Human resources	Labor cost, labor quality, labor force, work ethics, technical capability, labor hours, and labor categorization.
	Natural resources	Location and area of the country, whether natural resources adequate, quality, climate, weather, geographical relation with other countries, etc.
	Knowledge resources	College, government research institutes, private institute, government statistics department,

		business or science journal, market research report and database, industrial association, and vocational training institute, etc.
	Capital	Money market, capital market, foreign exchange market, credit loan, mortgage loan, bond market, venture investment (venture capital), and banking system, etc.
	Infrastructures	Transportation system, telecommunication system, network facility, post and courier, payment and transfer, health insurance, culture organization, and house supply, etc.
Demand condition Related and supporting industry Firm strategy, structure and rivalry	Domestic market characteristics	Degree of categorization of market segmentation, market demand, similarity in international demand, etc.
	Consumer maturity	Sensitive customers with professional knowledge, demand in domestic market earlier than that in international market.
	Market size	Domestic market demand size, growth rate, saturation degree, customer size, degree of concentration or dispersion, etc.
	Value diffusion overseas	Identity to domestic value by overseas market, whether there is multinational local buyer, domestic value education or transferred to foreign customers, demonstration effects by leading countries, political alliance or historical relation between countries.
Demand condition Related and supporting industry	Situation of Up- and down-Stream firms	Whether up- and down-stream firms have international competitiveness, innovation, and upgrading ability
	Pull-through effect	Related industry's cooperation and sharing mechanism, complementary effect, building value network linking with other industries, opportunity partnership, or alliance relation, etc.
Firm strategy, structure and rivalry Demand condition Related and	National character	Impact of national culture on business model, leadership oriented, internal training and education pattern, relation between team and organization, degree of risk-taking, national glory and identity,

supporting industry Firm strategy, structure and rivalry		internal cooperation capability, and labor relation, etc. °
	World view	Attitude toward internationalization, attitude toward foreign culture, world view of administrator, etc.
	Business operating model	Business target, shareholder structure, creditor's attitude, nature of the management, internal incentive system, willingness to venture, and loyalty to industry, etc.
	Rivalry	Competitor size, competitor scale, and competition intensity, etc.
	Emerging Business pattern	New business type from diversification or business diffusion, new firms from market with new demand, etc.
Government	National policy	Subsidy policy, education policy, manipulation in capital market, interference or noninterference, etc.
	Legal development maturity	Degree of IP rights readiness, stipulation of product norm, regulation on marketing, and regulation on banking market, etc.

#### 4. Results

This study intends to combine the Porter Diamond Model, hoping to fully understand the characteristics of the whole leased line market, and understand the resources and conditions for the country to develop this industry. If it is only imitating other countries, it is like the UK and ignores it. The characteristics of the industry may lose the best timing and results of industrial development. This study uses Porter's (1990) Diamond Model of national advantages to analyze relevant facets, and uses the fuzzy-level analysis method combined with a survey by expert questionnaires to discuss the hierarchical weight distribution on individual facets and factors, and concludes that Taiwan is in the fixed-line industry. Develop the most critical facets and identify the less influential factors in the development of the industry, so as not to invest too much unnecessary resources. In the analysis of further individual facet sub-elements, it aims to find the most important factors and the least important factors.

During the calculation of weights, to enhance study quality, the study employs the FAHP, which is more complex than the traditional AHP in calculation. Therefore, this study uses Power Choice, a professional AHP (FAHP) analysis software, for subsequent analysis and calculation. First, we conduct the consistency ratio (C.R.) test for the ten questionnaires, with the principle of consistency index (C.I.) and random index (R.I.). After the calculation, the C.R. value less than 0.1 indicates the matrix achieves logic consistency. The formula is given blow:

Let fuzzy  $\lambda_{\max} = (p, q, r, s)$ , then the fuzzy C.R. =  $(\frac{p-n}{n-1}, \frac{q-n}{n-1}, \frac{r-n}{n-1}, \frac{s-n}{n-1})$

Let fuzzy C.R. =  $(a, b, c, d)$ ,

- If  $(b+c)/2 \geq 0.1$ , then inconsistent
- If  $(a+2b+2c+d)/6 \geq 0.1$ , then inconsistent

There are two questionnaires failing to pass the C.R. test and are eliminated. The rest questionnaires are further analyzed and pass the C.R. test in Dimension I. The values in four appraisal attributes of the market dimension exceeding 20 scores include “government”, “related and supporting industry”, “demand conditions”, where the dimension “government” achieves the highest score; the values in five appraisal attributes of the demand dimension exceeding 20 scores include “capital”, and “infrastructures”; the values in four appraisal attributes of the market dimension exceeding 20 scores include “market size”, “domestic market characteristics” and “consumer maturity”; for two appraisal attributes of the related and supporting industry dimension, “pull-through effect by related industry” achieves the highest score; for two appraisal attributes of the government, “government policy” is slightly higher than “legal development maturity”. Concluding the selected appraisal items and statistic results, all appraisal attributes are allowed to be listed in the measurement framework. Related data are shown in Table 6-11, and overall weights of the dimensions and attributes and ranking are listed in Table 12.

**Table 6**

Comparison table of main dimension weights vs. importance

dimension	weights	importance
Factor element	0.102848	5
Demand condition	0.212313	3
Related and supporting industry	0.232302	2
Firm strategy, structure and rivalry	0.120905	4
Government	0.331631	1
$\lambda_{\max}=5.101324$ , C.I=0.025331 , C.R=0.022616		

**Table 7**

Comparison table of factor element weights vs. importance

dimension	weights	importance
Human	0.099846	4
Natural	0.066957	5
Knowledge	0.122112	3
Capital	0.319951	1
Infrastructures	0.391135	2
$\lambda_{\max}=5.096854$ , C.I=0.02421375 , C.R=0.0216196		

**Table 8**

Comparison table of demand weights vs. importance

<b>dimension</b>	<b>weights</b>	<b>importance</b>
Domestic market characteristics	0.236198	3
Consumer maturity	0.236254	2
Market size	0.447063	1
Value diffusion overseas	0.080485	4
$\lambda_{\max}=4.0989230$ , C.I=0.032974 , C.R=0.036638		

**Table 9**

Comparison table of related and supporting industry weights vs. importance

<b>dimension</b>	<b>weights</b>	<b>importance</b>
Situation of Up- and down-Stream firms	0.332475	2
Pull-through effect	0.667525	1
$\lambda_{\max}=2.002647$ , C.I=0.002647 , C.R=0		

**Table 10**

Comparison table of firm strategy, structure and rivalry weights vs. importance

<b>dimension</b>	<b>weights</b>	<b>importance</b>
National character	0.009581	4
World view	0.009403	5
Business operating model	0.027511	3
Rivalry	0.046735	1
Emerging Business pattern	0.027675	2
$\lambda_{\max}=2.000082$ , C.I=0.015600 , C.R=0.013928		

**Table 11**

Comparison table of government weights vs. importance

<b>dimension</b>	<b>weights</b>	<b>importance</b>
National policy	0.535875	1
Legal development maturity	0.464125	2
$\lambda_{\max}=2.000082$ , C.I=0.000083 , C.R=0		

**Table 12**

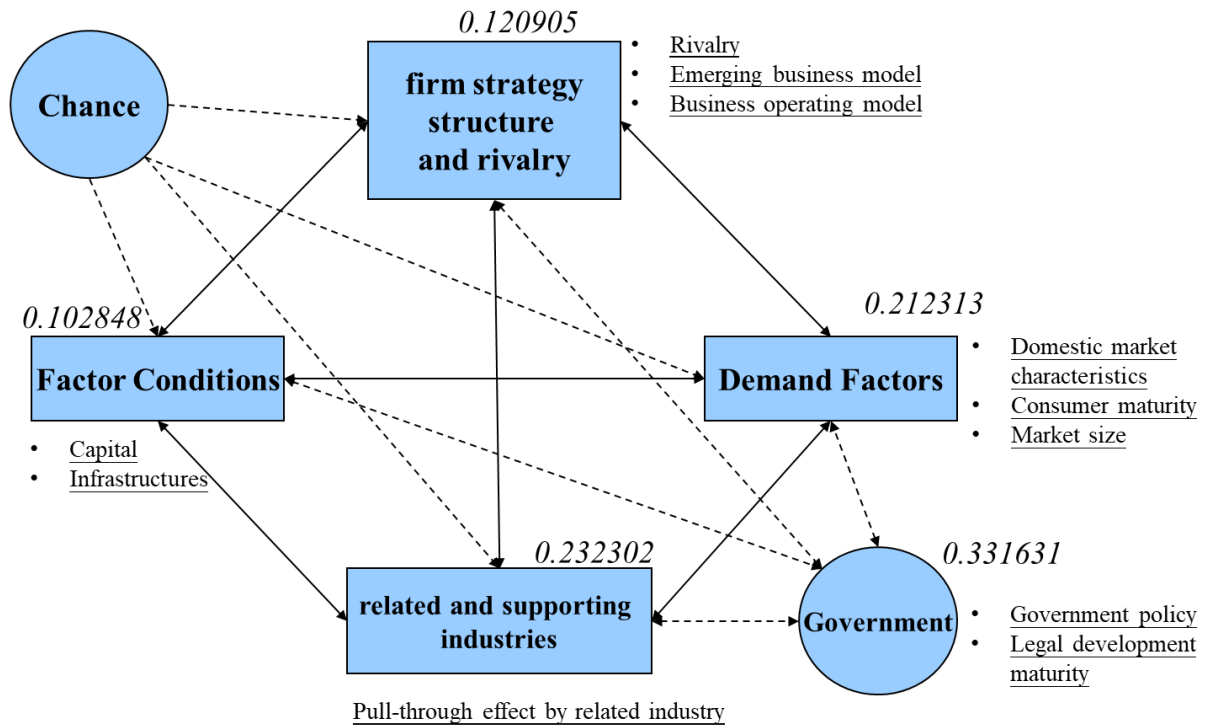
Weights of all appraisal dimension and criteria, and ranking

<b>Dimension 1</b>	<b>Dimension 2</b>	<b>Overall weight</b>	<b>Ranking</b>
Level 1	Factor element	0.102848	8



	Demand condition	0.212313	3
	Related and supporting industry	0.232302	2
	Firm strategy, structure and rivalry	0.120905	7
	Government	0.331631	1
Factor element	Human resources	0.010269	20
	Natural resources	0.006886	23
	Knowledge resources	0.012559	19
	Capital	0.032906	15
	Infrastructures	0.040228	14
Demand condition	Domestic market characteristics	0.050148	12
	Consumer maturity	0.05016	11
	Market size	0.094917	9
	Value diffusion overseas	0.017088	18
Related and supporting industry	Situation of Up- and down-Stream firms	0.077235	10
	Pull-through effect	0.155067	5
Firm strategy, structure and rivalry	National character	0.009581	21
	World view	0.009403	22
	Business operating model	0.027511	17
	Rivalry	0.046735	13
	Emerging Business pattern	0.027675	16
Government	National policy	0.177713	4
	Legal development maturity maturity	0.153919	6

In conclusion, with overall appraisal results incorporating Porter's Diamond model with the Fuzzy AHP, factors with greater influence in the dimensions are integrated in the figure below.



**Figure 3:** Overall appraisal results incorporating Porter's Diamond model with the Fuzzy AHP

Source: Revised from Porter (1990)

## 5. Discussion

The evaluation of WEF Global Competitiveness Ranking covers a total of 140 economic entities, and it is mainly focused on the factors of national competitiveness including productivity, institution, policy, and infrastructure. The Global Competitiveness Ranking of the countries in this study is based on the order of Germany, Japan, Britain, Taiwan, and Australia. In this study, the comparison has been made according to the important factors generated in the previous stage in conjunction with the primary evaluation items in WEF and the associated criteria. It reveals that Taiwan performs better in the categories of Conflict of interest regulation, ICT adoption, Mobile-cellular telephone subscriptions, Inflation, Extent of market dominance, and Buyer sophistication as shown in Table 13 below. As indicated in this table, the evaluation factors of the government, such as Judicial independence, Efficiency of legal framework in challenging regulations, Efficiency of legal framework in settling disputes, and Future orientation of government, are rather far from the mean value. This part of statistics are consistent with the suggestion obtained from expert questionnaire, that telecommunication is one of the important infrastructures for sustainable development of digital economy, hence the government should provide investment incentives in the policies for the next generation network construction of telecommunication industry, and the exclusion of construction obstacles and the strengthening of policy coordination mechanism are very important. There are also experts mentioned that the factors of enhancement of national competitiveness, improvement of

industrial order, and maintenance of fair market competition can be included in the national policies. The policy objectives should take into consideration the current market status and future development direction. In terms of associated and supporting industries, after the Fuzzy AHP is used in conjunction with the aspects and criteria of Porter Diamond Model in this study corresponding to the evaluation criteria proposed by WEF - Multi-stakeholder collaboration, we get the conclusion that there will be mutual influences among associated and supporting industries, corporate strategies, corporate structures, and intensity of peer competition, such as the merger and acquisition behaviors of corporations. In addition, the emphasis of future 5G era will be on the high integration with vertical application industry, and the importance of this factor will be enhanced because powerful backhaul facilities will be needed in the 5G era. It is also a critical impact factor for development of line rental wholesale service industry that whether or not the service providers have properly utilize their own infrastructures to allow network operators and vertical application industry to promote emerging business models. If the government aspect has been taken into consideration for this subject, there can be corresponding supporting measures from urban areas to villages such that new technologies can be gradually spread throughout the entire country to speed up the enhancement of network environment.

In terms of requirement conditions, from the table we know that Product market, Distortive effect of taxes and subsidies on competition, Market size, and Buyer sophistication are all possible evaluation criteria. Among them, Product market and Market size are the disadvantages of development of line rental wholesales service industry in Taiwan. The mutual competition among various styles of online approaches is rather high, and the simple control over industrial cost cannot provide too much help. Considering the future diffusion of telecommunication industry, the capability of extension to the demands of other service markets could also be taken into consideration. Besides, the wholesale prices and retail prices in Taiwan are not transparent. Even though the competent authority does control the price cap, the matter of fact is that the dominant company could provide a price much lower than the controlled price, so the dominant company could still determine the price, thus indirectly affecting the market scale. Facing the increasing demand for bandwidth, the emergency of new style information industry, and the increasing line demand, the policy development should be heading towards the direction of economic benefits.

In addition to the three aspect factors with significant impact, from the aspect of production factor, experts also stated that the knowledge resources and technology R&D energy in the production factor conditions should be very important for telecommunication industry/line rental wholesales service, and we should boldly deploy new technologies and improve the deficiencies of existing technologies. However, Taiwan is a country facing numerous typhoons and earthquakes, so the line deployment will require more maintenance cost, and the construction cost could be rather high due to the general requirement of underground construction. Sometimes the facility cost will be increased due to the construction of user loop by dominant company. The pipeline excavation cost can be really high, and small companies can only afford the renting approach. In terms of corporate competition, experts mentioned that the capital investment in 5G network will be several times of that for 4G, so the cooperation of network construction will be an important key to the popularization of 5G network. The line rental wholesale service market is

dominated by large companies, and the entry barrier for emerging company is rather high. With no investment incentives, the investments by large companies will be affected by customer demands. The line rental wholesale service needs a huge amount of investment, and it's going to be difficult for small companies to get rewarded by their investments. The market mechanism orientation can prevent market monopoly. The peer prices should not be higher than consumer price or corporate price, for it may induce unfair competition that impedes the market development.

**Table 13**

The evaluation based on critical factors affecting line rental wholesale service industry in conjunction with WEF evaluation criteria

<b>Economy</b>	<b>Germany</b>	<b>Japan</b>	<b>United Kingdom</b>	<b>Taiwan</b>	<b>Australia</b>	<b>Best Economy</b>	<b>Avg.</b>	<b>Corresponding to Porter five facets</b>
<b>Rank</b>	3	5	8	13	14			
<b>Institutions</b>	73.5	71.1	76.8	68.5	73.6	New Zealand	72.7	Factor element
<b>Social capital</b>	61.1	47.8	61.3	54.2	66.2	Australia	58.12	Factor element
<b>Judicial independence</b>	72.7	84.7	82.2	57.6	86	Finland	76.64	Government
<b>Efficiency of legal framework in challenging regulations</b>	69.5	60.8	64.4	44.7	53.2	Finland	58.52	Government
<b>Burden of government regulation</b>	63.9	50.4	51.1	50.4	38.3	Singapore	50.82	Government
<b>Efficiency of legal framework in settling disputes</b>	69.7	72.5	72.3	45.9	62.1	Singapore	64.5	Government
<b>Future orientation of government</b>	67.5	60.8	59.1	45.6	53	Singapore	57.2	Government
<b>Conflict of interest regulation</b>	50	70	83	67	60	Multiple	66	Government
<b>Infrastructure</b>	90.2	91.5	89	82.6	77.9	Singapore	86.24	Factor element
<b>ICT adoption</b>	69.3	87.4	71.1	77.9	73.5	Korea, Rep	75.84	Factor element
<b>Mobile-cellular telephone subscriptions</b>	100	100	99.7	100	93.9	Multiple (68)	98.72	Factor element
<b>Fixed-broadband Internet subscriptions</b>	80.9	63.4	78.6	48.4	64.8	Switzerland	67.22	Factor element
<b>Internet users</b>	89.6	93.2	94.8	79.7	88.2	Iceland	89.1	Factor element

<b>Inflation</b>	100	99.1	100	100	100	Multiple (74)	99.82	Factor element
<b>Skills</b>	85.4	73.7	80.2	75.6	81	Finland	79.18	Factor element
<b>Product market</b>	72	72.9	68.7	65.7	70.2	Singapore	69.9	Demand condition
<b>Distortive effect of taxes and subsidies on competition</b>	66.7	63.7	59.3	52.7	56.2	Singapore	59.72	Demand condition ; Firm strategy, structure and rivalry
<b>Extent of market dominance</b>	75.8	81.6	64	70.1	54.2	Switzerland	69.14	Firm strategy, structure and rivalry
<b>Market size</b>	85.8	86.7	81.7	74.2	72.3	China	80.14	Demand condition
<b>Multi-stakeholder collaboration</b>	73.4	62.6	67.5	61.5	54.7	United States	63.94	Related and supporting industry ; Firm strategy, structure and rivalry
<b>Buyer sophistication</b>	66.1	65.7	61.4	61.9	50.6	United States	61.14	Demand condition

## 6. Conclusion(Outcomes and Policy Implications)

Understand the importance of the various conditions for the development of wholesale leased line services and their key influencing factors. Know where the industry's operational support is based and the decision-making factors for successful development and smooth development of wholesale leased line services. The contributions of this study are as summarized below:

- (1) In this study the telecommunication industry development environment and line rental development and regulation trend in Germany, Japan, Britain, and Australia are investigated. With literature reviews and interviews, the 5 aspects of impact on line rental wholesale service industry are summarized, including “Production factor conditions”, “Demand conditions”, “Associated and supporting industries”, “Corporate strategies, corporate structures, and peer competition”, and “Government”; and there are 18 evaluation attributes.
- (2) In this study the fuzzy comprehensive selection approach and the architecture of hierarchical analysis are used in conjunction with Porter Diamond Model to analyze the expert questionnaire on the positioning or market concept of line rental wholesale service. The analysis indicates that “Government” (with the weight of 0.331631), “Associated and supporting industries” (with the weight of 0.232302), and “Demand conditions” (with the weight of 0.212313) all have deep impact on industrial development. And the “Government” aspect is the one with the greatest impact.
- (3) The order of the overall weights of top important impact factors for line rental industrial development is: national policies (0.177713)>pulling effect of associated industries (0.155067)>maturity of development of laws and regulations (0.153919)>market scale (0.094917)>status of upstream and downstream companies (0.077235)>consumer maturity (0.05016)>nature of domestic market (0.050148)>competition in the industry (0.046735)>infrastructure conditions (0.040228)>capital conditions (0.032906).
- (4) The situations of line rental environments in various countries are utilized in conjunction with the aspects of Fuzzy AHP established in this study for empirical analysis in order to prove the applicability of evaluation attributes and weights selected in this study.
- (5) The combination of WEF evaluation criteria, scores, and orders can be used to verify that the items need to be strengthened for the line rental industry in Taiwan are the Judicial independence, Efficiency of legal framework in challenging regulations, Efficiency of legal framework in settling disputes, and Future orientation of government of the “Government” aspect; in the aspect of “Associated and supporting industries”, the importance of Multi-stakeholder collaboration will be enhanced along with the emphasis of future 5G era on the high integration of vertical application industry. This is because the 5G era will need powerful backhaul facilities. It is also a critical impact factor for the development of line rental wholesale service industry that whether or not the line rental wholesale service providers can properly utilize their own infrastructures to allow network operators to work with vertical application industry to promote emerging business models; and there are Product market and Market size in the aspect of “Demand conditions”.

In terms of management implications, with the more and more obvious trend of rapid technology advancement in the world, all industries will be facing competitors from all other countries with different environments and laws and regulations. Thus all kinds of factors must be taken into consideration for the enhancement of industrial competitiveness. Therefore, in this study we hope to use a systematic mechanism to extract the wisdom of experts in order to understand the problems to be considered during the process of development of this industry, and the importance of them. In summary, the management implications of critical factors of development of line rental wholesale service in this study can be described as the following:

- (1) Objectivity of decision making: the evaluation model established in this study via FAHP approach is objective, and empirical operation and verification can be conducted to make the decision making even more objective, thus helping manager make right decision.
- (2) In this study the research method can generate the criteria weights of critical factor mode for the development of line rental wholesale service industry in Taiwan. However, the industrial investment perspectives and expected investment target will continue to vary along with the changes of future industrial trends and demand conditions. Therefore, the regulation evaluation based on questionnaires modified based on WEF criteria should be conducted at least once every three years.
- (3) The critical factor with the greatest impact obtained by this study is “Government”. Based on the experts’ opinions, in the future we can first consider testing the demand flexibility of market to figure out whether or not there is the need for price control of the market. Otherwise the direction of control could prevent companies from continuous investment in infrastructure.

The network deployment cost of telecommunication industry in Taiwan is rather high, and the deployment is difficult (such as the problems of right of way and channels), thus making it difficult for other competitors to compete with CHT. So it appears that the development is rather limited.



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