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有線電視獨占市場分組付費轉換之誘因政策分析與設計

Policy Analysis and Design for Incentivizing Tiered Charging Conversion in a Monopolistic Cable Television Market

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電二 207 實驗室到國青、管院到博理，活中到 118 巷，水源 BOT 到國青宿舍，辛亥路到仁愛路、數不清的高鐵來回票，堆疊成不同時期的回憶，just move on。驚喜的是，為了補強論述而翻開書櫃上塵封著的、那些年沒真正上完的個經課本，發現不變的是對經濟學、對機制與財政的熱愛，而且又再看懂了些什麼了。謝謝那個勇於追求這個機會、選擇這條道路的自己，妳是如此幸運，也謝謝妳堅持走完。謝謝父母、孟樺、摯友們一路相伴，謝謝兩個寶貝豐富我的人生，謹以此文獻給這麼愛我的你們。

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中文摘要

分組付費（tiered charging, TC）政策是有線電視市場的主流政策，旨在維護價格合理性、節目類型多樣性、提升內容品質等市場良性發展。然而，由獨占的有線電視市場由單一費率（flat rate, FR）轉換為 TC 需要監理機關提出創新且具誘因性的措施，以使系統業者（system operator, SO）和消費者處於柏拉圖改進(Pareto Improvement)的雙贏局面。提出具有誘因效果的政策需要分析原市場施行分組付費的潛在誘因及機會，並設計、評估出合理的分組付費相關參數範圍，如：單一費率頻道組合下的每頻道價格、基本頻道組合(basic channel bundle, BCB) 的頻道數量，以及進階頻道組合(advanced channel bundle, ACB)的數量、頻道組合及價格。

本研究之設計挑戰在於：SO 提供給監理機關的數據有限而分散，並且缺乏用以分析的計量模型。本研究提出的創新方法，係利用有限的分區實務數據來衡量、分析訂戶如何依據其偏好，做出頻道套餐的訂閱選擇決策。結合消費者偏好模型，我們建構出 SO 收費方案和消費者之間可能的交互作用模型，並設計出由兩個雙贏條件指數所組成的價格頻道縮減（Price-Channel-Downscale, PCD）和 ACB 的建議費率結構。

在本研究中，我們為監理機關提出了一個針對獨占有線電視市場的創新 TC 政策誘因設計。監理機關需評估在 TC 政策架構下，具有適當 BCB 規模和 ACB 價格水準等參數設定，並以計量性佐證分組付費政策可激勵 SO 和消費者從單一費率頻道組合 FR 改採 TC 方案與收視消費，達成柏拉圖改進(Pareto improvement)，即所謂市場中的「雙贏」狀態。此設計方法整合了機率建模及以實證數據為基礎的數值模擬，可供監理機關運用較直觀的 TC 政策參數設置，來評估「當服務費率方

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案由 FR 轉換為 TC 時，在該區域獨占的 SO 和訂戶是雙贏的」政策結果。TC 政策誘因設計在此使用了臺灣兩個經濟特性不同但皆為獨占 SO 的有線電視服務區（一偏遠地區(臺東縣，TTC)及一個臺灣西部市區(臺南市永康區，YKFA)的有線電視服務區）的實務數據進行評估和分析。

模擬評估和分析結果顯示，各區 TC 政策參數都存有相當的合適區間供 SO 設定其分組付費方案並與消費者獲致雙贏。偏遠地區的雙贏 TC 政策參數可設定範圍比市區大，因為偏遠地區在經濟特性上具有較高的價格彈性。本論文研究提出的 TC 政策誘因設計方法，有利於監理機關為 TC 政策的激勵設計提供量化分析與評估工具，並可供實證檢驗。藉著劃定雙贏區域及 TC 政策可設定的參數範圍，為推動與實現政策目標提供了可執行的基礎。

關鍵字：柏拉圖改進、政策參數設定、分組付費政策、誘因定價機制、實證數據模型、有線電視服務、獨占市場

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ABSTRACT

Tiered charging (TC) policy is a mainstream policy of cable television (cable TV) markets to facilitate healthy market developments such as maintaining the price rationality, enriching the variety of programs, and raising content quality. However, conversion from a flat rate (FR) monopolistic cable TV market to TC policy needs innovative incentivization by the market regulator such that both system operators (SOs) and consumers are in a Pareto improvement, that is, win-win situation. Incentivizing TC policy requires analyzing TC policy potential for the legacy market and quantitative design of TC policy parameters such as the bundle size of basic channel bundle (BCB) at the same per-channel price as the legacy bundle and the bundle size, channel mix and price of advanced channel bundles (ACBs). Design challenges are that SO data provided to a regulator is limited and fragmented and that there is lack of quantitative design models.

In this research, we present an innovative design for incentivizing TC policy for a monopolistic cable TV market regulator. The incentivization is achieved through properly setting, by the regulator, TC policy parameters such as the BCB size and the price level of ACBs. The design approach integrates probabilistic modeling and empirical market data-based simulation. Such an approach enables a regulator to identify TC policy parameter settings where the monopolistic SO and the subscribers are win-win when the service charging scheme converts from FR to TC. Evaluation and analysis of the incentivizing TC policy design are over the empirical data of two economically different but monopolistic cable TV service districts in Taiwan, one rural and one urban cable TV service districts.

Results show that there exists a Pareto improvement region of TC policy parameter

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settings for each district. The win-win TC policy parameter setting region of the rural district is larger than the urban one, because the rural district has a higher price elasticity. Such method proposed in this research is beneficial for regulatory authorities, as it provides quantitative analysis and evaluation tools for TC policy incentive design, and can be used for empirical testing, serving as an executable basis for promoting and achieving policy goals.

Keywords: Pareto improvement; policy parameter setting; tiered charging policy; incentive pricing mechanism; empirical-data-based model; cable television service; monopolistic market

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Chapter 1 Introduction

1.1 Motivation

Tiered charging (TC) policy is a mainstream policy of cable television (cable TV) markets to facilitate healthy market developments such as maintaining the price rationality, enriching the variety of programs, and raising content quality. However, conversion from a flat rate (FR) monopolistic cable TV market to TC policy needs innovative incentivization by the market regulator such that both system operators (SOs) and consumers are in win-win situations.

In 2013, Taiwan's National Communications Commission (NCC) introduced a new tiered pricing policy for cable TV services, set to replace the existing single flat rate (FR) in 2017. The NCC's tiered pricing proposal garnered significant support from subscribers, with 61.2% of Taiwanese in favor at the time of the announcement [DCD13], and 64.6% expressing support six months later [DCD14]. However, the system operators (SOs) tend to be reluctant to change the legacy flat rate (FR) and the implementation of tiered charging is delayed until 2021.

There are five multiple-system operators (MSOs) in Taiwan [NCC14], along with several independent operators, providing cable TV services to 51 franchise areas across the country in 2014. Until 2022, there are 43 SOs belonging to 6 MSOs, and the number of franchise areas was down to 41 [WaL22]. The number of households in these areas ranges from 2,000 to 414,000, with most areas experiencing monopolization [Shi12]. In this context, operators often cut costs by increasing the hours of program replays, lacking the incentive to invest in original programming, which leads to low consumer satisfaction [KuL17].

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For more than 80% of households, the main source of viewing is cable television in Taiwan [Shi12]. The current cable TV service charge is a flat rate ranging from NT$480 to NT$590 per month for a 100-channel package [NCC14b]. According to the Survey of Digital Convergence conducted in the latter half of 2013, 54.1% of consumers expressed dissatisfaction with the subscription fee, while 47.1% were dissatisfied with the quality and charging rate [DCD14].

The initial plan announced in 2013 forces the division of the current basic channel bundle (BCB), approximately 100 channels, into one BCB with smaller size and put at least three advanced channel bundles (ACB) on the menu, subject to a corresponding price ceiling. With the promotion of cable TV digitalization, the price of this combination will decrease year by year. [CKP13]. Liu and Chuang [LiC15] indicated that Taiwan's cable TV market structure (with 47 monopolized franchise areas in 2015) enabled SOs to maintain a stable profit by implementing the FR charging and controlling program quality as costs. Tiered charging policy can enhance consumer viewing rights and reduce the subscription fee, help SOs and channels retain their customers by new services and create new profitable space [LTN13].

In the most countries as the U.S., the U.K., Japan, and South Korea have SOs compete on a national level and implement a channel-tiered charging model. In the U.S., the tiered charging model and the legalization of cable TV were implemented concurrently, segmenting viewing options into BCB, ACBs, a la carte, and pay-per-view modes. In Japan, the charging model includes a flat rate for BCB and an a la carte approach for additional channels [CCL04].

In the cable TV market, the main tools to regulate cable TV industry are monitoring the CP price ceiling, service charging combination and the operation plan

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of SO [THH21]. As TC policy implementation, different levels of CP will have their own price ceiling, and the combinations of policy parameters are more complicated than regulating structure of pure FR charging era. Regulators thus need quantitative tools to set and adjust TC policy parameters during policy transforming period.

1.2 Literature Survey

The literature survey covers some existing research about tiered charging mode in cable TV market.

Tiered-Charging Mode in Cable TV Market

Numerous research studies highlight the benefits of the channel-tiered charging model. According to the minutes of a Satellite Television Broadcasting Association R.O.C. meeting [STB13], some researchers propose that the optimal time to implement the downward-tiered charging model is after the digital switchover of cable TV. However, the digitalization rate is only 14.93% in 2012 Q2, showing that promotion is slow and challenging [CKP13]. Similarly, Chen et al. [CTC06] recommend that regulators establish the policy for a tiered basic channel model and put it into effect once digital cable TV penetration reaches 65%. Since 2013, NCC has provided subsidies from cable funds to encourage SOs to invest in digital network construction. By the end of 2019, the digitalization level of cable TV has reached nearly 100% [THH21]. The digitization of cable systems will make it more feasible for SOs to bundle different channel packages.

Tsai et al. [TCC11] emphasized that the implementation of a downward-tiered charging model should consider both consumer awareness of digital services and the

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progress of digitalization within the industry. Noting that the number of basic channels in Taiwan exceeds the global average, Chiang et al. [CCL04] recommended that regulators adopt the downward-tiered charging model by dividing basic channels into two bundles: a BCB and an ACB, with suggested markups of 45% for the BCB and 55% for the ACB. In 2022, NCC announced there were 5 new TC payment plans from SOs [NCC22]. According to the announcement, out of the 41 operating districts, 12 areas remained monopolistic franchise areas.

System operators (SOs) hold differing opinions on the issue. Over 80% of cable TV operators oppose any scheme that implements the downward-tiered charging model. Some SOs argue that TC structure would significantly alter viewer subscription and viewing behaviors, raising concerns that subscribers may end up paying more for cable TV services. They are concerned that uncertainties arising from modifications in the charging model might adversely affect subscription and advertising revenues, along with profit distribution strategies, which could potentially harm the entire industry [TCC11]. Furthermore, they assert that consumers anticipate higher costs for additional services (e.g., special sport events, and high-definition programming) when required. However, after the announcement of new regulations for BCB and ACB charging, subscribers still consider the price ceiling to be higher than reasonable [LTN13]. Both the monopolistic SO and consumers need incentives to migrate to a TC-based market.

The Effect of Charging Mode Transformation

Research conducted in the U.S. highlights the impact of transitioning from a tiered pricing model to an a la carte pricing model. Phillips [Phi08] contends that while an a

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la carte pricing model may initially benefit consumer rights, it could eventually lead operators to shift their costs to subscription fees due to the opaque cost structure faced by subscribers. Just and Wansink [JuW11] also found that in a flat-rate context, individuals may consume an amount that maximizes their perceived value, rather than continuing to consume until their marginal utility of consumption reaches zero. Brewster [Bre14] advised that regulators should refrain from adopting an a la carte pricing model in the market, as it could encourage program creators to concentrate solely on a few programs that cater to majority preferences, thereby limiting market diversity. Chu et al. [CLS11] concluded that bundle-size pricing is a straightforward strategy that is generally more profitable than pricing individual products separately, and it closely approximates the profits achieved through mixed bundling.

1.3 Scope of Research

In this study, we propose an intensive design of tiered charging for both SO and consumers under TC policy and an empirical-data-based assessing method to analyze the policy in a monopolistic cable TV service market, which is beneficial to regulator in staged policy parameter setting mission. The novel approach consists of i) a probabilistic interaction model between one SO and subscribers under TC policy, ii) two tiered-charging indices employing probabilistic analysis and simply describing the rate structure of TC policy assembled with BCB and ACB packages and iii) a consumer package selecting (CPS) simulation exploiting consumer preference analysis from empirical data and results in numerical welfare under a given market circumstance. The contributions of this research can be summarized as follows:

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- A win-win situation between SO and consumers under the transformation to TC is possible, but the incentives for SOs are limited if we introduce only the price-channel-downscaled (PCD) package design to a pure FR market as a downward-tiered-charging strategy.
- After adding the design of an ACB package to an FR or PCD market, a win-win situation will exist within any PCD package size, and the price of the ACB package will be reasonable.
- In two economically different districts, the foregoing two statements are consistent.

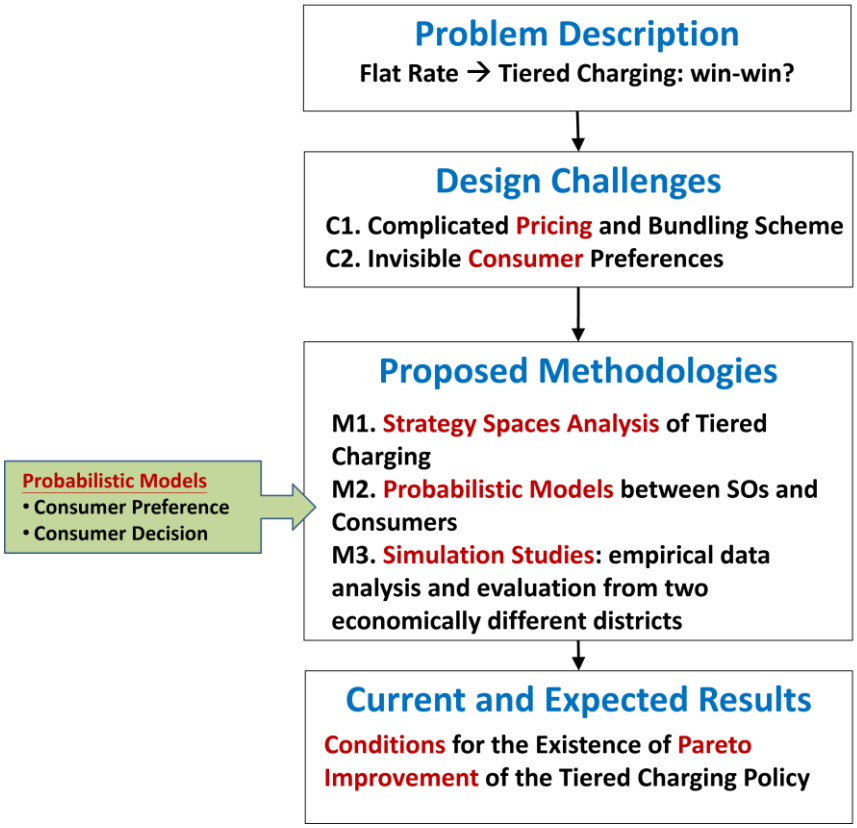

Figure 1-1 Research Structure

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1.4 Thesis Organization

The remainder of this research is organized as follows. Chapter 2 describes monopolistic cable TV market structure, regulatory environment and strategy spaces. Chapter 3 shows the probabilistic models. In Chapter 4, a simulation study using empirical data from two real cases shows how the conditions may be applied. Numerical analyses are given in Chapter 5. Chapter 6 concludes this research.

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Chapter 2 Cable TV Service Market Structure and Regulatory Strategies

This chapter introduces the framework of the cable TV service market, and then describes the main problem which the thesis will attempt to answer: why should cable TV charging mode be conversed in Taiwan? In sections 2.1 and 2.2, the composition and features of cable TV market are introduced. Section 2.3 then summarizes the possible surplus effects of the different charging modes. In section 2.4, the problems and challenges of the tiered charging policy are described in detail.

2.1 Composition of Cable TV Service Market

As shown in Figure 2-1, there are three main roles in the cable TV service market: channel operators, cable SOs, and consumers. Channel operators are the content providers, and SOs bundle different channels into various channel packages (CPs) for service provision. Consumers decide which SO and which CP to subscribe to, based on their willingness-to-pay (WTP) prices and on the subscription fees.

Consumers choose their cable service providers and pay for broadcasting services in the cable service market. Cable operators act as suppliers, offering these services on cable TV platform systems and charging consumers subscription fees. SOs will use this platform system to understand the consumers they face and their subscription characteristics or habits. In the channel content market, channel operators deliver content services to cable operators and, in return, receive authorization fees from them. When SOs negotiate content licensing fees and conditions with channel operators, their pricing is often based on the total number of subscribers of the system. Therefore,

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the number of subscribers controlled by SO will affect the acquisition of channel operators [WaL22]. Both channel and cable operators can provide advertisement services and receive advertisement fees from advertisement buyers.

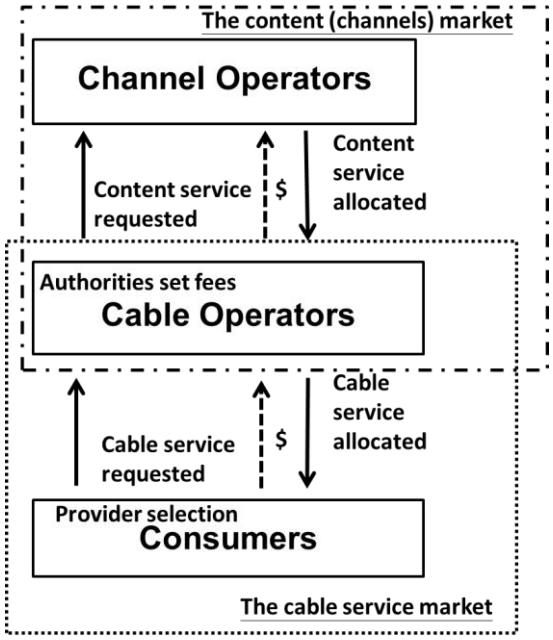

Figure 2-1 Cable Television Market Structure [LiC15]

2.2 Features of Cable TV Industry

In this section, we introduce two features of the cable TV service.

F1. Franchise and price regulation

Cable TV is a kind of mass communication medium, and SO must build a cable system for the households to provide service, which is similar with other public utilities such as electricity and water. Thus, cable TV service is always considered a franchise industry. The entry and price are both regulated to ensure public interest.

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F2. Complex of products provided

One of the major features of making the industry different from other public utilities is the diversity of the products provided in the cable TV service market. Traditionally, SOs adopt pure bundling and charge a fixed price not only to maximize profits, but also because of the constraint of transmission technology. However, consumer preference over the individual channels differs by program types, quality and other demographic factors. As technology advances, now it is possible to provide channels in different combinations, and the design of channels packages has become an important issue in the industry.

2.3 Charging Modes of Cable Service Market and Regulatory Environment

Sundararajan concluded that in a mature market which applies flat rate (FR) for service, operators can increase their profit by expanding usage-based charging options [Sun04]. Hayashi proved that the level of social welfare with FR is lower than usage-based charging rate under the circumstances of operator with limited capacity and wider type of consumer preferences [Hay09]. We propose a mix-bundle charging structure from a basic channel bundle (BCB) only to BCBs plus advanced channel bundles (ACBs) to increase the social welfare. The reason is that consumers who faced “unreasonable” FR fees may choose to refuse or cancel cable TV subscription will choose to become one of subscribers, or consumers who want to get money’s worth [JuW11] would reduce their over-usage to their marginal utility of consumption is 0.

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Bundles are categorized into basic channel bundles (BCBs) and advanced channel bundles (ACBs) [CCL04]. The two types differ in terms of channel quality and variety. Consumers can subscribe to an ACB package only if they have a subscription classified as a BCB package. The FR package mentioned in Section 1 is considered a BCB (FR-BCB) package. Consumers also have the option of not subscribing (NS) to any package.

Let us examine key strategies for regulating operators' channel bundles and pricing structure following the transition from the current FR-BCB model.

The Strategy Spaces of Tiered Charging in Market

S1. Price reduction strategy

The regulator directly reduces the price of the BCB package, and we set the general package in the age of analogy cable TV as an FR package. As SO faces a decreased price in flat rate basic channel bundle package, we marked the strategy as DPFR-BCB. This price reduction strategy boosts consumer surplus (CS) by lowering subscription costs and attracting new subscribers to the market. However, since operating costs remain unchanged from before the reduction, supplier surplus (SS) is expected to decrease. As other conditions remain unchanged, this strategy is often only feasible with the authority of a regulatory policy.

S2. Tiered Charging (TC) strategies

The regulation of TC structure has been discussed in various literature sources, we summarized into three charging subtypes as strategies: upward-tiered, compromise-tiered, and downward-tiered charging strategies:

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S2.1 Upward-tiered strategy

This method is generally accepted by operators [TCC11] because it retains the existing packages and does not detract from SOs' existing profit margins. This structural design also adds several mutually exclusive and higher-priced packages to ACB to attract different consumers to add different subscriptions based on their needs. Intuitively, this strategy increases the subscription fees of current subscribers through one or more high-quality packages (ACBs) bundled with FR-BCB package, thereby increasing the surplus of consumers and suppliers. However, it does not respect consumers' rights to access fewer channels and pay less unless they choose to forgo a subscription entirely. This is not a result that the supervisory authorities want to see.

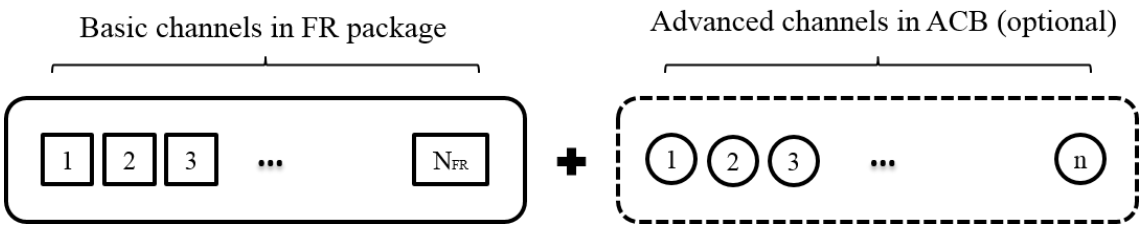

Figure 2-2 Upward-tiered strategy [Che16]

S2.2 Downward-tiered strategy [NCC13]

This strategy aims to safeguard two major rights and interests of consumers: having basic channels in smaller packages and having the choice of high-quality channels. It requires operators to provide packages with fewer channels (PCD packages) in BCB at a limited price and provide multiple alternatives in ACB, and we marked the package as PCD-BCB. By attracting new subscribers with PCD and ACB packages and providing new options for existing subscribers to switch their subscriptions, this approach may significantly increase CS due to the expanded

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choices available to consumers. However, it may also lead to a reduction in SS if there aren't sufficient subscriptions to the ACB alternatives, which cannot cover the revenue loss from switching subscriptions.

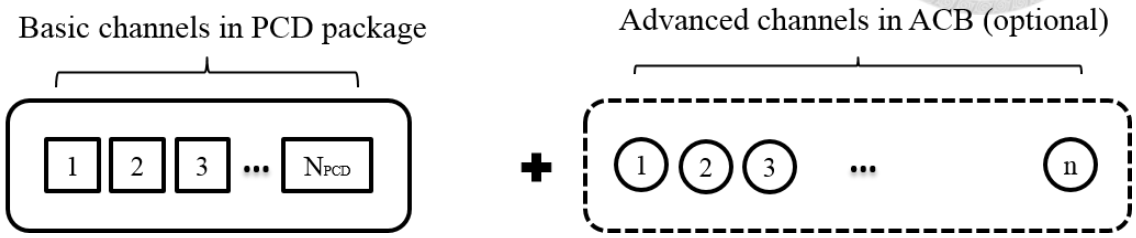

Figure 2-3 Downward-tiered strategy [Che16]

S2.3 Compromise-tiered strategy [NCC13]

This strategy reserves the FR-BCB package for SOs while retaining the right to choose smaller packages in BCB for consumers, requiring SOs to offer PCD packages in BCB as the basic choice. The compromise-tiered strategy simultaneously retains the advantages of upward-tiered strategy and allows SO to provide multiple packages in ACB. By adopting this hybrid strategy, both CS and SS are expected to increase. However, this is achieved by raising the expenses of current subscribers in the ACB packages and attracting new subscribers to the PCD package. The subscription rate directly affects SO's revenue and costs. In fact, even with adding ACB packages in this strategy, the dynamic results of the new PCD package subscription rate and the conversion rate of original subscribers to subscribe to PCD packages still lead to uncertainty in SO's revenue.

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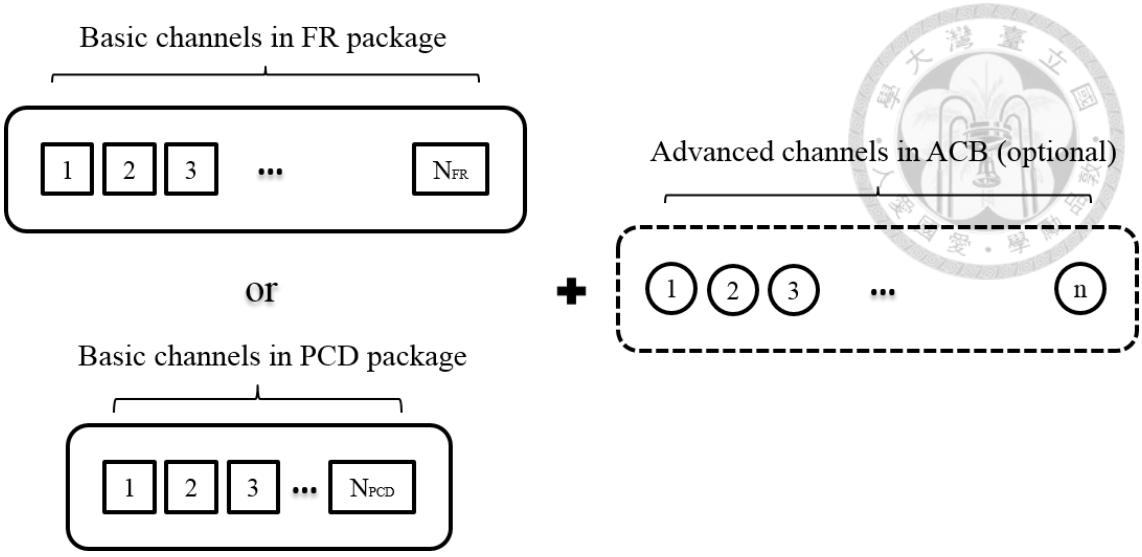

Figure 2-4 Compromised-tiered strategy [Che16]

Table 2-1 summarized the interpretations of the classification of CPs in different strategies above. To simplify notation, BCB will be omitted below.

Table 2-1 Classification of CPs

Classification	**Interpretation**	**Classification after Simplification**
DPFR-BCB	Decreased Price of Flat Rate package in Basic Channel Bundles	DPFR
FR-BCB	Flat Rate package in Basic Channel Bundles	FR
PCD-BCB	Price-Channel-Downscaled package in Basic Channel Bundles	PCD
ACB	Package in Advanced Channel Bundles	ACB
NS	No Subscription	NS

Table 2-2 summarizes the consumer options and the analytic results of surplus effects with the strategies mentioned above. It is evident that different types of charging strategies can result in varying CS and SS outcomes. Price reduction and downward-tiered charging strategies are most advantageous for consumers, while upward-tiered charging strategies benefit operators.

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Table 2-2 Consumer Available Options and Surplus Effects under Different Strategies

Strategies	Consumer options	Surplus effect (CS, SS)	Additive surplus effect (CS, SS)
Price reduction	1. DPFR	(+[a], -[b])	(+, -)
	2. NS	(0, 0)	
Upward-tiered	1. FR	(0, 0)	(+, +)
	2. FR+ACB	(+, +)	
	3. NS	(0, 0)	
Downward-tiered	1. PCD	(+, -)	(+,?)
	2. PCD, ACB	(+,?)	
	3. NS	(0, 0)	
Compromised-tiered	1. FR	(0, 0)	(+,?)
	2. PCD	(+, -)	
	3. FR+ ACB	(+, +)	
	4. PCD+ ACB	(+,?[c])	
	5. NS	(0, 0)	

[a] Increasing, [b] Decreasing, [c] Undetermined

Given the current practice of the FR package, introducing an additional option to it would be more readily accepted by consumers. It is possible to design an upward option that increases operator surplus without negatively impacting consumer surplus. However, it remains uncertain and less evidence whether introducing a smaller-size option to the FR package, such as the PCD package, would result in a Pareto improvement scenario for both CS and SS.

2.4 Problems and Challenges of Channel-Tiered Charging Conversion Policy

Referring to the expected effects of channel-tiered charging policy enhancing consumer welfare in the cable TV market, we focus on one focal issue in the cable TV

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service market:

Can the convert of a FR package to a carefully designed tiered charging pricing structure with price-channel-downscaled (PCD) package and advanced channel bundle (ACB) package achieve Pareto improvement between SOs and consumers?

We first focus on one monopolistic cable service market and build a market model, in which "CPs" are products. A CP consists of several channels, and a few CPs are grouped into a "bundle." There is one SO that faces a group of consumers sharing almost the same preferences and the consumers evaluate channels independently and rationally. A representative tiered charging pricing structure would be suggested. The research is also expected to derive the conditions of win-win situation to analyze the tiered charging policy effect.

By neoclassical economic theory, Pareto improvement occurs when a change in economic circumstance that harms no one even as it improves the lot of at least one person [MaY04]. To evaluate the policy effects and solve the related problem mentioned above, we must consider the vertical interaction between consumers and SO. The associated challenges are presented as follows.

C1. From Flat Rate to Tiered Charging- A Transform Challenge

C1.1 Pricing and Bundling Schemes are Complicated

There are more than two hundred channel operators in the cable TV industry, which means the feasible bundle combinations of products would be numerous. As product bundles being complicated, so do the following design for pricing schemes.

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Thus, trying to find a simple and representable bundling and pricing method would be a challenge during research.

C1.2 Consumer Preferences are Invisible Information

Consumer preferences are different from person to person and invisible. We also cannot define the dependent variables of consumer evaluation clearly or analyze it independently. However, we should try to extract some representable indices from different observation data or investigations to approximately the true characteristics of consumer preferences.

C2. The Strategies of SOs are Complicated and Their Cost is Private Information

SOs persuade profit maximization which results in their final choice. SOs believe that a new combination of tiered charging pricing structure may result in consumer churn probability of original product and harm their revenue. The choice between bundling cost as customer churn of new services and the possible income from an attractive service would be a difficult strategy-choose issue to SO. Deviation of the conditions of conversion strategies also face a constraint of the private cost information of SOs.

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Chapter 3 Models of Cable TV Service Market

This research includes two parts: i) cable service market framework with appropriate pricing structure and probabilistic models of consumer evaluation; and ii) SO profit maximization decision and strategies under policy. For the first part, we proposed several probabilistic models to describe the interaction between SOs and consumers. In general, the model includes one SO and a group of consumers. With a close but simple description of assumptions from empirical data and researcher's observations, SO can design and provide many types of bundles to the market. The probabilistic analysis for interaction between SO and consumers, a reasonable inference to SO cost is expected to clarify the SO decisions under policy.

Figure 3-1 depicts the market framework, the flow of information and the interactions in market and the consumer subscription decision process with probabilistic models between two groups of players in the market: SOs and consumers. SOs in this market decide their content of bundles and the bundle prices based on their database, which collects consumer viewing behaviors and subscription information. This research focuses on consumer evaluation of channels and services. As consumers visit SOs website, they can search for the services they want and decide whether they want to become a subscriber. As consumer preferences are always invisible, this research proposes a consumer preference model to depict their evaluation of services and a consumer decision model to capture their subscribing behavior.

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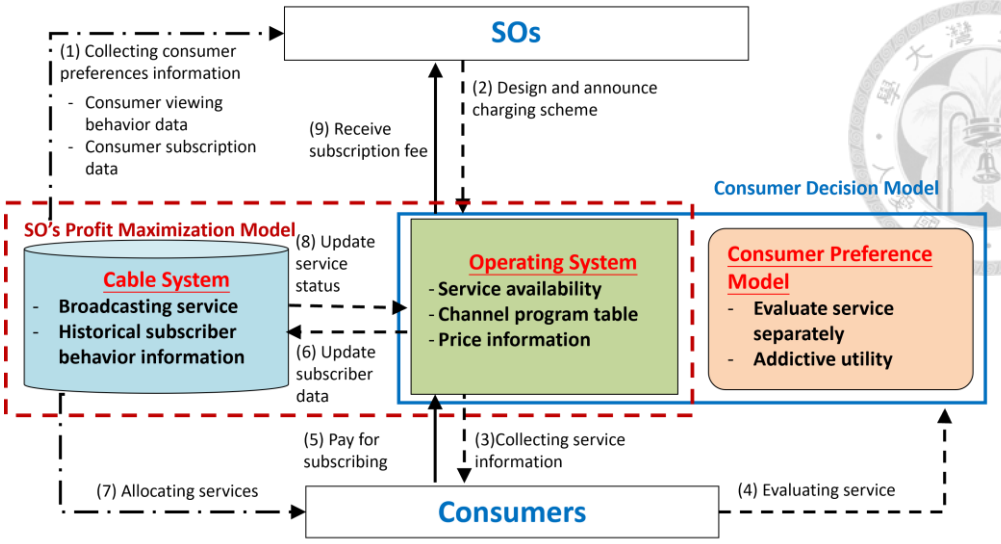

Figure 3-1 Consumers and SOs Interaction Flow in Cable Service Market

3.1 Assumptions Regarding Channel Packages and Consumer Preferences

As in Figure 3-1, there are three models, consumer preference model, consumer decision model and SO's profit maximization model, in service market and draw the picture of interactions between SOs and consumers. Before we start the modeling, we should build up the definitions of the products in the market, channel packages (CPs):

- A CP consists of several channels, and a few CPs are grouped into a "bundle." Different bundles vary in CPs, and CPs vary in number, type and quality composition of channels.
- Consumers evaluate each channel independently.
- Each channel possesses a unique consumer valuation, referred to as the WTP price. The WTP price for a channel among consumers is modeled approximately as a normally distributed random variable. This

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approximation balances practicality with the feasibility of deriving closed-form analytic solutions. In summary, the single-channel WTP price per package indicates that the likelihood of a negative total WTP price for a package is very low, rendering its impact negligible. For instance, if the per-channel preference distribution is normally distributed with a mean of 16 and a standard deviation of 38 based on subscriber studies, the WTP price of a 60-CP follows a normal distribution with a mean of 960 and a standard deviation of 294.35. Consequently, the probability of a negative total WTP price is 0.055%.

- Valuation of a package from one consumer is determined by summing the consumer's WTP price for each individual channel within that package.
- For the simplicity of this discussion, a consumer perceives a channel's quality at three distinct levels: a, b, and c.
- Operators understand consumers' perceptions of channel quality and WTP price follows the normal probability distribution through their marketing and sales data, that is, the “cable system” in Figure 3-1.

Before developing the models, let's define all the notations as outlined in Table 3-1.

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Table 3-1 Notations for the Cable Service Market Model

SW	Social welfare
π	Operator's profit
CS	Consumer surplus
N	Number of channels
n	Channel index, $n \in S_k$
K	Number of channel packages
k	Channel packages index, provided from operator, $k=0,1,2,\ldots,K$, $k=0$ represents a consumer unwilling to subscribe to any channel
S_k	Set of channels in package k
IN	Income of operator
EX	Expense of operator
I	Number of consumers
i	Consumer index, $i=1,2,\ldots,I$
CS_i	Surplus of consumer i
$P_{i,n}^W$	WTP price for channel n from consumer i
$CP_{i,k}^W$	WTP price for package k from consumer i
CP_k^S	Subscription fee for subscribing package k
$L_{i,n}$	Index of channel quality level, which is an evaluation of channel n from consumer i, and the highest level is "a," second is "b" and the lowest level is "c," $L_{i,n} \in \{a,b,c\}$
$\mu_{L_{i,n}}$	Mean WTP price for a channel of level L
$\sigma_{L_{i,n}}^2$	Variance of WTP price for a channel of level L
$q_{L_{i,n}}$	Channel quality level
$\delta_{i,k}$	Consumer channel package subscription decision index, binary index for the decision of whether consumer i chooses channel package k

3.2 Consumer Preference and Decision Models

The consumer preference model consists of two parts. The first part illustrates how a consumer perceives the quality level of a channel, with the probability that a

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consumer will consider a channel of a specific quality level as follows:

$$q_{L_{i,n}} = Pr(\text{a channel perceived to have quality } L), \quad L_{i,n} \in \{a,b,c\} \tag{3.1}$$

The distribution of the WTP price for each type of channel is modeled as independent and identically distributed and normal among consumers, i.e.,

$$P_{i,n}^{W} \sim N\left(\mu_{L_{i,n}}, \sigma_{L_{i,n}}^{2}\right), \quad L_{i,n} \in \{a,b,c\}. \tag{3.2}$$

How consumer i valuates one CP is summing up all the WTP prices of channels in that package by consumer i, then we can get the WTP price of the CP:

$$CP_{i,k}^{W} = \sum_{n \in S_k} \sum_{L_{i,n} \in \{a,b,c\}} P_{i,n}^{W} | q_{L_{i,n}}. \tag{3.3}$$

From Figure 3-1, operators know all these collective customer preference information from their cable system, thus we assume they can easily extract the preferences distributions from the database.

As a consumer's WTP price for the package exceeds the announced subscription fee, the consumer would become a subscriber. Among more than one package, the optimal subscription decision involves selecting the package that maximizes the utilities, while adhering to the constraint that each subscriber can only subscribe to one package, as specified in equation (3.4) and (3.5) below. As the note of package equal to 0, it indicates no subscription.

$$\max_{\delta_{i,k}} \sum_{k=1}^{K} \delta_{i,k} \cdot \left[\left(\sum_{n \in S_k} P_{i,n}^{W} \right) - CP_{k}^{S} \right], \tag{3.4}$$

Subject to

$$\sum_{k=0}^{K} \delta_{i,k} = 1, \delta_{i,k} \in \{0,1\}, \quad i = 1, \ldots, I; \forall\, k = 0,1,2, \ldots, K. \tag{3.5}$$

The optimal decision implies (3.6), where a consumer would choose a package

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of the maximum surplus from all the optional packages.

$$\delta_{i,k}\begin{cases}\leq 1, if\left(\sum_{n\in S_k} P_{i,n}^{W}\right)-CP_k^{S}>0\\ =0, \text{otherwise.}\end{cases}, \qquad (3.6)$$

Consumer surplus can then be represented in terms of the decision variables $\{\delta_{i,k}\}$ as

$$CS=\sum_{i=1}^{I} CS_i=\sum_{i=1}^{I}\sum_{k=1}^{K}\delta_{i,k}\cdot\left(CP_{i,k}^{W}-CP_k^{S}\right) \qquad (3.7)$$

where the total CS is sum up with each consumer's surplus, which is calculated as the total WTP prices minus the announced subscription fees within the corresponding subscribed package.

3.3 Basic Welfare Model and Supplier Profit Maximization Model

To assess the potential impacts of changes in the market's charging mode, we employ the most commonly used definition of social welfare (SW) in public finance: the sum of CS and SS. In the context of a cable TV service market, we define the operators' profit as the SS, and thus, the SW is

$$SW=\pi+CS \qquad (3.8)$$

The objective function of SO is to maximize its profit, which is the sum of the SO's revenue minus expenses, i.e.,

$$\max \pi=\sum_{k}\left(P_k^{S}\cdot\sum_{i=1}^{I}\delta_{i,k}\right)-EX\cdot\delta_{i,k}. \qquad (3.9)$$

In this research, since some channel operators use the number of subscribers as

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the basis for calculation when negotiating authorization conditions with SOs [WaL22], we set the operator expense EX proportional to its income from selling CPs as a variable cost to SO, and we set fix cost equal to zero.

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Chapter 4 Field-Data-Based Scenario Design for Analyzing Tiered Charging Effects

This section would like to demonstrate numerical analysis of the conditions for Pareto improvement, the win-win situations, in section 4.1. The two economically different subscription scenarios are presented in section 4.2. Section 4.3 shows how we extract and set the TC policy parameters. The design of a tiered charging pricing structure with PCD and ACB package is expected to improve the quality of service and impel the success of the policy.

4.1 Conditions for Pareto Improvement of the Tiered Charging Policy

As mentioned in section 2.3, Pareto Improvement means there's at least one person who gets more satisfaction with no harm to anyone in the market. In our simulation studies, we define and check the condition of Pareto improvement as the value of CS and SS greater than zero, even if one of the values is equal to zero.

We use α and β to construct the tiered-charging pricing in this research. The two indices simplify the change of tiered charging rates by describing the pricing strategies with a ratio of package size (α) and the average channel price (β). Thus, we can focus on the reactions from SO and consumers after we make some CPs available in the market.

4.1.1 Conditions for a Downward-Tiered Charging Policy

We first focus on the BCB certification, and in the following discussion, we will refer to FR-BCB as the FR package and PCD-BCB as the PCD package, which are

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simplified in Table 2-1. As assumed in Section 2, SO is aware of the parameters of consumer preferences and its preference distribution from operating database. Since it's a monopolistic service market, the WTP prices for the FR and PCD packages are denoted as P_{FR}^{W} and P_{PCD}^{W}, respectively, while P_{FR}^{S} and P_{PCD}^{S} represents the announced subscription fees on operator system of each package, respectively.

We assumed that the size of PCD package is smaller than the FR package and α represents the ratio of number of channels, calculated as the value of N_{PCD} divided by N_{FR}. The subscription fees for the PCD and FR packages are directly proportional to the number of channels each package includes. Thus,

$$\alpha = \frac{N_{PCD}}{N_{FR}} = \frac{P_{PCD}^{S}}{P_{FR}^{S}}, 0 \le \alpha \le 1 \qquad (4.1)$$

Additionally, with the assumption of sharing the same channel bundles, BCB, with the same quality level of channels, the ratio of the expected WTP price to the subscription fee is the same for both the PCD package and the FR package:

$$\frac{E\left(P_{FR}^{W}\right)}{P_{FR}^{S}} = \frac{E\left(P_{PCD}^{W}\right)}{P_{PCD}^{S}} \qquad (4.2)$$

The subscription decision condition for a consumer in the FR package is based solely on the positive surplus generated from subscribing to the FR package. There is a two-staged decision-making process in which the consumer first compares the WTP price minus the subscription fee of both the FR and PCD packages and then selects the package that offers the greater positive surplus. Let *F* represent the event where the value of CS from subscribing to the FR package is at least as high as the value of CS from subscribing to the PCD package:

$$\Pr\left(F\right) = \Pr\left(P_{FR}^{W} - P_{FR}^{S} \ge P_{PCD}^{W} - P_{PCD}^{S}\right). \qquad (4.3)$$

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Let $\overline{F}$ event represent the opposite situation to *F* with probability

$$\Pr\left(\overline{F}\right) = \Pr\left(P_{PCD}^{W} - P_{PCD}^{S} > P_{FR}^{W} - P_{FR}^{S}\right). \tag{4.4}$$

Setting PCD, FR as the events of subscribing different packages, PCD subscribers may originate from two distinct groups in the FR charging legacy. The first group consists of subscribers who did not choose the FR package due to a lack of positive surplus from subscribing to FR, with a subscribing probability $\Pr\left(\overline{F} \cap \overline{FR} \cap PCD\right)$. The second group comprises subscribers who transition from subscribing to FR to subscribing to PCD, with a subscribing probability $\Pr\left(\overline{F} \cap FR\right)$ (Table 4-1).

If the total subscription income from PCD package subscribers is at least equal to the reduction in FR package income due to switching subscribers, operators will not incur losses, and the circumstance achieve Pareto improvement. The condition is described by Eq. (4.5):

$$\begin{aligned} & P_{PCD}^{S} \cdot \Pr\left(\overline{F} \cap \overline{FR} \cap PCD\right) \cdot I \\ & \geq \left(P_{FR}^{S} - P_{PCD}^{S}\right) \cdot \Pr\left(\overline{F} \cap \mathrm{FR}\right) \cdot I. \end{aligned} \tag{4.5}$$

Combining (4.1) and (4.5) yields

$$\alpha \geq \frac{\Pr\left(PCD \cap FR\right)}{\Pr\left(\overline{F}\right) - \Pr\left(\overline{F} \cap \overline{FR} \cap \overline{PCD}\right)}, \tag{4.6}$$

and then substituting (4.1) into (4.6), we obtain the

win-win condition

$$\begin{aligned} & P_{PCD}^{S} \cdot \left[\Pr\left(\overline{F}\right) - \Pr\left(\overline{F} \cap \overline{FR} \cap \overline{PCD}\right)\right] \cdot I \\ & \geq P_{FR}^{S} \cdot \Pr\left(\overline{F} \cap FR\right) \cdot I. \end{aligned} \tag{4.7}$$

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Thus, a Pareto improvement occurs whenever the revenue gained from the new addition of a PCD package exceeds the revenue lost from subscribers switching from the FR package to the PCD package. Assuming that the SO knows the consumer preferences, they can determine the appropriate number of channels, N_{PCD}, and the corresponding price of the PCD package, P_{PCD}^{S}, by using eq. (4.7).

Table 4-1 Consumer Choice from Flat Rate to Downward-Tiered Charging Mode

Original options	**Adding PCD options**	**Subscribing rate**
FR	FR	$\Pr(F \cap FR \cap PCD) + \Pr\left(F \cap FR \cap \overline{PCD}\right) = \Pr(F \cap FR)$
	PCD	$\Pr\left(\overline{F} \cap FR\right)$
NS		$\Pr\left(\overline{F} \cap \overline{FR} \cap PCD\right)$
	NS	$\Pr\left(F \cap \overline{FR} \cap \overline{PCD}\right) + \Pr\left(\overline{F} \cap \overline{FR} \cap \overline{PCD}\right) = \Pr\left(\overline{FR} \cap \overline{PCD}\right)$

4.1.2 Conditions for a Compromised-Tiered Charging Policy

In addition to the possible CP optional spaces ({FR, PCD, NS}) that consumers can subscribe to in part A, we added an ACB package as another operator's optional market strategy. However, under this circumstance, consumers are allowed to subscribe to the ACB package after they choose to become a subscriber, that is, they should subscribe to a BCB-certificated package (FR or PCD package) before they want to consume an ACB package. Thus, the optional subscribing spaces in the market would be {FR, PCD, FR+ACB, PCD+ACB, NS}.

The ACB package is an additional option for consumers, whose valuation of the package depends on what types of channels are bundled by the SO. Under this assumption, the average WTP per channel in the package should be higher than that in

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the BCB-certificated package, either FR or PCD described in part A. SOs must set the ACB package price as P_{ACB}^{S}, and the size of the ACB package, N_{ACB}. We set the average price of an ACB package to be a proportion of the FR package, that is,

$$\frac{P_{ACB}^{S}}{N_{ACB}} = \beta \cdot \frac{P_{FR}^{S}}{N_{FR}}, \beta > 1 \qquad (4.8)$$

and β should be higher than 1 because the ACB package should be a better choice for the consumer, for instance, a high-quality channel package to consumers, and include a better channel portfolio than that in BCB. Descriptions of cost-profit value for CPs are shown in Eq. (4.9), and the average price of an ACB package is the highest price of the three.

$$\frac{P_{ACB}^{S}}{N_{ACB}} > \frac{P_{PCD}^{S}}{N_{PCD}} = \frac{P_{FR}^{S}}{N_{FR}}. \qquad (4.9)$$

Two new probability events are added by introducing an ACB package into the market:

1) Pr(ACB): the probability of consumer surplus greater than zero for subscribing to the ACB package,

$$\Pr(ACB) = \Pr\left(P_{ACB}^{W} - P_{ACB}^{S} \geq 0\right). \qquad (4.10)$$

2) Pr(A): the subscribing probability of a consumer who has not become a subscriber but would be attracted by a positive ACB surplus and become a new subscriber after adding the ACB package option to the market,

$$\Pr(A) = \Pr\left[\begin{array}{l}\left(P_{ACB}^{W} - P_{ACB}^{S}\right) \\ -\min\left\{\left|P_{FR}^{W} - P_{FR}^{S}\right|, \left|P_{PCD}^{W} - P_{PCD}^{S}\right|\right\} \geq 0\end{array}\right].$$

$$\text{Where} \quad P_{FR}^{W} - P_{FR}^{S} \leq 0, P_{PCD}^{W} - P_{PCD}^{S} \leq 0. \qquad (4.11)$$

Table 4-2 shows that subscribers to the ACB package may be existing FR or

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PCD subscribers as well as new subscribers. Because the ACB package is an additional option for consumers to consume a higher level of cable TV services, consumers will decide whether they want to subscribe to an ACB package or not according to the consumer decision model described in subsection 3. The ACB subscription rate from FR subscribers will have a probability $\Pr\left(F \cap FR \cap ACB\right)$, and that from PCD subscribers will have a probability $\Pr\left(\overline{F} \cap PCD \cap ACB\right)$. New subscribers who were never attracted by the FR or PCD packages have two subscribing probabilities: $\Pr\left(F \cap \overline{FR} \cap \overline{PCD} \cap ACB \cap A\right)$ for those who become an FR subscriber and $\Pr\left(\overline{F} \cap \overline{FR} \cap \overline{PCD} \cap ACB \cap A\right)$ for those who prefer the PCD plus ACB package.

Table 4-2 Consumer Choice from Flat Rate to Compromise Tiered Charging Mode

Original options	**Adding PCD options**	**Adding ACB options**	**Subscribing rate**
FR	FR	FR	$Pr(F \cap FR \cap \overline{ACB})$
		FR+ACB	$Pr(F \cap FR \cap ACB)$
	PCD	PCD	$Pr(\overline{F} \cap PCD \cap \overline{ACB})$
		PCD+ACB	$Pr(\overline{F} \cap PCD \cap ACB)$
NS	NS	FR+ACB	$Pr(F \cap \overline{FR} \cap \overline{PCD} \cap ACB \cap A)$
		PCD+ACB	$Pr(\overline{F} \cap \overline{FR} \cap \overline{PCD} \cap ACB \cap A)$
		NS	$Pr(\overline{FR} \cap \overline{PCD} \cap \overline{ACB} \cap \overline{A})$ $+ Pr(\overline{FR} \cap \overline{PCD} \cap ACB \cap \overline{A})$ $= Pr(\overline{FR} \cap \overline{PCD} \cap \overline{A})$

If the total subscription income from ACB package subscribers can expand the total profit, operators would have more incentive to coordinate with the

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downward-tiered policy. The income changes from adding an ACB package to an FR/PCD-package market is described by Eq. (4.12):

$$\begin{aligned}
&P_{PCD}^{S}\cdot \Pr\left(\overline{F}\cap PCD\cap \overline{ACB}\right)\cdot I\\
&+P_{ACB}^{S}\cdot \Pr\left(F\cap FR\cap ACB\right)\cdot I\\
&+P_{ACB}^{S}\cdot \Pr\left(\overline{F}\cap PCD\cap ACB\right)\cdot I\\
&+\left(P_{FR}^{S}+P_{ACB}^{S}\right)\cdot \Pr\left(F\cap \overline{FR}\cap \overline{PCD}\cap ACB\cap A\right)\cdot I\\
&\geq P_{FR}^{S}\cdot \Pr\left(\overline{F}\cap FR\right)\cdot I
\end{aligned} \tag{4.12}$$

To simplify the equation, we represent $\beta'=\beta\cdot\left(\frac{N_{ACB}}{N_{FR}}\right)\beta'=\beta\cdot\left(\frac{N_{ACB}}{N_{FR}}\right)$ and substitute (4.13) and (4.14) into (4.12), obtaining (4.15).

$$P_{ACB}^{S}=\beta'\cdot P_{FR}^{S} \tag{4.13}$$

$$P_{PCD}^{S}=\alpha\cdot P_{FR}^{S} \tag{4.14}$$

$$\begin{aligned}
&\alpha\cdot\left[\Pr\left(\overline{F}\cap PCD\cap \overline{ACB}\right)+\Pr\left(\overline{F}\cap \overline{FR}\cap \overline{PCD}\cap ACB\cap A\right)\right]\\
&+\beta'\cdot\begin{bmatrix}\Pr\left(F\cap FR\cap ACB\right)+\Pr\left(\overline{F}\cap PCD\cap ACB\right)\\+\Pr\left(F\cap \overline{FR}\cap \overline{PCD}\cap ACB\cap A\right)\\+\Pr\left(\overline{F}\cap \overline{FR}\cap \overline{PCD}\cap ACB\cap A\right)\end{bmatrix}\\
&+\Pr\left(F\cap \overline{FR}\cap \overline{PCD}\cap ACB\cap A\right)\\
&\geq \Pr\left(\overline{F}\cap FR\cap PCD\right).
\end{aligned} \tag{4.15}$$

For notational simplicity, we represent τ_{FR} as the subscription transfer rate of FR (because of adding the PCD and ACB packages to the market) in Eq. (4.16), υ_{ACB} for the subscription rate of the ACB package in Eq. (4.17) and υ_{PCD} for the subscription rate of the PCD package in Eq.(4.18):

$$\begin{aligned}
\tau_{FR}&=\Pr\left(\overline{F}\cap FR\cap PCD\right)\\
&-\Pr\left(F\cap \overline{FR}\cap \overline{PCD}\cap ACB\cap A\right),
\end{aligned} \tag{4.16}$$

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$$\upsilon_{ACB} = \Pr\left(F \cap FR \cap ACB\right) + \Pr\left(\overline{F} \cap PCD \cap ACB\right) + \Pr\left(F \cap \overline{FR} \cap \overline{PCD} \cap ACB \cap A\right) + \Pr\left(\overline{F} \cap \overline{FR} \cap \overline{PCD} \cap ACB \cap A\right), \tag{4.17}$$

$$\upsilon_{PCD} = \Pr\left(\overline{F} \cap PCD \cap \overline{ACB}\right) + \Pr\left(\overline{F} \cap \overline{FR} \cap \overline{PCD} \cap ACB \cap A\right). \tag{4.18}$$

Under the win-win condition, where operators would not suffer from the pricing scheme transformation, we can conclude the lower bound of alpha as Eq. (4.19) from above, which means the strategy spaces are enlarged by adding ACB strategy options to the market:

$$\alpha \geq \frac{\tau_{FR} - \beta' \cdot \upsilon_{ACB}}{\upsilon_{PCD}}. \tag{4.19}$$

In Eq. (4.13), as subscription rates are always no less than zero, whenever there is an ACB option for consumers, it can depress the lower bound of alpha, indicating that there are more options for PCD package size to achieve a win-win situation. If one consumer is attracted by the ACB package and wants to be a subscriber, he/she should choose one of the BCB packages such as FR or PCD to subscribe to first; thus, the values of the subscription transfer rate of the FR package and the subscription rate of the PCD package may undergo little change from the introduction of an ACB package to the market. However, as the setting of package size differs from the BCB to the ACB package, the change rate in τ_{FR} and υ_{PCD} would be so small that we could not ignore the ACB-package influence in α.

Under the premise that we fixed the package size and average mean price of consumers' WTP for the ACB package, the value of υ_{ACB} may be higher whenever β' is closer to 1 in the market. However, as β' is closer to 1, SOs may receive less

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income from subscription fees; that is, SOs must determine the optimal price for the ACB package.

4.2 Two Representative Franchise Areas Data-Based Subscription Scenarios

Closed-form analytic solutions are difficult, if not impossible, to derive for the decision problems formulated in Chapter 3 because the modeling subscriptions are based on individual customer preferences of channels and packages. Instead, simulations are performed to capture possible customer reactions to the design of the PCD or PCD plus ACB package, and the market is analyzed numerically. The numerical simulations, which include field data from two economically distinct districts, the Yong Kang franchise area (YKFA) and Taitung County (TTC), are developed to study the following two focal issues:

1) Does a win-win situation exist in both districts with the condition that the profit created by new subscriptions of a PCD package can cover the loss from the transition from FR to PCD?

2) Under the premise that we fixed the package size and average mean price of consumers' WTP for the ACB package, does the ACB package change the lower bound of optional PCD package sizes in both markets? What are the optimal ACB charging rates (β) for SOs to receive maximum profit, and what does it take for the regulator to achieve a higher level of SW?

The field data for our numerical simulation study originates from NCC databases [NCC14] [NCC14b] and statistics data from the Department of Household

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Registration, Ministry of the Interior, Taiwan. The YKFA district includes an approximate population of 200,000 individuals and TTC district includes about 80,000 individuals. Table 4-3 lists the prices and subscription rates of the 102-channel FR package from 2008 to 2014 in YKFA, and Table 7 lists the information from 2008 to 2013 in TTC.

In Table 4-3 and Table 4-4, subscription prices for the two districts are shown to decrease, whereas subscription rates indicate an overall increase. Despite having similar populations, the area of TTC, located in eastern Taiwan, is 3,515 square kilometers, which is approximately 87 times larger than the YKFA, a district of Tainan City in western Taiwan. Because of the immense difference in population density, NCC permitted a higher service price to be charged by SOs in TTC to cover the fixed cost for constructing necessary infrastructure and ensuring all households have the right to subscribe to cable TV services. For identical service packages, the cable TV service price in TTC is always higher than that in YKFA.

From 2008 to 2014, the average annual household income in the YKFA was NT$982,810, which is approximately 1.23 times as much as that in TTC (NT$797,679). As shown in Table 4-3 and Table 4-4, SOs in TTC experienced lower subscription rates than SOs in the YKFA. We were also interested in the economic differences between the two districts, where YKFA represents an urban area, and TTC represents a rural region.

Table 4-3 Prices and Subscription Rates in YKFA (102 Channels)

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Price (NT$)	560	540	540	540	510	510	515

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Subscription rate (%)	66.19	69.46	67.71	66.95	67.44	68.85	69.39
Mean (NT$, %)	-	($540, 68.04%)			($512, 68.56%)		

Table 4-4 Prices and Subscription Rates in TTC (102 Channels)

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Price (NT$)	600	600	570	580	580	580
Subscription rate (%)	32.76	39.83	41.08	40.74	40.69	41.27
Mean (NT$, %)	($600, 36.29%)		-		($580, 40.90%)	

4.3 Consumer Model Parameter Extraction

An investigation of consumer preferences for different CP options by Tsai et al. [TCC11] suggests that different CP options exist that contain all the channels in BCBs in addition to shopping channels, religious channels and stock market channels. In the study, three alternatives resulted in a higher consumer satisfaction level. Thus, we conclude that the three quality levels of channels a, b, and c, modeled in Eq. (3.1), should have corresponding percentages of q_a=20%, q_b=60% and q_c=20%, respectively (Table 4-5).

As described in Eq. (3.2), parameters such as the mean and standard deviation of WTP for different channel quality levels are required to approximate consumer preferences. Using a Monte Carlo simulation, we construct a probability table for approximating subscription. This allows us to fit and extract the parameters of the normal distribution, such as the mean and standard deviations, which represents consumer preference across different channels. From the three sets of statistics for the YKFA in Table 4-3 and Table 4-4, we use two pairs of price and subscription rate data, NT$560 and the 66.08% subscription rate in 2008 and NT$540 and the 68.04% mean

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subscription rate from 2009 to 2011, to determine the WTP price of a single channel by quality level.

Consumer preference parameters in the YFKA, as shown in Table 4-5, are N(16, 382) for quality a, N(5.4, 382) for b and N(2.7, 372) for c. Similarly, the set of consumer preference parameters obtained for TTC is N(11.7, 242) for level a, N(3.9, 242) for b and N(1.8, 242) for c, based on the average prices and subscription rates from 2008 to 2009 and 2010. The price elasticity, calculated and presented in Table 4-5, is approximately -2.64 for consumers in TTC, which is a greater value than -0.78 in the YKFA, signifying that consumers in TTC will respond more sensitively than those in the YKFA to an identical change in price.

Table 4-5 CP and Consumer Preference Parameters by WTP Quality Level

WTP quality level	**FR package**	**PCD package**	**ACB package**	**Consumer preference in the YKFA (mean, SD)**	**Consumer preference in TTC (mean, SD)**
a	20%	20%	50%	(16, 38)	(11.7, 24)
b	60%	60%	50%	(5.4, 38)	(3.9, 24)
c	20%	20%	0%	(2.7, 37)	(1.8, 24)
Number of channels	102	Less than 102	8	-	-
Price elasticity	-	-	-	-0.7826	-2.6398

We applied a 1000-sample Chi-square test to inspect the goodness of fit with the parameters above. Data from 2012 to 2014 in the YKFA are used, with an average price at NT$512 and a 68.56% subscription rate. The result of the goodness of fit test

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is $\chi^2 = 1.081 < \chi^2_{df=1,\alpha=0.05} = 3.84$, indicating the model is a "good fit" under the 95% confidence level. The Chi-square test for TTC consumer preference that uses data from 2010 results in $\chi^2 = 3.65 < \chi^2_{df=1,\alpha=0.05} = 3.84$, also signifying a "good fit" model under the 95% confidence level.

In Section 5.2, a representative design of an ACB package is used, which is observed from the CP menu [HYA16] of SOs, containing, on average, eight channels with a higher average consumer WTP. As the ACB package is better and more attractive to consumers, we established 50% for quality a and 50% for quality b. The average channel prices of the ACB package are approximately 1.04 times the price of the FR package in the YKFA and there are no ACB options available to consumers in TTC. For establishing the upper limits of the ACB package charging ratio, we verify the average channel price of the ACB package in Taichung city district to be approximately 2.05 times the price of the district's FR package. Thus, we set the charging rate of the ACB package as β and simulate different scales (of β, β =1β, 1.1, 1.2, …, 2) to examine which scale of charging rate for the ACB package can lead to a higher level of SW improvement.

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Chapter 5 TC Policy Evaluation over Two Representative Franchise Areas

5.1 Numerical Simulation Study Design

In the test scenario design, there are 10,000 hypothetical consumers and Table 5-1 lists the simulation test parameter items. Based on such settings, the designs of two simulation study cases addressing focal issues I1 and I2 are:

SS1) Welfare changes from the addition of a PCD package, which is designed to simulate the effect of downward-tiered strategy, and

SS2) Welfare changes from the addition of an ACB package, which is designed to test the effect of compromise tiered strategy.

Design details and the hypotheses of simulation studies are as follows.

Table 5-1 Simulation Test Parameters

	Items	**Notations**	**SS1**	**SS2**
Independent variables	Consumer preferences	$WTP(\mu_a, \sigma_a, \mu_b, \sigma_b, \mu_c, \sigma_c)$	V	V
	Level of alpha; number of PCD channels	CHs=101,100,…,1	V	V
	Level of beta; charging ratio for ACB package (beta>1)	Beta=1,1.1,1.2,…,2		V
Consumer options	FR package subscription	FR	V	V
	PCD package subscription	PCD	V	V
	FR and ACB package subscription	FR+ACB		V
	PCD and ACB package subscription	PCD+ACB		V
	No subscription	NS	V	V
Dependent variables	Change of SW	NT$	V	V
	Change of SS	NT$	V	V
	Change of CS	NT$	V	V
	Subscription rate	%	V	V

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SS1) Welfare Changes from the Addition of a PCD package:

Simulation Study 1 (SS1) addresses whether a Pareto improvement situation exists under different consumer preferences and the addition of a PCD package. To achieve the study goal, the control variables of this case are two sets combinations of consumer preferences from YKFA and TTC and the number of PCD channels from 1 to 101 channels, and the dependent variables are containing SW, CS, SS and subscription rates of FR, PCD or NS. Considering the 2 types of consumer preferences with 101 different channels of PCD package, we conduct 202 Monte Carlo simulation runs. Hypotheses for the 202 simulation tests performed are:

H1) Both the YKFA and TTC market should achieve a win-win outcome after adding a PCD package.

H2) A PCD package in TTC is expected to attract a higher proportion of FR subscribers than the same package in the YKFA and the SOs in TTC will lose more subscriptions from the higher transfer rate from FR to PCD.

H3) A PCD package in TTC is expected to attract more subscribers than the same package in the YKFA market.

Such expectations may be attributed to more price-sensitive consumers in TTC. A smaller and less expensive CP option may attract more subscribers who are willing to change their preferences after a new PCD package alternative is added to the market.

SS2) Welfare Changes from the Addition of an ACB package:

Simulation Study 2 (SS2) is designed to analyze the differences observed after increasing the number of alternatives with the addition of an ACB package. In this study, we add ACB price levels as control variable with two sets of consumer preferences and the number of PCD channels same in SS1. The dependent variables

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are containing SW, CS, SS and subscription rates are expanded to those of FR, PCD, FR plus ACB, PCD plus ACB or NS. The 2,222 simulation tests are composed of control variables as 11 ACB price levels with 101 channel sizes and 2 types of consumer preferences. Hypotheses for SS2 issues are as follows:

H4) SS may be higher than that in SS1 and the interval of α resulting in a win-win situation may become wider.

H5) The level of CS increases when the ACB charging ratio β decreases.

The forementioned hypotheses are formulated based on the consumer decision model in Eq. (3.4) in Section 3.3: consumers always choose a package with a higher level of CS.

5.2 Evaluation of Tiered Charging Policy Effects

Monte-Carlo simulations of the two scenario designs in Section 5.1 are primarily on how adding a PCD and ACB package to a pure FR market may impact on SW, SS and CS. In all simulations, a consumer subscribes to a specific package when the package has the highest positive CS to the consumer according to the consumer package selection model. Simulation results and the analyses of SS1 and SS2 are as follows.

5.2.1 Setting and Benefits of Adding a PCD package

In Figure 5-1, the horizontal axis represents different number of channels of PCD package, and the vertical axis shows the corresponding change of surplus. Figure 5-1 shows that:

Finding I: In both YKFA and TTC cases, hypothesis H1 holds, and the win-win conditions exist over different sizes of interval with a wider interval as [30, 101] in TTC and narrower one as [76,101] in YKFA:

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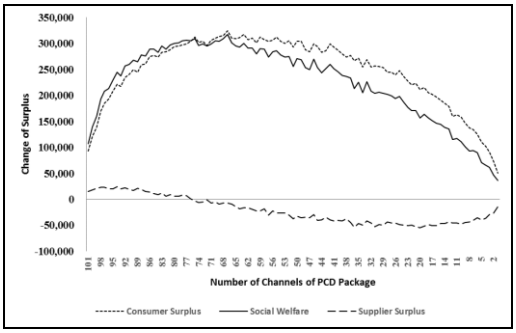

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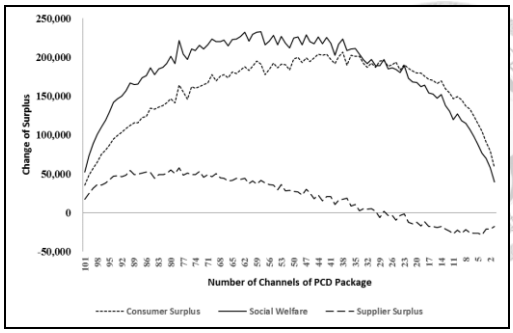

(II)

Figure 5-1 Surplus and social welfare of FR or PCD in the YKFA (I) and TTC (II) (10,000 samples)

1) In Figure 5-1 (I) (YKFA case), the simulation study of how the number of subscriptions varies with the number of PCD channels in the YKFA reveals that win-win situation can be achieved through a TC service of FR or PCD package (instead of "FR only") when the number of PCD package channels falls within [76, 101] with the corresponding charges calculated according to Eq. (4.1). The maximum SW increase is 9.66%, which occurs when there are 67 channels in the PCD package; but it is not a win-win situation.

2) In contrast, in Figure 5-1 (II) (TTC case), the Pareto improvement interval of PCD package channel numbers in TTC is [30, 101]. The maximum simulated increase of SW is 20.58% at 58 channels, which is also a win-win situation.

Table 5-2 gives some numerical values of Figure 5-1.

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Table 5-2 Introducing the PCD package into YKFA and TTC

	YKFA	**TTC**
Maximum SW (channel scale, differences)	+317,769 (67, +9.32%)	+233,294 (58, +20.58%)
Maximum SS* (channel scale, differences)	+24,003 (92, +2.48%)	+57,618 (78, +10.70%)
Pareto improvement interval	[76, 101]	[30, 101]
Maximum CS (channel scale, differences)	+324,974 (63, +13.03%)	+206,625 (38, +33.83%)
SS improvement at 76 CHs (from consumer transferring, from new PCD subscribers)	0.12% (-7.82%, 7.94%)	9.57% (-7.8%, 16.53%)

(Sample scale: 10,000 samples; unit: NT dollars)

*Operator profit is approximately 40% of revenue in Taiwan [TCC11].

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Finding II: A PCD package in TTC attracts a higher proportion of FR subscribers than the same package in the YKFA and hence the SO in TTC loses more subscriptions because of the higher transfer rate from FR to PCD. That is, H2 is supported.

Figure 5-1 and Table 5-2 Introducing the PCD package into YKFA and TTC show that a PCD package benefits consumers irrespective of the number of channels. But SOs will benefit only up to a limited number of channels. The profit increase of SO is much lower than that in CS for the same PCD package channel quantity. For example, at a 76-channel PCD in YKFA, the SO experiences 0.12% improvement with a transferring rate from FR to PCD of approximately 30.72% and a new PCD subscription rate of 6.95%, while consumers are enjoying approximately 12.88% additional surplus given the PCD. In TTC case, a 76-channel PCD package attracts approximately 33.53%, a higher proportion of FR subscribers who decide to transfer their subscription and a new PCD subscription rate of 8.65%. Those new PCD subscribers in TTC contribute to an 8.73% improvement to SO's profit.

Finding III: Given the same number of channels, a PCD package attracts a greater percentage of subscribers in TTC than a PCD package does in the YKFA market from 4.07% to 124.84%, i.e., H3 holds in SS1.

It is clear in Table 5-2 that SS in TTC is more than that in the YKFA. For example, for a 76-channel package, the SO in the YKFA improves 0.12% in profit, in which the new PCD subscribers contribute approximately 7.94% to profits and customer transfer from FR results in a 7.82% loss. Conversely, for a 76-channel PCD package in TTC, SO profits increased by 9.57% as compared with the pure FR market, with a new subscription rate of 8.65% contributing approximately 16.53% to profits, while customers from FR results in a 7.80% profit loss. Consumers in TTC are more

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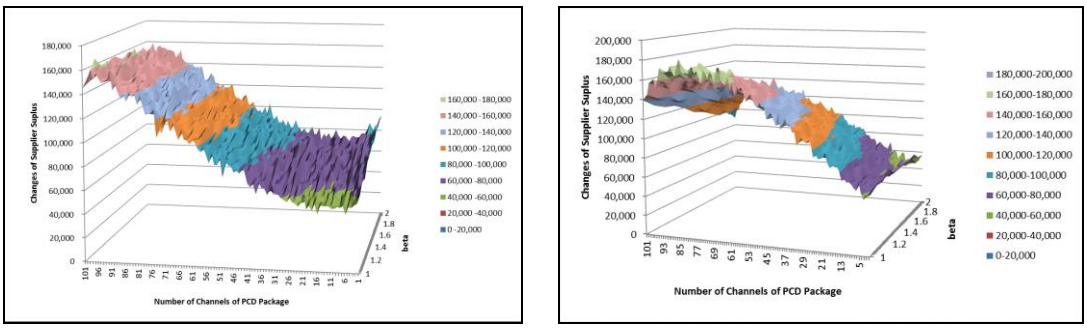
sensitive to price change than those in YKFA, implying a higher number of PCD channels are required to obtain a win-win situation in YKFA than in TTC.

5.2.2 Setting and Benefits of Introducing an ACB Package

In Figure 5-2 Change scale of supplier surplus by adding an ACB package in YKFA (I) and in TTC (II) (10,000 samples, compared with a pure FR market), the three axis represent SS, channel numbers of PCD package and the charging level of ACB package (β value). Figure 4 shows how CS varies with different combinations of channel numbers of PCD package and charging level of ACB package. Findings are as follows.



(I) (II)

Figure 5-2 Change scale of supplier surplus by adding an ACB package in YKFA (I) and in TTC (II) (10,000 samples, compared with a pure FR market)

Finding IV: SS is significantly higher than that in SS1 and win-win situation holds for all PCD package size ranging from 1 to 101 channels, i.e., every channel scale of PCD package in SS2. H4 holds in SS2.

Figure 5-2 shows that by adding an ACB package, the SO in either district has a positive SS value for all PCD package size ranging from 1 to 101 channels and

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different scales of β from 1 to 2. Compared to the SS in a FR or PCD package market, the SS gain of a SO is at least 5.25-fold in YKFA and 1.14-fold in TTC. Such a Pareto improvement may very likely be achieved even under different charging rates of the ACB package and different channel sizes of the PCD package as Sundararajan [Sun04] suggested.

Finding V: H5 holds in SS2 that CS increases when the ACB charging ratio β decreases.

Figure 5-3 (I) and (II) support H5, where at a given number of PCD package channels, the color changes from red (low CS) to blue (high CS) as β value decreases from 2 to 1. As we keep the same quality of ACB package, the lower the charging ratio is set, the higher surplus subscribers get. Figures 4(I) and (II) illustrate the welfare transfer between operator and subscribers as described in Subsection 2.4 and 2.5.

SS2 results demonstrate that an ACB package facilitates win-win situations between consumers and SOs. It is rooted in the design of the tiered charging structure with ACB packages that since an ACB package is made more attractive to consumers than a FR or PCD package, consumers would first choose FR or PCD packages, become subscribers and then further subscribe an ACB package. The tiered charging structure with ACB packages induces subscribers to consume more and receive more surpluses from their consumption, while SOs obtain more profit from these behaviors.

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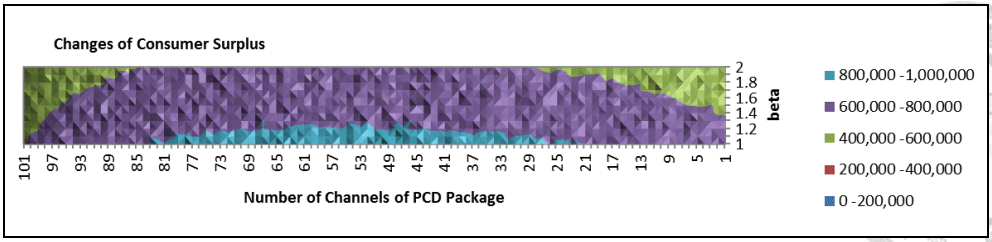
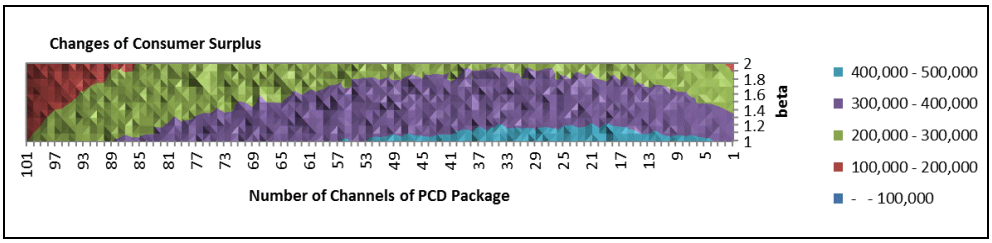


(I)



(II)

Figure 5-3 Change in scale of consumer surplus resulting from the addition of an ACB package in the YKFA (I) and TTC (II)

(10,000 samples, compared with a pure FR market)

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Chapter 6 Conclusions and Future Work

6.1 Conclusions

This research presents a novel model-based policy evaluation method with two simple indices and several quantitative probabilistic models. This approach illustrates the consequences of a monopolistic cable operator being forced to convert its charging scheme from a pure FR charging scheme to tiered charging. We also demonstrate two simulation studies to show that the new options like PCD and ACB packages would subsequently attract enough new subscribers without harming operator profits and would result in greater consumer satisfaction. Thus, the adoption of a tiered charging scheme can increase the level of SW and facilitate Pareto improvement, that is, a win-win situation.

This research demonstrates that win-win situations exist with the introduction of a PCD package to the pure FR market and the provision of an alternative such as an ACB package to the FR or PCD market. Simulations are performed to calculate the distribution of social welfare between two economically and demographically distinct districts, the YKFA and TTC. First, it is determined that after adding a PCD package to the market, the resulting case analysis, based on empirical data from the YKFA and TTC, shows that the supplier experiences no profit loss when the lower limits of price and number of channels for a new CP are approximately 74% and 29%, respectively. That means Pareto improvement exists if the size of new PCD packages is not less than 74% and 29% of FR package in YKFA and TTC, which provides a wider imagination of charging strategies for operators under TC policy. When one more option for subscribers, an ACB package, is added, the results reveal that a win-win situation still exists, as does a greater SW increase in the two districts, and no matter which size of PCD package is

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selected, the operator does not incur a loss. The quantitative models simplify the policy evaluation procedure and provide a feasible method for regulators to evaluate a policy prior to its implementation.

6.2 Future Work

In addition to the discussion of TC policy in cable TV market, NCC's regulatory policies also regulate the expansion of franchise areas. This study focuses on the analysis of the monopolistic market and needs to expand the analysis to the competition between SOs in two monopolistic markets and the franchise area expansion policy. Chen [Che16] has conducted research on two monopolistic markets and the competition between two SOs of the same size. In the future, further research will be conducted on how to set parameters such as different sizes and market shares of SOs and discuss how to affect the distribution of social welfare surplus in the new scope of market.

On the other hand, with the development of technology and changes in people's lifestyle and viewing habits, consumers now have many streaming services to choose from, which has impacted cable TV subscription rates and industry revenue. This study uses cable TV as a scenario to analyze and explore consumer behavior, product portfolio strategies from operators and the effect of policy implementation. The analysis methodology can be further applied to the same consumer group in scenarios facing different streaming services with appropriate parameter setting, which can contribute to authorities who need to regulate new media platforms in the future.

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