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Optimization of telecommunication regulation in Thailand: Mathematical setting of social welfare function

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ABSTRACT

The social wefare function is necessary for the dynamic optimization of the telecommunication regulation. It will assure that the study can investigate the current situation of the regulator in Thailand, find the optimal stage for the regulator, and show the stable path leading the current situation to the optimal stage. This study proposes a social welfare function that is modified to suit the telecommunications industry and analyses the effects of telecommunications policies.

Keywords: Telecommunications industry, telecommunications policy, social welfare function, dynamic optimization, telecommunications regulation

1. Rationale

A regulator is facing three targets in regulating the telecommunication industry. First, the regulator should provide the environment that ensures fair competition among operators. Second, it should control the quality of telecommunication services to meet the international standard in order to protect customers. Last, it needs to expand the coverage of the telecommunication services to all over the country.

In fulfilling these tasks, the regulator must find a path to move from current situation to the optimal stage. The path is called the stable path. It leads the regulator to an equilibrium that yields the best position, the optimal stage, to satisfy all the three targets of the telecommunication regulation.

This study will investigate the current situation of the regulator in Thailand. It will also find the optimal stage for the regulator. Then it will show the stable path leading the current situation to the optimal stage. This can be done by the development of an optmization model.

The model can be constructed by maximizing social welfare subjected to some constraints. To complete the study, the study will be divided into 3 steps. First, it will construct the social welfare function and do the optimization. Second, it will collect empirical data regarding the telecommunication industry in Thailand. The data will reveal the current situation of the country on the phase diagram. The study will find the position where the optimal stage of the country should be. It will draw the stable path which leads to the optimal stage. Then it will predict whether the current situation would move toward the optimal stage or not. Last, it will search for an appropriate set of policies that would shape the situation and lead the country toward the optimal stage via the stable path.

2. Literature review

The issue of dynamic optimization of telecommunication regulation has appeared in several academic works. The optimization in telecommunication industry is mainly focused at the optimal pricing. This appears in the works of Kohno and Mitomo (1998) and Mitomo (1992) who find the optimal pricing and optimal two-part tariff of telecommunications service in Japan. Later, Knieps (2003) and de Bilj and Peitz (2000) link the dynamism to the regulation of competition while Biglaiser and Riordan (2000) relate the dynamism to price regulation.

Knieps (2003) studies the competition in telecommunications and internet services. This study uses the term “dynamic perspective” to separate the short run and the long run effect. In the short run, the study focuses on the narrow band internet while in the long run it turns to the broadband internet. However, the study does not use any mathematical method for dynamic optimization.

The work of Biglaiser and Riordan (2000) use mathematical methods to find optimal prices of telecommunication services. In the paper, they compare two methods of regulation, the rate-of-return regulation and the price-cap regulation. Steps of this study is close to the steps in this proposal. However, the study includes only one parameter to be optimized, the price, while this proposal considers more parameters such as price, concentration index and payment rate for Universal Service Obligation (USO).

The book of Bilj and Peitz (2000) covers essential points of the competition and regulation. They determine the equilibrium by Nash equilibrium and use simulation method developed by Mathematica software to find the equilibrium. They separate their analysis into non-segmented market and segmented market. In the end, they give some policy recommendation for the appropriate way for the regulation. The steps in this book are more alike to the process that the proposal would try to do. The difference between this book and the proposal is at the calculation of the equilibrium. While the book uses simulation method, the proposal will try to collect empirical data to reflect the real situation of the regulator in Thailand. Moreover, the proposal will cover a broader target, not only the competition but also quality and coverage of telecommunication services.

3. Research questions

The research questions of this study are specified as follows:

1) Where are the optimal position of the cometition, coverage and consumer protection that maximize the social welfare in Thailand?

2) How different between the current situation in the telecommunications industry in Thailand and the optimal position?

3) What are the appropriate set of policies that the telecommunications regulator in Thailand should implement to drive the current situation toward the optimal position.

4. Literature review of social welfare functions

Social welfare function has been developed by many literatures as shown in the following table. The literature review in this part aims at the definition of social welfare, economic welfare and well-being generated by fixed broadband.

Table 1: The development of social welfare functions in the literatures.

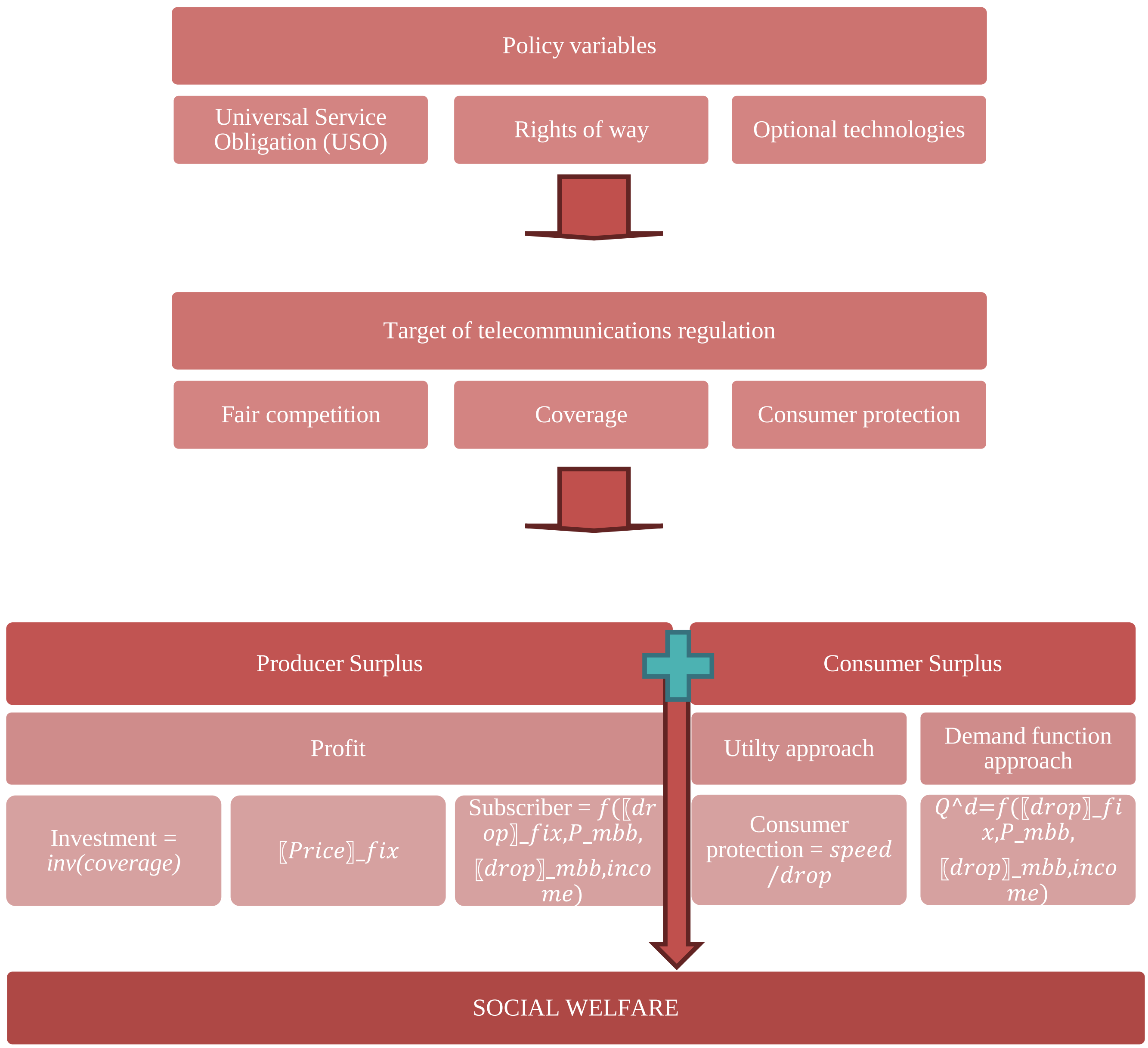
Year	Paper Title	Author(s)	Objective	Function
2009	Entry, access pricing, and welfare in the telecommunications industry	Stefan Behringer	The paper investigates the effect of entry on welfare in the Telecommunications industry (the social welfare implications of entry in the Telecommunications industry). The author model the competitive outcome extending the basic framework of the theoretical economics literature with firms choosing the access charges non-cooperatively. Equilibrium pricing parameters for monopoly and duopoly situations are determined. Welfare comparisons between	The monopoly produces at constant marginal cost c per unit of its service and incurs a fixed cost F>0. V_x is a consumer's utility net of the two-part tariff resulting from active calls only. β is vertical preference parameter for outgoing calls $\beta > 0$ q is the amount of calls initiated p is a unit price **Welfare in Monopoly** -Profit of the monopolist $$\Pi^M = \left\{\beta \int_{p^M=c}^{\infty} q(\zeta)d\zeta - F\right\}$$ -Total consumer utility

Year	Paper Title	Author(s)	Objective	Function
			alternative access pricing regimes are also performed.	$$CU_{n=1} = t\int_0^{\hat{x}}(1-\zeta)d\zeta + \hat{x}V_{\hat{x}}$$ For a profit maximizing two-part tariff of the monopolist there will be no net surplus to the marginal consumer $\hat{x}$ over and above his horizontal preferences for the services of the monopolist network, i.e. $V_{\hat{x}} = 0$ for any $\hat{x} \in [0,1]$. Total consumer utility thus simplifies to $CU_{n=1} = (1/2)t$. Welfare in Duopoly -Total consumer utility $$CU_{n=2}(a) = 2t\int_0^{\hat{x}}(1-\zeta)d\zeta + V_{\hat{x}}$$
2008	Profit sharing and investment by regulated utilities: A welfare analysis	Michele Moretto, Paolo M. Panteghini, Carlo Scarpa	The paper analyzes the effects of different regulatory schemes (price cap and profit sharing) on the endogenous size of a firm's investment. Using a real option approach in continuous time. It also evaluate the effects of profit sharing on social welfare, determining profit level that should optimally trigger tighter regulation.	$$W(x_1, x_h; \tilde{\Pi}) = S(x_1, x_h; \tilde{\Pi}) + \lambda V(x_1, x_h; \tilde{\Pi})$$ where S is the consumer surplus, V is the firm's value and $\lambda \leq 1$ is the weight of profits in the welfare function Firm's value $$V(x_1, x_h; \tilde{\Pi}) = V^{PC}(x_1) + \Delta V^{PS}(x_1, x_h; \tilde{\Pi})$$ where $V^{PC}(x_1)$ is the project value under pure price-cap regulation $V^{PS}(x_1, x_h; \tilde{\Pi}) < 0$ represents the decrease in the firm's value due to profit sharing Consumer surplus $$S(x_1, x_h; \tilde{\Pi}) = S^{PC}(x_1) + \Delta S^{PS}(x_1, x_h; \tilde{\Pi})$$ where $S^{PC}(x_1)$ is the consumer surplus under price-cap regulation $S^{PS}(x_1, x_h; \tilde{\Pi})$ is the increase in consumer surplus due to profit sharing

Year	Paper Title	Author(s)	Objective	Function
				Then $$W(x_1, x_h; \widetilde{\Pi}) = W^{PC}(x_1) + \Delta W^{PS}(x_1, x_h; \widetilde{\Pi})$$ Where $W^{PC}(x_1) \equiv S^{PC}(x_1) + \lambda V^{PC}(x_1)$ $$\Delta W^{PS}(x_1, x_h; \widetilde{\Pi}) \equiv \Delta S^{PS}(x_1, x_h; \widetilde{\Pi}) + \lambda\, \Delta V^{PS}(x_1, x_h; \widetilde{\Pi})$$
2012	Welfare, competition, specialization and growth	Daria Onori	The paper analyzes how consumers' welfare varies in terms of the degree of competition and the degree of returns to specialization. By starting from the decentralized economy analysis they derive the differential equation which describes the dynamics of the amount of labor used in R&D. It admits two steady states: one is balanced growth path solution, and it is unstable; the other one, which is equal to the total labor force, is instead a stable solution. Equilibrium trajectories is solved by using the transversality condition.	Transversality condition $$\lim_{t \to +\infty} e^{-\rho t} \frac{1}{C(t)} a(t) = 0$$
1999	Growth versus welfare in a model of nonrival infrastructure	Dipandar Dasgupta	The paper constructs a model of endogenous growth where infrastructure acts as an accumulable stock generating a nonrival input service. Stady state growth paths are studied for Market and Command Economices.	Society's welfare $$W = \int_0^\infty \frac{C(\theta)^{1-\sigma}}{1-\sigma} e^{-\rho\theta} d\theta$$ where $C(\theta)$ represents consumption at point of time θ constant ρ is a positive discount parameter and $1 \neq \sigma > 0$ the elasticity of instantaneous marginal utility

Year	Paper Title	Author(s)	Objective	Function
2007	Joint Optimization of Pricing and Resource Allocation in Competitive Telecommunications Networks	Mustapha Bouhtou, Guillaume Erbs, Michel Minoux	The authors study a problem of revenue management for a network operator. The paper presents a natural formulation for the problem that uses bilinear bilevel programming models. However, such an approach leads to optimization problems that are very difficult to solve exactly on the large scale instances found in the telecommunications industry. The paper introduces a new alternative formulation for the problem and propose solution methods related to this formulation.	**Revenue Optimization Model** Operator's Revenue Maximization $\max_{T_m^0, C_m^0, \phi_{m,s}^0} \sum_{m \in M} T_m^0 \sum_{s} \phi_{m,s}^0$ s.t. $\sum_{m \in M: a \in f_m^0} C_m^0 \leq c_a \quad \forall a \in A$ $T_m^0 \geq 0 \quad \forall m \in M$ Clients' Price Minimization $\min_{\phi_{m,s}^0, \phi_{m,s}^c} \sum_{m \in M} \sum_{s \in S} \Theta(T_m^0, U_{m,s}^0) \phi_{m,s}^0 + \Theta(T_m^c, U_{m,s}^c) \phi_{m,s}^c$ s.t. $\phi_{m,s}^0 + \phi_{m,s}^c = d_{m,s} \quad \forall s \in S, \forall m \in M$ $\sum_{s \in S} \phi_{m,s}^0 \leq C_m^0 \quad \forall m \in M$ $\phi_{m,s}^0, \phi_{m,s}^c \geq 0 \quad \forall s \in S, \forall m \in M$

5. Research framework



6. Formulation of social welfare function in the fixed broadband market.

Here are the development of the social welfare functions for static optimization. There may be more possibilities to construct the social welfare functions in other ways that the author will try to find them later.

The Social welfare function for static optimization can be determined as follows:

$S = f$ *(consumer's surplus, producer's surplus)*

The social welfare depends on two counterparts of the economy: suppliers and consumers. Therefore, the social welfare can be formulated by the function of producer's surplus (PS) plus consumer's surplus (CS)

$$\begin{aligned}
S &= PS + CS \\
&= \{TR - TC\} + CS \\
&= \{TR - (TFC + TVC)\} + CS \\
&= \left\{\left((1 - USO)\left(P_{fix} \cdot Q\left(cov, P_{fix}, d_{fix}, P_{mbb}, d_{mbb}\right)\right)\right) - \left(TFC(inv, WACC) + TVC(cov, csp)\right)\right\} + \sum \Delta U \\
&= \left\{\left((1 - USO)\left(P_{fix} \cdot Q\left(cov, P_{fix}, d_{fix}, P_{mbb}, d_{mbb}\right)\right)\right)\right. \\
&\qquad \left. - \left(\left(TFC(inv(cov, csp, tech, rtw), WACC(cov, csp, tech, rtw)\right) + TVC(cov, csp)\right)\right\} \\
&\qquad + \left\{\sum_{i=1}^{Q} U_i\left(cov, csp, P(compet), gcov(USO)\right) - \bar{U}Q\left(cov, P(compet)\right)\right\}
\end{aligned} \tag{1}$$

$$\begin{aligned}
S = &\left\{(1 - USO)\left(P_{fix} \cdot \left(\alpha y e^{-\frac{P_{fix}}{P_{mbb} \cdot d_{mbb}}} + \beta cov\right)\right)\right. \\
&- \left(\left(1 - R - \frac{R}{n}\right)\left(\left(k \sum_{i=1}^{4} w_i tech_i \cdot cov \cdot csp\right)(1 + WACC)\right)\right. \\
&\left.\left. + \left(\frac{Total\ operation\ cost}{\bar{Q}} \cdot \left(\alpha y e^{-\frac{P_{fix}}{P_{mbb} \cdot d_{mbb}}} + \beta cov\right)\right)\right)\right\} + \left\{\left(\sum_{j=1}^{Q} U_i\right) - \bar{U}Q\right\}
\end{aligned} \tag{2}$$

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