Conference ID #56927

PROCEEDING

#5th

ISRITI 2022

Yogyakarta - Indonesia
8 December 2022

BUSINESS INTELLIGENCE IN DIGITAL ERA

isriti.utdi.ac.id

UNIVERSITAS TEKNOLOGI DIGITAL INDONESIA

IEEE INDONESIA SECTION

UTDI IEEE Student Branch

2022 5th International Seminar on Research of Information Technology and Intelligent Systems (ISRITI) | 978-1-6654-5512-1/22/$31.00 ©2022 IEEE | DOI: 10.1109/ISRITI56927.2022.10052962

2022 5th International Seminar on Research of Information Technology and Intelligent Systems (ISRITI) | 978-1-6654-5512-1/22/$31.00 ©2022 IEEE | DOI: 10.1109/ISRITI56927.2022.10053061

STEERING COMMITTEE

Chuan-Ming Liu (National Taipei University of Technology, Taiwan)

Totok Suprawoto (STMIK AKAKOM Yogyakarta, Indonesia)

Setyawan Widyarto (Universiti Selangor, Malaysia)

ORGANIZING COMMITTEE

General Chair

Widyastuti Andriyani (Universitas Teknologi Digital Indonesia & UTDI, Indonesia)

General Co-Chair

Bambang Purnomosidi Dwi Putranto (Universitas Teknologi Digital Indonesia & PT Zenit Merdeka Raya, Indonesia)

Secretary

Maria Mediatrix (STMIK AKAKOM, Indonesia)

Treasurer

Sumiyatun Sumiyatun (Universitas Teknologi Digital Indonesia, Indonesia)

Registration Chair

Muhammad Agung Nugroho (Universitas Teknologi Digital Indonesia, Indonesia)

Publication Chair

Rikie Kartadie (Universitas Teknologi Digital Indonesia, Indonesia)

TECHNICAL COMMITTEE

Domy Kristomo (Universitas Teknologi Digital Indonesia, Indonesia)

Robby Cokro Buwono (Universitas Teknologi Digital Indonesia, Indonesia)

Danny Kriestanto (STMIK AKAKOM Yogyakarta, Indonesia)

Luthfan Hadi Pramono (Universitas Teknologi Digital Indonesia, Indonesia)

Cosmas Haryawan (Universitas Teknologi Digital Indonesia, Indonesia)

Plenary and Parallel Session Division

Plenary Session Moderator

Siska Lidya Revianti (STMIK AKAKOM Yogyakarta, Indonesia)

Parallel Session Chair

Al Agus Subagyo (STMIK AKAKOM, Indonesia)

Robby Cokro Buwono (Universitas Teknologi Digital Indonesia,

Indonesia)
Yagus Cahyadi (Universitas Teknologi Digital Indonesia, Indonesia)
Edi Faizal (Universitas Teknologi Digital Indonesia, Indonesia)
Cosmas Haryawan (Universitas Teknologi Digital Indonesia, Indonesia)
Domy Kristomo (Universitas Teknologi Digital Indonesia, Indonesia)
Mesti Woro Mahatmi (Universitas Teknologi Digital Indonesia, Indonesia)
Faizal Makhrus (Universitas Gadjah mada, Indonesia)
Yohakim Marwanta (Universitas Teknologi Digital Indonesia, Indonesia)
Maria Mediatrix (STMIK AKAKOM, Indonesia)
Asyahri Hadi Nasyuha (STMIK Triguna Dharma, Indonesia)
Fx. Henry Nugroho (Universitas Teknologi Digital Indonesia, Indonesia)
Muhammad Agung Nugroho (Universitas Teknologi Digital Indonesia, Indonesia)
Luthfan Hadi Pramono (Universitas Teknologi Digital Indonesia, Indonesia)
Agung Budi Prasetyo (STMIK AKAKOM Yogyakarta, Indonesia)
Adiyuda Prayitna (Universitas Teknologi Digital Indonesia, Indonesia)
Edy Prayitno (Universitas Teknologi DIgital Indonesia, Indonesia)
Bambang Purnomosidi Dwi Putranto (Universitas Teknologi Digital Indonesia & PT Zenit Merdeka Raya, Indonesia)
Pulut Suryati (Universitas Teknologi Digital Indonesia, Indonesia)
Emy Susanti (Universitas Teknologi Digital Indonesia, Indonesia)
Bagas Triaji (Universitas Teknologi Digital Indonesia, Indonesia)
Agnes Nora Eko Wahyu Utami (Universitas Teknologi Digital Indonesia, Indonesia)
Basuki Heri Winarno (Universitas Teknologi Digital Indonesia, Indonesia)

Information Services Financing Scheme Model with Marginal Costs and Supervisory Costs for Modified Cobb-Douglas and Linear Utility Functions

Indrawati
Mathematics Department
Mathematics and Natural Sciences Faculty
Sriwijaya University, South Sumatra

Fitri Maya Puspita*
Mathematics Department
Mathematics and Natural Sciences Faculty
Sriwijaya University, South Sumatra
*fitrimayapuspita@unsri.ac.id

Evi Yuliza
Mathematics Department
Mathematics and Natural Sciences Faculty
Sriwijaya University, South Sumatra

Eka Susanti
Mathematics Department
Mathematics and Natural Sciences Faculty
Sriwijaya University, South Sumatra

Sisca Octarina
Mathematics Department
Mathematics and Natural Sciences Faculty
Sriwijaya University, South Sumatra

Intan Lestari
Mathematics Department
Mathematics and Natural Sciences Faculty
Sriwijaya University, South Sumatra

Abstract—**This study aims to establish information service financing scheme model with three financing schemes, namely flat fee, usage-based and two-part tariff for Internet Service Providers (ISP) based on heterogeneous consumer satisfaction levels. This modified model was developed by adding the marginal cost and supervisory cost based on the Modified Cobb-Douglas utility function and the Linear utility function to obtain optimal results. The data used in the form of digilib traffic is obtained from a local server in the city of Palembang that is Politeknik Sriwijaya (Polsri) which is divided into busy and non-busy hours. This research is done analytically using differentially. The optimum solution obtained if using the differential method if use the linear utility in the flat fee financing scheme of IDR. 382.687/kbps.**

Keywords— Internet Service Provider, modified cobb-douglas utility function, linear utility function, marginal costs

I. INTRODUCTION

Hanggiasyifa [1] explained that ISP is a government-owned or private business entity that provides service facilities to be able to connect to the internet network. ISP is a gateway to connect a computer to the internet, so it is necessary to subscribe to an ISP in order to access the internet [2]. ISPs only have different characteristics both in terms of network quality, bandwidth, service maintenance, connection stability, and prices offered . With these characteristics, many companies compete to improve the best service quality so as to get customer satisfaction which is an important thing for the company. When customer satisfaction increases, it can affect customer loyalty and increase sales at the company.

Service quality or QoS [3], [4] is a measurement method used to determine network capabilities such as network applications, hosts or routers with the aim of providing better services and network planning so that they can meet the needs of a service[5], [6]. QoS aims to meet the needs of different services in using the same network. In this case QoS offers the ability to define the attributes of the services provided both quantitatively and qualitatively. QoS is a method to measure the capacity of a network by trying to define the characteristics and properties of services. QoS is used to measure performance attributes that have been defined and have been assigned to a service.

The utility function is the level of consumer satisfaction [7]–[9] in consuming goods. The function of the utility usually relates to user satisfaction when using an information service. Performance indicator, which is something you want to aim for such as maximization/minimization[10], [11]. With the utility function in the financing scheme, it will provide information to ISPs to get maximum profit. Therefore, ISPs must be able to provide the best quality of service to consumers.

The utility functions [12] used in this study are the modified cobb-douglas utility function [13]–[15] and the linear utility function. According to Wu & Banker [16], the form of the modified cobb-douglas function is as follows:

$$U(J,K) = d\,log(J+1) + e\,log(K+1) \quad (1)$$

where is the level of service usage at the time of peak hours and is the level of service usage at the time of non-peak hours, with and as a constant. Denœux & Shenoy [12] stated that the form of linear utility functions is as follows:

$$U\,(J,K)\; = \;dJ\; + \;eK \quad (2)$$

with *d* and *e* as constants, is the service usage rate at peak hours and is the service usage rate at non-peak hours, respectively. Sitepu et al. [17] stated that marginal costs are defined as costs whose determination is adjusted to the level of production of an item resulting in a difference in fixed costs due to an increase in the number of production units, while supervision costs are costs incurred by the company to supervise and control the activities carried out by agents in managing the company [18], [19]. According to Indrawati et al., [20] who have analyzed during peak hours and non-peak hours, it is recorded that the problem of peak hours and non-peak hours can be solved in the same way in the calculation of the financing scheme model for consumer problems with marginal costs as c and supervision costs as t.

Based on the background, it is a necessity to formulate a customer preference-based information services scheme model with the addition of marginal costs and supervisory costs based on the modified cobb-douglas utiity function and the linear utility function. The modification model is applied to high end and low end hetorogeneous consumers as well as for hetorogeneous high demand and low demand customers [5], [21] based on three financing schemes, namely flat fee, usage-based, and two-part tariffs [10], [16].

II. Research Method

The steps carried out in this study are as follows:

1. Define the parameters and decision variables used in each case of the model in the study.
2. Define an information services financing scheme model based on the modified cobb-douglas utility function and linear utility function with flat fee, usage-based and two-part tariff financing types for heterogeneous consumer problems with the addition of marginal costs and supervision costs.
3. Describe data on a local server, namely digilib traffic by sharing data during peak hours at 07.00 AM – 05.00 PM Indonesian time and non-peak hours at 05.01 PM – 06.59 AM Indonesian time. Data obtained is from secondary data for approximately one month starting from February 1, 2022 to February 28, 2022.
4. Apply a modified model of information service financing schemes based on three types of flat fee, usage-based, and two-part tariff financing schemes for heterogeneous consumers on local server data.
5. Complete the modified model in Step 4, the subsequent completion is done analytically with differentials.
6. Compare the results contained in Step 5 so that an optimal financing scheme is obtained for each type of consumer.

Fig.1 explains the framework of research conducted.

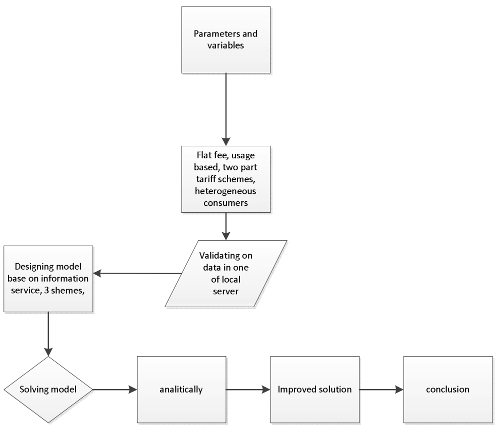

FIGURE 1. FLOWCHART OF THE RESEARCH CONDUCTED

III. Result and Discussion

This research discusses modification models with utility functions based on modification cobb-douglas and linear utility functions involving marginal costs and supervisory costs, which has been completed analytically using differential methods.

Traffic Data

The data used is digilib traffic data with two types of data, namely data received (inbound) and data sent (outbound). Traffic data is obtained from a local server in the city of Palembang, precisely from Sriwijaya Polytechnic. Secondary data expressed in bits per second units are distinguished by usage during peak hours starting 07.00 AM – 05.00 PM Indonesian time and non-peak hours at 05.01 PM – 06.59 AM Indonesian time.

Parameter and Variable Formulation

Table I to Table IV describes the parameters, decision variables and parameter values used in the information service financing scheme modification model for each heterogeneous consumer.

TABLE I. PARAMETERS FOR EACH FINANCING MODEL

Parameters for the model of the modification	
$U(J_g, K_g)$	The utility function of the consumer g with is the level of service usage at the time of peak hours J_g and is the level of service usage at the time of non-peak hours.
Q_J	Prices given by ISPs during peak hours
Q_K	Prices given by ISPs during off-peak hours
Q	Costs incurred if you follow the services provided
$\bar{J}_g$	Highest rate of consumers g in using services during peak hours
$\bar{K}_g$	Highest rate of consumers g in using services during off-peak hours
c	Marginal costs
t	Surveillance costs

TABLE II. VARIABLES FOR EACH FINANCING MODEL

Variables for modified models	
J_g	Peak hour service consumption rates
K_g	Service consumption rates during off-peak hours
L_g	A variable that is worth 1 if the consumer chooses to join and is worth 0 if they do not want to join
J_g^*	Consumer service consumption rate g during peak hours
K_g^*	Consumer service consumption rate g during off-peak hours
L_g^*	Consumer decision variables g about participation

TABLE III. PARAMETER VALUES FOR MODIFIED MODELS

Parameter	Value		
	Flat Fee	*Usage-Based*	*Two-Part Tariff*
C	$0 < c < 10$	$0 < c < 10$	$0 < c < 10$
T	0	$0 < t < 10$	$0 < t < 10$
$\bar{J}_1$	57.092	57.092	57.092
$\bar{J}_2$	9.982	9.982	9.982
$\bar{K}_1$	10.362	10.362	10.362
$\bar{K}_2$	10.179	10.179	10.179

TABLE IV. PARAMETER VALUES FOR HETEROGENEOUS CONSUMERS

Parameter	*High* End and *Low End* Heterogeneous Consumers	Heterogeneous *Consumers of High* Demand and *Low Demand*
d_1	4	3
d_2	3	3
e_1	3	2
e_2	2	2

with

d_1 : service constant during peak hours of high-end users.

d_2 : service constant during peak hours of lower-class users.

e_1 : service constant at the off-peak hours of high-end users.

e_2 : service constant during off-peak hours of lower-class users.

a. Modified Models for Heterogeneous Consumers on Modified Cobb-douglas Utility Functions

For *flat fee* financing schemes:

Optimization of consumer issues:

$$\max_{J_g,K_g,L_g} Y = d_g\,log(J_g+1) + e_g\,log(K_g+1) - Q_J J_g - Q_K K_g - QL_g - (J_g+K_g)c$$

Subject to

$$J_g \le \bar{J}L_g$$
$$K_g \le \bar{K}L_g$$
$$d_g\,log(J_g+1) + b_g\,log(K_g+1) - Q_J J_g - Q_K K_g - QL_g - (J_g+K_g)c \ge 0$$
$$L_g = 0 \text{ or } 1$$

Optimization of manufacturer issues:

$$\max_{Q,Q_J,Q_K} m(Q_J J_1^* + Q_K K_1^* + QL_1^*) + n(Q_J J_2^* + Q_K K_2^* + QL_2^*)$$

where

(J_g*, g*,L_g*) = argmax $d_g\,log(J_g+1) + b_g\,log(K_g+1) - Q_J J_g - Q_K K_g - QL_g - (J_g+K_g)c$

Subject to

$$J_g \le \bar{J}L_g$$
$$K_g \le \bar{K}L_g$$
$$d_g\,log(J_g+1) + b_g\,log(K_g+1) - Q_J J_g - Q_K K_g - QL_g - (J_g+K_g)c \ge 0$$
$$L_g = 0 \text{ or } 1.$$

For usage-based and two-part tariff financing schemes then the optimization of consumer issues will be

$$\max_{G_e,H_e,I_e} Y = d_g\,log(J_g+1) + e_g\,log(K_g+1) - Q_J J_g - Q_K K_g - QL_g - (c+t)J_g - (c+t)K_g$$

Subject to

$$J_g \le \bar{J}L_g$$
$$K_g \le \bar{K}L_g$$
$$d_g\,log(J_g+1) + b_g\,log(K_g+1) - Q_J J_g - Q_K K_g - QL_g - (c+t)J_g - (c+t)K_g \ge 0$$
$$L_g = 0 \text{ or } 1$$

Optimization of manufacturer issues:

$$\max_{Q,Q_J,Q_K} m(Q_J J_1^* + Q_K K_1^* + QL_1^*) + n(Q_J J_2^* + Q_K K_2^* + QL_2^*)$$

where (J_g*, g*,L_g*)

=argmax $(d_g\,log(J_g+1) + b_g\,log(K_g+1) - Q_J J_g - Q_K K_g - QL_g - (c+t)J_g - (c+t)K_g$

Subject to

$$J_g \le \bar{J}L_g$$
$$K_g \le \bar{K}L_g$$
$$d_g\,log(J_g+1) + b_g\,log(K_g+1) - Q_J J_g - Q_K K_g - QL_g - (c+t)J_g - (c+t)K_g \ge 0$$
$$L_g = 0 \text{ or } 1$$

Modified Models in Upper and Lower Class Heterogeneous Consumers

Case 1a: For case 1, if the ISP uses flat fee financing, then it is set $Q_J = 0$, $Q_K = 0$, and $Q > 0$. If the consumer chooses to join a given program, the maximum level of satisfaction is obtained by choosing the consumption level, or $J_1 = \bar{J}K_1 = \bar{K}J_2 = \bar{J}K_2 = \bar{J}$.Thus, ISPs can provide a price for each consumer of the upper class no more than and each consumer $d_2\,log(\bar{J}+1) + e_2\,log(\bar{K}+1) - (\bar{J}+\bar{K})c$ of the lower class no more than $d_2\,log(\bar{J}+1) + e_2\,log(\bar{K}+1) - (\bar{J}+\bar{K})c$.

If consumers are charged, then only the upper class consumers are $d_1\,log(\bar{J}+1) + e_1\,log(\bar{K}+1) - (\bar{J}+\bar{K})c$able to meet, but if consumers are charged as much as, then both types of consumers can follow the services of upper class consumers and lower $d_2\,log(\bar{J}+1) + e_2 lo\,g(\bar{K}+1) - (\bar{J}+\bar{K})c$ class consumers. To maximize profits, a fee is charged. Therefore, to maximize the benefits of ISPs using costs to consumers of the upper class and lower class. Thus, the optimization of the manufacturer's problem become

$d_2\,log(\bar{J}+1) + e_2\,log(\bar{K}+1) - (\bar{J}+\bar{K})c$ $d_2\,log(\bar{J}+1) + e_2\,log(\bar{K}+1) - (\bar{J}+\bar{K})c$:

Max $m(QL_1{}^*) + n\,(QL_2{}^*)$

$= (m+n)(\,d_2\,log(\bar{J}+1) + e_2\,log(\bar{K}+1) - (\bar{J}+\bar{K})c)$

The maximum profit obtained is:

$(m+n)(\,d_2\,log(\bar{J}+1) + e_2\,log(\bar{K}+1) - (\bar{J}+\bar{K})c)$

Based on this case the following lemma is obtained:

Lemma 1a. If the ISP uses flat fee financing, then the price charged to the consumer with the maximum profit obtained as follows. $Q = d_2\,log(\bar{J}+1) + e_2\,log(\bar{K}+1) - (\bar{J}+\bar{K})c$

$(m+n)(\,d_2\,log(\bar{J}+1) + e_2\,log(\bar{K}+1) - (\bar{J}+\bar{K})c)$.

Case 2a: If the ISP uses usage-based financing, it is determined that the problem optimization is obtained for the upper-class heterogeneous consumers $Q_J > 0$, $Q_K > 0$, dan $Q = 0$,.

The optimization function of consumer problems becomes:

$$\max_{J_g,K_g,L_g} Y = d_1\,log(J_1+1) + e_1\,log(K_1+1) - Q_J J_1 - Q_K K_1 - (c+t)J_1 - (c+t)K_1$$

To maximize the equation on the consumer problem is carried out differentiation to J_1 and K_1 provided that

$\frac{\partial Y}{\partial J_1} = 0$ and $\frac{\partial Y}{\partial K_1} = 0$

$$\Leftrightarrow \frac{\partial(d_1\,log(J_1+1) + e_1\,log(K_1+1) - Q_J J_1 - Q_K K_1 - (c+t)J_1 - (c+t)K_1)}{\partial J_1} = 0$$

$$\Leftrightarrow \frac{d_1}{J_1^*+1} - Q_J - (c+t) = 0$$

$$\Leftrightarrow J_1^* = \frac{d_1}{Q_J + (c+t)} - 1$$

and

$$\Leftrightarrow \frac{\partial(d_1\, log(J_1+1) + e_1\, log(K_1+1) - Q_J J_1 - Q_K K_1 - (c+t)J_1 - (c+t)K_1)}{\partial K_1} = 0$$

$$\Leftrightarrow \frac{e_1}{K_1^*+1} - Q_J - (c+t) = 0$$

$$\Leftrightarrow \frac{e_1}{K_1^*+1} - (c+t) = Q_J$$

$$\Leftrightarrow \frac{e_1}{K_1^*+1} = Q_J + (c+t)$$

$$\Leftrightarrow K_1^* = \frac{e_1}{Q_J + (c+t)} - 1$$

Optimization of heterogeneous consumer problems for the lower classes will be estimation of consumer problems as follows.

$$\underset{J_g,K_g,L_g}{\text{Max}}\ Y\ d\, log(J_2+1) + e_2\, log(J_2+1) - Q_J J_2 - Q_K K_2 - (c+t)J_2 - (c+t)K_2$$

To maximize the optimization, the equation of the consumer problem is carried out differentiatially provided that

$\frac{\partial Y}{\partial J_2} = 0$ and $\frac{\partial Y}{\partial K_2} = 0$

$$\Leftrightarrow \frac{\partial(d\, log(J_2+1) + e_2\, log(J_2+1) - Q_J J_2 - Q_K K_2 - (c+t)J_2 - (c+t)K_2)}{\partial J_2} = 0$$

$$\Leftrightarrow \frac{d_2}{J_2^*+1} - Q_J - (c+t) = 0$$

$$\Leftrightarrow \frac{d_2}{J_2^*+1} - (c+t) = Q_J$$

$$\Leftrightarrow \frac{d_2}{J_2^*+1} = Q_J + (c+t)$$

$\Leftrightarrow J_2^* = \frac{d_2}{Q_J+(c+t)} - 1$ and

$$\Leftrightarrow \frac{\partial(d\, log(J_2+1) + e_2\, log(J_2+1) - Q_J J_2 - Q_K K_2 - (c+t)J_2 - (c+t)K_2)}{\partial K_2} = 0$$

$$\Leftrightarrow \frac{e_2}{K_2^*+1} - Q_J - (c+t) = 0$$

$$\Leftrightarrow \frac{e_2}{K_2^*+1} - (c+t) = Q_J$$

$$\Leftrightarrow \frac{e_2}{K_2^*+1} = Q_J + (c+t)$$

$$\Leftrightarrow K_2^* = \frac{e_2}{Q_J + (c+t)} - 1$$

Optimization of the manufacturer's problem will be to

$$\underset{Q_J,Q_K}{\text{Max}}\ m(Q_J J_1^* + Q_K K_1^*) + n(Q_J J_2^* + Q_K K_2^*)$$

$$= \underset{\boldsymbol{Q_J,Q_K}}{\text{Max}}\ m\left(Q_J\left(\frac{d_1}{Q_J+(c+t)} - 1\right) + Q_K\left(\frac{e_1}{Q_K+(c+t)} - 1\right)\right) + n\left(Q_J\left(\frac{d_2}{Q_J+(c+t)} - 1\right) + Q_K\left(\frac{e_2}{Q_K+(c+t)} - 1\right)\right)$$

$$= \underset{\boldsymbol{Q_J,Q_K}}{\text{Max}}\ m\left(\frac{d_1 Q_J}{Q_J+c+t} - Q_J + \frac{b_1 Q_K}{Q_K+c+t} - Q_K\right) + n\left(\frac{d_2 Q_J}{Q_J+c+t} - Q_J + \frac{b_2 Q_K}{Q_K+c+t} - Q_K\right)$$

To maximize the optimization equation of the manufacturer's problem, the values of Q_J and Q_K must be minimized since J_1, J_2, K_1, K_2 are constrained then J_1^*, J_2^*, K_1^*, and K_2^* cannot exceed $\bar{J}$ and $\bar{K}$. If applied to a problem during peak hours, ISP must minimize Q_J, with $Q_J \le \frac{d_1}{\bar{J}+1} - (c+t)$. On the other hand, if the ISP sets the price $Q_J \le \frac{d_2}{\bar{J}+1} - (c+t)$, then the profit is not optimal at the time of $J_1^* \le \bar{J}$ or $J_2^* \le \bar{J}$. Therefore, the best price is

$$Q_J, Q_J \le \frac{d_1}{\bar{J}+1} - (c+t)Q_J \le \frac{d_2}{\bar{J}+1} - (c+t), J_1\bar{J}J_2\bar{J}.Q_J\ \frac{d_2}{\bar{J}+1} - (c+t) \le Q_J \le \frac{d_1}{\bar{J}+1} - (c+t)Q_K\frac{e_1}{\bar{K}+1} - (c+t)\ Q_K \le \frac{e_2}{\bar{K}+1} - (c+t)\ K_1\bar{K}\ K_2\bar{K}Q_K\frac{e_2}{\bar{K}+1} - (c+t) \le Q_K \le \frac{e_1}{\bar{K}+1} - (c+t)$$

The best price should be between d_1 and d_2 . When prices are at that interval, the demand of $Q_J\ d_1\ d_2$ upper class consumers become fixed and the demand of $\bar{J}$ lower class consumers increase in proportion to the decrease in prices. Thus Q_J and Q_K will be $Q_J = \frac{d_2}{\bar{J}+1} - (c+t)$ dan $Q_K = \frac{e_2}{\bar{K}+1} - (c+t)$ with the maximum profit obtained are: $Q_J Q_K Q_J = \frac{d_2}{\bar{J}+1} - (c+t)Q_K = \frac{e_2}{\bar{K}+1} - (c+t)$

$$(m+n)\left(\frac{d_2\bar{J}}{\bar{J}+1} + \frac{e_2\bar{K}}{\bar{K}+1} - (c+t)\bar{J} - (c+t)\bar{K}\right)$$

Based on this case the following lemma is obtained:

Lemma 2a. If the ISP uses usage-based financing, then the optimal price is and with the maximum profit obtained is: $Q_J = \frac{d_2}{\bar{J}+1} - (c+t)Q_K = \frac{e_2}{\bar{K}+1} - (c+t)$

$$(m+n)\left(\frac{d_2\bar{J}}{\bar{J}+1} + \frac{e_2\bar{K}}{\bar{K}+1} - (c+t)\bar{J} - (c+t)\bar{K}\right)$$

Case 3a: In case 3, if the ISP uses a two-part tariff financing then $Q > 0$. First if the ISP sets the price – ($Q_J > 0 Q_K > 0 Q_J \ge \frac{d_1}{\bar{J}+1}c+t$)

Optimization of the manufacturer's problem to:

$$\underset{Q_J,Q}{\text{Max}}\ m(Q_J J_1^*) + n(Q_J J_2^*) + (m+n)Q$$

$$= \underset{Q_J}{\text{Max}}\ m(d_1 - Q_J) + n(d_2 - Q_J\text{- (c + t)} + \text{(m + n)}\int_0^{\frac{d_2}{Q_J}-1}(\frac{a_2}{J_2+1} - Q_J\ dJ_2$$

$$= \underset{Q_J}{\text{Max}}\ m\,(d_1 - d_2) + (m+n)d_2\, log\,(\tfrac{d_2}{Q_J}) - (c+t)$$

To maximize the optimization function of the ISP manufacturer's problem should be minimized, so that the best price is at intervals with a profit of $(d_1 -$

d_2)+(m+n) $- d_2 \, log \frac{d_1}{d_2} (\bar{J}+1) -(c+t)$. If the ISP sets the price $\frac{d_2}{\bar{J}+1} \leq Q_J \leq \frac{d_1}{\bar{J}+1}$ optimization of the manufacturer's problem to be as following.

$$\max_{Q_J, Q} m(Q_J J_1{}^*) + n(Q_J J_2{}^*) + (m+n)Q$$

$= \max_{Q_J} m \, (\bar{J}+1) \, Q_J - md_2) + (m+n) \, d_2 \log (\frac{d_2}{Q_J}) - (c + t)$

The best price is at intervals with maximum profit $Q_J \, \frac{d_2}{\bar{J}+1}$ - $(c+t) \, (m+n) \, d_2 \, log \;\; (\bar{J}+1)$ - $(c+t)$.

Third, if the ISP sets the price then manufacturer's problem to: $0 < Q_J < \frac{d_2}{\bar{J}+1} - (c+t)$.

$$\max_{Q_J, Q} m(Q_J J_1{}^*) + n(Q_J J_2{}^*) + (m+n)Q$$

$= \max_{Q_J} m \, ()) - (Q_J \bar{J} + n(Q_J \bar{J} c{+}t) + (m{+}n)) \int_0^{\bar{J}} (\frac{d_2}{J_2+1} - Q_J \; dJ_2$

$= \max_{Q_J} (m+n) \, d_2 \log (\bar{J}+1) - \; (c+t)$

Manufacturers can set optimal prices between 0 and $\frac{d_2}{\bar{J}+1} - (c \; + t)$ or between 0 and $\frac{e_2}{\bar{K}+1} - (c+t)$. When prices are at that interval the demand of the $\frac{e_2}{\bar{K}+1} - (c+t)$, then upper class consumers become fixed and the demand of $\bar{J}$ the lower-class consumers remain proportional to the decrease in prices. In other words, $Q_J = \frac{d_2}{\bar{J}+1} - (c \; + t)$, $Q_K = \frac{e_2}{\bar{K}+1} - (c+t)$ and minimize $Q = d_2 \, log(\bar{J}+1) + e_2 \, log(\bar{K}+1) - \frac{d_2 \bar{J}}{\bar{J}+1} + \frac{e_2 \bar{K}}{\bar{K}+1} - (c+t)\bar{J} - (c+t)\bar{K}$.

The maximum profit obtained is:

$(m+n)(\, d_2 \, log(\bar{J}+1) + e_2 \, log(\bar{K}+1) - (c \; + t) \, \bar{J} - (c+t)\bar{K} \,)$.

Based on this case the following lemma is obtained:

Lemma 3a. If the ISP uses a two-part tariff financing scheme, then the optimal price is and with the maximum profit obtained is $Q_J = \frac{d_2}{\bar{J}+1} - (c \; + t)$, $Q_K = \frac{e_2}{\bar{K}+1} - (c+t)$ $\quad Q = d_2 \, log(\bar{J}+1) + e_2 \, log(\bar{K}+1) - (c+t)\bar{J} - (c+t)\bar{K}$

$$(m+n)(\, d_2 \, log(\bar{J}+1) + e_2 \, log(\bar{K}+1) - (c+t)\bar{J} - (c+t)\bar{K} \,)$$

Modified Models In Heterogeneous Consumers of High User Levels and Low User Rates

Using similar evidence for the next three lemmas, the following lemmas were obtained.

Lemma 4a. If the ISP uses flat fee financing, then the fee paid with the maximum profit earned is $d \, log(\bar{J}_2+1) + e \, log(\bar{K}_2+1) - (\bar{J}_2+\bar{K}_2)c(m+n)[d \, log(\bar{J}_2+1) + e \, log(\bar{K}_2+1) - (\bar{J}_2+\bar{K}_2)c]$

Lemma 5a. If the ISP uses usage-based financing, if $n\bar{J}_2 \geq m$ then the optimal price for $Q_J = \frac{d}{\bar{J}_2+1} - (c+t)n\bar{K}_2 \geq m$. On the contrary if given the optimal price and with the profit of $Q_K = \frac{e}{\bar{K}_2+1} - (c+t)(m+n)(\frac{d\bar{J}_2}{\bar{J}+1} + \frac{e\bar{K}_2}{\bar{K}+1} - (c+t)\bar{J}_2 - (c+t)K_2) Q_J = \frac{d}{\bar{J}_1+1} - (c+t) Q_K = \frac{e}{\bar{K}_1+1} - (c+t)$

$$m \, (\frac{d\bar{J}_1}{\bar{J}_1+1} + \frac{e\bar{K}_1}{\bar{K}_1+1} - (c+t)\bar{J}_1 - (c+t)\bar{K}_1) + n \, (\frac{d\bar{J}_2}{\bar{J}_2+1} + \frac{e\bar{K}_2}{\bar{K}_2+1} - (c+t)\bar{K}_2 - (c+t)K_2)$$

Lemma 6a. If the ISP uses a two-part tariff financing scheme, then the optimal price is – (c+t), $Q_J = \frac{d}{\bar{J}_1+1}$ – (c+ $Q_K = \frac{e}{\bar{K}_1+1}$t), and with the maximum profit obtained it is: $Q = d \, log(\bar{J}_2+1) - (c+t) + e \, log(\bar{K}_2+1) - (c+t) - \left(\frac{d\bar{J}_2}{\bar{J}_1+1} + \frac{e\bar{K}_2}{\bar{K}_1+1}\right)$

$$m[d \, \frac{\bar{J}_1 - \bar{J}_2}{\bar{J}_1+1} + e \frac{\bar{K}_1 - \bar{K}_2}{\bar{K}+1}] \, (m+n) \, [d \, log(\bar{J}_2+1) - (c+t) + e \, log(\bar{K}_2+1) - (c+t)]$$

b. Modified Models in Heterogeneous Consumers for Linear Utility Functions

By using a similar proof as in previous utility function, the following lemma is obtained.

Modified Models in Upper-class and Lower-Class Heterogeneous Consumers are presented as follows.

Lemma 1b. If the ISP uses flat fee financing, then the price charged to the consumer becomes $Q = d_2\bar{J} + e_2\bar{K} - (\bar{J}+\bar{K})c$ and the maximum profit obtained is $(m+n)(d_{\,2}\bar{J} + e_2\bar{K} - (\bar{J}+\bar{K})c)$

Lemma 2b. If the ISP uses usage-based financing, then the optimal price is and with the maximum profit obtained is $Q_J = d_2 - (c+t) Q_J = e_2 - (c+t)$

$$(m+n)(d_2\bar{J} + e_2\bar{K} - (c+t)\bar{J} - (c+t)\bar{K})$$

Lemma 3b. If the ISP uses a *two-part tariff* financing scheme, then the optimal price is, and with the maximum profit obtained is $Q_J = d_2 - (c+t) Q_K = e_2 - (c+t) Q = 0$

$(m+n)(d_2\bar{J} + e_2\bar{K} - (c+t)\bar{J} - (c+t)\bar{K})$.

Modified Models in Heterogeneous Consumers of High Usage Rates and Low Usage Rates

Lemma 4b. If the ISP uses flat fee financing, then the fees paid and the maximum profit obtained are $d\bar{J}_2 + e\bar{K}_2 - (\bar{J}_2+\bar{K}_2)c \; (m+n)[d\bar{J}_2 + e\bar{K}_2 - (\bar{J}_2+\bar{K}_2)c]$

Lemma 5b. If the ISP uses usage-based financing, then the optimal price is and with the maximum profit obtained is: $Q_J = d - (c+t) Q_K = e - (c+t)$

$m(d\bar{J}_1 + e\bar{K}_1 - (c+t)J_1 - (c+t)\bar{K}_1) + n(d\bar{J}_2 + e\bar{K}_2 - (c+t)\bar{J}_2 - (c+t)\bar{K}_2)$.

Lemma 6b: If the ISP uses a two-part financing rate, then the optimal price is, , and with the maximum profit obtained is: $Q_J = d - (c+t) Q_K = e - (c+t) Q = 0$

$$m(d\bar{J}_1 + e\bar{K}_1 - (c+t)\bar{J}_1 - (c+t)\bar{K}_1) + n(dJ_2 + eK_2 - (c+t)\bar{J}_2 - (c+t)\bar{K}_2)$$

Based on the calculations that have been carried out for heterogeneous consumers, the following results are obtained. Based on Table V the maximum profit obtained on the modified cobb-douglas utility function is IDR.13.456/kbps obtained when using the flat fee and two-part tariff financing scheme, while in the linear utility function the maximum profit obtained is when using the flat fee financing scheme , which is IDR. 382,687/kbps. From the above lemmas, the nonlinear utility function reach better solutions with flat fee schemes.

TABLE V. MAXIMUM PROFIT FOR HETEROGENEOUS CONSUMERS

Financing Scheme	Utility Functions			
	Cobb-douglas		Linear	
	Types of consumers			
	Upper and Lower Class	High and Low Usage Rates	Upper and Lower Class	High and Low Usage Rates
Flat fee	13.456	10.034	382.687	100.276
Usage-based	0.844	7.568	300.69	240.553
Two-part tariff	13.456	12.125	300.69	240.553

IV. CONCLUSION

Based on the discussion and analysis results for the problem of optimizing internet service financing schemes with supervision costs and marginal costs, it can be concluded that the optimal solution obtained for heterogeneous consumers is optimized and analytically for customer preference-based heterogeneous customers, using the utility function cobb-douglas modification of its maximum profit when using *flat* fee financing schemes and two-part tariff is IDR.13.456/kbps. In the linear utility function, the maximum profit when using the flat fee financing scheme is IDR. 382,687/ kbps.

ACKNOWLEDGMENT

The research/publication of this article was funded by DIPA of Public Service Agency of Universitas Sriwijaya 2022. SP DIPA-023.17.2.677515/2022 on December 13, 2021. In accordance with the Rector's Decree Number:0109/UN9.3/SK/2022, on April 28, 2022.

REFERENCES

[1] I. Hanggiasyifa, "The effect of service quality on customer satisfaction and customer loyalty," *J. Pustak. Indones.*, vol. 18, no. 1, pp. 42–53, 2020.

[2] J. Hwang, D. Lee, and K. Lee, "Internet Pricing and Network Neutrality: How Internet Pricing Schemes Affect the Incentives of Internet Service Providers," *Int. Telecommun. Policy Rev.*, vol. 18, no. 1, pp. 17–44, 2011.

[3] E. Ronald, S. Moningkey, and P. Kapele, "Analisa Quality of Service Jaringan Komputer Di Smk Kristen I Tumohon," *Eng. Educ. J.*, vol. 5, no. 1, pp. 1–7, 2017.

[4] F. M. Puspita and M. Oktaryna, "Improved bundle pricing model on wireless internet pricing scheme in serving multiple qos network based on quasi-linear utility function," 2017.

[5] A. Chowdhury and S. A. Raut, "A survey study on Internet of Things resource management," *J. Netw. Comput. Appl.*, vol. 120, pp. 42–60, 2018.

[6] L. Audah, Z. Sun, and H. Cruickshank, "QoS based Admission Control using Multipath Scheduler for IP over Satellite Networks," *Int. J. Electr. Comput. Eng.*, vol. 7, no. 6, pp. 2958–2969, 2017.

[7] O. S. Itani, F. Jaramillo, and B. Paesbrugghe, "Between a rock and a hard place: Seizing the opportunity of demanding customers by means of frontline service behaviors," *J. Retail. Consum. Serv.*, vol. 53, no. May 2019, p. 101978, 2020.

[8] Indrawati, F. M. Puspita, E. Yuliza, O. Dwipurwani, Y. E. Putri, and Affriyanti, "Improved cloud computing model of internet pricing schemes based on Cobb-Douglas utility function," in *Journal of Physics: Conference Series*, 2019, vol. 1282, no. 1.

[9] M. U. H. Uzir *et al.*, "The effects of service quality, perceived value and trust in home delivery service personnel on customer satisfaction: Evidence from a developing country," *J. Retail. Consum. Serv.*, vol. 63, no. April, p. 102721, 2021.

[10] I. Indrawati, F. M. Puspita, R. Resmadona, E. Yuliza, O. Dwipurwani, and S. Octarina, "Analysis of Information Service Pricing Scheme Model Based on Customer Self-Selection," *Sci. Technol. Indones.*, vol. 6, no. 4, 2021.

[11] Y. Liu, Y. Li, Q. Ma, S. Ioannidis, and E. Yeh, "Fair caching networks," *Perform. Eval.*, vol. 143, p. 102138, 2020.

[12] T. Denoeux and P. P. Shenoy, "An Axiomatic Utility Theory for Dempster-Shafer Belief Functions," in *Proceedings of the Eleventh International Symposium on Imprecise Probabilities: Theories and Applications*, 2019, vol. 103, pp. 145–155, [Online]. A

[13] M. F. Quaas, S. Baumgärtner, M. A. Drupp, and J. N. Meya, "Intertemporal utility with heterogeneous goods and constant elasticity of substitution," *Econ. Lett.*, vol. 191, p. 109092, 2020.

[14] F. M. Puspita, A. Wulandari, E. Yuliza, R. Sitepu, and Yunita, "Modification of Wireless Reverse Charging Scheme with Bundling Optimization Issues," 2020.

[15] P. Bhattacharya, "A Growth Framework Using the Constant Elasticity of Substitution Model," *J. Appl. Math. Phys.*, vol. 05, no. 11, pp. 2183–2195, 2017.

[16] S. Y. Wu and R. D. Banker, "Best pricing strategy for information services," *J. Assoc. Inf. Syst.*, vol. 11, no. 6, pp. 339–366, 2010.

[17] R. Sitepu, F. M. Puspita, H. Tanuji, and I. P. Novyasti, "Cobb-Douglas Utility Function Of Information Service Pricing Scheme Based On Monitoring And Marginal Costs," 2016.

[18] P. Alexander, M. Alexander, and K. Ilya, "Long-term iron ore price modeling: Marginal costs vs. incentive price," *Resour. Policy*, vol. 38, no. 4, pp. 558–567, 2013.

[19] L. M. Hitt and P. Y. Chen, "Bundling with customer self-selection: A simple approach to bundling low-marginal-cost goods," *Manage. Sci.*, vol. 51, no. 10, pp. 1481–1493, 2005, doi: 10.1287/mnsc.1050.0403.

[20] Indrawati, Irmeilyana, F. M. Puspita, and M. P. Lestari, "Cobb-Douglass utility function in optimizing the internet pricing scheme model," *Telkomnika (Telecommunication Comput. Electron. Control.*, vol. 12, no. 1, 2014.

[21] N. Zheng and N. Geroliminis, "Area-based equitable pricing strategies for multimodal urban networks with heterogeneous users," *Transp. Res. Part A Policy Pract.*, vol. 136, no. April, pp. 357–374, 2020,.

UNIVERSITAS TEKNOLOGI DIGITAL INDONESIA

5th ISRITI

Certificate

This certificate is presented to:

Indrawati, Fitri Maya Puspita, Evi Yuliza, Eka Susanti, Sisca Octarina, Intan Lestari

As Author(s) for Paper:

Information Services Financing Scheme Model with Marginal Costs and Supervisory Costs for Modified Cobb-Douglas and Linear Utility Functions

For outstanding contribution in the 5th 2022 International Seminar On Research Of Information Technology And Intelligent Systems (ISRITI), Organized by Universitas Teknologi Digital Indoneisa, Yogyakarta, Indonesia.

Yogyakarta, 8 December 2022

General Chair,

Dr. Widyastuti Andriyani, M.Kom.

IEEE Advancing Technology for Humanity

IEEE INDONESIA SECTION

UTDI IEEE Student Branch

UNIVERSITAS TEKNOLOGI DIGITAL INDONESIA

Yogyakarta, 8 December 2022