Implication for the Incidence of Wastewater Treatment Charges: Estimates from Bangkok Households' Demands[1]

Nantarat Tangvitoontham[2]

Faculty of Economics, Chulalongkorn University

Abstract

This study determines the effects of the wastewater treatment charge of Bangkok Metropolitan Administration using partial equilibrium analysis. We use Linear Expenditure System (LES) to estimate households demand patterns. Measuring households' surplus change by using equivalent variation confirms that the charge is regressive. We found that households lose their surplus 42.579 baht per household per month. The policy affects decreasing in household's water consumption by 8.105 percent and directly decreasing wastewater discharged at the same proportion. The result proves that the policy, imposing the charge at 2 baht per m^3, encourages net social welfare gains.

Field: Environmental Economics

Introduction

Bangkok Socio Economics and Wastewater Overview

Bangkok is located in the central part of the country on the low-flat plain of the Chao Phraya River. Bangkok was established in 1782 as the new capital of Thailand.

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[2] Ms Nantarat Tangvitoontham, Ph.D. Student in Faculty of Economics, Chulalongkorn University, Thailand. E Mail: ntploy@yahoo.com

Nowadays the city comprises of 50 districts. Bangkok is the growth centre of the whole kingdom with total area of 1,568.737 square kilometers. The population density is 7,643 persons per km^2 with estimated 2,000,000 households in Bangkok area or about 10 million inhabitants.

Total revenue of Bangkok Metropolitan Administrative is 43,612 million baht in year 2006. The revenues from taxes and duties account for 80 percent of all revenues. More than 70 percent of public expenditures are used for public service and social purposes. BMA spends about 12.86 percent of all its expenses for public cleansing and 11.44 percent for wastewater treatment, water drainage and sewerage disposal.[3]

Increasing population and rapid urbanization brought about number of infrastructures and other constructions to Bangkok. This very density populated city is currently facing some unavoidable urban pollution problems. Like any other large city, Bangkok has developed without a proper plan. The city has undergone many changes towards increased urbanization including the switching from water transportation to roadway transportation. Canals and river became a throwing away site of unwanted water and trashes from households living along the river bank and from those living farther away. Wastewater from the residential community constantly deteriorated the city's canals and river creating bad smell and bad scene of the city. The total wastewater from all areas is approximately 938.32 million m^3 per year in 2006 which increase by 33.23 percent from year 2002. Also, the volume of wastewater is estimated to increase by 15 percent in the next five years. Additionally, wastewater from the residential area including wastewater from houses, apartment, dormitory, and village accounted for 60 percent of all wastewater discharged or about 563 million m^3 per year.[4] BMA has recently built seven municipal centralized wastewater management plants. Some plants are already in operation and some plants are under construction. Moreover, BMA has been assigned the responsibility to operate 12 community plants by the National Housing Authority. The treatment capacity of BMA's wastewater treatment

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[3] Source: The budget expenditure appropriation report fiscal year 2006 , The Bangkok Metropolitan Administration Budget Department

[4] Source: Annual report fiscal year 2006, Investment Planning and Information Division, Metropolitan Water Authority

plants is 1.03 million m^3 per day or approximately 365 million m^3 per year. In other words, Bangkok's treatment plants can treat only 65 percent of all discharged wastewater from the residential area. Moreover, BMA faces an additional problem. Due to the uncompleted pipe system, the discharged water pipe systems can collect the wastewater and distribute to the treatment plants only 0.48 million m^3 per day or approximately 175 million m^3 per year.[5] Therefore, besides wastewater treatment plants, BMA has to set up budgets for renovating and building discharged water pipe systems in order to efficiently collect the wastewater from the sources and distribute to the treatment plants.

For these reasons, BMA has to seek new tools to control water pollution and increase revenues. Economic instruments tend to be favored by economists in comparison to traditional command and control regulations due to their costs minimizing characteristics, encouraging dynamic efficiency, lowering informational requirements and relatively ease of administration. A wastewater charge seems to be more efficient and more effective compared to other tools. Moreover, the charge can be a new source of income due to generation of new clean-up activities and it can recover the operation cost of existing wastewater treatment plants. BMA plans to impose a wastewater treatment charge as a tool to eliminate wastewater discharge. The charge rate is set at 2 baht per m^3.

According to two research studies done on the residents living in Bangkok, the willingness to pay were found to be 1.8 baht per m^3 (Tapvong & Kruavan, 2003), and 3.29 baht per m^3 (Roomratanapan, 2000). Thus, the residential charge rate at 2 baht per m^3 should be satisfactory, even though BMA did not yet conduct research on a wastewater treatment charge's effects on consumer behaviors and welfare. Although the charge rate will be acceptable, the welfare effects are still ambiguous.

This paper aims to estimate the incidence of BMA's wastewater treatment charge on household tap water use by using households' perspective. We use Linear Expenditure System Approach (LES) to estimate households' demand in Bangkok. The model includes the following consumer product categories: food & beverage, personal

[5] Source: Wastewater discharged and water quality analysis, Water Drainage and Sewerage Management Department of Bangkok Metropolitan Administration

appearance, housing, tap water, transportation, education, tobacco & alcohol beverage, and medical care. This paper, consequently, measures the changes in welfare of Bangkok's households when BMA imposes wastewater treatment charge on the household tap water use in Bangkok.

This paper is organized as follows. Section 1 briefly presented the background to the study and the literature review and background. Section 2 introduces the model framework and research methodology. Section 3 specifies and estimates the econometric model of consumer demands. The section statistically summarizes of each commodity categorized; as well as, calculates elasticity of commodities and equivalent. It also includes the welfare effects of the policy.

Literature Review

We can classify demand function estimation into 2 main methods. First, it is direct method such as interviewing focus groups, samplings, survey on consumers, consumer clinic and market experiment. This method provides the primary data for estimation. Second is data analysis which known as indirect method. Normally, the study analysis time series data, cross section data and combination of both. This section aims to estimate the demand function by using households' perspective. There are several researches on data analysis of demand estimation.

Standard approaches to specifying and estimating demand systems that ignore the non – negativity constraints. Deaton (1986) found that the problem of dealing with zero expenditure is one of the most pressing in applied demand analysis. Then Lee and Pitt (1987) and Lee (1993) have proposed methods for estimating demand with binding non – negativity constraints. The approach is based on the Kuhn – Tucker conditions associated with a stochastic direct utility function. The development of discrete choice model was presented by Mc Fadden (1989). Contrary to discrete choice model, simulated method of moments for consumer demands with non – negativity constraints require more than a simple generation of random numbers.

According to earlier literatures, Almost Ideal Demand System (AIDS) is also well-known approach developed by Deaton and Muellbaure (1980). The advantage of this system is giving a first-order approximation to any demand system. It also imposes

neither separability nor homotheticity. The sample of the study which used AIDS in Thailand is Kardkarnklai (1992). She used partial equilibrium analysis to analyze the effects of carbon dioxide taxes on consumption expenditure. From demand estimation, she found that consumers mostly spend on their food and beverages, recreation and transportation, respectively. However, they reduced their consumption on food and beverages, transportation and recreation after imposing carbon dioxide taxes. She claimed that the proportion of private consumption to Gross Domestic Product (GDP) also decreased. Then Banks et al. (1997) said expenditures on some goods are non – linear in total expenditure or income while some are linear. Therefore, he decided to flexible functional form of consumer preferences, which can handle non – linear expenditure effect. This methods is called the quadratic extension. Brannlund and Nordstrom (2004) use the Quadratic Almost Ideal Demand System (QAIDS) model to determine the differences in consumption patterns between different household categories in order to examine the affect of the government policy on households' consumption.

Extended Linear Expenditure System (ELES) and Linear Expenditure System (LES) are also widely used. These two methods assume that consumer households are risk – neutral and maximize their utility subject to a budget constraint. This system is attractive because of its linear structures in expenditure. In other words, the expenditure on each good is a linear function of all prices, although it is restrictive in that the implied Engel curve is linear. The LES estimation is much more sensitive compared to ELES. The peculiarity of LES is erratic behavior - parameters. Yet, the set of parameters are roughly the same in both model. Unlike LES, ELES attempts to use income instead of total expenditure to complete demand system, but it can also be decomposed into the LES. This study intends to use LES which is normally used to estimate the demand for consumer products. This approach was pioneered by Stone (1954). Stone's approach has been generally used in the literature on private goods market by using either primary data or secondary data to estimate the coefficients. Linear Expenditure System is also appropriate for simultaneously estimating several equations. Then Pollak and Wales (1981) added demographic variables such as family size and age composition in the analysis of household budget data. Also, there are some researches using LES in

Thailand such as Arunsmit (1997), Sarntisart (1999), and Chomtohsuwan (2004). Arunsmit used LES as a part of CAMGEM – H. She found that households decreased their consumptions on transportation, chemical, and entertainment while the expenses on luxury goods increased during the recession in 1997. Sarntisart (1999) researched on effects of value added tax (VAT) on households' consumption. He also used LES to estimate demand of Thai's households. He found that VAT was regressive because the ratio of tax incidences to the total expenditure of high income households was more than low income households. Moreover, we can evaluate the incidence of taxes and welfare effects by estimating the consumption pattern of households. For instance, Sarntisart (1999) found that households loss their welfare about 104 baht or about 1,246 baht per month when government increased VAT rate from 7 percent to 10 percent. Moreover, there are other studies which examined the consequence of government policy; especially the tax policies, by estimating the consumption pattern such as Blundell (1993), Paris (2003) and West and Williams (2004).

Research Methodology

This study simplifies the determination of households' behavior by considering on their expenditure and prices of goods. Also, the model assumes that other factors remain constant. In our model, households receive income and transfers from other actors. Households use their income to pay for direct taxes, charges, fees, and their consumptions. The model includes eight consumer product categories: food & beverage, personal appearance, housing, transportation, education, tobacco & alcohol beverage, medical care and tap water.

This study will estimate the demand function of Bangkok's households for private goods according to Linear Expenditure System which is derived from utility maximization. This estimated system also assumes that expenditures are independent and do not depend on saving. The conditions which are necessary for Linear Expenditure System demand function are additively and homogeneity. Therefore, $\beta_i \geq 0$ and $\sum \beta_i = 1$. The model assumes that households maximized their utilities subject to their expenditure.

Maximize $U = \prod (c_i - \gamma_i)^{\beta_i}$ ---------- 1

Subject to $E = \sum P_i c_i$ ---------- 2

From equation 5.1 & 5.2, we can derive Marshallian demand for private goods accordingly.

$$c_i(P_i, E) = \gamma_i + \frac{\beta_i}{P_i}(E - \sum P_i \gamma_i) \quad \text{---------- 3}$$

where

U = households' utility

i = commodity; i = 1, 2, 3, . . ., n

c_i = consumption of private goods i

γ_i = committed levels of expenditure of commodity i

β_i = consumption expenditure share of commodity i

P_i = price of commodity i

E = total expenditure of household

From equation 3, we see that the households' consumption level depends on three components. They are the price of the goods, the prices of other goods and the households' expenditures. The unknown parameters, which we needed to estimate, are the committed levels of expenditure (γ_i) and the consumption expenditure share of commodities (β_i). The results and estimation method will be shown in the next section. We can classify households' expenses into 2 parts. First, the committed level of expenditure is the necessity of the consumption level of households. The households will spend until they reach the committed level to fulfill their basic needs. The second part is supernumerary expenditure. This part is not necessity and can more sensitive to prices.

To expand our analysis, elasticity is considered. Elasticity is a tool which is used for describing the relationship between variables. It is defined as the percentage change in a dependent variable caused by a percentage change in prices. This paper considers two types of elasticities. First, expenditure demand elasticity on commodities explains the responses of households' spending on each commodity when prices

change. Additionally, price elasticity is the necessity for analysis of households' behaviors. Price elasticity measures of the percentage change in quantity demanded of a commodity caused by a percentage change in a price when other factors remain unchanged. According to Llunch C. and Williams R (1975), own price elasticities, cross price elasticities and expenditure demand elasticities are calculated as follows:

$-\Phi = 1-\left(\frac{1}{E}\sum_{i=1}^{n} P_i\gamma_i\right)$ ---------- 4

$w_i = \frac{E_i}{E}$ ---------- 5

$\eta_i = \frac{\beta_i}{w_i}$ ---------- 6

$\varepsilon_{ij} = \phi\eta_i - \eta_i w_i(1+\phi\eta_i)$, i = j ---------- 7a

$= -\eta_i w_j(1+\phi\eta_j)$, i ≠ j ---------- 7b

$\varepsilon_{ij}^* = \eta_i(1-\beta_i)\phi$, i = j ---------- 8a

$= -\eta_i\beta_j\phi$, i ≠ j ---------- 8b

Also, the above inequalities hold $\varepsilon_{ii,}\varepsilon_{ii}^* < 0$, $\varepsilon_{ij} < 0$ and $\varepsilon_{ij}^* > 0$ for i ≠ j, where

$-\Phi$ = supernumerary ratio

w_i = expenditure share of commodity i

η_i = expenditure demand elasticity of commodity i

ε_{ij} = uncompensated price elasticity

ε_{ij}^* = compensated price elasticity

The expenditure demand elasticity is the tool to categorize goods into luxury and necessity while price elasticities are the tool to determine the relationship among variables. The calculation of elasticities and the analysis are presented in the next section.

Estimation and Results

Data, variable derivation, and summary statistics

According to the section above, to analyze households' expenditure behaviors in Bangkok area, prices and expenditures data are required. In this empirical study, the socio-economic survey (SES) of year 2002, 2004 and 2006 is used as a main component. The SES collected data from households in Bangkok area monthly. The data include the total expenditures of each household in Bangkok area and amount of expenditures of each household on each good such as the expenditure of household$_i$ on consumption and non-consumption goods such as food & beverages, personal care, transportation, reading, insurance premiums, and interest. The data also include a wide variety of household income measures such as income from pension payments, property and loans. However, the demand function estimation in this analysis focuses only on the expenditure of consumption goods of households.

This study used the pooled data method which is the combination set of both a cross-sectional and a time-series component. The total numbers of Bangkok area observations were 6,778. The total consumption expenditure equals to the amount spent on food & beverage, personal appearance, housing, tap water, transportation, education, tobacco & alcohol beverage, and medical care. In order to clearly analyze the effects of the policy on households' behaviors, we also categorized households into three categories which are low income households, medium income households, and high income households.

From the literature, the low income level households are the households whose incomes lower than the poverty line. From the SES data, we found that 99 percent of households' incomes in Bangkok area are above the poverty line. The households which are considered as low income households in this study have current monthly incomes lower than minimum income levels which have to pay income taxes. There are 2,069 observations in low income households. For the medium income households, we consider households whose monthly incomes are range between minimum income levels which have to pay income taxes to 50,000 baht per household per month. The observations of medium income households are 3,558. The high income households' incomes are equal to and higher than 50,001 baht per household per month which are 1,151 observations. As you can see, more than half of Bangkok households are classifying in medium income level which accounted for 52.49 percent. 30.52 percent

are low income households and the least are high income household which accounted for 16.98 percent of all.

In order to estimating demand function, the prices of commodities are also needed. The price data of food & beverage, tobacco & alcohol, personal appearance, housing, medical care, transportation, and education are from the Consumer Price Index (CPI) provided by the Interior Commerce Department, Ministry of Commerce. The CPI of water is available at Investment Planning and Information Division, Metropolitan Water Authority.

Table 1: Statistical Summary of Each Commodity Categorized

Commodity Categories	Mean Expenditure of Each Income Level				Weight	Expenditure Share of Each Income Level			
	Low	Medium	High	TOTAL		Low	Medium	High	TOTAL
Food & beverages	2664.4630	4799.2847	7367.1364	4410.474	5462.3	0.4071	0.3585	0.2064	0.2909
Tobacco Product & alcoholic beverages	245.7081	324.0579	349.4570	302.8573	473.75	0.0379	0.0243	0.0098	0.0193
Personal Appearances	305.9952	690.1563	2539.1529	922.145	509.97	0.0495	0.0537	0.0744	0.1911
Housing	1356.8304	2586.6900	7293.0686	3233.802	3557.56	0.2172	0.1813	0.2137	0.1279
Medical care	188.8376	464.7097	1221.9505	546.1262	824.58	0.0307	0.0360	0.0356	0.0323
Transportation	1018.6501	3172.8367	11961.4170	4300.367	2206.6	0.1926	0.2553	0.3592	0.2544
Education	277.9232	930.2662	3031.4613	1169.327	939.68	0.0441	0.0724	0.0891	0.0691
Tap water used	132.8014	242.8673	406.4596	236.8781	177.46	0.0211	0.0186	0.0117	0.0150
Total Consumption Expenditure	7026.0960	15767.6759	42313.7732	17476.76		1	1	1	1

Source: Socio Economic Survey

Table 1 provides a summary of statistics for the Bangkok households' expenditures. We found that Bangkok's households average expenditures are 17476.76 baht per month. They spent mainly on food & beverages compared to other commodities. The average expenditure of this commodity is 29.09 percent of all , or equals to 4410.474 baht per month per household, followed by transportation, housing, education, personal appearance, medical care and tobacco & alcoholic beverages which are 4300.367, 3233.802, 1169.327, 922.145, 546.1262, and 302.8573 baht per household per month, respectively. For commodity weight, Interior Commerce Department judges according to the necessity and average expenditure of goods, so the weight is heavier on food & beverages follows by housing, transportation, education, medical care, personal appearance, tobacco & alcoholic beverages and water used, respectively. Tap water is normally a component of housing category while we consider tap water expenditure as another commodity category in our model. Consequently, the expenditure share of this commodity is the least proportion, equaling to 1.50 percent. Expenditure on food & beverages also gets the highest share which accounts for 29.09 percent.

We also found that the first three consumption goods which households in each income level spent mainly on the same categories which are food & beverages, transportation, and housing though the order are different. Low income and medium income households spent on food & beverages in the most proportion while high income households spent on transportation. However, high income and medium income households spent on housing in the third order as low income households spent on transportation in the third order. Moreover, the last three consumption goods which Bangkok's households spent slightest are the same categories which are medical care, tobacco product & alcoholic beverages, and tap water. The order also differs among each income level. Low income and medium income households spent smallest amount on tap water although high income households spent least on tobacco product & alcoholic beverages. High income and medium income households spent on medical care more than tobacco product & alcoholic beverages even though low income households spent on tobacco product & alcoholic beverages more than medical care.

For the low income households, their average consumption expenditures are 7,026.096 baht per household per month. They spent a large amount on food & beverages and equals to 4,266.46 baht per household per month, accounted for 40.71 percent of all, followed by housing, transportation, personal appearance, education, tobacco & alcoholic beverages, medical care and tap water which are 1,356.83, 1,018.65, 305.995, 277.92, 245.70, 188.84, and 132.80 baht per household per month respectively.

Same as low income households, the medium income level spent mainly on food & beverages and equals to 4266.46 baht per household per month, accounted for 35.85 percent of all, followed by transportation, housing, education, personal appearance, medical care, tobacco & alcoholic beverages, and tap water which are 3,172.84, 2,586.69, 930.27, 690.16, 464.71, 324.06, 242.87 baht per household per month respectively. Their average consumption expenditures are 15,767.676 baht per household per month.

Finally, the high income households' average consumption expenditures are 42,313.773 baht per household per month. Unlike low income and medium income households, they spent most on transportation which equals to 11,961.417 baht per household per month, accounted for 35.92 percent of all, followed by food & beverages, housing, education, personal appearance, medical care, tap water and tobacco & alcoholic beverages which are 7,367.14, 7,293.07, 3,031.46, 2,539.15, 1,221.95, 406.46, and 349.46 baht per household per month respectively.

System Estimation and Results

Since the demand estimation contains a number of linear equations and they have the same parameter vector, it would be unrealistic to expect that the equation errors would be uncorrelated. Our estimation of each equation uses the same data set, so they have possibilities that the errors may be correlated across the equations. Thus, the equations seem independent of each other, but the equations are related through the correlation in the errors. Seemingly Unrelated Regression (SUR) model estimation; therefore, is obtained in this study. It is a technique for analyzing a system of multiple

equations with cross-equation parameter restrictions and correlated error terms. In other words, SUR is an extension of the linear regression model which allows correlated errors between equations. Thus, rather than estimating the system equations individually by least squares, the method of SUR is applied.

In this study, we separate private goods in our model into eight categories which are food & beverage, personal appearance, housing, tap water, transportation, education, tobacco & alcohol, and medical care. This study uses partial equilibrium analysis based on Linear Expenditure System to estimate the demand of private consumption. According to section 2, the demand functions of all categories can be written as follows:

$$fb(P_i, E) = \gamma_{fb} + \frac{\beta_{fb}}{P_{fh}}(E - \sum P_i\gamma_i) \quad \text{---------- 9a}$$

$$pa(P_i, E) = \gamma_{pa} + \frac{\beta_{pa}}{P_{pa}}(E - \sum P_i\gamma_i) \quad \text{---------- 9b}$$

$$h(P_i, E) = \gamma_{h} + \frac{\beta_{h}}{P_{h}}(E - \sum P_i\gamma_i) \quad \text{---------- 9c}$$

$$trn(P_i, E) = \gamma_{trn} + \frac{\beta_{trn}}{P_{trn}}(E - \sum P_i\gamma_i) \quad \text{---------- 9d}$$

$$edu(P_i, E) = \gamma_{edu} + \frac{\beta_{edu}}{P_{edu}}(E - \sum P_i\gamma_i) \quad \text{---------- 9e}$$

$$med(P_i, E) = \gamma_{med} + \frac{\beta_{med}}{P_{med}}(E - \sum P_i\gamma_i) \quad \text{---------- 9f}$$

$$tal(P_i, E) = \gamma_{tal} + \frac{\beta_{tal}}{P_{tal}}(E - \sum P_i\gamma_i) \quad \text{---------- 9g}$$

$$w(P_i, E) = \gamma_{w} + \frac{\beta_{w}}{P_{w}}(E - \sum P_i\gamma_i) \quad \text{---------- 9h}$$

where

fb = food & beverage demand

pa = personal appearance demand

h = housing demand

trn = transportation & communication demand

edu = education, recreation & reading demand

med = medical care & personal care demand

tal = tobacco & alcohol beverage demand

w = water demand

E = total expenditure of household

i = fb, pa, h, trn, edu, med, tal, or w

The estimated coefficients, the committed levels of expenditure (γ_i) and the consumption expenditure share of commodities (β_i) are presented in table 2. The results show that coefficients have high level of statistical significance which is indicated by the value of the probabilities. Also, we found that all key variables have the expected sign ($\beta_i \geq 0$ and $0 < \gamma_i < c_i$). First, committed consumption level (γ) is discussed. It means the minimum expenditure, which household spends on each category. We found that committed consumption levels are all positive. All Bangkok households' minimum expenditure on food & beverage, tobacco & alcohol, personal appearance, housing, medical care, transportation, education, and tap water are 2722.1795, 249.9476, 502.7559, 943.7221, 235.7066, 564.7852, 530.5887, and 165.0788 bath per household per month, successively. Considering by the households' types and minimum level of expenditures, we found that households, which have higher incomes, pay higher in minimum level of consumption in each category.

For example, high income households pay for the minimum level of consumption on food & beverage equal to 4075.7285 bath per household per month which higher than medium income level households. Also, medium income level households pay for the minimum level of consumption on food & beverage equal to 2120.7529 bath per household per month which higher than low income level households

The marginal budget share also means that every increase in expenditure of households will increase spending on each product equal to β. For example, if Bangkok households increase their expenditure by one bath, they will increase their spending on food & beverage equal to 0.1165 baht and on housing equals to 0.2050 baht. Also, they spend on tobacco & alcohol, personal appearance, medical care, transportation, education, and tap water accordingly.

Table 2: Coefficient Estimation of Bangkok Households' Demand Function

Household Categories	Goods Categories	β	Prob	γ	Prob
Average Households	Food & Beverage	0.1165	0.0000	2722.1795	0.5186
	Tobacco Product & Alcohol Beverage	0.0033	0.0000	249.9476	0.0000
	Personal Appearance	0.0389	0.0000	502.7559	0.0000
	Housing	0.2050	0.0000	943.7221	0.0000
	Medical Care	0.0271	0.0000	235.7066	0.0000
	Transportation	0.3401	0.0000	564.7852	0.0000
	Education	0.0575	0.0000	530.5887	0.0000
	Tap Water	0.0050	0.0000	165.0788	0.0000
Low Income Household	Food & Beverage	0.3844	0.0000	610.7906	0.0000
	Tobacco Product & Alcohol Beverage	0.025	0.0000	111.4608	0.0000
	Personal Appearance	0.0128	0.0000	246.2507	0.0000
	Housing	0.1069	0.0000	827.3539	0.0000
	Medical Care	0.0391	0.0000	0.2751	0.9440
	Transportation	0.2139	0.0000	138.2974	0.0000
	Education	0.0558	0.0000	2.7093	0.8196
	Tap Water	0.0068	0.0000	90.6218	0.0000
Medium Income Household	Food & Beverage	0.2232	0.0000	2120.7529	0.0000
	Tobacco Product & Alcohol Beverage	0.0095	0.0000	210.1851	0.0000
	Personal Appearance	0.0086	0.0000	608.5461	0.0000
	Housing	0.1438	0.0000	830.0886	0.0000
	Medical Care	0.0361	0.0000	83.664	0.0001
	Transportation	0.2736	0.0000	371.1243	0.0002
	Education	0.0487	0.0000	421.7977	0.0000
	Tap Water	0.0045	0.0000	180.0343	0.0000
High Income Household	Food & Beverage	0.0930	0.0000	4075.7285	0.0000
	Tobacco Product & Alcohol Beverage	0.0021	0.0021	270.4575	0.0000
	Personal Appearance	0.0298	0.0000	1701.0158	0.0000
	Housing	0.2157	0.0000	1131.1115	0.0144
	Medical Care	0.0197	0.0000	640.3594	0.0000
	Transportation	0.3279	0.0000	2562.2148	0.0000
	Education	0.0392	0.0000	1916.1523	0.0000
	Tap Water	0.0038	0.0000	270.3529	0.0000

Source: Estimated using Eview 4.1

Additionally, we found that households will increase their spending most on transportation which equals to 0.3401, followed by housing, food & beverage, education, personal appearance, medical care, and tap water successively. They spend the least on tobacco product & alcohol beverage.

Next, marginal budget shares (β) are all positive. The marginal budget share of on food & beverage, tobacco & alcohol, personal appearance, housing, medical care, transportation, education, and tap water are 0.1165, 0.0033, 0.0389, 0.2050, 0.0271, 0.3401, 0.0575, and 0.0050, respectively for overall households in Bangkok area.

According to the table, we found that the marginal budget shares on food & beverage of lower income households are more than higher income households. Like food & beverage, lower income households spend their money on tobacco product & alcohol beverage, medical care, education and tap water in the higher proportion than higher income households. However, the marginal budget shares on housing and transportation are different. The reason is higher income households have more extra money to spend or buy other goods than lower income households. Moreover, higher income households always choose to spend the money on more luxury houses and transportations compare to lower income households. Therefore, higher income households expend their money on both categories in higher proportion than lower income households.

Noticeably, the marginal budget share of personal appearance of high income households is higher than medium and low income households. As we mention before, the high income households have more extra money to buy more expensive goods. They can buy brand name clothes, accessories, shoes and even luxury jewelry while low income households and medium income households just spend their money on normal personal appearance goods. However, the marginal budget share of this category of medium income households is lower than low income households. The pattern of consumptions of these 2 types of households are almost the same but the amount of money that low income households can allocate are more limited than medium income households. Therefore, based on the money in the pockets, low income households have to spend on personal appearance goods in higher proportion than medium income households.

Elasticity

The expenditure demand elasticity can identify the necessity and luxury goods. If the elasticity is greater than 1, it means that the good is a luxury good. However, if the elasticity is less than 1, it implies that the good is a necessity good. In economics, a luxury good is a good for which demand increases more than proportionally as income rises, in contrast to a necessity good for which demand increases less than proportionally as income rises. Luxury goods are said to have high income elasticity of demand. A good may become a normal good, a luxury good or even an inferior good at different income levels.

Table 3: Expenditure Demand Elasticity

Category of Goods	Expenditure Demand Elasticity			
	Low Income Household	Medium Income Household	High Income Household	All Households
Food & Beverages	0.9444	0.6226	0.4504	0.4742
Tobacco Products & Alcohol Beverages	0.6596	0.3908	0.2140	0.1931
Personal Appearance	0.2590	0.1596	0.4008	0.7242
Housing	0.4922	0.7932	1.0094	1.1058
Medical Care	1.2760	1.0022	0.5523	0.8665
Transportation	1.1106	1.0717	0.9128	1.3373
Education	1.2651	0.6727	0.4402	0.8514
Water	0.3219	0.2391	0.3230	0.3701

Source: Own calculation

From table 3, we found that transportation and housing are luxury goods while other products are necessity for overall Bangkok households' perspectives in average household category. The expenditure demand elasticity for food & beverage, tobacco products & alcohol beverages, personal appearance, housing, medical care, transportation, education, and water are 0.4742, 0.1931, 0.7242, 1.1058, 0.8665, 1.3373, 0.8514, 0.3701, respectively.

Noticeably, transportation is a luxury good because the expenditure data which provided by SES include expenditure on public and private transportation as well as expenditure on local transportation, travel expenses, domestic trip, out bound tours, souvenir during the out bound tour, vehicle purchase, fuel, maintenance costs and all vehicle operations. The expenditure on public transportation which is considered as a necessity good is a very small proportion compared to other kinds of transportation expenses which are considered as luxury goods. Transportation, moreover, includes communication expenses. The consumption of communication is more fashionable, so the communication products are sensitive to prices compare to other goods. Therefore, the results turn out to support that transportation is the luxury good in Bangkok households' perspectives. Same as transportation, housing is luxury. The expenditure data include rent, electricity, maintenance, local servant services, major and minor equipments such as microwave, bed, sofa, refrigerators, linen, and curtains. Thus the expenses on luxury equipment, furnishers and facilities have more proportion than the necessity expend on housing.

We would like to intensely consider into each type of households. Normally, food & beverages, personal appearance, and tap water are necessary for basic living. According to the expenditure demand elasticity, they are reasonable necessity goods for all household types. Tobacco products & alcohol beverages are also necessity goods. Since whisky, beer and cigarettes are addicted products, households maintain the consumption in both regularity and frequency despite income changes. On the other hand, housing, medical care, transportation, and education are considered differently among each type of households. Medical care is considered as a luxury good for low income households and medium income households while it is necessity for high income households. From the data providing by SES, medical care includes

public & private health services, public & private hospitals, traditional medical services, modern drugs, traditional drugs, and herbal drugs even spa and massage therapy. As you can see, the special medical care services and drugs are larger proportion than basic medical care services. Additionally, since most of the households in these 2 types normally use the government medical care program. Also, most of them use the social security's medical care benefit. They do not pay the other special services. They will design to pay the extra special medical care services which are more expensive even when their incomes increase. In contrast, medical care is the necessity goods for high income households because they habitually spend their money on special medical services, expensive drugs, spa and massage. High income households satisfy to pay for medical care in order to protect the disease unlike the lower income households. Lower income households will pay for the services only if they already got the disease and it is very serious. Otherwise, they may choose not to cure rather than spend their money on the services because they think they have other essential and more important things to spend on at the same amount of money.

Like medical care, transportation, is considered as a luxury good for low income households and medium income households while it is necessity for high income households. The explanations are the same as medical care service. The luxury transportation, travel products, vehicle purchases and vehicle operation such as taxi, private cars, ferry, domestic trip, out bound tour, and gasoline are larger proportion than basic public services such as bus and train. Low and medium income households normally use the pubic transportation, but they easily switch to more expensive transportation such as Bangkok Mass Transit System (BTS) and taxi in the beginning of the month. Moreover, the installment program and promotion, such as zero percent down payment, increase opportunity for medium income households to buy their own private cars. They have to keep a fixed amount of money to pay the installment monthly which affects demand on private car increasing more than proportionally as income rises. However, high income households use the luxury transportation as a part of their lives and works. They, additionally, spend on leisure such as travelling both domestic and outbound trip during the weekend while low and medium income households will travel only on the national holiday.

As housing is a basic necessity of life, it is considered as a necessity good for medium income households and low income households. Nevertheless, high income households usually spend on expensive and designed furniture and facilities, which they can express their luxury life styles. It is therefore considered a luxury good for high income households. Education is considered as a luxury good for low income households while it is necessity for high income households and medium income households. Since low income households concern more about the products that necessity for the living such as food & beverages, than they will spend their extra money to education. Moreover, most of low income households normally use the free public education provision which provides by BMA while medium and high income households regularly use the private educational institutions with high tuition fees. The low income households spend only on the accessories such as uniforms, books and stationery which are very small amount compared to tuition fee.

Table 4.1: Uncompensated and Compensated Price Elasticities for Average Households

Categories of Goods	Uncompensated Demand Elasticity								Compensated Demand Elasticity							
	Food & Beverages	Tobacco Products & Alcohol Beverages	Personal Appearance	Housing	Medical Care	Transportation	Education	water	Food & Beverages	Tobacco Products & Alcohol Beverages	Personal Appearance	Housing	Medical Care	Transportation	Education	water
Food & Beverages	-0.1929	-0.0070	-0.0137	-0.0259	-0.0066	-0.0178	-0.0146	-0.0049	-0.2672	0.0010	0.0118	0.0620	0.0082	0.1028	0.0174	0.0015
Tobacco Products & Alcohol Beverages	-0.0331	-0.1207	-0.0056	-0.0106	-0.0027	-0.0072	-0.0060	-0.0020	0.0143	-0.1227	0.0048	0.0252	0.0033	0.0419	0.0071	0.0006
Personal Appearance	-0.1241	-0.0107	-0.4191	-0.0396	-0.0101	-0.0271	-0.0223	-0.0075	0.0538	0.0015	-0.4439	0.0947	0.0125	0.1570	0.0265	0.0023
Housing	-0.1895	-0.0164	-0.0319	-0.4298	-0.0155	-0.0414	-0.0341	-0.0115	0.0821	0.0023	0.0274	-0.5605	0.0191	0.2398	0.0405	0.0035
Medical Care	-0.1485	-0.0128	-0.0250	-0.0474	-0.5203	-0.0324	-0.0267	-0.0090	0.0644	0.0018	0.0215	0.1133	-0.5376	0.1879	0.0318	0.0028
Transportation	-0.2291	-0.0198	-0.0386	-0.0731	-0.0187	-0.3459	-0.0413	-0.0139	0.0993	0.0028	0.0331	0.1748	0.0231	-0.5628	0.0490	0.0043
Education	-0.1459	-0.0126	-0.0246	-0.0466	-0.0119	-0.0319	-0.4750	-0.0088	0.0632	0.0018	0.0211	0.1113	0.0147	0.1846	-0.5117	0.0027
Water	-0.0634	-0.0055	-0.0107	-0.0202	-0.0052	-0.0139	-0.0114	-0.2316	0.0275	0.0008	0.0092	0.0484	0.0064	0.0802	0.0136	-0.2348

Source: Own calculation

Table 4.2: Uncompensated Price Elasticity

Categories of Goods	Low Income Level								Medium Income Level								High Income Level							
	Food & Beverages	Tobacco Products & Alcohol Beverages	Personal Appearance	Housing	Medical Care	Transportation	Education	water	Food & Beverages	Tobacco Products & Alcohol Beverages	Personal Appearance	Housing	Medical Care	Transportation	Education	water	Food & Beverages	Tobacco Products & Alcohol Beverages	Personal Appearance	Housing	Medical Care	Transportation	Education	water
Food & Beverages	-0.137	-0.019	-0.038	-0.135	-0.003	-0.041	-0.005	-0.015	-0.176	-0.011	-0.030	-0.052	-0.007	-0.044	-0.025	-0.010	-0.216	-0.004	-0.024	-0.030	-0.010	-0.061	-0.028	-0.004
Tobacco Products & Alcohol Beverages	-0.092	-0.431	-0.027	-0.094	-0.002	-0.029	-0.003	-0.011	-0.081	-0.255	-0.019	-0.033	-0.005	-0.028	-0.015	-0.006	-0.031	-0.144	-0.012	-0.014	-0.005	-0.029	-0.013	-0.002
Personal Appearance	-0.036	-0.005	-0.169	-0.037	-0.001	-0.011	-0.001	-0.004	-0.033	-0.003	-0.101	-0.013	-0.002	-0.011	-0.006	-0.002	-0.057	-0.003	-0.245	-0.027	-0.009	-0.054	-0.025	-0.004
Housing	-0.068	-0.010	-0.020	-0.232	-0.002	-0.021	-0.003	-0.008	-0.165	-0.014	-0.038	-0.362	-0.009	-0.056	-0.031	-0.012	-0.144	-0.008	-0.055	-0.394	-0.022	-0.136	-0.063	-0.009
Medical Care	-0.177	-0.026	-0.052	-0.182	-0.828	-0.055	-0.007	-0.021	-0.208	-0.018	-0.048	-0.084	-0.629	-0.071	-0.040	-0.016	-0.079	-0.005	-0.030	-0.037	-0.357	-0.075	-0.034	-0.005
Transportation	-0.154	-0.023	-0.045	-0.158	-0.004	-0.460	-0.006	-0.018	-0.223	-0.019	-0.051	-0.090	-0.012	-0.341	-0.042	-0.017	-0.130	-0.008	-0.049	-0.061	-0.020	-0.195	-0.057	-0.008
Education	-0.176	-0.026	-0.051	-0.180	-0.004	-0.055	-0.795	-0.021	-0.140	-0.012	-0.032	-0.057	-0.008	-0.047	-0.400	-0.011	-0.063	-0.004	-0.024	-0.029	-0.010	-0.059	-0.262	-0.004
Water	-0.045	-0.007	-0.013	-0.046	-0.001	-0.014	-0.002	-0.218	-0.050	-0.004	-0.011	-0.020	-0.003	-0.017	-0.009	-0.158	-0.046	-0.003	-0.017	-0.021	-0.007	-0.044	-0.020	-0.217

Source: Own calculation

Table 4.3: Compensated Price Elasticity

Categories of Goods	Low Income Level								Medium Income Level								High Income Level							
	Food & Beverages	Tobacco Products & Alcohol Beverages	Personal Appearance	Housing	Medical Care	Transportation	Education	water	Food & Beverages	Tobacco Products & Alcohol Beverages	Personal Appearance	Housing	Medical Care	Transportation	Education	water	Food & Beverages	Tobacco Products & Alcohol Beverages	Personal Appearance	Housing	Medical Care	Transportation	Education	water
Food & Beverages	-0.406	0.016	0.008	0.070	0.026	0.141	0.037	0.004	-0.327	0.004	0.004	0.061	0.015	0.115	0.020	0.002	-0.279	0.001	0.009	0.066	0.006	0.101	0.012	0.001
Tobacco Products & Alcohol Beverages	0.177	-0.449	0.006	0.049	0.018	0.098	0.026	0.003	0.059	-0.262	0.002	0.038	0.010	0.072	0.013	0.001	0.014	-0.146	0.004	0.032	0.003	0.048	0.006	0.001
Personal Appearance	0.069	0.005	-0.178	0.019	0.007	0.039	0.010	0.001	0.024	0.001	-0.107	0.016	0.004	0.030	0.005	0.000	0.025	0.001	-0.266	0.059	0.005	0.090	0.011	0.001
Housing	0.132	0.009	0.004	-0.307	0.013	0.073	0.019	0.002	0.120	0.005	0.005	-0.459	0.019	0.147	0.026	0.002	0.064	0.001	0.021	-0.541	0.014	0.226	0.027	0.003
Medical Care	0.342	0.022	0.011	0.095	-0.855	0.190	0.050	0.006	0.151	0.006	0.006	0.097	-0.653	0.185	0.033	0.003	0.035	0.001	0.011	0.081	-0.370	0.124	0.015	0.001
Transportation	0.298	0.019	0.010	0.083	0.030	-0.609	0.043	0.005	0.162	0.007	0.006	0.104	0.026	-0.526	0.035	0.003	0.058	0.001	0.019	0.135	0.012	-0.419	0.024	0.002
Education	0.339	0.022	0.011	0.094	0.035	0.189	-0.833	0.006	0.101	0.004	0.004	0.065	0.016	0.124	-0.432	0.002	0.028	0.001	0.009	0.065	0.006	0.099	-0.289	0.001
Water	0.086	0.006	0.003	0.024	0.009	0.048	0.013	-0.223	0.036	0.002	0.001	0.023	0.006	0.044	0.008	-0.161	0.021	0.000	0.007	0.048	0.004	0.072	0.009	-0.220

Source: Own calculation

Table 4.1 shows uncompensated and compensated price elasticities. It presents both own prices and cross prices elasticities. The own price elasticity is the responsiveness of demand to its price changes. We found that all calculations have theoretically expected sign. The own price elasticities of uncompensated demand of all households in Bangkok of food & beverage, tobacco products & alcohol beverages, personal appearance, housing, medical care, transportation, education, and water are -0.1929, -0.1207, -0.4191,-0.4298, -0.5203, -0.3459, -0.4750 and -0.2316, respectively. It also can be used to forecast the effects of price changes on quantity. For example, the quantity demanded of housing will decrease by 42.98 percent if its price rises by 1 percent. Moreover, the table 4.1 shows the cross price elasticity that can estimate how consumption of other goods change when price of one change. As you can see, all cross price elasticities are negative. These imply that increasing on price of one good affects decreasing in consumption of other goods. In other words, whenever BMA imposes wastewater treatment charge on tap water which directly increases its price, Bangkok households' consumption will accordingly decrease.

Table 4.1 also shows compensated price elasticities. The compensated price elasticities are calculated from Hecksian demand function which drops off all income effects. The own price elasticities of compensated demand are all negative sign. Since increasing in its own price affects decreasing in its consumption. The elasticities of compensated demand of food & beverage, tobacco products & alcohol beverages, personal appearance, housing, medical care, transportation, education, and water are -0.2672, -0.1227, -0.4439, -0.5605, -0.5376, -0.5628, -0.5117 and -0.2348, respectively. It also can be used to estimate the substitutional effects of price changes on quantity. Theoretically, if households consume a bundle of goods and one's price increases, households will decrease consumption of the one but increase their consumptions on other goods in order to remain on the same level of utility. As you can see from the table, all cross price elasticities are positive. This means if one's price increases, households will increase their consumptions on other goods which are according to the theory.

If we consider deeply into each household type, we found that the both uncompensated and compensated demand elasticities of all types of households are

according to the theory. From table 4.2 and 4.3, own price and cross price elasticities of uncompensated demand are all negative. However, increasing in one's price affects on its demand more than other goods' demands.

The own price elasticities of uncompensated demand of low income households in Bangkok of food & beverage, tobacco products & alcohol beverages, personal appearance, housing, medical care, transportation, education, and water consumption are -0.137, -0.431, -0.169, -0.232, -0.828, -0.460, -0.795, and -0.218. Medium income households' own price elasticities of uncompensated demand of food & beverage, tobacco products & alcohol beverages, personal appearance, housing, medical care, transportation, education, and tap water consumption are -0.176, -0.255, -0.101, -0.362, -0.629, -0.341, -0.400, -0.158, respectively. The own price elasticiites of high income households are -0.216, -0.144, -0.245, -0.394, -0.357, -0.195, -0.262 and -0.217, accordingly. Also, own price elasticities of compensated demand of all type of households are negative while cross price elasticities are positive. The elasticities of compensated demand of food & beverage, tobacco products & alcohol beverages, personal appearance, housing, medical care, transportation, education, and water for the low income households are -0.406, -0.449, -0.178, -0.307, -0.855, -0.609, -0.833 and -0.223, respectively. Medium income households' own price elasticities of compensated demand of food & beverage, tobacco products & alcohol beverages, personal appearance, housing, medical care, transportation, education, and tap water are -0.327, -0.262, -0.107, -0.459, -0.653, -0.526, -0.432, and -0.161, respectively. The own price elasticities of high income households are -0.279, -0.146, -0.266, -0.541, -0.370, -0.419, -0.289, and -0.220, accordingly.

In general, most tax, fee and charge policies are regressive. Tax policies affect lower income households more than higher income households. In consideration of a tap water category, own price elasticity of uncompensated demand of low income, medium income, and high income households are -0.218, -0.158 and -0.217, successively. This implies that the wastewater treatment charge affects on low income households and high income households more than medium income households. Comparing between the low and medium income households' elasticities are according

to the theory. Treatment charge affects on low income households more than medium income households while the policy affects least on high income households.

Welfare Estimation

Table 5 shows the estimation of net social welfare analysis. It includes all indicators which can examine the study such as water consumption expenses, total expenses, wastewater discharged, equivalent variation, total charge revenues, and dead weight loss when BMA imposing the wastewater treatment charge on households' water consumption at 2 baht per m^3. The study bases on 2 million households in Bangkok area which approximately consists of 610,505 households in a low income household type, 1,049,867 households in a medium income household type, and 339,628 households in a high income household type.

First of all, we would like to discuss about expenditures of average income households and each household type. The percent of water consumption expenses to total expenses of households in Bangkok without the treatment charge is 1.558 percent. They are 2.107, 1.862, and 1.169 percent for low, medium, and high income households. The average expenditure of all households in Bangkok is 15,162.50 per household per month. The average expenditure of low, medium, and high income households are 6,264.76, 13,080.97, and 34,540 baht per household per month. The average water consumption expense is 236.16 baht per household per month. They are 131.99, 243.60, and 403.73 baht per month for low, medium, and high income households. While with the treatment charge, the average expenditure of all households in Bangkok is decreased to 15,134.93 per household per month.

The average expenditure of low, medium, and high income households are decreased to 6,248.63, 13,052.63, and 34,498.55 baht per household per month. The water consumption expense of all households after imposing the charge is averagely decreased to 235.99 baht per household per month. They are slightly decreased to 131.86, 243.43, and 403.52 baht per month for low, medium, and high income households.

Table 5: Net Social Welfare Analysis

	Without Charge				With Charge (2 Baht per m3)			
	Low Income	Medium Income	High Income	Average Household	Low Income	Medium Income	High Income	Average Household
1. Number of Households	610,505	1,049,867	339,628	2,000,000	610,505	1,049,867	339,628	2,000,000
2. Other Goods Expenses (Baht)	6,132.76	12,837.37	34,136.27	14,926.34	6,116.77	12,809.20	34,095.03	14,898.94
3. Water Expenses(฿) (Ratio = 3 / 4)	131.99 (2.107%)	243.60 (1.862%)	403.73 (1.169%)	236.16 (1.558%)	131.86 (2.110%)	243.43 (1.865%)	403.52 (1.170%)	235.99 (1.559%)
4. Total Expenses (Baht) 2 + 3	6,264.75	13,080.97	34,540.00	15,162.50	6,248.63	13,052.63	34,498.55	15,134.93
5. EV per Household (฿) (Ratio = 5 / 4)	-	-	-	-	23.992 (0.384%)	44.110 (0.338%)	70.939 (0.206%)	42.579 (0.281%)
6. Total EV / Month (Million Baht) 5 x 1	-	-	-	-	14.647	46.310	24.093	85.159
7. Charge /Household (฿) (Ratio = 7 / 4)	-	-	-	-	23.585	43.595	69.774	41.930
8. Total Charge / Month (Million Baht) 7 x 1	-	-	-	-	14.399	45.768	23.697	83.860
9. DWL / Household (฿) 5 – 7 (Ratio = 9 / 6)	-	-	-	-	0.407	0.515	1.165	0.649
10. Total DWL / Month (Million Baht) 6 - 8	-	-	-	-	0.248	0.541	0.396	1.299
11. Water Consumption / Household (Unit)	121.14	223.580	370.550	216.760	112.045	207.100	331.470	199.192
12. Total Water Cons. / Month (Unit)	73.96	234.73	125.85	433.52	68.40	217.43	112.58	398.38
13. Wastewater/Household (Unit) 11 x 0.8	96.91	178.86	296.44	173.408	89.64	165.68	265.18	159.35
14. Total Wastewater / Month (Million Unit) 12 x 0.8	59.17	187.783	100.679	346.816	54.723	173.942	90.061	318.707
15. Change of Wastewater (%)	-	-	-	-	-7.510%	-7.371%	-10.546%	-8.105%

Source: Own Calculation

Although the water consumption decreases, the price of tap water increases. These affect the proportion of water consumption expenses to total expenses of households very slightly increases to 1.559 percent. Like the average income households' ratio, the ratios of low, medium, and high income households are slightly increased to 2.110, 1.865, and 1.170 percent. Indeed, the treatment charge affects decreasing in all expenses and water consumption expenses of all type of households. However, the proportions of water expenses to the total expenses in all types of households are slightly increase because the price of water increases.

The average expenditure of low, medium, and high income households are decreased to 6,248.63, 13,052.63, and 34,498.55 baht per household per month. The water consumption expense of all households after imposing the charge is averagely decreased to 235.99 baht per household per month. They are slightly decreased to 131.86, 243.43, and 403.52 baht per month for low, medium, and high income households. Although the water consumption decreases, the price of tap water increases. These affect the proportion of water consumption expenses to total expenses of households very slightly increases to 1.559 percent. Like the average income households' ratio, the ratios of low, medium, and high income households are slightly increased to 2.110, 1.865, and 1.170 percent. Indeed, the treatment charge affects decreasing in all expenses and water consumption expenses of all type of households. However, the proportions of water expenses to the total expenses in all types of households are slightly increase because the price of water increases.

Equivalent Variation (EV) also the important indicator to measure the welfare changes. EV reflects surplus loss in term of money. With the treatment charge, households averagely lose 42.579 baht per household per month. However, the charge policy affects differently in different types of households. Low, medium, high income households lose their surplus equal to 23.992, 44.110, and 70.939 baht per household per month, respectively. In the sense of amount of money, the policy impacts on higher income household types more than lower income household types. Nonetheless, if we consider the ratio of EV to total expenses, it shows different results. The ratio is 28.1 percent for average income households while they are 38.4, 33.8, and 20.6 percent for low, medium, and high income households, successively. The ratio shows the

proportion of households' welfare changes to their total expenses. Consequently, the more of the proportion, the more relatively affects of policy incidences on the households. We can conclude that the policy is regressive because the ratios of lower income households are more than the ratios of higher income households. It impacts lower income household types more than higher income household types. Households in Bangkok lose their surplus about 85.159 million baht per month as a whole which are contributed from low, medium and high income households equal 14.647, 46.310, and 24.093 million baht per month, respectively.

In the BMA point of view, a wastewater treatment charge is the new source of their revenues. At rate 2 baht per m^3, BMA can gain 83.86 million baht per month which averagely 41.93 baht per household per month. It collects the charge about 23.585, 43.595, 69.774 baht per household per month from low, medium, and high income households. Otherwise, we can conclude that BMA receives revenues from low, medium, and high income households about 14.399, 45.768, and 23.697 million baht per month. Noticeably, the amounts of money that households give to BMA are slightly different to the EV or surplus that the households lose. This implies that there are some amounts of money loss into the economy, Dead Weight Loss.

Dead Weight Loss (DWL) reflects the excess burden which occurs when the charge is imposed to the households. In this study, we calculate DWL in monetary term in order to simply illustrate the effects of the policy. With the treatment charge, DWL is averagely 0.649 baht per household per month or 1.299 million baht per month. However, it affects differently in different types of households. The DWL which occurs in low, medium, high income households equal 0.407, 0.515, and 1.165 baht per household per month, respectively, or about 248,000, 541,000, and 396,000 baht per month, successively. If we consider only amount of money, the policy impacts on higher income household types more than lower income household types. Nonetheless, according to the ratio of DWL to EV, the results are different. The ratio is 1.524 percent for average income households while they are 1.696, 1.168, and 1.642 percent for low, medium, and high income households, successively. Consequently, the policy mostly impacts on low income households compare to other household types. However, it affects on high income household more than medium income households.

Next, we would like to discuss about the consumers' behaviors. Certainly, the treatment charge policy also affects the water consumption and wastewater discharged of Bangkok's households. The results show that the charge affects decreasing in water consumption about 8.11 percent, averagely. The water consumptions decrease 7.51, 7.37 and 10.55 percent for low, medium, and high income households. These influence decreasing in wastewater discharged from the households at the same proportion. Households averagely reduce their water consumption from 216.76 units per household per month to 199.192 units per household per month. It is averagely reduced from 121.14 units to 112.045 units per household per month in low income households. Medium income households averagely reduce their water consumptions from 223.58 units to 207.10 units per household per month. Lastly, high income households averagely reduce from 370.55 units to 331.47 units per household per month. Therefore, the wastewater discharged is averagely decreased from 346.816 million units per month to 318.707 million units per month as a whole.

Certainly, these results answer the questions that we ask in the beginning of our study. The wastewater treatment charge policy solves water pollution in Bangkok area because the policy affects Bangkok households' behaviors. It decreases water consumption in all type of households, so it directly reduces wastewater discharged from households.

Conclusion

First, from the households' demand estimation. We find that transportation and housing are luxury goods while other products are necessity for Bangkok households' perspectives in average household category. The expenditure demand elasticity for food & beverage, tobacco products & alcohol beverages, personal appearance, housing, medical care, transportation, education, and water are 0.4742, 0.1931, 0.7242, 1.1058, 0.8665, 1.3373, 0.8514, 0.3701, respectively.

According to the expenditure demand elasticity, food & beverages, personal appearance, and tap water are necessary for basic living, so they are reasonable necessity goods for all household types. Tobacco products & alcohol beverages are

also necessity goods. Since whisky, beer and cigarettes are addicted products, households maintain the consumption in both regularity and frequency despite income changes. On the other hand, housing, medical care, transportation, and education are considered differently among each type of households. Medical care is considered as a luxury good for low income households and medium income households while it is necessity for high income households. This implies that high income households have more awareness on medical care and personal care. Education is also interested category. It is considered as a luxury good for low income households while it is necessity for high income households and medium income households. Since low income households concern more about the products that necessity for the living such as food & beverages, than they will spend their extra money to education. This can be concluded that low income households trend to reduce their expense on education if their income decreases. As we can see that children from low income households in Bangkok always have part time jobs during their schooling period.

If we consider deeply into price elasticities of each household type, we found that the both uncompensated and compensated demand elasticities of all types of households are according to the theory. Own price and cross price elasticities of uncompensated demand are all negative. However, increasing in one's price affects on its demand more than other goods' demands. Also, own price elasticities of compensated demand of all type of households are negative while cross price elasticities are positive.

Then from net social welfare estimation, we find that the treatment charge affects decreasing in all expenses and water consumption expenses of all type of households. However, the proportions of water expenses to the total expenses in all types of households are slightly increase because the price of water increases.

According to equivalent variation, with the treatment charge, households averagely lose 42.579 baht per household per month. However, the charge policy affects differently in different types of households. Low, medium, high income households lose their surplus equal to 23.992, 44.110, and 70.939 baht per household per month, respectively. Determining by the proportion of welfare changes on households to total expenses, we find that the charge policy is regressive in this case.

Lower income household types are affected from the incidences more than higher income household types. Moreover, households in Bangkok lose their surplus about 85.159 million baht per month in total.

The wastewater treatment charge policy solves water pollution in Bangkok area because the policy affects Bangkok households' behaviors. It decreases water consumption in all type of households, and reduces wastewater discharged. Although, households somewhat loss their surplus and the dead weight loss occurs, the public sector which BMA responds for all activities gains the welfare from the charge revenues. However, this study does not include the welfare gains from the abatement cost saving of faintly decreasing wastewater discharged of households and some gains from improving recreation and public health which will automatically occur when water pollution has been decreased. In other words, the policy should affect the net social welfare gain to the Bangkok as a whole.

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Appendices

APPENDIX 1: Results from Demand Coefficient Estimation of Low Income Households

System: Low Income

Estimation Method: Seemingly Unrelated Regression

Date: 07/21/08 Time: 01:11

Sample: 1 2069

Included observations: 2069

Total system (balanced) observations 16552

Iterate coefficients after one-step weighting matrix

Convergence not achieved after: 1 weight matrix, 514 total coef iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	24.71418	3.072699	8.043151	0.0000
C(9)	0.384425	0.008608	44.66136	0.0000
C(2)	-10.55750	0.879717	-12.00102	0.0000
C(3)	15.69238	0.499371	31.42431	0.0000
C(4)	-28.76376	1.316710	-21.84517	0.0000
C(5)	0.524523	7.471901	0.070199	0.9440
C(6)	-11.75999	2.194951	-5.357746	0.0000
C(7)	1.646007	7.219250	0.228003	0.8196
C(8)	-9.519553	0.208395	-45.68026	0.0000
C(10)	0.024980	0.002544	9.817453	0.0000
C(11)	0.012808	0.002481	5.161933	0.0000
C(12)	0.106903	0.007150	14.95204	0.0000
C(13)	0.039118	0.003477	11.24962	0.0000
C(14)	0.213857	0.008660	24.69398	0.0000
C(15)	0.055828	0.003849	14.50519	0.0000
C(16)	0.006783	0.000530	12.80609	0.0000
Determinant residual covariance		5.60E+44		

Source: Estimated using Eview 4.1

APPENDIX 2: Results from Demand Coefficient Estimation of Medium Income Households

System: Medium Income

Estimation Method: Iterative Seemingly Unrelated Regression

Date: 07/18/08 Time: 03:37

Sample: 1 3558

Included observations: 3558

Total system (balanced) observations 28464

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 6 weight matrices, 7 total coef iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	47.73217	1.349409	35.37264	0.0000
C(9)	0.223163	0.005184	43.05028	0.0000
C(2)	14.73959	0.558023	26.41395	0.0000
C(3)	24.81001	0.432180	57.40666	0.0000
C(4)	33.76670	2.062951	16.36815	0.0000
C(5)	10.50648	1.971578	5.328970	0.0000
C(6)	23.34520	4.173995	5.593012	0.0000
C(7)	21.43057	1.233283	17.37685	0.0000
C(8)	13.52732	0.155114	87.20884	0.0000
C(10)	0.009490	0.001100	8.623915	0.0000
C(11)	0.008509	0.001418	6.001076	0.0000
C(12)	0.147844	0.005346	27.65309	0.0000
C(13)	0.036061	0.002276	15.84146	0.0000
C(14)	0.274508	0.007180	38.23177	0.0000
C(15)	0.048582	0.002519	19.28254	0.0000
C(16)	0.004461	0.000265	16.81525	0.0000
Determinant residual covariance		7.85E+49		

Source: Estimated using Eview 4.1

APPENDIX 3: Results from Demand Coefficient Estimation of High Income Households

System: High Income

Estimation Method: Iterative Seemingly Unrelated Regression

Date: 07/18/08 Time: 03:44

Sample: 1 1151

Included observations: 1151

Total system (balanced) observations 9208

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 6 weight matrices, 7 total coef iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	63.84143	2.022155	31.57098	0.0000
C(9)	0.092974	0.004670	19.91025	0.0000
C(2)	16.44559	0.939188	17.51043	0.0000
C(3)	41.24337	1.726769	23.88471	0.0000
C(4)	33.63200	13.74510	2.446835	0.0144
C(5)	25.30532	2.559881	9.885351	0.0000
C(6)	50.61832	11.33274	4.466556	0.0000
C(7)	43.77388	2.552598	17.14875	0.0000
C(8)	16.44241	0.412418	39.86832	0.0000
C(10)	0.002102	0.000683	3.076369	0.0021
C(11)	0.029808	0.002496	11.94211	0.0000
C(12)	0.215735	0.010248	21.05241	0.0000
C(13)	0.019670	0.002320	8.478051	0.0000
C(14)	0.327885	0.012805	25.60625	0.0000
C(15)	0.039238	0.003340	11.74730	0.0000
C(16)	0.003775	0.000255	14.83354	0.0000
Determinant residual covariance		7.88E+55		

Source: Estimated using Eview 4.1

APPENDIX 4: Results from Demand Coefficient Estimation of Average Income Households

System: Average Household

Estimation Method: Iterative Seemingly Unrelated Regression

Date: 09/14/08 Time: 14:30

Sample: 1 6270

Included observations: 6270

Total system (balanced) observations 50160

Simultaneous weighting matrix & coefficient iteration

Convergence achieved after: 6 weight matrices, 7 total coef iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	52.17451	0.718240	72.64219	0.0000
C(9)	0.116475	0.002190	53.18653	0.0000
C(2)	15.80973	0.294396	53.70228	0.0000
C(3)	22.42222	0.724884	30.93215	0.0000
C(4)	30.72006	2.956077	10.39217	0.0000
C(5)	15.35274	1.020455	15.04500	0.0000
C(6)	23.76521	5.131566	4.631181	0.0000
C(7)	23.03451	1.194414	19.28520	0.0000
C(8)	12.84830	0.143441	89.57218	0.0000
C(10)	0.003257	0.000398	8.184500	0.0000
C(11)	0.038860	0.000928	41.85894	0.0000
C(12)	0.205011	0.003582	57.24031	0.0000
C(13)	0.027073	0.001010	26.79740	0.0000
C(14)	0.340053	0.004572	74.37068	0.0000
C(15)	0.057470	0.001304	44.08854	0.0000
C(16)	0.005033	0.000117	43.19254	0.0000
Determinant residual covariance		7.65E+51		

Source: Estimated using Eview 4.1

where

C(1) = Square root of committed levels of expenditure of food & beverage (γ_{fb})

C(2) = Square root of committed levels of expenditure of tobacco & alcohol beverage (γ_{ta})

C(3) = Square root of committed levels of expenditure of personal appearance (γ_{pa})

C(4) = Square root of committed levels of expenditure of housing (γ_{h})

C(5) = Square root of committed levels of expenditure of medical care (γ_{med})

C(6) = Square root of committed levels of expenditure of transportation (γ_{tran})

C(7) = Square root of committed levels of expenditure of education (γ_{edu})

C(8) = Square root of committed levels of expenditure of water used (γ_{w})

C(9) = Consumption expenditure share of food & beverage (β_{fb})

C(10) = Consumption expenditure share of tobacco & alcohol beverage (β_{ta})

C(11) = Consumption expenditure share of personal appearance (β_{aw})

C(12) = Consumption expenditure share of housing (β_{h})

C(13) = Consumption expenditure share of medical care (β_{med})

C(14) = Consumption expenditure share of transportation (β_{tc})

C(15) = Consumption expenditure share of education (β_{edu})

C(16) = Consumption expenditure share of water used (β_{w})

where

Food & beverage	= food & non alcohol beverage
Tobacco & alcohol beverage	= tobacco products and alcohol beverage
Personal appearance	= appearance & foot wear
Housing	= rental, utilities, and equipment except water supply
Medical care	= personal care and medical care
Transportation	= transportation and communication
Education	= education, reading, and recreation
Tap water	= only public water supply