OPTIMAL TAX RATE OF CIGARETTE EXCISE TAX IN INDONESIA

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Abstract

We analyze the optimal cigarette excise tax rate based on the optimal tax theory. We find that the optimal tax is different when there is an illegal production of cigarettes. We find that, without illegal production of cigarettes, the government can achieve the first best optimum condition by fully internalizing externality. The government can optimally choose the amount of tax on legal cigarettes that is equal to the marginal cost of health care. When there is an illegal production of cigarettes, we find that the rate of cigarette excise tax is not equal to the marginal cost of health care. Therefore, the government need more policy instruments to achieve the optimal tax rate in this case. We also find that an increase in the work hours of a legal cigarette production reduces illegal cigarette productions. Policymakers can use marginal income tax policy as an incentive to reduce illegal production of cigarettes.

Keywords: Optimal Tax, Excise Tax, Indonesia Cigarettes Excise Tax.

JEL Classification: D11, H2, H21.

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1. Introduction

1.1 Background

In his article, Joel Slemrod (1990) writes,

> "The theory of optimal taxation has, for the past two decades, been the reigning normative approach to taxation. During its reign, it has generated several useful insights about the relationships between assumptions about the set of tax instruments available to the government, the structure of the economy, and the objectives of tax policy."

The optimal tax theory believes that optimizing social welfare based on a set of constraints by implementing a tax system is a must (Mankiw et al., 2009). The theory of optimal taxation deals with two discussions, namely the discussions on optimal commodity taxation and optimal income taxation. This study focuses on the optimal commodity taxation.

The purpose of the application of optimal commodity taxation is to fund the government's expense by minimizing the excess burden generated without using any lump-sum taxes (Rosen and Gayer, 2010). Ramsey (1927) has found a solution to that problem. The marginal excess burden for every additional commodity tax received must be the same for every item, and aimed at minimizing the overall excess burden. He concludes that, to minimize the total excess burden, the stipulation of tax rate should be based on the consideration that the elasticity of compensated demand must be the same for each commodity that is taxed since the excess burden is a result of a distortion in quantity.

This theory has a very interesting implication to the cigarette excise tax implementation in Indonesia. In the last few years, the stipulation of the cigarette excise tax level always evokes pros and cons. The stipulation of an excessive cigarette excise tax negatively affects the cigarette industry, but at the same time positively affects the government's income and the overall health of the society, especially smokers. On the other hand, if the cigarette excise tax is too low, the government's income and society's health would be adversely affected, while the cigarette industry would gain favorable effects.

Ahsan et al. (2012) explains in his research report that the increase of cigarette price through a boost in the cigarette excise tax is a win-win solution because this rise can reduce the amount of cigarette consumption and enhance the national income. Dropping cigarette consumption can cause improvement in health condition due to the reduction in smoking habits.

According to the data published by Tobacco Atlas (2016) regarding the number of smokers in Indonesia, in 2015, there are more than 496 thousand (10–14 years old) child smokers, and more than 53,2 million adult (above 15 years old) smokers. The total number of male smokers in Indonesia is 76.2 percent higher than the number of male smokers from countries with medium HDI (Human Development Index), while the number of female smokers is 3.6 percent less than the number for female smokers belonging to the adult class in the same countries. The number of child smokers in Indonesia is also higher compared to countries with medium human development index, i.e. 3.51 percent for male smokers and 0.39 percent for female smokers.

On the other hand, the cigarette industry people refuse the rise of cigarette excise tax since it causes a rise in the retail price as well. According to the report of Tobacco Atlas (2016), Indonesia produces 342 billion cigarettes in 2016. Six dominant companies in the Indonesian cigarette industry have revenues of more than 346 billion USD. This number is equal to 38 percent of Indonesia's Gross National Income in the same year. When the excise tax on cigarettes is increased, the production of cigarettes will go down. According to Wahyudiyanta (2017), a tobacco excise tax of 10.5 percent has caused a 2 percent decline in the 2017 cigarette production.

There are not many literatures that explain optimal taxation rate within the context of Indonesian tobacco's excise tax. However, there are some studies that explain the impact of the increase in Indonesian cigarette excise tax. Two of those studies are done by Adioetoemo et al. (2005) and Djutaharta et al. (2005). Adioetoemo et al. (2005) explains that price is not the most significant factor in deciding whether to smoke, but has a significant impact on the amount of cigarette consumed. The simulation of the research shows that a 10 percent increase in excise tax causes a 4.9 percent markup in the price of cigarettes. This in turn reduces cigarette consumption by 3 percent, and boost cigarette excise tax income by 6.7 percent, ceteris paribus. Djutaharta et al. (2005) estimate that the real price elasticity of cigarette demand is -0.345, and the income elasticity of cigarette demand is 0.473. In addition to that, this research had done a simulation in which 10 percent, 50 percent, or 100 percent increase of cigarette excise tax will boost the cigarette excise tax income by 9, 43, and 82 percent respectively.

Hu and Mao (2002) and Lee et al. (2005) suggest that tax brings about a negative influence on the cigarette consumption rate of the populace and a positive influence on the government. Jin et al (2017) write similar research in China, but with carbon tax as their research subject.

Aronsson and Sjogren (2010) and O'Donoghue and Rabin (2006) suggest that the application of tax for unhealthy commodities and the act of leaving the choice of consumption to the consumers could increase the social economic welfare. In terms of alcohol, the tax on imports gives incentives to the alcohol's domestic taxation rate under the marginal social damage. Furthermore, there is a need for a policy regulating the implementation of tax or subsidy for complementary goods or the substitutes for alcohol. Gruber and Koszegi (2004) argue that the traditional quantity-based measures of incidence are only appropriate under a very restrictive "time consistent" model of the consumption of sin goods. A model that is much more consistent with the existing evidence on smoking decision is a time-inconsistent formulation where excise taxes on cigarettes serve a self-control function that is valued by smokers who would like to quit but cannot.

O'Donoghue and Rabin write in their article entitled *Studying Optimal Paternalism, Illustrated by a Model of Sin Taxes* (2003),

> "The classical economic approach to policy analysis assumes that people always respond optimally to the costs and benefits of their available choices. A great deal of evidence suggests, however, that in some contexts people make errors that lead them not to behave in their own best interests. Economic policy prescriptions might change once we recognize that humans are humanly rational rather than superhumanly rational, and in particular it may be fruitful for economists to study the possible advantages of paternalistic policies that help people make better choices."

Paternalism in social philosophy could be seen as a form of a third-party intervention (family, nation, religion, et cetera) to people's lives performed by restricting their choice, with their welfare as the goal (Kapeliushnikov, 2015). Paternalism, in other words, is a form of coercion (limiting an individual's freedom of choice) to maximize their welfare. These individuals are assumed to be irrational in facing their choices (Kapeliushnikov, 2015). The relationship between parents and their child is an example of paternalism. The parents limit their child's behavior with norms, such as those derived from religion and culture. The relationship between a nation and its people could also be seen as a form of paternalism. The nation may limit its people's behavior by applying laws.

This approach is useful for analyzing the optimal tax rate. Economists and policymakers generally analyze commodity taxes based on the assumption that the choices made by people are their best choice as well as their optimal behavior. The economists and policymakers do not consider sin taxes, which are taxes imposed on goods or commodities that could cause illness in consumers (O'Donoghue and Rabin, 2003).

1.2 Research Purpose

We argue that the approach of the optimal taxation theory could be used as a tool to decide the efficient excise tax rate since the approach could accommodate factors outside the price and demand for cigarette, such as health variables and working hours.

Our analysis is also related to distortionary tax studies. In theory, tax policy could create a distortion on the economy. This distortion is caused by the redistribution of resource allocation to provide public commodities or to meet any other governmental objectives (Auerbach and Hines, 2001). A tax policy is considered optimal when the tax regulated could minimize the distortion and maximize the economic efficiency of governmental programs (in the form of tax). If there exists imperfect competition in the economic sector, the tax policy should be revised so that the resource allocation distributed to the government sector would stay efficient. Thus, this governmental tax-based income should be analyzed.

We use Hicksian demand function in the optimization process since Hicksian (Compensated) demand has a more inelastic demand curve when compared to the Marshallian (Uncompensated) demand curve. Hicksian demand does not include income effect to calculate any changes in the price of commodities. Therefore, it will generate fewer excess burdens than what Marshallian function generates.

2. Methodology

We utilize the model from Aronsson and Sjogren (2010). We modified the model to adjust it to the conditions in Indonesia and implemented additional parameters, e.g. $p^i, w^i l^i$, for consumer decision function and second stage cost constraint. These modifications generate derivation results that are different from the results generated using Aronsson and Sjogren's (2010) original model, particularly in terms of the illegal production of cigarettes. The results from the derivation is further discussed in the findings and discussions section.

An economy is assumed to have identical consumers, with the number of existing customers normalized into one. Consumer preferences are defined by a utility function of $u = u(c, x, z)$, where c means the non-cigarette commodity consumption, x means cigarette consumption and z means the leisure time. The function $u(\cdot)$ is assumed to have the characteristics of increasing on c and z, as well as strictly quasiconcave. Other assumptions used are that cigarette consumption damages health condition and that health related effects have already been rationally anticipated by consumers. The relationship between health condition and cigarettes are assumed to be embedded in the utility function. Cigarette consumption increases fiscal externalities since cigarette consumption forces the government to provide health care.

We modify the model made by Aronsson and Sjogren (2010) by removing the consumption variable which comes from imports, and adding the illegal cigarette consumer price and the wage level of the workers involved in illegal cigarette productions. This change is based on the fact that the consumption of imported cigarettes in Indonesia is in small numbers and that cigarette is also consumed ilegally. Based on the data from the Ministry of Industry (2012), the proportion of cigarette imports, when compared to the exports of cigarette, is only 1.05 percent. Consumers may buy two kinds of cigarettes, namely cigarettes coming from the legal market and those coming from illegal cigarettes. The number of cigarettes purchased on the legal market are denoted by x^d. The consumer price of legal cigarettes is denoted by q_x. Illegally and privately produced cigarettes are denoted by the production function of $x^i = f(l^i)$. l^i is the working hours needed to produce cigarettes and avoid government detection. $f(l^i)$ is assumed to have the characteristics of increasing and strictly concave. The concave of $f(\cdot)$ shows an increase in the illegal production of cigarettes, thus adding time spent to avoid detection and relatively reducing the time used for production.

Optimal tax models in this section are defined in the form of conditional utility function and conditional demand function. We optimize the consumer problem in 2 stages. In the first stage, we optimize the conditional utility of working hours in the official labor market, l.

$$\underset{c,x,x^d,l^i}{Max}\ u(c, x, H - l - l^i) \tag{1}$$

Subjects to

$$b = q_x x^d + q_c c + p^i f(l^i) \tag{2}$$

$$x = x^d + f(l^i) \tag{3}$$

q_c is the consumer price for non-cigarette commodities, b is the personal income after tax, which is assumed to be fixed in the first stage. p^i is the consumer price for illegal cigarettes, which is assumed to be fixed at a certain illegal cigarette price and exogenous. The time constraint has been substituted with a utility function, and thus becoming $z = H - l - l^i$. H is the time endowment. The model also assumes that the production of legal cigarettes (same as non-cigarettes) has the characteristics of a linear technology. The wage level and the cost of production is assumed to be fixed. Consumer prices are denoted by $q_c = p_c + t_c$ and $q_x = p_x + t_x$, where p_c and p_x are the producer price, while t_c and t_x are the commodity tax. First optimization stage implicitly defines the conditional demand and "supply" function.

$$x = x(b, l, q_c, q_x; p^i)$$

$$x^d = x^d(b, l, q_c, q_x; p^i)$$

$$c = c(b, l, q_c, q_x; p^i)$$

$$l^i = l^i(b, l, q_c; p^i) \tag{4}$$

Conditional indirect utility function is obtained by substituting the conditional demand and supply function with the direct utility function and also using the time constraint.

$v = v(b, l, q_c, q_x; p^i)$ (5)

In the second stage of optimization, l is used to perform a maximization of the indirect utility function subject to the cost constraint $b = wl + w^i l^i - T(wl)$. w is the wage level which is obtained from the official labor market, w^i is the wage level which is obtained from the illegal market and $T(\cdot)$ is the payment of personal income tax. First order condition:

$v_b w(1 - T') + v_l = 0$ (6)

$v_b = \partial v(\cdot)/\partial b$ and $v_l = \frac{\partial v(\cdot)}{\partial l} = -\partial u(\cdot)/\partial z$ show the marginal utilities of private income and the labor. $T' = \partial T(wl)/\partial(wl)$ is the marginal income tax rate.

The purpose of the government is to optimize the well-being of an individual, who has a utility function of $v = v(b, l, q_c, q_x; p^i)$ which is subjects to the cost constraint of the individual. Tax instruments refer to income tax and commodity tax. Tax revenue is used to finance expenditure in the health care sector. This model focuses on tax policy. Therefore, it does not consider the detection of illegal cigarette productions. The government's cost constraint can be written as follows.

$T(wl) + t_c c + t_x x^d - \rho(x) = 0$ (7)

$\rho(x)$ is the cost of health care, which increases as the cigarette consumption grows. Legal domestic cigarette tax base is determined according to the number of cigarettes purchased from the legal domestic market.

$T(\cdot)$ is the general income tax, that can be used in variety of combinations. This leads to the better direct use l and b as opposed to using parameter $T(\cdot)$ as decision variable. Therefore, l, b, t_c, t_x are used as decision variables.

Lagrange is written as follows.

$L = v(\cdot) + \gamma[wl - b + t_c c(\cdot) + t_x x^d(\cdot) - \rho(x(\cdot))]$ (8)

$x^d(\cdot) = x(\cdot) - f(l^i(\cdot))$, γ is the Lagrange multiplier associated with cost constraints. First order of optimization is shown in the appendix section.

3. Results and Discussions

This section shows the derivation results. The derivation results are divided into two cases, namely without illegal production of cigarettes and with illegal production of cigarettes.

3.1 Legal production of Cigarettes.

The case in which there is no illegal production of cigarettes assumes that $x^i = f(l^i) = 0$. Compensated demand function is denoted by $\tilde{x}$ and $\tilde{c}$. First order condition for t_c and t_x are denoted as follows. (Complete proof is shown in appendix.)

$$\begin{bmatrix} \frac{\partial \tilde{c}}{\partial q_c} & \frac{\partial \widetilde{x^d}}{\partial q_c} \\ \frac{\partial \tilde{c}}{\partial q_x} & \frac{\partial \widetilde{x^d}}{\partial q_x} \end{bmatrix} \times \begin{bmatrix} t_c \\ t_x \end{bmatrix} = \begin{bmatrix} \rho' \frac{\partial \tilde{x}}{\partial q_c} \\ \rho' \frac{\partial \tilde{x}}{\partial q_x} \end{bmatrix} \quad (9)$$

Equation 9 assumes that $x = x^d$. Cramer's rule is used to obtain t_c, t_x and T'.

$$|\boldsymbol{H}| = \frac{\partial \tilde{c}}{\partial q_c}\frac{\partial \widetilde{x^d}}{\partial q_x} - \frac{\partial \tilde{c}}{\partial q_x}\frac{\partial \widetilde{x^d}}{\partial q_c}$$

$$t_c = 0 \quad t_x = \rho' \text{ and } \quad T' = 0 \tag{10}$$

Equation 10 shows the result of optimal taxation for representative agent-model with externality correction. Equation 10 indicates that the government can achieve the first best optimum condition by fully internalizing externality. It is achieved by choosing t_x that is equal to the marginal cost of health care, ρ' . t_c and $T' = 0$ indicate that the income tax is a pure lump-sum tax. (Sandmo, 1975)

3.2. Illegal production of Cigarettes.

Case 2 assumes that $x^i = f(l^i)$, so $x^d = x - x^i$. x_i is the amount of cigarettes produced illegally and labor input use, l^i. The equations below are written by using several abbreviations as follows.

$$f' = \frac{\partial f(.)}{\partial l^i} \tag{11}$$

The result of derivation in case 2 uses the same method as case 1.

$$t_c = \frac{\rho' f'}{|\boldsymbol{H}|}\frac{\partial \widetilde{x_s}}{\partial q_x}\left[\frac{\partial \tilde{l^i}}{\partial q_c} - \frac{\frac{\partial \tilde{x}}{\partial q_c}}{\frac{\partial \widetilde{x_s}}{\partial q_x}}\frac{\partial \tilde{l^i}}{\partial q_x}\right] \tag{12}$$

$$t_x = \frac{\rho' f'}{|\boldsymbol{H}|}\frac{\partial \tilde{c}}{\partial q_c}\left[\frac{\partial \tilde{l^i}}{\partial q_x} - \frac{\frac{\partial \tilde{c}}{\partial q_x}}{\frac{\partial \tilde{c}}{\partial q_c}}\frac{\partial \tilde{l^i}}{\partial q_c}\right] + \rho' \tag{13}$$

The difference between case 1 and case 2 is the use of additional parameters. Aronsson and Sjogren (2010) argue that their purpose is to perform externality correction. The reason for this is that the t_x in case 2 cannot be fully internalized as case 1. The government may use additional instruments to control cigarette consumption. Equation 12 indicates the characteristic of $\frac{\partial \widetilde{x_s}}{\partial q_c}$ (cross price elasticity of cigarette demand). If the value of $\frac{\partial \widetilde{x_s}}{\partial q_c}$ is more than 0, the relationship between a cigarette commodity and a non-cigarette commodity is a substitutional relationship. This variable has a negative relationship with the tax rate of non-cigarette commodities. $\frac{\partial \widetilde{x_s}}{\partial q_x}$ is assumed to have a negative value because it indicates the own-price elasticity of cigarettes. It creates a positive relationship between the own-price elasticity of cigarette demand and the tax rate of non-cigarette commodities. Aronsson and Sjogren (2010) suggest that the characteristic of the relationship between non-cigarette and cigarette commodities (either substitutional or complementary) cannot determine whether non-cigarette or cigarette commodities should be taxed or subsidized. This is due to the government's desire to influence 4 variables, c, x^d, x^i and l with only 3 instruments, t_c, t_x and T.

The effect of the illegal production of cigarette in the equations of case 2 is shown by $\frac{\partial \tilde{l^i}}{\partial q_x}$. $\frac{\partial \tilde{l^i}}{\partial q_x}$>0 has a negative relationship with the rate of cigarette excise tax due to the negative value of $\frac{\partial \tilde{c}}{\partial q_c}$ in equation 13. Therefore, if there is an increase in the illegal production of cigarettes, the rate of cigarette excise tax is less than the marginal cost of health care. The relationship between the marginal cost of health care and both tax instruments is positive. However, we find that the rate of cigarette excise tax is not equal with the marginal cost of health care in case 2. This is due to the illegal production of cigarettes. Own-price elasticity of non-cigarette commodity demand is assumed to have a negative value in equation 13. The relationship between the own-price elasticity of non-cigarette commodity demand and the rate of cigarette excise tax is negative. The relationship between cross price elasticity of non-cigarette demand is positive when the non-cigarette commodity has a substitutional characteristic. It has a negative value if it has a complementary characteristic.

The results of the derivation of income tax are written as follows.

$$\Delta^{c}= \frac{\partial \tilde{c}}{\partial q_c}\left[\frac{\partial \widetilde{l^{\iota}}}{\partial q_x} - \frac{\frac{\partial \tilde{c}}{\partial q_x}}{\frac{\partial \tilde{c}}{\partial q_c}}\frac{\partial \widetilde{l^{\iota}}}{\partial q_c}\right] \tag{14}$$

$$\Delta^{x}= \frac{\partial \widetilde{x_s}}{\partial q_x}\left[\frac{\partial \widetilde{l^{\iota}}}{\partial q_c} - \frac{\frac{\partial \tilde{x}}{\partial q_c}}{\frac{\partial \widetilde{x_s}}{\partial q_x}}\frac{\partial \widetilde{l^{\iota}}}{\partial q_x}\right] \tag{15}$$

$$T' = \frac{\rho' f'}{w}\left[\frac{\partial \widetilde{l^{\iota}}}{\partial l} - \frac{1}{|\boldsymbol{H}|}\left(\Delta^{c}\frac{\partial \widetilde{x^{d}}}{\partial l} + \Delta^{x}\frac{\partial \tilde{c}}{\partial l}\right)\right] \tag{16}$$

Equation 16 has different signs when compared to Arronson and Sjogren's findings. This indicates that an increase in the work hours of a legal cigarette production will reduce illegal cigarette production if $\frac{\partial \widetilde{l^{\iota}}}{\partial l}<0$. Therefore, there is an incentive to increase legal cigarette production by reducing the marginal income tax. Equation 14 and 15 summarize the relationship between consumer price and illegal cigarette production which affect income tax structure. The role of equation 14 and 15 is to connect the derivation of compensated demand function for l. This means that, to realize efficiency, more policy instruments which are connected with each other are needed when there is an illegal production of cigarettes.

4. Conclusions

Our conclusions present some important results. We find that, without illegal production of cigarettes, the government can achieve the first best optimum condition by fully internalizing externality. The government can optimally choose t_x that is equal to the marginal cost of health care, ρ'. When there is an illegal production of cigarettes, we find that the rate of cigarette excise tax is not equal to the marginal cost of health care. Therefore, the government needs more policy instruments to achieve the optimal tax rate in that case. We also find that an increase in the work hours in a legal cigarette production reduces illegal cigarette production.

Policymakers can use the optimal tax analysis in deciding the tax rate or the optimal excise tax for the economy. Policymakers could use marginal income tax policy as an incentive to reduce illegal production of cigarettes since a decrease in the marginal income tax would increase labor hours in legal productions. Policymakers should consider the own-price elasticity of non-cigarette commodities and the own-price elasticity of cigarette commodities in deciding the rate of cigarette excise tax and the non-cigarette commodity tax because the own-price elasticity of cigarette demand has a positive relationship with the tax rate of non-cigarette commodities, and the own-price elasticity of non-cigarette demand has a negative relationship with the cigarette excise tax. However, it is important to acknowledge the limitations of this study, as it helps to identify important areas for future research. Our findings are still lacking of empirical support. The future research can estimate empirically from each parameter in our findings by using them as the base for numerical simulations.

References

Adioetomo, S. M., Djutaharta, T., & Hendratno. (2005). Cigarette Taxation, Consumption and Household Income. *Economics of Tobacco Control*.

Ahsan, A., Wiyono, N. H., & Aninditya, F. (2012). *Beban Konsumsi Rokok, Kebijakan Cukai dan Pengentasan Kemiskinan.* Depok: Lembaga Demografi, Fakultas Ekonomi dan Bisnis, Universitas Indonesia.

Aronsson, T., & Sjogren, T. (2010). An Optimal-Tax Approach to Alcohol Policy. *Public Finance Analysis Vol. 66 No.2*, 153-169.

Auerbach, A. J., & Hines Jr., J. R. (2001). Perfect Taxation with Imperfect Competition. *NBER Working Paper Series No. 8138*.

Chiang, A. C. (1984). *Fundamental Methods of Mathematical Economics.* New York: McGraw-Hill, Inc.

Gruber, J., & Koszegi, B. (2004). Tax incidence when individuals are time-inconsistent: the case of cigarette excise taxes. *Journal of Public Economics Volume 88, Issues 9-10*, 1959-1987.

Hu, T. W., & Mao, Z. (2002). Effects of cigarette tax on cigarette consumption and the Chinese economy. *Tobacco Control Volume 11*, 105-108.

Jin, M., Shi, X., Emrouznejad, A., & Yang, F. (2017). Determining the Optimal Carbon Tax Rate based on Data Envelopment Analysis. *Journal of Cleaner Production Volume 172*, 900-908.

Kapeliushnikov, R. (2015). Behavioral economics and the ‘new’ paternalism. *Russion Journal of Economics 1 Volume 1, Issue 1*, 81-107.

Kementerian Kesehatan. (2015, November 25). Retrieved from Kementerian Kesehatan Republik Indonesia Web Site: kemkes.go.id

Kementrian Keuangan. (2017). *Buku II Nota Keuangan Beserta Anggaran Pendapatan dan Belanja Negara.* Jakarta: Kementrian Keuangan Republik Indonesia.

Kementrian Perindustrian. (2012). Retrieved from Kementrian Perindustrian Web Site: Kemenperin.go.id

Laibson, D. (1997). Golden Eggs and Hyperbolic Discounting. *Quarterly Journal of Economics 112 Volume 112, Issue 2*, 443-477.

Lee, J.-M., Liao, D.-S., C-Y, Y., & Liao, W.-Z. (2005). Effect of cigarette tax increase on cigarette consumption in Taiwan. *Tobacco Control Vol. 14*, i71-i75.

Mankiw, N. G., Weinzierl, M., & Yagan, D. (2009). Optimal Taxation in Theory and Practice. *Journal of Economic Perspectives Volume 23, No.4*, 147-74.

O' Donoghue, R., & Rabin, M. (2006). Optimal Sin Taxes. *Journal of Public Economics Volume 90, Isuue 10-11*, 1825-1849.

O' Donoghue, T., & Rabin, M. (2003). Studying Optimal Paternalism, Illustrated by a Model of Sin Taxes. *The American Economic Review Vol. 93 No.2*, 186-191.

Ramsey, F. P. (1927). A Contribution to the Theory of Taxation. *The Economic Journal Vol 37 No 145*, 47-61.

Rosen, H. S., & Gayer, T. (2010). *Public Finance.* New York: McGraw - Hill, Inc.

Sandmo, A. (1975). Optimal Taxation in the Presence of Externalities . *The Swedish Journal of Economics Vol.77, No.1*, 86-98.

Slemrod, J. (1990). Optimal Taxation and Optimal Tax System. *Journal of Economics Perspectives Volume 4, No.1*, 157-178.

Tobacco Atlas. (2016). *Indonesia Country Facts.* American Cancer Society.

Wahyudiyanta, I. (2017, September 30). *Pelaku Industri Tembakau Tolak Kenaikan Tarif Cukai Rokok*. Retrieved from detiknews: https://news.detik.com/berita-jawa-timur/d-3664718/pelaku-industri-tembakau-tolak-kenaikan-tarif-cukai-rokok

Appendix

Appendix 1. Derivation/Proof

First Utility Function's Lagrange Optimization.

$$L = U + \lambda_1(b - q_x x^d + q_c c + p^i f(l^i)) + \lambda_2 \left(x - x^d - f(l^i)\right)$$

$$= 0$$

$$\frac{\partial L}{\partial x} = U_x + \lambda_2 = 0 \quad \text{(F1)}$$

$$U_x = \frac{\partial u}{\partial x}$$

$$\frac{\partial L}{\partial c} = U_c + \lambda_1 q_c = 0 \quad \text{(F2)}$$

$$U_c = \frac{\partial u}{\partial c}$$

$$\frac{\partial L}{\partial x^d} = \frac{\partial u}{\partial x} \cdot \frac{dx}{dx^d} - \lambda_1 q_x - \lambda_2 = 0 \quad \text{(F3)}$$

$$\frac{\partial L}{\partial l^i} = \frac{\partial u}{\partial z} \cdot \frac{\partial z}{\partial l^i} + \lambda_1 p^i \frac{\partial}{\partial l^i} f(l^i) - \lambda_2 \frac{\partial}{\partial l^i} f(l^i) = 0 \quad \text{(F4)}$$

$$\frac{\partial L}{\partial \lambda_1} = b - q_x x^d - q_c c = 0 \quad \text{(F5)}$$

$$\frac{\partial L}{\partial \lambda_2} = x - x^d - f(l^i) = 0 \quad \text{(F6)}$$

If |J|=|H| and |J|>0, Consequently the implicit function theorem is applicable, and we may express the optimal values of the endogenous variables as the implicit function of exogenous variables. This function is written in the model section.

$$| J |= \begin{vmatrix} \partial F1/\partial\lambda 1 & \partial F1/\partial\lambda 2 & \partial F1/\partial c & \partial F1/\partial xd & \partial F1/\partial li \\ \partial F2/\partial\lambda 1 & \partial F2/\partial\lambda 2 & \partial F2/\partial c & \partial F2/\partial xd & \partial F2/\partial li \\ \partial F3/\partial\lambda 1 & \partial F3/\partial\lambda 2 & \partial F3/\partial c & \partial F3/\partial xd & \partial F3/\partial li \\ \partial F4/\partial\lambda 1 & \partial F4/\partial\lambda 2 & \partial F4/\partial c & \partial F4/\partial xd & \partial F4/\partial li \\ \partial F5/\partial\lambda 1 & \partial F5/\partial\lambda 2 & \partial F5/\partial c & \partial F5/\partial xd & \partial F5/\partial li \\ \partial F6/\partial\lambda 1 & \partial F6/\partial\lambda 2 & \partial F6/\partial c & \partial F6/\partial xd & \partial F6/\partial li \end{vmatrix}$$

Indirect Utility Function, Individual Optimization Problem.

$$v = v(b, l, q_c, q_x; p^i)$$

$$s.t.$$

$$b = wl + w^i l^i - T(wl)$$

$$L = v(\cdot) + \lambda(b - wl - w^i l^i + T(\cdot)wl)$$

$$\frac{\partial L}{\partial b} = V_b + \lambda = 0$$

$$V_b = \frac{\partial v}{\partial b}$$

$$\frac{\partial L}{\partial l} = v_l - \lambda w + \lambda T_l w = 0$$

$$v_l = \frac{\partial v}{\partial l}$$

$$v_b = -\lambda$$

$$v_l + (T_l w - w)\lambda = 0$$

$$\lambda = \frac{v_l}{(T_l w - w)}$$

$$-v_b = \frac{v_l}{(T_l w - w)}$$

$$v_b(T_l w - w) + v_l = 0$$

$$-v_b T_l w + v_b w + v_l = 0$$

$$v_b w(-T_l + 1) + v_l = 0$$

$$v_b w(1 - T_l) + v_l = 0$$

Optimal Tax Problem

$$v = v(b, l, q_c, q_x; p^i)$$

$$s.t.$$

$$-b + wl + t_c c + t_x x^d - \rho\big(x(\cdot)\big) = 0\ ;\ \ x^d(\cdot) = x(\cdot) - f\left(l^i(\cdot)\right)$$

$$L = v(\cdot) + \lambda\left(-b + wl + t_c c + t_x x^d(\cdot) - \rho\big(x(\cdot)\big)\right) = 0$$

$$\frac{\partial L}{\partial l} = v_l + \lambda\left(w + t_c\frac{\partial c}{\partial l} + t_x\frac{\partial x^d}{\partial l} - \rho'\frac{\partial x}{\partial l}\right) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots... (17)$$

$$\rho' = \frac{\partial \rho}{\partial x}$$

$$\frac{\partial L}{\partial b} = v_b + \lambda\left(-1 + t_c\frac{\partial c}{\partial b} + t_x\frac{\partial x^d}{\partial b} - \rho'\frac{\partial x}{\partial b}\right) = 0 \quad \text{.........................} (18)$$

$$\frac{\partial L}{\partial t_c} = v_{q_c} + \lambda\left(c + t_c\frac{\partial c}{\partial q_c} + t_x\frac{\partial x^d}{\partial q_c} - \rho'\frac{\partial x}{\partial q_c}\right) = 0 \quad \text{.........................}(19)$$

$$v_{q_c} = -cv_b$$

$$\frac{\partial L}{\partial t_x} = v_{q_c} + \lambda\left(x^d + t_c\frac{\partial c}{\partial q_x} + t_x\frac{\partial x^d}{\partial q_x} - \rho'\frac{\partial x}{\partial q_x}\right) = 0 \quad \text{.........................}(20)$$

$$v_{q_x} = -x^d v_b$$

Solutions for equation 18–20

$$v_b + \lambda\left(-1 + t_c\frac{\partial c}{\partial b} + t_x\frac{\partial x^d}{\partial b} - \rho'\frac{\partial x}{\partial b}\right) = 0$$

$$t_c\frac{\partial c}{\partial q_c} + t_x\frac{\partial x^d}{\partial q_c} - \rho'\frac{\partial x}{\partial q_c} = 0$$

$$-x^d v_b + \lambda\left(x^d + t_c\frac{\partial c}{\partial q_x} + t_x\frac{\partial x^d}{\partial q_x} - \rho'\frac{\partial x}{\partial q_x}\right) = 0$$

$$t_c\frac{\partial c}{\partial q_x} + t_x\frac{\partial x^d}{\partial q_x} - \rho'\frac{\partial x}{\partial q_x} = 0$$

Case 1, $x^i = 0; x = x^d$, based on the equations above, we may write:

$$t_c\frac{\partial c}{\partial q_c} + t_x\frac{\partial x^d}{\partial q_c} = \rho'\frac{\partial x}{\partial q_c}$$

$$t_c\frac{\partial c}{\partial q_x} + t_x\frac{\partial x^d}{\partial q_x} = \rho'\frac{\partial x}{\partial q_x}$$

Cramer's rule is used to solve the equations above and obtain tax equations.

$|A| = \begin{vmatrix} \frac{\partial \tilde{c}}{\partial q_c} & \frac{\partial x^d}{\partial q_c} \\ \frac{\partial \tilde{c}}{\partial q_x} & \frac{\partial x^d}{\partial q_x} \end{vmatrix}$ or we may call this matrix as matrix $|H|$ in chapter 3.

$$|A_{tc}| = \begin{vmatrix} \rho'\frac{\partial \tilde{x}}{\partial q_c} & \frac{\partial \widetilde{x^d}}{\partial q_c} \\ \rho'\frac{\partial \tilde{x}}{\partial q_x} & \frac{\partial \widetilde{x^d}}{\partial q_x} \end{vmatrix} \quad |A_{tx}| = \begin{vmatrix} \frac{\partial \tilde{c}}{\partial q_c} & \rho'\frac{\partial \tilde{x}}{\partial q_c} \\ \frac{\partial \tilde{c}}{\partial q_x} & \rho'\frac{\partial \tilde{x}}{\partial q_x} \end{vmatrix} \quad t_c = \frac{|A_{tc}|}{|A|} \quad t_x = \frac{|A_{tx}|}{|A|}$$

$$t_c = \frac{\rho'\frac{\partial \tilde{x}}{\partial q_c}\frac{\partial \widetilde{x^d}}{\partial q_x} - \rho'\frac{\partial \tilde{x}}{\partial q_x}\frac{\partial \widetilde{x^d}}{\partial q_c}}{\frac{\partial \tilde{c}}{\partial q_c}\frac{\partial x^d}{\partial q_x} - \frac{\partial \tilde{c}}{\partial q_x}\frac{\partial x^d}{\partial q_c}}$$

$$= \frac{\rho'\frac{\partial\tilde{x}}{\partial q_c}\frac{\partial\widetilde{x^d}}{\partial q_x} - \rho'\frac{\partial\tilde{x}}{\partial q_x}\frac{\partial\widetilde{x^d}}{\partial q_c}}{|H|}$$

$$= \frac{\rho'}{|H|}\left(\rho'\frac{\partial\tilde{x}}{\partial q_c}\frac{\partial\widetilde{x^d}}{\partial q_x} - \rho'\frac{\partial\tilde{x}}{\partial q_x}\frac{\partial\widetilde{x^d}}{\partial q_c}\right) \text{ , since } x = x^d$$

$$= 0$$

$$t_x = \frac{\frac{\partial\tilde{c}}{\partial q_c}\rho'\frac{\partial\tilde{x}}{\partial q_x} - \frac{\partial\tilde{c}}{\partial q_x}\rho'\frac{\partial\tilde{x}}{\partial q_c}}{|H|}$$

$$= \frac{\rho'}{|H|}(|H|)$$

$$= \rho'$$

We can obtain T' by using the following procedure:

$$\lambda = \frac{-v_b}{-1 + t_c\frac{\partial c}{\partial b} + t_x\frac{\partial x^d}{\partial b} - \rho'\frac{\partial x}{\partial b}}$$

Since $t_x = \rho'$ and $t_c = 0$, then $T' = 0$

Case 2: Illegal production of cigarettes. Back to Lagrange optimal tax problem.

$$L = v(\cdot) + \lambda\left(-b + wl + t_c c(\cdot) + t_x x^d(\cdot) - \rho\big(x(\cdot)\big)\right) = 0$$

Before we derive with the same method used in case 1, there are differences in deriving several parameters.

We can write down a matrix as the one used in case 1 by using the same procedure. The difference between case 1 and case 2 is the process to find the explicit solution.

$$t_c = \frac{\left(\rho'\frac{\partial x}{\partial q_c}\frac{\partial x^d}{\partial q_x} - \rho'\frac{\partial x}{\partial q_x}\frac{\partial x^d}{\partial q_c}\right)}{|H|}$$

$\frac{\partial x^d}{\partial q_x}$ and $\frac{\partial x^d}{\partial q_c}$ We may deploy them into $\frac{\partial x}{\partial q_x} - f'\frac{\partial l^i}{\partial q_c}$ dan $\frac{\partial x}{\partial q_c} - f'\frac{\partial l^i}{\partial q_x}$

$$= \frac{\rho'\frac{\partial x}{\partial q_c}\frac{\partial x}{\partial q_x} - \rho' f'\frac{\partial x}{\partial q_c}\frac{\partial l^i}{\partial q_x} - \left(\rho'\frac{\partial x}{\partial q_x}\frac{\partial x}{\partial q_c} - \rho' f'\frac{\partial x}{\partial q_x}\frac{\partial l^i}{\partial q_c}\right)}{|H|}$$

$$= \frac{\rho' f'}{|H|}\left(\frac{\partial x}{\partial q_x}\frac{\partial l^i}{\partial q_c} - \frac{\partial x}{\partial q_c}\frac{\partial l^i}{\partial q_x}\right)$$

$$= \frac{\rho' f'}{|H|}\left(\left(\frac{\partial x^d}{\partial q_x} + \frac{\partial x^i}{\partial q_x}\right)\frac{\partial l^i}{\partial q_c} - \frac{\partial x}{\partial q_c}\frac{\partial l^i}{\partial q_x}\right)$$

$$= \frac{\rho' f'}{|H|}\frac{\partial\widetilde{x_S}}{\partial q_x}\frac{\partial\widetilde{l^i}}{\partial q_c} - \frac{\rho' f'}{|H|}\frac{\partial\tilde{x}}{\partial q_c}\frac{\partial\widetilde{l^i}}{\partial q_x}$$

$$t_c = \frac{\rho' f'}{|H|}\frac{\partial\widetilde{x_S}}{\partial q_x}\left(\frac{\partial\widetilde{l^i}}{\partial q_c} - \frac{\frac{\partial x}{\partial q_c}}{\frac{\partial\widetilde{x_S}}{\partial q_x}}\frac{\partial\widetilde{l^i}}{\partial q_x}\right)$$

$$t_x = \frac{\frac{\partial\tilde{c}}{\partial q_c}\rho'\frac{\partial\tilde{x}}{\partial q_x} - \frac{\partial\tilde{c}}{\partial q_x}\rho'\frac{\partial\tilde{x}}{\partial q_c}}{|H|}$$

$\frac{\partial\tilde{x}}{\partial q_x}$ and $\frac{\partial\tilde{x}}{\partial q_c}$ We may deploy them into $f'\frac{\partial l^i}{\partial q_x} + \frac{\partial x^d}{\partial q_x}$ and $f'\frac{\partial l^i}{\partial q_c} + \frac{\partial x^d}{\partial q_c}$

$$= \frac{\left(\left(f'\frac{\partial\tilde{l^i}}{\partial q_x} + \frac{\partial\widetilde{x^d}}{\partial q_x}\right)\rho'\frac{\partial\tilde{c}}{\partial q_c} - \left(f'\frac{\partial\tilde{l^i}}{\partial q_c} + \frac{\partial\widetilde{x^d}}{\partial q_c}\right)\rho'\frac{\partial\tilde{c}}{\partial q_x}\right)}{|H|}$$

$$= \frac{(f'\frac{\partial\tilde{c}}{\partial q_c}\frac{\partial\tilde{l^i}}{\partial q_x} - f'\frac{\partial\tilde{c}}{\partial q_x}\frac{\partial\tilde{l^i}}{\partial q_c} + \frac{\partial\tilde{c}}{\partial q_c}\frac{\partial\widetilde{x^d}}{\partial q_x} - \frac{\partial\tilde{c}}{\partial q_x}\frac{\partial\widetilde{x^d}}{\partial q_c})\rho'}{|H|}$$

$$= \frac{\left(f'\frac{\partial\tilde{c}}{\partial q_c}\frac{\partial\tilde{l^i}}{\partial q_x} - f'\frac{\partial\tilde{c}}{\partial q_x}\frac{\partial\tilde{l^i}}{\partial q_c} + |H|\right)\rho'}{|H|}$$

$$= \left(\frac{f'}{|H|}\frac{\partial\tilde{c}}{\partial q_c}\frac{\partial\tilde{l^i}}{\partial q_x} - \frac{f'}{|H|}\frac{\partial\tilde{c}}{\partial q_x}\frac{\partial\tilde{l^i}}{\partial q_c} + 1\right)\rho'$$

$$= \frac{\rho' f'}{|H|}\frac{\partial\tilde{c}}{\partial q_c}\frac{\partial\tilde{l^i}}{\partial q_x} - \frac{\rho' f'}{|H|}\frac{\partial\tilde{c}}{\partial q_x}\frac{\partial\tilde{l^i}}{\partial q_c} + \rho'$$

$$t_x = \frac{\rho' f'}{|H|}\frac{\partial\tilde{c}}{\partial q_c}\left(\frac{\partial\tilde{l^i}}{\partial q_x} - \frac{\frac{\partial\tilde{c}}{\partial q_x}}{\frac{\partial\tilde{c}}{\partial q_c}}\frac{\partial\tilde{l^i}}{\partial q_c}\right) + \rho'$$

Before we continue to derive T' in case 2, we must derive several parameters with respect to l.

$$u = v(b(u, l, q_c, q_x; p^i), l, q_c, q_x; p^i)$$
$$\tilde{c}(u, l, q_c, q_x; p^i) = c(b(u, l, q_c, q_x; p^i), l, q_c, q_x; p^i)$$
$$x^d(u, l, q_c, q_x; p^i) = x^d(b(u, l, q_c, q_x; p^i), l, q_c, q_x; p^i)$$

Then we may form equations:

$$\frac{\partial\widetilde{x^d}}{\partial l} = \frac{\partial x^d}{\partial l} - \frac{v_l}{v_b}\frac{\partial x^d}{\partial b}$$
$$\frac{\partial\tilde{c}}{\partial l} = \frac{\partial c}{\partial l} - \frac{v_l}{v_b}\frac{\partial c}{\partial b}$$

$$v_b w T' = v_l\left((t_x - \rho')\frac{\partial x}{\partial b} + t_c\frac{\partial c}{\partial b}\right) - v_b\left((t_x - \rho')\frac{\partial x}{\partial l} + t_c\frac{\partial c}{\partial l}\right)$$

$$wT' = \frac{v_l}{v_b}\left(\left(\frac{\rho' f'}{|H|}\Delta^c + \rho'\right)\frac{\partial x^d}{\partial b} - \rho'\frac{\partial x}{\partial b} + \frac{\rho' f'}{|H|}\Delta^x\frac{\partial c}{\partial b}\right) - \left(\left(\frac{\rho' f'}{|H|}\Delta^c + \rho'\right)\frac{\partial x^d}{\partial l} - \rho'\frac{\partial x}{\partial l} + \frac{\rho' f'}{|H|}\Delta^x\frac{\partial c}{\partial l}\right)$$

$$= \frac{v_l}{v_b}\left(\frac{\rho' f'}{|H|}\Delta^c\frac{\partial x^d}{\partial b} + \rho'\frac{\partial x^d}{\partial b} - \rho'\frac{\partial x}{\partial b} + \frac{\rho' f'}{|H|}\Delta^x\frac{\partial c}{\partial b}\right) - \left(\frac{\rho' f'}{|H|}\Delta^c\frac{\partial x^d}{\partial l} + \rho'\frac{\partial x^d}{\partial l} - \rho'\frac{\partial x}{\partial l} + \frac{\rho' f'}{|H|}\Delta^x\frac{\partial c}{\partial l}\right)$$

$$= \frac{v_l}{v_b}\frac{\rho' f'}{|H|}\Delta^c\frac{\partial x^d}{\partial b} + \frac{v_l}{v_b}\rho'\frac{\partial x^d}{\partial b} - \frac{v_l}{v_b}\rho'\frac{\partial x}{\partial b} + \frac{v_l}{v_b}\frac{\rho' f'}{|H|}\Delta^x\frac{\partial c}{\partial b} - \frac{\rho' f'}{|H|}\Delta^c\frac{\partial x^d}{\partial l} - \rho'\frac{\partial x^d}{\partial l} + \rho'\frac{\partial x}{\partial l} - \frac{\rho' f'}{|H|}\Delta^x\frac{\partial c}{\partial l}$$

$$= \left(\frac{v_l}{v_b}\frac{\partial x^d}{\partial b} - \frac{\partial x^d}{\partial l}\right)\frac{\rho' f'}{|H|}\Delta^c + \left(\frac{v_l}{v_b}\frac{\partial c}{\partial b} - \frac{\partial c}{\partial l}\right)\frac{\rho' f'}{|H|}\Delta^x + \left(\frac{v_l}{v_b}\frac{\partial x^d}{\partial b} - \frac{\partial x^d}{\partial l}\right)\rho' + \left(\frac{\partial x}{\partial l} - \frac{v_l}{v_b}\frac{\partial x}{\partial b}\right)\rho'$$

$$\frac{\partial x}{\partial l} = \frac{\partial x^d}{\partial l} + \frac{\partial f(l^i)}{\partial l} \; ; \; \frac{\partial f(l^i)}{\partial l} = \frac{\partial f}{\partial l^i}\frac{\partial l^i}{\partial l}$$

$$= -\frac{\partial \widetilde{x^d}}{\partial l}\frac{\rho' f'}{|H|}\Delta^c - \frac{\partial \tilde{c}}{\partial l}\frac{\rho' f'}{|H|}\Delta^x + f'\rho'\frac{\partial \widetilde{l^i}}{\partial l}$$

$$T' = \frac{\rho' f'}{w}\left(\frac{\partial \widetilde{l^i}}{\partial l} - \frac{1}{|H|}\left(\frac{\partial \widetilde{x^d}}{\partial l}\Delta^c + \frac{\partial \tilde{c}}{\partial l}\Delta^x\right)\right)$$

$$\Delta^c = \frac{\partial \tilde{c}}{\partial q_c}\left[\frac{\partial \widetilde{l^i}}{\partial q_x} - \frac{\frac{\partial \tilde{c}}{\partial q_x}}{\frac{\partial \tilde{c}}{\partial q_c}}\frac{\partial \widetilde{l^i}}{\partial q_c}\right]$$

$$\Delta^x = \frac{\partial \widetilde{x_s}}{\partial q_x}\left[\frac{\partial \widetilde{l^i}}{\partial q_c} - \frac{\frac{\partial \tilde{x}}{\partial q_c}}{\frac{\partial \widetilde{x_s}}{\partial q_x}}\frac{\partial \widetilde{l^i}}{\partial q_x}\right]$$