Optimal Oil Price Band for Gasoline Taxation

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Abstract

This article proposes a theoretical model in which the government is endowed with the option to change the tax policy on the gasoline market depending on the oil price. Real option theory is used to determine an optimal oil price band for gasoline taxation. Numerical results show that the more concentrated the industry, the sooner the introduction of a new tax and the later the removing of it. A lower price elasticity of the demand and a higher minimum special tax has similar results, that is to diminish both limit of the band. Finally, the expected growth rate and volatility of the oil price does not change the band limit.

Key words: Real Options, Oil Price, Taxation, Oligopoly.
JEL Classification: Q48; H23.

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1 Introduction

In early 2011, Scottish MPs suggested the UK government to reduce taxes on petrol when the oil price is high and increase them when oil price is low. The objective of such a proposal is to use the tax policy as stabilizer of gasoline price caused by fluctuations in the oil price, especially in the current context, characterized by great uncertainty due to recent problems in some oil producing countries undergoing political instability, which has jointed to the demand pressures caused by the growth of large emerging countries like China, India or Brazil which for years have been the main factor causing the high oil price.

The tax policy on oil derivatives products has basically a twofold objective. On the one hand, it penalizes the consumption of fuels that causes pollution. On the other hand, it is an important source of revenue of the government. In the market, consumers perceive that pay high prices for such products due to a large extend to high taxes. Therefore, the peculiarity of those markets needs a tax policy that lessen the negative effects on the market welfare without giving up to tax polluting fuels.

The oil price is a key variable of the economies, whether exporters or importers. In oil-importing countries, the main concern is that high prices lead to inflation cost. The reasons for this may be the low price elasticity of demand for oil derivatives and the nature of competition in these markets, characterized by a high concentration. Directly or indirectly all economic activities are affected by the variability of oil price. Considering that price stability is a good signal for the productive sector, the lesser the uncertainty, the lesser the effect on aggregate production.

Following the Scottish MPs' proposal and considering that the government has tools to influence on the gasoline price stability, the objective of this paper is to propose a dynamic tax policy on hydrocarbons depending on an exogenous variable i.e. the oil price. Therefore, we focus on gasoline retail market and how tax policy can be used as a stabilizer tool of the final price, such that, under a high oil price state, which lead to high average and marginal production costs of gasoline and consequently a higher final price for consumers, it could be dampened by a tax cutting. Conversely, under a low oil price state, which implies low average and marginal production costs and a lower price of gasoline, taxes could be increased such as to cushion the fall. The idea is to reduce fluctuations in the retail price of gasoline caused by fluctuations in the oil price by using a fiscal tool. Although, it is a microeconomic problem, its scope is a macroeconomic one, since that it can be accomplished to lessen the impact of oil price fluctuations on the aggregate supply of goods and services. The question is what are the oil prices that optimally induce changes in the tax policy on the retail market of gasoline? and how are these affected by changes in the price elasticity of demand, the cost structure of firms and competition in such a market?

The objective of this study is therefore to determine the optimal band of oil prices that induce changes in tax policy on the retail market of gasoline. We propose a theoretical model in which the government has the option to change the tax policy at any point in time depending on the price of oil and whose objective is to maximize the expected discounted present value of the social welfare. We use real options theory (Dixit and Pindyck,1994), which has become a powerful tool for decision making under uncertainty. The model allows to determine the oil price band that induces an optimal change in the tax policy. Whenever the price remains within the band, the government does not change the tax policy and it will only do in a certain direction when the oil price exceeds one of the band limits.

Our aim is the opening of a new tax policy on oil which can yield interesting policy implications.

The article is organized as follows. A brief literature review on fuel taxes is presented in next section. The theoretical model is presented in section 3. Section 4 provides the numerical results, while conclusions are drawn in section 5.

2 Brief Literature Review on Fuel Taxes

The literature on fuel taxes has been mainly oriented to the study of their use as a tool to tax polluting energies and their redistributive effects. Roy *et al.* (1995) point out that fuel taxes are generally considered as a powerful instrument to reduce CO2 emissions. Sterner (2007) notes that fuel taxes have restricted the growth of demand for them. He argues that gasoline demand in the short term is fairly inelastic and that if European governments had not pursued a strong policy of taxes, demand would double. In fact, Brons *et al.* (2008) presents a meta-analysis and found that price elasticities of short and long term are -0.34 and -0.84, respectively, so that, as generally expected, gasoline demand is not very sensitive to price changes. Sterner (2011) points out that consumption of fuels have decreased appreciably due to taxes, which produced that the carbon emissions in Europe and Japan have been much lower than in the absence of such taxes.

With regard to the redistributive effects of taxes on gasoline Asensio *et al.* (2003) estimate a function of fuel expenditure of households and finds that the key variables for this are the household structure, place of residence and income. In addition, they estimate the income elasticity of gasoline and found that in general is close to one. They also found that for families with lower incomes, the share of spending on gasoline increases with income, indicating that taxes are progressive. However, from a certain level of income the tax is regressive. Alm *et al.* (2009) show that changes in gasoline taxes are passed on fully to the final consumer.

Taxes on gasoline are far from homogeneous as indicated in a survey including about 120 articles by Gupta and Mahler (1994) in which they show that there is a great tax rate variety among countries. On the other hand, Parry and Small (2005) question the optimally of tax policy on gasoline in the United States and the United Kingdom, and estimate that the optimal tax on gasoline in the United States is 2.5 times higher than the current while in the UK is half that today.

Contin-Pylartes *et al.* (2009) pointed out that the gasoline market in Spain is a highly concentrated oligopoly and study the behavior of the retail price of gasoline. Their results suggest that the government and major companies worked together to reduce the impact of high oil prices on inflation, suggesting that the analysis of prices in this market requires alternative views to the classical hypothesis in which firms take advantages of market power. Pedregal et al. (2009) developed an econometric model for the five main petroleum products. Its objective is to estimate demand elasticities and their results suggest that the largest impact on the demand for oil products is real income, while prices have little impact. Perdiguero (2010) shows that the gasoline market in Spain can be characterized by tacit collusion on prices.

Closer to our goal, Uri and Boyd (1989) found that an increase in the gasoline tax has a negative effect on welfare measured in terms of utility. In addition, Decker and Wohar (2007) suggest that whenever the trucking industry is an important source of employment generation, they found that the greater the contribution, the lower the tax rate.

3 The Model

Let assume that the gasoline retail market behaves as an oligopoly *à la* Cournot with M firms. As suggested by Contin-Pylartes *et al.* (2009) and Perdiguero (2010), and as experience shows, this is a highly concentrated market far from being competitive. In any case, the idea is to present scenarios that involve realistic structures from more concentrated to other less concentrated.

Let the inverse linear demand of gasoline be given by

$$P = \alpha - \beta Q$$

where Q is the total quantity sold in the industry at each price P, being $Q = \sum_{i=1}^{M} q_i$ and q_i the quantity sold by the firm i.

The M firms produce an homogeneous good according to a technology that uses an intermediate good, oil, as an input. The model is posed in a flexible enough manner to accommodate different cases of returns to scale and therefore different cost functions. The key variable of the model (the oil price) flows through the cost function. Oil is the essential input in the production of gasoline which is given by a Cobb-Douglas production function as follows

$$q_i = f_i \left(K_i, O_i \right) = K_i^{\theta} O_i^{\phi}$$

where K are the units of capital and O_i is the amount of oil used as intermediate good to produce gasoline. The cost function is given by

$$c_i \left(q_i \right) = g \left(S \right) q_i^{\delta}$$

where $g \left(S \right) = \gamma S^{\frac{\phi}{\theta+\phi}}$, $\gamma = \left[\left(\frac{\theta}{\phi} \right)^{\frac{\phi}{\theta+\phi}} + \left(\frac{\theta}{\phi} \right)^{\frac{-\theta}{\theta+\phi}} \right] r^{\frac{\theta}{\theta+\phi}}$ and $\delta = \frac{1}{\theta+\phi}$.

Being r the price of input K and S is the oil price.

Initially, the government intervenes in the market collecting a minimum exogenous special tax, τ, which might be related to an environmental measure or simply to get revenues and therefore it is included in the final price of the gasoline, P, which is what consumers observe and pay per unit. Firms, however, receives $P - \tau$ per unit sold.

The solution to the oligopoly model assuming constant return to scale gives

$$\begin{aligned} q_1 &= q_2 ... = q_M = q^* = \frac{\alpha - \tau - \gamma S^{\phi}}{\beta (M+1)} \\ Q^* &= \frac{M\left(\alpha - \tau - \gamma S^{\phi}\right)}{\beta (M+1)} \\ P^* &= \alpha - \frac{M\left(\alpha - \tau - \gamma S^{\phi}\right)}{(M+1)} \end{aligned}$$

The social welfare at each period is given by

$$W(S) = CS(S) + \sum_{i=1}^{M} \pi_i(S) + \tau Q(S)$$

Where $CS(S)$ is the consumer surplus, $\pi_i(S)$ is the profits of the firm i and $\tau Q(S)$ is the tax revenue of the government.

$$\begin{aligned} CS(S) &= \frac{M}{2\beta}\left(\frac{\alpha - \tau - \gamma S^{\phi}}{M+1}\right)^2 \\ \pi_i(S) &= \frac{1}{\beta}\left(\frac{\alpha - \tau - \gamma S^{\phi}}{M+1}\right)^2 \\ \tau Q(S) &= \tau \frac{M\left(\alpha - \tau - \gamma S^{\phi}\right)}{\beta (M+1)} \end{aligned}$$

$$W(S) = \frac{3M\gamma^2 S^{2\phi}}{2\beta (M+1)^2} - \frac{[3\alpha + (M-2)\tau] M\gamma S^{\phi}}{\beta (M+1)^2} + \frac{M(\alpha - \tau)[(2M-1)\tau + 3\alpha]}{2\beta (M+1)^2} \tag{1}$$

Considers that all the uncertainty in this market comes from the oil price, S, which is assumed to follow a geometric Brownian motion as

$$\frac{dS}{S} = \mu dt + \sigma dz$$

where dz is an increment of a standard Wiener process, uncorrelated across time and at any one instant satisfies $E(dz) = 0$, $E(dz^2) = dt$, where

E denotes the expectations operator, μ is the expected growth rate of the oil price and σ is a measure of the volatility.

The government is endowed with the option to change the gasoline taxation policy in just λ monetary units once depending on oil price. If so, we can rewrite equation (1) when the increase in tax has been undertaken as

$$\begin{aligned} W(S,\lambda) &= CS(S,\lambda) + \sum_{i=1}^{M} \pi_i (S,\lambda) + (\tau+\lambda) Q(S,\lambda) \\ &= \frac{3M\gamma^2 S^{2\phi}}{2\beta (M+1)^2} - \frac{[3\alpha + (M-2)(\tau+\lambda)] M\gamma S^{\phi}}{\beta (M+1)^2} \\ &\quad + \frac{M(\alpha - (\tau+\lambda))[(2M-1)(\tau+\lambda) + 3\alpha]}{2\beta (M+1)^2} \end{aligned} \tag{2}$$

The objective of the government is to maximize the expected discounted present value of the social welfare and can optimally change the gasoline tax policy at any time. Should the oil price is decreasing the government can impose the tax. Should the oil price is increasing the government can remove the tax. Therefore, the conditions for the optimal exercising must be stated. Let $V(S)$ and $V_\lambda(S)$ be the Bellman value function following the optimal policy. $V(S)$ and $V_\lambda(S)$ can be interpreted as the value of an asset that yields each period a capital gain due to the stochastic movement of the oil price S and a dividend flow measure by the value of the social welfare. Therefore, under no-arbitrage opportunities it must be case that

$$\begin{aligned} \frac{E(dV(S))}{dt} + W(S) &= \rho V(S) \\ \frac{E(dV_\lambda(S))}{dt} + W(S,\lambda) &= \rho V_\lambda(S) \end{aligned} \tag{3}$$

where ρ is the discount factor and it is assumed that $\rho > \mu$, otherwise the present discount value of the social welfare is unbounded. Equation (3) states that the capital gains plus the dividend flow must equal the normal return.

Using Îto's lemma in equation (3) we obtain

$$\begin{aligned}
\frac{1}{2}\sigma^2 S^2 V''(S) + \mu S V'(S) - \rho V(S) &= -W(S) \qquad (4)\\
\frac{1}{2}\sigma^2 S^2 V_\lambda''(S) + \mu S V_\lambda'(S) - \rho V_\lambda(S) &= -W(S,\lambda)
\end{aligned}$$

The general solutions to equations in (4) are

$$\begin{aligned}
V(S) &= AS^{\eta_0} + BS^{\eta_1} + E\int_{t=0}^{\infty} W(S)\, e^{-\rho t} dt \qquad (5)\\
V_\lambda(S) &= A_\lambda S^{\eta_0} + B_\lambda S^{\eta_1} + E\int_{t=0}^{\infty} W(S,\lambda)\, e^{-\rho t} dt
\end{aligned}$$

where , A,B, A_λ and B_λ are positive constants to be determined and

$$\begin{aligned}
\eta_0 &= \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}} < 0\\
\eta_1 &= \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}} > 1
\end{aligned}$$

$$\begin{aligned}
E\int_{t=0}^{\infty} W(S)\, e^{-\rho t} dt &= XS^{2\phi} + YS^{\phi} + Z\\
E\int_{t=0}^{\infty} W(S,\lambda)\, e^{-\rho t} dt &= XS^{2\phi} + Y_\lambda S^{\phi} + Z_\lambda
\end{aligned}$$

With

$$\begin{aligned}
X &= -\frac{3M\gamma^2}{2\beta(M+1)^2\left[\phi(2\phi-1)\sigma^2+2\phi\mu-\rho\right]} \\
Y &= \frac{\left[3\alpha+\tau(M-2)\right]M\gamma}{\beta(M+1)^2\left[\frac{\sigma^2}{2}\phi(\phi-1)+\phi\mu-\rho\right]} \\
Z &= \frac{M(\alpha-\tau)\left[(2M-1)\tau+3\alpha\right]}{2\beta(M+1)^2\rho} \\
Y_\lambda &= \frac{\left[3\alpha+(M-2)(\tau+\lambda)\right]M\gamma}{\beta(M+1)^2\left[\frac{\sigma^2}{2}\phi(\phi-1)+\phi\mu-\rho\right]} \\
Z_\lambda &= \frac{M(\alpha-(\tau+\lambda))\left[(2M-1)(\tau+\lambda)+3\alpha\right]}{2\beta(M+1)^2\rho}
\end{aligned}$$

The solution for $V(S)$ $(V_\lambda(S))$ has two part. $AS^{\eta_0}+BS^{\eta_1}$ $(A_\lambda S^{\eta_0}+B_\lambda S^{\eta_1})$ collects the option value of changing the tax policy while $E\int_{t=0}^{\infty}W(S)e^{-\rho t}dt$ $(E\int_{t=0}^{\infty}W(S,\lambda)e^{-\rho t}dt)$ is the expected discounted present value of the dividend flow.

Since $V(S)$ and $V_\lambda(S)$ must remain bounded, boundary conditions should be imposed. Even though S is increasing, when there have been no tax increase, the option of reducing tax takes is worthless. However, when S is decreasing, the option of adding a tax increases. Therefore, we impose $B=0$. Once, the new tax is introduced, the option to increase tax is worthless since the government can not add another tax. However, the option of reducing it increases as S increases. Therefore, we impose $A_\lambda=0$. We rewrite equations in (5) as

$$\begin{aligned}
V(S) &= AS^{\eta_0}+E\int_{t=0}^{\infty}W(S)e^{-\rho t}dt \\
V_\lambda(S) &= B_\lambda S^{\eta_1}+E\int_{t=0}^{\infty}W(S,\lambda)e^{-\rho t}dt
\end{aligned}$$

The optimal exercising works as follows. Should the oil price is decreasing, there will be a threshold oil price low enough $\underline{S}$ that induces an optimal change in the tax policy, i.e. an increase in tax in λ. Therefore, whenever the oil price remains in the interval $(\underline{S}, \infty)$ there will not be tax increase. Changing the tax policy can be done at a sunk cost of I monetary units, related to cost due to changes in information system, in any case, an additional cost due to changes in the procedure of tax collection. The value-matching and smooth pasting conditions are

$$\begin{aligned} V\left(\underline{S}\right) &= V_{\lambda}\left(\underline{S}\right) - I \\ V'\left(\underline{S}\right) &= V'_{\lambda}\left(\underline{S}\right) \end{aligned} \tag{6}$$

$\underline{S}$ can be thought as the trigger oil price at which it only becomes optimal to increase in a magnitude λ the tax.

Once the tax increase is done, should the oil price is increasing, there will be a threshold oil price high enough,$\overline{S}$, that induces an optimal change in the tax policy, i.e. a decrease in the tax in λ and returning to the previous state. Therefore, the oil price remains in the interval $\left(0, \overline{S}\right)$ the tax will be not removed. Analogously, $\overline{S}$ can be seen as the trigger oil price at which it only becomes optimal to reduce taxes in a magnitude λ. The value-matching and smooth pasting conditions are

$$\begin{aligned} V_{\lambda}\left(\overline{S}\right) &= V\left(\overline{S}\right) - I \\ V'_{\lambda}\left(\overline{S}\right) &= V'\left(\overline{S}\right) \end{aligned} \tag{7}$$

Therefore, whenever the oil price moves into the interval $(\underline{S}, \overline{S})$ the government does not change the tax policy.

The value matching and smooth pasting conditions in (6) and (7) constitute a four-equation system to be solved for A, B_{λ}, $\underline{S}_n$ and $\overline{S}_n$ which can be written as

$$\begin{aligned} B_{\lambda}\underline{S}^{\eta_1} - A\underline{S}^{\eta_0} + y\underline{S}^{\phi} + z - I &= 0 \\ \eta_1 B_{\lambda}\underline{S}^{\eta_1 - 1} - \eta_0 A\underline{S}^{\eta_0 - 1} + \phi y\underline{S}^{\phi - 1} &= 0 \\ B_{\lambda}\overline{S}^{\eta_1} - A\overline{S}^{\eta_0} + y\overline{S}^{\phi} + z + I &= 0 \\ \eta_1 B_{\lambda}\overline{S}^{\eta_1 - 1} - \eta_0 A\overline{S}^{\eta_0 - 1} + \phi y\overline{S}^{\phi - 1} &= 0 \end{aligned} \tag{8}$$

Where

$$
\begin{aligned}
y &= Y_\lambda - Y = \frac{(M-2)\, M\gamma\lambda}{\beta\,(M+1)^2\left[\frac{\sigma^2}{2}\phi\,(\phi-1)+\phi\mu-\rho\right]} \\
z &= Z_\lambda - Z = \frac{\lambda\left[(2M-1)\,(\alpha M-(M+1)\,\tau+\lambda)-3\alpha\right]}{2\beta\,(M+1)^2\,\rho}
\end{aligned}
$$

This system of equations (8) has no analytical solution and it is therefore necessary to resort to numerical solutions.

4 Numerical Results

4.1 Baseline Case

In order to obtain as much as possible real values for the parameters, a kind of raw calibration is done. Data of Spain is used. The Spanish retail market of gasoline is characterized by few firms. In fact, there are three firms that cover a very large proportion of the market: Repsol, Cepsa and BP. Therefore, let consider $M = 3$. To obtain the parameter of the demand function, consider the average consumption of gasoline in Spain in the 2004-2010 period which is 7,679,217 Kiloliters per year and the average price in the same period, 1.0264€ per liter after tax as the equilibrium quantity (Q^*) and price (P^*) respectively. Moreover, according to Brons *et al.* (2008) the price elasticity of short term is $\varepsilon_P = -0.34$. The parameter α and β can be found from the following equation system

$$
\begin{aligned}
P^* &= \alpha - \beta Q^* \\
\varepsilon_P &= -\frac{1}{\beta}\frac{P^*}{Q^*}
\end{aligned}
$$

Regarding the cost function, consider $\phi = 0.75$, $r = \rho = 0.025$. The special tax on average in the 2004-2010 period is $\tau = 0.4$€ per liter. Let consider the average annual expected growth rate of oil price 2 percent ($\mu = 0.02$) and the variance of the price 4 percent per year ($\sigma^2 = 0.04$) and the standard deviation, as the square root of time, is 20 percent for one year ($\sigma = 0.2$) and 40 percent over four years. Let a positive sunk cost of changing the tax equal to one million euros ($I = 1,000,000$), otherwise $\underline{S} \approx \overline{S}$. Finally, the increment/decrease in tax policy is equal to 10 cents of Euro ($\lambda = 0.1$).

With the parametrization describe above, $\underline{S} = 98.5$ and $\overline{S} = 111.8$. Therefore, whenever the oil price is within the interval $(\underline{S}, \infty)$ the government maintain the option to increase the tax. Assume that the initial oil price is $S = 100$, should the oil price decrease and reaches the value $\underline{S} = 98.5$, it is optimal for the society increase the tax on gasoline price in 10 cents of Euro. Moreover, once the new tax has been introduced, whenever the oil price is within the interval $\left(0, \overline{S}\right)$ the government maintain the option to reduce the tax and it will be only optimal to reduce the tax in 10 cents of euro when the oil price reaches the value $\overline{S} = 111.8$, that is, once the increase of the tax has been done, oil price should increase in 13.5 percent to reduce the tax in the same magnitude.

4.2 Changes in the Parameters of the Model

Let consider more competitive markets. Figure 1 shows the trigger oil price for up to 10 firm in the market.[1] Notice that, the more firms in the market the lower the trigger oil prices. Therefore, departing from the initial oil price $S = 100$, should the oil price is decreasing, the lower the number of firms the sooner the increase in tax. In fact, with 3 firms oil price only has to diminish 1.5 percent, with 4 firm, 24.5 percent, with 5 firm, 34.3 percent and so on up to the case of 10 firm in which oil price should decrease 43.7 percent, which means that the oil price should reach the value of $\underline{S} = 53.3$. On the contrary, notice that the lower the number of firms the later the tax reduction. Consider that in all the market structures the increase in tax has be done. For instance, consider that the oil price has reached the value $S = 50$. For the case of 10 firms in the market, the oil price should reach the value of $\overline{S} = 58.7$ to reduce the tax in 10 cents of Euro, that is an increase in oil price of 17.4% while with 3 firms it has to increase 123.7%. It can be also notice in figure 1 that the trigger oil prices are specially sensitive in more concentrated industry. In fact, in industry with 3 up to 6 firms differences are very important. However, in more competitive industries, for $M \geq 7$, differences are very small.

The inaction band ($\underline{S}$,$\overline{S}$) is commonly called in the literature hysteresis. That is, whenever the oil price remains into the band the government does

[1] No numerical solutions were found for the monopoly and duopoly.

not alter the tax policy. However, it will change the tax police when the oil price exceeds the band limits.

Figure 1.

Hysteresis define as $\overline{S}/\underline{S}$ is also decreasing with the number of firms in the market. The ratio $\overline{S}/\underline{S}$ when there are 3 (10) firms is 1.14 (1.10) which means that in a market with 3 (10) firms, once the tax reduction has be done, the oil price has to increase 14% (10%) to reverse the decision. It should be stressed, however, that hysteresis is not remarkable different across market structure. The big difference is in the timing of the decision, that is in the absolute value of the trigger oil prices.

Let now consider a larger price elasticity of the demand such as $\varepsilon_P' = -0.4$. Therefore, quantities more sensitive to changes of price. Notice that a larger ε_P means lower α and β. Figure 2 shows that trigger oil prices shift down. Therefore, departing from an initial $S = 100$, the government makes the decision of introducing the new tax later for any market structure. The inaction band remain almost equal which means that once the tax has been introduce, to get rid of it would take a similar time.

Figure 2.

Changes in the expected growth rate and volatility of the oil price is shown in figure 3. Surprisingly, the result is that whatever the values of μ and σ, the trigger oil prices that induce changes in the tax policy remain practically unchanged. This striking result means that when the government optimally determine the trigger oil price does not take into account the evolution of the oil price. However, the results suggest that the timing of the decision of changing the tax policy can be modified, since the parameter μ and σ determine the fluctuation of the oil price. For example, departing from the initial value $S = 100$, a higher σ or lower μ could make the introduction of the tax sooner. This results contrast to the typical results regarding the effect of μ and σ on the trigger price. Dixit (1989a, 1989b) for the case of firms entering to a market show that a higher σ widen the inaction band while there is an inverse relation between the trigger price and the value of μ. In his models it makes sense since more volatility of the price act as barrier to enter in a new market and a higher expected growth rate of the price become an incentive to enter earlier. However, in this model, there is no reason for that to happen, since the decision of the government cannot be encouraged or deterred by the trend or inestability of oil market.

Figure 3.

Figure 4 the effect of double the sunk cost. A larger sunk cost make the hysteresis larger. The trigger oil price that induce the introduction of the new tax is lower and the trigger oil price that induce the reduction of the tax is higher. That is, departing from an initial $S = 100$, the introduction of the new taxes is made later. However, the reduction of the taxes is also made later. This is the normal result regarding the effect of changing the sunk cost on the hysteresis. Since it is more expensive to change the tax policy, the government wait more to undertake the policy. Once the decision is made, for the same reason, to get rid of the tax, the government wait for a higher oil price.

Figure 4.

Figure 5 shows the effect of increasing the special tax, τ. Both trigger oil price shift down. Therefore, departing from an initial value $S = 100$, the government will wait more to make the decision of increasing the tax. Intuitively, this is a sound result since the larger the special tax, the larger the gasoline price, so the government waits for a lower oil price to introduce the an additional tax of 0.1 cents of Euro. Since that the trigger exchange rate that induce to remove the new tax is also lower, the inaction band remains practically unchanged.

Figure 5.

Figure 6 shows the effect of increasing the new tax λ. Consider a value of $\lambda = 0.2$, that is the government now change the tax police on gasoline price in 2 cents of Euro instead of 1 cents of Euro. A very interesting results is found. With a larger λ, the government introduce the tax at a higher $\underline{S}$. However, the trigger oil price that induce the reduction of the tax $\overline{S}$ remains practically unchanged. That is, the hysteresis is lower. Therefore, the government will introduce the new tax sooner. However, the timing for the reduction of the tax remains unchanged.

Figure 6.

5 Conclusion

This article proposes a theoretical model in which the government has the option to change the tax policy on gasoline market depending on the oil price. The objective of the government is to maximize the expected discounted present value of the social welfare under an uncertainty environment because of oil price. Real option theory is used to determine an optimal oil price band for gasoline taxation. Numerical results show that the more concentrated the industry, the sooner the introduction of a new tax and the later the removing of it. A lower price elasticity of the demand and a higher minimum special tax has similar results, that is to diminish both limit of the band. Finally, the expected growth rate and volatility of the oil price does not change the band limit. However, obviously they can affect the timing of the decision.

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