Dynamic 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 price of oil. Real option theory is used to determine an optimal oil price band for gasoline taxation. Numerical results using Spanish data show that the more concentrated the industry, the sooner the new tax will be introduced and the later it will be removed. Moreover, the larger the price elasticity of the demand, the later the introduction of the additional tax. The cost of changing the tax policy has the typical sunk cost effect, that is, the larger the cost, the later the tax will be introduced and the later it will be removed.

Key words: Oil Price, Taxation, Oligopoly, Real Options.

JEL Classification: Q48; H23.

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1 Introduction

In July 2008, the British Conservative Party launched a proposal called "A Fair Fuel Stabiliser: a consultation on the future of fuel taxation". The general idea of the proposal is to develop a novel tax policy on fuel such as when fuel prices go up, fuel duty would fall; and when fuel prices go down, fuel duty would rise. The objective of such a proposal is to use the tax policy as a stabilizer of fuel prices caused by fluctuations in the price of oil, especially in light of the uncertainty arising in some oil-producing countries due to recent political instability. This situation is further compounded by the demand pressures caused by the growth of large emerging countries like China, India or Brazil, which for years have been the main drivers behind high oil prices.

The tax policy on oil derivatives products basically has a twofold objective. On the one hand, it penalizes the consumption of fuels that cause pollution. On the other hand, it is an important source of government revenue. In the market, consumers perceive that paying high prices for such products is largely due to high taxes. Therefore, the peculiarity of these markets requires a tax policy that lessens the negative effects on market welfare without giving up taxation on polluting fuels.

The price of oil is a key variable of any economy, whether exporters or importers. In oil-importing countries, the main concern is that high prices lead to inflation costs. 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 in oil prices. 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 proposal of the British Conservatives, and considering that the government has tools to influence gasoline price stability, the objective of this paper is to propose a dynamic tax policy on hydrocarbons depending on an exogenous variable: oil price. To this end, the paper focuses on the gasoline retail market and how tax policy can be used as a tool to stabilize the final price such that under a high oil price state, which leads to high average and marginal production costs of gasoline and consequently a higher final price for consumers, it could be dampened by cutting taxes. Conversely, under a low oil price state, which implies low average and marginal production costs and lower gasoline prices, taxes could be increased to cushion the fall. The idea is to reduce fluctuations in the retail price of gasoline caused by fluctuations in the price of oil using a fiscal tool. Although this is a microeconomic problem, it has a macroeconomic scope since the impact of oil price fluctuations on the aggregate supply of goods and services and the consumer price index can be lessened. The question is then: What oil prices optimally induce changes in the tax policy on the retail gasoline market and how are these prices affected by changes in the price elasticity of demand, the cost of changing the policy and competition in such a market?

The objective of this study is therefore to determine the optimal band of oil prices that induces changes in tax policy on the retail gasoline market. A theoretical model is proposed in which the government has the option to change the tax policy at any point in time depending on the price of oil with a view to maximizing the expected discounted present value of social welfare. We use real options theory (Dixit and Pindyck,1994), which has become a powerful tool for decision making under uncertainty. The model permits determining 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 will only do so when the oil price exceeds one of the band limits.

Since the model has no analytical solution, a numerical solution is found. Data for Spain are used and calibrated to give sound values to the parameters of the model. The main results are that *i*) the more concentrated the industry, the sooner a new tax is introduced and the later it is removed; *ii*) the larger the price elasticity of the demand, the later the introduction of the additional tax; and *iii*) the cost of changing the tax policy has the typical sunk cost effect in this kind of model, that is, the larger the cost, the later the tax is introduced and the later it is removed.

This article opens the door to a new tax policy on oil which can yield interesting policy implications.

The article is organized as follows. A brief review of the literature on fuel taxes is presented in the 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 fuels. He argues that gasoline demand in the short term is fairly inelastic and that if European governments do not pursue a strong tax policy, demand would double. In fact, the meta-analysis presented by Brons et al. (2008) found that short- and long-term price elasticities are -0.34 and -0.84, respectively, so, as generally expected, gasoline demand is not very sensitive to price changes. Sterner (2012) points out that fuel consumption has decreased appreciably due to taxes. As a result, 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 household fuel expenditure, finding that the key variables for such expenditure are household structure, place of residence and income. In addition, they estimate the income elasticity of gasoline, finding that, in general, it is close to one. They also find 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 being homogeneous as indicated in a survey including some 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 optimality 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 tax, while today in the UK it is half.

Contin-Pylartes et al. (2009) point 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. The objective of the model is to estimate demand elasticities. 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 in line with the goal of this article, Uri and Boyd (1989) find 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 the freight trucking industry's contribution to total state employment is a highly significant determinant of a state's diesel tax rate. Therefore, the greater this contribution, the lower the tax rate.

3 The Model

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

Let the inverse linear demand of gasoline be given by

$$P = \alpha - \beta Q, \qquad \text{with} \qquad \alpha, \beta > 0$$

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

The M firms produce a homogeneous good according to a technology that uses an intermediate good, oil, as an input. The key variable of the model (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 with constant return to scale as follows

$$q_i = f_i\left(K_i, O_i\right) = K_i^{1-\phi} O_i^{\phi}, \qquad \text{with} \qquad 0 < \phi < 1$$

where K_i is an input that can be interpreted as a combination of capital and labor or can simply be assumed to be units of capital. O_i is the amount of oil used as an intermediate good to produce gasoline. The cost function is given by

$$c_i\left(q_i\right) = g\left(S\right) q_i$$

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

where r is 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 collect revenues. The tax is therefore included in the final price of the gasoline, P, which is what consumers observe and pay per unit. Firms, however, receive $P-\tau$ per unit sold.

The solution to the oligopoly model 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 profit of the firm i and $\tau Q(S)$ is the tax revenue collected by the government.

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

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

We consider 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 λ monetary units just once depending on the oil price. If so, when the tax has been increased, equation (1) can be rewritten as

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

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

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

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

Using Îto's lemma in equations (3), we obtain

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

The general solutions to the equations in (4) making an educated guess, $V(S) = S^\eta$, are[1]

[1] A mathematical appendix is available upon request.

$$V(S) = AS^{\eta_0} + BS^{\eta_1} + E\int_{t=0}^{\infty} W(S)\, e^{-\rho t} dt \qquad (5)$$

$$V_\lambda(S) = A_\lambda S^{\eta_0} + B_\lambda S^{\eta_1} + E\int_{t=0}^{\infty} W(S,\lambda)\, e^{-\rho t} dt$$

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

$$\eta_0 = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}} < 0$$

$$\eta_1 = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}} > 1$$

$$E\int_{t=0}^{\infty} W(S)\, e^{-\rho t} dt = XS^{2\phi} + YS^{\phi} + Z$$

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

with

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

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

Since $V\left(S\right)$ and $V_\lambda\left(S\right)$ must remain bounded, boundary conditions should be imposed. Even though S is increasing, when there is no tax increase, the option of reducing the tax 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 of increasing the tax is worthless since the government cannot add another tax. However, the option of reducing the tax increases as S increases. Therefore, we impose $A_\lambda=0$. We rewrite the 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. If the oil price is decreasing, the threshold oil price will be low enough, $\underline{S}$, to induce 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 be no tax increase. Changing the tax policy can be done at a sunk cost of I monetary units, which is related to the cost of changing the computer system of the tax collection procedure. The value matching and smooth pasting conditions are

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

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

If the oil price is increasing once the tax has been increased, the threshold oil price will be high enough, $\overline{S}$, to induce an optimal change in the tax policy, i.e. a decrease in the tax in λ and returning to the previous state. Therefore, whenever 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 the most real values as possible for the parameters, a kind of raw calibration is done. Data for Spain is used for the 2004-2010 period. The main data regarding price, quantities and taxes were drawn from CORES (Corporación de Reservas Estratégicas de Productos Petrolíferos). The retail gasoline market of Spain is characterized by few firms. In fact, only three firms cover a very large proportion of the market: Repsol, Cepsa and BP. Therefore, let us consider that $M = 3$. To obtain the parameter of the demand function, consider the equilibrium quantity (Q^*), which is the average consumption of gasoline in Spain (7,679,217 kiloliters per year); and the equilibrium price (P^*), which is the average price after tax (1.0264 euros per liter). Moreover, according to Brons et al. (2008), the short-term price elasticity is $\varepsilon_P = -0.34$. The parameter α and β can be obtained from the following equation system

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

On average, the special tax in the 2004-2010 period is $\tau = 0.4$ euros per liter. Sound values for the remaining parameters are used. Regarding the cost function, consider $\phi = 0.75$, $r = \rho = 0.025$. Let us consider that the average annual expected growth rate of the price of oil is 2 percent ($\mu = 0.02$), the price variance is 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 the positive sunk cost of changing the tax be equal to one million euros ($I = 1,000,000$). Finally, the increase/decrease in tax policy is equal to 10 cents ($\lambda = 0.1$).

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

4.2 Changes in the Parameters of the Model

Let us now consider more competitive markets. Figure 1 shows the trigger oil price for up to ten firms in the market.[2] Notice that the greater the number of firms in the market, the lower the trigger oil prices. Therefore, departing from the initial oil price of $S = 100$, if the price is decreasing, the lower the number of firms and the sooner the increase in tax. In fact, in a market with three firms, the price of oil only has to decrease 1.5 percent; with four firms, 24.5 percent; with five firms, 34.3 percent and so on up to the case of ten firms when the price should decrease 43.7 percent to reach the value $\underline{S} = 53.3$. On the contrary, notice that the lower the number of firms, the later the tax reduction. Let us consider that the tax has already been introduced in all the market structures. For instance, consider that the oil price has reached the value $S = 50$. For the case of ten firms in the market, the price of oil should reach the value of $\overline{S} = 58.7$ to reduce the tax by 10 cents, that is, a 17.4% increase in price; while in the case of three firms, the price has to increase 123.7%. Figure 1 shows that trigger oil prices are especially sensitive in more concentrated industries. In fact, in an industry with three to six firms, the differences are significant. However, in more competitive industries, for $M \geq 7$, the differences are very small.

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

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

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

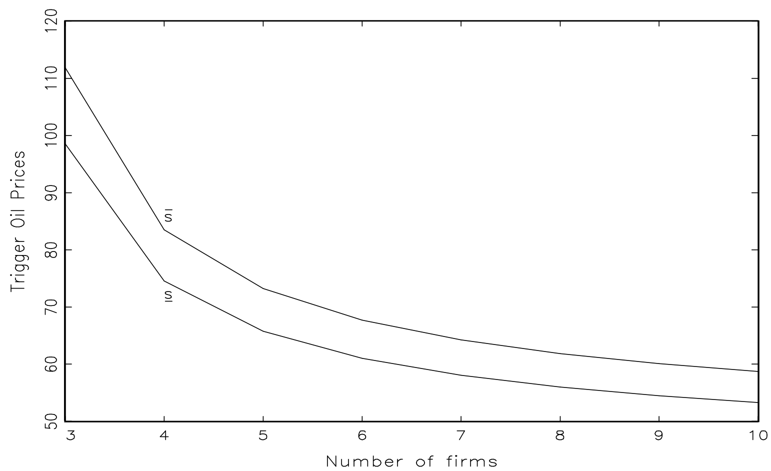

Figure 1. Changing the Number of firms.

Hysteresis, defined as $\overline{S}/\underline{S}$, is also decreasing with the number of firms in the market. When there are three (ten) firms, the $\overline{S}/\underline{S}$ ratio is 1.14 (1.10). This means that in a market with three (ten) firms, once the tax has been reduced, the oil price has to increase 14% (10%) to reverse the decision. It should be stressed, however, that hysteresis is not remarkably different across market structures. The largest difference is in the timing of the decision.

Let us now consider a larger price elasticity of the demand such as $\varepsilon_P = -0.4$ and hence quantities that are more sensitive to price changes. 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 value of $S = 100$, the government makes the decision to introduce the new tax later for any market structure. That is, when quantities are more sensitive to price changes, the government delays introducing the additional tax. The inaction band remains almost equal which means that once the tax has been introduced, it would take a similar amount of time to remove.

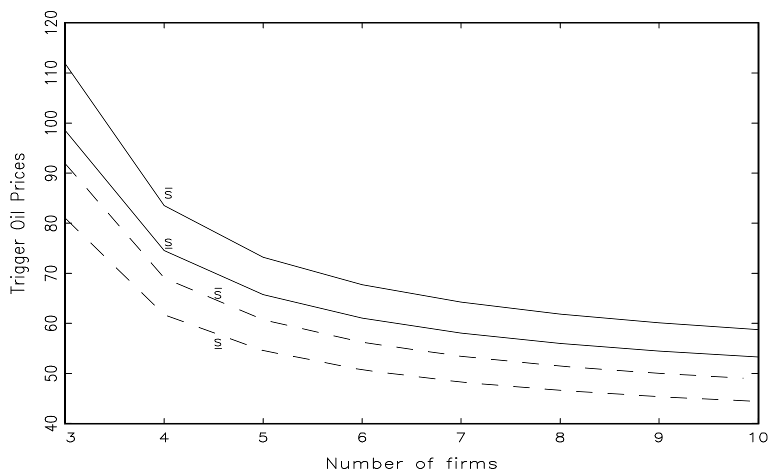

Figure 2. Changing Price Elasticity. $\varepsilon_P = -0.34$ (solid line).

$\varepsilon_P = -0.4$(dashed line).

Figure 3 shows the effect of doubling the sunk cost. A larger sunk cost make the hysteresis larger. The trigger oil price that induces the introduction of the new tax is lower, while the trigger oil price that induces the reduction of the tax is higher. That is, departing from an initial $S = 100$, the new tax is introduced later. However, the tax is also removed 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 will wait longer to implement the policy. For the same reason, once the decision has been made to remove the tax, the government will wait for a higher oil price.

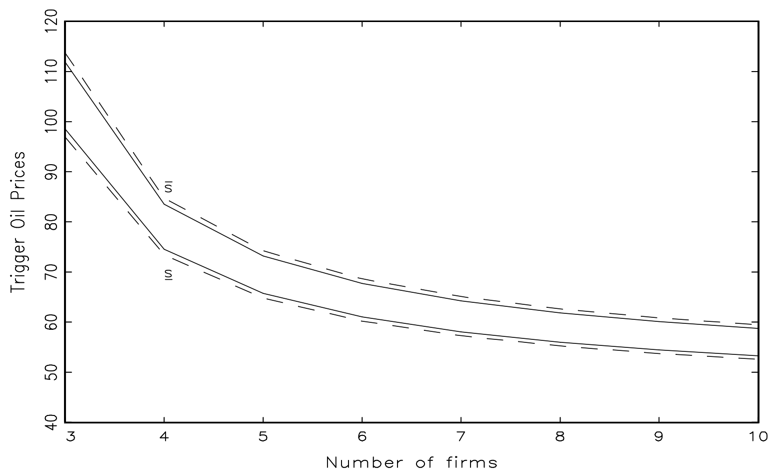

Figure 3. Changing the Sunk Cost. $I = 1,000,000$ (solid line).

$I = 2,000,000$ (dashed line).

Figure 4 shows the effect of increasing the special tax, τ. Both trigger oil price curves shift down. Therefore, departing from an initial value of $S = 100$, the government will wait longer before deciding to increase the tax. Intuitively, this is a sound result since the larger the special tax, the higher the price of gasoline, so the government will wait until the price of oil is lower to introduce the additional 10-cent tax. Since the trigger exchange rate that induces removing the new tax is also lower, the inaction band remains practically unchanged.

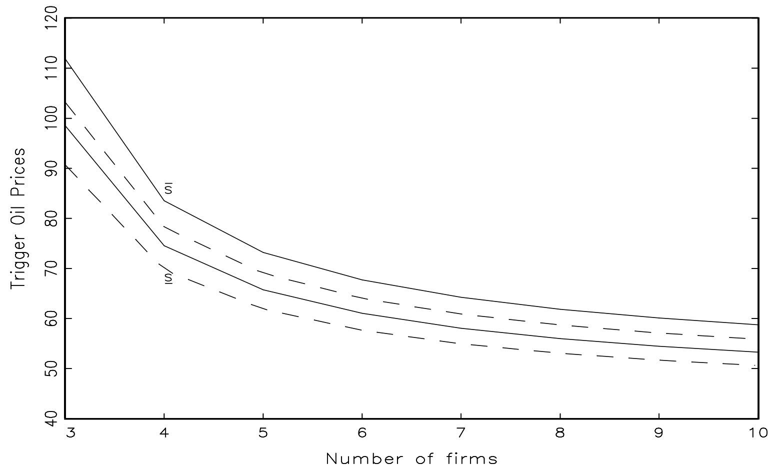

Figure 4. Changing the minimum tax, τ. $\tau = 0.4$ (solid line). $\tau = 0.5$ (dashed line).

5 Conclusion

This article proposes a theoretical model in which the government has the option to change the tax policy on the gasoline market depending on the price of oil. The government's objective is to maximize the expected discounted present value of social welfare under an uncertainty environment because of the price of oil. Real option theory is used to determine an optimal oil price band for gasoline taxation. Numerical results using data for Spain show that the more concentrated the industry, the sooner a new tax is introduced and the later it is removed. A lower price elasticity of the demand and a higher minimum special tax has similar results, that is, to diminish both limits of the band.

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