Regulating Gasoline Retail Markets: The Case of Germany

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Abstract

In 2011, price peaks in retail gasoline prices caused public outrage and attracted the attention of German regulatory agencies. After having examined the market, competition authorities concluded that tacit collusion existed but could not easily be prosecuted under the given competition law. In several other countries, various types of regulatory schemes are implemented to tackle tacit collusive behavior. E.g. there are price ceilings established in Luxembourg or per day limits of price increases given in Austria. However, research has found that none of them has led to satisfactory results. Hence, the following paper proposes a different regulatory approach, i.e. the implementation of corrective taxes. Results show that a special type of variable tax scheme successfully manages to render collusion an unprofitable business. In addition, it is also easy to levy and monitor. Thereby, the inherent vice of the gasoline retail market, i.e. the transparency that enables tacit—and therefore non-prosecutable—collusion, could be turned into a regulatory virtue as it becomes a powerful means to help successfully tackle imperfect competition and to bring about a more efficient market outcome.

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1. Introduction

In today's globalized economy, mobility is a crucial aspect of most people's everyday lives on both a professional and personal level. Many people still rely on cars to satisfy their demand for transportation[1]. Although the number of cars that run either partially (i.e. hybrid technologies) or totally on alternative energy sources is increasing steadily, the vast majority still relies entirely on fossil fuel based technologies[2]. Hence, the retail market for gasoline is a very important economic sector to most industrialized nations and any irregularities or turbulences draw a lot of attention from the general public, policy makers, and researchers alike (Haucap and Mueller 2012). European nations in general and Germany in particular is certainly no exception to that. E.g., with well above 500 cars per 1000 people Germany is among the world's top 12 nations in terms of car ownership[3]. Also, the German gasoline retail market experienced significant price peaks in 2011, which triggered in-depth investigations by German regulatory authorities (Bundeskartellamt 2011). Possible measures and regulatory actions to be taken are still under consideration (Bundeskartellamt 2013) which makes the German gasoline retail market an extremely interesting showcase for the analysis presented in this paper. Regarding the characteristics of the market in general, there is a vast strand of literature dealing with numerous aspects of the retail gasoline market. A lot of publications examine the characteristics of the demand side, such as elasticity of demand (Dahl 2012, Brons et al. 2008), using various methods and looking at various countries, e.g. North America (Lau et al. 2012, Park and Zhao 2010, Nicol 2003), South America (Hofstetter and Tovar 2008), China (Lin and Zeng 2013), the Middle East (Ben Sita et al. 2012), or Europe (Pock 2010). The general consensus across publication is that demand for gasoline is rather inelastic (Havranek et al. 2012, Haucap and Mueller 2012). Looking at the supply side of the retail market for gasoline, the general consensus is that the gasoline retail market is likely to suffer from a lack of competition and an oligopolistic market structure and non-prosecutable tacit collusion (Garcia 2013, Haucap and Mueller 2012, Andreoli-Versbach 2011, Bundeskartellamt 2011). Therefore, several countries have taken different regulatory measures in order to fight this economically undesirable status quo. However, it appears as though none of these measures have proven successful (Berninghaus et al. 2012, Haucap and Mueller 2012), i.e. neither have markets become significantly more competitive and less collusive nor has asymmetric price volatility been abolished (Polemis and Panagiotis 2013, Bettendorf et al. 2003). Hence, it seems as though, so far, regulation authorities do not have any feasible instrument available, to adequately address this problematic state of affair. However, the model presented in the following section might be an option which could help

to do away with the problem in question. The paper is structured as follows: Section two presents the formal structure of the proposed regulatory scheme as well as a numerical example. Section three takes a critical look at the proposed regulatory scheme and findings presented in section two using additional literary sources. Section four contains some concluding remarks.

2. Materials and methods

2.1 Literature Review

As has previously been mentioned above, one of the central aspects of research related to the demand structure of gasoline retail markets is dedicated to estimating elasticity of demand. As has already been mentioned above, the common denominator is that demand for gasoline is inelastic (Haucap and Mueller 2012). So far, there exist a total of well over 240 empirical gasoline demand studies that examine over 70 countries (Dahl 2011). With respect to diesel, there are another 60 studies dealing with over 55 countries. Dahl (2011) examined whether income and own-price elasticity differ across nations. While her data analysis showed that differences among countries exist, it nonetheless rendered important results as certain pattern emerged that allowed for estimating elasticity values for over a hundred nations. Moreover, Dahl also derives policy implications regarding the implementation of environmental and fuel mix policy measures in the retail gasoline market. Dahl's findings underpin those of Pock (2010) who also found that changes in diesel car usage do affect demand in the gasoline retail market, and therefore also influence the own-price and income elasticity levels of the latter. Dahl (2011) also found that price elasticity increased with prices of both gasoline and diesel fuel. A paper by Nicol (2003) examines the elasticity of demand with respect to Canada and the United States. Naturally, one has to differentiate between different types of income elasticity, while the most common ones analyzed are own-price and income elasticity (Nicol 2003). Moreover, introducing the time aspect into the model set, Noel's results show a significant difference between short and long run elasticity. In general, most empirical studies agree on a short (long) run own-price elasticity of around -0.26 (-0.86) regarding in the gasoline retail market (Nicol 2003). While the empirical model of Nicol (2003) does not contradict these results, it nonetheless finds significant proof of the fact that the exact level of both own-price and income elasticity of households differs across both household types and countries. These findings are certainly in line with standard economic theory which states that heterogeneous agent models render different results than a standard homogeneous agent models (Kirman 2006). Moreover, another important aspect that was identified by Pock

(2010) with respect to estimating gasoline demand in Europe is that of an increase in diesel car usage. With respect to empirical data analysis such trends have to be taken into account in order to render non-confounded results. Pock's analysis shows that the surge in diesel cars across Europe led to an overestimation of both income and own-price elasticity. With respect to the US retail market for gasoline, Park and Zhao (2010) focus on an empirical data analysis of post 2000 data. In their model setup price elasticity depends on the time horizon, budget constraints, as well as the economic characteristics of the good in question, i.e. whether it is necessary to economic subsistence or a luxury product, and whether substitutes are easily at hand (Park and Zhao 2010). Within their model set, time is not a relevant variable. This stems from the fact that their data is fixed by month and that substitution possibilities are hard to come by in the short run. Overall, Park and Zhao (2010) find that welfare could be increased by a shift from income to gasoline taxation and that deadweight loss for the most part depends on own-price elasticity. Lin and Zen (2013) analyze elasticity of demand in the Chinese gasoline market. Aside from calculating estimates for own-price and income elasticity whose ranges also comprise the estimates given by Nicol (2003) they also calculate the so called vehicle miles traveled elasticity (Lin and Zen 2013) which ranges somewhere between -0.882 and -0.579. In China, fuel taxes have been increased in 2009 and now also include agents that were previously exempted from the tax scheme, such as airlines and the army (Lin and Zen 2013). In their model setup, they find that demand seems slightly more elastic with respect to gasoline demand for transportation than other purposes. With respect to income elasticity of gasoline demand, Ben Sita, Marrouch and Abosedra (2012) analyze Lebanon data. They find that both government revenues and environmental standards do not benefit from a flat excise tax. Their model expresses gasoline demand as a function of structural changes that affect consumption, price and income. In doing so, they find that long run elasticity levels are higher than identified otherwise and conclude that structural changes have a significant effect on the demand for gasoline as they appear to affect people's economic behavior substantially (Ben Sita, Marrouch, Abosedra 2012). Looking at empirical findings regarding then general workings of gasoline retail markets, the following findings are of great interest to the analysis to come. Polemis and Fotis (2013) examine how gasoline price fluctuate in the EU and whether price changes are asymmetric, i.e. prices are more likely to, e.g., increase than decrease. In the course of their analysis they find that for most EU countries, the gasoline market is still dominated by a small number of large and international corporations that explicit a very high level of vertical integration (Polemis and Fotis 2013). Their analysis focuses on 11 EU countries, i.e. "Austria, Belgium, Finland, Greece, France, Germany,

Ireland, Italy, Netherlands, Portugal and Spain" (Polemis and Fotis, p. 426). It is assumed that the existence of asymmetric price volatility is a result of tacit collusion being prevalent within the gasoline retail market (Borenstein et al. 1997). In the course of their analysis, Polemis and Fotis find that asymmetric price changes are especially prevalent within the wholesale market in which positive retail price increases are passed on to consumer prices virtually instantly while price remain fairly sticky in the face of a decrease in wholesale prices. According to their analysis, policy measures which foster competition within the wholesale segment of the gasoline retail market would also pose a remedy regarding asymmetric price volatility. Garcia (2013) also researched price asymmetries in the market for gasoline using a Meta regression analysis. Aside from EU markets, his analysis also incorporates, among others, the North American hemisphere as well as Australia. Nonetheless, his findings are in line with those of Polemis and Fortis (2013) who also identify that the asymmetries occur mostly and most prominently with respect to the retail market segment. Moreover, he also identifies the lack of competition as the primary source of the problem. The Meta analysis conducted by Brons et al (2008) also examines the price elasticity of gasoline demand along with other important elasticities such as mileage per car. Their analysis shows that the latter is inelastic and values are in line with those identified by others such as Nicol (2003). They also identify differences in elasticity levels between countries which stem from structural differences such as infrastructure and availability of car substitutes such as public transportation. The paper by Suvankulov et al. (2011) focuses on the Canadian Research market and looks at how price regulation affects the retail market for gasoline. Their analysis shows that price regulation leads to a significant reduction in price volatility within the market which is also a good indicator on whether regulating price manages to successfully, i.e. negatively, affect tacit collusion within the market.

Overall, seminal research identifies a set of crucial characteristics inherent to the gasoline retail market: Inelastic demand, imperfect competition and tacit collusion. However, before the formal analysis conducted in the following section can commence, three important aspects have to be introduced. Firstly, it is important to note that the core of the proposed regulatory scheme presented in the following section draws from findings by M.A Adelman (1978). In his paper on the constraints on the world oil monopoly price he proposes that oil importing nations could successfully tackle the OPEC cartel by implementing a tax rate proportional to price. Whenever prices rise, the tax rate is adapted accordingly and the cartel is thereby deprived of the desired rise in revenue, which otherwise would have taken place due to a sufficiently inelastic demand function. In addition, a recent paper, Vetter (2013a) generates

valuable findings which proof that variable tax rate schemes on sales prices can indeed increase welfare in markets that exhibit certain types of imperfect competition. As is to be seen shortly, the results of the following sections serve as additional verification of Vetter's results. Secondly, the design of the proposed regulatory scheme adheres to the findings of Buchanan (1969) who has shown the importance of market structure in designing optimal regulation. The results of a recent paper by Kverndokk and Rosendahl (2011) also validate the importance of Buchanan's findings with respect to the oil market and transport sector in general. In particular, Kverndokk and Rosendahl found strong evidence that, in the presence of market power, effects on the oil market resulting from regulating the transport sector differ significantly from those under perfect competition. Thirdly, it is important to keep in mind what the regulatory scheme is supposed to accomplish. The proposed scheme is not meant to generate government income, i.e. a predictable stream of revenue to the government as discussed in Madowitz and Novan (2013). Also, it is not meant as a measure to internalize the negative effects of fossil fuel consumption, e.g. the energy tax, as in Fisher et al. (1996). Rather, it is meant as a measure to successfully correct and prevent market distortions that stem from the exertion of market power as in Adelman (1978).

2.2 Methods and Model Setup

First, relevant functions and variables with respect to supply and demand structures are defined.

2.2.1 Demand

There are two types of representative demand functions chosen:

$$D_I = a - bx_I$$
$$D_{II} = -\frac{1}{s}x_{II}^2 + a$$

$$(2.1)$$

with $a,b,s > 0$ and $x_I, x_{II}, D_I, D_{II} \geq 0$. In order to ensure comparability of results, the two representative demand functions do not only share the same reservation price at a eurocent/l (ct/l) but also the same saturation level of x^{sat} liters per period - e.g. per week – which means that the following equation has to hold:

$$b = \frac{x^{sat}}{s}.$$

$$(2.2)$$

Price elasticity of demand, i.e. $E = \frac{\partial x_i}{\partial p} \frac{p}{x_i(p)}$, with $i \in \{I, II\}$, is given by

$$E_{D_I} = -\frac{p}{a-p},$$

$$E_{D_{II}} = -\frac{p}{2(a-p)} \quad \text{with } p \in [0, 250]. \tag{2.3}$$

Within the entire price range $p \in [0, a]$ ct/l, D_{II} is more inelastic than D_I. The unitary elastic point is reached at $\frac{a}{2}$ ct/l for D_I and $\frac{2a}{3}$ ct/l for D_{II}. In general, demand within retail gasoline markets has proven to be rather inelastic (Haucap and Mueller 2012). However, it is certainly not perfectly inelastic along the entire range of the demand function. Rather, elasticity increases as the price rises (e.g. Adelman (1978)) which is also in line with the findings of Dahl (2011) that have been presented in section 2.1. Intuitively speaking, when gasoline prices are low, consumers' behavior, e.g. patterns of car usage, will not change significantly when prices fluctuate marginally. Once a significantly higher price level is reached, however, demand becomes increasingly more elastic with respect to price changes, because now people might more often choose to go by foot or take the bike instead of their car, as the opportunity cost of taking the car, just to get to the bakery around the corner, have become considerably higher. And, at the very end, i.e. a price approaching the reservation price, consumers start to switch almost entirely to using public transportation or to a car that runs on a different type of fuel. A graphical illustration along with a numerical example is presented in section 2.4.

2.2.2 Supply

Relevant cost structures and tax rates consist of unit cost of input (c) which contains per unit wholesale price as well as costs of transportation (Bundeskartellamt 2011). Naturally, looking at different countries, different types of taxes can be found to be present in retail gasoline markets. However, in order to be consistent with the focus of this paper on German market settings, standard VAT (t^U) along with a fixed energy tax (t^E) are taken into account in this model setup, i.e.

$$
\begin{aligned}
&c = \text{constant}, \, c > 0 \\
&t^E = \text{constant}, \, t^E > 0 \\
&t^U = \beta D_i \; \forall i = \{I, II\}, \text{ where } 0 \leq \beta < 1. \\
&\Rightarrow MC = c + t^E + t^U
\end{aligned}
\tag{2.4}
$$

2.2.3 Results without regulation against collusive behavior

Without collusion, companies arrive at a standard Betrand oligopoly outcome with zero profits, given the homogenous nature of the product in question (Haucap and Müller 2012).

Naturally, this standard result implicitly implies some simplifying assumptions, e.g. that there are homogenous cost structures and no economically relevant capacity restrictions prevalent. If, however, companies decide to act as one collusive cartel in order to achieve positive profits, they have to ensure that supervision and observation of compliance with collusive agreements – e.g. prices – are feasible. Also, sufficient means of sanctions and punishment must be readily available to maintain a successful collusive agreement. According to German competition authorities, these preconditions are all met by the German gasoline markets in general (Bundeskartellamt 2011). In particular, findings show that the supply side of the German gasoline retail market is comprised of an oligopoly that consists of five major companies - Aral, Esso, Jet, Shell, Total – and a negligible competitive fringe (Bundeskartellamt 2011). Generally speaking, given that collusive agreements are successfully reached and given that companies manage to act as a non-defective cartel, a monopoly-type market outcome emerges. Hence, profits are positive and are maximized according to the standard profit maximizing condition that marginal revenue (MR)

$$MR_I = a - 2bx_I$$
$$MR_{II} = a - \frac{3}{s}x_{II}^2$$

(2.5)

equals marginal cost (MC) as presented in equation (2.5). Thereby, just as standard theory predicts, market prices rise above marginal cost and quantity supplied declines as shown by equations (T1.I) and (T1.II) together with equations (T1.III) to (T1.VI) in **Table1**:

Equilibrium Results	Scenario	Non-collusive Bertrand oligopoly	Collusive Cartel
Market price (p^B vs p^{Cartel})	D_I, D_{II}	(T1.I) $\dfrac{c+t^E}{(1-\beta)}$ $\quad <$	(T1.II) $D_I : \dfrac{a+c+t^E}{(2-\beta)}, D_{II} : \dfrac{2a+c+t^E}{(3-\beta)}$
Quantity supplied (x^B vs x^{Cartel})	D_I	(T1.III) $\dfrac{(1-\beta)a-c-t^E}{(1-\beta)b} >$	(T1.IV) $\dfrac{(1-\beta)a-c-t^E}{(2-\beta)b}$.
	D_{II}	(T1.V) $\sqrt{s\dfrac{(1-\beta)a-c-t^E}{(1-\beta)}} >$	(T1.VI) $\sqrt{s\dfrac{(1-\beta)a-c-t^E}{(3-\beta)}}$

Table1: Equilibrium Results of Bertrand Oligopoly and Collusion

These findings are also implemented in the course of the numerical example presented in section 2.4. The results of the latter are then presented in **Table3**, and illustrated by **Figure5**, and **Figure6**.

2.2.4 Regulating collusive behavior

As has already been mentioned in section one, none of the present regulatory instruments, e.g. the Austrian rule, the Australian Fuel-Watch-Concept or Luxembourg's price ceilings, seems to deal effectively with the prominent collusive behavior prevalent in retail gasoline markets (Haucap and Mueller 2012, Bundeskartellamt 2011). Hence, it appears as though these instruments promise little success to German regulatory agencies. Therefore, one might ask oneself whether there is an alternative regulatory policy measure readily at hand. Its implementation should successfully manage to drive the collusive cartel into the Bertrand oligopoly outcome, thereby being a remedy to prevalent market distortion and increasing consumer welfare. As the following analysis shows, this can be successfully done by implementing a regulatory tax scheme that, by design, changes from regressive to progressive at the point where marginal cost equals price and thereby takes into account the propositions and findings of both Adelman (1978) and Buchanan (1969). Thereby, a successful regulatory scheme (t^{cartel}) manages to do away with the negative effects associated with collusive behavior. In case of the retail gasoline market such a regulatory scheme can be characterized as follows:

Proposition1: An optimal regulatory tax scheme (t^{cartel})

    a) collects cartel's profits for prices p above marginal costs

    b) puts additional costs on prices p below marginal costs

and

    c) is easily levied and monitored,

i.e.

$$t^{cartel} = |p - MC| > 0. \qquad (2.6)$$

Thereby, it

    i)   causes collusive behavior to become unprofitable,

    ii)   reduces the cartel's options for sanctioning defectors,

    iii)   strengthens the position of the competitive fringe,

and

    iv)   renders measures of collusive behavior easier to prosecute as they now turn into an act of tax evasion.

Proof: Before the different subsections of Proposition1 are discussed, **Figure1** is meant to give an illustration of the key variables that constitute equation (2.6). In short, the minimum of the regulatory tax level, i.e. $t_{Min}^{cartel} = 0$, is located at the zero profits Bertrand oligopoly outcome at which price equals marginal cost.
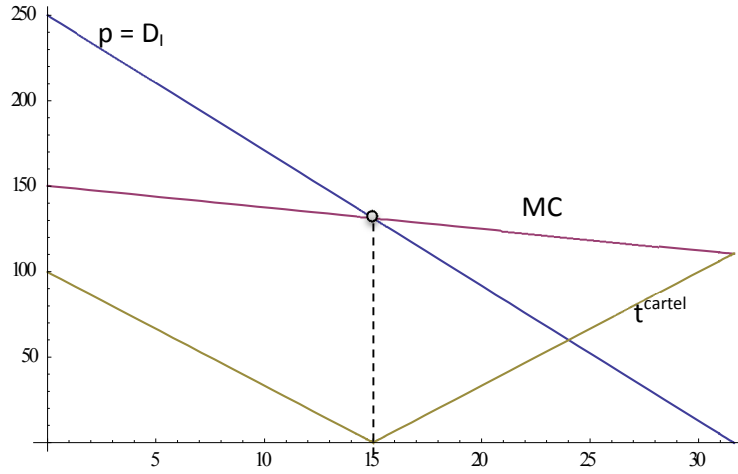

Figure1: Exemplary Scenario D_I Including Regulatory Tax t^{cartel}

Proof of Proposition1 part (a): Equations (T1.II), (T1.IV), and (T1.VI) of **Table1** serve as a basis for the following proof.[5] Profit maximization in case of collusive behavior renders positive profits π^{cartel} of

$$\pi^{cartel} = \beta \frac{(1-\beta)a - c - t^E}{b(\beta - 1)^2} > 0 \qquad (2.7)$$

given that VAT tax rates are less than a hundred percent, i.e. $b(\beta - 1)^2 > 0 \,\forall\, \beta < 1$ and that the reservation price a lies above the Bertrand oligopoly's marginal cost pricing, i.e. $a > \frac{c + t^E}{(1-\beta)}$.

Compared to the optimal regulatory tax rate specified by equation (2.6) it can easily be shown that $t^{cartel} \equiv \frac{\pi^{cartel}}{x^{Cartel}}$. ∎

Proof of Proposition1 part (b): As has been extensively proven by economic research, any cartel needs an effective sanctioning mechanism to ensure compliance and to discourage defection (e.g. Adelman 1978). As we are faced with price instead of Cournot competition, defection from collusive agreement means that defectors set a price p^{def} below the cartel's profit maximizing monopoly price and above marginal cost price, i.e. $\frac{c + t^E}{(1-\beta)} < p^{def} < \frac{c + t^E + \beta x_I}{(1-\beta)}$, to increase their share of supply and, hence, their share of profits

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from collusion. Given the high transparency of the gasoline retail market, however, such a behavior will not remain unnoticed by the other cartel members; e.g. in Germany every gas station, on average, monitors approximately 3.83 other gas stations (Bundeskartellamt 2011). Deterring sanctions could very well take the form of temporary predatory, i.e. below marginal cost pricing $p^{pred} < MC$. The proposed regulatory tax scheme also serves to curtail cartels sanctioning power as it doubles the cartel's cost C^{pred} of such punitive actions as

$$C^{pred} = \left| p^{pred} - MC \right| + t^{cartel} = 2 \left| p^{pred} - MC \right|. \blacksquare$$

Proof of Proposition1 part (c): The proposed regulatory tax scheme is easy to levy and transfer: The proposed regulatory tax scheme is equally simple as the well-known and well-functioning VAT scheme. Gasoline retailers have perfect information on their MC and price set. The absolute value of subtracting the two simply equals t^{cartel}.

The proposed tax is easy to monitor by regulation authorities: The reason why tacit collusion is upheld so easily within the gasoline retail market is that market agents' behavior in general and market prices in particular are highly transparent and readily observable at almost negligible cost (Haucap und Mueller 2012, Bundeskartellamt 2011). In addition, not only retail market structures but also data on wholesale prices and suppliers cost structures are accessible to regulation authorities (Bundeskartellamt 2011 and 2013). Through the proposed regulatory tax scheme, this inherent vice of the gasoline retail market, i.e. the transparency that enables tacit - and therefore non-prosecutable - collusion, is turned into a regulatory virtue as it becomes a powerful means to successfully tackle imperfect competition. This is also in line with findings of Vetter (2013a), who identifies information deficits as one of the most crucial issues when it comes to the practicability of variable tax rate schemes, such as a digressive tax rate.■

Proof of Proposition1 part (i): Given the design of the proposed regulatory tax scheme, skimming cartel's profits as shown in part a) of this proof holds along the entire range of possible price levels, which is also illustrated by **Figure1**. Hence, regarding companies' expected profits the result with collusion is now equal to or even less profitable than that of the non-collusive Bertrand oligopoly. Thus, even if costs associated with tacit collusion are very small but non-negative, e.g. the expected cost of prosecution by competition authorities or the cost of observing other gas stations as mentioned in part c) of this proof, the non-collusive Bertrand oligopoly becomes the profit maximizing equilibrium outcome.■

Proof of Proposition1 part (ii): Please refer to **part (b)** of the proof.■

Proof of Proposition1 part (iii) and part (iv): Without the proposed regulatory scheme and in case of tacit collusion, cartel members generate positive profits by charging monopoly price levels. One could ask themselves why companies of the competitive fringe do not intervene by putting competitive pressure on cartel members through setting a more competitive price. Aside from the fact that the gasoline retail market bears substantial costs of entry (Haucap and Mueller 2012) additional hints can be found in the fuel sector inquiry report of German competition authorities (Bundeskartellamt 2011). It states that influential gasoline retail market suppliers are directly associated with the major wholesale market players of the gasoline market. As a result, "free" gas stations which are not associated with wholesale gas suppliers are commonly charged a significantly higher wholesale gas price, i.e. $c^{free} > c,$ which implies that $\Delta C = c^{free} - c > 0.$ Competition authorities are aware of these actions but this practice cannot be prevented (Bundeskartellamt 2011). Hence, if c^{free} is chosen sufficiently high, the profit maximizing cartel price level is equal to the "free" gas stations' marginal cost price, i.e. with respect to scenario $D_I,$ $\Delta C \equiv \frac{(1-\beta)a-c-t^E}{(\frac{b}{\beta}+1-\beta)}.$ Through the proposed variable regulatory tax scheme, however, collusive behavior becomes unprofitable and tacit collusion itself is thereby shattered which causes protectionist wholesale pricing to become less called for. However, what is an even more important and valid argument, in economic terms, is that charging inflated wholesale prices now becomes an act of tax fraud that can be easily prosecuted under standard tax law, e.g. in Germany under §370 AO[4]. How does that come about? **Figure2** illustrates the point in question and facilitates the explanation of the subsequent formal analysis.
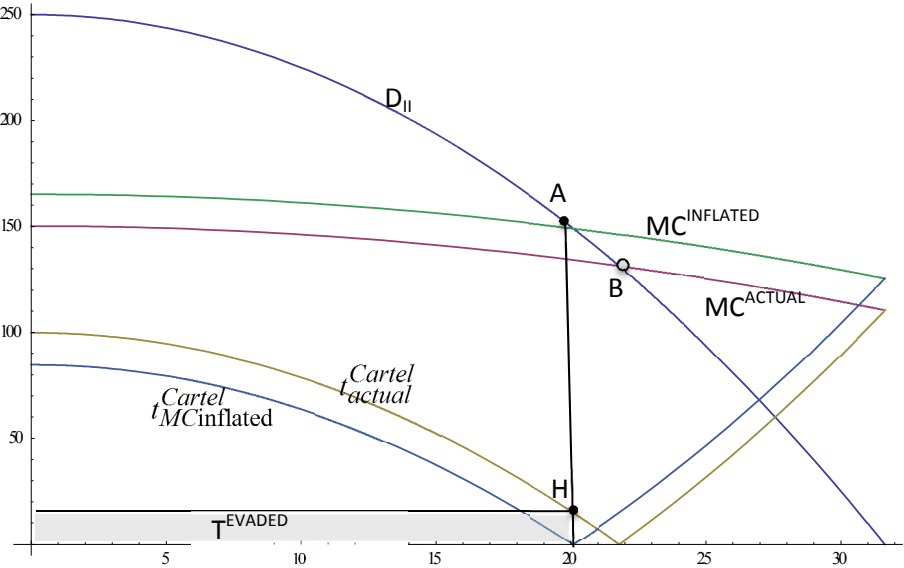

Figure2: Tax Evasion Caused By Inflating Marginal Cost

With wholesale gasoline suppliers charging actual costs, c, the market equilibrium is characterized by point B in **Figure2** and a resulting actual regulatory tax rate of zero. Billing $c^{free} > c$, however, leads to inflated marginal costs and results in a different gasoline retail market equilibrium which is represented by point A in **Figure2**. The shaded rectangle represents the tax volume evaded and its height equals the per unit tax rate evaded in point A. **Table2** presents the results of the underlying formal analysis in a concise manner:

Equilibrium Results	Scenario	Charging c (**Figure2**: Point B)	Charging $c^{free} > c$ (**Figure2:** Point A and H)
Market price (P^c vs. P^{free})	D_I, D_{II}	(T2.I) $\dfrac{c+t^E}{(1-\beta)}$ <	(T2.II) $\dfrac{c+t^E}{(1-\beta)} + \dfrac{\Delta C}{(1-\beta)}$
Quantity supplied (x^c vs. x^{free})	D_I	(T2.III) $\dfrac{(1-\beta)a-c-t^E}{(1-\beta)b} >$	(T2.IV) $\dfrac{(1-\beta)a-c-t^E}{(1-\beta)b} - \dfrac{\Delta C}{(1-\beta)b}$
	D_{II}	(T2.V) $\sqrt{s\dfrac{(1-\beta)a-c-t^E}{(1-\beta)}} >$	(T2.VI) $\sqrt{s\dfrac{(1-\beta)a-c-t^E}{(1-\beta)} - s\dfrac{\Delta C}{(1-\beta)}}$
Tax rate paid	$D_I = D_{II}$	(T2.VII) 0	(T2.VIII) $0^{\,5}$
Tax rate due	$D_I = D_{II}$		(T2.IX) $\Delta C^{\,6}$
Evaded tax volume	$D_I = D_{II}$		(T2.X) $\Delta C \times x^{free}$

Table2: Tax Evasion Caused By Inflating Marginal Cost

Equations (T2.I) and (T2.II) illustrate that inflating marginal cost leads to higher prices which results in lower quantities demanded as shown by equations (T2.III) to (T2.VI). The level of tax evasion is given by equation (T2.X). Due to the transparency inherent to both the gasoline wholesale and retail market segment such a tax evasion can be both easily detected and prosecuted. Hence, the expected payoff Π^{Exp} from charging inflated wholesale prices becomes negative, i.e.

$$\Pi^{Exp} = c^{free}x^{free} - \chi(c^{free}x^{free} + f^{fine}) < 0 \qquad\qquad (2.8)$$

with $\chi \to 1$ including a non-negative fine for committing tax fraud, i.e. $f^{fine} > 0$. Thereby, competition is fostered while collusive actions and profit skimming are successfully confounded in all, i.e. both retail and wholesale sectors of the gasoline market. ∎

2.3 Numerical Example

The analysis now proceeds by presenting further results and discussion based on a numerical example. These findings provide additional grounds that validate the results previously revealed in sections 2.1 to 2.3.

2.3.1 Demand

Representative demand functions are chosen in accordance with equation (2.1). Reservation price is assumed at 2.50€/l, i.e. 250ct/l[7]. Saturation level is set around 31 liters per period, e.g. per week[8]. This results in

$$D_I = 250 - 7.91 x_I$$
$$D_{II} = -1/4 x_{II}^2 + 250. \tag{2.9}$$

Hence, price elasticity of demand, as in equation (2.3), can be expressed as

$$E_{D_I} = -\frac{p}{250 - p},$$
$$E_{D_{II}} = -\frac{p}{2(250 - p)} \text{ with } p \in [0, 250]. \tag{2.10}$$

Within the entire price range between zero and 250ct/l of gasoline, D_{II} is more inelastic than D_I. The unitary elastic point is reached at 125ct/l for D_I and 166.67ct/l for D_{II} which is illustrated by **Figure3**:
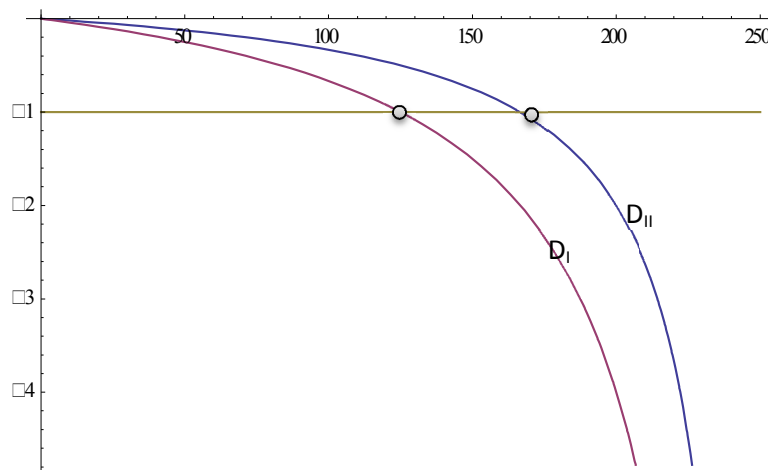

Figure3: Price Elasticity of Demand

2.3.2 Supply

Relevant cost structures and tax rates are chosen according to equation (2.4) combined with real live numbers, presented by German competition authorities in their final sector analysis

report (Bundeskartellamt 2011). Hence, unit cost of input (c) including per unit wholesale price and transportation, energy tax (t^E), and VAT (t^U) are adopted as follows:

$$c = 45$$
$$t^E = 65.45$$
$$t^U = \alpha D_i = 0.16 D_i \quad \forall i = \{I, II\}. \tag{2.11}$$
$$\Rightarrow MC = c + t^E + t^U$$

The cost and demand structure of this numerical model setup can be illustrated as shown in **Figure4**:
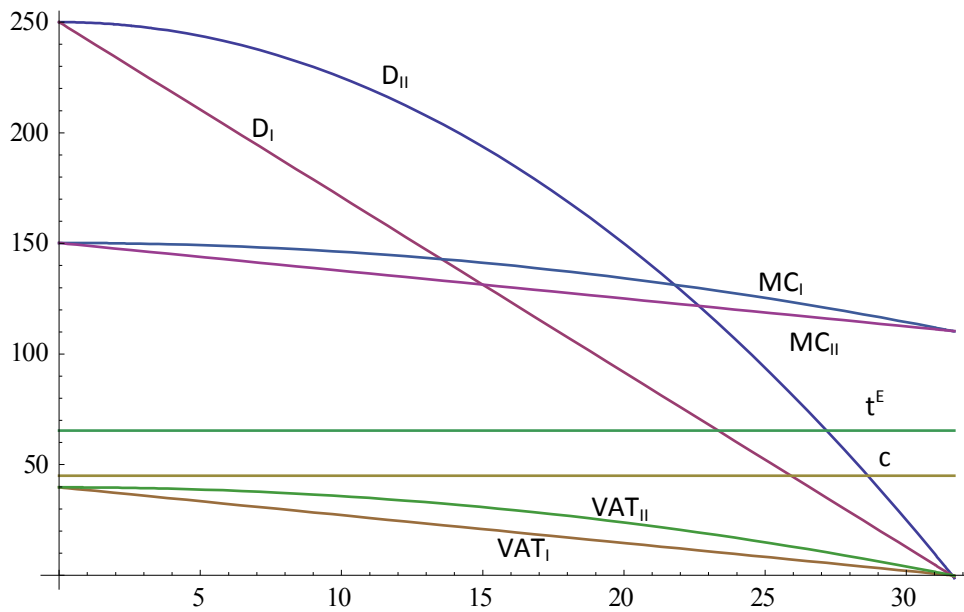

Figure4: Demand and Cost Structures

Both representative demand functions, D_I and D_{II}, are sketched along with resulting marginal cost curves, MC_I and MC_{II}. The latter include unit cost of input (c) as well as energy tax (t^E) and VAT in case of both scenarios. Section 2.4.3 to 2.4.4 are based on the settings illustrated in **Figure4** given the underlying demand and supply structures as characterized by equations (2.9) and (2.11).

2.3.3 Results without regulation against collusive behavior

As has already been elaborated upon in more detail in section 2.1, in the absence of collusion a standard Betrand oligopoly outcome with zero companies' profits emerges. If, however, a collusive cartel is established successfully, profits become positive and are maximized according to the standard profit maximizing condition that marginal revenue (MR)

$$MR_I = 250 - 15.82x_I$$

$$MR_{II} = 250 - \frac{3x_{II}^2}{4} \qquad (2.12)$$

equals marginal cost (MC) where the latter is defined by equation (2.11). **Table3** presents a comprehensive overview over the results of the four different scenarios presented so far, i.e. scenarios D_I and D_{II} given either non-collusive or collusive market outcome:

Equilibrium Results	Non-collusive Bertrand oligopoly	Collusive Cartel facing D_I	Collusive Cartel facing D_{II}
Quantities and Price: (Q*,P*) [Q* in liters, P* in eurocent/liter]	Scenario D_I: (15.0, 131.3) Scenario D_{II}: (21.79, 131.3)	(6.85,195.82)	(11.85, 214.89)
Suppliers' Profits	$\Pi^* = 0$	$\Pi^* = 371.49$	$\Pi^* = 832.77$
Consumers' Rent	$CS_{DI} = 890.18$ $CS_{DII} = 1724.52$	$CS_{DI} = 627.31$	$CS_{DII} = 277.38$
Tax revenue	$T_I^E = 981.75$, $T_I^U = 313.22$ $T_{II}^E = 1426.16$, $T_{II}^U = 454.87$	$T_I^E = 448.33$ $T_I^U = 213.28$	$T_{II}^E = 775.58$ $T_{II}^U = 404.89$
Aggregate Welfare	Scenario D_I: 2185.15 Scenario D_{II}:3605.55	D_I:1660.41	D_{II}:2290,62
Welfare Loss	-	**-24%**	**-34.5%**

Table3: Equilibrium Results of Bertrand Oligopoly and Collusion

In case of a non-collusive Bertrand oligopoly, both D_I and D_{II} render the same market price but, naturally, the more inelastic demand in case of D_{II} results in a higher quantity demanded. Once collusion is successfully accomplished, prices rise and quantity is reduced in both cases. Again, both effects are relatively more severe in case of the more inelastic scenario D_{II}.

Moreover, it is extremely interesting to see how prominent the effects of the difference in demand functions come up in these numbers. Although both saturation level and reservation price are completely identical for both D_I and D_{II}, the difference in inelasticity of demand D_I and D_{II} has a significant effect on price levels and rents, which is in line with standard microeconomic theory. In the non-collusive Bertrand oligopoly, quantity demanded as well as consumer rents are significantly higher in case of a more inelastic demand function, i.e. D_{II}. However, once a collusive cartel is established, supplier's profits rise tremendously - at the expense of consumer rents and tax revenue. This effect is especially prominent in case of inelastic demand where consumer rents decrease by over 83% and tax revenue decreases by 45% (energy tax)/ 11% (VAT). These findings are in line with those of Park and Zhao (2010) as has been mentioned in section 2.1. Hence, this example clearly shows that a successful regulation of such a retail gasoline cartel would entail a substantial welfare gain to society as a whole. **Figure5** and **Figure6** are meant to further illustrate the setups and results presented in **Table3**:
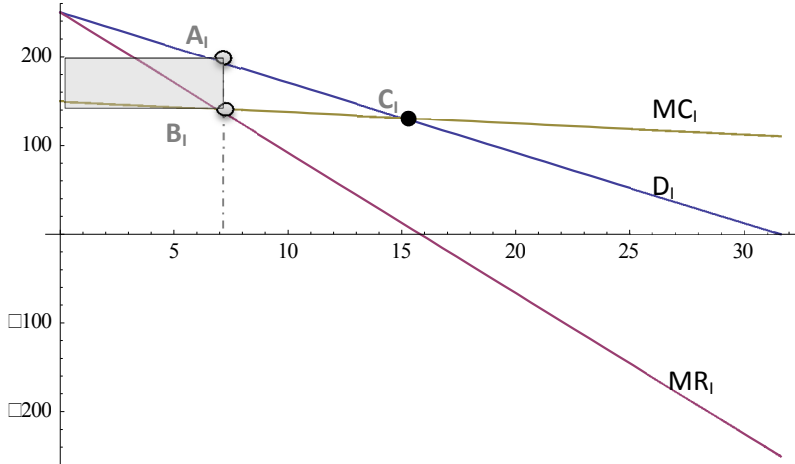

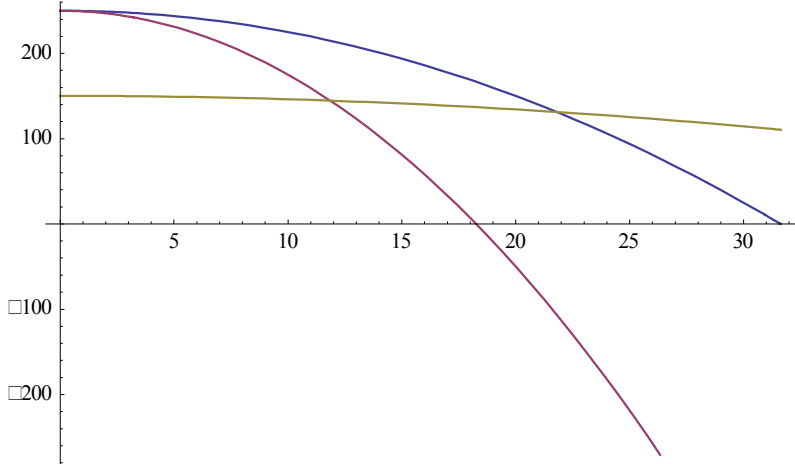Figure5: Demand D_I and Resulting Marginal Revenue and Marginal Cost

Figure6: Demand D_{II} and Resulting Marginal Revenue and Marginal Cost

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Points C_I and C_{II} represent equilibrium results in case of a non-collusive Bertrand oligopoly. Points A_I and A_{II} represent equilibrium market outcomes in case of a collusive cartel. Cartel's profits are sketched by the rectangular shape. Welfare losses of collusion are easily identified as the area between the lines connecting points A_I, B_I, and C_I in **Figure5** and A_{II}, B_{II}, and C_{II} in **Figure6**.

2.3.4 Regulating collusive behavior

Now, the proposed regulatory policy scheme that has previously been introduced in section 2.3 is applied to the numerical setup of section 2.4.1 to 2.4.3. As has been elaborated upon before, its implementation is meant to drive the collusive cartel into the Bertrand oligopoly outcome represented by both equations (T1.II), (T1.IV), and (T1.VI) of **Table1** and column two of **Table3**. Optimal tax levels are identified according to equation (2.6) of **Proposition1** in section 2.3 in combination with the information given by equation (2.9) of section 2.4.1 and equation (2.11) of section 2.4.2. Hence, combining both the formal and numerical model settings presented above, the following equations render the functions which determine the appropriate tax rate in each of the two representative demand scenarios:

$$t_I^{Cartel} = \left|((1-0.159)p - 45 - 65.45)\right|,$$
$$t_{II}^{Cartel} = \left|((1-0.159)p - 45 - 65.45)\right|$$

or

$$t_I^{Cartel} = \left|((1-0.159)(250 - 7.91x_I) - 45 - 65.45)\right|,$$
$$t_{II}^{Cartel} = \left|((1-0.159)(-1/4x_{II}^2 + 250) - 45 - 65.45)\right|$$

$$\forall x_I, x_{II} \in \{0, 31.63\}.$$

(2.13)

Figure7 illustrates the respective functions which may serve to facilitate the understanding of the results presented in **Table4** and **Table5**:
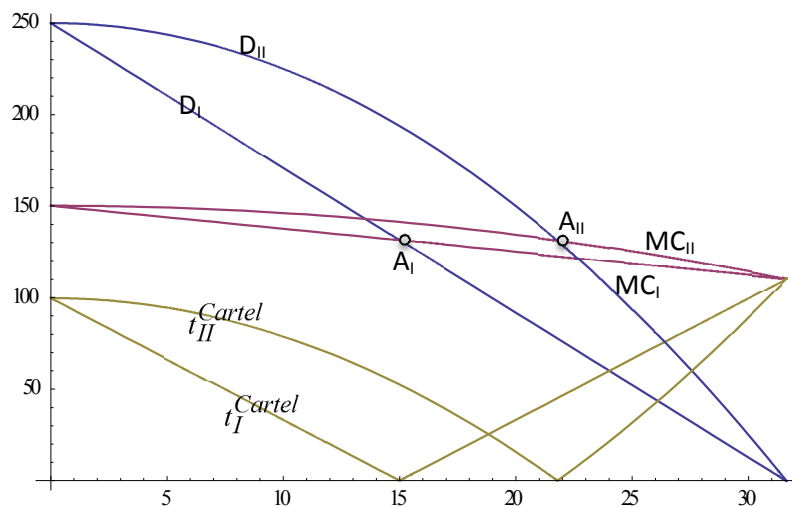

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Figure7 depicts demand and marginal cost structures as well as optimal tax rates of both scenarios D_I and D_{II}. Point A_I (A_{II}) represents the equilibrium market outcome in case of demand scenario D_I (D_{II}). The former characterizes both the Bertrand oligopoly result, as given by column two in **Table3,** as well as the case of the collusive cartel, regulated by the tax rate given by equation (2.13).

Equilibrium Results	Non-collusive Bertrand oligopoly	
	Collusive Cartel facing D_I	Collusive Cartel facing D_{II}
Quantities and Price: (Q*,P*)	Scenario D_I: (15.0, 131.3)	Scenario D_{II}: (21.79, 131.3)
Suppliers' Profits	Π*= 0	
Consumers' Rent	CS_{DI} = 890.18	CS_{DII}= 1724.52
Tax revenue	T_I^E = 981.75, T_I^U = 313.22, T_I^{Cartel} = 0	T_{II}^E =1426.16, T_{II}^U =454.87, T_{II}^{Cartel} = 0
Aggregate Welfare	Scenario D_I: 2185.15	Scenario D_{II}:3605.55
Welfare Loss	Δ **0%**	

Table4: Equilibrium Results Including Regulatory Tax Rate t^{Cartel}

Thereby, as has also been proven in section 2.3, **Figure7** in combination with **Table4** portrays how collusive behavior becomes unprofitable and its negative effects on society's welfare are successfully avoided. **Table5** presents the results regarding the scenario of charging inflated wholesale gasoline price c^{free} compared to charging the actual cost c:

Equilibrium Results	Charging c = 45	Charging c^{free} = 55
Market price (P^c vs. P^{free})	Scenario D_I: 131.3 Scenario D_{II}: 131.3	Scenario D_I: 143.22 Scenario D_{II}: 143.22

Quantity supplied (x^c vs. x^{free})	Scenario D_I: 15.0 Scenario D_{II}: 21.79	Scenario D_I: 13.5 Scenario D_{II}: 20.67
Tax rate paid		0
Tax rate due	0	$\Delta C = 10$
Evaded tax volume		Scenario D_I: 135 Scenario D_{II}: 206.7

Table5: Equilibrium Results Including Regulatory Tax Rate t^{Cartel}

3. Results and Discussion

The analysis of the previous section greatly draws from the propositions and findings of Adelman (1978) when it comes to choosing the proposed policy measure. Some might argue that this is a very confined view. However, even Danielsen (1979) does not question the concept of successfully squeezing a cartel's profits through implementing an ad valorem regulatory tax scheme (Adelman 1979) in the course of his critical comment on Adelman's paper. He mainly questions whether all nations in demand of OPEC supply could uniformly consent to implementing such a tax policy. However, this problem certainly does not arise in case of the gasoline retail market as the regulatory policy proposed in section 2.3 deals with a cartel comprised of companies instead of sovereign nations such as OPEC. Moreover, the work of Delipalla (1992) also provides additional grounds in favor of implementing an ad valorem tax policy to do away with market distortions, given certain market conditions. In her paper Delipalla shows that, under imperfect competition, an ad valorem tax scheme renders optimal results in terms of improving social and consumer welfare. Naturally, there are also market conditions under which findings can be exactly the opposite, as Vetter (2013b) proves in his paper on endogenous competition in a Bertrand-Edgeworth duopoly. Nonetheless, in his paper on taxing a monopoly (Vetter 2013a), Vetter's finding directly support the findings made in the previous sections, as in his model, a variable tax rate also serves to improve welfare, both in a monopoly as well as in certain types of oligopoly settings. However, the question remains whether there are other policy measures at hand that would render a better regulatory performance than the one proposed in the previous sections. While Haucap and Mueller (2012) as well as Berninghaus et al. (2012) find that none of the other currently available regulatory measures, as mentioned in section 2.3., renders satisfactory results, Dewenter and Heimershoff (2012) draw a less radical conclusion when it comes to the Austrian rule. This means that their empirical analysis indicates that limiting the number of

per day price increases might indeed hamper collusive behavior. However, neither is this result a unanimous finding of all the seminal literary sources in question, nor do these findings directly oppose the findings presented in section two. In addition, one might now ask oneself whether current European competition law, i.e. 101TFEU and 102TFEU, or national competition law, such as §20GWB (3) in case of Germany, might not suffice and, hence, render any further regulations as proposed in section two obsolete. However, both Luxembourg and Austria are EU member states and have, at the same time implemented regulatory measures to fight collusive behavior in their national gasoline retail market (Haucap and Mueller 2012). This might serve as a valid indicator on how vanishingly low the chances of successfully prosecuting collusive behavior within the gasoline retail market under these given competition laws really is. The legal setting is identical and, hence, no better for any other EU member state, such as Germany and its competition authorities. Therefore, the need for implementing a regulatory policy scheme such as the alternative presented in this paper cannot be refuted.

One last critical aspect might lie in the question whether the existence of price cycles such as described by Maskin and Tirole (1988), Noel (2007), or Wang (2009) might pose a problem when implementing the proposed regulatory tax policy. In short, the underlying idea is based on the fact that demand for gasoline is not just relatively inelastic (Haucap and Mueller 2012) but that, due to its particular characteristics, its elasticity actually fluctuates. Intuitively speaking, these fluctuations can be, e.g., either time-induced or location-induced. For instance, if you own a gasoline fueled vehicle and use it in your everyday life, time-induced fluctuation might stem from holiday season or adherence to common work schedules and location-induced fluctuation might result from the lack of exit possibilities on a highway you are driving on. Hence, if all suppliers are able to anticipate when and/or where a large number of their customers are in fairly desperate demand of the good in question and cannot postpone that demand due to exogenously given time restrictions, prices and profits can be increased through a time- or location-specific price increase. If companies successfully engage in coordinating their pricing strategies within these cycles a collusive cartel emerges (Wang 2009). The question of how such tacit collusion can be successfully tackled remains highly debated upon (Posner 2001 in Wang 2009, Turner 1962 in Wang 2009). However, upon having taken a look at the analysis presented in the previous section of this paper, it seems as though, regarding the debate on whether and how to successfully tackle tacit collusion, a new alternative has been brought to the table. In short, the latter statement is based on the following reasoning: In accordance with the analysis presented by Adelman (1978), the

proposed variableble tax scheme renders tacit collusion an unprofitable business. In addition, it puts an additional cost on predatory pricing. Moreover, cartel members cannot shift profits to the wholesale market by inflating marginal costs as that would result in knowingly aiding and abetting tax evasion. However, as long as companies do not inflate wholesale prices, they can charge any retail market price p they deem apt but they not only have to transfer resulting VAT but also regulatory tax t^{cartel}. Hence, companies remain free of choice, while the underlying regulatory framework is designed as such that, in equilibrium, the Bertrand oligopoly outcome is reached at an optimal regulatory tax rate level of $t^{cartel} = 0$.

4. Conclusion and Policy Implications

As the analysis in this paper has shown, a successful regulation of the retail gasoline market is not only vital to avoid unnecessary economic welfare losses to society but it also appears feasible. According to seminal research, virtually all of the various regulatory instruments currently in place, such as the Austrian rule, the Fuel-Watch-Concept in Australia, or price ceilings in Luxembourg, have not led to satisfactory results (Berninghaus et al. 2012, Haucap and Mueller 2012). Hence, it has been the goal of the analysis presented in this paper to identify a policy measure that proposes a both valid and promising regulatory alternative. This has been successfully achieved in section two. However, there are always at least to sides to every story. Hence, section three critically evaluates the regulatory policy instrument proposed in section two of this paper. However, the main idea and findings of the proposed regulatory scheme appear to have successfully withstood the test. The former can be summarized as follows: The main idea was to identify an alternative policy measure that squeezes Cartel's profits, increases consumer welfare and fosters competition within the market. As shown by the analysis presented in this paper, all of these targets can be successfully accomplished by the proposed policy scheme. It does so by taking a different approach based on the theory of M.A. Adelman (1978) while, at the same time, taking into account Buchanan's (1969) findings on the effect of imperfect competition on optimal tax rates. Results show that the proposed regulatory tax scheme successfully manages to render collusion an unprofitable endeavor. In addition, selling gasoline to companies of the competitive fringe at wholesale prices above marginal cost could now even be prosecuted under well-established laws of tax evasion. So far, such a behavior, although common and well-known to regulation authorities, cannot be reasonably prosecuted under competition law[9], although it substantially hampers competition within the gasoline retail market (Dewenter and Heimeshoff 2012, Bundeskartellamt 2011). Moreover, sanctioning defective

cartel members or harming the competitive fringe through predatory, i.e. below marginal cost pricing, becomes additionally costly under the proposed tax scheme. Last but not least, the proposed tax scheme can easily be levied and monitored as gasoline stations' cost structures and wholesale prices of gasoline are fairly easy to access (Bundeskartellamt 2011 and 2013) and gasoline retail prices are highly transparent (Haucap and Mueller 2012). Thereby, the imminent vice of the gasoline retail market, i.e. the transparency that enables tacit - and therefore non-prosecutable - collusion, turns into a regulatory virtue as it becomes a powerful means to successfully tackle imperfect competition and to bring about an efficient market outcome.

5. Acknowledgements

6. Footnotes

[1] http://www.huffingtonpost.ca/2011/08/23/car-population_n_934291.html
[2] http://data.worldbank.org/indicator/IS.VEH.PCAR.P3/countries/1W?display=default
[3] http://www.electricdrive.org/index.php?ht=d/sp/i/27132/pid/27132
[4] http://www.gesetze-im-internet.de/ao_1977/__370.html (German version) or http://www.gesetze-im-internet.de/englisch_ao/englisch_ao.html#p2106 (English version)

[5] Solving $t^{cartel} = |P - MC|$ leads to $t^{cartel} = (1-\beta)\dfrac{c + t^E + \Delta C}{(1-\beta)} - c - t^E + \Delta C \equiv 0$.

[6] Inserting x^{free}, equation (T2.IV), into $t^{cartel} = (1-\beta) \times p(x^{free}) - c - t^E$ renders

$$t^{cartel} = (1-\beta) \times (a - b \times \frac{(1-\beta) \times a - c - t^E - \Delta C}{b(1-\beta)}) - c - t^E \Rightarrow t^{cartel} \equiv \Delta C.$$

[7] Taking the Green parties 1998 proposal of 5 DMark per liter of gasoline as a vivid and well known example which, to-date, whips up significant outrage among German car owners http://www.spiegel.de/auto/aktuell/kraftstoffpreis-warum-benzin-viel-zu-billig-ist-a-553489.html
[8] Given an average weekly amount of kilometers driven by German car owners of around $\dfrac{14000 km\ p.a.}{52\ weeks\ p.a.} \approx \dfrac{270 km}{week}$ (http://de.statista.com/statistik/daten/studie/2579/umfrage/durchschnittlich-pro-jahr-mit-kfz-gefahrene-kilometer/) and given an average fuel consumption of 8.5l/100km per car (http://www.upi-institut.de/iaa.htm) renders an average demand of around 23 l/week. Therefore, assuming a saturation level of 31 l/week appears well justified.
[9] As, despite of 101TFEU, 102TFEU, or §20GWB (3), prosecution under these competition laws appears tedious in case of both gasoline wholesale and retail price setting behavior, although, in case of wholesale prices that hamper competition, initial steps have been taken by German competition authorities in early 2012. So far, however, there has, been no conviction.

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