Transport regulations and the effects in the oil market – does market power matter?¹

by

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Abstract

Several instruments to regulate consumption of oil in the transport sector are used or proposed. They typically include fuel taxes, biofuel requirements and fuel efficiency. The impacts of these instruments on the consumption of oil and the oil price vary. One important factor here is the market setting. We show that if market power is present in the oil market, the conclusions for the directions of change in consumption and price may contrast those in a competitive market. This may have important impacts, not only for the effectiveness of the policy instruments to reduce oil consumption, but also for terms of trade and carbon leakage.

JEL codes: D42, Q54, R48

Keywords: Transport regulations, oil market, monopoly, terms of trade effects, carbon leakage

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1 Introduction

Climate change is high on the global policy agenda, and studies like IPCC (2007) and Stern (2007) have established the need for ambitious international climate agreements and strong domestic climate policies. This will have important consequences for the oil market. Current policies and treaties such as the EU emission trading scheme (EU ETS), the Kyoto Protocol, and the Copenhagen Accord are widely seen as just the beginning. At the same time, energy-importing countries are concerned about energy security and oil dependence. Most developed countries import oil from the Middle East, and they may worry about macroeconomic disruption costs from the risk of oil price shocks, constraints on foreign policy (e.g., questions on human rights and democratic freedom in oil exporting nations), and the possible funding of terrorist activities by oil revenues. Europe and the US are expected to increase their import dependency on oil over the next decades as their own supplies are depleted, whereas OPEC most likely will increase its market share and, consequently, its market power.

Both climate change impacts and energy security call for policies to reduce the demand for oil in most consumer countries. These goals can be achieved through many policies such as mandated biofuel shares, emission standards, a quota system for CO₂ emissions, taxation of CO₂ emissions or energy use, support of renewable energy production, standards for energy equipment, etc. Examples of policies that are rarely cost-effective, yet politically popular, are policies that target the transport sector such as a fuel tax, a required share of biofuels in fuel consumption and emission standards for vehicles, see Parry et al. (2007). All are either implemented or suggested in the EU and the US but to different degrees. While the US has rather low tax rates by international standards, fuel taxes are relatively high in many European countries (OECD, 2009). On the other hand, the US aggressively tightened their fuel economy standards in 2007 and 2009.

The transport sector is essential when studying the demand for oil. Transportation currently accounts for over 60% of all oil consumed globally, and the transportation systems in the world are over 90% dependent on oil and oil products. Thus, there are few alternatives that

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4 A combination of goals will usually imply a different mix of policies than if one only had the aim of reducing greenhouse gas emissions. For instance, broad taxes are more cost-effective than fuel standards or biofuel shares if the aim is to reduce global warming.

5 The new Corporate Average Fuel Economy (CAFE) standards for manufacturers are equivalent to 39 miles per gallon for their new car fleets, and 30 miles per gallon for their light-truck fleets, by 2016 (see, e.g., Parry, 2009).
can compete widely with oil in the transport market today, and the substitution possibilities are, therefore, low. According to EIA (2008), the transportation sector accounts for 74 percent of the projected increase in global liquid use from 2005 to 2030. We will, therefore, focus on policy instrument to reduce the demand for oil in the transport sector in this paper.

Policies to regulate transport may have different impacts in a competitive market and a market with a dominant producer. The oil sector is dominated by the OPEC cartel and several independent producers, and it can hardly be considered a competitive market as OPEC exhibits some kind of market power (see, e.g., Berg et al., 1997a; Alhajii; 2004). Thus, in this paper we study the impacts of different types of transportation regulations in the presence of market power. In particular we compare three different types of policy instruments: a fuel tax (e.g., a tax on CO₂-emissions), a required share of biofuels (blending requirements) in the transport market, and fuel efficiency (e.g., minimum miles per gallon requirements).

The literature on this topic can be divided into two strands; one that studies the oil market and focuses on the supply side, and one that analyses regulations in the transport sector in more detail by mainly focusing on the demand side. Starting with the first strand of literature, Sinn (2008) studies different policy measures from an intertemporal supply-side perspective for a non-renewable resource, but do not consider market power on the supply side. There are studies of carbon taxation with intertemporal supply considerations under different market settings (e.g., Berg et al. 1997b), but to our knowledge there are no rigorous comparisons of policy instrument when market power is taken into account.

Most studies on regulations in the transportation sector are demand side analyses (assuming fixed producer prices) that use a utility function as the starting point to, e.g., calculate optimal fuel taxes (e.g., Parry and Small, 2005; West and Williams, 2007; Parry, 2009), to measure welfare effects of fuel economy regulations (e.g., Fischer et al., 2007), or to calculate costs of different regulations to meet certain levels of gasoline consumption (e.g., West and Williams, 2005). Morrow et al. (2010) study the impacts of different policies to reduce oil consumption and greenhouse gas emissions from the US transportation sector, but assume an exogenous oil price. There is a large literature on fuel efficiency standards, and market power is introduced when examining, e.g., effects of such standards under possibilities of price discrimination when consumers have different tastes (e.g., Plourde and Bardsis, 1999), and the effects of standards on cars sales, prices and fuel consumption (e.g., Goldberg, 1998). But, these studies
introduce market power in the supply of cars and not in the oil market. The economic literature on biofuels has also emerged the last few years (see, e.g., Rajagopal and Zilberman, 2007). De Gorter and Just (2007) study the effect of biofuel subsides on oil consumption in a competitive market, while Hertel et al. (2010) analyze the impacts of biofuel mandates in a global computable general equilibrium model. A recent paper by Hochman et al. (2010) is relevant to our paper as it focus on the impact of biofuel when OPEC acts as a cartel, in the main scenario modeled as a cartel-of-nations. They specify two regions in the world, an oil exporting and an oil importing, and study the different impacts on the oil price in the two regions. However, this paper does not make comparisons with other policy instruments to reduce oil consumption.

In this paper we combine the two strands of literature. But instead of focusing on the preferences of consumers, we study the importance of the supply side of the oil market for the effects of transport regulations. We do not consider intertemporal optimization on the supply side as the focus is on market power. Our interest is on the effects on the price and quantity of oil consumption under different market settings. The price effect is rather important. Assuming for instance that transport regulations follow from a climate treaty, signatory countries may be concerned about increased emissions in non-signatory countries due to a lower oil price (carbon leakage), see Felder and Rutherford (1993). It is also well known that environmental regulations may have terms of trade effects (Krutilla, 1991). Regulations that change the oil price will also affect terms of trade, and oil-importing countries may worry about policy measures that can increase the oil price. Therefore, we do comparisons of the effects on the oil price for different regulations under different market settings.

The paper is organized as follows. In the next section we use a static model for a closed economy to study the impacts of the different policy instruments in a competitive market as well as in a monopoly market. While both these market forms are too simplistic in describing the oil market, they represent useful indicators of pointing out the effects of transport regulations in the oil market when market power is introduced. In the third section we extend the analysis to an open economy to further study the terms of trade and carbon leakage effects from regulations in the transport sector. The final section concludes.
2 Transport regulations in a closed economy

In order to focus on the effects of market power, we use a static partial equilibrium model. In this section we consider a closed market. A natural interpretation is to think of the global oil market. Nevertheless, we will also discuss implications for a single country that is importing oil, and in the following section we will model an open market, assuming linear demand and marginal cost functions. As the substitution possibilities are small in the transport market, we implicitly keep prices of other energy goods constant.

Different transport regulations to reduce fossil fuel consumption and hence CO₂ emissions are studied under the assumption that they are widely introduced. If we think of the global oil market, these regulations could for instance be the outcome of an international climate agreement. So far it seems more realistic to consider such regulations within a single or a group of countries, and that is why we examine an open economy in the next section. The regulations we consider are the following:

i) A fuel tax set as a tax \( t \) per unit of oil.

ii) A required share of biofuels as a fraction \( \dot{a} \) of total transport fuel consumption. Define \( \dot{a} = a/(1+a) \), meaning that for each unit oil that is sold, one also need to sell \( a \) units of biofuel.\(^6\)

iii) An efficiency standard interpreted as a (binding) minimum average vehicle efficiency \( m \) measured as miles per gallon (mileage).

We will compare the effects of these policy instruments in a competitive market \((C)\) and a monopoly market \((M)\), and we assume throughout the paper that the changes in \( t, a \) or \( m \) are the same in the two market settings.

2.1 The demand for oil

Let us start by defining the demand for transport services, measured in miles driven \((q)\) as a function of mileage \((m)\), oil consumption for transport use \((x)\) and biofuel requirements \((a)\). Oil consumption is measured in gallons of oil.\(^7\) Then we have:

\[
(1) \quad q = m \cdot x + m \cdot ax = m(1+a)x
\]

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\(^6\) One example is gasoline mixed with ethanol.

\(^7\) To simplify the analysis, we ignore oil consumption outside the transport sector throughout the analysis.
To drive a mile, one can either use oil or biofuels as the fuel source. As oil is measured in gallons, $mx$ is the number of miles driven on oil and $m\,ax$ is the number of miles driven on biofuels. We see that for a given demand of transport services $q$, increased mileage or increased biofuel share means that the consumption of oil is reduced accordingly.

Now, let us turn to the demand for oil. To do this, assume that an increase in $m$ increases mileage by the same percentage rate for all transport consumers, so that an increase in $m$ has the same effect on the demand function for all quantities of oil. Moreover, we disregard any costs related to making cars more fuel-efficient and costs related to supplying the necessary amount of biofuels. These are assumed to be covered by the government and not by consumers or producers in the oil market. Thus, we assume that the price of biofuels is equal to the price of oil, e.g., that gasoline is mixed with biofuels when sold at a gas station.

Let $P_q(q)$ denote the inverse demand function for transport services, i.e., the price consumers are willing to pay for an extra mile as a function of miles driven. Furthermore, $P_x(x)$ denotes the inverse demand function for oil facing the producer(s) of oil. Note that the consumer price of oil is then $P_x(x) + t$, i.e., the producer price plus the fuel tax. Based on this, we find that

\[ P_q(q) = \frac{P_x(x) + t}{m} \]

i.e., the price per mile driven is equal to the consumer price of oil per gallon divided by the mileage.

From (1) and (2) we can write the inverse demand function for oil facing the producer(s) of oil:

\[ P_x(x) = mP_q(m(1 + a)x) - t \]

where $P_x'(x) < 0$ and $P_q'(q) < 0$.

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8 We disregard other sources such as electricity and hydrogen in this analysis, as they are usually not regulated through any of the policy measures studied here.
Equation (3) shows quite clearly that the three different policy instruments affect the inverse demand function for oil very differently. This is illustrated in Figure 1, where \( P_x^t \), \( i=a,m,t \), are the new demand functions under the different regulation schemes. A fuel tax, \( t \), shifts the whole inverse demand function downward, while a required share of biofuels, \( a \), makes the function steeper, with the same choke (maximum) price as before.

Increased efficiency, \( m \), also makes the inverse demand function steeper, but the choke price is increased because it has become cheaper to drive a mile if prices are unchanged. Thus, as opposed to the two other instruments, increased efficiency increases demand for some (high) price levels.\(^9\) To see this, note that with higher mileage one does not need as much gasoline to drive the same distance as before, which goes in the direction of lower oil demand. On the other hand, it will be cheaper to drive a mile since the car uses less fuel, and the demand for transport services increases. This last effect goes in the direction of more demand for gasoline and oil. Thus, there are two opposite effects.\(^10\)

< Insert Figure 1 >

2.2 Quantity effects in a competitive oil market

Let us now examine the effects of the different policies in a competitive market. For simplicity we assume that \( a = t = 0 \) and \( m = 1 \) initially, i.e., we study the effects of introducing transport regulations where there are no such regulations initially. To simplify the notation we use \( P(x) \) instead of \( P_x(x) \).

Assume that a representative producer faces a cost function \( c(x) \), with the following properties; \( c'(x) > 0 \) and \( c''(x) \geq 0 \). The market outcome of this producer can easily be derived by considering the maximization problem when the price is taken as given

\[
\text{Max } P(x)x - c(x)
\]

\(^9\) If there is no choke price, i.e., the price goes towards infinity when consumption goes towards zero, the \( P_x^m \)-curve may possibly lie below the \( P_x \)-curve for all \( x \). This is, e.g., the case if \( P_x = x^{-k} \), where \( k > 1 \) (i.e., price elasticity below one in absolute value).

\(^10\) The crossing demand functions can also be seen from equation (3). Increasing \( m \) has two effects as \( m \) is multiplied with \( P_x(q) \) and also increases \( q \) everything else given. As \( P'_x(q) < 0 \), we see that \( P_x(x) \) may either increase or decrease for an increase in \( m \).
This gives the well-known first order condition

\[ P = c'(x). \]

Inserting from (3) and then differentiating (setting \( a = t = 0 \) and \( m = 1 \)) gives the following equation:

\[ c''(x) - P'(x) \quad dx = \quad P(x) + xP'(x) \quad dm + xP'(x)da - dt \]

Thus, we get the following effects of the different instruments in a competitive market:

1. \[ \frac{dx^c}{dt} = -\frac{1}{c''(x) - P'(x)} < 0 \]

2. \[ \frac{dx^c}{da} = \frac{xP'(x)}{c''(x) - P'(x)} < 0 \]

3. \[ \frac{dx^c}{dm} = \frac{P(x)\left(1 + \frac{1}{\varepsilon(x)}\right)}{c''(x) - P'(x)} \]

where \( \varepsilon(x) = \frac{P(x)}{xP'(x)} \) (price elasticity of demand).\(^{12}\)

Not surprisingly, oil consumption drops if either a tax or a required share of biofuels is introduced. On the other hand, we notice from (7) iii) that the effect of increased mileage on oil consumption is ambiguous. This is also easily seen from Figure 1. If the marginal cost function crosses above the intersection of the \( P_x \)- and the \( P_x^{m} \)-curves, oil consumption increases when mileage is raised, otherwise it will fall. Furthermore, we see from (7) iii) that the direction of change in consumption depends on the size of the price elasticity of demand: Increased fuel efficiency will increase oil consumption if and only if the price elasticity in the market equilibrium is above one in absolute value. Most recent empirical analyses seem to conclude that price elasticities are rather low in absolute value and most likely below one (see, e.g., Hughes et al., 2006; Parry, 2009). Thus, if the oil market can be viewed as a

\(^{12}\) Note that \( x(P) \) is the demand function for oil, which is the inverse of \( P(x) \).
competitive market, introducing an efficiency standard for transportation will most likely reduce total consumption of oil.\(^{13}\)

### 2.3 Quantity effects in a monopoly market

To see the effect of transport regulations when market power is introduced, we confront the conclusions above with an analysis of a market with monopoly on the supply side. While this is a simple representation of market power, it will still show some important implications. In the next section we will consider an open economy with a dominant producer and a competitive fringe in the special case with linear demand and marginal cost functions. Thus, in this section we will briefly report the results of assuming linear functions.

A monopolist also considers the maximization problem in (4), but does not take the price as given. This gives the standard first order condition:

\[
MR(x) = xP'(x) + P(x) = c'(x),
\]

and the second order condition:

\[
\Gamma(x) = c''(x) - 2P'(x) - xP''(x) > 0.
\]

From (3) we find that \(P'(x) = m^2(1+a)P_q'(m(1+a)x)\). Differentiating this expression gives:

\[
dP' = (1+a)\left[2mP_q'dm + m^2P_q''(1+a)xdm + mxda + m(1+a)dx\right] + m^2P_q'da.
\]

Inserting from (3) in (8) and then differentiating, using (10), \(a = t = 0\) and \(m = 1\), \(P' = P_q'\) and \(P'' = P_q''\) (see equation (2)), gives the following expression:

\[
c''(x) - 2P'(x) - xP''(x) \ dx = P(x) + 3xP'(x) + x^2P''(x) \ dm + 2xP'(x) + x^2P''(x) \ da - dt.
\]

\(^{13}\) If the price elasticity is above unity at high prices (as with, e.g., some linear and concave demand functions), a gradual increase in unit production costs over time due to resource scarcity will increase the likelihood that increased mileage will stimulate consumption.
Thus,
\[
\begin{align*}
\text{i)} \quad \frac{dx^M}{dt} &= -\frac{1}{c''(x) - 2P'(x) - xP''(x)} = -\frac{1}{\Gamma(x)} < 0 \\
\text{ii)} \quad \frac{dx^M}{da} &= \frac{2xP'(x) + x^2P''(x)}{c''(x) - 2P'(x) - xP''(x)} = \frac{xP'(x)}{\Gamma(x)} (2 + \gamma(x)) \\
\text{iii)} \quad \frac{dx^M}{dm} &= \frac{3xP'(x) + x^2P''(x)}{c''(x) - 2P'(x) - xP''(x)} = \frac{xP'(x)}{\Gamma(x)} (3 + \varepsilon(x) + \gamma(x)),
\end{align*}
\]

where \( \gamma(x) = x \frac{P''(x)}{P'(x)} \), and \( \Gamma(x) > 0 \) is given from (9). In a monopoly market we recall that \( \varepsilon(x^M) \leq -1 \) for the marginal revenue to be positive.\(^{14}\)

We notice that the size of \( \gamma \) is crucial for the impact of the policies. This parameter is the elasticity of \( P'(x) \) with respect to \( x \) and says something about the curvation of the demand function. Throughout the paper we will distinguish between three cases: i) \( \gamma > -1 \), which means that the inverse demand function is either concave (\( \gamma > 0 \)), linear (\( \gamma = 0 \)) or “slightly convex” (\( -1 < \gamma < 0 \)), in the sense that the price derivative does not change too fast when \( x \) changes; ii) \( -2 < \gamma < -1 \), in which case we will refer to a “quite convex” inverse demand function; and iii) \( \gamma < -2 \), which means that the inverse demand function is “very convex”.\(^{15}\)

From equations (12) we first observe that a tax will unambiguously reduce consumption of oil, just as in the competitive market. This is shown in Figure 2. In the special linear case we can easily show that the relative output reduction will be the same in the two market settings.

< Insert Figure 2 >

\(^{14}\) As mentioned in Section 2.2 above, empirical studies find the price elasticity to be less than one (in absolute value) in the oil market. However, this does not rule out market power in this market. The oil market can be characterized as having a dominant producer (OPEC) and a competitive fringe (cf. e.g. Hansen and Lindholt, 2008). It is profitable for a dominant producer to adjust its production to a level where the price elasticity of the residual demand is larger than one (in absolute value). This elasticity will be larger than the demand elasticity (in absolute value), so we may still have a dominant producer in the oil market even if the demand elasticity is “low”. As already mentioned, in the next section we will investigate a model with a dominant producer.

\(^{15}\) Note that \( \gamma \) is a function of \( x \), i.e., it is not necessarily constant. We have ruled out \( \gamma = -1 \) and \( \gamma = -2 \) in the cases above. For \( \gamma = -2 \), \( dP/dx \) is not defined for \( da>0 \), see equation (14) below. For \( \gamma = -1 \), we see from (13) and (14) below that \( dP/dx \) is similar in a monopoly and a competitive market for both \( dt>0 \) and \( da>0 \).
Further, a required biofuel share will reduce oil consumption if and only if the inverse demand function is not very convex ($\gamma > -2$). Figure 3 shows an example with linear demand functions where oil consumption will fall with a higher share of biofuels. In the special linear case, the relative output reduction will be bigger in a monopoly market than in a competitive market (unless marginal costs are constant). The reason is that the demand function becomes steeper, and thus the monopolist finds it profitable to reduce output relatively more than in the tax case.

< Insert Figure 3 >

However, for more convex inverse demand functions ($\gamma < -2$), oil consumption will actually increase. Note that in this case, the marginal revenue function will in fact increase in $x$. An increase in the biofuel share will then increase the marginal revenue for a given production level even if the price goes down (remember that the inverse demand function moves down). The reason is that the price function will be less steep for a given $x$. Thus, whereas a required share of biofuel always reduces consumption in a competitive market, oil consumption may actually increase in a monopoly market if the inverse demand function is very convex. Notice, however, that a very convex inverse demand function typically (but not necessarily) will have negative marginal revenue even for low values of $x$, which conflicts with (8), and thus makes increased oil consumption rather unlikely.

As for the competitive market, the effect of increased fuel efficiency on oil consumption is in general ambiguous also in a monopoly market. The sign of the numerator in (12) iii) depends on the sum of $\gamma$ and the price elasticity $\varepsilon$. As $\varepsilon < -1$ in a monopoly market, we see that if the inverse demand function is very convex ($\gamma < -2$), oil consumption will increase when fuel efficiency is increased. Nevertheless, a more realistic scenario may be that $-2 < \varepsilon < -1$ and $\gamma > -1$, so that the numerator in (12) iii) is negative, in which case oil consumption decreases.

An example of increased fuel efficiency in the oil market is shown in Figure 4. Here we have assumed that the price elasticity is above one in absolute value in the competitive outcome, so that higher fuel efficiency will increase oil demand in this market setting (from $x^{C1}$ to $x^{C2}$). On

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16 By differentiating (8) we find that $\partial MR(x)/\partial x > 0$ for $\gamma < -2$. Note that for the second order condition in (9) to be fulfilled, $c'(x)$ has to increase faster than $MR(x)$.

17 One straightforward example of this is $P(x) = x^2$, in which case $\gamma = -3$ and $MR = -x^2$. An example where we in fact get higher oil consumption is the following: $P(x) = Min (3 ; 2 + x^2)$. On
the other hand, it will decrease oil demand (from $x^M$ to $x^M$) in the presence of a monopoly. This is not accidental – in the special linear case, we can show that it is more likely that increased efficiency leads to reduced consumption in a monopoly market than in a competitive market (more precisely, we will never get higher $x^M$ and lower $x^C$). If we rather assumed a flatter marginal cost curve lying below the crossing point for the two demand curves (which we know is equivalent to inelastic demand in the competitive outcome), oil demand would decrease in the competitive case, too. From the figure we notice that the oil price increases in both market settings, even though the quantity effect goes in different directions. The price effects will be further studied below.

To sum up (see also Table 1), the effects of regulations become somewhat more ambiguous with market power. While both a fuel tax and an increased biofuel share will definitely reduce oil demand in a competitive market, the fuel tax is the only instrument of the three studied that has an unambiguous negative effect on oil demand in a monopoly market. Nevertheless, in most realistic cases we think that oil consumption will fall irrespective of policy instrument and market setting studied above. Moreover, it is difficult to state in general terms whether the quantity reductions are largest in a competitive or a monopoly market. The brief discussion of the special linear case may indicate, however, that the relative output reduction may be biggest in the monopoly market except in the tax case.

Table 1. Quantity effects of policy instruments in competitive (C) and monopoly (M) markets

<table>
<thead>
<tr>
<th></th>
<th>Fuel tax</th>
<th>Biofuel share</th>
<th>Efficiency standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C</strong></td>
<td>−</td>
<td>−</td>
<td>− if $\varepsilon(x^C) &gt; -1$ + if $\varepsilon(x^C) &lt; -1$</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>−</td>
<td>− if $\gamma(x^M) &gt; -2$</td>
<td>− if $\varepsilon(x^M) &lt; -3 - \gamma(x^M)$</td>
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<tr>
<td></td>
<td></td>
<td>+ if $\gamma(x^M) &lt; -2$</td>
<td>+ if $\varepsilon(x^M) &lt; -3 - \gamma(x^M)$</td>
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2.4 Price effects

We now turn to the price effects of the different policy instruments in the two market settings. Figures 2-4 above gave some indications of these effects, but we will discuss this more thoroughly.
Below, we concentrate on the producer price $P$, i.e., the price the oil producer(s) receive(s). In a closed market, this is of interest with respect to distributional issues, i.e., to what degree are monopolists able to charge a mark-up over marginal costs. Thus, the analysis may shed light on which policy instruments large oil producers would prefer and lobby for, given that oil consumption will have to come down.

If we think of an open market (which will be modeled in the next section), price effects are of interest for at least two more reasons: First, if the country is importing oil, the change in $P$ can be interpreted as a \textit{terms of trade effect}. Thus, the country would like $P$ to fall as much as possible when $x$ is reduced to improve its terms of trade. Second, if the country is concerned about \textit{carbon leakage}, i.e., increased emissions due to higher fuel consumption outside the country, it would like $P$ to fall as little as possible (or even better, increase) so that foreign demand is not stimulated too much when it reduces its own oil consumption.

We will analyze the price effect by calculating the price change relative to the change in consumption. In a competitive market, it is obvious from the first order condition (5) that we must have:

\begin{equation}
\frac{dP^c}{dx^c} = c''(x),
\end{equation}

irrespective of which policy instrument is used to reduce consumption of $x$. With standard assumptions under competitive markets ($c''(x) > 0$), we see first of all that the price and quantity always move in the same direction. Examples of this are given in Figures 2, 3 and 4. Moreover and importantly, the relative price effect is \textit{independent of instrument choice}.

In a monopoly market, however, the price effect depends highly on the instrument choice. It is straightforward to show (by total differentiation of (3) and inserting from (12)) that we get the following price effects:

\begin{equation}
i) \quad \left. \frac{dP^M}{dx^M} \right|_{\delta=0} = c''(x) - P''(x) \left(1 + \gamma(x) \right)
\end{equation}
\begin{align*}
\text{(14) ii) } & \quad \frac{dP^M}{dx^M} \bigg|_{dx>0} = \frac{c''(x)}{2 + \gamma(x)} \\
\text{iii) } & \quad \frac{dP^M}{dx^M} \bigg|_{dx>0} = \frac{c'(x) 1 + \varepsilon(x) + P'(x) \left[ 1 - \varepsilon(x) 1 + \gamma(x) \right]}{3 + \varepsilon(x) + \gamma(x)}
\end{align*}

where we know that \(c(x^M) \leq -1\) in a monopoly market.

Based on this, we immediately see that the size of \(\gamma\) is crucial for the comparisons of the price effects, but so is also the third derivative of the cost function. Note that \(x\) will always be higher in a competitive market than with monopoly. Thus, the sign of \(c'''(x)\) for \(x \in [x^M, x^C]\) determines whether \(c'(x)\) will be higher or lower with monopoly compared to a competitive market.

Let us first look at the tax case. We notice that the price reduction (relative to the output reduction) can be either bigger (e.g., if \(\gamma > -1\) and \(c'''(x) \leq 0\)) or smaller (e.g., if \(\gamma < -1\) and \(c'''(x) \geq 0\)) in a monopoly market than in a competitive market. In the special linear case, the price reduction will be biggest in a monopoly market. On the other hand, if \(\gamma < -1\), it is possible that the producer price increases if the inverse demand function is sufficiently steep compared to the marginal cost function. The explanation is that the fuel tax moves consumption towards a more inelastic part of the demand function, making it profitable for the monopolist to decrease production more substantially.

Consider now an increase in the biofuel share. Again we see that the relative price reduction can be either bigger (e.g., if \(-2 < \gamma < -1\) and \(c'''(x) \leq 0\)) or smaller (e.g., if \(\gamma > -1\) and \(c'''(x) \geq 0\)) in a monopoly market than in a competitive market. However, as we see, the conditions on \(\gamma\) for whether the price effect is bigger or smaller is completely turned around compared to the tax case. Thus, in the special linear case, the price reduction will be smallest in a monopoly market. It follows that, in this special case, the price reduction in a monopoly market will be smaller with a biofuel share than with a tax. As explained above, the demand curve facing the monopolist becomes steeper (more inelastic) only in the former case, and thus it becomes more profitable to withhold production. If the inverse demand function is very convex (\(\gamma < -2\)), we know from the discussion in Section 2.3 that oil consumption will increase when a biofuel share is imposed. Equation (14) ii) shows that the price will decrease also in this case. Thus, the price will unambiguously fall if a biofuel share is introduced.
Last but not least, if fuel efficiency is increased, it can be shown that the price of oil will always increase as long as oil consumption decreases. This is completely opposite of the price effect in a competitive market, where the price and quantity always move in the same direction (see (13)). If increased fuel efficiency stimulates oil consumption, the price effect is ambiguous and depends on the marginal cost and inverse demand functions.

To sum up the price effects in a monopoly market, if the policy makers are concerned about the mark-up for big oil producers (or the terms of trade effects in an open market), they should avoid fuel efficiency standards as the main policy instrument to reduce oil consumption. We have just shown that this policy will in fact increase the producer price of oil. If the inverse demand function is not too convex, they should rather go for a fuel tax. Or alternatively, if the inverse demand function is quite convex, a biofuel standard is most advantageous in this respect. But remember that if the function is very convex, a biofuel standard will not reduce oil consumption. On the other hand, if policy makers prefer high prices (e.g., due to concern about carbon leakage – see next section), the conclusions naturally become completely turned around. The same reasoning can be applied to big oil producers, who would find it in their interest to lobby for fuel efficiency standards rather than fuel taxes and biofuel shares. Table 2 sums up the price effects of the three policy instruments in the two market settings, showing that the direction of change depends significantly on the market setting.

<table>
<thead>
<tr>
<th></th>
<th>Fuel tax</th>
<th>Biofuel share</th>
<th>Efficiency standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>dx&lt;sub&gt;C&lt;/sub&gt; &lt; 0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>dx&lt;sub&gt;C&lt;/sub&gt; &gt; 0</td>
<td>N.A.</td>
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<tr>
<td>M</td>
<td>dx&lt;sub&gt;M&lt;/sub&gt; &lt; 0</td>
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<tr>
<td></td>
<td>dx&lt;sub&gt;M&lt;/sub&gt; &gt; 0</td>
<td>N.A.</td>
<td>–</td>
</tr>
</tbody>
</table>

18 Note that x<sub>M</sub> decreases if and only if $3 + \varepsilon + \gamma > 0$, see (12) iii). Thus, the denominator in (14) iii) is positive. The first term in the numerator is negative since $\varepsilon \leq -1$, and the second term is also negative when $3 + \gamma + \varepsilon > 0$.

19 Of course, there are other (potentially more important) issues to consider when choosing between policy instruments, such as cost-effectiveness. Such issues are not the topic of this paper, however.
3 Transport regulations in an open economy

In the preceding section we learned that the price effect of reducing oil consumption is independent of the policy instrument in a competitive market, but highly dependent on the instrument choice in a monopoly market. In particular, whereas a biofuel share and (most likely) a fuel tax will reduce the producer price of oil in a monopoly market, increased efficiency will increase the price (given that the instrument leads to lower oil consumption).

In this section we will explore this issue further in an open economy with either a monopolist or a dominant firm with a competitive fringe. As the analysis becomes much more complicated in an open economy, we will make a number of simplifying assumptions and also present some numerical illustrations.

Thus, assume now that there are two regions in the world consuming oil, region A and B. Region A imports oil from region B, which is the only region producing oil. Both regions are assumed to have linear transport demand functions. Moreover, we disregard transport policies in region B, so that \( q_B = x_B \). Consequently, using equation (3), the consuming regions have the following inverse demand functions for oil, where \( \alpha_1 > 0, \alpha_2 > 0, \beta_1 > 0, \beta_2 > 0 \) and footnote \( i = A,B \), represents the variable of region \( i \):

\[
\begin{align*}
P(x_A) &= m(\alpha_1 - \alpha_2 m(1 + a)x_A) - t \\
P(x_B) &= \beta_1 - \beta_2 x_B
\end{align*}
\]

Here \( P \) denotes the world market price of oil. We normalise price and quantity units so that \( \alpha_1 = \alpha_2 = 1 \). Moreover, we assume that \( \beta_1 = 1 \), i.e., the choke price is identical in the two regions (at \( m = 1 \)).

In region B there is a dominant firm (\( D \)) and a competitive fringe (\( F \)). The marginal costs of producer \( j \) is specified as

\[
(17) \quad c'(x_j) = c_{j1} + c_{j2} \cdot x_j
\]

---

20 Below we discuss the implications of having oil production in the importing region A as well. xx
We assume that $c_j < 1$ to ensure positive production of oil. The fringe has the same first order condition as in a competitive market, see equation (5). Note that a monopoly market emerges as a special case if $c_{F2} \rightarrow \infty$.

We will refer to demand in region $B$ minus fringe production as the residual demand in region $B$ ($x_B^D$). From equations (5), (16) and (3) we have that $x_B^D$ is given by:

\begin{equation}
(18) \quad P(x_B^D) = \beta_1^D - \beta_2^D x_a^D
\end{equation}

where $\beta_1^D = \frac{c_{F2} + \beta_2^D c_{F1}}{\beta_2 + c_{F2}}$ and $\beta_2^D = \frac{\beta_2 c_{F2}}{\beta_2 + c_{F2}}$.

The total residual demand facing the dominant firm ($x^D$) consists of $x_B^D$ and $x_A$. From equation (18) and (15) we find that:

\begin{equation}
(19) \quad P(x^D) = \frac{1}{\gamma_3(m,a)} \left[ \gamma_1(m,a,t) - \gamma_2(m,a)x^D \right]
\end{equation}

where $\gamma_1 = \beta_1^D m^2 (1+a) + \beta_2^D m - \beta_2^D t$, $\gamma_2 = \beta_2^D m^2 (1+a)$ and $\gamma_3 = \beta_2^D + m^2 (1+a)$.

By using the first order condition of a dominant firm, which is the same as for a monopolist (cf. equation (8)), we can derive the following expressions for the equilibrium price and residual demand in this market (as functions of the policy instruments):

\begin{equation}
(20) \quad P = \frac{\gamma_1(m,a,t)\gamma_2(m,a) + \gamma_1(m,a,t)\gamma_3(m,a)c_{D2} + \gamma_2(m,a)\gamma_3(m,a)c_{D1}}{2\gamma_2(m,a)\gamma_3(m,a) + \gamma_3(m,a)^2 c_{D2}}
\end{equation}

\begin{equation}
(21) \quad x^D = \frac{\gamma_1(m,a,t) - \gamma_3(m,a)c_{D2}}{2\gamma_2(m,a) + \gamma_3(m,a)c_{D2}}
\end{equation}

Equilibrium consumption in the two regions and fringe production then follows straightforwardly from the equations above.
We are now ready to investigate the effects of the different policy instruments. It turns out, however, that it is difficult to derive analytical and interpretable expressions in the case of a dominant firm with a competitive fringe (except in the tax case). Thus, in the first subsection below we consider a monopoly market, and examine analytically the effects of the policy instruments in this market setting. We also present some numerical illustrations. Then, in Subsection 3.2 we present some numerical illustrations showing how the existence of a competitive fringe affects the results.

3.1 Monopoly market

In a monopoly market we have of course that \( \beta_1^D = 1 \) and \( \beta_2^D = \beta_2 \) (this is also easily seen by letting \( c_{F2} \rightarrow \infty \) in the expressions for \( \beta_1^D \) and \( \beta_2^D \)). The steepness of the inverse aggregate demand curve is then given by \( \beta_2 / (1 + \beta_2) \). We make a final simplification by assuming that \( c_{D1} = 0 \).

In the appendix we show that the three different policy instruments affect consumption in region A and region B and the producer price in the following way:

\[
\begin{align*}
\text{(i)} \quad & \frac{dx_A}{dt} = - \frac{\beta_2^2 + 2\beta_2 + \beta_2 c_{D2} + c_{D2}}{\beta_2 + 1} < 0 \\
\text{(ii)} \quad & \frac{dx_A}{da} = - \frac{\beta_2^2 + 2\beta_2 + c_{D2}}{2\beta_2 + c_{D1}\beta_2 + c_{D2}} < 0 \\
\text{(iii)} \quad & \frac{dx_A}{dm} = \frac{2\beta_2 c_{D2}^2 + 3\beta_2^2 c_{D2} + \beta_2^3 c_{D2} + 2\beta_2^2 c_{D2}^2 + c_{D2}^2 + \beta_2^2 c_{D2}^2 - 2\beta_2^3}{\beta_2 + 1} \frac{1}{2\beta_2 + c_{D2}\beta_2 + c_{D2}} < 0 \\
\text{(i)} \quad & \frac{dx_B}{dt} = - \frac{1}{\beta_2} \frac{dP}{dt} = \frac{\beta_2 + \beta_2 c_{D2} + c_{D2}}{\beta_2 + 1} \frac{2\beta_2 + c_{D2}\beta_2 + c_{D2}}{2\beta_2 + c_{D2}\beta_2 + c_{D2}} > 0 \\
\text{(ii)} \quad & \frac{dx_B}{da} = - \frac{1}{\beta_2} \frac{dP}{da} = \frac{\beta_2 c_{D2}}{2\beta_2 + c_{D2}\beta_2 + c_{D2}} > 0 \\
\text{(iii)} \quad & \frac{dx_B}{dm} = - \frac{1}{\beta_2} \frac{dP}{dm} = - \frac{2\beta_2^2 c_{D2} + 2\beta_2^2 c_{D2} + 2\beta_2^2 c_{D2}^2 + \beta_2^2 c_{D2}^2 + \beta_2^2 c_{D2}^2}{\beta_2 + 1} \frac{1}{2\beta_2 + c_{D2}\beta_2 + c_{D2}} < 0
\end{align*}
\]

\( ^{21} \) This can also be viewed as a normalization, if we first subtract \( c_{D1} \) from \( \alpha_1 \) and \( \beta_1 \) and then normalize prices and quantities so that \( \alpha_1 - c_{D1} = 1 \) (and \( \alpha_2 = 1 \)). Riktig???
We first notice that a fuel tax and a biofuel share will unambiguously reduce consumption in Region A as well as the producer price of oil, and increase consumption in Region B. Increased fuel efficiency, however, will unambiguously increase the producer price of oil and hence reduce consumption in Region B. The effects on consumption in Region A are ambiguous, and depend on the steepness of the demand curve in Region B and the marginal costs of the monopolist. These results are consistent with the results found in Section 2 in the case of a closed market (a closed market can of course be seen as a special case of an open market with $\beta_2 \to \infty$).

Let us first examine in which cases increased fuel efficiency will reduce fuel consumption in Region A. Figure 5 shows what combinations of $\beta_2$ and $c_{D2}$ that makes $dx_A/dm$ negative. If Region B is large compared to Region A, $\beta_2$ will be small. Thus, although $c_{D2}$ typically will be small when $\beta_2$ is small (because of the normalization), equation (22)-iii) shows that the sign of $dx_A/dm$ more likely will be positive when Region A is small compared to Region B. Thus, a small country facing a monopolist on the world market should not introduce fuel efficiency standards if it aims to reduce domestic consumption (given the simple model framework outlined above). The explanation is that the equilibrium price in a monopoly market with linear demand functions will always be above the crossing point of the old and new demand curve shown in Figure 1. As the small region has little influence on the price, consumption will increase.

\[ \frac{dP}{dx_A}_{dm>0} = \frac{\beta_2 \beta_2 c_{D2} + 2 \beta_2 c_{D2}^2 + 2 \beta_3 c_{D2}^2 + \beta_2 c_{D2} + \beta_2^2 c_{D2}^2 - 2 \beta_2^3}{2 \beta_2 c_{D2}^2 + 3 \beta_2 c_{D2} + \beta_2^3 c_{D2} + 2 \beta_2 c_{D2} + c_{D2}^2 + 2 \beta_2^2 c_{D2} - 2 \beta_2^3} \]

\[ (24) \]

\[ i) \quad \frac{dP}{dx_A}_{dA=0} = \frac{\beta_2^2 + \beta_2 c_{D2} + \beta_2^2 c_{D2}}{\beta_2^2 + 2 \beta_2 + \beta_2^2 c_{D2} + c_{D2}} > 0 \]

\[ ii) \quad \frac{dP}{dx_A}_{dA=0} = \frac{\beta_2 c_{D2}}{2 \beta_2 + c_{D2}} > 0 \]

\[ iii) \quad \frac{dP}{dx_A}_{dA=0} = \frac{\beta_2 \beta_2 c_{D2} + 2 \beta_2 c_{D2}^2 + 2 \beta_3 c_{D2}^2 + \beta_2 c_{D2} + \beta_2^2 c_{D2}^2}{2 \beta_2 c_{D2}^2 + 3 \beta_2 c_{D2} + \beta_2^3 c_{D2} + 2 \beta_2 c_{D2} + c_{D2}^2 + 2 \beta_2^2 c_{D2} - 2 \beta_2^3} \]

If the two regions are equally large ($\beta_2 = 1$), increased fuel efficiency will reduce oil consumption in Region A if and only if $c_{D2} < (1^{0.5} - 3) / 4 \approx 0.28$, cf. equation (22)-iii) and

---

22 Assume for instance that $c_{D2}$ is proportional by a factor $k$ to $\beta_2 / (1 + \beta_2)$, i.e., the steepness of the inverse aggregate demand curve. Then, for any $k > 0$ we can always find a $\beta_2^*$ so that $dx_A/dm > 0$ for all $\beta_2 < \beta_2^*$. 

---
Figure 5. We further see that consumption in Region A will always increase if $c_{D2} \geq 2$, irrespective of the size of $\beta_2$. Moreover, if Region B is small compared to Region A (i.e., $\beta_2 >> 1$), consumption will decrease in the latter region if the value of $c_{D2}$ is (sufficiently) below 2. In the limit, when $\beta_2 \to \infty$, this result is consistent with the findings in Section 2.

In the following discussion we will focus on the situations where the policy instruments lead to reduced oil consumption in Region A. We are interested in how the producer price of oil changes relative to the consumption reduction in Region A, i.e., equations (24). We know already that the fuel tax and the biofuel share will reduce the price, whereas fuel efficiency will increase the price. In Figure 6 we keep $\beta_2 = 1$, and vary $c_{D2}$. In Figure 7 we keep $c_{D2} = \beta_2 / (1 + \beta_2)$, and vary $\beta_2$.

< Insert Figure 6 >

Figure 6 shows that the price reduction will be consistently and significantly larger if a tax is imposed than if a biofuel share is imposed. By comparing equations (24) it can be shown that this holds more generally, unless $c_{D2} \geq 7$ and $\beta_2$ is sufficiently above one and sufficiently below $c_{D2}$. In other words, unless the marginal cost function is several times steeper than the aggregate demand curve (which we find highly unlikely), a fuel tax will lead to larger price reductions than a biofuel share. This is in line with the reasoning explained in Section 2. The figure further demonstrates that the steeper the monopolist’s marginal costs are, the more the price drops when consumption is reduced due to a fuel tax or a biofuel share, which sounds intuitively.

The figure also shows that the price effect is much bigger when fuel efficiency is enhanced, and can be very big relative to the consumption reduction when $c_{D2}$ approaches 0.28. This, however, is because the efficiency standard hardly reduces consumption when $c_{D2}$ is above 0.25.

Figure 7 illustrates that the price reduction under a tax or a biofuel share increases with the relative size of Region A. For instance, if Region A is two times bigger than Region B, the price reduction is 50-60 per cent higher than if the regions are equally big. Moreover, when Region A is very small compared to the rest of the world, we see that the price reduction is negligible. These results are not surprising, and follow the discussion above.
On the other hand, if fuel efficiency is increased, Region A must be at least three times bigger than Region B in order to achieve reduced consumption (assuming here the same steepness of marginal costs and aggregate demand). Again, the price increase relative to the consumption reduction can be very big, but decreases as we increase the relative size of Region A. This is because the policy instrument becomes more effective in reducing consumption when the region is large, and so the relative price increase falls.

In what way do these findings influence the optimal choice of policy instrument in Region A? As mentioned in Section 2, policy makers in the region may be concerned about both terms-of-trade effects and carbon leakage in Region B. The costs of the different policies obviously matter as well, but this is not the topic of this analysis (we also disregard distributional aspects here). The international (net) benefits \(d\Omega\) for Region A of policy instrument \(i\) can then be expressed as:

\[
\frac{d\Omega}{dx_A} = x_A \frac{dP}{dx_A} + \tau \frac{dx_B}{dx_A}
\]

where \(\tau\) denotes the shadow price of increased consumption abroad.

If carbon leakage is not important, we are left with \(x_A dP/dx_A\), which we have discussed above. But what if \(\tau > 0\)? Figures 8 and 9 correspond to Figures 6 and 7, and show how the international benefits depend on the relative sizes of the two regions as well as the steepness of the marginal cost curve relative to the aggregate demand curve. The shadow price \(\tau\) has been set to respectively 10\% or 100\% of the producer price in the figures.
The figures indicate that the fuel tax fares best when the shadow price of foreign emissions is not too high. Then the terms-of-trade benefits from reduced oil price dominate over the leakage effect. If Region A values foreign emissions very much, the biofuel share may come better out than the tax if the size of Region A is rather small.

Whereas the fuel tax and the biofuel share seem to give positive international benefits in most cases, increased fuel efficiency seems to give negative benefits. The shadow price of foreign consumption must be much higher than the price of oil before this policy instrument is the preferred one within our model framework.

How large are the net benefits shown in Figures 8 and 9 compared to the benefits of reduced domestic consumption (again we disregard the costs here)? The answer to this depends of course on the valuation of domestic reductions. If we for instance assume that Region A values domestic and foreign consumption reductions equally much (e.g., due to greenhouses gas emissions), the domestic benefits will be in the range 0.05-0.08 (10%) and 0.5-0.8 (100%) in Figure 8 and equal 0.067 (10%) and 0.67 (100%) in Figure 9. Thus, we see that the international (net) benefits are at least comparable with the domestic benefits, and possibly much more important (at least if the region is not too small).

### 3.2 Dominant firm with competitive fringe

As explained above, it is difficult to derive interpretable expressions similar to equations (22)-(24) in the case with a dominant firm and competitive fringe. Thus, in this subsection we will only present some numerical illustrations that show how the existence of the fringe can influence on the results discussed above. To simplify the comparison with the preceding subsection, we assume that $c_{F1} = c_{D1} = 0$.

In the figures below we have assumed that $c_{F2} = 2c_{D2}$, i.e., the fringe can produce half as much as the dominant firm at a given marginal cost level. In the market equilibrium, however, it will supply more than one third of the market, and possibly more than 50 per cent (depending on the values of $c_{D2}$ and $\beta_2$). The existence of the fringe increases the likelihood that increased fuel efficiency in Region A will reduce consumption in that region. On the other hand, it is now possible that the price of oil can fall.
Figures 10 and 11 correspond to Figures 6 and 8 above, i.e., $\beta_2 = 1$. First of all, we see that the existence of the fringe significantly changes the terms-of-trade effect for Region A if fuel efficiency is increased. If the marginal cost curves are rather flat, higher fuel efficiency will decrease the price of oil. The reason is that the fringe will react quite significantly to a change in the price. If the curves are steeper (but not too steep), we get the same qualitative result as in the monopoly case. In the tax case, we see that the price reduction is much smaller than in Figure 6 if the marginal cost curves are flat, which again is explained by the fringe’s responsiveness.

< Insert Figure 10 >

< Insert Figure 11 >

Figure 11 shows that if marginal costs are rather flat (and small), the different policy instruments fare quite similar. The reason is again that the fringe responds significantly to any price changes and hence the dominant firm has little room to manoeuvre. When marginal costs are steeper, the results are more similar to the ones in Figure 8. We notice, however, that the difference between the fuel tax and the biofuel share is much smaller when the fringe exists – this is because the price reduction under a tax is smaller than under a monopoly market.

4. Conclusions

This paper has shown that the effects of different policy measures to regulate the transport sector depend on the market structure in the oil market. If a policy instrument is introduced in a large scale, for instance as a part of an international climate treaty, its effect depends on the market power in the oil market. In a competitive market, a fuel tax as well as a biofuel share requirement will always reduce oil demand. A fuel efficiency standard on the other hand, will have ambiguous effects on oil demand as it lowers the price on mileage and therefore increases the demand for mileage, but also reduces the demand for oil for a certain level of transport services. We show that as long as the price elasticity of demand is above one in absolute value, increased fuel efficiency will increase oil consumption.
If there is a monopoly on the supply side in the oil market, the effects of transport regulations become even more ambiguous. While a fuel tax will reduce oil consumption as in a competitive market, a required share of biofuel may actually increase oil consumption with a monopoly if the inverse demand function is very convex. Fuel efficiency standards still have uncertain impacts on oil consumption as in a competitive market. Also in this case, the more convex the inverse demand function is, the more likely it is that oil consumption increases with increased fuel efficiency.

A regulating body may also care about the effects on the oil price. For instance, an oil importing country may worsen its \textit{terms of trade} if the oil price rises, while it will be the other way around for an oil exporting country. The effects on the oil price may also be important if an international climate treaty is in place. If not all countries have signed the treaty, a lower oil price may increase oil demand in non-signatory countries and lead to \textit{carbon leakages}. Thus, countries signing a carbon treaty may favor instruments that increase the oil price.

The price effects depend on the market setting. In a competitive market, the producer price always move in the same direction as the consumption, so a lower consumption level as with a fuel tax, also gives a lower producer price. With monopoly, the effects are more ambiguous and depend on the curvature of the inverse demand function and the cost function, and there is a possibility that a fuel tax increases the producer price of oil if the inverse demand function is sufficiently steep compared to the marginal cost function. With a biofuel requirement the producer price will decrease, even if we get higher consumption of oil, however, with a fuel efficiency standard the price of oil will always increase if oil consumption decreases, which is quite opposite to the effect with perfect competition. If oil consumption falls, the effects are more ambiguous.

In an open economy, with an oil producing region as well as an oil-importing region, we show that under reasonable assumptions, both taxes and biofuel shares will reduce oil consumption if they are introduced in the oil-importing region. Again, the effects of increased fuel efficiency is ambiguous. With monopoly on the production side, oil consumption in the importing region is more likely to increase if it is small compared to the exporting region. If there is a competitive fringe producing oil in the oil-importing region, the likelihood of reduced oil consumption is higher if fuel efficiency standards are introduced.
It is hard to make policy recommendations based on this analysis as policy makers’ preferences for the effects on their oil consumption and the producer price of oil may contrast. If we assume that the main objective of transport regulations is to reduce oil consumption, a fuel tax is the safest alternative, as it will always reduce oil consumption, also with market power on the supply side. Note however, that with a competitive market, the producer price will always move in the same direction as the consumption, so a lower oil consumption always go hand in hand with a lower the oil price. This may give preferred terms of trade effects for an oil importing country, but will induce carbon leakages effects and undermine attempts to reduce global carbon emissions.

With market power, the recommendations are more complex. If the policy makers are concerned about the terms of trade effects as an oil-importing nation, they should avoid fuel efficiency standards as the main policy instrument to reduce oil consumption. If the inverse demand function is not too convex, they should rather go for a fuel tax. Or alternatively, if the inverse demand function is quite convex, a biofuel standard is most advantageous with respect to terms of trade effects, but in this case the standard will not reduce oil consumption, which may contrast the main aim of the policy. On the other hand, if policy makers are more concerned about carbon leakage, the conclusions naturally become completely turned around.
References


Figure 1: Impacts of different policy instruments on the demand for oil
Figure 2: Impacts of carbon taxation in a monopoly market
Figure 3: Impacts of a required share of biofuels in a monopoly market for oil
Figure 4: Impacts of emission standards in the oil market

Price

Marginal costs

old demand function

new demand function
Figure 5: Combinations of $\beta_2$ and $c_{D2}$ that gives respectively increased and decreased domestic oil consumption when fuel efficiency is increased. Monopoly market.
Figure 6: Effects on the producer price of oil ($dP/dx_A$) under different policy instruments when $\beta_2 = 1$. Monopoly market.
Figure 7: Effects on the producer price of oil \((dP/dx_A)\) under different policy instruments when \(c_{D2} = \beta_2 / (1 + \beta_2)\). Monopoly market.
Figure 8: Effects on international (net) benefits ($d\Omega/dx_A$) under different policy instruments when $\beta_2 = 1$. Monopoly market.
Figure 9: Effects on international (net) benefits ($d\Omega/dx_A$) under different policy instruments when $c_{D2} = \beta_2 / (1 + \beta_2)$. Monopoly market.
Figure 10: Effects on the producer price of oil ($dP/dx_A$) under different policy instruments when $β_2 = 1$. Dominant firm model.
Figure 11: Effects on international (net) benefits ($d\Omega/dx_A$) under different policy instruments when $\beta_2 = 1$. Dominant firm model.
Appendix

Still to be written.