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Oil Dependence: Is Transport Running Out of Affordable Fuel?

SUMMARY AND CONCLUSIONS

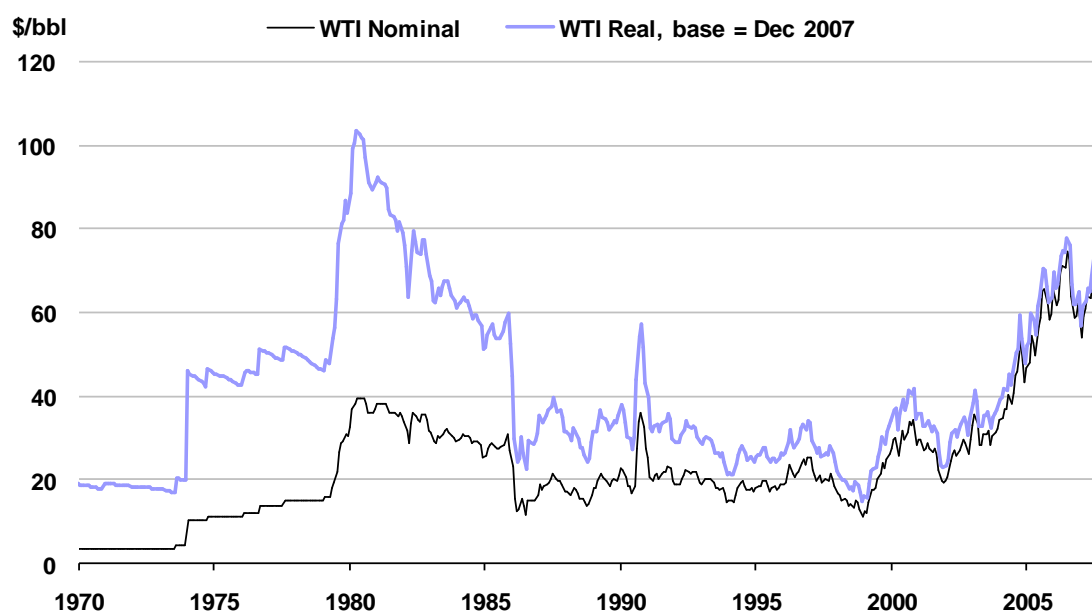
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Executive Summary

The transport sector's demand for oil is less price sensitive than any other part of the economy. This is partly because demand for transport services is relatively insensitive to price and partly because substitutes for oil in road transport are currently far from cost-effective. Evidence from the USA suggests that as incomes rise, transport sector oil demand becomes even less price sensitive. This implies that oil consumption is set to become increasingly concentrated in the transport sector. It also implies that relatively limited fluctuations in demand can have increasingly significant effects on oil prices.

Figure 1. **Spot crude oil price 1970-2007: real and nominal prices**



Notes: Price sources: Dow Jones for pre-Jan 1985 data, Platts monthly Cushing spot west Texas intermediate (WTI) crude from Jan 1985; Deflated taking December 2007 baseline and using monthly OECD consumer price index data.

Source: IEA.

Oil prices approached their historical 1980 peak in real terms in November 2007, when the Round Table convened (see Figure 1). Because of growth in incomes since 1980 and the reduced oil dependence of OECD economies, the economic impact of

high prices has been weaker than during earlier oil price peaks. Moreover, the current high prices are a result of strong economic growth rather than a supply shock as was the case in the oil crises of the 1970s. Nevertheless, the transport sector is the most exposed part of the economy to oil prices.

OPEC market power is expected to increase. OPEC, and particularly the Middle East, will see its share world oil supply increase because production of conventional oil from other parts of the world has either peaked and entered a phase of permanent decline or reached a plateau for the foreseeable future. OPEC will therefore be in a strong position to defend high prices against a background of rising demand, particularly from the emerging economies.

That is not to say prices will inevitably rise further or even stay at current levels. They could also fall substantially if economic growth weakens, particularly in the increasingly interdependent US and Chinese economies. Price instability is likely to persist. This creates uncertainties that delay major investments in new oil production and refining capacity, as well as in fuel efficient car technology.

In the longer term, non-conventional oil resources could supply a large part of oil demand at prices from around \$40 a barrel. The conventional view is that reserves of tar sands, oil shale and coal are sufficient to provide for decades of further growth in oil consumption but this was challenged by some round table participants who believe coal supply has already peaked. As non-conventional oil sources become more critical to world oil supply, a better understanding of their availability and the economics of production is increasingly important.

Policy responses to growing OPEC market power can seek to either promote non-conventional oil production in non-OPEC countries or reduce oil consumption. Policies to promote alternative fuels are also relevant but of limited short term potential as discussed in the conclusions of the JTRC Round Table on Biofuels: Linking Support to Performance (OECD/ITF 2007). Non-conventional sources of oil

are associated with more than twice the emissions of greenhouse gasses from conventional oil. Their development may therefore be constrained by climate policy.

Intervention to internalize the costs of CO₂ emissions from transport serves to both mitigate climate change and reduce oil consumption at the same time. Carbon taxes are the preferred instrument of many economists to achieve this because they provide incentives for attainment of the environmental target at least-cost. However, vehicle fuel efficiency or CO₂ emissions standards have some advantages, not least in terms of political acceptability. They are also able to correct the difference between social and private discount rates at the point of vehicle purchase. Differences between social and private discount rates, and imperfections in consumers' decisions on what fuel economy to buy, may justify standards even if taxes reflect external costs.

Standards are vulnerable to being undermined by the rebound effect – i.e. the cost savings resulting from increased fuel efficiency may be taken up by additional driving or upgrading of the power or weight of the vehicles purchased. There is considerable agreement that the rebound effect in terms of increased driving is small (around 20%, maybe smaller¹), so that standards do translate into substantial reductions in fuel consumption. To the extent that the rebound effect is a problem, it indicates a failure to price CO₂ emissions and other transport externalities correctly. This suggests that if a standard is the primary tool adopted for reducing transport sector CO₂ emissions a secondary tax element is required – ideally in the form of a carbon tax or alternatively through fuel taxes or differentiation of taxes on vehicle purchase or ownership. It also increases the urgency of introducing tools to manage congestion.

Transport, environment and oil security policies interact in a number of ways and there are trade-offs beyond the environmental impacts of developing non-

¹ US data suggests that with rising incomes price elasticities for private road passenger transport have declined. As a consequence, there has been a change in the way drivers respond to higher fuel prices, with the vehicle-kilometres driven less sensitive to the price of fuel than the fuel efficiency of vehicles.

conventional oil. Dieselisation of the car fleet, initially triggered by relatively low taxes on diesel fuels, has been the cornerstone of progress in Europe to reduce CO₂ emissions from the transport sector. As a consequence, the market share of diesel has grown strongly and has reached almost 70% of road transport fuels in the EU. But there are limits to the degree to which the refining process can switch production from one type of fuel to another without consuming large additional amounts of energy to convert oil products. The excess diesel demand in Europe is currently met through trade, with diesel imported from Russia and the USA and gasoline exported from Europe to America. If any other major car market were to follow the dieselization path, diesel prices would rise sharply and CO₂ emissions would increase.

Two important issues arise when the energy security and greenhouse gas emissions from transport are viewed from a broader perspective. First, there is the question of how to distribute greenhouse gas abatement efforts among different sectors. Cost-effective CO₂ abatement strategies should aim to distribute efforts over sectors efficiently. The challenge is to minimize simultaneously CO₂ abatement costs, potential losses in the competitiveness of industry and the costs of energy import dependence. In this sense, the large share of transport in total CO₂ emissions in itself provides little guidance on how large this sector's contribution should be, although it needs to be recognised that the political process very likely will request a substantial contribution from transport to cutting overall emissions.

Second, intervention to reduce greenhouse gas emissions from the transport sector needs to be integrated with policies to reduce the other external costs of transport – local air pollutants, accidents and especially congestion. Congestion costs greatly outweigh the cost of CO₂ emissions from transport according to most studies. The large impact on CO₂ emissions (-20%) of congestion charges in London and Stockholm suggests that congestion management can facilitate the attainment of CO₂ reduction targets in congested areas.

1. Introduction

Crude oil prices were nearly 100 dollars a barrel when the Round Table convened in November 2007. In real dollar values, this matched the historic peak in oil prices of 1980 (Figure 1). The gradual rise in oil prices to these levels over the last five years was driven fundamentally by growing demand, especially from China, in combination with limited elasticities of supply. Whilst the outlook for supply and demand suggests prices are likely to remain high in the next five years, any slowdown in world trade and economic growth would result in a fall in oil prices, and probably a large fall. Whether prices rise or fall, they are expected to continue to be characterized by sharp spikes and troughs.

The Round Table examined the factors that drive oil prices and those likely to be most important over the next 25 years. It then reviewed recent evidence on the response of road transport activity to changes in fuel prices in order to explore linkages between transport and energy policies. The Round Table also examined the outlook for oil supply, together with the implications for climate policy if very heavy crude oils, tar sands, oil shales or coal-to-liquid fuels are developed on a large scale. Discussions then turned to potential policy responses, on the supply side and on the demand side, revealing some critical trade-offs between climate change and oil security policies. If these interactions are ignored, energy policies in the transport sector could result in large unnecessary costs.

2. Oil Prices Drivers 1960 to 2007

The impact on oil prices of action by the Organization of Petroleum Exporting Countries (OPEC) to restrict oil supplies in 1973 and 1979 is obvious in Figure 1. The motivation for restricting supply was in both cases political (the Yom Kippur War and the Iranian revolution) rather than aimed at maximizing profits² but coincided with peaking of US oil production, which endowed OPEC with market power to control

² Although the 1973 Arab-Israeli War and subsequent oil embargo was preceded by re-negotiations of oil concessions and nationalisations of oil companies in the Middle East and Africa and by OPEC coordinating oil production tax and price increases in response to a weak dollar.

prices. OPEC subsequently used this power to defend high oil prices by setting production quotas for its members. Although oil producers in the USA were unable to expand supply, the high prices did drive exploration and rapid development of oil fields in other non-OPEC countries. This gradually eroded OPEC market power until the point in 1985/6 when prices collapsed.

This price collapse stranded high-cost investments made by the major oil companies. The effects are still felt today, with a strong aversion to (over-) investing in oil production, oil refining and fuel efficiency on the part of private oil companies and car manufacturers. The consequence is that supply is not very elastic, even with strongly rising demand. And uncertainty over future prices, as well as rising resource costs for extraction and refining, further discourages major investments.

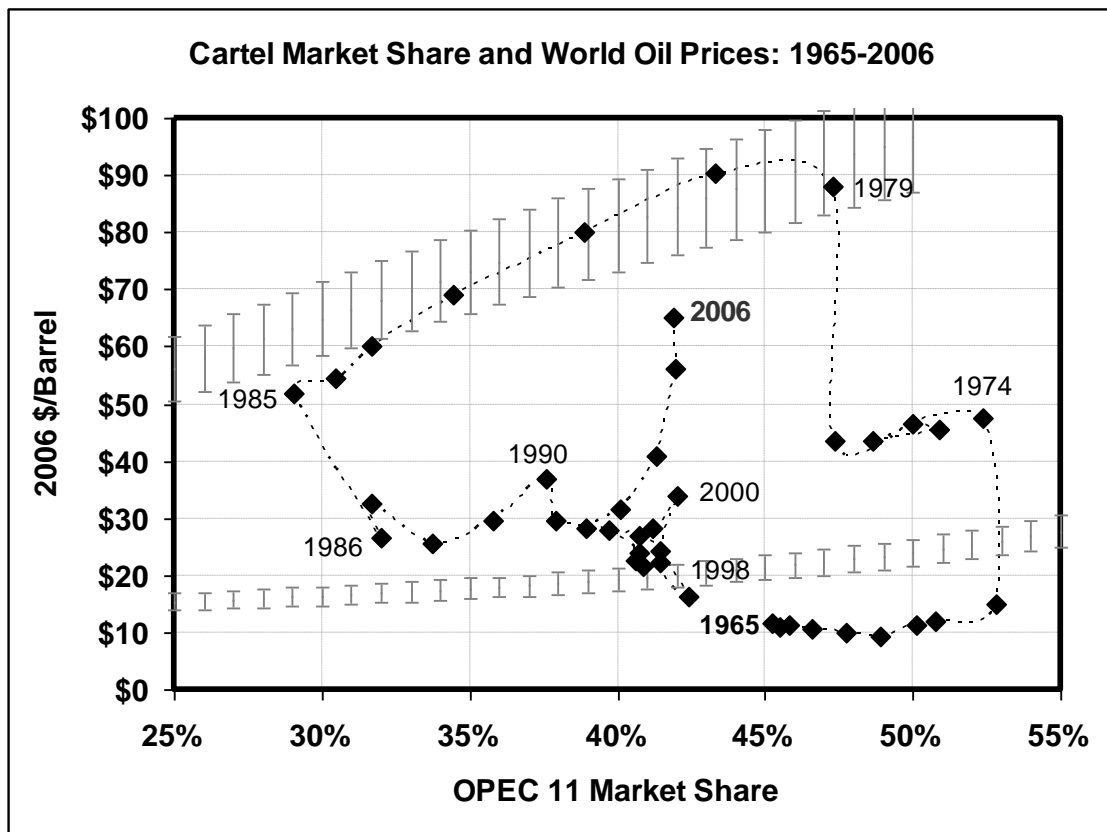
Even during periods of market dominance, OPEC decisions on production targets have sometimes resulted in sharp falls in prices, underlining the uncertainties in the market. The net effect is to increase upward pressure on oil prices.

David Greene traces these developments in price and market power in his report for the Round Table (Greene, 2007), summarized in Figure 2. The graph plots upper and lower bounds for oil prices, assuming OPEC seeks to maximize profit, as a function of short and long run oil price elasticities and as a function of conditions of supply outside OPEC. The maximum price band is calculated on the basis of short run price elasticities for oil demand, i.e. the potential for rapid oil substitution and demand reduction in response to price increases, and short run elasticities for oil supply from the rest of the world. The lower band is based on the larger, long-run elasticities of demand and supply. These account for changes that take time to affect the market, such as the introduction of more fuel efficient vehicles or oil substitution in other industries.

It should be underlined that the upper limit band is rather wide because short run supply and demand elasticities are not easily calculated. It should also be noted that

the band indicates a range for price trends and not an absolute limit. In particular, given that the underlying model is deterministic, prices can substantially overshoot these bounds for short periods.

Figure 2. **World Oil Prices Since 1965 in the Context of OPEC's Long- and Short-run Profit-Maximizing Price Functions**



Source: Greene 2007.

Nevertheless, Figure 2 suggests a strong positive relation between OPEC market power and prices. Plotting historical prices on this framework reveals that until 1973 oil prices were below the lower bound. In 1979, OPEC raised prices to the level of the upper band and had sufficient market power to defend prices in this band through 1985. The cartel was able to increase profits by cutting output until a point where their market share fell below 30% of world oil supply. At this point longer term demand and supply responses started to be felt, discipline broke down in the cartel,

production quotas were exceeded and the oil price collapsed, falling close to the lower bound of the model. OPEC nevertheless continued to control the bulk of low-cost oil production capacity and gradually recovered market share.

What does the analysis tell us about more recent history, and about the near future? Production of conventional oil in non-OPEC countries is not expected to expand rapidly in response to current high oil prices. Some analysts foresee continuous decline and most expect a prolonged plateau in overall production levels. Extraction rates from existing oil fields cannot be accelerated beyond the limits imposed by the physical characteristics of each reservoir and the development of new sources is uncertain and slow. The bottom line is that in the near future the Middle East is expected to produce a rising share of world oil supply, which will tend to increase OPEC's market power.

In terms of Figure 2, current oil prices and OPEC market share are close to conditions that prevailed in the second oil shock. With a tendency for both oil demand and the cartel's market share to increase, OPEC is likely to be able to defend prices and maintain large economic rents for several years, until longer term responses begin to be felt.

3. Oil Price Volatility and Cyclical Effects

In addition to the overall supply and demand balance and OPEC production rates, a large number of other factors can have a significant influence crude oil and oil product prices in the short term. On the supply side these include wars, political unrest, strikes, storms and hurricanes, accidents and unexpected maintenance. Refining is vulnerable to a similar set of problems. Crude oil and oil product stocks provide a buffer between supply and demand but stock changes can also have a strong influence on prices. On the demand side the most significant factors are colder or milder than average winter heating periods and economic downturns. Both crude and products are traded on international exchanges that have developed forward contracts to manage the price risks. Interaction between contract, spot and

forward markets, between crude and product markets and between different types of trader increases the complexity of price behaviour.

At the time the Round Table took place crude oil prices on the spot market were higher than on futures markets. This had been the situation for some weeks, with forward prices falling the further into the future the date for settlement, despite a general expectation that oil supplies would remain tight. With this configuration of prices³ there is pressure for traders to sell on the spot market and buy on the futures market until prices even out. However, the gains to be made this way have to be assessed against supply security, oil quality and timing of delivery risks. Refiners, which are an important part of the market, can only sell part of their inventory as they need to hold stocks for refining. The size of the gap between spot and futures prices is sometimes taken as a measure of the tightness of supply, but the situation is unstable and eventually there is a readjustment of prices, often a sharp fall in spot prices.

Although oil product prices are dependent on the price of crude oil they are also subject to trading pressures of their own. At the time of the Round Table oil refiners and distributors held sufficient stocks of products that competition between them to supply the end user markets coupled with a fear that further price increases would suppress demand prevented them fully passing on increases in the cost of crude oil to consumers. This ended a five-year run of unusually high refining margins and is now expected to squeeze investment in new refining capacity.

Cuts in refinery investment will affect the supply and price of products in the future. This lagged effect is characteristic of both refining and crude oil production, driving cycles of over and under supply. Cycles initiated by the oil crises of the 1970s and the subsequent oil price collapse of 1985-86 continue to have an influence on markets today.

³ Known as “backwardisation”.

4. The Short Run Oil Price Outlook

There are a very large number of factors that drive oil prices in the short term but their impact depends ultimately on the fundamental balance between supply and demand. Sustained expansion of global economic activity is the underlying reason oil prices have risen to current levels, with consequent demand for oil expanding ahead of supply. Continued strong demand, particularly from China, is expected to maintain these oil market conditions for some time. China's economy is vulnerable, however, to any slowdown in demand for its exports. The difficulties in financial markets that began with the sub-prime mortgage crisis in the USA in 2007 illustrates the downside risks; China's industry Minister has warned of the potential for a sharp downturn in Chinese output as a result. (Financial Times, 16 October 2007).

Above ground constraints currently play a greater role in determining oil supply and prices than the long term dynamics of oil reserves, exploration and production. The most important is cost escalation in the oil services industry (drilling, oilfield development and pipeline construction) due to shortages of skilled labour and increases in the costs of raw materials.

Social and political tensions have depressed production in a number of regions, notably Nigeria and Venezuela, and war in Iraq has taken a large part of that country's potential output out of commission. In the medium term, output from these regions is expected to be restored, albeit under arrangements that allow for profit maximizing under OPEC coordination. More generally, it was noted that oil production concession agreements that provide lower rents (after adjusting for production costs) than in OPEC and other countries are inherently unstable, leading to renegotiation and eventually adjustment of the agreements.

Changes in the taxation of oil field development and production also have an impact. This concerns not only renegotiation of concession conditions in countries like Venezuela but also OECD countries where, for example, tax changes in the UK sector of the North Sea have depressed exploration and development activity.

The refining investment cycle mentioned already above could also affect prices for transport fuels over the coming five years. The oil majors lost large amounts of money in refining in the period 1996 to 2003 and as a result cut investment. The consequence was a shortage of capacity in the period 2004 to 2007 that helped drive up prices. New capacity is now coming on stream, particularly in the Middle East and India. More generally there has been investment in converting heavy fuel oil into diesel and other higher value products. This could result in over-supply of the market and falling prices in the medium term, although opinions are divided as to how likely this is.

5. Long Term Oil Supply Outlook

Kjell Aleklett's paper for the Round Table examines the production history of oil fields around the world stressing the inevitable eventual decline in output from all fields. Aleklett's paper also makes the important point that there are physical limits to the rate at which petroleum can be extracted from oil fields, determined by the characteristics of the reservoir and the oil. This limits the rate at which extraction from fields already in production can be increased in response to increasing demand or in response to supply disruptions. Based on work at Uppsala and Reading Universities, which models oil field development field by field around the world, the paper suggests non-OPEC production is already in irreversible decline and that the peak in production of conventional oil globally will arrive in only a few years, with an irreversible decline setting in thereafter.

This contrasts to analyses by the US Energy Information Administration (EIA) and the International Energy Agency (IEA), which foresee a prolonged plateau in non-OPEC production levels and do not rule out increases in production from new fields and as a result of technological innovation. With strong growth in oil demand, either a decline or a plateau in non-OPEC production indicates increasing market power for OPEC in the future.

Views on potential production in the Middle East diverge sharply, largely because data on reserves in the region are poor. The Association for Peak Oil foresees an imminent peak and Aleklett's paper incorporates new data from Saudi Arabia reinforcing this view. The view is supported by a number of other analyses, reviewed in Boyle and Bentley 2007 contrasting with the conventional view that the peak is far enough away, or that sufficient non-conventional oil reserves can be developed at prices above \$40/bbl, to ensure oil-based energy for transport for the foreseeable future.

The models on which the peak oil analyses are based are no more uncertain, and rather less complex, than models of climate change and merit similarly serious consideration. One implication for climate policy is that the rate at which fossil fuels are burnt and the rate at which the stock of carbon dioxide in the atmosphere increases in the near term may merit more attention than the total accumulation of carbon dioxide over the very long term.

Aleklett sees most scenarios for the growth of oil supply, including those employed by the IEA and the Inter-governmental Panel on Climate Change (IPCC), as over-optimistic, and there was some support for the view that they tell us more about where demand "would like to go" than where supply will be able to meet demand.

6. Non-Conventional Oil

Oil can be produced profitably at current prices from a range of unconventional sources. The Orinoco Belt in Venezuela is estimated to contain 230 to 300 billion barrels of very heavy crude oil. This is around the size of Saudi Arabia's oil reserves. Canada holds a similar amount of very heavy oil in its tar sand deposits in Alberta. Both deposits are already in production and profitable at prices above \$40/bbl. Extraction is expanding rapidly, and the main constraints are environmental, not technological. Canada produced 1M bbl/day in 2005 and expects to produce 2M bbl/day in 2010. The USA, Russia and the Middle East also have large tar sand deposits.

Oil shales hold even larger quantities of potentially recoverable oil, estimated at around 3000 billion barrels. There are deposits in many countries with large quantities located in the USA, Russia and Brazil. Oil shale is used to fire power generation in a number of countries. It would probably be profitable to produce oil from shale at current prices with currently available technology. Costs would fall substantially with expansion of production.

Coal has been converted to oil by SASOL in South Africa since 1955 and China is currently building two South African designed plants. There are large coal deposits in a wide range of countries around the world⁴, with the USA holding the largest reserves. 2007 saw several bills presented to the US Congress for subsidies to finance coal to liquid fuel plants. Operating costs for such plants are covered at oil prices above \$40/bbl.

If these non-conventional sources hold the promise of very large quantities of oil to be produced at today's prices they pose serious environmental challenges. Extraction and processing into refinery grade oil requires a lot of extra energy, resulting in more than twice the CO₂ emissions associated with conventional oil (Greene 2007). Because of this, the potential of using nuclear power to provide process energy is being considered for Canadian tar sands. Stripping the forest and soil cover overlying the Canadian tar sands deposits also releases large amounts of greenhouse gases. Production of shale and coal requires large amounts of water, and many of the potential mines are in areas with water resources under stress.

Carbon capture and storage might be employed to reduce the CO₂ emissions associated with tar sand and shale oil production to levels closer to conventional oil but it is as yet an unproven technology. It is difficult to envisage a large scale retrofit programme in Venezuela and Canada if it were to prove viable. Coal-to-liquid fuel

⁴ Though Aleklett believes that coal production, like oil, has peaked.

production is somewhat more suited to carbon capture as the Fischer-Tropsch process employed produces a very pure waste stream of carbon dioxide.

Aleklett argues (Aleklett 2007b) that applying a peak-oil type analysis to coal and non-conventional oil reserves demonstrates that there are insufficient hydrocarbon resources to produce the CO₂ necessary to increase concentrations in the atmosphere to the levels envisaged by the Inter-Governmental Panel on Climate Change (IPCC). The majority of participants at the Round Table, however, viewed greenhouse gas emissions rather than oil supply shortages as the key long term issue for oil demand from the transport sector. At the same time, as governments begin to develop policies to guard against catastrophic climate change despite large uncertainties in climate modeling, the precautionary principle suggests they might give similar consideration to peak-oil arguments despite uncertainty over the extent of their conservative bias.

7. Does a Price of \$100 a Barrel of Oil Matter

Oil price shocks destroy demand for oil and have repercussions for activity across the economy. They reduce economic activity to the extent that short run substitution and efficiency responses are unable to prevent the cost of production of goods and transport services rising to levels that exceed the willingness of consumers to pay for them. This reduces economic output and results in business failures and unemployment.

In the 1970s, OECD economies were highly vulnerable to external shocks because of widespread government intervention in prices and rigidities in labour and financial markets. Growing inflation meant a sharp downward adjustment was probably inevitable, and this was precipitated by the 1973 oil embargo. Many of the immediate responses of OECD governments exacerbated the crisis: additional price controls on domestic oil production in the USA; restrictions on domestic oil production to preserve resources in Canada.

Today, OECD economies are much less oil intensive and exhibit fewer rigidities. OECD economies are not exposed to inflation (although it is rising) and markets are much freer to adjust to changes in energy prices. The countries where oil prices are determined by governments rather than markets lie in the Middle East and Asia, including China, with artificially low prices one of the factors contributing to strong growth in oil demand in these developing economies. More generally, incomes have increased substantially in most parts of the world and energy costs account for a smaller part of disposable income. Most of the world's economy is therefore much more resilient to price shocks than it was in the 1970s.

The current low level of the dollar against other major currencies is also significant, as oil prices are quoted in dollars throughout the world. The dollar was trading at 0.68 euros in November 2007 compared to 0.99 euros in January 2000, i.e. one third lower. The price for crude oil in euros is thus only two thirds what it might have been if dollar parity had been maintained over the period of steady oil price increases since 2000. Though the yen/dollar exchange rate has only moved 8% since 2000, compared to 1973 the Japanese yen is now worth three times what it was in dollars.

For all these reasons the economic impact of \$100/bbl oil is much less than it was in 1979. That said, some economies will feel the effects of today's high oil prices more than others will. US consumers have experienced a bigger impact on prices, especially for transport fuels, because oil is priced in dollars and because excise taxes are a relatively small part of prices at the pump compared to most other OECD countries.

If high oil prices eventually contribute to an economic slowdown in the USA, imports from China will fall. China's growth is highly dependent on its exports, and the USA accounts for the largest part of its trade by volume, although the weak dollar has put Europe in first place in trade by value (Financial Times 10.12.2007). China is also exposed to high international oil prices because the government controls domestic oil product prices at levels currently below cost. It will be forced to pay refiners large

sums in compensation so long as prices stay high. This combination of factors could contribute to falling prices in the next few years.

8. Transport Sector Responses to Changes in Oil Prices

Transport is the one sector of the economy where substitution with other fuels has been negligible. Consumer responses to changes in fuel prices are often measured through elasticities. There is considerable agreement that the price elasticity of fuel demand is fairly low, meaning that prices have no big impact on demand – but “no big impact” is different from “no impact”. The long run elasticity of fuel demand has historically been in the range of -0.4 to -0.6. Since the absolute value of the elasticity is below one, fuel consumption declines when prices rise but expenditures increase. The resulting shifts in allocation of expenditure to travel from other goods and services depress consumption in other parts of the economy, and result in a transfer of wealth to domestic and foreign oil producers.

Higher fuel prices affect fuel demand through two main channels. First, consumers respond by driving less. Second, they invest more in fuel economy, i.e. in more fuel efficient vehicles. Recent evidence for the US (Small and Van Dender, 2007) suggests that the relative importance of those two effects has changed as incomes increased: the responsiveness in terms of reduced driving has become substantially smaller, so that a bigger share of the total response comes through improved fuel economy.

Note that smaller responses in terms of driving imply a more limited overall fuel price elasticity of demand, around -0.24 instead of -0.36 for the US in 2000-2004; and price effects are counteracted by the income effect, which implies growing consumption as incomes rise.

It should be emphasized that elasticities of demand refer to consumer prices of fuel. Gasoline and diesel are taxed at much higher rates than oil products for use in other sectors, especially in Europe and Japan. Prices for gasoline after tax currently equate to over \$300/bbl in many European countries. The higher consumer prices in

Europe and Japan are one reason why elasticities in these parts of the world may be higher than those in the US. Another reason is that more European and Japanese drivers have access to alternative transport modes than US drivers. Slightly lower real incomes contribute to higher elasticities as well. On the other hand, more US households have access to several vehicles, providing the opportunity to switch to a more fuel efficient vehicle when oil prices are high. Although differences in elasticities between the US and Europe or Japan are likely to be small, it will not be entirely clear that the finding of declining elasticities in the US is transferable to other countries without empirical studies in those countries.

Freight transport is less affected by oil price increases than private car use as fuel accounts for only a small part of the total cost of producing most goods. Salaries, vehicles and tax are larger items of expenditure than fuel for transport companies. In France it is estimated that the cost of crude oil would have to increase eight fold to double the cost of road freight transport (Chevroulet 2007). The difficulty for freight transport companies is primarily the delay in passing on fuel costs to clients in periods when prices rise rapidly; contracts cover extended periods and do not always provide for fuel costs to be passed on until renegotiation of the contract itself.

9. Motivating Transport Policies – Market Failures

Transport generates a range of social costs that are not taken into account by consumers or firms when they decide on how much and what kind of transport to use. Such external costs sometimes justify policy intervention because market outcomes are less than optimal. The main external costs are related to accidents, climate change, congestion and local air pollution. Some of these costs (e.g. congestion) are fairly well understood and relatively accurately measured. Others, notably the costs of climate change, are poorly understood and their measurement continues to generate controversy.⁵

⁵ The consequences of climate change are at best understood in a probabilistic sense. In addition, since some of the more catastrophic consequences are likely to take place in the far future, there is the problem of converting these costs to present values. Such conversion inevitably requires judgments on intergenerational equity, and it was pointed

Debate at the Round Table highlighted the substantial uncertainty about the future availability of oil and the prices at which it will be sold. Part of the price uncertainty relates to OPEC's market power. But are uncertainty and import-dependency a basis for government intervention in energy or transport markets?

Uncertainty is pervasive throughout the economy, and not in itself a source of market failure. As long as both firms and consumers make decisions on the best available information markets respond optimally to uncertainty. Despite large uncertainties, oil companies do invest in exploration and production and in refinery capacity. The clearest rationale for government intervention is thus ensuring high quality information is widely available.⁶

Oil dependency is primarily an issue of market power. Concentration of oil production in the hands of a cartel that explicitly aims to control prices is a clear case of market failure. Despite government and private sector efforts to diversify sources of oil supply, concentration of market power in the Middle East is expected to grow rather than diminish.

There is also an externality dimension to oil dependence. The USA is a very large consumer and importer of oil so probably enjoys a degree of monopsony power on the world oil market; lower US demand reduces world prices. Individual US consumers ignore this effect when deciding on their purchases of oil and of vehicles and other oil consuming equipment. This potential monopsony effect is therefore external to the market. Without government intervention its potential benefits will be foregone.

out that the well-known Stern report implies substantial sacrifices by current generations to improve the welfare of more wealthy future generations.

⁶ While the private sector produces large amounts of oil market information on a commercial basis, the data and analysis of the IEA and of national administrations, such as the EIA in the USA, is essential in providing a complete and authoritative picture; the

Another dimension to oil import dependency is the transfer of resources from importing to exporting countries. In strict economic terms transfers are not of particular concern because oil revenues will eventually be recycled to the oil importing countries through purchases of goods and services and through investment. But with high oil prices the transfers are very large, politically highly visible and they can create large temporary imbalances.

Policies to reduce market power through oil substitution and fuel efficiency are the most relevant responses to oil dependency although it would be possible to transfer some of the economic rent from oil production to the importing countries through additional taxes on oil product consumption, albeit at the risk of pushing prices even higher.

10. Policy Instruments

Fuel excise duty and carbon tax

Excise duty on transport fuels is widely used in OECD countries as a reliable source of government income because of the relatively low price elasticities of demand. The overall effect on oil prices of simultaneous attempts by OPEC to maximise its profits and by oil importing countries to increase fuel taxes is not easy to predict. It is conceivable that higher fuel taxes in the USA would increase welfare if accompanied by reductions in taxes on labour and capital. In addition, such tax increases would reduce some of the rent from oil production accruing to oil exporting countries, because reduced consumption in the USA eases pressure on world prices. Note that at present the reverse situation applies. Fuel excise taxes have been stable in nominal terms in the US and many other OECD countries for the last 5-10 years, eroding their value in real terms.

A number of governments have responded to oil price increases with small cuts in fuel excise tax. The potential to shield consumers in this way is, however, limited by

work of university researchers on peak oil has been invaluable in improving the understanding of data on oil reserves reported by oil companies.

the size and the duration of the impact on government finance. It is also counterproductive as it reduces incentives for fuel conservation and dampens consumer response to oil price increases. Not only does this interfere with the response but it also reduces the price elasticity operating on the oil exporting countries and thus increases their market power.

Governments are not likely to increase fuel taxes when oil prices are rising as this would exacerbate the short run impacts of high oil prices. It might, however, be possible to increase excise taxes when prices fall.

A tax on carbon would have a very similar effect to fuel excise duty in transport markets, as non-carbon based fuels are not likely to gain a large market share soon. The main difference is that a carbon tax would apply equally to all sectors of the economy whereas current taxes on oil products differ enormously between sectors. For example, domestic heating oil is normally taxed at very low rates in comparison to auto diesel, which is a very similar product, just put to a different use. Tax subsidies for diesel compared to gasoline would also disappear, as on a volumetric basis diesel would attract a slightly higher carbon tax than gasoline.

A pigouvian carbon tax to internalise the social costs of CO₂ emissions, applicable at the same rate to all sectors of the economy and applied in a large number of countries, would be the most efficient policy response to the threat of climate change. Setting the rate for such a tax is a political exercise because of the very real uncertainties in estimating the costs of climate change through its physical impacts on sea level and the weather and consequent effects on crop production, river flows, ecosystems, health and the frequency and intensity of natural disasters related to the weather. Proxies have been calculated from the expected costs of expenditures to reduce emissions to rates that would stabilise the accumulation of CO₂ in the atmosphere at a level believed sufficient to avoid catastrophic climate change. The most influential recent report on climate policy, the Stern Report (Stern 2006), estimated total damage costs from future warming at 5—20% of world GDP in

perpetuity and recommends a current social cost equivalent to \$311 per ton of carbon (Euros 60 per ton of CO₂) according to calculations by Resources for the Future (Harrington et al 2006). This is much larger than some other values frequently employed, such as the average level of trading for carbon permits in the second session of the European Trading System (around Euro 20 per ton)⁷ but it is still much lower than the level of fuel excise tax in any European country. For example, UK fuel excise duty, at the top of the range in Europe, of Euros 0.70 per litre equates to Euros 304/ton CO₂ for gasoline and Euros 270/ton CO₂ for diesel; French excise duty on gasoline of Euros 0.60 per litre equates to Euros 259/ton CO₂ and excise duty on diesel of Euros 0.43 per litre equates to Euros 163/ton CO₂.

This begs the question of what fuel excise duties are for. In the USA federal fuel duties are earmarked for the Highway Trust Fund, which finances road and transit projects, and which sees real revenues declining because of falling real gas taxes. Fuel taxes are not hypothecated in most other countries, but instead contribute to general revenue. As long as sophisticated road-pricing systems are the exception rather than the rule, a reasonable system of road charges would see the fixed costs of road provision covered from general revenue⁸ and the variable costs of road use paid through variable charges, such as fuel tax. The variable costs include road maintenance (as far as related to use and not the weather) and the external costs of greenhouse gas emissions, local air pollution, accidents and congestion⁹. In high fuel excise tax countries such as the UK research has estimated that charges currently roughly balance costs, even if there are mismatches in their differentiation by type of vehicle, location and time of use (Sansom 2001). Parry and Small (2005) found UK

⁷ Note the price is determined by the amount of carbon allowed to be emitted by the participants in the scheme, currently determined largely on the basis of what they emitted prior to the scheme. Such “grandfathering” of emissions rights weakens the effectiveness of the system to cut emissions and illustrates the artificial nature of the price of carbon that results. The EU plans to reduce the cap on the amount of carbon traded in the system, which will force the price up.

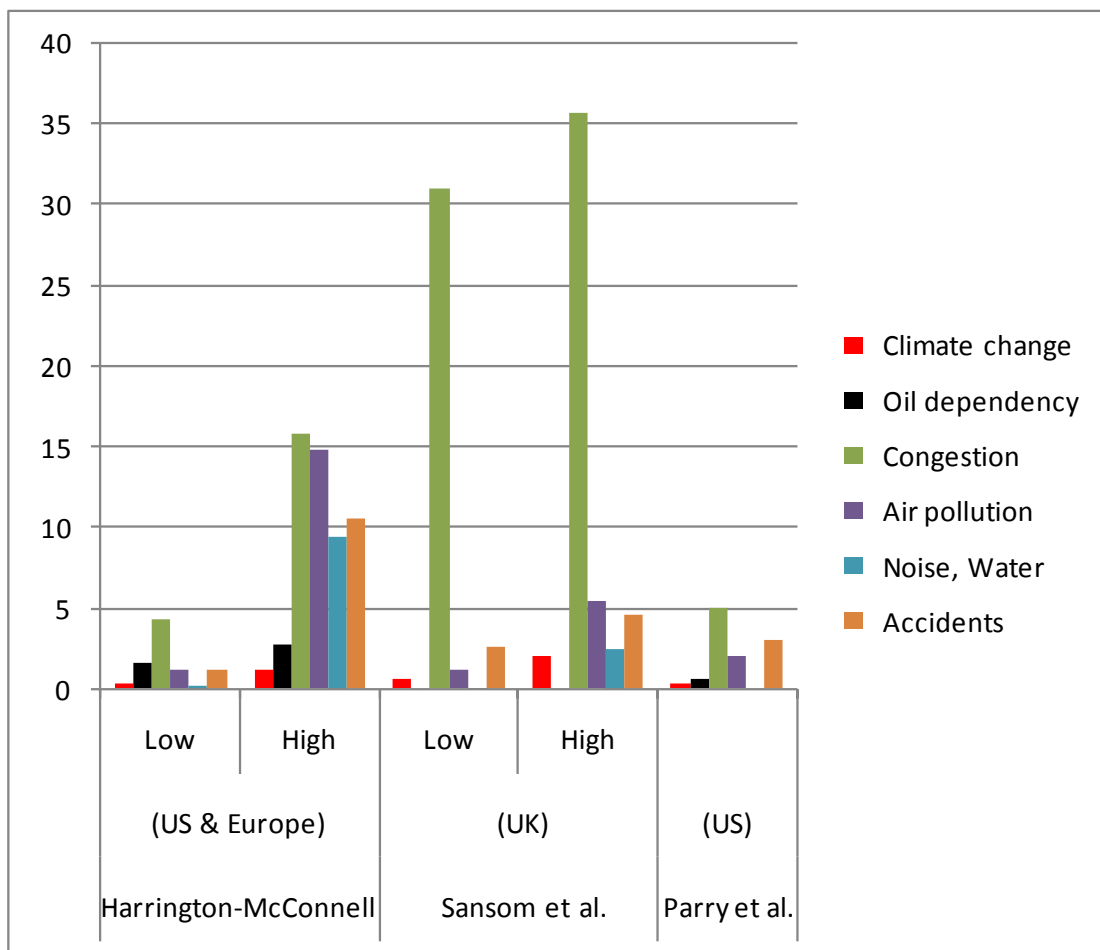
⁸ Or possibly from fixed transport charges, such as annual circulation taxes.

⁹ Though fuel tax is not the best targeted instrument for some of these costs.

fuel taxes to be too high and those in the US too low, taking this “second-best” approach to relating fuel taxes to external costs.

At the same time, most studies of the external costs of road use find CO₂ emissions to be small relative to other types of externality, especially congestion (Figures 3 and 4). This is not to say that the cost of climate change is not large, rather there are other more pressing market failures in transport.

Figure 3. **CO₂ Relative to Other External Costs**
(US cents/mile)



Source: Small and Van Dender (2007).

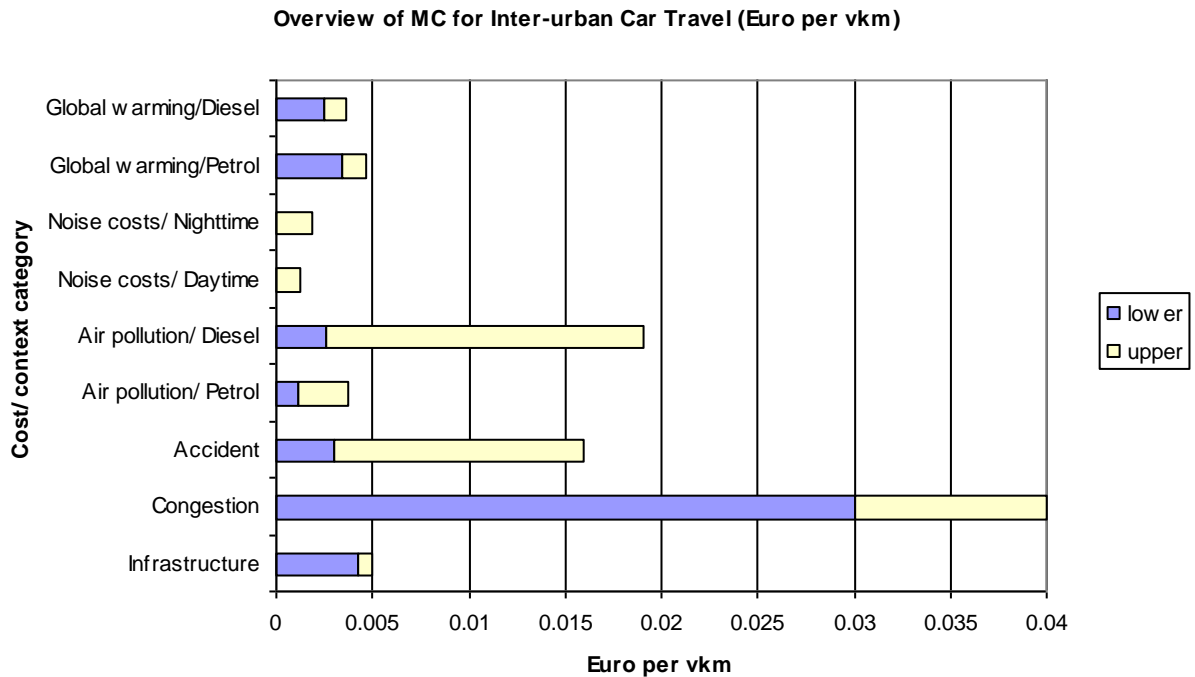
Taxes on transport fuels can perform three functions:

- The Pigouvian objective of internalising external costs;

- The Ramsey objective of providing public revenues in the least allocatively distorting manner. Since fuel taxes are changed in a context of pre-existing taxes, the relevant concern here is how the change exacerbates or relieves the allocational distortions of these pre-existing taxes. Labour taxes are particularly distorting, so the issue becomes whether higher fuel taxes lead to higher or lower real wages, and this depends as much on how revenues are used as on the tax change itself.
- A distributional objective by attempting to transfer rents from governments in oil exporting countries to governments in net oil importing countries.

If a fuel excise duty were to be employed to achieve all three objectives, how should its rate be set? In general, this depends on the weights given to the various functions, which in turn reflects policy objectives. When government cares strongly about revenues, high fuel taxes seem justified to the extent they offset increases in labour taxes. This may reflect European practice.

Figure 4



Source: Nash (2003).

Vehicle efficiency regulations

In relation to oil import dependency it is not clear from the discussion above that taxation is an appropriate instrument to address either market power or the external benefits of reducing fuel consumption. Alternative policies to promote fuel efficiency are indicated, primarily fuel efficiency regulations.

Intervention to promote fuel efficiency is frequently argued for on the basis that consumers undervalue fuel savings when they purchase cars (and other equipment) because they employ higher discount rates than socially optimal (their planning horizon is shorter than that of the government). Consumers make decisions on how much fuel economy to buy in a context of combined uncertainty and risk aversion. This leads to lower fuel economy compared to a risk-neutral environment but is not in itself a market failure if we assume consumers are adequately informed of the cost of running a car (and there is a wealth of car magazines available to inform car buyers

on this point). However, there is a case for government intervention effectively to substitute a social discount rate for the shorter, typical private discount rates applied by consumers in making decisions on car purchase.

Regulatory emissions limits have been employed fairly successfully to address local air pollution externalities. They can also be employed in the case of CO₂ emissions and equivalent regulations were introduced in response to the oil price rises of the 1970s in the USA as Corporate Average Fuel Efficiency (CAFE) regulations.

Compared to a pure carbon tax, regulations have the drawback that they are sector specific and tend to favour one technology over another according to the level at which they are set and the way in which they are measured. Regulations have to be designed carefully to avoid perverse effects. For example, differentiating CO₂ emissions standards according to vehicle class or weight in an attempt to avoid one manufacturer facing higher costs than another can provide perverse incentives that favour high emission vehicles. This was the case with the US CAFE regulations in force until 2007, where weaker standards for light trucks were instrumental in stimulating a shift in demand from conventional cars to SUVs. Curvilinear rather than stepwise differentiation can reduce the problem, but can still reduce incentives for cutting emissions through weight reduction – where there is a large, relatively low cost potential for savings (see Plotkin 2007 and OECD/ITF 2008 for a more detailed discussion). Differentiation according to vehicle “footprint” (wheelbase x axle width) is a somewhat less distorting approach because there are larger costs for manufacturers associated with changing wheelbase. Allowing weight to increase can actually cut costs. Other constraints also make it difficult to increase vehicle footprint, for example the size of typical parking spaces in underground garages and multi-storey car parks.

Regulations also entail monitoring and enforcement costs that are avoided with simple taxes. Regulations do, however, have some advantages compared to taxes, not least in terms of political acceptability.

Using a standard instead of a tax also has the advantage of reducing uncertainty for vehicle manufacturers in the sense that they can be relatively certain how both consumers and competitors will respond to a standard, compared with much larger uncertainty under a tax policy. This certainty facilitates the large investments required to introduce new generations of fuel efficient technologies.

Regulatory standards for CO₂ emissions are undermined to some extent by the rebound effect. By reducing average fuel consumption they reduce the costs of driving, other things being equal, which will provide an incentive to drive more often and further, partially off-setting the impact of the regulation. To correct for this effect it is possible to combine regulatory standards with a carbon tax designed to compensate for the fuel cost savings otherwise engendered by the standard. A combination of vehicle standards and carbon tax is also indicated as regulations alone risk simply postponing emissions of CO₂ rather than restricting the ultimate quantity of CO₂ emitted from the world's stock of crude oil to an acceptable (efficient) level, which a pigouvian tax should achieve if the price can be based on reasonably accurate damage estimates.

A note of warning was sounded at the Round Table, however, over combining too many instruments to achieve greenhouse gas mitigation and oil security objectives. A proliferation of instruments results in a lack of transparency and difficulty in tracing the effects of interventions and increases the cost of implementation and enforcement, ultimately undermining cost-effectiveness. This does not rule out using complementary instruments but underlines the need to understand how transport, environment and energy policies interact. Effective and efficient combinations of instruments are examined in a companion publication (OECD/ITF 2008).

Designing transport policies: the need for integrating transport, environment and energy dimensions

There are potential trade-offs to be made in addressing the failures that affect oil and transport markets. The current structure of oil supply, with production concentrated in

the hands of a cartel, suppresses oil demand and in this respect contributes to mitigating CO₂ emissions. Some policies to weaken OPEC market power and reduce oil prices could undermine policy towards climate change.

Promoting non-conventional oil, through subsidies for oil shale or coal-to-oil plants, as demanded by a number of bills presented to the US Congress in 2007, could reduce OPEC market power if a large enough part of US oil supply was provided from these plants but it would massively increase CO₂ emissions. It should be noted that with non-conventional oil production on a smaller scale, OPEC would continue to control prices and the non-conventional oil would be priced at the level of OPEC oil. Support for non-conventional oil would simply represent a transfer of resources from US tax-payers and oil consumers to oil shale and coal-to-oil producers.

Transport, oil and environmental policies also interact in more subtle ways. Fuel specifications have played a significant part in the costs of oil refining, the availability of oil products and the price of oil products in recent decades. For example, California's fuel specifications related to environmental protection isolate the local market from world oil products markets. Local refiners enjoy the protection that this provides and gasoline trades in Singapore at \$10/bbl below the wholesale price in California. Mismatches in product standards fragment markets and even if the effect is not as marked in other parts of the world this adds significantly to oil product prices everywhere.

Environmental regulations have sharply reduced the sulphur content of gasoline and diesel to reduce tailpipe emissions of sulphur dioxide, particulates and CO₂. Current engine technologies increase NO_x emissions when optimized to reduce fuel consumption. This requires NO_x reduction catalysers for the exhaust that are extremely sensitive to sulphur poisoning. Stripping sulphur out of oil at the refinery requires a lot of energy, resulting in additional emissions of CO₂ from the refinery itself. The balance in CO₂ gains and losses between car exhaust pipe and refinery emissions is shifting as sour (high sulphur) crudes account for an increasing share of

the refining slate. Demand for low sulphur diesel is one of the factors promoting production of biodiesel in Europe, as it is completely free of sulphur. Current biodiesel production may be associated with an increase rather than a decrease in greenhouse gas emissions compared to conventional diesel, taking into account N₂O emissions from the cultivation of feedstocks (OECD/ITF 2007).

Two thirds of the progress in reducing CO₂ emissions from new cars in the EU since the voluntary agreement with car manufacturers entered into force (in 1998) have been the result of a shift from gasoline to diesel engines. This has seen diesel consumption rise inexorably and it now outsells gasoline in Europe. The shift has created a large imbalance in Europe's refining industry, with excess gasoline sold to the USA and diesel imported from Russia. This has implications for CO₂ emissions as well as prices. Crude oil contains a mixture of different hydrocarbons. The mix of useful products that can be separated out with minimal energy input is determined by the nature of the crude. There is a degree of flexibility in the product mix produced, but shifting the mix requires large amounts of additional energy input. An increasing number of refineries in Europe convert heavy fuel oil (for which the market is weak most years) into diesel, but at the cost of additional CO₂ emissions from these refineries. The diesel-gasoline balance has been pushed to its limits in world refining markets. If the US government were to adopt policies to promote diesel cars¹⁰ diesel prices would rise significantly and CO₂ emissions would increase as additional crude oil, with deeper conversion processing, would be required to supply the market. It would not be possible to achieve the European degree of dieselization in any other major car market.

Regulatory standards or taxes intended to internalize the costs of greenhouse gas emissions thus need to be designed not only to avoid bias towards promoting particular technologies (in this case diesel engines) but also to avoid simply shifting emissions from one point (tailpipe exhaust) to another (refinery smoke stacks) and

¹⁰ Policies adopted initially in Europe to promote producers of diesel engines.

exacerbating other external costs - in this case NO_x emissions, as diesel engines produce higher levels of NO_x than gasoline engines and are generally subject to weaker emissions standards. These are basic tenants for the design of interventions to protect the environment but they are frequently overlooked in practice. Fuel taxes in Europe, to the extent they are intended to curb CO₂ emissions, clearly fail the test.

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