# DO ELECTRICITY MARKETS FAIL TO TAKE THE RISK OF FUEL SUPPLY INTERRUPTIONS INTO ACCOUNT?

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**The issue: externalities and energy import dependence**

Economic theory tells us that, if we are interested in economic efficiency – making the population as a whole as well off as it can be given available resources – goods and services in the market place should reflect their 'true' costs of production. In a competitive market, one where there are many buyers and sellers, we would expect market prices to be close to their (marginal) cost of production. In an imperfect market – one characterised by some form of monopolistic behaviour on the part of sellers, we would expect market prices to be above this marginal cost of production. But markets of any kind tend to neglect other features of the production and consumption process. These features are associated with the life-cycle of the product. In the case of fossil fuel energy, the life cycle runs from the point of extraction through to conversion into energy products and consumption of the final product.

The first category of effect that tends to be ignored by the market is environmental externality. Extraction, conversion, transport and consumption of energy generates solid wastes, gaseous and liquid wastes. These forms of pollution detract from human wellbeing and are classified in economics as a *negative externality*. An externality, or external effect, is any third party effect arising from the production and consumption of goods and services and which effect is either not compensated if the effect is detrimental, or appropriated if the effect is beneficial. The focus in economics tends to be on the negative environmental effects of energy production and use[1]. So long as externalities are ignored by the agent generating the effect, it is obvious that human wellbeing cannot be maximised: the market focuses on the gains to the producer and ignores the detrimental effects on any third party. There is economic inefficiency. There is a huge literature on the environmental externalities from energy production and consumption, and substantial efforts have been made to measure these detrimental effects in money terms. The basic rule is to find measures of society's willingness to pay (WTP) to avoid these environmental effects. WTP places the externality on the same footing as the market price of the energy since the market price is the willingness to pay of consumers for the last unit of output[2].

A second category of externality, usually also classified as an environmental externality, arises from the finite nature of fossil fuel stocks. Given that stocks are limited in absolute quantities, any use of a unit of energy today must be at the expense of consumption some time in the future. The larger the stocks (reserves) the further into the future that cost occurs. The smaller the stock, the higher this cost will be. This externality is given various names: *scarcity premium*, *user cost* and *royalty* are perhaps the most common terms. Whereas we can be fairly sure that unregulated markets will ignore the first category of externality above, we cannot be sure that markets will ignore user cost. This is because the owners of the resource will rationally want to take future scarcity into account when making their decisions about the rate at which to extract and process the resource. However, the economic theory underlying this expectation has repeatedly been questioned in terms of its relevance to world oil markets, not least because the time horizons to exhaustion repeatedly

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[1] But beneficial effects may be important. Liquid fuels permit far greater mobility than, say, coal. Electricity is associated with large economies of location, for example by divorcing industrial production from the need to locate near fuel sources.

[2] Put another way, demand curves are marginal WTP curves, a schedule of WTP for each incremental unit.

increase and never seem to decrease, and because what time horizons there are, are some considerable way off in time. If this is correct, then the user cost for oil would be very low. Adelman et al. (1991) did indeed suggest that the user cost of oil to Saudi Arabia was just a few cents per barrel.

**Energy security issues**

A third category of externality is usually classified as an *energy security externality*, or ESE. ESEs appear to arise when energy importing nations suffer some cost that arises from vulnerability to foreign sources of supply. But exactly what constitutes an ESE is not straightforward and a small but significant literature has emerged on the issue of defining an ESE (see, for example, Boardman 1986; Bohi and Toman 1993; 1994; 1996; Toman 1993; Lockwood 1997; Parry and Darmstadter 2003). An important issue is whether the effects that are usually identified are *externalities* at all, rather than some transfer of wealth between importing and exporting nations. If the effects are genuine externalities the implication is that the importing country could undertake some corrective action to avoid the externality. If the effect is a wealth transfer due, say, to monopolistic behaviour on the part of oil exporters, it is far less clear that an externality is involved. But the wealth transfer may still be very relevant to energy policy in the form of seeking extra 'energy security', and it is easy to see that policy measures such as a fossil fuel tax or other measures designed to switch out of the imported fuel are feasible.

The literature on ESEs tends to be confined to oil, but the growing use of traded natural gas implies that gas should also be considered. The basic argument is that there are features of the world market for oil and gas that lead to a divergence between market prices and the socially optimal price in an importing nation.

Two main sources of externality have been identified in the literature:

- The *monopsony wedge*. This effect arises from the fact that some importers of oil and gas, the USA or the European Union taken as a whole, have the power to influence the price of oil and gas in international markets. They are large buyers of energy. So long as the supply curve for energy is upwards sloping, extra demand by a monopsony country will raise the world price of energy. But this increased price also has to be paid by all existing users of energy as well as by those who are responsible for the increased demand. Higher prices have to be paid for the marginal imports (the extra imports) and for all the inframarginal imports (those that already exist). What happens is that the costs to individuals do not reflect the costs to the importing nation as a whole. Individuals consider only the costs to them and ignore the incremental costs paid by existing consumers. There is an externality but it shows up in a change in prices, which is very different to the environmental externalities which have a direct physical counterpart. One way of defining these ESEs is that they are *pecuniary* as opposed to *technological* externalities. Some writers, e.g. Lockwood (1997) regard all ESEs as pecuniary externalities. If so, the arguments for addressing them do not reside in concerns about economic efficiency but more in a failure of the importing country to capture all the 'rents' that it might exploit. Leiby et al. (1997) have estimated this monopsony premium for the USA at $1.3 to $5.0 per barrel (BBL) of oil on a benchmark world price of $25 BBL.

- Unanticipated price changes can impose costs to the importing economy. Again this will be ignored by individual importers, so that there is a further wedge between the cost faced by individuals and the cost to the economy as a whole. Also possible are physical interruptions of supply, perhaps due to war or political opposition to the importing country. It is this category of 'disruptive effects' – price volatility and potential supply interruptions - that we focus on[3].

Within this second category two broad effects arises:

- the increased cost of oil imports, which adds to any trade imbalance and transfers wealth from the importing country to the energy exporter. Since it is a transfer, the world as a whole does not lose, but the transfer itself is a cost to the importing country and is roughly equal to the size of imports multiplied by the price change. The wealth transfer can be thought of as a pecuniary externality. In their exhaustive analysis of the theoretical foundations of ESEs, Bohi and Toman (1996) argue that the policy implication of such transfers is not obvious since there is no 'compelling argument that the government can do better than the private sector in anticipating and responding to the direct costs of energy price variability' (p.27). Despite this, governments do take price variability seriously, e.g. by trying to diversify energy portfolios, stockpiling energy and so on.
- macroeconomic costs, sometimes called 'adjustment costs', which in turn occur because the increased cost of imports adds to inflationary pressure and risks of recession. Basically, GDP must decline if available factors of production have remained the same while the price of the energy factor increases. This loss will occur regardless of the speed of adjustment in the importing country. But the costs will be higher still if some markets are slow to adjust wages and prices, i.e. if there are market rigidities. The complex issue here is how policy should react: policies to address vulnerability to price changes might be better directed at removing domestic market rigidities, establishing strong forward markets etc. rather than trying to reduce import dependence. Bohi and Toman (1996) argue that these macroeconomic costs are in any event exaggerated in the general literature, but the issue remains a controversial one in terms of empirical evidence.

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[3] The 'energy security' literature focuses on both categories of pecuniary externality since both arise from a direct dependence on energy imports. Others argue that the monopsony effect is not a 'true' ESE and that ESEs should be defined to include only physical interruptions of supply and unanticipated price changes. This debate does not matter for current purposes since the focus is on the second category of 'disruptive' effects. It should be noted that some writers object to energy import dependence being classified as an externality, arguing that it misleadingly directs attention towards the idea that Pigouvian-style externality taxes will resolve a problem much of which is monopoly power (i.e. OPEC). See Greene et al. (1998). However, as noted above, energy insecurity is a pecuniary externality and as such no necessary implication about the optimal corrective policy carries over from the analysis of Pigouvian (technological) externalities to the analysis of pecuniary externalities. Moreover, taxes are still relevant if they direct domestic consumption away from risky imports to more dependable domestic energy sources.

Note that, while the focus of the ESE literature tends to be on disruption causes by changes in *import* prices, there is also an issue of energy security that can arise solely in domestic circumstances. Labour strikes would be an obvious example in some European countries, for example. In the United Kingdom, diversifying energy supply away from coal was a direct result of the energy insecurity that arose from miners' strikes.

Finally, it is worth noting that as long as energy sources are near substitutes, hikes in one energy price will be mirrored by hikes in other energy prices. And, if the energy sources are internationally traded, as is the case with oil and much gas, then domestic prices will follow world prices. Changes in the import prices of, say, oil will therefore affect (a) the price of domestically produced oil and (b) gas prices.

**Anticipated vs. unanticipated price effects**

If importers correctly anticipate oil price rises, they can be said to 'internalise' the externality. That is, they factor the expected prices into their decision and hence no externality arises. As Parry and Darmstadter (2003) note, however, it is extremely difficult to know how far price changes are anticipated. The obvious approach to estimating the anticipated and unanticipated components is to look at past price behaviour. Price 'shocks' for oil are now part of modern energy history centring on:

- The 1973 – 4 'hike' due to the Arab oil embargo on Israel and Israeli allies
- The 1979 - 81 hike due to the Iranian revolution
- The 1990 - 91 hike due to the first Gulf war
- The 1999 - 2000 increases due to OPEC cutbacks and demand increases
- The 2002 onwards rise due to the second Gulf war, rising demand, stock-building and some OPEC cutbacks.

While current oil prices exceed the peak 1981 prices in nominal terms, in real terms current prices are well below the 1981 peak (45-50 BBL compared to over $80 BBL at 2005 prices)[4]. Thus, a rational importer might well internalise expected price changes provided he/she is not subject to money illusion. Simulations of expected price shocks based on past events, or on combined probabilities of events using past data, have tended to produce fairly low 'oil premiums' of around $1 BBL (see Leiby et al. 1997). But Greene and Leiby (1993) estimated the cumulative costs of OPEC price controls to the US economy 1972 to 1991 at some $4 trillion. The empirical estimates of losses appear not to sit easily with an assumption that importers anticipate price volatility. However, rational expectations and the measures of loss may be compatible if one assumes that most of the losses relate to early periods of price hikes when expectations of further volatility might have been lower than today. There is some limited evidence that OECD energy importers have undertaken major adjustments to reduce vulnerability to future oil price shocks. As Greene et al. (1998) note, the most effective strategy to increase energy security would have been (and still is) to increase the supply and demand elasticities for energy through investment in non-oil technologies. Hence one would expect a marked reduction in the share of oil in total OECD energy demand. Table 1 (later) shows that OECD countries have

[4] See oil price data from US Energy Information Administration – www.eia.doe.gov

indeed reduced the fraction of demand met by oil from 50 to 40 per cent in the period 1971 to 2002, but oil demand has actually increased in absolute terms by 25 per cent. While Europe has made some major strides in reducing oil import dependency, the USA appears to have increased its dependency (Table 2).

Anticipation of price changes also requires forward markets, i.e. the ability to hedge against the changes. While there are numerous financial instruments in energy markets, their ability to deal optimally with price variability is very much open to question. A further factor not widely discussed in the literature is that energy importers are likely to have very much higher discount rates than governments. The social and private discount rates diverge. If so, one could argue that policy responses to price variability fail to account for the longer term interests of the nation.

Overall, then, it is hard to determine if the market has internalised oil price variability. The history of oil prices in the last three decades is such that one would expect rationality in importers, with the externality being largely internalised. But the same assumption about rationality does not appear to have carried over to efforts to reduce oil dependency, at least in the USA and arguably in OECD countries as a whole. Hedging and accounting for longer term supply risks are also probably inadequate for an optimal energy security policy. For the future, one factor that may increase the degree of anticipation and reduce un-anticipation is the growing sources of information on political risk. Insurance and other financial institutions regularly assemble such data for their own security and risk assessments – see the case study for the UK later in this paper.

**Adders**

Efforts to measure the costs of energy insecurity have focused on

(a) the costs to importing countries of monopolistic behaviour by oil exporters
(b) the costs to importing countries of 'securing' politically vulnerable supplies, e.g. through military expenditures.

While it is common to see these costs expressed in absolute terms, in keeping with the environmental externality literature, costs can also be expressed as 'premiums' or 'adders'. This means that the total cost of insecurity is divided by either (a) importer's energy consumption or (b) electricity consumption. The resulting premium or adder is then shown relative to the market price of oil or electricity. While the energy security literature does not generally focus much on gas, the issues are just as applicable to gas.

Several attempts have been made to estimate an oil premium based on military expenditures designed to secure overseas oil sources. Delucchi (1998) suggested that US military spending in the Middle East amounted to an oil premium of $0.2 to $2.9 BBL. However, the problems with computing the military premium are several. First, it is not at all clear how far military spending is due to the desire for secure oil supplies rather than other strategic or humanitarian concerns. Second, as Parry and Darmstadter (2003) note, military spending tends to take the form of a fixed cost, so that there is no corresponding marginal cost that varies with the scale of oil imports, which is what is required for a premium or adder to be computed. Third, Bohi and

Toman (1996) point out that military spending is a *mitigation cost* of insecurity, not a cost of damage arising from insecurity. In an analogy with environmental economics, military spending is a control cost not a damage cost. Technically, this is a sound argument, but in so far as greater energy security reduces military spending, there is a benefit of avoided expenditures. That is also a common approach in environmental economics. Finally, it may be hard to credit military spending by any one country as a benefit to that country alone. Most military expenditures, if they confer benefit at all, have a public good feature – they benefit other nations as well.

Despite Bohi and Toman's dismissal of the military expenditure argument as 'grievously flawed on logical grounds' (p.27), efforts to measure government expenditures on 'securing' foreign energy supplies continue.

**There are benefits too!**

The ESE literature tends to focus solely on the costs to economies of volatile energy prices. The literature is 'asymmetric' in two respects: (a) it narrows the focus down even further to price increases, ignoring price falls; (b) it focuses on costs only and ignores benefits. The issue of balancing out the effects of price increases and price falls is considered shortly. Where price increases occur, one of the effects may be to induce more energy conservation in the importing country than would otherwise have taken place. If so, there is an environmental benefit to the price hike. Indeed, as far as OPEC behaviour is concerned, it has long been argued that monopoly can be a friend of the environment. Reference to this beneficial effect of price hikes appears to be very scarce in the literature.

**Some basic facts**

OECD countries continue to be heavily dependent on fossil fuels, and, within the categories of fossil fuels, on oil and gas. In turn, dependence on imports from non-OECD countries remains significant and can be expected to increase. Tabl1 shows some basic data. In 1971 oil accounted for 51 per cent of primary energy demand, a fraction that fell to 40 per cent in 2002. Nonetheless, oil demand rose by 25 per cent in that 30 year period. The IEA Reference scenario suggests a stable fraction of demand being met by oil – at about 40 per cent - for the next few decades. Similar analysis for gas shows the fractions to be 19 per cent for 1971, 22 per cent for 2002, but 26 per cent by 2030, with a growth in gas demand of nearly 80 per cent 1971-2002 and a projected 40 per cent expansion 2002-2030. Table 1 also reveals the de facto nuclear moratorium in OECD countries with declining capacity 2002-2030. Finally, Table 1 shows the comparatively modest role played by non-nuclear non-fossil fuel sources even in 2030, around 8 per cent of primary demand.

Table 2 shows 'net import dependency' ratios for selected countries, measured as one minus the production consumption ratio[5]. Table 2 shows the near total or total dependency on oil and gas imports in Japan and Germany, the increasing import dependency in oil of the USA, and the generally declining dependency of the wider Europe on both oil and gas.

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[5] The production/consumption ratio measures the ratio of domestic oil (gas) production (Q) divided by consumption (C), i.e. Q/C. By definition $C = Q + M - X$ where M is imports and X is exports. Writing $M - X$ as net imports (nM) we have $nm/C = 1 - Q/C$.

**Table 1** **Primary energy demand by OECD countries. Mtoe**

| | 1971 | 2002 | 2020 (proj) | 2030 (proj) |
|---|---|---|---|---|
| **Coal** | 812 | 1095 | 1213 | 1192 |
| **Oil** | 1730 | 2167 | 2594 | 2725 |
| **Gas** | 655 | 1171 | 1635 | 1830 |
| **Nuclear** | 27 | 593 | 599 | 557 |
| **Other** | 162 | 320 | 510 | 649 |
| **TOTAL** | 3387 | 5346 | 6550 | 6953 |

Source: IEA (2004, Annex A 'Reference Scenario)

**Table 2 Net import dependency in selected countries 1990-2001 (nM/C)**

| | 1990 | | 2001 | | |
|---|---|---|---|---|---|
| | **Oil** | **Gas** | **Oil** | **Gas** | **Comment** |
| **Wider Europe** | 0.34 | 0.15 | 0.27 | 0.08 | Declining import dependence |
| **Norway** | - 7.68 | -10.41 | -16.73 | -9.11 | Exporter |
| **Germany** | 0.96 | 0.77 | 0.97 | 0.78 | More oil than gas dependent |
| **UK** | - 0.10 | 0.13 | -0.49 | -0.13 | Exporter |
| **Russia** | - 0.85 | -0.35 | -1.77 | -0.46 | Exporter |
| **USA** | 0.48 | 0.05 | 0.60 | 0.09 | Growing oil dependence, low gas dependence |
| **Japan** | 1.00 | 0.96 | 1.00 | 0.97 | Total dependence |
| **China** | -0.19 | 0 | 0.34 | 0 | Growing oil dependence |

Source: Eni (2002). Computed as 1 – Q/C. Negative numbers therefore represent net exporters, positive numbers represent net importers.

### Do the good times balance the bad times?

It was argued above that a case could be made for supposing that we have sufficient experience of oil (and now gas as well) price volatility for importers to 'internalise' energy insecurity costs. However, the empirical evidence on this is limited. A second argument for arguing that there is no real security externality is that volatility necessarily implies that there are price falls as well as price hikes. If the cycle is fairly regular, benefits in times of price falls may just offset costs in times of price increases. Parry and Darmstadter (2003) suggest three reasons why security costs will still arise. First, those who judge the market will be the oil and gas importers, while those who pay the costs of any price increases comprise virtually the entire population of an importing country. While the upstream market may gauge price volatility correctly, the rest of society will not. Second, price volatility traps many producers and consumers who have fixed capital stocks that cannot be changed with ease other than in the long run. The capital can range from a domestic heating boiler all the way to major plant investments. Hence adjustment costs can be very expensive. Third, the way in which markets would normally cope with price volatility is through insurance and forward markets. There appears to be limited scope for insurance in this context. As Helm (2002) remarks in the context of domestic price stability in the United Kingdom:

> 'A crucial fact for energy policy is that transparent liquid futures markets do not exist for anything like the timeframe over which price risk may need to be hedged'. (p.176).

Overall, Parry and Darmstadter suggest that recessions follow price hikes but accelerated economic growth does not follow price falls. This suggests that there is no 'swings and roundabouts' effect: the costs from price rises exceed the benefits from price falls.

**Case study: the USA**

Parry and Darmstadter (2003) review the US literature and present some estimates of the 'oil premium' for the USA arising from macroeconomic disruption, OPEC monopoly power and US monopsony power. They suggest a 'best estimate' of $5 BBL oil with a range of $0 to $14. The range depends on the extent to which oil price volatility can be said to be internalised through anticipation and hedging. Parry and Darmstadter do not provide a detailed breakdown of the estimates but they do note that one earlier study partitioned the overall premium one third monopsony and twp thirds macroeconomic disruption.

**Case study: the United Kingdom**

OXERA (2003) conducts a study of the non-market impacts of electricity generating technologies. Included in the analysis is an estimate of the risks to supply of adopting various generating mixes. Of particular relevance to the UK is its growing reliance on natural gas in a context where it own gas supplies have peaked, turning the UK into a net gas importer in the next few years. The insecurity events that are simulated are supply interruptions rather than price increases. OXERA argue that even though supply interruptions are unlikely, even small interruptions could have large effects. As far as gas is concerned, an interruption to imported gas is simulated. To determine the likelihood of such events, OXERA utilise insurance market data on political and technical risks. In the worst case scenario, the UK would not be able to meet gas demand in 2010-2011, compared to after 2020 for maximum gas supply, and 2016 for the 'average' case. In other words, potential supply interruptions could serious threaten the UK's energy security as early as the next five years. Scenarios in which new nuclear power or much expanded wind power is introduced substantially reduce this insecurity. Standard electricity sector values are used to value the 'lost load'. For England and Wales these values are give as some £UK 3000 per MWh. The base case scenario then produces a loss of security cost of £UK 300 million in 2020. This is reduced to £UK 180 million in the scenario in which there is a high amount of windpower and to £UK 120 million for the nuclear scenario. Significantly, security of supply benefits are the largest of all the benefits of the wind power and nuclear scenarios, being slightly larger than the maximum global warming benefits and up to five times the minimum value of global warming benefits.

**Conclusions**

There is no question that OECD governments take energy security seriously. This fact alone suggests that governments do not trust markets to cope with the energy security problem. The problems arise when one begins to consider just what the rationale is for government intervention. The standard argument for intervention would be that (a) a (technological) externality exists and (b) governments are good at resolving externality problems. But many of the externalities that make up an energy security externality are not technological externalities at all. That is, they do not affect overall economic efficiency. Rather they are pecuniary externalities which affect the distribution of rents. Despite this, it is easy to see that pecuniary externalities are relevant to policy. Even if the redistribution took place within a nation, governments might still be concerned about it. But the wealth transfers that concern the ESE literature are transfers between nations and no government is indifferent to the distribution of wealth out of a national jurisdiction. To this extent it does not matter much whether the externality is classified as technological or pecuniary – it still affects policy. What does need to be made clear is that most of the concern is not about losses of economic efficiency.

However, numerous commentators have suggested that some of the effects of supply instability do result in losses of potential GNP, i.e. there are efficiency effects. The debate then shifts to the reasons why those efficiency effects arise. If, as Bohi and Toman (1996) suggest for example, they arise because of inefficiencies in domestic goods and labour markets, then the costs incurred arise at least as much from domestic economic failures as to supply instability. Bohi and Toman also take leave to doubt that these costs are in any event very important. But in their review of the US literature, Parry and Darmstadter (2003) find a reasonable consensus of $0 – 10 BBL for the US oil premium and a best guess of $5 BBL. That is not inconsiderable.

Finally, if we take the Parry-Darmstadter range of $0 -10 BBL, the issue embodied in the title of this essay arises: the low end of the range appears to assume considerable anticipation and internalisation of disruptive effects by markets. The upper end assumes that markets are not very good at adjusting in a socially optimal manner. The evidence on forward contracts, differences in private and social discount rates, and continuing adherence to oil-based economies despite three decades of marked price variability in oil, all suggest that markets may not be very efficient in this respect. But whether governments can do better is another question!

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