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Insuring against Disruptions of Energy Supply

Social Costs of Energy Disruptions

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and
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Abstract

The costs of energy supply disruptions for industrialised economies go well beyond the economic measures of national accounts. According to different kinds of risks, physical shortages or price shocks, there are several categories of negative effects. Oil disruptions have both a direct and an indirect impact, (at global and local levels) and have a short- and a medium-term horizon. The economic effects of electricity shortages are also direct and indirect, but the temporal lag is shorter than for oil disruptions. In this paper, we summarise the different ways an economy is affected by an oil shock or a power black-out. Oil crises in the past produced high inflation rates, trade and payments imbalances, high unemployment, and weak business and consumer confidence. The social costs of electricity shortages have immediate negative results, and relatively small, indirect effects – depending on the extension of the disruption, the duration, the availability of advance warning and information. A specific assessment of the social costs of an electricity shortage remains a research task for the future.

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1. Introduction

There is general agreement within international literature about the nature of the costs of supply disruptions, affirming that they go well beyond the economic measures of the national accounts. Energy use pervades daily life in such a constant and ubiquitous way that it is very difficult to distinguish among all the short- and long-term negative effects.

Energy security and supply disruption

To assess the social costs resulting from a supply disruption, it is first necessary to have a precise definition of what a supply disruption is. It seems useful to start from the definition of energy security: energy security is defined in terms of the *physical availability of supplies to satisfy demand at a given price*. So, the security problem involves a quantity risk and a price risk. And it has a long-term and a short-term component (a long-term trend of rising prices for energy imports has a different implication for an economy than a sudden price hike or price volatility). Thus, a supply disruption occurs when the physical availability of the resource falls under some defined threshold (for a 'sufficient' length of time) or its price overcomes some other threshold or both, with the obvious consequence that the definition of disruption becomes quite arbitrary, as it depends on the assumed thresholds. It is also important to understand that the social cost of a primary energy-supply crisis tends to be heavily influenced by the specific historical setting and the geopolitical situation in which it occurs (IEA, 2001a, p. 76).

Generally speaking, the social costs of supply disruptions can be classified under the category of economic externalities. The social costs of security are those costs that accrue to others in the economy, generating a need for governments to step in and take protective measures (IEA, 2001a). In order to differentiate among the main components of external social costs, it is necessary to clearly separate internal (or private) costs from external (social) costs.

The social costs of energy disruption can be allocated into different categories, based on the varying kinds of risks posed, such as a physical oil shortage, a prolonged interruption in electric power (quantity risk) or a sudden rise in oil prices (price risk). Usually oil disruptions (especially quantity shortages) have both direct and indirect effects, with a short and medium-term horizon. With regard to power-generating shortages, the economic effects for society are also direct and indirect, but the temporal lag is shorter than for oil disruptions.

Using these characteristics, it is possible to separately analyse the economic impact of oil crises and power-generation or distribution interruptions. In any case, a perfect distinction between internal and external costs (i.e. private and social costs) is a very difficult task.

2. Social costs of oil disruptions

With regard to oil disruptions, energy security is defined in terms of the physical availability of supplies to satisfy demand at a given price. Oil shocks can be split into several categories, notably price, quantity and technology (Helm, 2002):

- price shocks are the most common;
- quantity shocks relate to physical constraints; and

- technology shocks relate to new concepts and ideas, to failures (i.e. the discovery of nuclear design faults) or to new constraints (i.e. an unanticipated technical advantage of nuclear energy over oil with the discovery of the climate-change problem).

Thus, the security problem also has a long-term and short-term component: long-term rising prices for oil imports have a different implication for an economy than a sudden price hike or price volatility.

Looking at the past, after the main oil crises, OECD countries and the world were stricken by high inflation, trade and payments imbalances, high unemployment, and weak business and consumer confidence. Generally speaking, an increase in oil prices leads to a transfer of income from the importing to the exporting country through a shift in the terms of trade. For net oil-importing countries, an increase in oil prices directly reduces real national income because spending on oil rises and there is less national income available to spend on other goods. For net oil-exporting countries, a price increase directly increases real national income through higher export earnings. The boost to economic growth in oil-exporting countries provided by higher oil prices is generally less than the loss of economic growth in importing countries, such that the net effect on the global economy is negative.

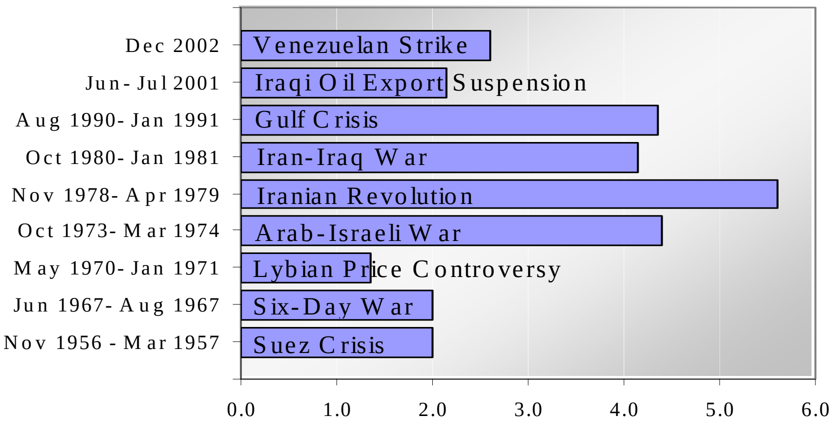
Oil supply disruptions have occurred rather frequently: over the past half century, there have been at least 14 significant disruptions involving a loss of 0.5 mb/d or more of crude oil. Most of these disruptions were related to political or military upheavals, especially in the Middle East. Since 1973, four major crises – the 1973 Arab-Israeli war, the 1978-89 Iranian revolution, the 1980 Iran-Iraq war and the 1990-91 Gulf war – resulted in initial shortfalls of between 4.0 and 5.6 mb/d. Virtually all past oil disruptions have been short, typically lasting a maximum of nine months.

Based on the most relevant literature on the subject (IEA, 2001a; Toman, 2002), the politically-based disruptions can be grouped into two categories:

- random shocks, caused by internal unrest in OPEC countries, such as the Iranian revolution in 1978-79, the Nigerian civil war of 1967-70 or the Iran-Iraq war and the 1990 Iraq invasion of Kuwait; and

- strategic shocks involving the exercise of market power by Middle Eastern oil producers such as the Arab oil embargoes of 1957, 1967 and 1973-74.

Figure 1. Magnitude of supply shortfall (mb/d), 1957-2002



Source: Harks, 2003.

Establishing the point at which an oil shortage becomes a crisis is not an easy task. In an attempt to identify a reference value for oil price variation and reductions in oil consumption based on past shocks (Figure 1 and Table 1), it emerges that a possible minimum value for price and consumption variations could be respectively 100% and 4 million barrels per day.[1]

Table 1. World oil supply disruptions

Dates	Supply disruption	Magnitude of supply shortfall (mb/d)	World oil consumption (mb/d)	Oil price change (%)
Mar. 1951–Oct. 1954	Iranian fields nationalised	0.7	13.2	12.87[a] (cum)
Nov. 1956–Mar. 1957	Suez war	2.0	17.5	9.47[a]
Dec. 1966 – Mar. 1967	Syrian transit fee dispute	0.7	34.3	n.a.
Jun. 1967 – Aug. 1967	Six Day War	2.0	40.0	n.a.
Jul. 1967 – Oct. 1968	Nigerian civil war	0.5	40.1	n.a.
May 1970 – Jan. 1971	Libyan price controversy	1.3	48.0	24.44[a]
Apr. 1971 – Aug. 1971	Algerian-French nationalisation struggle	0.6	50.2	n.a.
Mar. 1973 – May 1973	Lebanese political conflict	0.5	58.2	32.66[a]
Oct. 1973 – Mar. 1974	October Arab-Israeli war	**4.3**	58.2	252.98[a]
May 1977	Damage of Saudi oilfield	0.7	62.1	n.a.
Nov. 1978 – Apr. 1979	Iranian revolution	**5.6**	65.1	120.8[a]
Oct. 1980 – Jan. 1981	Outbreak of Iran-Iraq war	**4.1**	60.4	18.85[a]
Mar. 1989 – Apr. 1989	Exxon Valdez accident	<0.5	51.6	16.95 [b]
Apr. 1989 – Jun. 1989	UK Cormorant Platform	0.5	51.6	n.a.
Aug. 1990 – Jan. 1991	Iraqi invasion of Kuwait	**4.3**	66.3	113.21 [b]
Jun – Jul 2001	Iraqi oil export suspension	2.2	75.4	n.a.
Dec. 2002	Venezuelan strike	2.7	75.7	18.07 [b]

Notes: [a] Oil price increase on annual basis.
[b] Oil price increase on monthly basis.

Sources: Authors' elaborations on IEA (2001a), BP (2003) and EconStat (2003).

[1] An analysis based on the total value of oil shortfall ignores any evaluation about the relative magnitude of a crisis compared with total demand. As an example, during the Gulf war (1991) the percentage of reduction in oil supply compared to world demand was much higher, at 9%, than the reduction during the 1979 Iranian revolution at 7%. From the analysis of total value, however, opposite results emerge, with a greater magnitude of shortfall for the 1979 crisis.

2.1 Macroeconomic effects

Using these limit values to characterise relevant past crises, various studies have attempted to establish whether or not there are linkages between oil shocks (higher oil prices) and reduced economic growth rates. At first, it was widely believed that the 1974-75 recession and the emergence of 'stagflation' – a combination of inflation and rising unemployment – in industrialised countries was caused primarily by the oil price increase of 1973-74. But there is no general agreement on the magnitude of the negative impact of an oil shock on the whole economy.

In this regard, on one side there are studies such as those in Huntington (1998), where an asymmetric relationship has been demonstrated, in that a reduction in oil prices does not necessarily lead to noticeable output growth, while an increase can have a negative impact on output growth. Furthermore, disruptions in the oil market not only give rise to higher prices, but also increase oil-price volatility (Ferderer, 1996). Chaudhuri (2001) recently found that nonstationary commodity prices could be attributed to the nonstationarity of oil prices. In other words, as real oil prices and real commodity prices are co-integrated, oil shocks have a negative impact on economic performance.

Other studies, concentrated more on the role of fiscal and monetary policy, suggest that recessions in the oil-importing countries were less the direct result of higher prices and more the consequence of the economic policies adopted to alleviate the price shock (IEA, 2001b). In any case, looking at real data, oil-importing countries have experienced significant economic effects from oil shocks.

Highlighting some factors that are widely agreed upon, supply-side shocks appear in the economic system as autonomous variations of imported raw material costs, with *external* effects (at the international level) and *internal* effects (at the national level).

External, global effects

The main *external* effect of a shock is the income reallocation, between importing and exporting countries and also among importing countries. With regard to importing countries, an increase in the oil price directly reduces GDP, because the increased expenditure for imported oil reduces the income available for other goods and services. Within exporting countries, however, an increase of oil price (exported good) directly produces a growth of GDP, owing to the augmented revenues derived from exports. Nonetheless, positive GDP growth for exporting countries is generally considered to be lower than the reduction of growth in importing countries. Therefore, the total effect on the global economy is negative (Birol, 1998). Furthermore, income reallocation among importing countries is derived from the different capacity of each country to substitute imported energy with other energy carriers (or to substitute energy with other inputs).

Internal, local effects

The *internal* effects of a shock are linked to the typical economic policy variables (Pireddu, 1990), including:

- the activity level and the correlated employment rate;
- the inflation rate and the correlated income distribution between salaries and profits, which are determinants for capital accumulation and competitiveness at the national level; and
- the trade balance equilibrium and the correlated level of the exchange rate.

For countries that import oil, an increasing oil price in the global market can be seen to have three main (and direct) effects on their economies, which are:

- a *direct* effect on economic activity because more spending will be allocated to energy costs;
- a *financial* effect because of the rise of inflation and interest rates; and
- a *trade* effect relating to an increased oil import bill, which worsens the trade balance.

Apart from losses in GDP and balance of payments, other macroeconomic *indirect* effects, linked to the previous ones, may include the following:

- a fall in tax revenues pertaining to rigidities in government expenditure, which can produce an increase in the budget deficit and eventually drive interest rates up;
- because of the resistance to real declines in wages, an oil price increase typically leads to upward pressure on nominal-wage levels; together with reduced demand, wage pressures can in turn lead to higher unemployment; these effects are magnified by the swiftness of the price increase and inflexibility of the labour market (and could be further increased by the impact of higher oil prices on consumer and business confidence); and
- a decrease of exports because of the rise of the internal price, which reduces the competitiveness of national products.

Thus, increases in inflation and unemployment rates are the main, macroeconomic features of social costs, while other factors such as GDP loss and balance of payments are more difficult to allocate among their private and social components.

A comparison between two oil shocks

After the 1973 and 1979-80 oil price crises there were various negative effects in terms of GDP and balance of payments losses, each representing a substantial terms of trade deterioration for the OECD as a whole, equivalent to around 2% of GDP. Because of the rather low price-elasticity of oil in the short term, the increase in the net oil-import bill has been very large in both cases, even though total oil demand has declined because of lower GDP growth, as a result of oil-price increases.

Nevertheless, it should be noted that there are some differences between the 1973 and the 1979-80 oil price shock, because of the different magnitudes of price variation. In the first one, imported oil prices increased by 250%, while in the period from the end of 1978 to the end of 1980, imported oil prices increased by about 20% (see Table 1).

Even in the case of the inflation rate, although the two oil price shocks were similar, inflation was lower in the second oil shock. Inflation reacted more strongly in 1973 (when the spread of private-consumption deflator growth rates more than doubled between the second half of 1973 and the first half of 1974), than it did in the early 1980s because of the change of monetary policy in many countries.

2.2 Factors affecting the impact of a shock

The magnitude of the economic costs (private, social or both) of an oil price increase can be profoundly affected by several factors. The major factors highlighted by literature (Birol, 1998; IEA, 2001b; Mitchell, 2002; Pireddu, 1990) are the following:

- The main two determinants are obviously the level and the duration of the price increase and the quantity of crude oil available on the global market, both of which are directly linked to the characteristics of the market. It is particularly important to highlight that the duration of the macroeconomic impact of an oil shocks is generally limited to two years after the price change. Thus, it is important to distinguish between a fast and high increase and a steady rise in the price of oil.

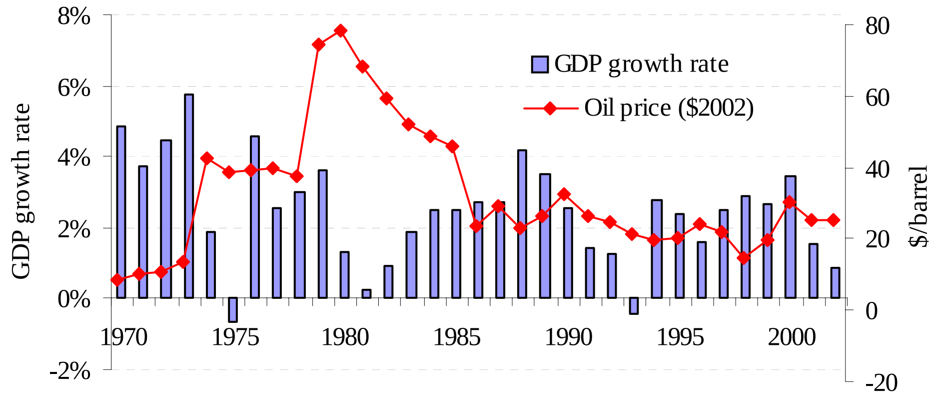
- The response of oil markets to an oil price hike, depending on the characteristics of the market, also contribute to determining the level of the economic costs.
- Other critical factors relate to the structural characteristics of the economy: first, the weight of energy costs on GDP, which is directly linked to the share of energy intensive sectors in the industry; second, the flexibility of the energy sector, i.e. its capacity to shift from one source to another; and third, the elasticity of internal prices to the price of imported oil, as in the short period the negative effects on economic activity could be reduced through a greater increase of internal prices (which in an open economy could otherwise have negative consequences in the longer term, by reducing the competitiveness of the country).
- Other country-specific factors can deeply influence the economic effects of an oil price increase: the macroeconomic trends acting before and during the oil shock; the economic policies applied before the crisis; specific institutional mechanisms, particularly for the industrial relationships and the labour market (wage and salary formation); the actual increase of energy prices in each country, in relation to the fuel mix, the specific fuel consumption and the level of petroleum-products taxation; and the response capacity of the energy system, in terms of industrial and institutional flexibility.
- Finally, the social costs of energy shocks are obviously affected by the specific historical and geopolitical context.

The above remarks show that, as stressed in many recent contributions, the impact of oil price shocks on the macroeconomy can be accentuated by the economic and energy-policy response to a combination of higher inflation, higher unemployment, lower exchange rates and lower real output. In particular, highly contractionary monetary and fiscal policies to contain inflationary pressures could exacerbate the effects on recessionary income and unemployment (Birol, 1998). Thus, as government policy can influence the overall impact on the economy over the longer term, even if it cannot eliminate such adverse impacts as those described above, it should operate to minimise them. To highlight just one critical factor in the effectiveness of the policy response, from experience it seems necessary to limit the spread of inflation across the whole economy. In the short term, the higher cost of imported energy could be faced either by trying to protect the activity level or by limiting the inflation rate. Economic theory shows that if the economic structure tends to be affected by a wage-price spiral, policy measures to reduce the cost of an oil shock could become less effective.

3. Some quantitative estimates

Although the general mechanism by which oil prices affect economic performance is generally well understood, the precise dynamics and magnitude of these effects – especially adjustments to changes in the terms of trade – are uncertain. Quantitative estimates of the overall macroeconomic damage caused by past oil-price shocks and the gains from the 1986 price collapse to the economies of oil-importing countries vary substantially. This is partly a result of differences in the models used to examine the issue. Nevertheless, the effects were certainly significant: economic growth fell sharply in most oil-importing countries in the two years following the price hikes of 1973-74 and 1979-80. The impact of the first oil shock was undoubtedly accentuated by inappropriate policy responses. Conversely, economic growth in importing countries was boosted by the fall in prices in 1986, with the full economic impact becoming apparent in 1987-88. Looking at the GDP growth rate compared to the real oil price trend (net of GDP-deflator rate) in the European Union, a general correlation between higher oil prices and a lower GDP growth rate with a one or two-year lag is quite clear (Figure 2).

Figure 2. Oil price and GDP growth rate in European Union, 1970-2001



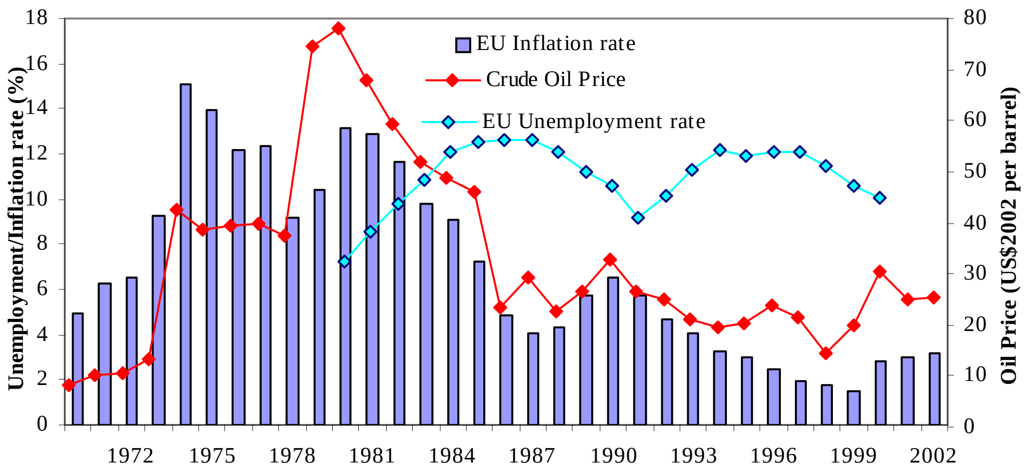
Sources: Authors' elaborations on data from the World Bank (GDP growth rate) and EconStat (oil price).

A general assessment of the magnitude of GDP loss could be built by analysing the GDP growth-rate variation after the three main oil crises. After any crisis a negative impact on GDP growth seems evident. As a matter of fact, during last forty years the EU GDP growth rate was negative only twice: in 1975 and in 1993. In both cases it happened with a one or two-year time lag after an oil price shock. In view of these results, even if the recession after the first oil shock was exacerbated by fiscal and monetary policies in oil importing countries, a negative influence on GDP is evident in all the crises (Table 2).

3.1 Negative effects on society: inflation and unemployment

Other negative effects on economic performance, with a more direct impact in terms of social costs could be seen in trends in the inflation rate and unemployment (see Table 2 and Figure 3). These two factors directly affect governments and citizens, through higher public expenditures on welfare measures such as increasing subsidies for unemployment and reduced market power for consumers. Because of the inelasticity of oil demand, especially in the transport sector, lower-income households could pay a big bill for oil price shocks.

Figure 3. Inflation rate and oil prices in the EU, 1970-2002



Source: Authors' elaborations on data from the World Bank (inflation rate) and BP (oil price).

Table 2. Impact of oil shocks on the main economic factors, EU 1970-2002

Year	Change of real price of imported crude (%)	Change of oil consumption (%)	GDP growth rate	Inflation rate	Unemployment rate (%)	Balance of Payments (current $ billion)
1970	-5.65	10.57	4.83	4.98	-	-
1971	19.48	4.47	3.73	6.28	-	5.83
1972	7.21	6.82	4.47	6.57	-	0.85
1973	**24.76**	**6.83**	**5.77**	**9.24**	**-**	**-1.80**
1974	**217.19**	**-6.65**	**1.86**	**15.11**	**-**	**-7.02**
1975	-8.74	-4.89	-0.63	13.98	-	5.74
1976	1.48	6.5	4.60	12.21	-	-9.83
1977	0.88	-1.67	2.57	12.33	-	13.55
1978	-4.98	4.22	2.97	9.19	-	24.94
1979	**98.39**	**2.52**	**3.59**	**10.38**	**-**	**-27.33**
1980	**4.70**	**-7.2**	**1.34**	**13.13**	**5.45**	**-35.71**
1981	-13.00	-6.41	0.23	12.93	7.07	26.03
1982	-12.74	-5.04	0.92	11.67	8.11	10.92
1983	-12.23	-2.59	1.88	9.78	9.10	14.83
1984	-6.60	0.66	2.51	9.05	9.58	8.44
1985	-5.22	-1.29	2.48	7.23	9.59	11.42
1986	-48.85	3.68	2.73	4.88	9.42	37.37
1987	23.59	0	2.70	4.06	8.98	-10.47
1988	-21.99	1.35	4.17	4.33	8.41	-23.61
1989	**16.12**	**0.91**	**3.52**	**5.7**	**7.69**	**-19.41**
1990	**24.12**	**1.87**	**2.57**	**6.53**	**7.20**	**0.21**
1991	-19.18	2.35	1.43	5.71	7.63	-32.43
1992	-6.27	1.54	1.26	4.66	8.51	19.07
1993	-14.42	-0.63	-0.41	4.02	9.99	80.12
1994	-8.75	0.06	2.77	3.3	10.24	19.14
1995	4.58	1.28	2.38	3.04	9.74	36.85
1996	17.71	1.82	1.59	2.46	9.83	28.37
1997	-9.36	1.05	2.50	1.98	9.23	6.68
1998	-33.16	1.79	2.90	1.78	8.53	-18.43
1999	**36.25**	**0.32**	**2.67**	**1.48**	**7.54**	**-66.49**
2000	**53.58**	**-0.7**	**3.45**	**2.8**	**7.21**	**-52.40**
2001	-16.86	1.22	1.53	2.97	-	49.13
2002	0.09	-0.93	0.88	2.49	-	-94.88

Sources: Authors' elaborations on data from the World Bank and BP.

Historical data show that oil shocks have different effects in terms of inflation and unemployment. Inflation rates have a sudden response to an oil price increase because of the direct market-transmission mechanism. Conversely, an increase in the unemployment rate is the result of an indirect mechanism, owing to the rigidity of the EU's nominal wages in the labour market, with possible lags (one or two years) after the oil shock: wage pressure and a diminishing GDP growth rate tend to lead to higher unemployment only in successive periods. In any case, such negative results in terms of increasing unemployment should take into account a typical medium-term economic cycle and other structural factors. Looking at

Figure 3, it can be noted that negative effects after 1991 appear higher than after 1981, while increases in both the inflation rate and in the price of oil have been far less.

3.2 A tool for quantitative assessments of past oil crises

In order to show the different effects of past oil shocks and to develop an analytical tool to evaluate supply disruption scenarios, it is useful to analyse the elasticity of oil demand with respect to the price of crude oil, which occurred in OECD countries during previous oil crises, with a focus on the EU (Birol, 1998). In Table 3, section (a) compares the percentage of oil consumption variation while (b) and (c) relate this change to variations in economic activity and real crude oil prices. Finally, the implicit price elasticities for the assumption of unitary-income elasticities have been derived in section (d).

Table 3. Effects of oil price changes on oil demand

	1973-75	**1979-82**	**1985-88**	**1989-91**	**1996-98**	**1998-2000**
(a) Change of oil consumption (%)						
OECD North America	-4.26	-11.61	9.54	-1.45	3.95	3.9%
OECD Europe	-9.84	-10.43	5.43	1.72	3.07	-0.3%
OECD Pacific	-7.97	-12.51	8.54	5.52	-3.88	1.0%
European Union	-11.21	-10.96	5.08	1.87	2.86	-0.4%
(b) Change of GDP constant (%)						
OECD North America	0.03	6.62	10.88	1.74	9.06	8.7%
OECD Europe	1.21	5.42	9.79	4.50	5.61	6.1%
OECD Pacific	2.00	11.28	14.28	4.94	1.30	3.3%
European Union	1.22	5.22	9.90	2.57	5.47	6.2%
(c) Change of real price of imported crude (%)						
OECD North America	189.45	80.72	-50.68	24.12	-39.41	109.2%
OECD Europe	189.45	80.72	-50.68	24.12	-39.41	109.2%
OECD Pacific	189.45	80.72	-50.68	24.12	-39.41	109.2%
European Union	189.45	80.72	-50.68	24.12	-39.41	109.2%
(d) Oil price elasticities (a-b)/c						
OECD North America	-0.02	-0.23	0.03	-0.13	0.13	-0.04
OECD Europe	-0.06	-0.20	0.09	-0.12	0.06	-0.06
OECD Pacific	-0.05	-0.29	0.11	0.02	0.13	-0.02
European Union	-0.07	-0.20	0.10	-0.03	0.07	-0.06

Source: Authors' elaborations on data from Birol (1998a) the World Bank and EconStats.

Computed price elasticities (the last rows on Table 3) underline the asymmetry between the demand reactions experienced over the previous price increases and the one experienced over the past price decline. Comparing price elasticities obtained from the high price crisis with those obtained from the low price periods, it is clear that the effects are opposite. During the latter, price elasticities are always positive, while in the former they are always negative. So the dynamic pattern of energy demand appears to be asymmetrical with respect to the sign of a change in oil prices, creating a larger demand adjustment than a comparable price decline.

Different reasons, such as the irreversibility of technological improvement, energy conservation policies of the OECD governments, asymmetrical depreciation and transaction costs associated with conservation programmes may explain this asymmetrical evolution. Moreover, consumers may have an expectation that the oil prices will increase again. If consumers expect higher fuel prices in the (not too distant) future and if adjustment is costly, then it may not be 'advisable' to opt for the short-term opportunities offered by the low price.

The greatest negative impact on the economy was produced by the first oil shock, when the energy systems were characterised by a high rigidity of demand. In such a context, the ineffective policies implemented by the importing countries exacerbated the negative effects.

Indeed, the elasticity of oil demand was much higher during the second crisis (1979-82), when the reduction of oil consumption was similar to the previous one (-11%), while the price rise was much less. Considering the general changes that occurred in the second crisis, higher price elasticities could explain the reduced negative impact in terms of GDP losses, because of higher reductions in oil consumption, and consequently, the reduced negative effect on the economic system.

Interesting results emerged during the following crisis, where the elasticity of demand was again lower. An explanation for this low elasticity can be found in the reduced use of fuel oil in electricity generation, while oil use is more and more concentrated in the transport sector, where demand is rigid and fuel substitutability is difficult. Nevertheless, the third crisis (1989-1992) was characterised by a slower increase in oil prices, owing to the utilisation of oil stocks within OECD countries, so that the percentage change in oil consumption was not negative (apart from North America), and at the same time the GDP growth was even positive and higher than the period 1979-82. Further, during the first Gulf war, the rigidity of demand is partially explained by the utilisation of oil stocks, which were quickly able to give the market enough oil to offset the negative effects of the reductions in oil supplied by exporting countries (Peters, 2003).

In conclusion, among the main factors that influence the economic impact of a crisis, the amount of oil reserves available at the national level and import dependence have to be included: high oil reserves and low import dependence can produce a significant reduction of the negative economic impact of an oil shock (Razavi, 1997).

Finally, the positive effects of oil price reductions for importing countries can be evaluated by considering the positive elasticity of demand and the high GDP growth rate during the periods 1985-88 and 1996-98. In both cases, the positive elasticity of demand indicates that oil consumption grows less than GDP. These data show that a sharp and substantial variation of oil price will probably reduce global income: as the price reduction is not followed by a strong increase in oil demand by importing countries, there will certainly be a loss for exporting countries, probably higher than the gain obtained by importing countries.

3.3 Some estimates of GDP loss

An estimation of GDP elasticity with respect to oil price could be a simple tool to evaluate the negative economic impact of an oil crisis (Razavi, 1997), but within the international literature there are also some supply/demand models capable of generating forecasts of near-term price movements (weeks or months ahead) or simulating supply disruptions. These models are helpful in predicting price responses to supply crisis, by determining the baseline around which prices will fluctuate, according to expectation and speculative factors. For example, DRI/McGraw-Hill maintains a large-scale econometric model of the world spot oil market and produces regular price forecasts and simulations (IEA, 2001a). The US Department of Energy (DOE) also maintains a spreadsheet model designed explicitly to predict oil price and demand responses in the event of a major disruption (IEA, 2001a).

Based on the DRI model, a sudden cut in oil production of around 1 mb/d leads approximately to an average increase in crude oil price of $1.50-$2.00 per barrel within about three months, assuming prices in the $15-$20 per barrel range. In the DOE model, prices are more sensitive to supply losses. Each 1 mb/d of lost supply increases spot crude oil prices by $3.50-$4.00 per barrel in the first quarter and progressively less for the second and third quarters.

The lack of a clear correlation between initial supply losses and the resulting oil price increases occurs, because during past crises these losses were in most instances rapidly offset by production increases in countries not affected by the crises (IEA, 2001b).

Other studies have focused on analysing the economic impact of oil price increases. For instance, one of the official EU documents about security of oil supply has estimates that an increase of $10 in the price of a barrel of crude oil is likely to reduce economic growth in the industrialised countries by around 0.5%. Another study produced by the International Monetary Found estimates that a $10 per barrel increase in the oil price, if sustained for a year, reduces global GDP by 0.6% – ignoring the secondary effects on confidence, stock markets and policy responses (EU, 2002).

4. Social costs of electricity shortages

The social costs of energy disruptions related to electricity shortages are easier to distinguish as a result of their immediate negative impact and relatively small, indirect and successive effects. Generally, the social costs of an electricity disruption depend on the quality and composition of various factors:

- the extension of the disruption in terms of the area affected (and the demographic density of the territory);
- the existence of alternative energy sources that could or could not replace the missing energy (i.e. the solar energy disposals in a small area in New York guaranteed their inhabitants a continuous energy flow during the last disruption on 14 August 2003);
- the duration and the continuity of the disruption;
- the specific time of day at which the disruption occurred;
- the season, given that climate is a very important factor for both the magnitude of the disruption and the scale of consequences (usually summer black-outs are more serious due to air conditioning); and
- the availability of advance warning and information.

In order to evaluate all the public and governmental sectors affected by an energy shortage, it is useful to overview what happened during previous black-outs in North America and in Europe. A possible list of social costs that could occur after an energy disruption is below.

1. Expenditure for military, police and emergence actions (excluding health)

- Costs of activating a counter-terrorism response, because of the lack of an immediate warning about the black-out
- Costs of emergency requests to police and public order forces (arrests, riots)
- Costs of emergencies for fire workers (i.e. fires, elevators, closing doors, subway, etc.)

2. Expenditures for public transport

- Costs to public railways owing to interruption include reduced revenues, increased emergencies, delays (affecting both the public transport system and consumers) and increased risks of accidents (i.e. computer interruptions in the traffic planning-system)
- Costs of subway interruptions include reduced revenues, increased emergencies, increased risk of accidents, delays (affecting both the public transport system and consumers)
- Costs of flights, increased emergencies, delays (effects on consumers) increased risk of accidents

3. Health care expenditures

- Immediate costs to the health care infrastructure (hospitals, emergencies, laboratories) such as emergency surgery, emergency medical-service calls, loss of medicines, organs, blood and analysis (and experiments) owing to reduced refrigerating capacity (prolonged shortage)
- Post black-out health expenditures (relating to violence, injuries as a result of fires, food poisoning, panic attacks and uncomfortable temperatures)

4. Sanitation and waste disposals

- Immediate costs for the interruption in sanitation services and waste disposal, as well as recycling systems or composting/incinerator disposals
- Further costs owing to excessive waste accumulation
- Possible sanitary costs relating to the reduced capacity of wastewater treatment facilities

5. Other public services

- Costs relating to the interruption of classes in public schools and universities
- Food losses (reduced refrigeration capacity) throughout public facilities
- Social costs for illness (reduced work capacity)
- Costs pertaining to the interruption of other public administrative services (councils, assistance, etc.)
- Loss of museum revenues
- Political ‘fallout’

6. Human life values

- Costs relating to mortalities
- Costs as a result of illness
- Losses of leisure time, personal injury, fear and panic

Additionally, all of the sectors described above could face further high costs (Rios et al., 1999), which are linked to:

- idle but paid-for resources such as labour or capital
- equipment damage
- process-restart costs
- spoilage of resources
- utility restoration costs

In order to analyse the links between the direct and indirect effects of energy disruptions, a classic example could be the negative impact of electricity shortages on farmers and consequently on consumers. In this case, however, the time lag of the consequences could be longer, even up to one year. The example taken from US experience can be perfectly adapted to the situation in the EU, owing to the high subsidies that characterise the agricultural sector in the two regions. The economic losses borne by farmers in terms of reduced income are partly replaced by public subsidies, changing the private cost (to farmers) into a social cost (taxes for citizens).

Looking at disruptions of energy supply to agriculture of even short durations, the effects on farmers could be a substantial reduction or even a complete loss of an entire growing season (such as a shortage of electricity to pump water during a drought season or to milk cows, etc.).

Following studies from the US National Council of Farmer Cooperatives (NCFC) and the US Agriculture Department, agriculture and the rest of the rural sector are typically at the end of the energy distribution chain, with fewer alternative supply options and greater vulnerability to disruptions. An initial (direct) effect could be the shortage of energy-dependent services (i.e. irrigation or milking cows) and a consequent loss of crops. Another (indirect) effect depends on energy price increases. In the event of energy price spikes, farmers, as price-takers for their commodity, are unable to pass price increases for energy or fertilizer on to the consumer, and therefore receive an even lower return for their products.

The US Department of Agriculture recently estimated that the price increases for energy inputs and fertilizer owing to energy disruptions during the past few months in California – if projected into the year – could result in a 1-2% increase in total costs of production. This may not seem significant, but it becomes a serious matter when considering that this cost increase would translate into a one-third decrease in net farm cash-income.

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About INDES

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The INDES project focuses on market-compatible, cost-effective security of supply responses by the European Union. Security of supply is understood as insurance against risks, in which responsibility is shared between the EU, member states, energy companies and customers. Thus security of supply is seen as an economic risk-management strategy. Critical to such an approach is first the minimisation of the insurance 'premium' to achieve the degree of security that is politically called for. Second, there is a need to identify the best systemic actor able to 'hedge' the risk. This can be governments, companies, consumers or in some cases, the market itself subsequent to careful design. Based on these premises, INDES research has emphasised two areas: i) costs of energy supply disruptions and ii) costs of potential policy responses. Towards this end, robust methodologies to assess costs and a sound empirical basis for cost data were used as the precondition for informed policy choices reflecting both effectiveness and cost-efficiency. Following this work, INDES research sought to identify the appropriate market-compatible instrument and the associated actors that would convey the process, be they governments, companies or consumers.

INDES has operated around three axes. The first was academic workshops that developed and refined the methodological framework and empirical base. The second was stakeholder workshops that presented and discussed findings with policy-makers and other stakeholders. The third axis has been the promotion of publications – both academic and policy-relevant – that aim at participating in the existing academic debate and influencing policy-makers. For more information on the project and the series of working papers, visit the INDES website at http://www.energymarkets.info/indes/index.html.

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