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VALUING THE ENVIRONMENTAL IMPACTS OF OPEN CAST COAL MINING:

The case of the Trent Valley in North Staffordshire

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Abstract
Opencast coal-mining is often associated with extensive environmental costs, which are not usually accounted for in financial appraisals of opencast projects. We examine the case of a proposal for an opencast mine in the Trent Valley, part of the North Staffordshire coalfield of the United Kingdom. We report the results of a survey of local estate agents, which suggests that, as measured by the impact upon local house prices, the monetary environmental costs could be sufficient to reduce substantially the economic viability of the proposal. Moreover, we conclude that opencast coal in the Trent Valley is almost certainly more costly to produce than alternative deep mined coal.

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Introduction

Over the past twelve or so years there has been a marked increase in opencast coal-mining in the United Kingdom. Annual production of opencast coal has risen from 13 million tonnes in 1979 to 19 million tonnes in 1992 (The Flowers Commission, 1981, Trade and Industry Select Committee, 1992). About 16 million tonnes of the current production is produced by British Coal, the rest by a small private sector. The increase in opencast production has been largely driven by the need to make the coal industry more profitable in preparation for its privatisation. The low financial costs of extracting opencast coal make it the most profitable part of British Coal's operations. Although opencast coal production makes up only about a fifth of British Coal's output, the profits generated by opencast for 1991/92 were £171 million out of a total operating profit of £361 million (British Coal Opencast, 1992a).

In order to renew these profits over the next few years British Coal will have to continue to develop new sites for opencast mining. There are 58 sites currently producing opencast coal in the U.K. but each year about 12 of them become exhausted and need to be replaced (*ibid.*). The main difficulty which British Coal confronts in obtaining planning permission for these sites is the opposition to the environmental damage which can be generated by opencast mining techniques. The Council for the Protection of Rural England, for example, has stated that opencast coal-mining is "one of the most environmentally destructive activities being carried out in the UK" (Trade and Industry Select Committee, 1993, p. 73). Any trawl through the monthly opencast updates of *UK Coal Review* reveals that numerous local pressure groups have been formed throughout the coalfields in opposition to opencast mining. Common complaints are that opencast mining generates noise from the use of heavy machinery, dust from the extraction of top soil during the summer months, traffic problems, visual impact, and not least the long-term environmental damage which can be caused to rural areas even after restoration. Indeed, the Flowers Commission (1981) reported that

"...the combined effects of opencast operations can, for those badly affected, add up to a very severe diminution in the quality of life" (p. 83).

The tension between the profitability and environmental damage of opencast coal-mining has taken centre stage in the debate over British energy policy which has ensued in the wake of the announcement in October 1992 of the UK Government's (deep mine) pit closure programme. One of the key recommendations of the much publicised report of the Trade and Industry Select Committee (1993) is that, "in view of the environmental disadvantages", British Coal, or perhaps a proposed "Coal Reserves Authority", should "use their control over licences to bring about a reduction in opencast coal output" (p. 119). This would increase the market for deep-mined coal, thereby reducing the number of deep mine pits which need to be closed.

In response to this argument, the Government has recognised that a reduction in opencast production would leave more room in the market for deep-mined coal. The recent White Paper on the coal industry reports that British Coal "project a reduction in its opencast output from the current level of 16 million tonnes to 12 million tonnes in 1997/98" (Department of Trade and Industry, 1993, p. 110). This projected fall, however, is presented merely as an internal decision by British Coal "during the transitional period while it reduces deep-mined costs in order to secure a viable deep mine industry in the longer term" (*ibid.*, p. 110). The Government has not made any policy recommendation on the overall level of opencast coal production. Moreover, on the question of licences, "it will be for current or prospective developers in the licensed sector, in the light of their own business plans, to decide the level of output for which they wish to aim" (*ibid.*, p. 111). There is a clear belief that, since opencast coal-mining is profitable, the market should be allowed to decide how much production should take place. The *Sunday Telegraph* concludes that "the outlook for open-cast was brightened by Heseltine's white paper, which promised looser rules once British Coal is privatised" (4.4.93).

This liberalising of the rules over the licensing of opencast sites, by the Department of Trade and Industry, is to some extent contradicted by a tightening up of the rules in the new interim planning guidance issued by the Department of Environment. Paragraphs 5 and 6 of the original Mineral Planning Guidance Note 3 (MPG3), which included a double presumption in favour of opencast coal, have been withdrawn. The new interim guidelines state that whilst "coal which can be produced economically is an important energy resource" it must be produced in an "environmentally acceptable way and consistently with wider environmental objectives, including the principles of sustainable development" (Department of Environment, 1993, p. 2). Mineral planning authorities are now instructed to prepare Mineral Local Plans, which decide which prospective sites should and should not be developed by comparing the benefits, economic or otherwise, with the environmental costs.

In this paper we seek to undertake such a comparison in relation to a case study for the Trent Valley, a prospective opencast site on the edge of the North Staffordshire coalfield. This site is of a fairly typical size, covering only a slightly larger area than the typical site developed by British Coal. The site is situated in a green belt area in which part of its boundary runs along the banks of the infant River Trent, where the land is used entirely for agricultural purposes. Although one advantage of opencast mining is that it can be used to reclaim derelict land, no such benefit can be derived from the Trent Valley site. Indeed this seems to be the case with most new prospective opencast sites. As far back as 1980, the Flowers Commission (1981) calculated that, of all the land used for opencast mining, only "...about 14.4% could be attributed to some form of derelict land clearance" (p. 82). Beynon *et al.* (1990) observe that "opencast operations are slowly moving onto land of higher agricultural potential and into areas of greater environmental sensitivity" (p. 110). The Trent Valley proposal is therefore fairly typical of new prospective opencast projects in that its inception would most likely generate adverse environmental impacts.

The main objective of this study is to calculate the costs of the environmental impacts of an opencast project and compare them to the benefits to be gained from the coal extraction. The key question to be addressed is whether the social benefits outweigh the social costs, a surplus implying an economically viable project. A social project appraisal of the site is carried out to quantify the environmental impacts and compare them to the financial returns. In the first part of the paper we introduce the technique of social project appraisal and look at the problems associated with the estimation of shadow prices for the case of opencast coal-mining. We explain how the exclusion of external costs and benefits from a project appraisal can lead to a divergence between economic and financial viability. In the second part, the Trent Valley site is introduced and we examine the benefits which could be gained from the production of opencast coal. In the third part, we consider which methodology would be most appropriate for measuring the environmental costs of the opencast project . The technique we employ for the valuation is the hedonic pricing method, through which the environmental costs incurred by a project can be identified by looking at the impact on house prices. In the final part, this methodology is applied to the Trent Valley site using a survey of estate agents with a specialised knowledge of the area. The environmental costs are compared to the benefits from the project, and a tentative assessment of its economic viability is provided.

An Introduction to Social Project Appraisal

In the view of Pearce and Nash (1981), cost-benefit analysis (CBA) "merely formalises a common-sense concept of rationality" (p.5). Accordingly, it is argued that a rational individual is one who weighs up the costs and benefits of an action in deciding whether to perform that action. Of course, what we term "benefits" and "costs" depends on our own personal orientations and motivations. But the essential point remains that it is rational to make a decision which implies a surplus of ensuing benefits over costs.

If we accept that we all, to a greater or less extent, perform our own personal cost-benefit analyses whenever we make a decision, then we might think it reasonable to translate this form of reasoning to the higher level of social decision-making. We can expect social decisions to involve a potentially wide range of different costs and benefits falling upon many individuals. This latter feature could present us with a problem. For whereas we might think it acceptable for an individual to trade off *personal* costs against *personal* benefits, we might be less willing to allow some decision-making body to trade off individuals *against each other*, depending on whether they benefit or suffer from a decision. We are then left with a number of options. Firstly, we could require all decisions to be made on the basis of unanimity, in which case actions would in general only be taken if all individuals were likely to be made better off, or at least no worse off. Alternatively, we might require any individuals who were made worse off to be compensated by those who gained. Such a decision rule is consistent with the criterion of *Pareto improvement.* Thirdly, we might allow actions to be taken so long as there was a general surplus of benefits over costs, irrespective of any actual compensation taking place. This is the Hicks-Kaldor compensation test (Hicks, 1939; Kaldor, 1939), based on a criterion of *potential* Pareto improvement.

It is this latter approach which is adopted when CBA is performed for social project appraisal. Accordingly, a project is deemed to be socially worthwhile if the sum of all the benefits exceeds the sum of all the costs. This has a number of implications. Firstly, the fact that costs and benefits need to be aggregated and compared implies that they must be measured in money values to overcome the problem of interpersonal comparisons of utility. Similarly, calculations are generally in terms of present values to permit the comparison of costs and benefits which occur at different times. Secondly, what is "economically" justifiable in terms of the results of a CBA may not be politically or morally acceptable. This is because the use of money as a yardstick says nothing about where or when individual costs and benefits actually fall. The use of distributive weights has been suggested to take account of the problem of suboptimal income distribution, although their use is controversial. Discount rate differentials are often advocated to take account of the interests of future generations when projects have a long lifespan. Policies of *sustainable development* serve the same purpose. Finally, it is *economic* costs and benefits which matter for the purpose of a CBA. Standard market prices can only be used as estimates of these when markets are perfect and complete; when they are not, we cannot expect economically justified projects to be necessarily financially viable. Similarly, financially viable projects may not always be economically justified.

It could be argued that the absence and imperfection of markets are the *raison d',etre* of economics as a discipline. Absent markets are what tend to characterise environmental goods and services, and as a result we can normally expect the environment to be neglected by private agents. Therefore, a large part of social project appraisal is often the incorporation of these items into the project balance sheet. We will consider methods for doing this in a later section. Here we need to consider briefly why market prices might not be accurate indicators of economic value, and how we might try to adjust them. This process of adjustment is generally termed *shadow pricing*.

When appraising a project, for market prices to be accurate measures of economic value, the following necessary conditions must be met (Pearce & Nash, 1981). For the case of project outputs, individuals should be able to purchase, at a given price, as much of the good in question as they wish. The price of the output is then equal to the marginal benefit derived from its consumption. Similarly for inputs, we need to assume that the price paid is equal to the marginal product of the input in production. This ensures that the input price is equal to the opportunity cost of diverting the input from another valuable use elsewhere in the economy.

Pearce and Nash (1981) have examined in some detail the imperfections which might lead to a need for shadow pricing. For the present case of opencast coal-mining, we can identify several potentially relevant instances. Firstly, as is often the case with extractive industries, the structure of coal mining in the United Kingdom is significantly oligopolistic, with the nationalised British Coal and its subsidiaries accounting for 76% of the domestic market (Department of Trade and Industry, 1993). As we have already indicated, monopolistic practices such as pricing in excess of marginal cost will not necessarily cause us a problem because prices can still reflect customers' marginal willingness to pay, and hence the marginal benefit of production. However, even within the context of an electricity supply industry privatised since 1990, the coal market is only now beginning "to free up" and escape the restrictions of long-term purchase contracts which had greater political motive than economic *rationale*. The "Joint Understanding" was estimated to cost the then Central Electricity Generating Board £950 million per year in 1985 (Vickers & Yarrow, 1985). The fact that the future of the domestic coal industry is regarded as being under threat now that these contracts are coming to an end is an indicator of the extent to which the price at which coal has been traded in the domestic market has exceeded customers' marginal valuation. The integration of the world coal market implies that it is the world price which is the appropriate indicator of the value of coal. Given the small size of the United Kingdom coal market relative to the world market, and the willingness of new country producers to increase their supply, "the large gap between United Kingdom and world prices is likely to be closed by levelling the United Kingdom price down rather than bidding the world price up" (Robinson, 1989, p.94).

In a similar way, market prices can be misleading when inputs to a project are priced in excess of marginal cost. Then what appear as financial costs which depress private profit can actually represent significantly smaller economic costs. This is often said to be the case with the labour market, where labour can continue to earn positive returns despite the existence of high rates of unemployment, implying low opportunity cost. Strictly, in this situation wages should not be included as an economic cost in the appraisal of a project. This does assume that the new employment resulting from the project will be an actual increase in the amount of labour employed in the economy, whereas in situations of long-term, structural or voluntary unemployment, there is a possibility that the project might serve simply to attract already-employed workers away from their present positions. Unfortunately, the methodology we choose for calculating the expected costs of the North Staffordshire opencast project does not allow us to separate out labour from other costs. However, we might reasonably assume that opencast mining is not a labour-intensive activity. In 1991/2, only 6,500 workers produced 16.7 million tonnes of opencast coal (389 workers per million tonnes), compared with 54,000 workers producing 77 million tonnes of deep-mined coal (701 workers per million tonnes) (Department of Trade and Industry, 1993). Failing to adjust for any labour market imperfection is therefore unlikely to have a substantial impact on the outcome of the appraisal.

Finally, the presence of taxes and subsidies can cause economic and financial prices to diverge. It might be the case that taxes and subsidies have been imposed in a genuine attempt to correct a previously identified market imperfection, in which case it is perfectly legitimate to include them in the appraisal calculations. However, many such interventions exist for purely political ends or by historical accident. The first-best solution to this problem is the removal of the offending policy, but for various reasons a second-best treatment might be necessary via shadow pricing (Pearce & Nash, 1981).

For the current case, the most likely example of a *non-economic* subsidy which might concern us is mortgage interest tax relief, or mortgage interest relief at source (MIRAS), as it is known in the United Kingdom. As we explain in a later section, the method we choose for estimating the value of the environmental impacts of the opencast proposal involves the collection of data on house prices and estimates of likely changes. But the effect of MIRAS is to subsidise house purchase, so that house prices will exceed purchasers' marginal willingness to pay. Willis *et al.* (1993) have illustrated how the impact of MIRAS can be extracted from existing prices, and we follow this procedure in the environmental valuation.

Coal in the Trent Valley

George Orwell, in his famous study of social conditions in the industrial North of England in the 1930s, *The Road to Wigan Pier*, made a short visit to the Pottery towns of Stoke-on-Trent. On noting the problems which industrial development generated in this area, he was able to conclude that

> *"The best thing one can say for the pottery towns*
> *is that they are fairly small and stop abruptly.*
> *Less than ten miles away you can stand*
> *in undefiled country on almost naked hills,*
> *and the pottery towns are only a smudge in the distance"*
> *(Orwell, 1937, p. 96).*

Between two of the hills between which Orwell must have travelled can be found the area of the Trent Valley. To the north of the Potteries, the Trent Valley is situated on the boundary between the city of Stoke-on-Trent and the District of Staffordshire Moorlands. It is here that the Potteries come to an abrupt end, with the urban/industrial landscape replaced by rural farmland.

British Coal have been prospecting for coal in the Trent Valley, using bore holes to examine the nature of the coal reserves, since November 1992. As yet, no formal planning application has been submitted to mine this area, only a prospecting clearance boundary plan. In this plan the prospective opencast site is referred to as Biddulph South.

Figure 1 shows a map of the site with the urban fringe of Stoke-on-Trent represented by Ball Green to the east, and the rural villages of Staffordshire Moorlands represented by Brown Edge to the west. The head of the River Trent is shown to run its course through the valley from Knypersley Pool southwards towards the Potteries. The site covers an area of 269.7 hectares on the western side of the valley, where the coal seams outcrop from the North Staffordshire coalfield.

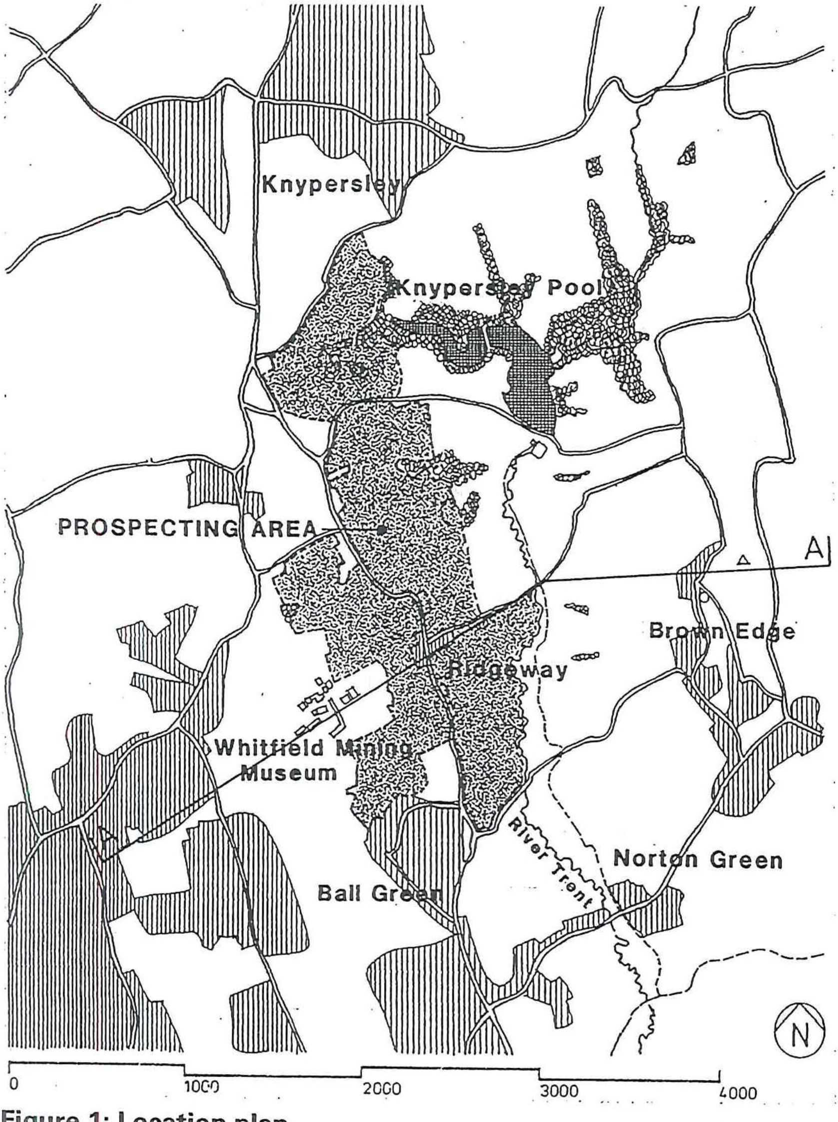

Figure 1: Location plan

Figure 2 shows a cross section of the site drawn from Brown Edge Church southwards along Tongue Lane, which joins Brown Edge with the small village of Ridgeway. Using information taken from bore hole reports of the geology of this area, the cross section shows the coal seams which outcrop on the site.

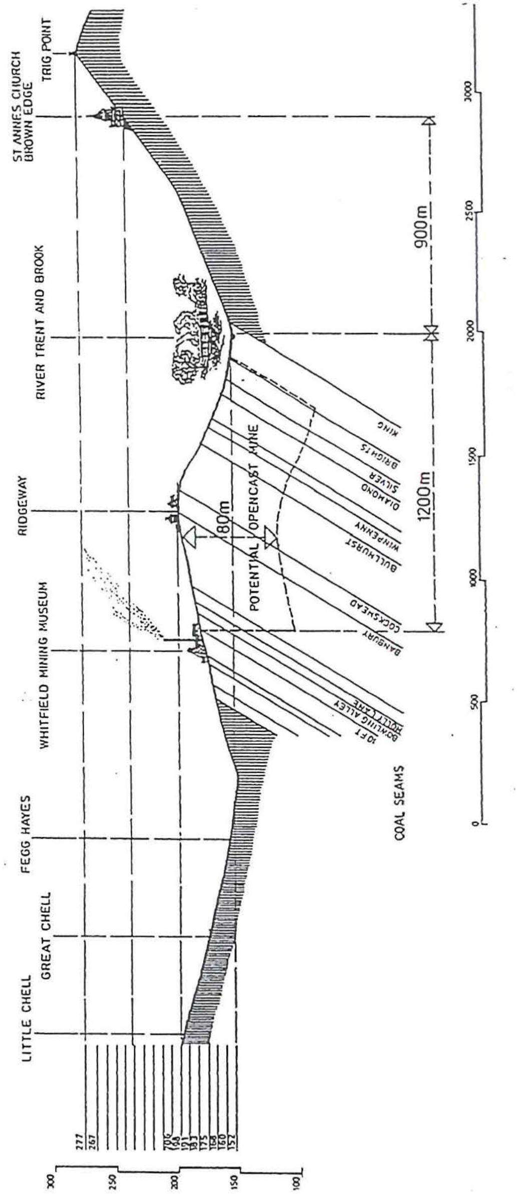

Figure 2: Section AA

To calculate the benefits which can be generated from mining the site we need to estimate how much coal could be extracted. While we do know the thickness of the seams and the area of the site, we do not know how deep British Coal would be prepared to mine it. British Coal Opencast (1992c) report that the most common depth for opencast mines in the UK is about 80 metres in depth, which is shown in Figure 2, but even if this depth was used it is very difficult to predict how much of the coal reserves would be extracted. British Coal, or its licensed contractors, could either extract the coal by digging mines either side of the small village of Ridgeway, or, as is shown in the cross-section, they could buy up the houses in the village and take out all of the coal. It is also not known how much of the coal may have already been extracted from old mine workings. The cross-section diagram therefore serves simply as an illustration of how the coal reserves in the Trent valley could be mined by opencast methods.

An estimate of the volume of the coal which could be extracted from the site can be made using national figures on opencast coal production. British Coal Opencast (1992a) reports that the typical opencast site in the UK consists of 206 hectares and produces 2.2 million tonnes of coal during the course of its lifetime. Since the Trent Valley site is about a third larger than the average size at 269 hectares, we can make the simplifying assumption that it produces about a third more coal than the typical site, a figure of 2.9m tonnes. The validity of this assumption is supported by the observation in Figure 2 that there are eleven seams which outcrop on the Trent Valley site. British Coal Opencast (1992c) reports that, for the average site, eleven coal seams are mined.

Some similar calculations using national figures are needed to estimate the costs which British Coal would incur from mining the Trent Valley site. Such calculations are difficult because there is a long gestation period from initial drilling to the production of coal. "Typically, it may take five to seven years from initial drilling before site work can start, longer if a Public

Inquiry is involved" (British Coal Opencast, 1992b, p. 13). Since exploratory drilling for the site started in 1992, we need to predict the costs of mining opencast coal from 1997 onwards. The Trade and Industry Select Committee (1993) reports that "British Coal expects its opencast costs to be between £1.10 and £1.20 per GJ by 1997-98" (p. 74). We shall assume that opencast coal in the Trent Valley could be produced in 1997-98 at a price of £1.15 per tonne.

The profits which can be made from mining the site depend on the price at which the coal can be sold. The price which British Coal will command for its coal in 1997/8 is difficult to forecast because it will depend on the competitiveness of imported coal. The private electricity generator National Power considers that a price of £1.30 per GJ "would give a delivered power station price roughly equivalent to that for internationally-traded steam coal over the longer term" (Trade and Industry Select Committee 1993, p. 34). The Select Committee itself considers that a price of £1.33 per GJ would make it "probable that BC coal will be competitive by 1997/98", if only at "most inland power stations" (*ibid.*, p. 34). This latter price will be taken as the bench-mark figure for the market price of coal.

Using these forecasts it can be assumed that British Coal could gain profits of £0.18 per GJ if it were to develop the Trent Valley for opencast coal-mining. This estimate must now be translated from GJs to tonnes using information for the North Staffordshire coalfield in which the Trent Valley is situated. North Staffordshire coals vary in their calorific value from 14,300 to 15,700 BTUs/lb, or 25-35 GJ per tonne. (Fenton *et al.*, 1961; Milliot, 1941; Milliot *et al.*, 1946). We shall use the mean of 30 GJ per tonne for coals in the Trent Valley. Given the assumed production of 2.9m tonnes a total profit of £15.5m is predicted for the site.

These profits will, however, be produced over a period of time, and "the average working life of an opencast mine is just six years" (British Coal

Opencast 1992c, p. 7). Since the Trent Valley site is about a third larger than the typical site we shall assume that it would have a working life of eight years. These profits would not, of course, be produced evenly over this period. The first year or so of development involves some initial costs of equipping the site and removing the overburden before coal production can commence. We shall therefore assume that the predicted coal profits will be earned over a period of seven years starting from the second year of the project. The profits generated per year would therefore be £2.2m. Applying the Treasury discount rate of 8 per cent, gives a total discounted profit of £7.8m.

This volume of profits gives an indication of the possible benefits to be gained from mining opencast coal from the Trent Valley site. Since the calculation assumes an internationally traded price for coal, it shows the benefits to be gained from mining opencast coal relative to the price of importing coal from outside the UK. Also of interest are the benefits to be gained from mining opencast coal relative to the costs of producing deep-mined coal. As it currently stands there is a shrinking market for coal in the UK energy market, and as has been observed earlier there is, to some extent, direct competition between deep-mined and opencast coal.

The Trade and Industry Select Committee (1993) reports British Coal's predictions for 1997/98 to be "average deep mine costs of £1.25 to £1.30" (p. 74). We shall use the mean of £1.275 per GJ as an indicator of the costs of deep-mined coal. This prediction is, to some extent, consistent with the forecasts for the deep mine pit nearest to the Trent Valley, Silverdale in North Staffordshire, one of the 31 pits earmarked for closure in October 1992. A Government-appointed review of 21 of these pits forecasts costs per GJ at Silverdale of £1.26, assuming a full range of improvements in productivity over the next two to five years (Department of Trade and Industry, 1993).

Using the predicted deep-mined cost per GJ of £1.275 and comparing this with the predicted cost of opencast coal (£1.15) gives a difference of £0.125 per GJ. Assuming 30 GJ per tonne gives a total net cost differential between opencast and deep-mined coal of £10.8m. Discounting results in a prediction of £5.4m for the relative benefits of opencast (compared with alternative deep-mined coal) for the Trent Valley site. In other words, opencast coal from the Trent Valley site could be about £5.4m cheaper to produce than if a comparable volume of coal was produced using existing deep-mined capacity. British Coal would make £5.4m more profit from developing the Trent Valley than it would from alternative deep-mined production.

These estimates of the benefits of opencast coal concentrate purely on the total profits to be gained from the Trent Valley site, and the magnitude of these profits relative to the profits from coal extracted from deep-mined pits. There are, in principle, other gains associated with opencast coal-mining. The new interim planning guidance for opencasting states: "It is also relevant to consider whether a particular proposal for coal extraction would itself provide national, regional or local benefits to offset the disturbance occasioned during development and restoration - e.g. through contributing to U.K. employment, the clearance of dereliction or other improvements to the quality of land, the creation of nature reserves or the provision of other benefits" (Department of Trade and Industry, 1993). These additional criteria do not apply to the Trent Valley site. We have already noted that opencasting is much less labour-intensive than deep-mined production so that it does not directly contribute to employment. In addition, since the land in the Trent Valley is currently used for agricultural purposes, there are no benefits to be gained from reclamation. There are also two nature reserves already *in situ* at Ford Green, which is a SSI (Site of Special Scientific Interest) to the south of the site, and at Greenway Bank Country Park, a popular tourist attraction situated at Knypersley Pool. There are no clearly discernable benefits to be gained from opencasting in the Trent Valley other than the profits which could be made from the coal itself.

Approaches to the Valuation of Environmental Impacts

The total economic value (TEV) of a commodity is made up of several components. Use value is the most obvious, and is likely to constitute the majority of the value of most commodities. It relates to the preferences people have simply for using an asset directly or consuming the services it provides. But individuals might be uncertain about the direction their preferences might take in future. Then they might be willing to pay a premium over and above their simple use value, in order to secure the *option* of use in the future. This "option value" (Weisbrod, 1964) has been shown to be equivalent to a standard insurance premium under general assumptions (Cicchetti and Freeman, 1971). Moreover, commodities might be valued purely for their existence independent of any current or future direct use. This "existence" or "non-use" value tends to be more important when it relates to a unique or well-known commodity. Only experimental methods are available for its estimation (see below).

Even if markets were not perfect, as long as they were complete we could expect all of these types of values to be reflected at least to some extent in the prices of all commodities. We have already seen how the process of shadow pricing can be used to address the problem of market imperfection, and to amend existing market prices so that they reflect more accurately marginal social costs and benefits. But a large class of commodities is not traded on standard markets, so prices do not obviously exist. This is true of the great majority of environmental commodities. As is well known (e.g. Baumol & Oates, 1988), a lack of pricing implies the presence of externalities, which in turn produces resource misallocation. For the purposes of social project appraisal, therefore, it is clearly desirable to attempt to incorporate these external benefits and costs into the project balance sheet. But, whereas in the case of imperfect markets we at least had existing prices to use as a starting point for estimating the correct shadow prices, missing markets implies by definition missing prices.

Because of this, several valuation techniques have been developed for the estimation of values of commodities for which conventional markets do not exist. The household production function (HPF) approach uses expenditures on goods that are substitutes or complements for the commodity in question to value changes in that commodity. For instance, expenditure on sound insulation might be taken as a proxy for the benefits of noise reduction. Similarly, the recreation and amenity benefits of a particular site might be estimated from the expenditure and time required for the visit. Market-based approaches concentrate on "dose-response" relationships and replacement-cost estimates. Accordingly, some of the costs of air pollution could be estimated by the value, in market prices, of any drop in the yield of agricultural products due to poor air quality (dose-response), and the cost of repairing damage caused to buildings for similar reasons (replacement cost). Experimental methods generally involve the direct elicitation of individuals' preferences via questionnaire. Most commonly, these questionnaires ask for money valuations of non-market goods *contingent* on markets actually existing. (Hence this method is termed *contingent valuation*). This is the only method available for the estimation of non-use values (see above). Further, researchers are not constrained to observe existing behaviour or to employ surrogate markets. These advantages are countered by the fact that study design and implementation may need to be quite complex and expensive if the results are to be reliable.

All of the above techniques have their limitations, which make them unsuitable for our purposes of valuing the environmental impacts of an opencast mining project. The market-based approaches are too piecemeal and would need to be supplemented by other estimates. But a full-blown contingent valuation or travel-cost estimation, although probably the ideal, would require a large input of time and resources. Ultimately, it is not our intention to perform a full social cost-benefit analysis on the North Staffordshire proposal. Rather we hope to illustrate how economic costs and benefits can be incorporated into a project appraisal, and how a purely financial computation of the viability of an opencast mining project might be misleading from a social point of view.

To this end, we selected a variant of the *hedonic pricing* approach for our environmental valuation exercise. In its conventional form, this approach interprets market goods as bundles of characteristics, and uses cross-sectional analysis to derive the implicit, or *hedonic*, prices for each of them. Values for optional automobile features (e.g. Griliches, 1971) and work-related risk (e.g. Marin & Psacharopoulos, 1982) have been estimated in this way. It has also been applied extensively to the property market. Freeman (1979) notes that the classical theory of rents has long recognised that productivity differentials will yield differential rents to land and therefore differential land values. Productivity here can refer to real impacts on the outputs of physical goods, or to more qualitative services such as the amenity provided by the environment.

It is this latter class which is likely to be more relevant to the case of residential property. We can interpret a house in Lancasterian fashion as a bundle of characteristics, which provides housing services of a given quantity and quality. The environmental impacts experienced through residence in a particular house, such as a pleasant view, or traffic noise from a busy road, are simply additional attributes (Pearce & Nash, 1981), and can be expected to be associated with their own implicit prices. Hence, we can postulate a housing expenditure (*H*) function of the form

$$H = h(a_1 ... a_n)$$

where the a_i variables are the various characteristics the housing stock may possess (*ibid.*). The conventional hedonic approach uses cross-sectional data to provide many observations on this single function. However, in the present case of the North Staffordshire proposal, we could assume that all other characteristics of the affected houses would remain unchanged by the project, while the environmental characteristics varied directly as a result of increases in noise, dust, reduced amenity and recreational possibilities, and so on. We might then expect housing expenditure to change such that

$$\Delta H = h(\Delta a_1^o \ldots \Delta a_n^o, \Delta a_1^e \ldots \Delta a_n^e)$$

where the *e* superscript refers to explicitly environmental characteristics, and *o* refers to all others. If we can obtain estimates of ΔH via some means, and assume that $(\Delta a^o_1 \ldots \Delta a^o_n) = 0$, then this should provide us with a simple monetary estimate of the values of all those impacts, due to the opencast proposal, which are associated with residence in the area. The obvious advantage of this approach is that it is only observations, or predictions gained from interviews with estate agents, for instance, of ΔH which are required, and this should not be overwhelming given a reasonably developed housing market. The difficult problem of identifying all of the economically-relevant environmental impacts is avoided.

Freeman (1979) has indicated under what conditions we are able to assume that changes in property values are a measure of benefit changes. Most importantly, we must be able to assume that "some mechanism exists to ensure that all potential surpluses are eliminated by higher land rents" (*ibid.*, p 111). Thus

> *"If potential land users are forced to bid against each other for the use of a parcel of land [of higher environmental value], rents and property values will rise until land users are indifferent between [more valuable] parcels at higher rents and [less valuable] parcels at lower rents. Then land users' willingness to pay for [more valuable environments] is completely captured by land owners as rent" (ibid., p.111).*

There are a number of features of residential housing markets which might mean that this process of competitive bidding might not be complete in practice. The most obvious is that markets might not be open enough, and the mobility of residents and potential residents might be restricted. Then competition might not be intense enough to ensure that all the surpluses are bid away, and utility levels between residents will not be equalised. In other words, existing residents might be able to continue to enjoy the benefits of surpluses without having to increase their rent payments.

Is this a serious problem for our desired methodology? There is reason to believe that it may not be. For what a lack of mobility implies is that rents will not rise sufficiently to remove the surpluses enjoyed by existing land users. Then, using changes in property values will provide an *underestimate* of the actual change in benefits. But as we have already indicated, this is not critical to our objectives. And it might well be that the North Staffordshire proposal would turn out to be economically unjustified even on the strength of underestimates of its environmental impacts.

In fact, there is good reason to expect a property price-based approach to lead to an underestimate of the environmental impacts, even if all surpluses were competed away. This is because there are likely to be other environmental impacts which are not related specifically to residence. For instance, non-residents are able to spend time and resources travelling to a site for amenity and recreational purposes, but these benefits will not be captured in house prices. Further, non-residents and residents alike might hold non-use values (see above) which are not related to being in contact with the site in question. These values will also be missed.

These points should be borne in mind. In the next section, we detail the procedure used to arrive at an estimate of the value of the environmental impacts of the North Staffordshire proposal. For reasons outlined in this section, we can assume that the value arrived at is a *lower-bound* estimate.

Valuing the Environmental Costs of the Trent Valley Proposal

In assessing the environmental costs of developing the Trent valley site for the production of opencast coal, we shall concentrate on the possible impacts on housing equity in the several villages which surround the site. If the mine were to generate a fall in house prices in these villages, then this would provide an indication of the environmental or social costs of developing the site.

In order to measure the possible impacts of the prospective mine on house prices, a survey was carried out of estate agents with specialised knowledge of the Trent Valley area. A pilot visit to one of the local estate agents was made in July 1992 so as to establish what problems might arise in designing an appropriate survey. The full survey itself was carried out in December 1992 and January 1993. Out of the seven estate agents interviewed five were qualified chartered surveyors, although those which were not had considerable experience of valuing properties in the Trent Valley area. Of particular importance is the considerable experience which all seven interviewees had of other opencast coal-mining sites in North Staffordshire and the impacts of these sites on house prices.

Each estate agent was visited in person and asked to answer verbal questions from a structured questionnaire. In response to an initial open-ended question, all seven interviewees considered that opencast mining on the Trent valley site would have an adverse effect on house prices. In support of this position evidence was offered in relation to existing opencast mines in North Staffordshire. Disturbance to house prices was also reported to have taken place due to the uncertainty created by prospective opencast developments, including the Trent Valley site itself.

More specific questions were asked about the extent to which house prices would fall if the opencast mine was developed in the Trent Valley. Interviewees were asked to consider four types of property, valued at £35,000, £65,000, £120,000 and £250,000. For each category the question was asked, "By how much do you think the value of such a property would change if it were located next to the opencast site?", for which all interviewees were able to provide an answer.

The estate agents were then asked to identify on a map which areas they considered the predicted falls would be likely to affect (see figure 1). The villages of Ball Green and Ridgeway were considered to be most severely affected because of their close proximity to the site. Other less pronounced falls in house prices were estimated for Knypersley, which is slightly further away, and parts of Brown Edge and Norton Green which overlook the site. A sketch of the view from Brown Edge village of the prospective site is shown in Figure 3.

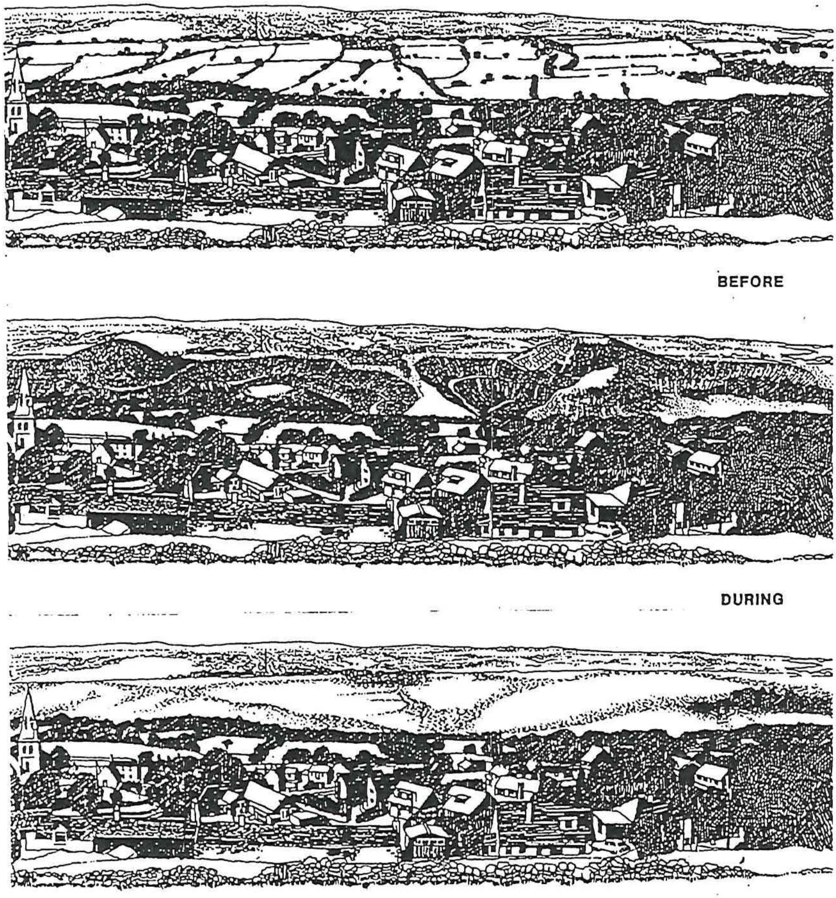

Figure 3: Before, during and after

The first frame shows the view before the opencast development, the second frame shows what the site might look like during the development, and in the final frame a possible view of the site after restoration is shown.

The average predicted falls in house prices for each of these areas are reported in Table 1.

Table 1 Average predicted falls in house prices

Property value	Ball Green/ Ridgeway	Knypersley	Brown Edge/ Norton Green
35k	21%	18%	10%
65k	29%	24%	14%
120k	32%	25%	16%
250k	40%	33%	19%

Overall the estate agents predict that house prices could fall by between 10 and 40 per cent, depending on the location and value of the property. The importance of framing the questionnaire such that predictions are sought for properties across a range of values is confirmed by the strong negative correlation between property values and the magnitude of predicted falls. This result is also consistent with the expectation that money valuations of environmental impacts should be an increasing function of individual income.

In order to aggregate the overall effect of these predicted falls in housing equity, we need to calculate the value of the housing stock in the villages concerned. This information can be obtained from the new council tax bands, which were published for England and Wales in December 1992. By examining the council tax registers available from Stoke-on-Trent City Council and Staffordshire Moorlands District Council the properties in each of the villages of interest have been allocated to their respective council tax bands (see Table 2). It can be seen from these valuations that the Ball Green/Ridgeway area contains a different housing mix than the other two areas. Most of the properties in Ball Green are in the lowest council tax band (A), reflecting the predominance of small terraced and council-owned properties. The other areas of Knypersley and Brown Edge are more prosperous, with a clustering of properties around the C and D bands. These contrasting mixes in the type of properties found in each area will tend to lower the overall effect of the opencast project on house prices since the highest falls are predicted for the area with the lowest property values.

Table 2 Council tax bands for villages affected by opencast

Council tax band	Ball Green/ Ridgeway	Knypersley	Brown Edge/ Norton Green
Up to 40k (A)	616	8	131
40-52k (B)	91	33	35
52-68k (C)	115	234	161
68-88k (D)	24	83	109
88-120k (E)	10	17	39
120-160k (F)	3	2	4
160-320k (G)	1	2	3
TOTAL	860	379	482

By taking the mean values of each council tax band and matching these valuations with the predicted falls in Table 1, it has been estimated that the total housing stock would fall by £17.7m if the opencast development were to go ahead. As intimated earlier, however, this figure is an overestimate of the impact since house prices are inflated by the existence of government subsidies in the form of MIRAS. Willis *et al.* (1993) calculate at a real mortgage rate of 8 percent that this amounts to £7,500 per dwelling. Subtracting this subsidy from the housing stock in our sample results in a new figure of £15.2m for the total predicted fall in housing equity due to the opencast development.

Of course, the disturbance caused by the opencast mine should only last for the eight years for which it is likely to be worked. Indeed, some of the estate agents in the sample considered that house prices could start to return back to their original price towards the end of a site's life cycle, as speculators buy up property in anticipation of the site's restoration. A simulation of disturbance over the eight year period does not, however, include the disturbance to house prices which the estate agents identified over the five to seven year period before the site's development in which the planning application is processed. On balance we therefore assume that there will be a drop in house prices which is maintained over the eight year period.

The usual method for estimating the costs of a project over a period of time is to calculate the rental which could have been earned had the lost capital been invested elsewhere. Assuming a return of 8 per cent the rental from the total loss in housing stock is £1.2m per year. Discounting this annual return back to the base year gives a total discounted environmental cost of £5.1m.

Table 3 shows a comparison of these predicted costs with the benefits from coal production reported in the third part of the paper. The first balance sheet compares the predicted profits from the Trent Valley site with the environmental costs. The net benefits from developing the site for opencast mining are £2.7m. This amounts to just over a third of the discounted profits predicted for the site. This means that the net economic benefits to be gained from the site, which take into account the social costs, are significantly less than the financial benefits calculated in terms of monetary profits.

Table 3 Comparing the costs and benefits

Balance sheet 1		Balance sheet 2	
Profits	£7.8 million	Profits	£5.4 million
Social costs	£5.1 million	Social costs	£5.1 million
Net benefits	£2.7 million	Net benefits	£0.3 million

The second balance sheet in Table 3 compares the environmental costs with the benefits provided by the opencast coal relative to deep-mined coal. The net benefits are shown to be £0.3m. This means that once environmental costs of the opencast coal are taken into account, alternative deep-mined coal could be mined for roughly the same cost as opencast coal from the Trent Valley site. This result shows clearly that opencast coal-mining in the Trent Valley is no more economic than existing deep-mined capacity.

Conclusions

In this paper we have used the hedonic pricing method to value the environmental costs of opencast coal-mining if it were introduced for the Trent Valley site. From a survey of estate agents with experience of both the housing market in the Trent Valley area and of opencast coal-mining in North Staffordshire, we have found that the environmental costs, valued in terms of the effect on house prices, could be as high as £5.1 million. This represents a significant proportion of the £7.8 million discounted profit British Coal could make from the site. This estimate of the environmental costs can also be used to compare the costs of opencast coal with British Coal's forecasts of the future costs of deep-mined coal. Opencast coal from the Trent Valley is estimated to cost roughly the same to produce as alternative coal from existing deep-mined capacity.

These estimates should of course be treated with caution since they depend on a number of variables, such as the forecasts given by British Coal and the assumption that the Trent Valley site produces an amount of coal equivalent to that produced by the typical opencast site. We have argued, however, that there are two main reasons why these estimates provide a lower bound estimate of the environmental costs. Firstly, house prices only shadow part of the fall in amenity value from the site. The housing market is not sufficiently open for rents to be bid downwards by an amount equivalent to the loss in utility associated with the opencast development. The second reason is that we have not assembled the full menu of environmental impacts which a complete social project appraisal of the proposal would include. There are a number of environmental costs which are quite separate from the housing market. For example, a travel-cost model could estimate the amenity value of the site for visitors to the Greenway Bank Country

Park. There could be additional costs associated with the physical damage to the site. An assessment of such additional costs provides a possible focus for future research.

Given that the environmental costs estimated in this study are a lower bound estimate, a full social project appraisal might well conclude that the development of the Trent Valley site for opencasting is not economically desirable - the social costs might outweigh the financial benefits. Moreover, since even the lower bound estimate shows that opencast and deep-mined coal would incur the same costs, opencast coal from the Trent Valley is almost certainly more costly to produce than deep-mined coal. The UK Government argues that "opencast production is economic and can already compete in the market place with alternative fuels" (Department of Trade and Industry, 1993, p.110). However, whereas opencast production might be financially viable, its economic viability is much less certain, and its competitiveness relative to alternative fuels, and relative to deep-mined coal in particular, is a result of a failure to recognise the full social costs of opencast methods of production.

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