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Valuation of public environmental assets by private companies: optimal dust abatement and air quality

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Abstract

This study investigates a new problem in the area of environmental valuation: how much is a public environmental asset worth to a private company? We ask this question in the context of dust abatement, where the asset is air quality. A company wants to know what level of dust abatement is optimal, given the engineering costs of abating and the social costs of not abating. We show that the optimal point for the company lies in between the textbook cases of so-called private optimum and social optimum, which constitute, respectively, a lower and an upper bound for dust abatement. We calculate the upper bound and provide elements for the calculation of the lower bound.

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1. Introduction

Improved environmental performance and accountability has become of increasing commercial interest as firms realise that it can be economically beneficial to be an environmental leader and can sometimes hurt (financially) to be an environmental laggard (Schaltegger and Burritt, 2000). However, what are the benefits to a company for improved environmental performance? In contrast, what are the costs to a company if they fail to be accountable? Such questions are essentially asking one question; how much is a public environmental asset worth to a private company? This is a question that is increasingly being asked by companies as they realise the benefits of pollution reduction and the potential costs to the company of no further abatement.

Addressing this question is a complex process and implies the need for a quantitative approach. Traditionally, this question has been asked from a public perspective the aim of which is to maximise social welfare. Environmental valuation techniques have been extensively studied and practiced to estimate the value of an environmental asset, but have been specifically targeted towards public valuations. However, a method specifically targeted to estimate private valuations do not exist. Such a method requires the adaptation and expansion of non-market valuation techniques, and the question of "valuation" needs to be asked from another perspective: that of the private firm. Accordingly, the objectives of the approach become completely different. The problem now is: to what extent is a public environmental asset, such as air quality, of value to a private firm, and how can we measure that value? The answer provides the basis for understanding and determining the firm's own decision towards a privately optimal level of pollution. As we shall see, this optimal level differs from the classic text book case.

The aim of this study is to identify, using current environmental valuation methods and innovative approaches, a quantifiable methodology, which illustrates a way of tackling this private valuation problem. Furthermore, this study aims to implement this approach practically through a case study to derive information that can be used to infer an optimal level of environmental impact from the company's perspective. Unlike pervious approaches, this optimal level is not a function of government intervention, but is an autonomous and endogenous company decision.

The case study used to apply the project aims and objectives is the issue of dust abatement in Dampier. Dust emissions from a private mining operation in Dampier have raised concerns in the local community where dust is an aesthetic and amenity problem for residents. In this case the public environmental asset is air quality, where an externality is being imposed on the local community who are not *totally* compensated for the external costs of pollution.

The outline of this report is as follows: 1) An introduction to the issue that this report raises, how much is a public environmental asset worth to a private company, 2) A theoretical framework which provides a model approach towards identifying the privately optimal abatement level, which is different compared to the classical text book case of optimal pollution control, 3) Discusses the practical application of this theoretical

framework in the context of this study concerning dust abatement in Dampier, 4) Briefly discusses the design and administration of the survey delivered to Dampier residents, 5) Discusses the results from the survey, focusing on estimations of the lower and upper bound of abatement, 6) Provides overall conclusions and limitations of the research.

2. Optimal environmental impact for a private company: A Theoretical Framework

Public environmental assets have been and still are prone to degradation from private industry. The lack of property rights associated with such assets has lead to external costs imposed on the general community rather than on the polluting agents. These external costs, in the absence of government regulation, are not readily incorporated into a polluting company's decision-making, leading to over exploitation of the public good. In terms of this study, over exploitation is more than the socially optimal level of air pollution in Dampier.

2.1 Optimal environmental impact: Private and social discrepancies

The notion of optimality in economic terms requires the maximization of net benefits. In the presence of environmental costs from pollution, such costs need to be offset by the benefits of which pollution is a by-product. A private company's operations are considered a "good" as is the environmental asset that is being degraded; therefore optimality is reached where benefits from both goods are maximized. However, the private and social value of the environmental asset can be vastly different leading to discrepancies between the optimal levels of environmental impact. This discrepancy between private and social optimum's can be explained through the simple text book case of maximisation of net benefits and Pareto Optimality. Consider figure 1 below. An allocation is said to be Pareto Optimal if no other feasible allocation could benefit some people without having a harmful effect on at least one other person (Tietenberg, 2000). For an economically rational private company, the optimal level of pollution is where its marginal private benefits (MPB) are equal to its marginal private costs (MPC). However, the socially optimal level of pollution is considerably less. The difference between these two marginal cost curves, and thus the optimal level of environmental impact, is the external cost of pollution.

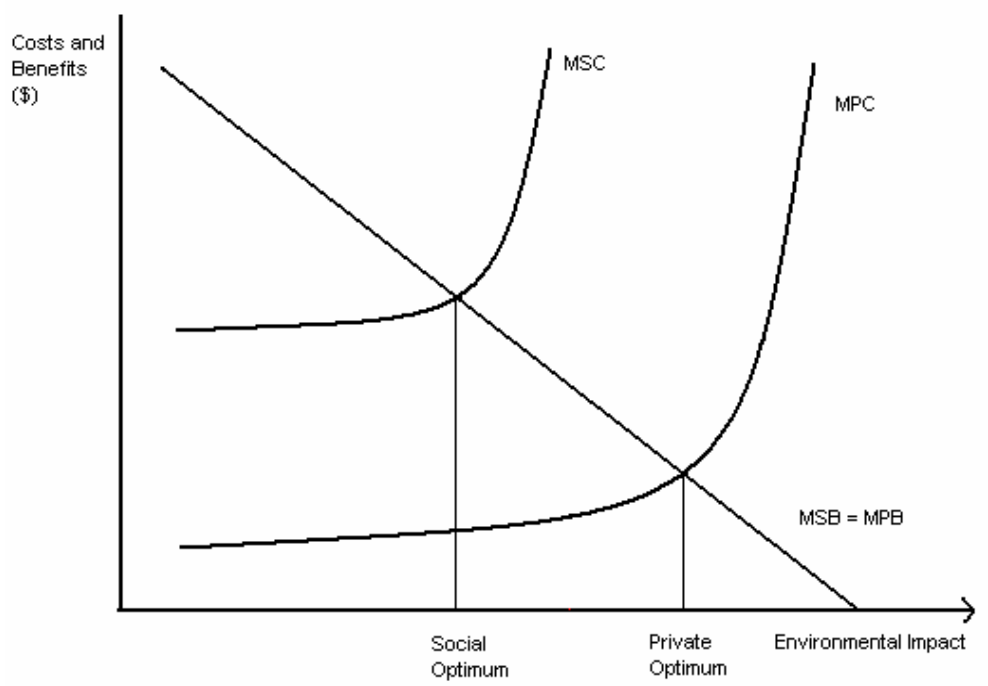

Figure 1 *Classical social and private optimum levels of environmental impact of a public good.* (Adapted from Hanley, H., Shogren, J. F., and White, B., 2001). Where MSC=marginal social costs of pollution, MPC=marginal private costs of pollution, MSB=marginal benefit to society from production (marginal social benefit), MPB=marginal private benefit from production. Marginal benefit curve is downward sloping as environmental impact increases. Environmental impact is assumed directly proportional to production output.

In this textbook situation, pollution of a public good creates a negative externality. Therefore, the costs of environmental damage are borne by society rather than the polluter. This situation is not Pareto optimal and is therefore inefficient. In situation's where the disparity been privately and socially optimal levels is large, government regulations have been and are used to force companies to internalise some of the externalities from its operations. Government regulations and environmental legislation operates as a bare minimum to control the use of such environmental assets by private industries. However, some companies are now viewing over-compliance with regulations as being economically beneficial in the long term.

2.2 Self-internalisation of externalities and the private optimum

Private companies who focus on short term and immediate costs and benefits from pollution and production can overlook the potentially large hidden, indirect costs and benefits, which flow from the company's current environmental decision-making (Lesourd and Schilizzi, 2001). Self-internalisation results from companies increasing their time horizon when considering environmental costs and benefits. A major source of cost in this regard may arise from the company's stakeholders. A stakeholder is any individual whose level of income, wealth or satisfaction is affected, directly or indirectly, by the company's activities or decisions (Schilizzi, 2002). Self-internalisation means that the company implicitly values the potential costs of stakeholder pressure and

dissatisfaction from environmental externalities as they may, over time, translate into direct, financial costs for the company.

Similarly, companies may also value benefits of improved reputation and market acceptance, which flow from enhanced environmental performance. In essence, self-internalisation is where companies incorporate potential indirect costs of pollution into their current decision-making process. Companies can do this by internalising part of their external costs. Thus, self-internalising companies attempt to mitigate future liabilities and invest for future benefits.

A self-internalising company therefore differs from the text book case of private optimal pollution abatement. A self-internalising company's aim is to identify potential future costs and benefits that can stem from their current and future environmental performance. They then incorporate these costs and benefits into current decision making in order to prevent future liabilities. In theory, such a company should seek an optimal level of environmental impact that prevents or minimises stakeholder-induced costs while at the same time yielding a sufficient return on production. This level would lie somewhere between the classical social and private optimal levels of environmental impact. This is shown in Figure 2.

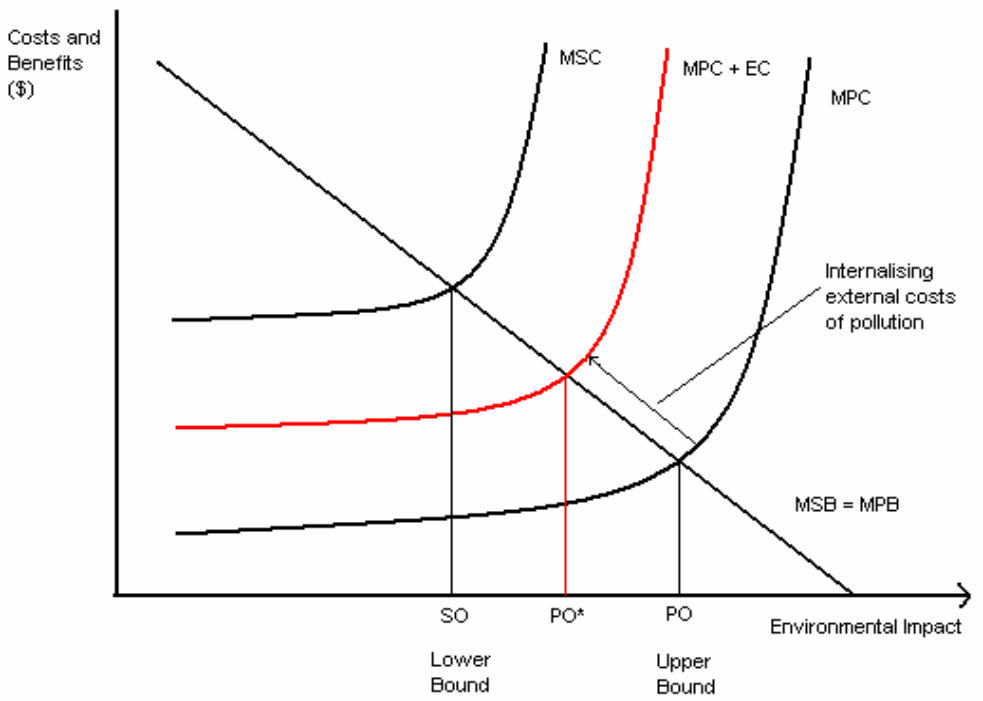

Figure 2. *Internalising external costs: The optimal level of pollution.*
(Adapted from Hanley, H., Shogren, J. F., and White, B., 2001). Where SO=social optimum, PO=private optimum (excluding external costs), PO*=new private optimum (MPC + a proportion of the external costs [EC] of pollution). Environmental impact is directly proportional to production output. The Lower bound is indicated as the same line as the social optimum. The Upper bound is the same line as the private optimum.

Accordingly, the optimal self-internalised level of environmental impact should lie between two bounds (Figure 2):

- A lower bound defined by the social optimal, where external costs are 100% internalised; and
- An upper bound defined by the neo-classical private optimal, where external costs are not internalised by the company.

The lower bound of environmental impact is that at which a company internalises 100% of the external costs of pollution. Therefore, a company that internalises to this point is incurring an external cost today to avoid an appreciating external cost in the future. The value of this lower bound is very much dependent on stakeholders' valuation of the environmental asset (EA) at stake and the extent of the externality if the asset is mismanaged. If nobody in the community, even when prompted, expresses any concern for the EA, then the economic value of the asset to the company is no more than its direct value as a waste dump or emissions sink (Schilizzi, 2002). In this case, the externality is zero and the lower bound is equivalent to the neo-classical private optimal level of environmental impact (see Figure 1). Therefore, estimating stakeholders' valuation of the EA is critical to determining the lower bound.

The upper bound of environmental impact occurs when internalisation is effectively zero. A company, which pollutes at this level, is essentially deferring its external costs until they become direct costs to the company in the future. The optimal level of production therefore corresponds to the classical private optimal level at which the marginal private benefit (MPB) is equal to the marginal private cost (MPC). The marginal private costs also include costs associated with different forms of stakeholder action in response to continual EA mismanagement by the company. This, in turn, depends on the type of action and the likelihood of such action, which would be directly proportional to stakeholders' valuation of that asset, ceteris paribus (Schilizzi, 2002). Action can come in the form of:[1]

- Legal or political action from local communities
- Dumping of company shares by "ethical investors"
- Employee strikes from unsatisfactory working conditions
- Government action through refusal of license renewal or regulations more stringent than self regulations
- Consumer and customer boycott of products

This would suggest that a highly valued EA would lead to more severe and costly action, which has the potential to impact on the company's financial bottom line.

If the lower and upper bounds are estimated accurately, then the optimal level of environmental impact for a company depends on the extent to which it internalises the external costs of pollution (as indicated by the arrow in Figure 2). The extent of internalisation will depend on several factors:

- *The company's time horizon*. - A company that considers and values future costs and benefits (10, 20, or 30 years in the future) of their current environmental performance

[1] The following actions are derived from Lesourd and Schilizzi, 2001

will, all else being equal, want to internalise a greater proportion of the external costs than a company that only accounts for short term costs and benefits.

- *The company's discount rate*. - This ties in with the company's time horizon and reflects the company's value of time. A company with a low discount rate is one that values future costs and benefits and would internalise a greater proportion of external costs in the present if, by doing so, it would minimise potential costs in the future. A company with a high discount rate would only account for present costs and benefits, as it would value future costs and benefits closer to zero in present value terms.
- *Company ethics*. Regardless of the previous two factors a socially and environmentally ethical company may also internalise external costs on ethical grounds.

The assessment of stakeholder induced costs due to environmental impacts is extremely uncertain. Coupled with this uncertainty is whether stakeholder pressure will actually translate into future costs for the company. These uncertainties attach to the following estimates.

1. Estimation of the lower and upper bounds of environmental impacts require the estimation of stakeholders' valuation of the EA. Non-market valuation techniques provide rough estimates of environmental valuations, where the methods themselves contain many biases, and the results themselves have been subject to much criticism over the validity of the estimates.
2. Estimating stakeholders' level and likelihood of taking action is very difficult and has not been studied seriously in an economic framework.
3. In addition to the uncertainty of empirical estimates is the uncertainty of the future. This is where risk management becomes a factor, where decisions are made on value judgments and policies concerning the level of acceptable risk.

Such uncertainties would be contributing factors that would prevent company's taking this self-internalising approach.

2.3 Conclusion

Public environmental assets such as air quality or biodiversity are subject to over-exploitation or mismanagement leading to negative externalities on the polluting company's stakeholders and the environment. The text book case suggests that an economically rational company should not account for external costs of pollution when defining their optimal private level of environmental impact. Such an approach by a company in today's society, where stakeholders are demanding environmental accountability of industry, could have extensive repercussions on the company's future financial situation. A company that self-internalises external costs of pollution is essentially incorporating potential future stakeholder costs into their current decision making in order to reduce or prevent such costs from occurring. However, in order to do so, a company must estimate the optimal level of pollution that achieves such an outcome.

3. Application: Dampier Case Study

Estimation of the optimal level of environmental impact from the point of view of a private company is a difficult because it will depend upon a wide range of economic, managerial, environmental, and societal factors. As discussed in chapter three, the privately optimal level of environmental impact is different from the publicly or socially optimal level. The aim of this study is not to estimate the actual optimal level, but to identify a quantitative methodology, which illustrates a way of tackling the private valuation problem. As illustrated in the pervious chapter, identifying the lower and upper bounds of environmental impact, between which the optimal level will lie, requires estimation of the following two aspects:

1. The stakeholders' valuation of the environmental asset which should, in theory, provide the lower bound of environmental impact
2. The immediate and lagged costs to the company of stakeholder action if the environmental asset is mismanaged, which should, in theory, give the upper bound of environmental impact (the point where these costs impact on the company's financial bottom line).

The first point, which is the first study objective, would require a form of non-market valuation to estimate how much stakeholders (Dampier residents) value an improvement in the quality of an environmental asset (air quality). The second point requires comprehensive accounting techniques, which is beyond the scope of this study. Therefore, the second study objective of this study was to measure only the level and likelihood of stakeholder action, where this information could then be used to estimate costs to the company.

3.1 Valuation approach

In the present study, a willingness to pay (WTP) approach was taken to estimate Dampier residents' valuation of improved air quality (reduction in dust levels) in Dampier. Within the WTP approach was the contentious issue of whether to use a closed-ended or open-ended format. Prior to 1985, most CV surveys used open-ended WTP questions (Hanemann, 1995). However, Hanemann and the National Oceanic and Atmospheric Administration (NOAA) state that a closed-ended format is more reliable and is recommended (NOAA, 1992; Hanemann, 1995). Initially, a closed-ended format was developed to estimate residents' WTP. Respondents were asked to choose a level of dust reduction that they would prefer, which had a corresponding personal cost associated. The problems associated with this approach were:

1. The associated costs were arbitrary and not realistic
2. Severe starting point bias since price/cost was not varied for a given level of dust reduction.
3. Requirements of the company. A condition of survey approval was that a closed-ended format was not used due to concerns raised in point 1.

As a result WTP was elicited through an open-ended format where respondents were asked to state their maximum WTP for a chosen level of dust abatement.

The open-ended contingent valuation method, with an averting expenditure payment vehicle, was, in the end, the result of a compromise and in hindsight may not have been the optimal approach to this valuation objective. However, this development process does depict the difficulties inherent in non-market valuation, and shows how standard techniques are not universally applicable. The following section discusses the background behind the adopted approach and how these two methods have been amalgamated in the past.

3.2 Payment Vehicle difficulties

The payment vehicle was a contentious issue in this study where the final choice was not optimal but a compromise. Throughout the design of the WTP question, three payment vehicles were considered.

Vehicle 1 - Indirect payment by residents through reduced community funding by the company in Dampier to cover the capital and operating costs of abating dust emissions.

Vehicle 2 - A tax payment imposed by the government on Dampier residents, which contributes to half the company's capital costs of implementing dust control equipment.

Vehicle 3 - An averting expenditure approach, which asks how much respondents are willing to spend to avoid the unwanted effect of dust impacting on their property.

The concept behind vehicle 1 was that residents could have an indirect cost imposed on them from reducing the company's community funding in Dampier. The company invests funds into sporting and social events as well as schools and hospitals in the local area (Hamersley Iron, 2001). This payment vehicle was deemed to be inappropriate in this situation because residents would view community funding received from the company as an "acquired benefit" for working and living in Dampier. Residents could perceive that they have the "right" to this benefit and therefore can not be altered. A reduction in community funding would potentially lead to high protest votes and non-responses.

Vehicle 2 was adopted to give a more direct payment and to overcome the problem of acquired benefits i.e. to trade off something that isn't provided by the company. Vehicle 2 forces residents to trade off between the benefit of dust abatement and the cost of a tax payment, which is a personal rather than public cost. Vehicle 2 assumes that the government (local, state, Commonwealth) will contribute to a percentage of the implementation costs of dust abatement. The justification of government investment is that air quality is an issue of public welfare and that there are possible health concerns. This vehicle was deemed inappropriate mainly due to company concerns over the involvement of government.

Vehicle 3 was adopted as the payment vehicle for several reasons:

1. It provided a true trade off between costs and benefits rather than considering payment through community funding or an "acquired benefit".
2. It attempts to direct the valuation of air quality/dust reduction away from the company. In other words it doesn't state that the company is or will make any

changes in dust levels that could be construed by the respondent as a statement of intent.

3. It allows respondents to estimate their WTP in terms of the cost of market goods (averting expenditure approach) as well as in terms of non-use values (amenity, aesthetic values).

3.3 Averting expenditure approach

The averting expenditure method is a revealed preference approach, which attempts to measure people's valuation of an environmental good through their market behaviour. An averting expenditure is defined as any expenditure taken to avoid or mitigate the effects of an adverse change in environmental quality (Coulson *et al*, 1985). The application of the averting expenditure approach in this study was through the payment vehicle (as discussed above) of a contingent valuation survey (which will be discussed in the next section). Residents were asked to state their WTP in terms of how much they are prepared to spend on dust-reduction measures (e.g. vegetation, pool, car, boat covers etc) to reduce dust on and around their property. A shortcoming here is the initial state problem. Homeowners may already have invested in dust-reduction measures, whereas others haven't – This produces a state-dependent valuation problem, which needed to be controlled.

3.4 Contingent Valuation Method

The Contingent Valuation (CV) Method is a form of stated preference method and is used for placing monetary values on environmental goods and services not bought and sold in the marketplace (Carson, 2000). It is a survey-based technique, which elicits people's WTP based on hypothetical market scenarios (Garrod and Willis, 1999). The most commonly used format of CV is where respondents are asked to choose between two alternatives, the status quo or and improvement in an environmental good or service at a cost to the respondent (Carson, 2000). In the present study The CV format was slightly altered by providing a status quo option (no further dust abatement) and a series of dust abatement levels from which the respondent could choose their preferred level (Dunn, 2002).

Previous studies (Coulson *et al*, 1985; Abdalla *et al*, 1992) have compared the WTP estimates from both averting expenditure and contingent valuation methods. Averting expenditure and CV have been used in conjunction to estimate WTP; however, the context has been predominantly health related. Although there are health-related concerns in Dampier with respect to dust, the major concern is in the form of discomfort and nuisance and property damage (DSDWG Dust survey, 2001). In previous studies WTP was derived from respondents' expenditure on marketable substitutes for a cleaner environment. Abdalla *et al* (1992) estimated WTP indirectly based on purchases of bottled water and costs on installing home water treatments. In the present study, it was conceived that respondents could state directly their WTP for improved air quality in terms on how much they are willing to spend to mitigate the effects of dust pollution on their property. Expenditures can be in terms of marketable goods e.g. filtered air conditioning, increased vegetation around home and pool, car and boat covers.

The main difference between previous studies and the approach of this study is that in previous studies WTP for an environmental improvement was derived indirectly from *ex post* market expenditures. The approach of this study asks respondents directly to state their WTP for an environmental improvement based on what they would be prepared to spend (*ex ante*) to avert environmental impacts.

3.5 Likelihood of stakeholder action

An important factor in estimating the optimal private level of environmental impact is to identify the cost to the company of no further abatement. These costs are generated by actions that unsatisfied stakeholders take against the company and which, sooner or later, will impose costs on the company (Schilizzi, 2002). The objective of this study was to identify the level and likelihood of Dampier residents to take action. However, identifying and even estimating how an individual or a community as a whole will respond to the deterioration of a valued environmental asset is a very difficult task and is something that has not yet been studied seriously[2]. An individual's likelihood to take action in response to environmental damage is influenced by many factors, many of which are perception-related.

Schilizzi (2002) made the assumption that an individual's willingness to take action is, ceteris paribus, directly proportional to their own valuation of the environment asset[3]. This assumption suggests that the higher the valuation of the asset, the more likely and the more severe the action undertaken for a given level and duration of impact. This assumption makes reference to two words: willingness and likelihood of action. These two words measure two different things: willingness measures intention to act whereas likelihood measures the chance of actual action. It is reasonable to suggest that willingness to take action will increase with increasing valuation; however, the likelihood of actually taking that action would be less directly related. The likelihood of taking action is dependent on several factors such as:

- Type of action
- Perceived effectiveness of that action
- Perceived stakeholder empowerment

These factors, combined with the likelihood of taking action, are of importance to a company when attempting to estimate the potential stakeholder-induced costs from prolonged environmental impact. In the case of individual stakeholder groups such as the Dampier community, the assumption should hold. However, their likelihood to take action should be vastly different to another stakeholder group, such as the government, due to differences in the factors stated above.

[2] People's action or response to a perceived change such as in this case has not been seriously studied in an economic context; however, sociologists and social psychologists have done work on this.

[3] A more rigorous assumption would be that it is "directly related". Proportionality implies a linear relationship, which is a simplification. However, it is probably a useful one to start with.

4. Experimental Procedure: Survey design and administration

This section is a brief outline of the experimental procedure of the construction and implementation of the survey for this study. The construction of this survey was met by several problems primarily due to the nature of the situation and the complexities of the community – company relationship, which is something that could not be avoided in this study.

The questionnaire consists of a cover letter and five sections totaling 19 questions, making up the body of the questionnaire. The following gives a brief explanation of the content of these sections (see Dunn, 2002 for questionnaire).

4.1 Pre-survey information

In July 2001 the Dampier-Samson Dust Working Group (DSGWG) conducted a community survey. The Working Group included representation from Hamersley Iron, Robe River Mining, Shire of Roebourne, Department of Environmental Protection and local community associations. Residents of Dampier and Karratha were surveyed to find out their opinions on issues relating to the dust in the respective towns.

The information gathered from the survey was planned to assist in the development of long-term strategies for dust reduction. Although not designed as a pre-survey, the results of the DSDWG community survey gives an overview of concerns of the Dampier community towards dust in their town. The key relevant findings from the survey were that Dampier respondents were (compared to Karratha residents)[4]:

- More concerned about dust
- More likely to officially complain about dust
- Feeling like Hamersley Iron should do more to control dust

Such information gives an insight into the concerns and attitudes of Dampier residents, which was important when designing questions for the project survey that would be relevant to residents. An important question that was asked in the DSDWG survey was "To what extent does dust impact on you?" as it establishes whether dust is at all a problem for residents. This question was entered into the project survey, as it would be a key determinant in respondents' willingness to pay and would give insight into trends in action responses. Responses from the project survey to this question could also be compared to the pre-survey responses to test for consistency, in other words to see if respondents' attitudes are representative of the larger (DSDWG survey) sample.

4.2 Sample Selection and Survey Administration

Dampier residents were selected as the target population because they are the primary stakeholders who are directly affected by the company's port operations. The population of Dampier is approximately 1500 people. The survey was advertised in Dampier a week preceding survey administration. Firstly, information about the questionnaire was posted in the Dampier Community Association, which is distributed, to every household in Dampier.

[4] Survey results are care of the Dampier-Samson Dust Working Group

Surveys were administered by mail through a letterbox drop to every mailbox in Dampier. A total of 521 surveys were delivered during the 9th and 10th of September, 2002. Respondents were asked to return completed surveys to the local Community Association or the Post Office, which are no more than 5 minutes away from every household in Dampier.

5. Results

5.1 Response rate

The population of the survey was defined as the residents of Dampier, Northwest coast of Western Australia. All residents are considered to be subject to relatively the same dust levels as those found across the entire town. There were 1,081 adult (over 18 years of age) residents of Dampier during 2001 (ABS, 2001). 521 surveys were administered to every household[5] in Dampier. Table 1 shows that 66 residents responded, which is a response rate of 12.7%. Within the sample, 51.5% of respondents gave a positive willingness to pay (WTP>0), 16.7% gave a WTP=0 for zero dust reductions and 31.8% were protestors, refusing to pay for a variety of reasons, the most common being that they should not have to pay for what they consider as being caused by the company.

Table 1 – Sample sizes and response rate

	Number of individuals	Response Rate (%)	
N^{o} surveys delivered	521	100.0	-
Survey sample[a]	66	12.7	100.0
Respondents (WTP>0)	34	6.6	51.5
Respondents (WTP=0)	11	2.1	16.7
Protestors	21	4.0	31.8

[a] Number of surveys returned

5.2 Social optimum and the lower bound of environmental impact

The first objective of this study was to estimate how much Dampier residents value dust abatement. The concept of the private optimal level of environmental impact indicated that stakeholders' valuation of an environmental asset would, in theory, be an estimate of the lower bound of environmental impact. According to the results in Table 2, the Dampier community, on average, prefers a 22% reduction in dust and is willing to pay approximately $234,000 to achieve this reduction. A 22% reduction in dust is essentially the apparent social optimal level of dust abatement, with an attached value of $234,000 to the community, assuming reliability in the results.

From an economist's perspective, the estimated total WTP would suggest that this is what should be spent on dust abatement to maximise social welfare. Traditional environmental

[5] Households are considered as every residential dwelling with a postal address

valuation techniques, such as dichotomous choice contingent valuation tend to fix the quantity of the environmental good and vary the willingness to pay to analyse the marginal change (Hanneman, 1995; Garrod and Willis, 1999). However, from the company's perspective, their interest lies in the preferred level of abatement. The variation in quantity provides a direct elicitation of the preferred level of abatement, whereas if quantity is fixed then such information is not available or can only be inferred. In this therefore, willingness to pay estimates may have been secondary to the estimation of the preferred abatement level.

Table 2– Calculated WTP and preferred level of dust abatement in Dampier over all households

%DR[a]	*M(WTP)*[b]	*A(WTP)*	*Total WTP*[c]
22%	**$10,660**	**$450**	**$234,529**

[a] Calculated average level of dust reduction is the aggregated weighted average of the preferred dust reductions over both respondents and the expected values for non-respondents

[b] Marginal WTP = WTP of all households per % dust reduction = A(WTP)/%DR*(Nº Households)

[c] Calculated total WTP is the aggregated weight averages of WTP of both actual responses, both WTP=0 and WTP>0, and expected responses of those who did not respond.

Extrapolated estimates of Dampier households' willingness to pay were calculated from very limited data and from a sample that was biased (Dunn, 2002). Furthermore the percent dust reduction of 22% would be an under estimate as there was a large number of protestors who would want dust abated but did not respond to the questionnaire.

5.3 Action likelihood analysis and the upper bound of environmental impact

Figure 3 indicates the distribution of respondents' preferred type of action that they would be willing to take in response to different increases in dust levels. The following simple observations can be made from figure 3.

- If dust levels did not change the mode response is to take no action (47%).
- If dust increased by 10% the mode response is to complain (44%).
- If dust was to increase by 50% the mode response is to become actively involved in an action group (38%).

Further observations can be made on the vertical ordering of responses. Under no change, "no action" is clearly the preferred behaviour, whereas if dust increased by 10%, the majority of respondents are prepared to complain. This indicates community dissatisfaction under such a condition, which can be interpreted as a warning to the company as it signals the development of potential liabilities if such a trend continues. Petition appears not to be a preferred type of action showing low response rates under all dust levels. Horizontal ordering over action group, media and lawsuit for different dust levels indicate that there is not enough information to consider these actions separately (i.e. respondents are approximately equally likely to take any of the three types of actions under each dust increase), in which case they should be aggregated. It is clear from figure

3 that there is a changing pattern in the choice of action when considering hypothetical increases in dust.

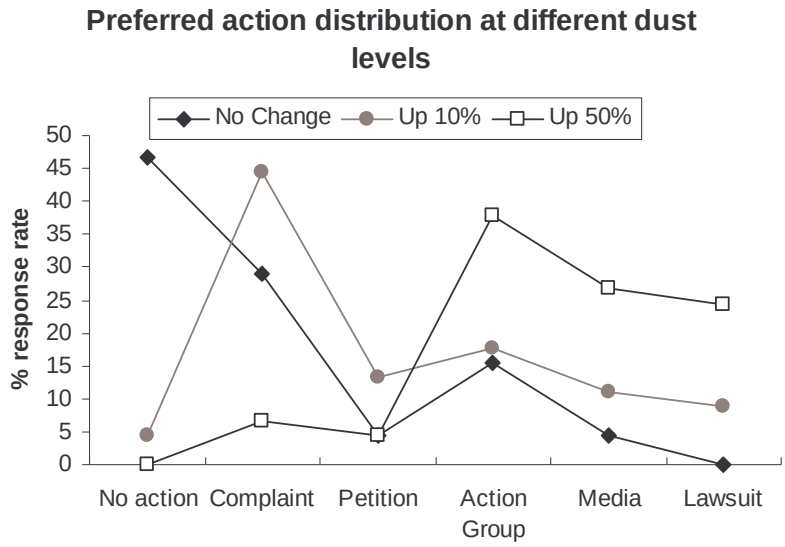

Figure 3 – Action definitions: "Complaint" – Making a complaint to the company, "Petition" – Conducting a petition around the community collecting signatures, "Action Group" – Join and become actively involved in an action group, "Media" – Contact the media (e.g. newspapers, TV, radio), "Lawsuit" – Enter a class action lawsuit against the company.

Figure 4 shows that the proportion of respondents who will take no action rapidly decreases if dust levels were to increase, to a point where everyone is prepared to take some form of action (Up 50%). The figure also indicates that passive action will increase if dust increases a small amount (Up 10%), possibly signaling to the company the existence of a liability, and that for a further, larger increase (Up 50%) in dust, passive action takers will move to active action, which is potentially costly to the company. However, an increase in dust by 50% is a rather unrealistic scenario and unlikely to happen. However it does indicate a clear preference trend.

When respondents were asked to consider present dust levels or to consider a scenario where dust levels stay the same, 29% and 7% were prepared to take passive and active action respectively. This could indicate what form of action a proportion of respondents (and possibly a proportion of non-respondents) is currently undertaking. Assuming that this information is reliable, such figures indicate that there already exists a liability which could affect the company in the future.

Figure 4 (as well as figure 3) only indicates action preferences. This information does not indicate whether respondents will actually carry out this type of action, which is of importance to the company when they evaluate the potential costs from such action. Put simply, the cost to the company would be equivalent to the cost of action multiplied by the likelihood of stakeholders prepared to take that action.

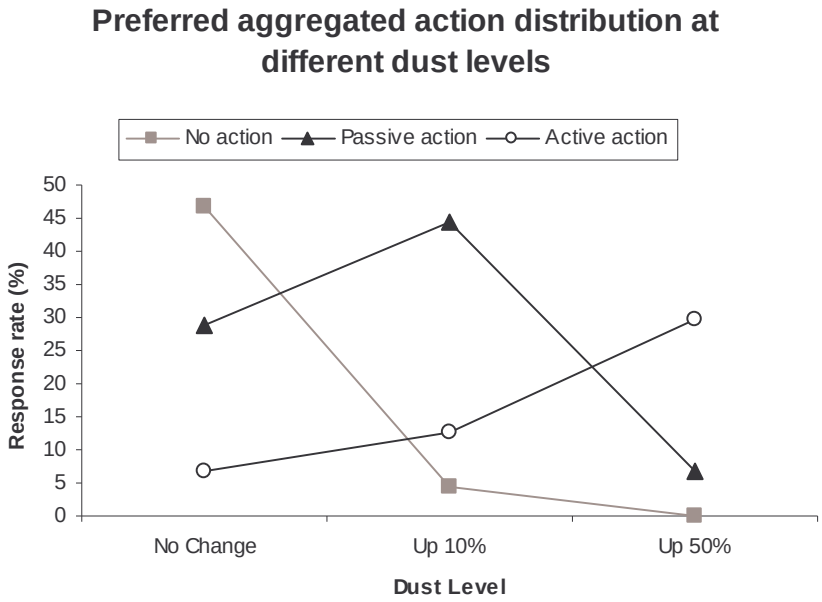

Figure 8.2 – Responses to the three types of actions are independent of each other therefore the vertical percentages for each level of dust increase does not add up to 100%. Protestors were excluded from this figure; however, it was unlikely that their inclusion would have changed to basic trends in preferences.

The upper bound of environmental impact is defined as the point where the internalisation of external costs is effectively zero. The company in this case study is currently internalising some of the external costs of dust pollution, through current dust abatement practices, community funding and educational programs (Hamersley Iron, 2001). However, figures 3 and 4 have indicated the existence of potential liabilities from stakeholder action at the current level of dust abatement and if no further abatement is taken. The magnitude of this potential liability would have to be estimated by calculating the costs of action to the company. The information gathered from the approach of this study could not estimate these costs; however, it does provide one half of the equation. The other half is to translate the type and likelihood of action into expected costs to the company if they don't meet the 22% abatement level. The expected costs of no further abatement would be compared to the costs of further abatement. The optimal level of environmental impact, in theory, would approximately be the point where these two marginal costs are equal.

An example of this process can be considered under the no change scenario used in figures 3 and 4. According to these figures it is clear that a proportion of Dampier residents (assuming that the figures are representative of the community) are prepared and likely to take some form of action against the company under no further abatement. A question that could be asked by the company is "what level of abatement would be required to achieve 100% "no action" with a 95% level of confidence that no action will occur?" The answer to this question is very much dependent on the subjective view of the company, where the optimal level of abatement will depend upon the firm's approach

to risk aversion, their value of time and their evaluation of the benefits of improved environmental performance.

6. Conclusions

6.1 Main findings

The aim of this project was to study the problem of estimating the optimal level of environmental impact from the point of view of a private company. This aim was tackled through a case study involving dust pollution in Dampier, Western Australia. Through to design and implementation of a contingent valuation survey the overall response rate was 12.7% (8.7% excluding protestors). From the results obtained from the survey responses and estimation of the upper bound of dust abatement (or the apparent socially optimal level of dust abatement) was calculated over all households as 22% below current levels. Action responses indicated that 37% of respondents were prepared to take some form of action against the company if no further abatement occurs. Under increasing dust levels, respondents are prepared and more likely to take higher levels of action. These results highlight the presence of current stakeholder dissatisfaction, indicating the existence of a potential and growing liability for the company if dust pollution is not abated. Although not a direct estimate of the lower bound of dust abatement it does provide half of the information required to calculate these potential liabilities to the company.

6.2 Implications for the company

The results obtained from this study indicate that the *apparent* socially optimal level of dust abatement (with respect to the Dampier community) is 22%. Whether the company reduces its emissions to this *socially optimal* level will depend on the costs to the company if they do not reduce dust by 22%. The results obtained from the second objective of this study indicate that there is potential for stakeholder action against the company if the company does not make any further abatement. Therefore, the results suggest that the company should consider further abatement; however, whether they abate to 22% is very much dependent on the value the company places on the concept of self-internalisation and risk management.

6.3 Limitations of the results

The results obtained through the approach that was taken are only one half of the quantitative process of estimating the private optimal level of environmental impact. They are also largely exploratory, indicating a possible approach to a difficult problem and therefore contain a certain degree of uncertainty. Therefore, the results are limited to the extent to which the company accounts for them in their decision-making process, which is very much contingent on the company's approach to uncertainty and risk.

During this project there were several problems that limited the reliability of the results. An averting expenditure payment vehicle was ex-post considered as being sub-optimal to estimate residents' willingness to pay in this situation. The adoption of this approach was a combination of company requirements and the lack of adequate knowledge about the community's perceived property rights over the environmental asset. In retrospect, an equivalent gain approach may have reduced non-responses and protest votes.

Furthermore, the exclusion of the protestors has lead to an underestimation in the community's valuation of dust abatement. A more robust extrapolation (through the inclusion of protestors) to the other households in Dampier would have improved this estimation.

6.4 Future Research

Valuation of public environmental assets has primarily been for the purpose of policy decision-making. Valuations tend to be made from a public perspective, which attempt to maximize social welfare by estimating the total benefits of an environmental improvement. Valuation of a public environmental asset from a private perspective is a relatively new area of study. The methodology of estimating the private optimal level of environmental impact is at a premature stage as illustrated through the methodological problems of this present study. In the context of this case study, potential research could be focused on the possible divergence of public and private valuation in terms of non-market valuation techniques. The focus of private valuation is potentially based on the preferred level of abatement rather than the valuation of abatement, which is often the focus of public valuation.

6.5 Conclusions

The initial aim of this study was to address the quantitative problems in estimating the optimal private level of environmental impact. The optimal level of impact essentially corresponds to the extent to which a company self-internalises the costs of environmental externalities from the pollution of an environmental asset. The scope of this study however did not produce estimates for this optimal level. The main findings of the study were only indicative of the lower and upper bounds of dust abatement between which the private optimal level will lie. The study did not directly estimate the upper bound of environmental impact (lower bound of abatement), as it requires extensive accounting techniques to estimate. Furthermore, the methods used to achieve the study objectives proved to be sub-optimal. Future research is required to refine a method suitable for achieving these objectives.

Despite these problems, this study did provide an innovative approach to addressing an important question in corporate management and environmental economics, "how much is a public environmental asset worth to a private company?" Appropriate answers to such a question will most likely be of increasing relevance and importance to private industry as firms realize the benefits of self-internalisation and accounting for potential future costs from pollution in current decision-making. This study has also opened doors for other research in this field in the aim of developing an appropriate method to estimate the private valuation of a public environmental asset.

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