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Economic aspects of Safety in the Construction Industry

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Abstract
This paper addresses the economic impacts of construction safety in Greece, based on a methodology for determining the overall costs of safety, namely the sum of the costs of accidents, the costs of effective preventive efforts, and the costs of safety management failures not involving an accident. The methodology was applied to three construction projects in Greece to test the methodology and to offer some preliminary evidence on the business case for safety**.** The methodology incorporated systematic criteria for determining which costs are counted in the overall cost of safety. The results suggest that while the overall costs of safety for a principal contractor were very small compared with the overall project budget, but up to 11.5% of gross profits. Those projects that appeared to manage safety most cost-effectively achieved the lowest overall safety cost. The practical work was supported by a theoretical analysis that showed that in the construction industry there is a plausible business case that the pursuit of 'zero accidents' is justified on economically.

Keywords
Costs of Accidents, Costs of Management Failures, Prevention Costs, Safety Costs

1. Introduction

There are three primary motivators for the achievement of high safety standards. First, it is unethical for employers to place their work people, and others, at unreasonable risk. Secondly, in most countries there are statutory duties to secure safe working conditions. Thirdly, it has been argued that preventing accidents is cost-beneficial: resources spent on preventing accidents can be justified exclusively on economic grounds, see, eg, HSE (1993), Panopoulos (1993), Geistfeld (2001). While the cited research has explored primarily the costs of accidents and ill health, there has been very little work on a systematic approach to measuring the costs of *prevention*. But unless decision makers know what the prevention costs are going to be then it is impossible for them to judge whether expenditure on prevention is merited purely in economic terms. This paper seeks to determine, theoretically and practically, whether preventive expenditure can be justified exclusively on economic grounds – the 'business case' for safety.

The paper has three main objectives, to describe a practical and transparent methodology for gathering and analysing data on accident and accident prevention costs and thus to determine the total costs of safety for a 'principal' contractor; to summarise the findings of a safety costing study carried out on three construction projects in Greece; to review the 'business case' for safety in the construction industry and discuss the criteria that determine the strength of the case, and in particular to discuss the factors that determine whether the pursuit 'zero accidents' can ever be the optimum economic organisational goal.

2. The costs of safety

Our safety costing methodology is founded on the basis that the total costs of safety are the addition of:

- *Prevention costs (PC),* meaning any expenditure made in an effective and timely way to prevent accidents occurring, or mitigating their consequences. In our methodology, PCs do not include any expenditure that is essential for operational reasons, even if a safety benefit might accrue.
- *Accident costs (AC),* namely any cost, including the costs of damage, arising from an incident resulting in personal injuries or with the potential to cause injuries. Accident costs (AC) include the costs of investigations, first aid treatment, hospital treatment, court appearances, and in general any spend that would not have been incurred in the absence of an accident.
- *Management failures with-no-accident cost (MfwnAC)* meaning wasted expenditure making no contribution to prevention and/or costs consequent upon failing to meet applicable safety standards, though no accident has occurred and irrespective of the potential for an accident. These costs include the cost of personal protective equipment (PPE) that does not conform to CE standards, the costs of penalties failing to comply with regulations, and costs associated with a loss of image.

Each one of the cost components (PC, AC & MfwnAC) comprises in turn the addition of costs under the following subcategories: Human Resources, Materials, Equipment, Other Expenses (down time costs, legal costs, etc), and Corporate Image (where applicable). Our analysis involved the division of costs into 120 discrete sub-categories, supported by a number of decision flow charts

There are considerable challenges in determining the sub-categorisation of each of these costs, how the raw cost data is obtained, and the calculation of plausible indirect costs such as loss of corporate image (reputation). Losses of image to a contractor, eg, adverse publicity following an accident or a prosecution, have significant cost implications, but are difficult to quantify with certainty. In Panopoulos (2003) an image cost rate has been used that was based on the first author's expert judgement. The rate can easily be changed by altering a 'constant' in the costing calculations. Moreover, the findings of a safety costing study may be dramatically affected by the definition of an accident. Our definition for an accident (see above) only includes accidents that had the *potential* to cause personal injury. If a broader definition of accident is used, as by the GB Health and Safety Executive (HSE, 1993), where damage-only accidents (with no potential for personal injury) are also included, then any comparison between prevention costs and accident costs is not comparing like with like.There are cases where it may be impracticable to include a prevention cost. For instance all tower cranes come with a Safe Working Load Indicator (SWLI). The crane could do the job without the SWLI. But to count this cost as a prevention cost we would need to know what proportion of the hire cost of the tower crane is for the SWLI.

3. The Business Case

Empirical, employer-level, measurement of accident and prevention costs could in practice be counter-productive as an inducement to employers to spend more – devote more effort - on safety. It might be shown from a Cost Benefit Analysis (CBA) for example, that safety expenditure is appropriate or indeed excessive, and that the occurrence of a substantial number of accidents is justified economically. Thus it is necessary first to establish, at least on a theoretical basis, that the pursuit of 'zero accidents' may prove to be the optimum economic case in practice. Some accident costs are borne by the employer, some by insurance companies, some by individuals and some by society. In each country, the costs of occupational accidents borne by society compared with those borne by employers will vary dramatically depending upon the social security system, the insurance market and legislation. Moreover the costs of accidents to employers will also depend on the rigour of local statutory enforcement (Geistfeld, 2001). Thus the business case for safety may be far more powerful in some countries than in others.

CBA needs to be distinguished from Cost-Effectiveness Analysis (CEA). CEA seeks to maximise the extent of achievement of a given beneficial goal within a predetermined budget or, alternatively, to minimise the expenditure required to achieve a pre-specified goal (Fabrycky et al 1998).

Figure 1 shows the conventional presentation of the costs and benefits of accident prevention. We have added to the graph the costs of MfwnAC which are assumed to correlate with accident costs. The graphs reveal that as PCs are reduced then the number of accidents (and MfwnACs) rise. The figure shows that the total Safety Cost (SC) is PC + AC + MfwnAC. The 'optimum' level of PCs is shown, associated with a finite number of accidents.

The problem with figure 1 is that it suggests that zero accidents is only achievable at infinite cost. Thus the graph is unhelpful in the promotion of zero accidents as a plausible corporate goal. We now discuss the hypothesis, via graphical representations, that prevention efforts leading to zero accidents can, in some circumstances, represent the best business case.

Figures 2 and 3 illustrate the hypothesis supporting the business case for excellence in safety. The key difference between figure 1, and figures 2 & 3, is that the latter explore the business case assuming finite values of prevention costs for zero accidents. The rationale for suggesting that zero accidents can be achieved at finite cost is justified by empirical evidence that the safest enterprises are those who are also the keenest advocates of the business case. Figure 2 shows the case where (absolute) safety 'pays', ie, the case where zero accidents is the optimum economic outcome. In contrast, figure 3 shows the case where zero accidents is not the optimum case.

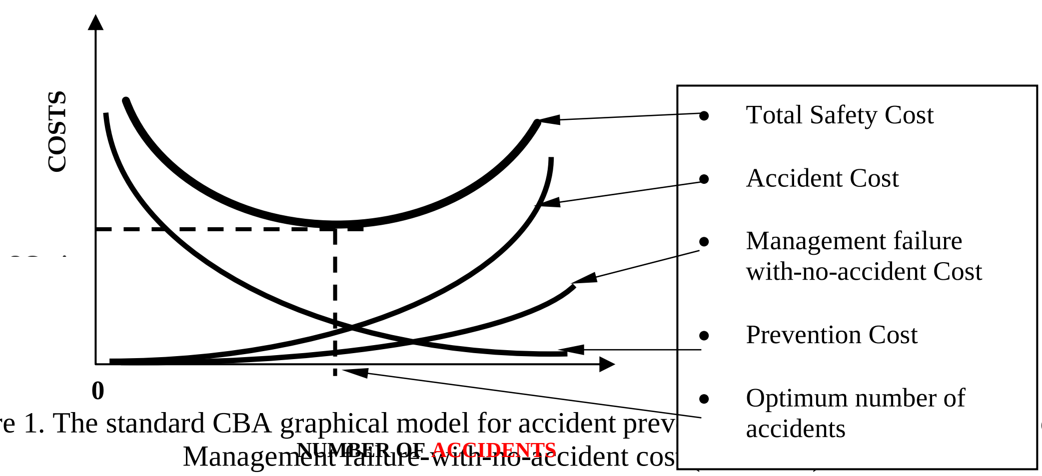

Figure 1. The standard CBA graphical model for accident prev … of Management failure-with-no-accident cos …

In both figures, the line denoted 'Average accident cost' (AC) increases non-linearly. The reason is that the greater the number of accidents, the greater the likelihood that some very serious (and costly) accidents will occur. The curve 'Average management failure with-no-accident…' shows that as accidents increase, so will MfwnAC (as suggested in figure 1). The curve ‘Optimum prevention cost’ represents the appropriate prevention cost associated with the number of accidents. This curve is also non-linear because preventing the ‘residual’ risks could be disproportionately expensive, as was shown in figure 1. Finally, the ‘Optimum Safety Cost’ presents the addition of the costs of the other three curves.

For the zero accidents scenario the AC is of course zero. As only the optimum prevention cost is considered, the MfwnAC is also zero, as stated above, and the SC equals the optimum prevention cost for zero accidents (Panopoulos and Booth, 2003). Here the ‘100% of optimum PC for zero accidents’ is equal to the ‘100% of optimum SC for zero accidents’ point in both graphs. The key questions now are, with an increasing number of accidents, does the PC decrease slower than the AC and the MfwnAC increase, or does the PC decrease faster than the AC and the MfwnAC increase? In figure 2, the crucial point is that the ‘best’ case is represented by ‘zero’ accidents because of the relative movement of the contributing costs - the ‘Optimum SC’ is at its lowest value at ‘zero’ accidents. In contrast to figure 2, figure 3 represents the case where the prevention cost declines faster than the management failure cost increases for up to a certain number of accidents and then for higher number of accidents the management failure cost gain ground over the prevention cost. Here the optimum business case is one where having a certain number of accidents is the ‘best’ result. Therefore, safety, or more strictly absolute safety, does not pay. But a break-even point is reached where a large number of (often expensive) accidents can be seen to be more expensive than ‘zero accidents’.

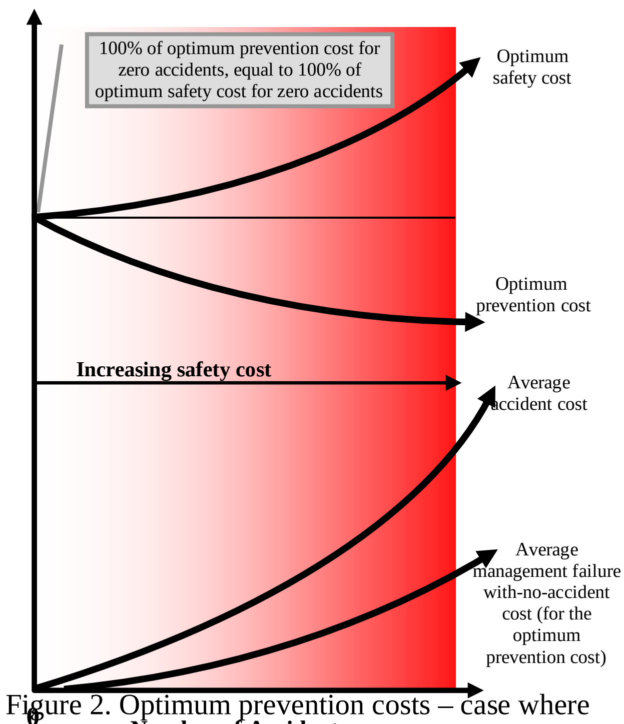

Figure 2. Optimum prevention costs – case where ‘safety (zero accidents) pays’

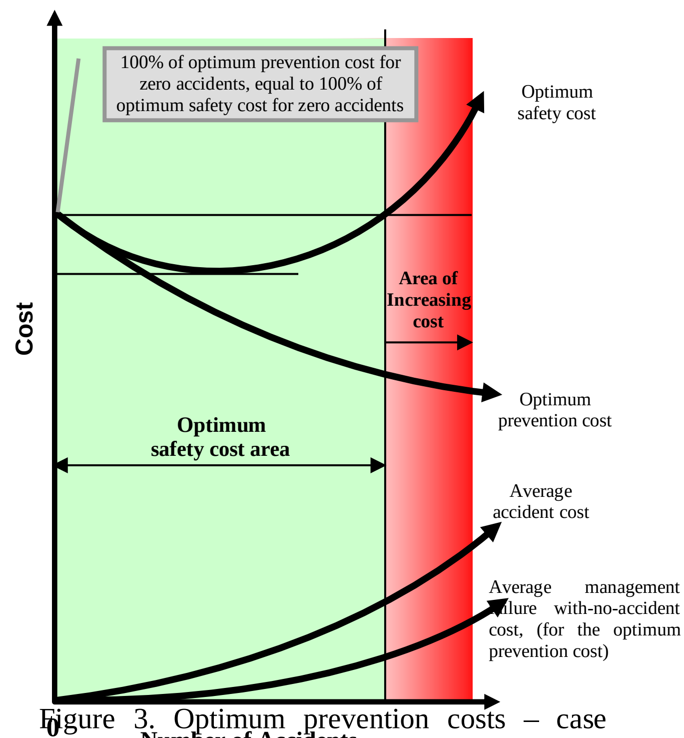

Figure 3. Optimum prevention costs – case where ‘safety (zero accidents) does not necessarily pay’

Zero accidents is likely to be the optimum business case (figure 2) if there is a likelihood that there will be a high proportion of serious accidents, eg, falls from heights and the prevention cost falls gradually as safety standards deteriorate. In contrast, the case for ‘allowing’ some accidents to happen is likely to be the optimum business case (figure 3) if there is a likelihood that there will be a high proportion of minor injury accidents, eg, falls on the level, and the prevention costs fall dramatically as safety standards deteriorate (and accidents increase).

In the construction industry in particular, it may be argued that figure 2 best represents reality. First, the industry is associated with potentially large numbers of serious accidents compared with minor-injury accidents. Secondly, site *compliance* with good safety standards is the crucial issue. If the appropriate safety facilities are already provided, eg, scaffolding edge protection and PPE, the prevention cost has been largely spent. What matters is whether the edge protection is kept in place, and that the PPE is worn. This case is predicated on a positive safety culture where compliance is the norm, and the cost-effective use of resources. The hypothesis that 'zero accidents' is the optimum business case (figure 2) is a plausible argument that can be adopted in discussion with employers.

4. Outline of Accident and Prevention Costing Survey

The survey was carried out in three sites, namely the Public Power Plant SA Ptolemais plant cooling towers reinforcement and renovation project (PPC), the administration building in the Thessaloniki MAMIDAKIS OIL SA refinery (ECO), and the Thessaloniki by pass from junctions K1 to K4 (K1-K4). The basic costing methodology for the survey has been summarised above. The survey work took place between February 1999 and December 2001 and involved 27 months of costing work on site. The key challenge was to ensure that all relevant costing information was obtained from the sites. We believe that prevention costs were reasonably fully recorded in all cases, and also serious accidents. But first aid accidents were only properly recorded in the ECO study. In practice, as the costs of first aid accidents in the ECO case were found to be very small, it may be assumed that the under-reporting in the two other cases has not substantially affected the results.

Table 1 Summary of the findings of the three projects

	K1-K4			**ECO**			**PPC**		
COST CATEGORY	€	CATEGORY/ SAFETY COST %	CATEGORY/ BUDGET %	€	CATEGORY/ SAFETY COST %	CATEGORY/ BUDGET %	€	CATEGORY/ SAFETY COST %	CATEGORY/ BUDGET %
BUDGET	**22,890,682**			**1,100,513**			**2,330,564**		
PREVENTION	68,707	89.53	0.30	5,288	54.36	0.48	15,186	37.61	0.65
MFWNA	0	0.00	0.00	959	9.86	0.09	13,603	33.69	0.58
ACCIDENT	6,531	8.51	0.03	1,580	16.25	0.14	8,691	21.52	0.37
IMAGE	1,500	1.95	0.01	1,900	19.53	0.17	2,900	7.18	0.12
TOTAL SAFETY COST				**9,727**	**100.00**	**0.88**	**40,380**	**100.00**	**1.72**

Table 1 summarises the raw findings of the survey. The overall costs of safety as a percentage of project budgets (contract price) varied from 0.33% (K1-K4) to 1.73% (PPC). It should be noted that these are very small percentages. However, with a gross profit assumed at 15% of the project value for the main contractor, the total cost of safety varied from 2.2% to 11.5% of the gross profit. In the HSE (1993) study, the cost of accidents to the main contractor was 3.1% of the tender price. But HSE (1993) included all damage costs where the accident did not necessarily involve the potential to cause harm to people.

Table 2 compares our average accident costs with the findings with the two HSE studies – the latter covers the average of data from different industries. The average costs of accidents varied substantially between our three projects. Part of the explanation lies in the small numbers involved, and in the case of first aid accidents, the fact that only at ECO were these accidents properly recorded. However, the weighted average cost of our first aid injury accidents was 65 Euros. The weighted average cost of our injury accidents involving over three-day's absence from work was 1,571 Euros. These figures are of the same order of magnitude as the evidence from HSE, where available.

Table 2 Average Accident costs in the three projects and in (HSE, 1993) and HSE (2003)

	STUDY/REFERENCE									
	K1-K4		ECO		PPC		HSE 1993		HSE 2003	
INCIDENT	**Nos**	**AVERAGE COST**	**Nos**	**AVERAGE COST**	**Nos**	**AVERAGE COST**	**Nos**	**AVERAGE COST**	**Nos**	**AVERAGE COST**
FIRST AID	5	285	35	34	N/A	N/A	56	12	N/A	50
OVER 3-DAYS	2	2407	1	337	3	1425	0	N/A	N/A	3142
DAMAGE ONLY	1	295	2	195	1	4063	3570	107	N/A	212

An important, though provisional, finding of the present work is that the prevention cost as a percentage of the total safety cost is an important factor. The higher the prevention cost the less the cost of safety overall. Figure 4 shows this tentative relationship. A theoretical analysis was carried out where the AC and costs of MfwnAC to were re-allocated to prevention. It was concluded that spending the same amount of money for safety the overall safety performance was dramatically better and consequently the potential cost of accidents and management failure with-no-accident was much lower.

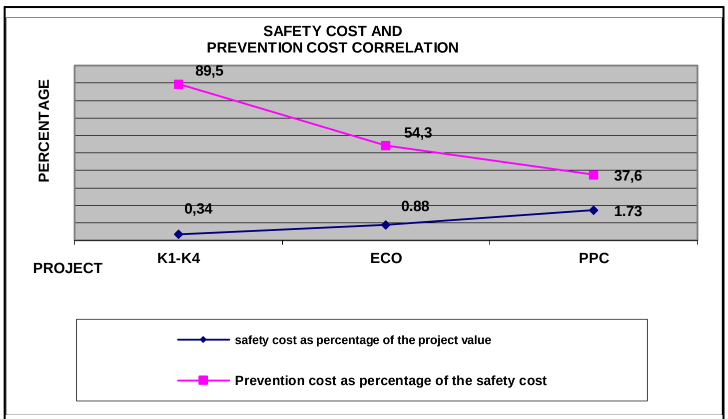

Figure 4. The grater **the lower the latter as a percentage of the project value**

5. Conclusions

The paper has described the development of, and the challenges associated with, an accident and accident prevention costing methodology. The methodology presented here is novel, transparent, and capable of being adapted to other activities and to other countries. We have demonstrated that, in a graphical representation, the 'business case' for the pursuit of zero accidents in the construction industry is economically justified. A practical study of the costs of accidents and their prevention revealed that the total safety costs represented between 2.2% and 11.5% of the project gross profits. It appears, on our data, that the more resources that are allocated appropriately to prevention, the less the total safety cost. Those projects which appeared to manage safety most cost-effectively achieved the lowest overall costs.

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