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Economic valuation of damages originated by major accidents in port areas

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ABSTRACT

Due to special features of ports – variety of activities: storage and loading/unloading of hazardous materials; circulation of ships, lorries and trains; proximity to urban zones; etc. – major accidents can be associated with severe damages. The cost of such accidents must be known to allow for compensation to people and companies. A procedure is presented to estimate the cost of damages suffered by people, equipment and environment. Criteria to assess the cost of damage to people – a controversial issue – are discussed, establishing a method to predict the number of people killed, injured and evacuated. Economic compensation is proposed. Environmental damages are also considered. These include potential damage to the atmosphere, soil, water and fauna. Estimates of the cost of the equipment and buildings affected by the accident are proposed. Finally, an assessment of the loss of profits due to activity breakdown and indirect costs is analysed. The methodology presented can easily be extended to general, inland process and storage sites.

1. Introduction

A great variety of activities are performed in ports: transport of passengers; transport of cargo; storage of oil and chemicals; storage and transport of cars; circulation of ships, lorries and trains; etc. Due to this intense activity, ports are very important facilities for the economy of a country.

To give an idea, in 2001, 357 million persons travelled through EU ports and the total tonnage of goods handled in the EU was estimated at 3000 million tonnes (Eurostat, 2003a). There were 261 maritime ports handling over 1 million tonnes of goods per year; 70% of all trade with third countries was channelled through the ports (Eurostat, 2003b).

Nevertheless, among all these activities there are some which imply a certain risk. In 2002, of the 6000 million tonnes of seaborne cargo, 1700 million tonnes were represented by crude oil, around 500 by other oil products and a significant part of the rest are other hazardous materials.

This entails risk of large-scale accidents, to which port areas and their vicinities are highly exposed. Accidents such as those of the 'Haven' (1991, Genoa) or the 'Prestige' (2002, A Coruña) highlight the financial and social repercussions of these events. Other less known accidents occur from time to time which also entail serious losses: of equipment or, sometimes, of human lives. The consequences of these accidents, beyond direct material or human losses, include the costs of emergency action, cleaning-up affected areas, spilled product recovery, etc. Table 1 lists some of the most severe accidents that have happened in port settings. Data are extracted from a list of 1029 accidents previously analysed (Darbra, Ronza, Carol, Vílchez, & Casal, 2004), which in turn proceeded from the MHIDAS database (Health and Safety Executive, 2005). Since information on accidental costs is seldom available, the data of Table 1 are not representative of the worst accidents occurred in ports. Nevertheless, they are significant examples of how port HazMat accidents can have significant economic consequences.

Although risk analysis and control of major accidents in fixed installations is regulated in the EU by the Seveso II Directive (European Parliament and the Council of the European Union, 1996), this does not affect the transportation of hazardous substances, whether airborne, seaborne, by road, rail or inland waterway. Moreover, the risk associated with the presence of hazardous substances on ships and/or in port areas is difficult to evaluate, due to the particular nature of these systems. A "port area" is characterised by a wide range of activities: whereas some of these are common to the majority of industrial areas (e.g., big oil terminals, presence of rail or road traffic, chemical and petrochemical plants, etc.), there are several activities that are to be encountered exclusively in harbour settings. The latter involve all

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Nomenclature

a	constant in Eq. (2) (-)
A	overall terrestrial surface of the port (ha)
A_a	surface affected by the accident (ha)
A_s	area affected (soil) (km^2)
A_w	area affected (water) (km^2)
b	constant in Eq. (2) (-)
C_{act}	breakdown costs (€)
C_{cl}	cleaning cost of the spill (US $ 1981 for Eq. (4); € for Eq. (5))
C_E	compensation for one evacuee per day (€/day)
C_{env}	cost of environmental damage (€)
$C_{I,k}$	compensation for a person injured in category k (€)
C_K	compensation for one fatality (€)
C_{LI}	compensation for a lightly injured person (€)
C_{LP}	total costs of lost profits (€)
C_{LW}	cost of lost wages (€)
C_p	cost of damage to population (€)
C_{plant}	cost of a process plant (€)
C_r	capital ratio (-)
C_s	unit cost of soil remediation (€/km^2)
C_{SI}	compensation for a severely injured person (€)
C_t	cost (free on board) of storage tanks (US $ 1969)
C_{va}	unit cost of a valuable animal (€)
C_{VSI}	compensation for a very severely injured person (€)
C_w	cost of cleaning-up water (€/km^2)
d	number of days (of evacuation or interruption of activity) (days)
F	annual turnover of a plant (€)
f	recovered fraction (-)
g	constant in Eq. (6) (€)
h	constant in Eq. (6)
I	daily income of port (€/day)
K	constant in Eq. (5) (€)
L	total mooring line length (m)
L_a	length of mooring line affected (m)
M	mass of hydrocarbon recovered (tonnes)
N_E	number of evacuated people (-)
N_I	number of injured people (-)
$N_{I,k}$	number of injured people in category k (-)
N_K	number of fatalities (-)
n_{ODW}	number of off-duty workers (-)
N_{va}	number of valuable animals lost (-)
Q	amount spilled (m^3)
S_a	affected plant area (m^2)
S_t	overall plant area (m^2)
V	volume of hydrocarbon recovered (gallons)
V_t	tank volume (m^3)
W	daily wage (€/day)
α, α_0, α_1, α_2	constants in Eqs. (4) and (5)

Table 1
Some port accidents that caused vast economic damage (source: Health and Safety Executive, 2005).

Date	Location	Economic damage (10^6 $)[a]	Description of the accident	N_K	N_I	N_E
01/1981	New York, NY, USA	280	Grounding of the tank ship "Concho"; 75% of NY Bay was covered with fuel oil.	0	0	0
09/1979	Deer Park, TX, USA	68	A ship off-loading vacuum distillate was struck by lightning and exploded. A piece of vessel punctured an ethanol tank at the refinery, igniting its contents. The explosions in the ship's hold spread, burning the distillate which set fire to several docks and four petroleum products barges.	3	12	
10/1979	Newcastle, Australia	Almost 60	A coal loader (cost: $90 m) was extensively damaged by a fire started with coal dust explosions. The conveyor belt was also damaged. The Exports of coal from New South Wales were cut by at least a third.			
03/1993	San Vicente, Chile	>50	Massive pool fire on sea water, ignited by a welding spark during ship discharge.			
02/1976	Houston, TX, USA	45	One row of a multi-storey concrete grain elevator was destroyed. A ship was damaged by debris. The 5×10^6 t of grain was destroyed, as well as the underground loading system.	9	7	
11/1979	Istanbul, Turkey	>40	A tanker exploded after a collision with a Greek freighter near docks. Three weeks after the oil burning in the harbour had been brought under control, the ship, still burning, suffered further explosions sending flames 300 m high and hurling burning debris on shore.	52	3	
04/1979	Port Neches, TX, USA	35	Fire, followed by blasts, engulfed the Liberian tanker "Sea Tiger".	2	30	
09/1997	Visakhapatnam, India	25.5	A vessel was unloading LPG into a storage tank when a leaking pipe caught fire. The fire spread to other storage tanks containing kerosene, crude oil, and petroleum products. The buildings nearby were significantly damaged. Very high death toll. 100,000 people were evacuated.	56	20	100,000
12/1976	San Pedro, CA, USA	21.6	"SS Sansinena" was being ballasted after off-loading crude oil. A flash fire was followed by a massive explosion (windows broken to 4 km). The entire tank deck rose 250 m into the air.	9	58	1000
12/1985	Naples, Italy	>20	An explosion/fire during transfer of petrol from a ship to storage tanks spread to 27 storage tanks containing 72,000 t of gasoline/diesel/oil. Two people outside the depot were killed by falling masonry.	4	170	2001
05/1976	La Coruña, Spain	18.7	The tanker "Urquiola" struck an uncharted rock while approaching the harbour. Authorities ordered the ship to remain offshore. The ship holed again and a subsequent series of fires/explosions sank her, spilling 102,000 t of oil, at least 30,000 t of which were washed up along 210 km of shore.	1	0	

[a] The source does not specify to what year the values here reported have to be referred.