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Hedging Strategies and the Financing of the 1992 International Oil Pollution Compensation Fund[1]

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Abstract

The maritime oil transport is regulated by the 1992 Civil Liability Convention for Oil Damage and the 1992 Oil Pollution Compensation Fund. In this compensation regime, contributions of oil firms are based on the aggregate risk of the Fund and are assessed each time an oil spill is registered. In this paper, we present the main characteristics of such a compensation regime and we explain why oil firms would benefit from a reorganization of the financing of the Fund by introducing appropriate hedging mechanisms. As standard insurance is shown to be too limited for the coverage of oil spills, we highlight the arguments that justify the introduction of financial hedging instruments in the management of the compensation system related to oil spills.

Keywords: Oil spill, IOPC Fund, risk management, insurance, financial hedging.

JEL Classification: D80, G22, K32, Q25.

1 Introduction

Activities of oil industries entail high risks, especially because the goods that are produced and transported can cause serious damage in the absence of precaution. The danger is especially significant when dealing with maritime transport and may induce cargo loss, environmental pollution or human death. Until the late 1960s, maritime organisations and international maritime law laid emphasis on the safety of shipmen and the protection of economic interests. Environmental protection has only become a major concern over the last three decades. This is not surprising given the frequency of oil spills during this period. Large oil spills (spilling more than 700 tons of heavy oil) were not uncommon in the 1970s and averaged out at 24.2 per year as estimated by the International Tanker Owners Pollution Federation Limited (ITOPF hereafter)[1]. Nevertheless, the introduction of a new international regime for the protection of the sea environment and the compensation of victims cannot be exclusively attributed to recurrent spills. The widespread media coverage of major oil spills and their impact on public opinion are also reasons that prompted governments to reform world oil transport. Indeed, in the wake of the Torrey Canyon incident in 1967[2], legislators from different countries recognized the gaps and shortcomings in national laws to regulate world oil transport. This disaster was the starting point in implementing a new regime, the main features of which still exist in most countries, apart from notably the United States. This regime currently includes the 1992 International Convention on Civil Liability for Oil Pollution Damage and the 1992 International Convention for the Establishment of an International Fund

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[1]ITOPF is a non-profit making organization based in London representing a vast majority of tanker-owners and their oil pollution insurers. Its main objective is to provide technical service to respond to oil spills.

[2]In March 1967, the Torrey Canyon, a tanker owned by a subsidiary of Union Oil, registered in Liberia and chartered to BP, approached the Scilly Islands off the Cornwall coast. The tanker hit a reef and ripped open six tanks. Over the next weeks, all the oil escaped and polluted the south coast of England and the Normandy coast in France.

for Compensation for Oil Pollution damage (1992 IOPC Fund)[3]. More recently, the scale of the Erika and Prestige wrecks[4] led to a sharp increase in the maximun compensation available and also to the implementation of a third tier called the Supplementary Fund. Furthermore, in the United States, the 1990 Oil Pollution Act (OPA 90)[5] was passed by Congress following a major oil spill caused by the Exxon Valdez[6].

Clearly, public opinion has not been the only explanation for the decrease in the number of oil spills - the tightening of control of ships' safety and economic considerations (cargo loss) are two other main reasons - but public opinion nevertheless played an important role all along. As a result, the average number of large oil spills during the 1990s was less than a third of that during the 1970s (source : ITOPF).

This paper focuses on the compensation system which is implemented when an oil spill is registered in the territorial waters of any member state of the 1992 Civil Liability Convention. Compensation is available from the 1992 IOPC Fund beyond the (limited) payment of the insurers of the firm held liable for the oil spill (in fact, the owner of the tanker). Members of the Fund are required to send contributions each time a damage is registered, whatever the flag of the wrecked tanker and whatever the citizenship of the owner of the oil. Hence funds are levied at random dates and expenses are not smoothed through time; the 1992 IOPC Fund does not work as an insurance system, despite the fact that it is often presented as a way to improve the compensation of victims. Moreover, coverage provided by the insurer of the tanker depends on the size

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[3]As at 1st September 2005, 86 Member states have signed both conventions and 6 states are due to join them by october 2005.

[4]The Erika cargo boat broke in two off the French coast on 12 December 1999. It was carrying approximately $30,000$ tons of heavy fuel oil and some $19,800$ tons were spilled. More recently, on 13 November 2002, the Prestige was carrying 77,000 tons of heavy fuel and broke in two off the coast of Galicia.

[5]Public Law 101-380 (33 U.S.C. 2701 et seq.; 104 Stat. 484). This act amended the Federal Water Pollution Control Act (33 U.S.C. 1301 et. seq.) to provide enhanced capabilities for oil spill response and natural resource damage assessment by the U.S. Fish and Wildlife Service.

[6]On March 24th 1989, the Exxon Valdez oil tanker ran aground in the Prince William Sound off Alaska, spilling 232,000 barrels of oil.

of the ship and, consequently, is limited compared to the damage that an oil spill can cause. For example, US$ 11 million were available from the Erika shipowner liability insurer, while total damage was estimated by the IOPC Fund to be more than US$ 1 billion.

Finally, despite major improvements in sea environment protection as outlined above, the current regime is still subject to severe criticism every time a new major incident occurs. We seek to show that the oil industry would benefit from a reorganization of its compensation regime closer to hedging mechanisms.

Although risk hedging is a good strategy, we will also present the difficulties in applying standard insurance mechanisms when covering large risks, such as large oil spills, especially because insurers are only partially able to diversify highly correlated risks. Capital markets seem to be able to solve this issue of diversification and also to mitigate transaction costs. Following Doherty (2000) and Froot (2001), we put forward alternative arguments that lead to a different rationale to hedge large risks. We systematically apply our reasoning to the oil industry and show how a joint hedging contract, which encompasses standard insurance and financial coverage, can improve the compensation regime of oil spills.

The paper is organised as follows. In section 2, we present the main features of the 1992 Civil Liability Convention and the 1992 IOPC Fund. We discuss in particular the limits of such a regime. In section 3, we highligt several reasons that make insurance profitable for firms in general, even if they act as risk-neutral entities protected by the corporate limited liability rule. We explain why standard insurance is not appropriate for solving the issue of large risks compensation: if an insurer were to bear all the risk of the Fund, he would run an increased risk of insolvency, knowing that a disaster would entail high levels of financial compensation. In Section 4, we analyse the theoretical literature and propose using the ability of wide diversification of financial markets to provide a mixed hedging mechanism for the specific risk of oil spill. Standard insurance is appropriate for small and medium spills, while financial market investments will enable the Fund to cover large oil spills. In seection 5, we conclude the paper.

2 The 1992 Civil Liability Convention and the 1992 IOPC Fund

International maritime transport (except notably that in the United States[7]) has been regulated by the 1992 Convention and by the 1992 International Oil Pollution Compensation Fund Convention since May 24th 2002. Before that date, both the 1969 conventions and the 1992 conventions applied simultaneously. Since the current conventions are very similar to the 1969 ones, we first present the latter Conventions and, then we present their amendments. The limits of the current regime are then subsenquently discussed.

2.1 The international compensation regimes

Following the 1967 Torrey Canyon incident [8], a major oil spill that shocked public opinion at the time, legislators in different countries recognized gaps and shortcomings in national laws in regulating the world oil transport. Under the auspices of the International Maritime Organization (IMO), governments adopted two conventions: the 1969 Civil Liability Convention for Oil Pollution Damage (the 1969 CLC), and the 1971 Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (the 1971 IOPC Fund). This double-tiered framework sought to define liability and compensation respectively for persistent oil pollution damage caused by oil spills.

Under the 1969 CLC, the owner of the ship is "strictly liable for any pollution damage caused by the ship as a result of the incident" that occurs in the territory or territorial waters of any member state. Indeed, the ship's flag and the ownership of the oil are not taken into consideration. The shipowner is only exonerated if the damage results from an act of war, an act of a third party, or negligence of a government in charge of the maintenance of maritime traffic devices.

The shipowner was designated as the only liable party in order to make it easier for the victims to receive compensation. However, the 1969 Convention limits his liability at

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[7]We present briefly the Oil Pollution Act voted by the American Congress in 1990 in the Annex.

[8]See Footnote 2.

133 Special Drawing Rights[9] (SDRs) per ton, with a maximum ceiling of 14 million SDRs. Moreover, the 1969 CLC requires the shipowner to purchase insurance for ships carrying more than 2,000 tons of oil in bulk as cargo. This coverage is most often contracted at a P&I Club (P&I stands for Protection and Indemnity). This is a non-profit making mutual insurance association, providing insurance for shipowners and charterer members against liabilities in their respective businesses. The 19 P&I Clubs are grouped in the International Group of P&I Clubs, which plays a key role for higher-value claims, since it provides collective insurance and reinsurance.

As defined in the 1971 Fund Convention, this first insurance tier is complemented by the IOPC Fund either if the amount available does not cover all claims; if the shipowner is exonerated from liability, or if he is not financially able to fulfill his obligations in full. The maximum amount payable according to the 1971 Fund is 60 million SDRs (Special Drawing Rights) less the compensation paid by the shipowner's insurer. If the total amount of claims exceeds this level, victims only receive a fixed proportion of their claims[10].

The 1969 and 1971 Conventions were both amended to create the 1992 Civil Liability Convention and the 1992 Fund Convention. The main differences deal with the maximum amount available for compensation which was raised to 135 million SDRs, and the fact that the Fund would also apply preventive measures to prevent or minimize damage[11]. Because of this features, most countries have ratified the new conventions. The 1971 Fund convention ceased to be in force as of 24 May 2002. The United States is the only country to have adopted its own national law to regulate oil transport as defined

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[9]The SDR is an international reserve asset. It serves as a unit of account for the International Monetary Fund and a number of other international organizations. In September 2005, the value of one SDR was US$ 1.48.

[10]In the Erika case, people received about 80% of the losses estimated by the IOPC Fund, while the purcentage for victims of the Prestige wreck falls to 15% at this date.

[11]The 1992 conventions cover "exclusively preventives measures to prevent or minimize such damages", article 2b of the 1992 CLC convention and article 3b of the 1992 IOPC convention. This includes only the immediate measures to prevent pollution.

in the Oil Pollution Act of 1990[12]. After the Erika wreck off the French coast in 1999, a new maximum amount was set to 203 million SDRs. This new limit has applied since 1 November 2003.

An important feature of the Fund Conventions is its financing mechanisms. The IOPC Fund is financed by contributions from the oil industry of member states receiving more than 150,000 tons of oil (crude and heavy fuel oil) per year after sea transport[13]. Each company's contributions are proportional to the annual tonnage received. The amount of contributions is decided every October by the Assembly of the Fund. The amount is to cover administrative costs and part of the estimated compensation payments for previous oil spills. There are in fact two seperate funds. The G*eneral Fund* covers administrative costs and claims for (small) oil spill incidents for which the total amount payable does not exceed a given amount per incident[14]. The *Major Claims Fund* cover payments in excess of the amount payable from the General Fund for any incident which gives rise to subsantial compensation payments. It should be noted that contributions to the General Fund are quite regular and only represent a very small part of total contributions after a major oil spill has occured. For instance, in October 2001, the assembly decided to levy £5 million ($ 7.35 million) for the General Fund[15] whereas £11 million ($16.17 million) was levied to the Nakhodka Major Claims Fund and £46 million ($67.64 million) to the Erika Major Claims Fund. As a rule, only a relatively small amount has to be paid by 1 March and the remaining is paid later. £25 million ($35.5 million) of the Erika Major Claims Fund had to be paid by 1 March 2002. It is important to note that several and

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[12]See Ketkar (1995), Jin and Kite-Powell (1999) (1995), and the annex of this paper for some details on this specific legislation.

[13]This exonerates some developing countries from paying contributions while they benefit from the compensation available in this regime if an incident should occur in their territorial waters. Thus, it contributes to the solidarity of the regime between industrialized countries and the global South. Manson (2002) notes further that the implementation of a regional oil pollution compensation fund by the European commission would certainly breach this solidarity principle since it would reduce the transfer of liability funds.

[14]4 million SDRs for the 1992 Fund and 1 million SDRs for the 1971 Fund.

[15]About £2 million ($2.94 million) are spent for administrative costs per year.

successive levies can be made for the same incident because the level of compensation can be reappraised. The point is to satisfy the claimants compensation request as quickly as possible and at the same time to avoid excessive cash outflows from the oil industry[16].

Recently a new Supplementary Fund was set up. The aim of this fund is to increase significantly the available funds for compensation. The principal characteristics of this third fund are discussed below.

2.2   Limits of the IOPC Fund

Some people have argued that this international compensation regime works well. They maintain that it has improved the protection of the sea environment against oil pollution as attested by the decrease in the number of huge oil spills occured over the last two decades. It also makes it easier for victims of pollution to claim settlements, and it has increased the compensation available to them, which is the real purpose of the Fund. Although claims for damage to the ecosystem are not admissible, compensation is granted for a wide range of costs: clean-up operations; property damage as well as economic loss; measures taken to prevent or minimize pollution (under the 1992 regime), as well as costs for "reasonable" measures to reinstate the contaminated environment. Finally, governments do not pay and the contributions borne by the oil industry really are fair compared to the revenues generated by oil related activities.

This regime has never displayed certain limitations regarding the total compensation available for victims and the incentives to enhance environment prevention undertaken by all parties involved in maritime oil transport.

As stated, the main objective of the IOPC Fund is to ensure appropriate compensation. This objective was not achieved recently in three major incidents involving the Nakhodka wreck (Japanese coast, 1997), the Erika wreck (French coast, 1999) and the Prestige wreck (Spanish coast, 2002). In the case of the Erika, the shipowner's insurer,

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[16]In fact, if the amount levied for a specific incident of the major claims Fund appears to be too high, the IOPC refunds the money in excess to the contributors (oil importers). No refunding is possible through the general Fund.

Steamship Mutual P&I Club, provided US$ 11 million for compensation and the IOPC Fund made a further US$145 million available. In the case of the Prestige, the IOPC Fund is not able today to guarantee more than 15% of coverage for each victim, after the indemnity paid by the insurer.[17]

Therefore the double-tiered regime has been recently complemented by a new fund: the International Oil Pollution Compensation Supplementary Fund. Its aim is to significantly increase the levels of compensation if compensation available through the Civil Liability Convention and the IOPC Fund should prove insufficient. The protocol establishing the Supplementary Fund was adopted in May 2003. It makes 547 million SDRs available in addition to the 203 million SDRs available from the IOPC Fund. As a result, Member States that joined this third tier will have a total amount of 750 million SDRs available to them for compensation which represents US$ 1155 million (based on a rate of exchange of 1 SDR=US $ 1.48 in September 2005). The Supplementary Fund Protocol enters into force three months after it has been ratified by at least eight states. These conditions were fulfilled on 3 December 2004 when Denmark, Finland, France, Germany, Ireland, Japan, Norway and Spain had all ratified the protocol. The Supplementary Fund will therefore come into force on 3rd March 2005. Figure 1 displays the amounts available under the new triple tier compensation regime.

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Figure 1 about here

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However, the Supplementary Fund does not respond to the main criticism levelled at the international regime: it does not appear to set sufficient incentives to reduce the risk of future oil pollution incidents and to encourage the social optimal level of prevention. When drafting the different conventions, it was considered that the compensation burden should be shared by the shipowner through the first tier, as defined in the CLC, and

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[17]Grey (1999) shows that, historically, insurers and the IOPC Fund have contributed in rather equitable proportion to compensation and rehabilitation up to now.

by the oil industry through the IOPC Fund. Although there is a direct link between compensation and the incident for the shipowner, the whole oil industry pays for each oil spill: no direct compensation between the oil owner and victims can be established. This in turn implies that charterers do not bear any liability for a specific incident. It is in the interest of oil companies to subcontract oil transport and there are no sufficient financial incentives for them to ensure a high level of ship safety[18].

Furthermore, if the shipowner is directly liable he may fail to ensure the ship is maintained properly and to ensure that appropriate safety measures are in place. This is because he is insured, at least partially, and he is also protected by the corporate limited liability rule which mostly benefits low market value firms (Schmitt and Spaeter, 2005; Dionne and Spaeter, 2003).

Another problem is the absence of any risk transfer system. By contributing a percentage of the aggregate loss of the IOPC Fund, oil firms participate in a system close to mutualization. Partial diversification is obtained within the pool, but there is no transfer of risk to an agent external to the Fund, like an insurer or a financial investor, despite the fact that the aggregate loss remains random after redistribution. In the next section, we put forward arguments that justify the direct use of insurance mechanisms by the oil firms or by the Fund.

3 The insurance issue

New firms' management of risks tries to encompass all types of risks and, for that reason, is called global risk management. Firms have to cope with numerous sources of uncertainties, linked to production processes; unanticipated market evolutions; unexpected internal organisation issues and also the existence of large risks. Large risks are often catastrophe risks. The rate of recurrence of such risks is very low but they can cause very significant economic damage, irreversible ecological destruction and sometimes loss

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[18]See Ringleb and Wiggins (1990) who discuss the issue of subcontracting from a firm to another firm and the risk transfer induced by this operation.

of human life. However, we will show that catastrophe risks like those caused by the marine transport of oil cannot be managed like other standard risks and, consequently, standard insurance processes are no longer sufficient to hedge those risks. However, it is first necessary to explain why risk is costly even for limited liability firms or, more specifically, for oil firms that are not held financially liable by the environmental legislation after an oil spill. The monetary gains for the firm to adopt an appropriate hedging strategy will form part of the arguments that justify the need for new hedging instruments and strategies.

3.1   The cost of risk

It is commonly believed that oil industry companies are not affected by the financial implications of a major oil spill. Under the 1992 CLC and 1992 IOPC conventions, the shipowner - and not the charterer - is held liable, and compensation available through the IOPC Fund is borne by the entire oil industry. Hence, the principle of mutualization firmly applies to the second tier of this regime. The risk of an incident and the financial losses incurred are spread out over a large number of oil importers. Moreover, the individual annual contribution to the Fund per ton of oil received after sea transport is quite low, ranging from 0.011 £ to 0.062£ for the period 1996 - 2001. This represents at most 0,05% of the price per ton of crude oil received.

In fact, oil companies are concerned about levels of contributions. Firstly, there are only about 400 companies worlwide that contribute to the IOPC Fund. Moreover, the highly concentrated oil industry sector explains the preponderance of a few multinational companies. For example, given today's estimates Shell will have to pay out around £20 million ($36.3 million) for the incident Prestige alone. Furthermore, a recent study by the ITOPF has shown that the burden of compensation is equally shared by the tankowners through their insurers and the oil industries.

Companies can also suffer from indirect financial costs which are sometimes much higher than contributions to the IOPC Fund. We mentioned earlier the role of public

opinion in prompting new regulations. Public opinion can also urge oil companies that have chartered ships involved in an oil spill to pay damages when the maximum amount available from the IOPC Fund is insufficient to cover all costs. This was the case for the Erika incident when Total[19] participated in clean-up operations and publicity campaigns to restore the Altantic coast's as a popular tourist destination. To restore its own image, the firm undertook not to apply for the 1992 Fund compensation since its (legally justified) claims would have lowered the compensation available for other parties.

The sharp decrease in the number of major oil spills does not necessarily mean that the total compensation to be paid by the IOPC Fund will keep diminishing. Actually, there is no linear relationship between the tonnage of oil spilled and total claims. What is striking about the two last major incidents - the Erika and the Prestige - is that although the tonnage of oil spill was relatively low as compared to preceding major incidents, the level of claims was extremely high. It was in fact much higher than the IOPC's maximum available compensation. There is a set of established factors affecting the cost of an oil spill, such as weather conditions, type of oil spilled and geographical proximity of the coast[20]. Besides this, intense economic development of coastal areas leads to an increased number of claims in case of an incident. The demographic growth of France's Altlantic regions for example has been much higher than the national average over the past decade. Interestingly, half of the 6000 claims received by the IOPC Fund for the Erika wreck come from the field of tourism compared to one third from the fishing sector.

Apart from the large amount of payments to be made after a major oil spill, oil companies are also exposed to volatile and unpredictable levels of contributions. As explained in Section 2, the only constant levels of invoicing are those related to the General Fund because they are dedicated to the payment of the administrative costs and

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[19]TotalFinaElf at the time of the Erika wreck

[20]White and Molloy (2003) offer a comprehensive analysis of these factors and their combination to explain the cost of oil spills. Interestingly, they assert that the management and the control of the response operations are also crucial factors. They blame political, public and media pressures for leading to inadequate decisions that can in some cases rise the cost of any incident.

to the coverage of minor oil spills (less than 4 millions SDR with the 1992 Fund). The greatest share of contributions goes to the Major Claims Fund. Invoices are sent after the incident, which leads to irregular and significant cash outflows for oil companies. This in turn leads to capital budgeting difficulties, and requires active risk management to hedge this volatility.

As regards the legislation, we know that limited liability protects a manager responsible for a damage from having to pay out the claim from his own wealth beyond the net value of the firm. Thus the manager has no incentives to cover the entire risk induced by his activity, and actions that he could take in order to reduce this risk are more costly for him than for a regulator in charge of reducing the global risk borne by Society. As discussed above, in the oil industry the 1992 Civil Liability Convention states that the liable party in case of an oil spill is the owner of the wrecked tanker, and not the owner of the oil. From a theoretical point of view, this does not give the oil industry incentives to care about appropriate risk hedging. However, in addition to the arguments specific to the oil industry laid out above, there are many other good reasons for a firm to spend time and money in insuring its risks, especially large risks that may harshly affect its earnings. As argued by Doherty (2000), hedging risk enables the firm to lower transaction costs due to agency issues and to bankruptcy threat and also to improve the relations between shareholders and bondholders. Hedging risks may also have a positive impact on the refinancing possibilities of firms by affecting the access conditions to external funds. This positive impact on the financing possibilities of the firm through external funds can be easily illustrated. If the manager hedges the risks inherent in the projects he selects, the main goal of the firm becomes to create value through production. This could also be interpreted as a good signal by potential investors, who would assign a higher value to the project. Insurance makes funds available for projects that would otherwise be rejected because of their risky components. Projects become more valuable and access to credit is facilitated. Moreover, a risk hedging strategy leads to a decrease in the probability of bankruptcy and this makes external financing cheaper.

Since insurance means the firm can smooth its revenues through time, future investments are not contingent to losses when they are hedged. Hence, the manager can focus on the development of new projects, and undertake the required investment without having to cope with a threat of a sudden fall in the financing availabilities because of an unanticipated accident. Furthermore, when risk is hedged some conflicts of interest between managers and shareholders are partially solved. For the benefit of both parties, managers can focus exclusively on making profit and they can be rewarded (penalized) in case of high (low) output. Closely related to this point is the mitigation of agency costs between, this time, the bondholders and the shareholders. The latter may (partially) control what is decided within the firm, while the former only act as outside creditors. Since shareholders are protected by limited liability rules, bondholders may anticipate a higher level of risk in projects than the optimal one. They may include this increasing risk in financial conditions offered to the firm. Shareholders will be better off if they could announce that risk is hedged in order to obtain a decrease in cost of financing (Mayers and Smith, 1983).

Finally hedging risks can generate substantial monetary gains or, symetrically, important reductions in transaction costs. Beyond short term monetary gains, risk hedging is also a way of sending the market a positive signal about the willingness of the firm or, more broadly, of the industry, to internalize the environmental dimension induced by its productive activities. Several American and Canadian empirical studies show that financial markets are sensitive to information on how firms manage environmental risks (Lanoie et al., 1998). Moreover, events that were not anticipated by markets often lead investors on capital markets to reconsider their investment strategy, knowing that an event such as a catastrophe does not only affect the short run profitability of the firm, but can be interpreted as a signal of poor prevention policy and, consequently, may lead to high risk in the future.

Given to all these arguments, risk hedging is an important objective in terms of reducing inefficiencies and, consequently increasing potential profits. Moreover, if risk

hedging is profitable for the firm, then it also improves social welfare, since the cost of risk reduction and of increasing ex post compensation is internalized through the strategy of the firm. Insurance and reinsurance markets provide a wide range of strategies, but they rely on some specific characteristics that large risks may fail to present. In what follows we develop the advantages and the limits of standard (re)insurance.

3.2   The limits of standard insurance

It has often been argued that statistics on catastrophe risks are difficult to obtain and that estimations of insurance premia are difficult to compute because of their low frequence. This argument has been put forward to justifiy that it is impossible to properly cover catastrophe risks. Nevertheless, it does not explain the incompleteness of catastrophe risk insurance markets.

Standard insurance mechanisms fail to diversify large risks properly. The transfer principle, which consists in a risk averse individual transferring his risk to another agent, who is able to bear this risk in counterpart of the payment of an insurance premium, is no longer applicable here. Indeed, risks among agents are highly correlated so that when an insurer registers a claim from one agent from a given area following environmental damage, it is almost certain that many other agents from this same area are also affected by this incident and will ask for financial compensation. As disasters often necessitate very high compensation levels, the financial funds of the insurer may rapidly become insufficient to pay for the insured losses. In the oil industry, firms play the role of agents: each of them bears a proportion of the agreggate risk of the IOPC Fund through their random contributions.

Furthermore, the mutuality principle(which consists in gathering the risks of individuals in a pool and distributing a percentage of the agreggate risk to each agent depending on his risk aversion degree (Borch, 1962; Wilson, 1968)) is also called into question[21] because, notably, the law of large numbers cannot be applied. Indeed, the

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[21]Doherty and Dionne (1993) mentionned that this principle was often moved away from analyses for the benefit of the transfer principle.

number of firms contributing to the Fund is limited compared to the magnitude of the aggregate risk. All these arguments still apply when focusing on the relationship between insurers and reinsurance firms so that reinsurers may also fail to diversify environmental risks properly[22].

It is well known that transaction costs account for a large part of insurance premia. For standard risks, they account for no less than 30% of the price of coverage[23]. When dealing with large risks, this percentage is often significantly higher. This is because of risks of insolvency of firms and/or insurers following an accident; difficulties in obtaining adequate information on the liabilities of the different parties involved in the accident (the shipowner, the commission that was in charge of cheking the safety of the cargo boat, the captain of the boat and his crew, the owner of the cargo, the maritime authorities, etc...) and because of evaluation procedures in dealing with the numerous claims caused by the disaster.

Another important related point, which limits the efficiency of standard insurance, is moral hazard. A firm whose risk is covered by an insurer has less incentive to develop preventive strategies that would reduce the risk of pollution. In such a situation, either the insurer will not cover the risk, or the insurance premium increases to take into account the extra risk induced by low risk-reduction activities. This phenomenon is often cited to justify why insurers try to commit firms into long term contractual relations. Financial markets can partially solve this agency problem because it is in a firm's interest to send a good signal to the market about their risk reduction strategies in order to have access to good financing or hedging conditions (Lanoie et al., 1998).

Lastly, insurers have to compensate an insured damage only if the environmental legislation states that the insured firm is liable. The 1992 Civil Liability Convention clearly states that only the owner of the tanker is liable in case of an oil spill, so that the

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[22]Doherty (2000) details the limits of reinsurance. In particular, he shows that moral hazard can lead to high costs that make reinsurance less valuable for the primary insurer than pure financial hedging strategies.

[23]These costs refer principally to administrative procedures, expert charges and audit.

owner of the oil is not prosecuted. Hence, only the shipowner's insurer is compelled to indemnify the victims. The insurer of the oil company is not involved in compensations, and the 1992 IOPC Fund intervenes without decisions of any court of justice. It is enough for the oil spill to occur in the territorial waters of one of its members. Hence insurers of oil firms could play a significant role if current international legislation were modified in the spirit of the American reglementation[24].

Finally, this is because of the dramatic consequences they may induce; the correlation that exists between the risks of agents or firms, and also the negative externalities induced by environmentally risky activities of limited liability firms. Standard principles of insurance are no longer sufficient to provide an appropriate hedging strategy of large risks. Alternative hedging mechanisms that can diversify risks over a wider range of individuals and transfer risk to agents, like financial investors, who can build a portfolio with assets from the entire world must be found. Capital markets seem to be able to realize such a risk spreading.

4 Providing a better hedging strategy of oil spills' catastrophes through capital markets

Firstly, we determine the characteristics of an optimal mixed strategy, namely a strategy that combines standard insurance and investment on the financial markets. This is done with regard to the theoretical literature. Secondly, we discuss the possibility of duplicating the optimal contract using a combination of financial assets that already exist on the markets.

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[24]In the United States, the owner of the oil transported by the wrecked boat is also held financially liable. On that point, the (american) Oil Protection Act displays some similarities with CERCLA.

4.1 The optimal mixed hedging contract

Insurance markets are efficient in insuring what is insurable. The definition of insurability[25] invovlves many factors. Sufficient statistics about passed events must be available, the damage must have been caused by an unpredictable event in the sense that only the probability of it happening was known, the demand of insurance should be sufficient and risks among agents should not be too highly correlated. If these factors are not present, an insurer will not be able to diversify all the risk in his portfolio. Consequently, insurance premia will increase and/or the supply of policies will significantly diminish. Insurers have been excluding pollution risks from their property liability insurance contracts since the 1970s in the United States and the 1980s in Europe. They found themselves no longer able to cover large risks that would affect their solvency and the development in environmental legislation worldwide made their position even less safe. Indeed, the so called 'liability crisis' yielded several important changes in risk management by insurers, but also by financial institutions such as banks. While the former began specializing in the coverage of standard risks, banks refused more and more projects by firms for financing. These even included some projects with high positive net value. This was especially the case in the United States, after Congress adopted the CERCLA legislation on waste management[26].

In Europe, the financial industry was also for several years opposed to the possible implementation of stringent environmental legislation[27] For this reason specific coinsurance groups were set up to propose specific pollution insurance contracts to firms.

In order to cope with the large risks generated by their activities, several firms in a given sector decided to do self-insurance by pooling their individual risks and redistrib-

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[25]See Epstein (1996) and Zeckhauser (1996) for instance.

[26]This legislation adopts the principle of joint and retroactive liability, so that banks and insurers became potentially responsible for any passed, present and future pollution created by their clients. See Anderson (1998).

[27]Finally, the European Council and the European Parliament decided to propose a new directive based on the need of financial guarantees rather than on a kind of extended liability, contrary to the United States.

uting a share of the aggregate risk to each individual firm. The share depends either on the risk attitude of the firm or on its level of activity. This system displays the properties of the mutuality principle. It is implemented in the nuclear sector (with the creation of 'captives') and it is close to the regime of the IOPC Fund. However, because the environmental risks generated by the activities of an industry, which are highly correlated, may have huge financial consequences compared to the limited number of firms within the industry, the aggregate risk can no longer be diversified within the group. Risk-retention, or self-insurance, is no more efficient here if considered alone. Such a risk spreading technique must be linked to other hedging mechanisms. One possibility is to combine standard insurance with public coverage. Herring and Pauly (2001) enhance the fact that a government is able to spread a given risk, for instance of flood in a specific region, over the whole population and to finance potential losses through taxes. Another alternative consists in harnessing the financial markets' ability to diversify risks among people from many regions of the world. As an illustration, Doherty and Schlesinger (2002) notice that Hurricane Andrew and the Northridge earthquake have caused between $50 and 100 billion in damage respectively and provision of the (re)insurance industry is worth about $300 billion. Indeed, "Losses of this magnitude are less than one standard deviation of the daily value traded in U.S. capital markets". Moreover, many differents assets are priced on markets and some can be combined in order to obtain appropriate coverage. This second alternative is considered by Doherty and Dionne (1993), Doherty and Richter (2002), Doherty and Schlesinger (2002), Mahul (2002) and by Schmitt and Spaeter (2005). The works of Doherty and Dionne (1993), Doherty and Schlesinger (2002)and Mahul (2002) focus on participating contracts: they involve using standard insurance to cover an idiosyncratic risk, specific to the agent as well as financing on capital markets in order to cover a systemic risk, common to a group of agents. The idea is that individuals are able to diversify their idiosyncratic risk within the pool but the systemic component needs to resort to other hedging instruments, like those provided by financial markets. The systemic risk, for instance a climatic one, is first covered by standard insurance, but the insurance premium is variable: its ex post

adjustment depends on the level of the damage caused. This variable premium is then hedged through appropriate investment in the financial market. The optimal coverage contract depends on the level of the cost of the financial investment compared to the one related to standard insurance. Hence, a mixed strategy with insurance and financial hedging would be a better solution than using exclusively standard insurance or doing self-insurance.

The hedging system designed by the State of California is a good illustration of this point. In order to increase funds available for earthquake insurance, the California Earthquake Authority set up. Its main goal is to gather provisions in order to be able to offer (limited) coverage of earthquake catastrophes and also to find other hedging mechanisms than standard insurance to remain solvent even if a huge loss occurs. These other mechanisms deal essentially with capital markets, against which some indexes based on catastrophe levels are built. We discuss this point with further detail in the next subsection.

If one adopts the mixed strategy, the aim is to find the optimal risk-sharing rule between insurance and financial markets. From a theoretical point of view, this solution is optimal for our case study, namely oil pollution risks. Indeed we show in Schmitt and Spaeter (2004) that the oil industry would benefit from a reorganization of the compensation system related to the IOPC Fund. To date, each oil firm bears a proportion of the aggregate risks, but no coverage system of the random contributions to the Fund exists. Hence we show that the aggregate risk of the Fund, which is equal to the sum of the individual oil spill risks of each firm, can be managed through a joint contract. Here a standard insurer would manage small and medium losses and those related to the General Fund, and investment on financial markets would help to cover catastrophe losses, which until then had been dealt by the Major Claims Fund. When the catastrophe component of the risk is borne by the financial market, the insurance sector can insure small and medium risks, which are considered standard ones, and ones that are easily diversifiable, at a lower cost than if it had to take into account all the risks, especially the states of nature with huge consequences. This decrease in the cost transaction means

the firm can obtain better insurance conditions for small and medium risks. In the case of a very large incident [28] the insurer provides an upper limit of coverage at optimum and the residual risk is hedged thanks to appropriate investments on financial markets. This is optimal if the price of financial hedging is lower than the one that would have been offered by a standard insurer if he had had to cover all the risk. This hypothesis is fair because of the arguments given earlier in the text.

We highlight in Schmitt and Spaeter (2004) that it is still in an oil firm's interest to invest in risk-reducing activities even if its risk is covered, because financial markets are sensitive to its environmental policy. If prevention is secured, which means here that the oil firm agrees to pay to charter a safe boat, a positive signal is sent to the market and access to external financing will be facilitated for the reasons given in Substion 3.1.

4.2   Some financial insights

The question is ultimately to determine which type of financial assets is the most appropriate for hedging large risks. In other words, is it possible to duplicate the optimal contract obtained through the theoretical analysis by a combination of financial assets traded on the markets?

Mahul (2002) proposes two types of alternative risk transfers: captives, which are based on the mutuality principle and index based derivatives, related to the transfer principle. The captives' mechanism consists in covering the risks within the firm or the industry. Captives are alimented by the firms or the industry and work as self-insurance. They came into being in order to solve the problem of limited coverage for large risks displayed by the (re)insurance market (Doherty et al., 1990). Such contracts usually involve firms with similar activities, or similar risks, and they can encompass firms in several different regions, countries or continents, so that diversification becomes possible once again. A captive can work as self-insurance for medium risks, that means with low financial consequences but relatively high occurence and can also be used to manage part

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[28]Such as those that the IOPC Fund could not fully compensate.

of large losses. This description is close to that of the IOPC Funds: the General Fund for small oil spills and the Major Claims Fund for large incidents. However, diversification is still limited in the context of oil spills because the limited number of member states and the concentration of the oil industry does not make it possible to eliminate all the risk driven by the aggregate input of the IOPC Fund.

The second alternative involves investing on capital markets by buying and selling appropriate securities. As mentionned by Doherty and Schlesinger (2002), "Securitization is often a substitute for reinsurance in that it allows for insurers to transfer excess risk. However, securitization can offer an ability to carve out pieces of the risk, rather than trading the risk as a whole". This point, applied to the relation between a firm and an insurance sector, goes backs up our results: Insurance should provide coverage for small and medium losses, while capital markets are useful to manage large losses.

Catastrophe options (CAT options) on a given index are particularly interesting for the purpose of large risks[29]. A CAT option is a contract that gives the holder the right to sell a specified underlying at a predetermined price. Some CAT options have been traded on the Chicago Board of Trade since 1992. Contracts are defined on different industries' indices of property liability losses. The indices are defined by region and each region of the United States is taken into account so that risk can be spread over a large area. The CAT option works as a standard option: each time index losses are higher than the striking price, the holder of the contract receives the difference between the index value and the striking price. In the oil industry, such a contract could be based on the amount of compensation paid for the oil spills. It is important to notice that CAT options dot not eliminate the risk of default. Sellers of CAT options must present financial guarantees, which may be very limited compared to the potential losses. In order to preclude this negative point, we suggest using stop loss contracts.

Figure 2 depicts a mixed strategy scheme (standard insurance/financial hedging) and introduces graphically stop loss contracts. X is the aggregate risk borne by the Fund.

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[29]CAT bonds are an alternative to CAT options. A CAT bond is a bond on which the principal is forgiven if the catastrophe occurs. Thus the risk is transferred to the investor who bought the contract.

$I(X)$ is the share of the indemnity covered by the standard insurer. In this example, $\bar{I}$ is the maximum amount provided by the insurance company for any level of damge higher than $\overline{X}$. Here, we assume that the residual risk is hedged on the financial market through a linear process. Hence β is the share of the residual risk hedged on the financial market. If β equals one, then the risk X is fully covered by the mixed contract (minus the deductible D for agency reasons). If we design an option contract with a strike price equal to $\overline{X}$, the seller of the option bears the entire risk for any damage higher than $\overline{X}$. Such a contract would only be attractive to very few investors and liquidity would be very low. Stop loss contracts enable to share the total risk between different investors. For instance, the buyer of a stop loss contract in the range $\left[\overline{X}, \overline{X}_1\right]$ will not be affected by amounts of damage higher than $\overline{X}_1$. Note that, in financial terms, a stop loss contract $\left[\overline{X}, \overline{X}_1\right]$ corresponds to a bunch of call options : buy a call option with strike price $\overline{X}$ and sell a call option with strike price $\overline{X}_1$.

Figure 2 about here

Finally, it is important to highlight that from the supply side investors may be attracted by these financial instruments because they are not (or at most weakly) correlated with other financial assets. This property is very attractive in terms of the theory of portfolio diversification. Whereas this argument holds true for all types of catastrophe risks, oil pollution risks are specific in that, over and above weather conditions and the location of the wreck, they also depend on human decisions, especially on the level of safety of the chartered boats or on possible act of sabotage. Nevertheless, the amount of the aggregate loss of the Fund is assessed by independent experts and eligibility for compensation can be rejected if a specific incident is proven to be deliberately caused. Financial quotations are very unlikely to be influenced by individual actions.

Finally, although losses incurred under the current international maritime regime are far lower than hurricane or earthquake losses, the implementation of the Supplementary

Fund will make oil companies even more sensitive to oil pollution risk. According to several executives at the Marsh Company, a world leader in business risk management and insurance broking, even the biggest oil companies are now aware of the needs to hedge this kind of risk. Indeed, the Supplementary Fund introduces a third tier that sets the total amount of compensation payable for any incident to a combined total of 750 million Special Drawing Rights (just over US$1,160 million), including the amount of compensation paid under the existing CLC/Fund Convention. This is more than three times higher than the current limit. Furthermore, this third tier will be taken over by a few companies. Indeed the Supplementary Fund is likely only to be ratified by European countries and Japan because only countries receiving more than 1,000,000 tons of oil a year can join the Supplementary Fund convention. This, in turn, means that the mutuality principle is weakened and splitting the total risk by issuing appropriate financial instruments is likely to become less costly than insurance coverage.

ANNEX : A brief description of the 1990 Oil Pollution Act.

The Oil Pollution Act (OPA) was signed into law in August 1990 in the United States. It raised the limits of liability and broadened the scope of damages that claimants can recover. It created the Oil Spill Liability Trust Fund which is available to provide up to one billion dollars per spill incident. The largest source of income of this fund has been the five-cents-a-barrel fee on domestic and imported oil until the fund was complete in 1994. The act also requires that newly constructed tankers operating in U.S. waters to be equipped by double hulls, and the phaseout or retrofit of existing single hull vessels by 2015.

Under OPA, all parties may be prosecuted to pay for costs and damage. Actually there are limits of liability that a company is required to spend on any oil spill. "However, if the incident is caused by gross negligence or willful misconduct or is the result of violation of applicable Federal regulation, then the responsible party is liable for the full cost of the response"[30]. In recent years, the sums recovered from responsible parties

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[30]Source : National Pollution Funds Center.

have represented over 25% of Fund expenditures. However, the National Pollution Funds Center admits that in nearly 50% of spills, it is impossible to identify the source of the spill or identify a responsible party. Furthermore, the government cannot always collect enough evidence to compel the responsible party because he is bankrupt, deceased or unable to pay. For more details see Ketkar (1995).

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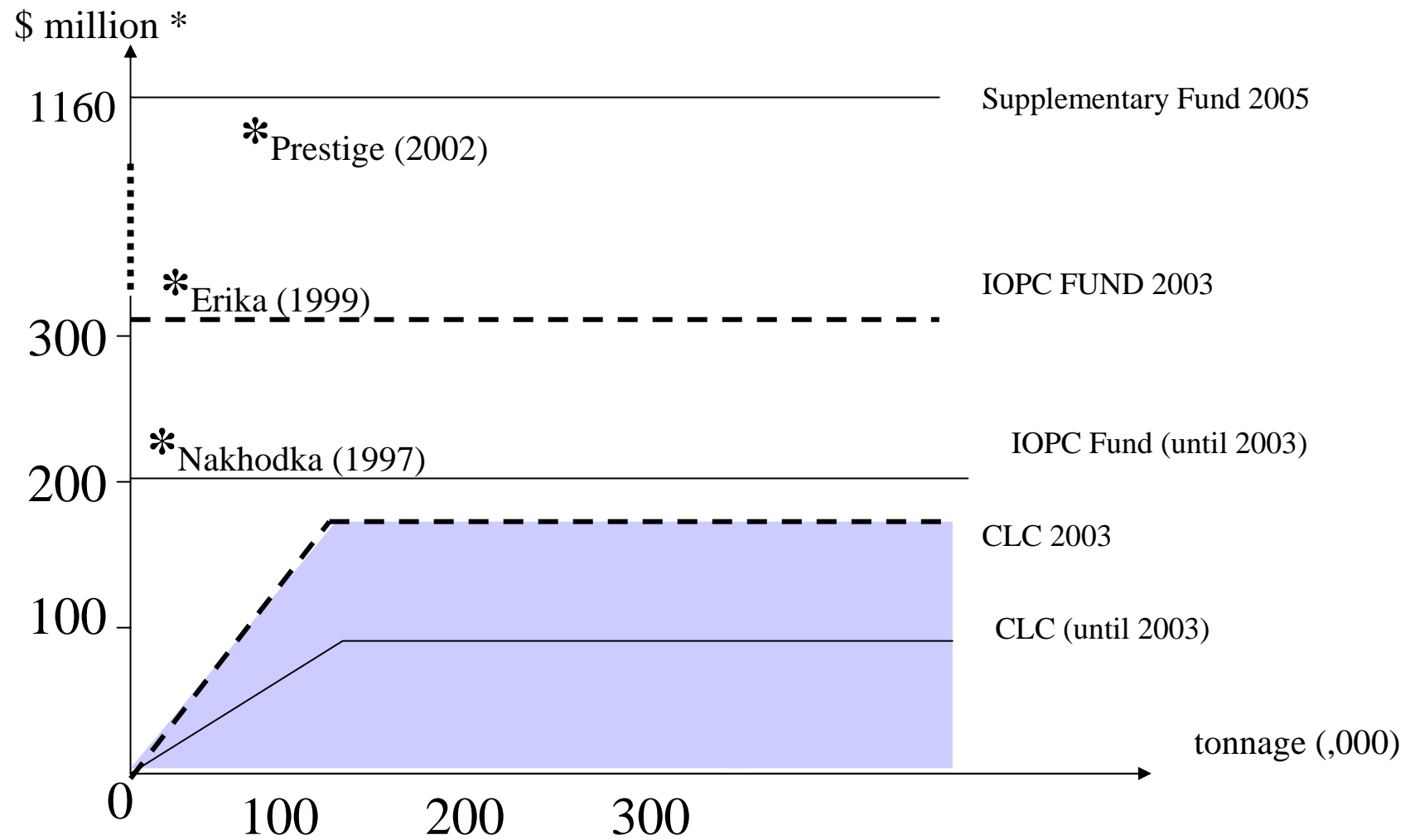
Figure 1. Maximum amounts of compensation available under the conventions
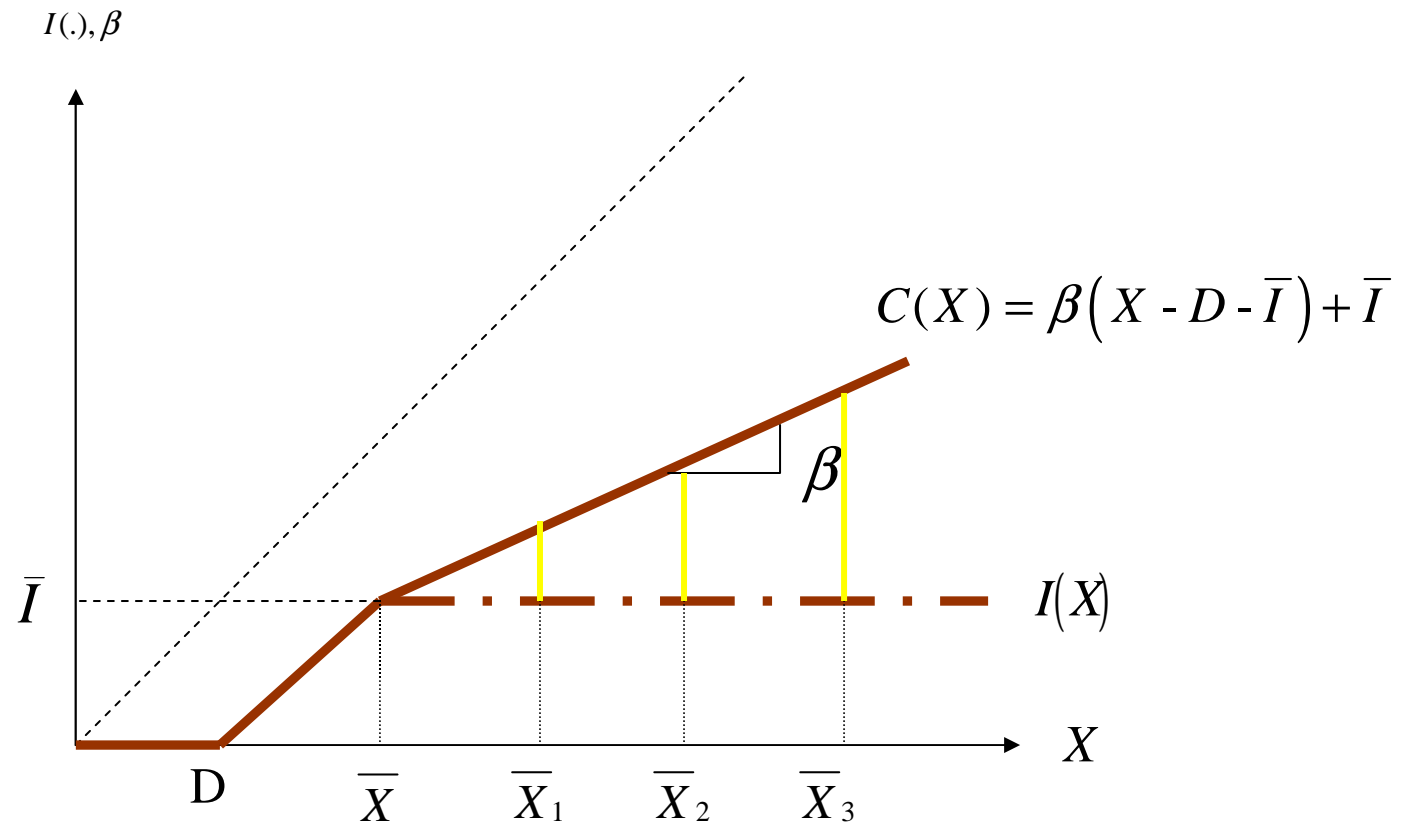
* Based on a 1 SDR=US $ 1.48 (September 2005)

Figure 2. An example of stop loss contracts with strike prices $\overline{X}$, $\overline{X}_1$, $\overline{X}_2$ and $\overline{X}_3$

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