# MEASUREMENT OF RISK IN THE APPRAISAL OF SHIPPING PROJECTS

**Hercules HARALAMBIDES**
**Senior Lecturer in Maritime Economics**
**World Maritime University**
**Malmoe-Sweden**

Recent years have seen a remarkable de-coupling of ship values and ocean freight rates. To a considerable extent this was a result of the increased speculative activity in the ship S&P market. In an interesting article on financial gearing in the June 1990 issue of Lloyds Shipping Economist it was correctly argued that "...ships have increasingly become a self-contained index of value ... and their prices have been dictated as much by the expectations of speculators and their access to liquidity as by genuine supply/demand considerations...".

The resulting increased volatility in ship values is consequently placing new emphasis on cash flow considerations for the evaluation of a project's viability over and above the collateral mortgage considerations.

Among the many tools that are available to the financial analyst for the evaluation of a shipping project are those that usually come under the title of *Discounting Cash Flow (DCF) Techniques* and more particularly the criteria of Net Present Value (NPV) and Internal Rate of Return (IRR).

Roughly speaking, the NPV criterion evaluates a project's financial attractiveness by discounting expected net income and then comparing it with the initial capital outlay required for the acquisition of the vessel. Given the shipowner's cost of capital, a positive NPV means that the present value of expected net income exceeds the initial capital outlay and the project in question is worth undertaking since its implementation automatically increases the shipowner's wealth.

A project's Internal Rate of Return is the rate of return on capital tied-up in the project, while it is tied-up and after allowing for the recoupment of the initial outlay. The IRR criterion consists of calculating *that* rate of return on investment that will turn out a zero NPV. For this reason the IRR is also known as the "hurdle rate". Although more difficult to calculate, the basic advantage of IRR over the NPV criterion is that it provides the evaluator with a very tangible and understandable percentage figure (such as 20%) which is directly comparable with the investor's cost of capital: If the latter is less than the project's IRR the project should be undertaken otherwise not.

In the traditional, *single estimate*, approach to project appraisal, the analyst assigns unique values, his "best estimate", to the possible yearly outcomes (net cash flows) of a contemplated investment proposal. On the basis of these outcomes, the analyst calculates the project's NPV and IRR which, as a consequence, also assume a unique value. One of the major criticisms of this approach is that it does not supply the analyst with any information about how safe or confident he can be with the result of his appraisal; something that is particularly important in the case of projects of marginal profitability such as the shipping projects during times of recession.

The point made here is that just the derivation of a single figure for the project's IRR (or NPV) does not provide the analyst with all the information that he would like to have prior to taking his decision. Assume that the rate of return on a shipping project is 20%. There is a number of other things that every analyst would like to know in addition to the above percentage:

a) What is the likelihood of not achieving the above return?
b) How likely is it to achieve a return of less than 10%?
c) How sensitive is the estimated IRR to changes in freight rates, interest rates and operating costs?

In the risk analysis approach which is demonstrated below, the analyst, just because of his uncertainty about what the future may hold, considers not just one but a range of possible outcomes for every year of the project's anticipated economic life. To every possible outcome the analyst assigns a certain, subjective, probability of occurrence according to his prior information experience and expertise. In this way, instead of a single IRR, a probability distribution of IRR is obtained.

Let us try to explore further the above idea with the use of a simplified example. This is the case of a shipowner considering the acquisition of a second hand vessel that costs $100. The shipowner is planning to use the vessel for a period of three years and then scrap it at zero salvage value. His cost of capital is assumed to be 10%. For each of the three years of operation he considers not one, but seven possible outcomes, and to each one of them he assigns a probability of occurrence on the basis of his personal expectations regarding future developments in the proposed freight market. These outcomes and the corresponding probabilities appear in Table 1.

As can be seen from this table, the investor is considering a range of possible outcomes for each year. For the first year the range starts with a very pessimistic $10, with a low probability of occurrence (5%), and ends with a very optimistic anticipation of $70 also with a low probability of occurrence (5%). The investor's "best bet" or most possible outcome is somewhere in the middle, $40 in this case, carrying a probability of 30%. This last outcome of $40, the investor's best estimate, would be the value to use as the expected NCF, in the traditional single estimate approach to project appraisal.

The same can be said for the range of possible outcomes of years 2 and 3. It should be observed, however, that these ranges have been extended at both ends to ($5,$80) and ($0,90), reflecting the investor's increasing uncertainty about outcomes in the more distant future. This is a very plausible assumption to make and approach to follow in assigning subjective probabilities to possible future outcomes. Although the investor may anticipate a gradual improvement in the project's performance, as time goes

Table 1

| Possible Outcome Year 1 | Possible Outcome Year 2 | Possible Outcome Year 3 | Prob. |
|---|---|---|---|
| 10 | 5 | 0 | 5% |
| 20 | 25 | 35 | 10% |
| 30 | 40 | 45 | 20% |
| 40 | 55 | 60 | 30% |
| 50 | 65 | 75 | 20% |
| 60 | 70 | 85 | 10% |
| 70 | 80 | 90 | 5% |

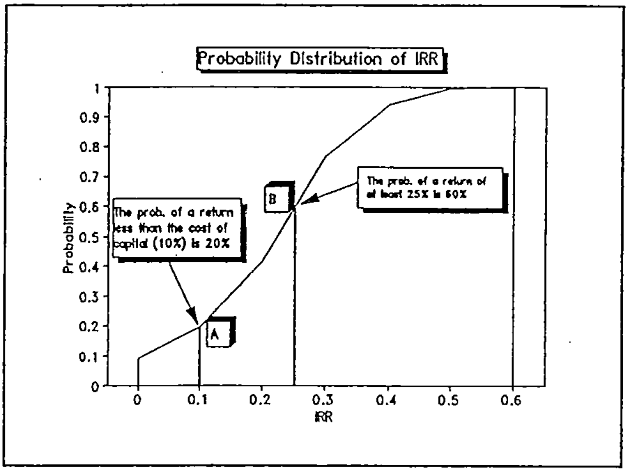
by, at the same time his uncertainty (or ignorance) about the things that can go wrong (or right) also increases. The probability distribution of possible outcomes is thus said to become flatter from one year to the other.

Let us now return to Table 1. In the traditional single estimate approach the investor would consider only one value for each year as the only possible outcome (NCF) and this would be his best estimate; in our case, $40 for the first year, $55 for the second and $60 for the third. A single value would also be obtained as the project's IRR equal to 23.7%

Now, however, due to the investor's uncertainty, not one but seven outcomes for each year are considered possible. For example, the second possible outcome for the first year, $20, the third for the second year, $40, and the seventh for the third year, $90, could come up. To this new triplet of possible outcomes (20,40,90) corresponds a new IRR equal to 18.2%. In this particular example there can be $7^3=343$ such triplets of possible outcomes and to each of them corresponds an IRR.

The calculation of the 343 IRRs and their probabilities, however tedious, can still be performed manually without the use of a computer. In the case of a more realistic 10 year project, however, the number of IRRs is counted in millions and their calculation, even with the help of a computer, would be a formidable task. However, a *Random Number Generator* can be used to sample from the multi-variate probability distribution of Table 1. The sample mean (expected IRR) and standard deviation, $\sigma$, can subsequently be calculated the latter providing a measure of the project risk. The idea here is that the standard deviation is a measure of the average distance of possible IRRs from their mean (expected IRR). A small standard deviation means that the bulk of possible IRRs are concentrated relatively closely around the expected IRR. This simply means that the likelihood of something happening that is at great "variance" from the investor's expectations is rather small. Thus, the smaller the standard deviation the more confident the investor about the things that can go wrong (or right).

Graph 1




The *Cumulative Probability Distribution* of IRR in Graph 1 can also provide the investor with a lot of additional and rather useful information. For example, point B gives the probability of realising a return of at least 25% as being equal to 60% while point A gives a 20% probability that the investor will realise a return less than his cost of capital (10% in this example). This last probability can be used as an alternative measure of the project's risk; i.e. the probability of selecting a project that proves to be unprofitable.

Given the possible outcomes of Table 1, the above defined project risk can be seen to be a function of both the initial capital outlay, C, and the cost of capital, i. That is,

$$r = f(C,i), \qquad f'_c > 0,\ f'_i > 0 \tag{1}$$

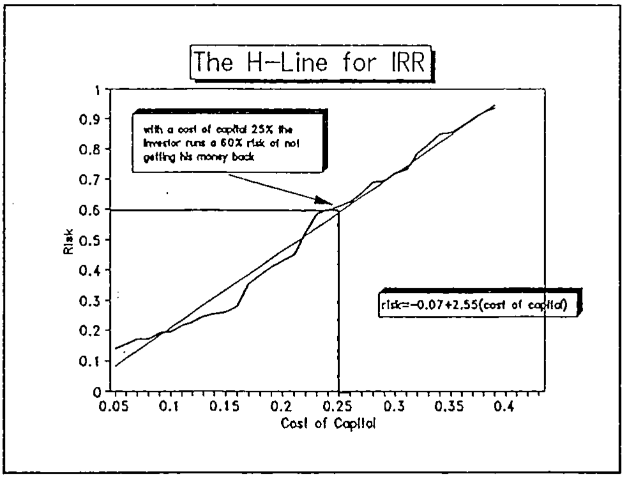
It is only reasonable to say that for any given cost of capital, i, the higher the initial outlay the higher the probability of the investor not getting his money back. Also, for any given initial outlay, C, the higher the cost of capital the higher the probability of realising a rate of return that does not exceed it.

The relationship between risk and the investor's cost of capital can be seen with the help of the H-Line of Graph 2. In the present example of C=100 and i=10%, the H-line for IRR can be constructed as follows: all observations in the sample of IRRs are examined and those with a value of less than 10% are identified, counted and their sum expressed as a percentage of the sample size. In this example, 40 IRRs out of a total of 200 were found to have a value of less than 10% and thus the risk of the particular project (i.e. the probability of realising a return less than the cost of capital) was 40/200 or 20% (point A of Graph 1).

Next, the above exercise is repeated a great number of times each time for a different cost of capital. The risk values that are obtained in this way are then plotted to give the jagged line of Graph 2. Finally, the above risk values are regressed on the corresponding cost of capital to give the regression line of Graph 2 which is the H-line for IRR.

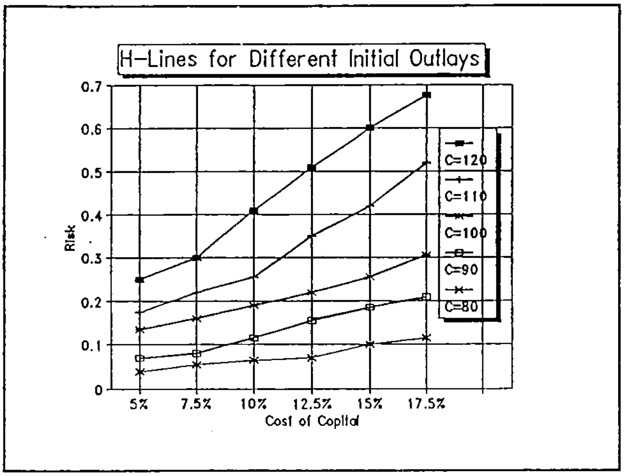
The H-line for IRR can be interpreted in the following way: for example, from Graph 2 it can be seen that if the investor has a cost of capital of 25%, by undertaking the particular project he runs a 60% risk of not getting his money back. To express the same thing in the opposite way, if our investor's risk profile is such that he would not be prepared to consider any project with a risk higher than 60%, then he should only initiate the particular project if he can ensure a cost of capital of no more than 25%. The slope coefficient of the H-line, b=2.55, shows the sensitivity of risk to changes in the cost of capital. In the present example a 1% increase in the cost of capital will increase project risk by 2.55%.

Graph 2



The H-line of Graph 2 was constructed for the case of an initial capital outlay of $100. But as it was explained above, a project's risk is a function of both the cost of capital and the initial capital outlay. If the latter increases, the number of IRRs that will not exceed any given capital cost will increase too and the H-line will shift upwards. Conversely, a decrease in C will shift the line downwards. Graph 3 presents H-lines for different initial capital outlays. It is interesting to note that as C increases the H-line not only shifts upwards but it also becomes steeper. This fact can be easily explained by the time value of money principle: The initial capital outlay is an amount usually committed in the current period and thus even a small change in it affects much more drastically the project's IRR than a relatively more substantial change in one of the cash flows that takes place some time in the distant future.

Graph 3




Graph 3 was created from data of a table similar to Table 2 below which is a *sensitivity analysis* table giving risk values for different capital costs and initial capital outlays. This table can be rather useful to the investor or his financier in a number of different ways. Let us consider again our simplified hypothetical case of a shipowner contemplating the acquisition of a vessel which he will operate for three years and then scrap with zero salvage value. There are now a number of ships readily available to him with prices ranging from $80 to $120 depending on age and maintenance record. The shipowner is most interested in a particular ship that costs $95. If his cost of capital is 12.5%, from Table 2 he can find out that by buying this ship he runs a 19% risk of not getting his money back.

Assume now that the shipowner has no preference for a particular ship, he has a cost of capital of 7.5% and that he does not feel comfortable with projects that demonstrate a risk higher than 16%. In this case Table 2 recommends that our shipowner should not pay anything more than $100 for his ship.

This time assume that there is only one ship that the shipowner is considering and it costs $105. His company has a policy according to which no projects are undertaken with a risk higher than 35%. Here, Table 2 suggests that this ship should be bought only if the shipowner can ensure a cost of capital of less than 15%.

Table 2 can also be very helpful to the bank providing the finance for the project. Assume that our shipowner is submitting a loan application to his bank for the purchase of a ship that costs $90. If at the time of the loan application interest rates are at a level of 10%, the bank can find out that the particular project runs a risk of 11.5%. This information can help the loan officer in a number of ways:

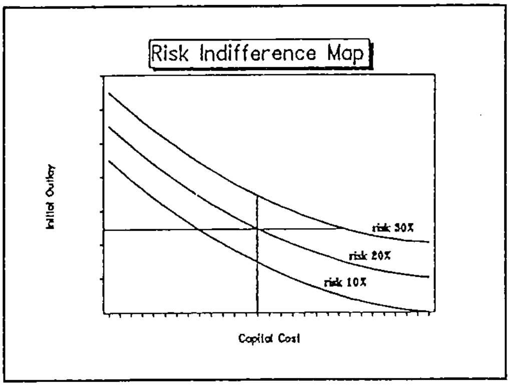
a) he can decide on the interest rate spread
b) he can decide on the type and amount of collateral required
c) he can manage the overall risk profile of the bank for its total shipping portfolio
d) if the calculated risk is deemed to be rather high, according to the bank's policies, he can suggest to the shipowner a cheaper alternative

Table 2

| C \ i | 5% | 7.5% | 10% | 12.5% | 15% | 17.5% |
|---|---|---|---|---|---|---|
| 80 | 0.04 | 0.055 | 0.065 | 0.07 | 0.1 | 0.115 |
| 85 | 0.065 | 0.07 | 0.075 | 0.11 | 0.125 | 0.17 |
| 90 | 0.07 | 0.08 | 0.115 | 0.155 | 0.185 | 0.21 |
| 95 | 0.085 | 0.13 | 0.155 | 0.19 | 0.22 | 0.25 |
| 100 | 0.135 | 0.16 | 0.19 | 0.22 | 0.255 | 0.305 |
| 105 | 0.16 | 0.175 | 0.22 | 0.255 | 0.35 | 0.42 |
| 110 | 0.175 | 0.22 | 0.255 | 0.35 | 0.42 | 0.52 |
| 115 | 0.21 | 0.255 | 0.345 | 0.415 | 0.525 | 0.6 |
| 120 | 0.25 | 0.3 | 0.41 | 0.51 | 0.6 | 0.675 |

Finally, Table 2 can be used to find the (C,i) combinations that will leave the investor on the same risk level. For example, a risk level of approximately 25% can be maintained with the following (C,i) combinations: (120,5%), (115,7.5%), (110,10%),...(95,17.5%). If these pairs of values are plotted in an XY graph a curve will be obtained which will be the investor's indifference curve between initial outlay and cost of capital. A number of such curves, each for a different risk level, are presented in Graph 4 which is the investor's *indifference map*. For any given capital cost, i, an increase in the initial capital outlay will shift the indifference curve upwards; a reduction in C will shift it downwards. Also, for any given C, an increase in the cost of capital, i, will shift the indifference curve to the right while a decrease in i will shift it towards the origin.

Graph 4




Theoretically, every indifference curve of Graph 4 can be derived by taking the total derivative of equation (1) and solve for C as a function of i.

$$0 = dC\frac{\partial r}{\partial C} + di\frac{\partial r}{\partial i}$$

It can also be established in this way that the indifference curves are downward sloping:

$$\frac{dC}{di} = -\frac{f_i'}{f_c'} < 0$$

given that, as it was mentioned above, both $f_i'$ and $f_c'$ are greater than zero.

It is hoped that the above exposition has demonstrated some of the advantages of the risk analysis approach to project appraisal over the traditional single estimate approach. The method's merits, however, should not be overemphasised and the approach should not be considered as a "panacea for all deceases". The investor's degree of confidence (as it can be measured by the estimated project risk) depends on the probabilities that he himself has assigned beforehand to the various possible outcomes and, in consequence, on his personal expectations and experience. This is a good point to state that the results from this or any other method can only be as good as the assumptions that were made in the outset. Every investor should be convinced in his own mind that if his initial assumptions are unrealistic or ungrounded he cannot really trust his results, no matter what the project's estimated risk is.

The above remarks do not invalidate the superiority of the risk analysis approach over the single estimate one. A bad single estimate is no better than a series of them; the latter always having the possibility to cancel out giving a more realistic average result. As a matter of fact it is just because of the evaluator's uncertainties and wariness about making a perhaps fatal single estimate that he should chose to consider a range of possible outcomes rather than only one.

The final question that has to be answered is whether the cost of time and money that is involved in the implementation of an approach like this is really justified by the improved results compared with those obtained from the single estimate approach. The answer here can only be general: *The merits of cost-benefit analysis are also a matter of cost-benefit analysis themselves.*

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