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APPRAISAL OF FISHING VESSEL ECONOMICS USING RISK ANALYSIS

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Abstract

The engineering economy approach is presented to help making investment decisions in coastal fishing. The relevant measures of profitability are identified and given. The reliability of the various deterministic approaches for the prediction of Profitability of fishing vessels is indicated. The Probabilistic approach for evaluating fishing vessel economics is presented. Particular emphasis is placed on the variabilities of both Revenues and Expenditures as well as their statistical parameters. The analysis is based on the assumption that Revenues and Expenditures follow the Normal density function. The effect of uncertainties in the prediction of both Revenues and Expenditures on the profit margin is investigated. It is shown that it is possible to determine the minimum Revenue/Production required from a projected coastal fishing vessel to satisfy an acceptable predetermined risk for investment in coastal fishing.

1. Introduction

Fishing vessel design, building and operation require social resources (manpower, materials and funds). The effectiveness in the use of these resources strongly depends upon the proper choice of ship type, size, material of construction, engine type and power, degree of mechanisation, degree of automation, quality and capacity of fishing equipment, type quality and capacity of fish preservation equipment, quality and versatility of outfittings, quality and variety of electronic equipment, quality and number of crew accommodation, etc. The most effective ship is the one which either performs the required job with minimal of resources or using the limited resources in the most effective way.

Solving some design problems (such as minimum hull weight, minimum resistance,) may be based on the use of engineering measures of effectiveness only. However, to compare relative merits of design alternatives, the engineering economy approach should be used.

It should be emphasized, that the cost of design, construction and fitting out of a modern fishing vessel is rather high. This requires a rational procedure for estimating Revenues and Expenditures so as not to overinvest in a fishing vessel to operate in a fishing condition with limited resources, revenues and/or high expenditures. Therefore, the compatibility among Revenues, Expenditures and Initial Investment cost should be very carefully examined so as to ensure an acceptable profit margin.

This paper is concerned mainly with the analysis of Revenues, Expenditures and Profit obtained from fishing vessels operating under conditions subjected to elements of uncertainties. It is shown that fishing vessel profitability should be based on an acceptable Risk determined from the uncertainties associated with the parameters affecting both Revenues and Expenditures.

2. Profitability

In the engineering economy approach (1), effectiveness can be replaced by profitability. The latter could be measured in different ways, of which the most simple and straight-forward one is given by:

$$M = R - E \qquad (2.1)$$

where:

M = annual profit margin

R = annual revenue

E = annual expenditure

Profitability could be also measured by the rate of return on the invested capital. The calculations could be carried out before or after tax depending on the conditions of investment. Assuming money spent as negative and returned as positive, the rate of interest is calculated from the following equation:

$$NPV = \sum_{j=0}^{n} A_j/(1+i)^j = 0 \qquad (2.2)$$

where: A_j = sum of money spent/returned in year "j"

n = ship's life in years

i = rate of interest

Equation (2.2) is very useful when the distribution of cash flow over a specified period of time is known or could be estimated with a reasonable degree of accuracy. However, this is not always the case, particularly for fishing vessels as Revenues can not be easily predicted.

This approach, therefore, is not reliable for predicting the profitability of fishing vessels. However, it could be very useful for analysing the profitability of a fishing vessel using available data from similar fishing vessels on Annual Revenues and Expenditures.

Assuming that the initial cost of the ship is paid as a lump sum at the beginning of ship's life, equation (2.2) could be used to determine the upper limit of investment cost as follows:

$$I \leq \sum_{j=1}^{n} B_j/(1+i)^j \qquad (2.3)$$

where: I = investment cost

B_j = annual net return in year "j"

Assuming also that the annual net return to be constant over the oeprational life of the fishing vessel, equation (2.3) becomes:

$$I \leq B. \sum_{j=1}^{n} 1/(1+i)^j \qquad (2.4)$$

Hence:

$$\frac{B}{I} \geq \frac{1}{\sum_{j=1}^{n} 1/(1+i)^{j}} = CRF$$

where: CRF = capital recovery factor

Therefore, profitability could be measured by the CRF, the greater this factor, the better is the investment (2).

This approach could be used to obtain an approximate value of the required investment cost for a fishing vessel using available data on B and CRF from similar vessels, as follows:

$$I \leq B/CRF$$

However, the estimated value of the investment cost should be adjusted to take account of the inflation rates, changes in ship prices, etc. This approach, however, will not yield reliable values for investment costs for projected investments in coastal fishing, as the assumptions used are not always valid.

If the investment cost is a borrowed capital, equation (2.2) becomes:

$$NPV = \sum_{j=1}^{n} (r_j - y_j - a_j) \times \frac{1}{(1+i)^{j}} \geq 0 \qquad (2.5)$$

where: r_j = annual revenue of year "j"
y_j = annual operational cost of year "j"
a_j = annual cost of capital in year "j"

$$a_j = \frac{1}{n-g} . \{ 1 + k[n-g-j) \}$$

g = grace period

I = borrowed capital

n = loan period

k = rate of interest of borrowed capital

Equation (2.5) could be used to examine the suitability of the conditions of the borrowed capital, for investment in a fishing vessel to operate under a certain fishing condition when data on Revenues and Expenditures can be reliably predicted.

It is evident from the foregoing that the various economic approaches outlined will not yield reliable estimates for investment costs of fishing vessels. This is due to the unpredictable values of both annual revenues and expenditures. The rational approach, therefore, should take into account the uncertainties associated with the parameters affecting both Revenues and Expenditures.

3. Statistical Parameters of Revenue

Revenues and Expenditures are not deterministic quantities as the parameters affecting both are subject to elements of uncertainties.

Annual revenues depend on the composition of species, catch volume and ex-vessel price of each species (3). It is evident that in fishing operations, the annual revenues are very unpredictable and rough estimates are always used for the expected catch volume.

The annual revenue "R" is given by :

$$R \equiv Q.C. \qquad (3.1)$$

where : Q = annual fish production, tonnes

C = average price per tonne of fish produced

Since Q and C are statistically independent, and could be assumed to follow the normal density function, the revenue "R" also follows the normal p.d.f. (4):

$$\text{i.e.} \quad R \equiv N\,[\overline{R},\ \sigma_R] \qquad (3.2)$$

where : $\overline{R} = \overline{Q} \times \overline{C}$

$$\sigma^2_R = \sigma^2_Q + \sigma^2_C$$

x = mean value of x, $x = Q$, C

σ_x = standard deviation of x, $x = Q$, C

4. Statistical Parameters of Expenditure

The annual expenditure "E" is given by (5):

$$E = E_F + E_V \qquad (4.1)$$

where: E_F = sum of all annual fixed cost items

E_V = sum of all annual variable cost items

Analysis of cost elements show that the annual fixed cost "E_F"

depends almost totally on the investment cost of the ship, whereas the annual variable cost element "E_V" depends on the investment cost, value of catch, exploitation time, engine power, competancy of the crew, etc. (5).

Therefore, the statistical parameters of the annual expenditure "E" could be estimated as follows:

$\bar{E} = \bar{E}_F + \bar{E}_V$, and

$\sigma_E \doteq \sigma_{E_V}$

where σ_x = standard deviation of x, x = E, E_V.
The mean value of Annual expenditure could be estimated using available data from similar vessels operating under similar fishing conditions. The cost of capital could be assessed using published data on the prices of similar fishing vessels.

5. Statistical Parameters of the Profit Margin.

The profit margin "M" is given by : $M = R - E > 0$ (5.1)

Therefore, the statistical parameters of "M" should be derived from the statistical parameters of both "R" and "E".

It is evident that the calculation of M and σ_M depends on the estimation of R, E, σ_E, σ_R. Since R and E are functions of several other parameters (6):

$R = R(x_1, x_2 \ldots x_n)$, and

$E = E(y_1, y_2 \ldots y_m)$ (5.2)

The mean and variance of "R" and "E" can be approximated using linear functions as follows:

$$\bar{R} = R\ (\bar{x}_1\ , \bar{x}_2, \ldots \bar{x}_n)$$

$$\bar{E} = E\ (\bar{y}_1\ , \bar{y}_2, \ldots \bar{y}_m) \qquad (5.3)$$

$$\sigma^2_R = \sum_{j=1}^{n} \left(\frac{\partial R}{\partial x_j}\right)^2 .\sigma^2_{x_j}$$

$$\sigma^2_E = \sum_{j=1}^{n} \left(\frac{\partial E}{\partial y_j}\right)^2 .\sigma^2_{y_j} \qquad (5.4)$$

It is evident that Annual Revenues and Expenditures are interrelated in so far as crew share & competency are concerned. This interrelationship depends on various factors, among them are Management Policy, Incentive Schemes, Condition of Vessel, etc. To take all these factors into account in the determination of the statistical parameters of the Profit Margin, will make the problem a very complex one. However, it is possible, under certain conditions, to assume that Revenues and Expenditures are statistically independent, without seriously affecting the results and conclusions.

Assuming that both "R" and "E" follow the Normal distribution, then the margin "M" also follows the Normal distribution, see Fig. (1), i.e. :

$$M \equiv N\ (\bar{M},\ \sigma_M) \qquad (5.5)$$

where $\bar{M} = \bar{R} - \bar{E}$

$$\sigma_M^2 = \sigma_R^2 + \sigma_E^2$$

Hence, the probability of making a loss "P_L"is given by, see Fig. (1)

$$P_L = P\ (R < E) = P\ (M < 0) = \int_{-\infty}^{0} p_M(m)\ d_m \qquad (5.6)$$

In order to simplify the calculation of "P_L", assume the following:

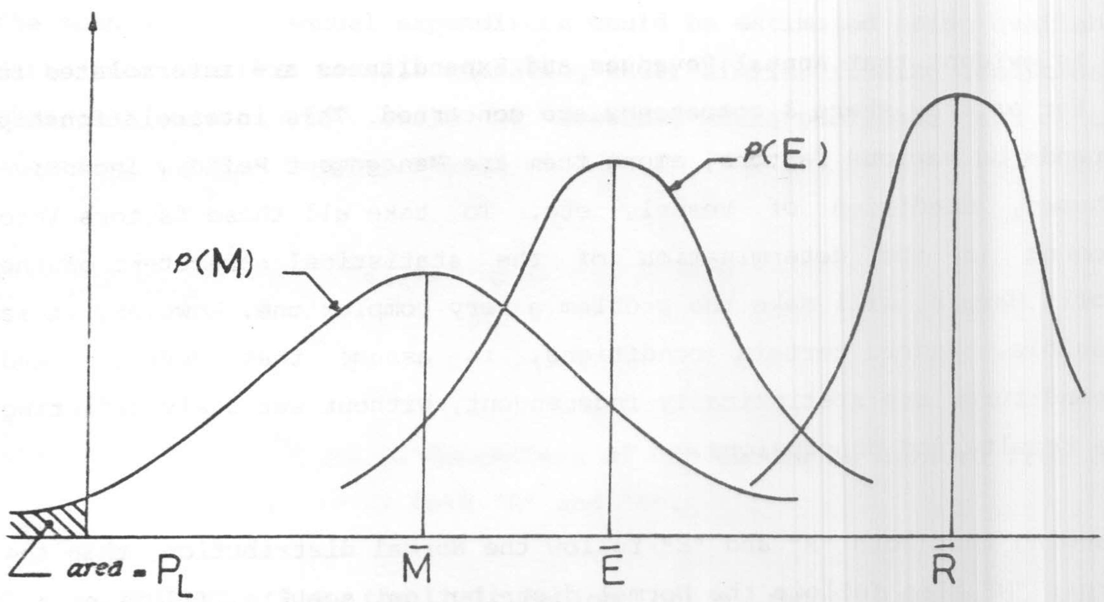


Fig. (1)

$$\beta = \bar{M}/\sigma_M \tag{5.7}$$

$$\gamma = \bar{R}/\bar{E} \tag{5.8}$$

Then

$$P_L = 1 - \varphi\left\{\frac{\gamma - 1}{\sqrt{\gamma^2 \cdot v_R^2 + v_E^2}}\right\} \tag{5.9}$$

where: $v_x = \sigma_x/\bar{x}$, X = R , E

v_x = coefficient of variation of x,x = R , E

The variation of "P_L" with the profitability factor, " γ " and the coefficients of variation of Revenue and Expenditure, i.e. v_R and v_E is shgwn in Figs. (2,3), for R = Normal and E = Normal and Figs. (4,5) for R = Extreme Type I and E = Extreme Types I and II.

Using the concepts given in reference (7), the average revenue required to satisfy an expected annual expenditure and an acceptable degree of risk could be estimated from the following equation:

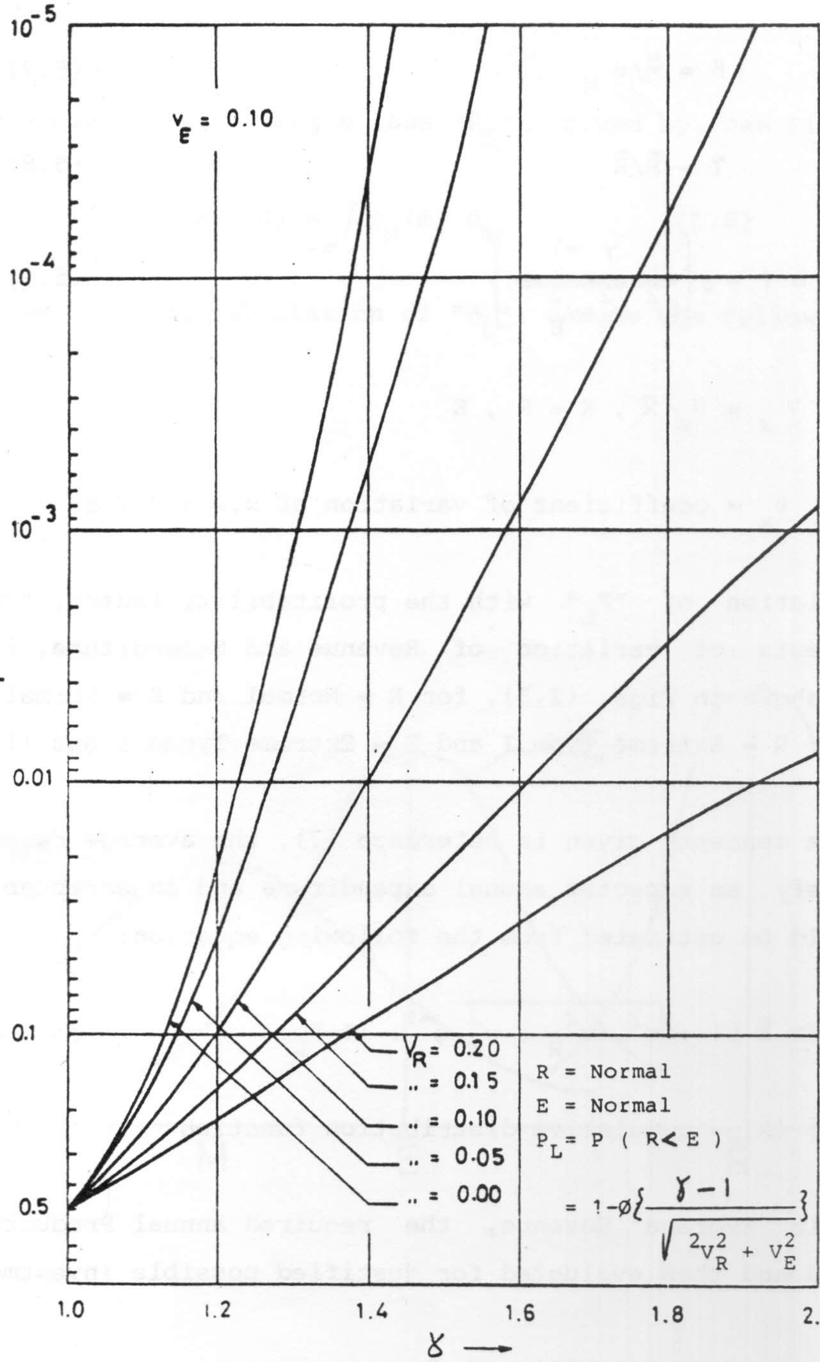
$$\bar{R} \geq \bar{E}\{1 + \sqrt{\gamma^2 \cdot v_R^2 + v_E^2} \cdot \varphi^{-1} \cdot (1-P_L) \tag{5.10}$$

where: φ (X) = cumulative distribution function

From this average Revenue, the required annual Production could be estimated and then evaluated for justified possible investment.

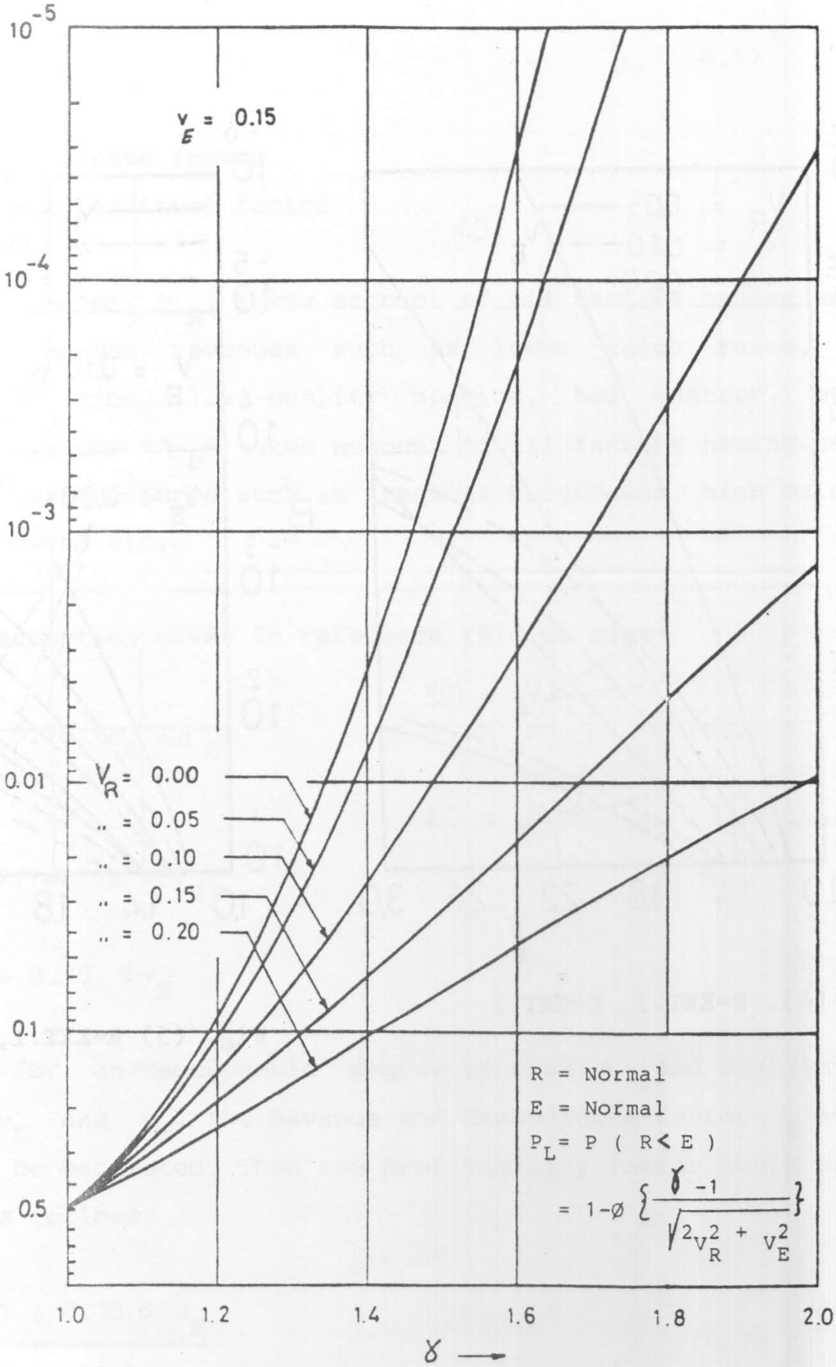
6. Analysis of Profitability Factor

The profitability factor " γ " could be separated into two factors (7):



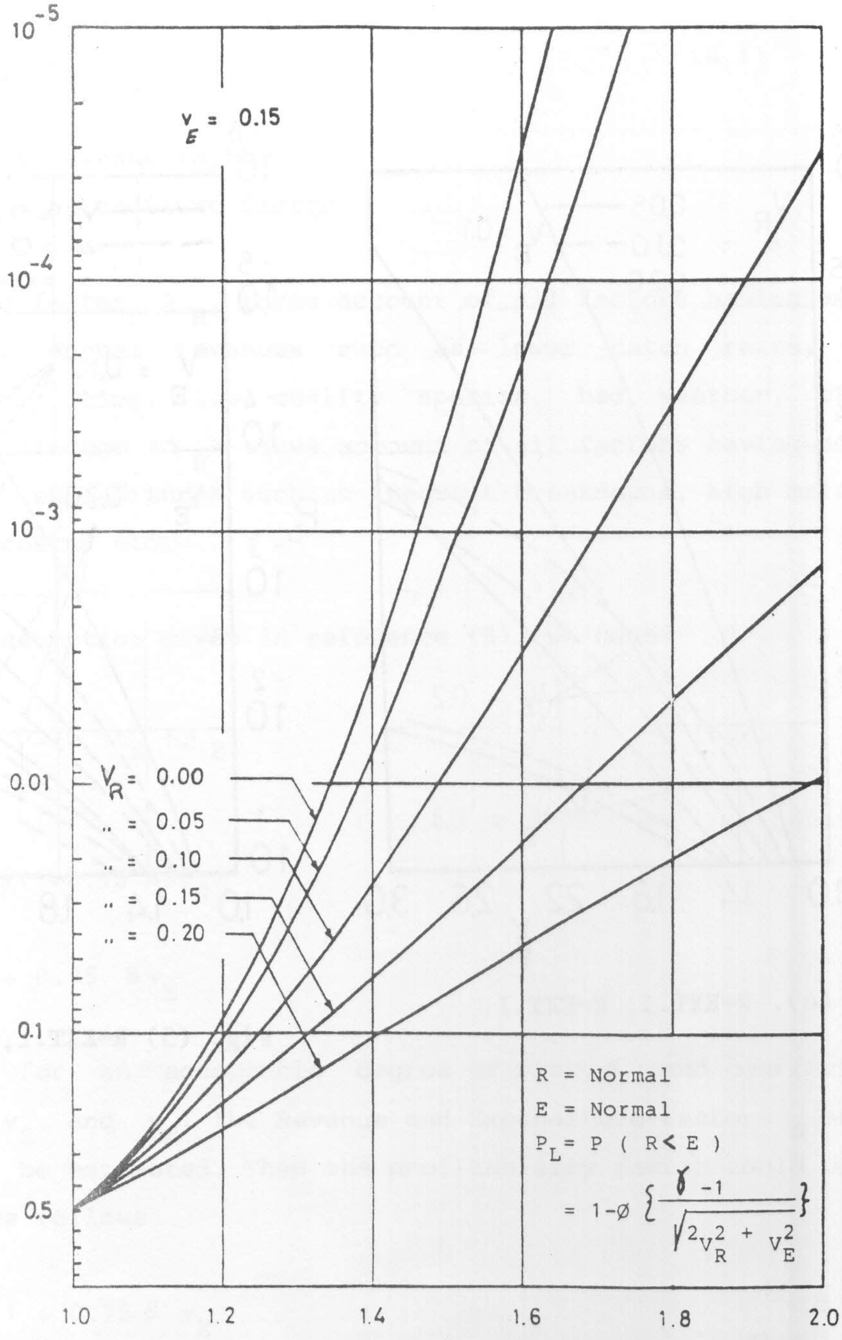
10^{-5}
10^{-4}
10^{-3}
0.01
0.1
0.5
V_E = 0.10
P_L
V_R = 0.20
.. = 0.15
.. = 0.10
.. = 0.05
.. = 0.00
R = Normal
E = Normal
$P_L = P (R < E)$
$= 1-\emptyset\left\{\frac{\gamma-1}{\sqrt{\gamma^2 V_R^2 + V_E^2}}\right\}$
1.0
1.2
1.4
1.6
1.8
2.0
γ

FIG. (2)



10^-5
10^-4
10^-3
0.01
0.1
0.5
P_L
V_E = 0.15
V_R = 0.00
.. = 0.05
.. = 0.10
.. = 0.15
.. = 0.20
R = Normal
E = Normal
P_L = P (R < E)
= 1-Ø {(γ - 1) / √(γ² V_R² + V_E²)}
1.0
1.2
1.4
1.6
1.8
2.0
γ

FIG. (3)



10^{-5}
10^{-4}
10^{-3}
0.01
0.1
0.5
P_L
V_E = 0.15
V_R = 0.00
.. = 0.05
.. = 0.10
.. = 0.15
.. = 0.20
R = Normal
E = Normal
$P_L = P(R < E)$
$= 1 - \emptyset \left\{ \frac{\gamma - 1}{\sqrt{\gamma^2 V_R^2 + V_E^2}} \right\}$
1.0
1.2
1.4
1.6
1.8
2.0
γ

FIG. (3)

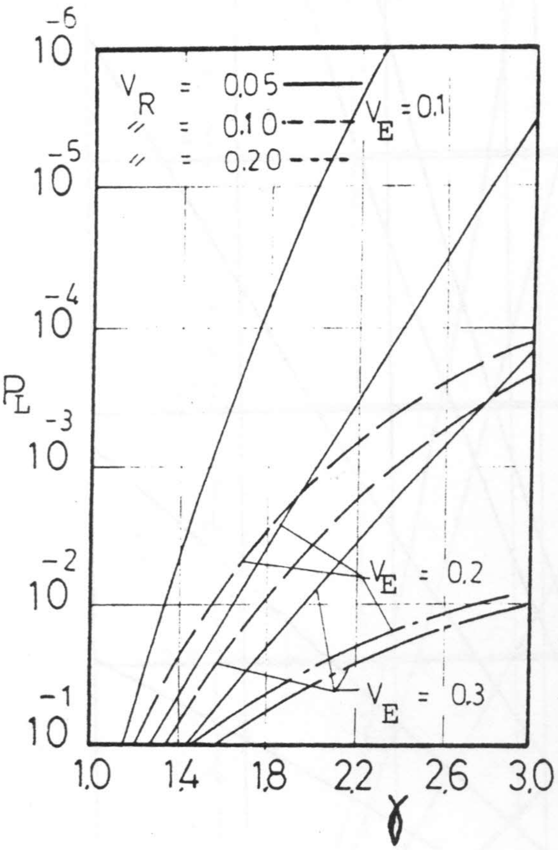


Fig. (4). R=EXT.I, E=EXT.I

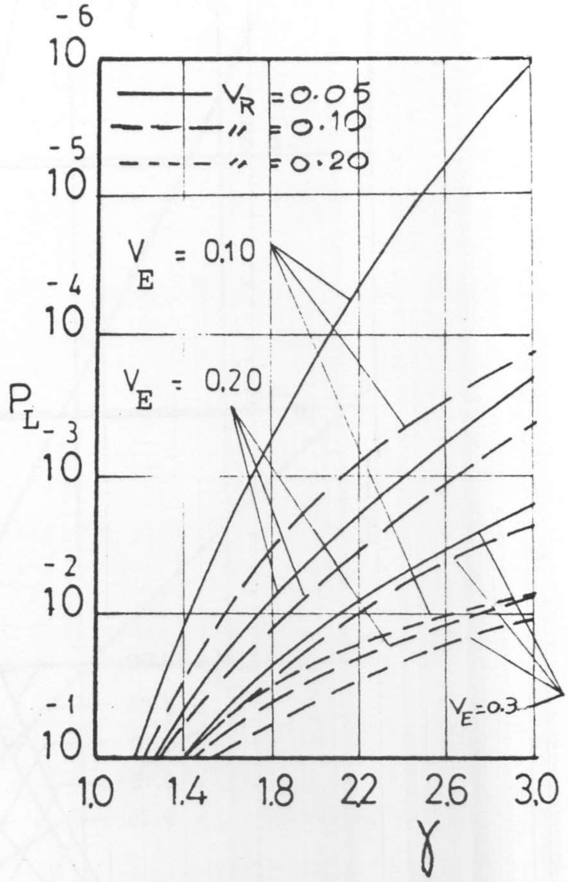


Fig. (5) R=EXT.I, E=EXT. II

$$\gamma = \gamma_R \cdot \gamma_E \qquad (6.1)$$

where: γ_R = revenue factor

γ_E = expenditure factor

The revenue factor, γ_R, takes account of all factors having adverse effects on annual revenues such as lower catch rates, reduced exploitation time, low quality species, bad weather, etc. The expenditure factor "γ_E" takes account of all factors having adverse effects on expenditures such as frequent breakdowns, high maintenance and repair costs, etc.

Using the assumption given in reference (8), we have:

$$\sqrt{\sigma_R^2 + \sigma_E^2} \simeq 0.75\ (\sigma_R + \sigma_E) \qquad (6.2)$$

Then:

$$\gamma_R = 1/(1-0.75\ \beta\ v_R)$$

$$\gamma_E = 1 + 0.75\ \beta\ v_E$$

Therefore, for an acceptable degree of risk, β, and coefficients of variation v_R and v_E, the Revenue and Expenditure factors γ_R and γ_E could be estimated. Then the profitability factor could be also evaluated as follows:

$$\gamma = \frac{1 + 0.75\ \beta\ v_E}{1 - .75\ \beta\ v_R} \qquad (6.3)$$

The variation of γ with β , v_E and v_R are given in the following table:

v_R	v_E	γ		
		β		
		2	3	4
0.1	0.1	1.353	1.581	1.857
	0.2	1.529	1.871	2.286
0.2	0.1	1.643	2.227	3.25
	0.2	1.857	2.636	4.00

It is evident that investment decisions could be based on estimating mean values and variabilities of annual revenues and costs together with an acceptable degree of risk. From these estimates, the minimum revenue required to justify the projected investment in coastal fishing could be evaluated.

The assessment of an acceptable degree of risk and ranges of variations of Revenues and Expenditures could be based on the analysis of available data obtained from the operating fishing fleet.

8. Example

It is required to estimate the minimum volume of production to justify the following investment condition:

- Expected annual expenditure = $ 60, 000
- Coefficient of variation of Expenditure = 0.1
- Coefficient of variation of Revenue = 0.1
- Accepted degree of Risk = 0.001
- Average fish price = $ 1000/tonne

<u>**Solution**</u>

Risk = 0.001

Hence, profitability index , $\beta = 3.15$

$$\text{Profitability factor} , \gamma = \frac{1 + 0.75^{\beta} v_E}{1 - 0.75^{\beta} v_R} = 1.618$$

Expected Revenue = 1.618 x 60,000

= $ 97,080

$$\text{Thus expected annual production} = \frac{97.080}{1000} = 97.08 \text{ tonnes}$$

Minimum catch rate $\geq$ 20 kg/hour

If the fishing condition can not satisfy this value it will be rather risky to invest in a fishing project that requires an annual expenditure of $60,000

If the Risk is 0.01, $\beta = 2.32$

Then, = 1.421

Minimum Revenue = $ 85.260

Minimum Production = 85.260 tonnes

It is evident that Risk and uncertainty should be taken into account to make proper investment decisions.

9. Conclusions

From the foregoing analysis, the following conclusions could be drawn:

1. It is evident that the assessment of Fishing Vessel Economics is a complex problem because of the unpredictable nature of both Revenues and Expenditures.

2. In order to secure an acceptable profit margin within the variable economic environment of coastal fishing, the Investment Cost of a fishing vessel should be compatible with the expected Annual Revenues and Expenditures.
3. All investments in coastal fishing are to some extent subject to the lements of risk and uncertainty. The cash outflows can generally be predicted with a fair degree of ceràinty. The inflows however, are highly unpredictable.
4. Investment decisions on coastal fishing should be based not only on the expected revenues and expenditures but also on their expected variations.
5. It is possible to estimate the minimum required Production/ Revenue to satisfy a projected investment at an acceptable degree of risk.
6. Statistical data should be collected on the various items of revenues and expenditures so as to formulate the variability profiles of all elements affecting both revenues and expenditures.

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