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ECONOMIC RESULTS OF STERN FREEZER TRAWLERS IN RELATION TO TECHNICAL PARAMETERS

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Agricultural Economics Research Institute LEI
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Abstract

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Data on the technical dimensions and economic performance of Dutch stern freezer trawlers are related in this study. For an analysis of the economic results in relation to vessel dimensions, a range of volumes of the fish-hold is chosen as independent variable and other technical parameters, for example installed power, vessel volume and freezing rate are taken to be its related variables. Economic criteria in terms of Net Present Value, Net Present Value Index, Internal Rate of Return and Pay Back Period are calculated on the basis of the relations found from these regressions. These economic results are compared and discussed, with a sensitivity analysis of the most important variables involved.

Trawlers/Stern freezer trawlers/Fish-hold/Economic results

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Preface

In the course of a twelve months' research assignment in The Netherlands Mr. Dai Tianyuan of the People's Republic of China has been working in two fisheries research institutes in this country. After taking part in technical research on stern freezer trawlers at the RIVO in IJmuiden he joined the Agricultural Economics Research Institute in The Hague to accomplish a study of the economic results of a range of the same type of vessels.

The report describes the results of this research, the dimensions of the trawlers having been defined in terms of horse power, vessel volume and fish-hold volume. Under certain assumptions regarding the price levels of fish and cost items the study arrives at optimal dimensions. Models like these could prove valuable in considering investment decisions in this industry.

The study has been completed in close co-operation with Mr. J. de Jager and Mr. J.W. de Wilde in the Fisheries Division of the Agricultural Economics Research Institute LEI.

The managing Director,

The Hague, november 1989 J. de Veer

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1. Introduction

In many fisheries, the fish-hold volume has been greatly increased recently along with the rapid rise of the principal ship dimensions and a similar increase of installed power of the main engines. In The Netherlands, a trawler with 10400 horse power of main engine, 7153 gross tons of vessel volume and 8400 m3 of cargo hold was commissioned in 1989.

However, from an economical point of view, do ever larger trawlers really perform better, or those with a certain optimum size? It is the aim of the report to try to answer this question.

After having collected the related data of stern freezer trawlers in The Netherlands from 1980 to 1987, the interrelations between various technical parameters and data on operational costs and earnings were investigated and a number of regressions were calculated. From this, several models for predicting economic performance with varying vessel dimensions were derived. As criteria for the economic performance Net Present Value (NPV), Net Present Value Index (NPVI), Internal Rate of Return (IRR) and Pay Back Period (PBP) are chosen. After calculating these for a range of fish-hold volumes, results are discussed, and several conclusions are obtained.

2. Materials and methods

2.1 The origins of data

The technical parameters of stern freezer trawlers were taken from the data collected by the Netherlands Institute for Fishery Investigations RIVO (Van Marlen, 1989). The range of data is: fish-hold volume, 1490-8400 m3; installed power of the main engine, 2800-10400 hp; vessel volume, 6705-26040 m3; freezing rate, 100-300 ton/day. The detailed data are shown in table 2.1.

Data on the economic performance of stern freezer trawlers from 1980 to 1987 were collected from the Agricultural Economics Research Institute LEI, The Netherlands. Most of these data have been made available through Internal Notes of the Institute (De Jager, 1985 & 1989), and averages of the main parameters - revenues, net results and crew wages - are given in Annual Reports on the economic results of the Dutch fisheries (Davidse et al., 1980-1989).

2.2 The calculation and selection of the technical variables

Fish-hold capacity is one of main factors to affect the yearly attainable landings (Van Marlen, 1989). It is closely

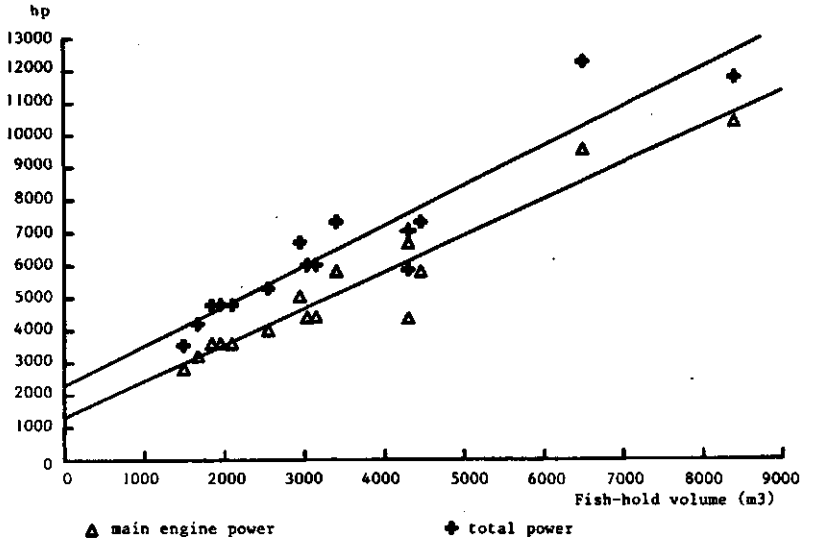

Figure 2.1 Main engine power and total installed power (in hp) of stern freezer trawlers in relation to fish hold volume, with regression lines

Table 2.1 Technical parameters of Dutch stern freezer trawlers built from 1980 to 1988

Ships ID	Year built	L o.a. (m)	B (m)	D-upp-deck (m)	V-vessel *) (m3)
Sch-106	1980	67.05	12.50	8.00	6705
SCH-171A	1981	71.25	12.50	8.00	7125
SCH-33	1981	71.25	12.50	8.00	7125
KW-170	1981	71.00	13.25	8.35	7855
KW-74	1982	78.20	13.25	8.35	8652
KW-80	1982	78.22	13.27	8.35	8667
SCH-303	1982	77.25	12.50	8.00	7725
KW-174	1983	95.18	14.50	8.60	11869
SCH-72	1983	88.13	14.00	9.00	11104
SCH-6	1984	88.10	14.00	9.00	11101
SCH-24	1984	93.90	15.00	9.40	13240
SCH-123	1984	94.00	15.00	9.40	13254
VL-70	1985	97.75	14.50	9.00	12756
KW-32	1986	90.20	13.50	8.35	10168
SCH-21	1987	101.7	15.00	9.40	14301
SCH-171B	1988	114.0	17.00	10.2	19762
SCH-54	1988	119.2	19.00	11.5	26041

Ships ID	HP inst. (hp)	HP aux. (hp)	Fish-hold (m3)	Cool-tanks (m3)	Freez.rate (ton/day)
Sch-106	2800	740	1490	100	100
SCH-171A	3600	1190	1840	100	100
SCH-33	3200	1000	1667	100	100
KW-170	3600	1195	1950	200	100
KW-74	4000	1290	2550	225	125
KW-80	4000	1290	2550	225	125
SCH-303	3600	1190	2098	150	122
KW-174	4350	1500	4300	225	150
SCH-72	4400	1597	3150	280	165
SCH-6	4400	1600	3040	262	155
SCH-24	5815	1500	3400	300	175
SCH-123	5800	1500	3400	303	175
VL-70	6662	0	4300	255	220
KW-32	5058	1650	2950	235	150
SCH-21	5803	1500	4456	300	175
SCH-171B	9546	2720	6500	505	253
SCH-54	10400	1380	8400	827	300

*) where V-vessel = L o.a * B * D upp deck, HP inst. means installed power of the main engine, and HP aux. means installed power of auxiliary engine.

related to other technical variables, as is clear from a check of regressions and squared correlation coefficients R^2. Therefore, it is chosen to be the independent variable with a range of six different values. Other technical variables result from this range on the basis of regressions of observed data.

Figure 2.1 shows the relation between the fish-hold volume and the power of the main engine and the total installed power. It can be seen clearly that these two variables are closely related to the fish-hold volume. In the following, the two regression formulae will be used to calculate two technical variables, on basis of the selected fish-hold volume.

The installed power of the main engine can be determined from:

$$Y = 1.118 * X + 1301 \qquad (R^2 = 0.91) \qquad (1)$$

where Y is the installed power of the main engine and X is the fishhold volume.

The total horse power can be obtained as follows:

$$Y = 1.229 * X + 2268 \qquad (R^2 = 0.87) \qquad (2)$$

where Y is the total installed power and X is the fish-hold volume.

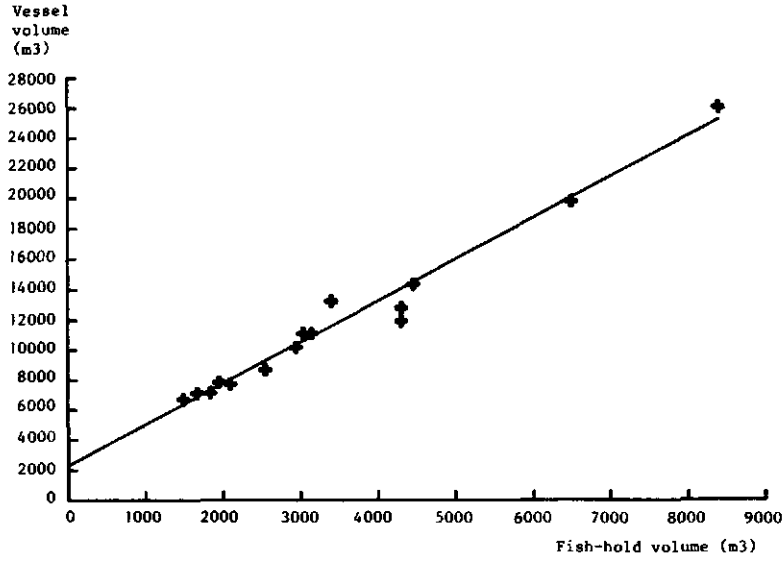

Figure 2.2 Vessel volume (length o.a. x beam x depth) of stern freezer trawlers in relation to fish-hold volume, with regression line

The relation between the fish-hold volume and the vessel volume is shown in figure 2.2, and the formula for estimating the vessel volume is as follows:

$$Y = 2.731 * X + 2293 \qquad (R^2 = 0.93) \qquad (3)$$

where Y is the vessel volume and X is the fish-hold volume.

For estimation of the freezing rate, the formula of the regression line in figure 2.3 is as follows:

$$Y = 0.0312 * X + 52.3 \qquad (R^2 = 0.92) \qquad (4)$$

where Y is the freezing rate and X is the fish-hold volume.

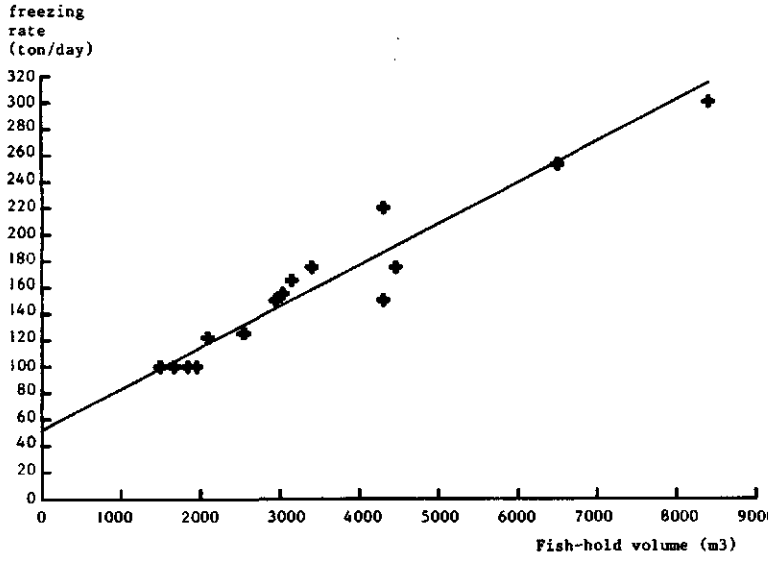

Figure 2.3 Freezing rate of stern freezer trawlers in relation to fish-hold volume, with regression line

The filling-coefficient is an index of the volume of actual catches in proportion to the fish-hold volume. The freezing-percentage expresses the relation between the actual freezing time and the time the vessel is on the fishing grounds. A sensitivity analysis indicates that the two variables have a strong influence on the economic results (Van Marlen, 1989). What is more, since they are affected by many factors like the weather conditions, fish resources, fishing grounds and the level of fishing technology etc., their values change from time to time. For estimates of the two indexes, several models are introduced as follows: (This is a slightly adapted version of Bob van Marlen, 1989).

Stow-factor = actual catch per trip / fish-hold volume (5)

*Filling-coefficient = stow-factor / (unit-pack-weight / (1000 * pack-unit-volume))* (6)

Time on fishing grounds per trip = days at sea / trip-number - steaming time per trip (7)

*Freezing-percentage = actual catch per trip / (freezing rate * time on fishing ground per trip)* (8)

In the estimates, it was assumed that the fishing grounds are in the Northern North Sea, and West of the United Kingdom and Ireland, with an average steaming time per trip of five days, according to the fishermen's experience. It is also taken that the unit-pack-volume is 0.02916 m3 and the average unit-pack-weight is 22.8 kg.

Bij looking into the calculating results of a number of observed stern freezer trawlers within the range of main engine power from 3600 to 6600 hp during several years (1980 - 1987), it is found that the values of the two variables are getting smaller with increasing fish-hold volume.

The average values of filling-coefficient decrease from 0.718 in the case of 1950 m3 fish-hold to 0.574 in the case of 4450 m3 fish-hold, and the average values of freezing-percentage from 0.658 to 0.458 in the above range of fish-hold sizes. Insufficient catch rates in the traditional fisheries on the usual fishing grounds may explain the decreasing trend of the filling-coefficient. The assumption of a constant steaming time per trip may have influenced the trend of the freezing-percentage. (If larger vessels took on average more time to reach farther away fishing grounds and smaller vessels stayed closer to home than

Table 2.2 Survey of technical variables estimated and chosen for the analysis of the economic results of stern freezer trawlers

	Fish-hold volume (m3)					
	2000	3000	4000	5000	6000	7000
Freezing rate(ton/day)	115	146	177	208	240	271
Main engine power(hp)	3540	4660	5770	6890	8010	9130
Total installed power(hp)	4730	5950	7180	8410	9640	10870
Vessel volume(m3)	7890	10450	13020	15580	18150	20710
Filling-coefficient	0.72	0.67	0.63	0.61	0.59	0.58
Freezing-percentage	0.58	0.56	0.54	0.52	0.50	0.48

supposed, this would raise the freezing percentage for larger vessels and lower it for the smaller ones). Lastly, on the basis of the observed relation between the two variables and the size of fish-hold, a range of values is chosen to estimate the economic results (see table 2.2).

The major technical variables estimated by the above formulae are arranged in table 2.2.

2.3 The calculation of economic performance

Estimates of the investment in the vessel built can be made in four ways on the basis of the relation between investment and technical parameters like fish-hold volume, main engine power, total installed power and vessel volume. It is found that the observation points are closer to the regression between total installed power and investment than those between other technical parameters and investment.

Therefore, the regression on total installed power is chosen to estimate the investment for the range of stern freezer trawlers in the analysis. The formula of the regression line is given below.

$$Y = 3.346 * X + 3231 \qquad (R^2 = 0.91) \qquad (9)$$

where Y is the investment in 1000 NLG, and X is the total installed power.

For making estimates of the annual revenues, it is assumed that days at sea are 290 days per year, and the skippers of the trawlers manage to keep on freezing when actually fishing. The annual catches can be obtained, according to the following model, and the results are given in table 2.3.

$$\textit{fishing time per trip} = \frac{(\textit{fish-hold volume} * \textit{stow-factor})}{\textit{freezing rate}} \qquad (10)$$

$$\textit{trip number} = \textit{days at sea} / (\textit{steaming time} + \frac{\textit{fishing time}}{\textit{freezing-percentage}}) \qquad (11)$$

$$\textit{total landings} = \textit{fish-hold volume} * \textit{stow-factor} * \textit{trip number} \qquad (12)$$

Fish prices are changing throughout the year according to the species of fish and the market. However, a range of average values of annual fish prices can be derived from dividing total proceeds by the total output of landings. The higher value is 0.847 NLG/kg, middle value is 0.70 NLG/kg and the lower value is 0.596 NLG/kg. To compare the influence of the different levels of fish price on the economic results, levels of average fish price

Table 2.3 Total proceeds (1000 NLG) of stern freezer trawlers with different technical parameters for a range of fish prices

Fish price (NLG/kg)	Fish-hold volume (m3) and total landings (ton)					
	2000	3000	4000	5000	6000	7000
	14885	18791	22311	25548	28558	31321
0.55	8187	10335	12271	14051	15707	17227
0.70	10420	13153	15618	17883	19991	21925
0.85	12653	15972	18965	21715	24275	26623

of 0.55, 0.70 and 0.85 NLG/kg were chosen to estimate the total revenues of stern freezer trawlers with a selected range of technical parameters. The resulting revenues are listed in table 2.3.

The running expenses can be divided into two parts. The fuel costs account for the major part of the total running expenses. The consumption of fuel oil is composed of fishing, steaming, freezing and other uses like light, loading and unloading. The other uses are not taken into account since they only take a small part of total fuel consumption. When fishing or steaming, the engines provide the power for fishing or steaming and at the same time for freezing. In other words, the fuel consumption of the freezing operation is contained in the parts of fishing and steaming.

It was assumed that full power of the main engine is used when fishing. (In the actual practice, sometimes it will be less and sometimes auxiliary engine power is added). It also is assumed that a proportion of 85% of the main engine power is used when steaming. On the basis of theoretical and practical observations, a fuel consumption of 0.16 kg per hour is taken for calculation. On these assumptions, the fuel consumption can be estimated by following formulae (the unit is ton):

*fuel consumption of fishing = (fishing time * trip-number * power of the main engine * 0.16) / 1000* (13)

*fuel consumption of steaming = (steaming time * trip-number * power of the main engine * 0.85 * 0.16) / 1000* (14)

Two kinds of fuel oil with different prices are used to operate stern trawler engines. By averaging the consumption provided to different types of engine, it is found that the proportion of gasoil is from 18,7% to 25,9% of the total fuel oil consumption of engines with more than 3600 hp. An average proportion of 21,4% is taken to estimate the consumption of gasoil, and the consumption of heavy diesel fuel is subsequently derived by subtracting gasoil from total fuel oil.

Table 2.4 Fuel oil costs (1000 NLG) of stern freezer trawlers with different dimensions for a range of fuel prices

Fuel prices (NLG/kg)	Fish-hold volume (m3)					
	2000	3000	4000	5000	6000	7000
0.3/0.2	560	713	855	988	1111	1222
0.5/0.35	967	1230	1475	1706	1917	2108
0.7/0.5	1373	1747	2096	2423	2723	2995

The variation of the fuel prices was rather great in the years observed, it varied from 0.33 to 0.83 NLG/kg for gasoil, and from 0.21 to 0.53 NLG/kg for the heavy diesel oil, taking the averages from 1981 to 1987.

To compare the operating costs at varying levels of fuel price, a range of fuel prices is chosen. The results are given in table 2.4.

The other running expenses, apart from the fuel oil costs, contain 14 items, which are related to various factors. By checking their relation and calculating their related values on the basis of the economic results of the stern freezer trawlers in

Table 2.5 Survey of the relations between running expenses and their related parameters

No.	Items	Parameters	Unit	Values
(1)	Lubricant oil	installed power	1000 NLG/HP	0.0222
(2)	Maintenance	installed power	1000 NLG/HP	0.1256
(3)	Equipment	installed power	1000 NLG/HP	0.0324
(4)	Insurance of vessel	installed power	1000 NLG/HP	0.0719
(5)	Tugboat	trip-number	1000 NLG/TRIP	1.2674
(6)	Fishing gear	installed power	1000 NLG/HP	0.1112
(7)	Packing costs	landings	1000 NLG/TON	0.0855
(8)	Charges for fishing organization	revenues	1000 NLG/1000 NLG	0.0019
(9)	Crew wages	revenues	1000 NLG/1000 NLG	0.2557
(10)	Social security for crew	men-days	1000 NLG/MAN-DAY	0.0624
(11)	Food and water	men-days	1000 NLG/MAN-DAY	0.0171
(12)	Travelling expenses	men-trips	1000 NLG/MAN-TRIP	0.0363
(13)	Harbor charges	per vessel	1000 NLG	28.0
(14)	Other costs	per vessel	1000 NLG	204.33

the Netherlands from 1980 to 1987, table 2.5, showing how to calculate these costs, was obtained.

Now the other running expenses of the stern freezer trawlers with the selected range of dimensions can be estimated by the

Table 2.6 Total running expenses (1000 NLG) of stern freezer trawlers with different dimensions for a range of fish and fuel prices*

Fuel price	Fish-hold volume (m3)					
	2000	3000	4000	5000	6000	7000
(Fish price = 0.55)						
- 0.3/0.2	6088	7602	9015	10337	11619	12833
- 0.5/0.35	6494	8119	9636	11054	12425	13720
- 0.7/0.5	6901	6901	10256	11771	13231	14606
(Fish price = 0.70)						
- 0.3/0.2	6663	8328	9877	11324	12722	14043
- 0.5/0.35	7069	8845	10498	12041	13528	14930
- 0.7/0.5	7476	9362	11118	12759	14335	15817
(Fish price = 0.85)						
- 0.3/0.2	7238	9054	10740	12311	13826	15253
- 0.5/0.35	7645	9571	11360	13028	14632	16140
- 0.7/0.5	8051	10088	11980	13746	15438	17027

Table 2.7 Annual returns (1000 NLG) of stern freezer trawlers with different dimensions for a range of fish and fuel prices

Fuel price	fish-hold volume (m3)					
	2000	3000	4000	5000	6000	7000
(Fish price = 0.55)						
- 0.3/0.2	2099	2733	3256	3715	4089	4394
- 0.5/0.35	1693	2216	2635	2997	3282	3507
- 0.7/0.5	1286	1699	2015	2280	2476	2620
(Fish price = 0.70)						
- 0.3/0.2	3757	4826	5740	6560	7269	7882
- 0.5/0.35	3350	4309	5120	5842	6463	6995
- 0.7/0.5	2944	3791	4500	5125	5656	6108
(Fish price = 0.85)						
- 0.3/0.2	5415	6918	8225	9405	10049	11370
- 0.5/0.35	5008	6401	7605	8687	9643	10483
- 0.7/0.5	4601	5884	6984	7970	8837	9596

product of the average values and the related parameters. The total running expenses, for a range of fish and fuel prices, are given in table 2.6. From checking and comparing the estimated results with the economic results obtained from the actual fishing, it appears that the models are reasonably realistic.

From the the annual revenues and running expenses, the annual returns are calculated and given in table 2.7.

2.4 The calculation of economic criteria

Four economic criteria, Net Present Value, Net Present Value Index, Internal Rate of Return and Pay Back Period are used to compare the economic results of stern freezer trawlers with different technical parameters. Before making the calculations, it was assumed that the stern freezer trawler's average life span is 15 years, and that the annual return is uniform throughout the life span and is available at the end of every year. An interest rate of 0.10 (before tax) is chosen, which is considered as a normal interest rate for discounting purposes in the Dutch situation. A series of formulae for calculcating these economic criteria are given in the following (Benford, 1963).

The basic formulae for Capital Recovery Functions (CRF) and Uniform Series Present Worth Factor (UPWF) are:

$$[CRF] = \frac{i * (1 + i)^n}{(1 + i)^n - 1} \qquad (15)$$

$$[UPWF] = 1 / [CRF] \qquad (16)$$

At the assumed life span and interest rate, CRF = 0.1315 and UPWF = 7.6061

1. Net Present Value (NPV)

$$NPV = R * [UPWF] - P \qquad (17)$$

2. Net Present Value Index (NPVI)

$$NPVI = NPV / P \qquad (18)$$

3. Internal Rate of Return (IRR)

$$IRR = \text{that value of i which makes NPV} = 0 \qquad (19)$$

4. Pay Back Period (PBP)

$$N = - \frac{\ln (1 - (P/R) * i)}{\ln (1 + i)} \qquad (20)$$

Where i is interest rate, n is the number of years, P is the initial investment and R is annual return.

3. Results and discussions

The results of calculations of CRF, NPV, NPVI, IRR and PBP are given in table 3.1-3, and also depicted in figure 3.1-4.

Table 3.1 Economic results of stern freezer trawlers with different technical parameters for a range of fish prices, at a gasoil price of 0.3 NLG/kg, and a diesel fuel price of 0.2 NLG/kg (financial amounts in 1000 NLG)

	Fish-hold volume (m3)					
	2000	3000	4000	5000	6000	7000
Main engine power (hp)	3540	4660	5770	6890	8010	9130
Investment	19057	23139	27254	31369	35485	39600
Fish price = 0.85 NLG/kg						
Total proceeds	12653	15972	18965	21715	24275	26623
Running expenses	7238	9054	10740	12311	13826	15253
Annual return	5415	6918	8225	9405	10049	11370
NPV1	22128	29483	35306	40162	43992	46880
NPVI1	1.161	1.274	1.295	1.280	1.240	1.184
IRR1	0.277	0.293	0.296	0.293	0.288	0.280
PBP1	4.55	4.27	4.22	4.26	4.35	4.49
Fish price = 0.70 NLG/kg						
Total proceeds	10420	13153	15618	17883	19991	21925
Running expenses	6663	8328	9877	11324	12722	14043
Annual return	3757	4826	5740	6560	7269	7882
NPV2	9519	13568	16408	18523	19803	20351
NPVI2	0.500	0.586	0.602	0.590	0.558	0.514
IRR2	0.181	0.194	0.196	0.195	0.190	0.183
PBP2	7.43	6.85	6.76	6.83	7.03	7.32
Fish price = 0.55 NLG/kg						
Total proceeds	8187	10335	12271	14051	15707	17227
Running expenses	6088	7602	9015	10337	11619	12833
Annual return	2099	2733	3256	3715	4089	4394
NPV3	-3089	-2348	-2490	-3116	-4387	-6179
NPVI3	-0.162	-0.101	-0.091	-0.099	-0.124	-0.156
IRR3	0.071	0.082	0.084	0.082	0.078	0.072
PBP3	25.00	19.66	19.04	19.53	21.24	24.29

Table 3.2 Economic results of stern freezer trawlers with different technical parameters for a range of fish prices, at a gasoil price of 0.5 NLG/kg, and a diesel fuel price of 0.35 NLG/kg (financial amounts in 1000 NLG)

	Fish-hold volume (m3)					
	2000	3000	4000	5000	6000	7000
Main engine power (hp)	3540	4660	5770	6890	8010	9130
Investment	19057	23139	27254	31369	35485	39600
Fish price = 0.85 NLG/kg						
Total proceeds	12653	15972	18965	21715	24275	26623
Running expenses	7645	9571	11360	13028	14632	16140
Annual return	5008	6401	7605	8687	9643	10483
NPV1	19035	25549	30587	34705	37860	40136
NPVI1	0.999	1.104	1.122	1.106	1.067	1.014
IRR1	0.254	0.269	0.271	0.269	0.264	0.25
PBP1	5.02	4.71	4.66	4.70	4.81	4.98
Fish price = 0.70 NLG/kg						
Total proceeds	10420	13153	15618	17883	19991	21925
Running expenses	7069	8845	10498	12041	13528	14930
Annual return	3350	4309	5120	5842	6463	6995
NPV2	6427	9633	11689	13066	13671	13606
NPVI2	0.337	0.416	0.429	0.417	0.385	0.344
IRR2	0.156	0.168	0.170	0.168	0.163	0.157
PBP2	8.83	8.08	7.79	8.08	8.36	8.76
Fish price = 0.55 NLG/kg						
Total proceeds	8187	10335	12271	14051	15707	17227
Running expenses	6494	8119	9636	11054	12425	13720
Annual return	1693	2216	2635	2997	3282	3507
NPV3	-6181	-6282	-7209	-8573	-10519	-12924
NPVI3	-0.324	-0.207	-0.265	-0.273	-0.296	-0.326
IRR3	0.025	0.049	0.051	0.049	0.044	0.038
PBP3	-	-	-	-	-	-

Table 3.3 Economic results of stern freezer trawlers with different technical parameters for a range of fish prices, at a gasoil price of 0.7 NLG/kg, and a diesel fuel price of 0.5 NLG/kg (financial amounts in 1000 NLG)

	Fish-holdvolume (m3)					
	2000	3000	4000	5000	6000	7000
Main engine power (hp)	3540	4660	5770	6890	8010	9130
Investment	19057	23139	27254	31369	35485	39600
Fish price = 0.85 NLG/kg						
Total proceeds	12653	15972	18965	21715	24275	26623
Running expenses	8051	10088	11980	13746	15438	17027
Annual return	4601	5884	6984	7970	8837	9596
NPV1	15943	21615	25868	29249	31728	33391
NPVI1	0.837	0.934	0.949	0.932	0.894	0.843
IRR1	0.231	0.245	0.247	0.245	0.239	0.232
PBP1	5.61	5.24	5.19	5.25	5.39	5.58
Fish price = 0.70 NLG/kg						
Total proceeds	10420	13153	15618	17883	19991	21925
Running expenses	7476	9362	11118	12759	14335	15817
Annual return	2944	3791	4500	5125	5656	6108
NPV2	3334	5699	6970	7610	7538	6861
NPVI2	0.175	0.246	0.256	0.243	0.212	0.173
IRR2	0.130	0.141	0.143	0.141	0.136	0.129
PBP2	10.94	9.89	9.76	9.94	10.36	10.96
Fish price = 0.55 NLG/kg						
Total proceeds	8187	10335	12271	14051	15707	17227
Running expenses	6901	8636	10256	11771	13231	14606
Annual return	1286	1699	2015	2280	2476	2620
NPV3	-9274	-10217	-11928	-14030	-16651	-19668
NPVI3	-0.487	-0.336	-0.438	-0.447	-0.469	-0.497
IRR3	-	0.012	0.013	0.011	0.006	-
PBP3	-	-	-	-	-	-

The Net Present Values for various levels of fish and fuel price are listed in tables 3.1-3. Figure 3.1 shows two groups of three curves of Net Present Value. When the fish price is on the level of 0.85 NLG/kg, the curves rise first fast then slowly and the space between them increases with increasing fish-hold size, indicating that the effect of fuel price on NPV enlarges with increasing fish-hold size. The highest value (of 46.8 mil. NLG) is reached at the biggest fish-hold volume (7000 m3). When the fish price is on the level of 0.70 NLG/kg, the curves go up slow-

ly for the fuel price of 0.3/0.2 NLG/kg, while they first rise and then drop for the levels of fuel prices of 0.5/0.35 and 0.7/0.55 NLG/kg. Their maxima move towards a smaller fish-hold when the fuel price levels rise. The maximum lies at 6000 m3 fish-hold volume for a fuel price of 0.5/0.35 NLG/kg, and at 5000 m3 fish-hold volume for a fuel price of 0.7/0.5 NLG/kg. On both levels of fish price, all Net Present Values are positive, showing the economic results to be profitable. It can also be seen that the curves with lower fuel price levels lie in higher positions, indicating a better economic result. When the fish price is 0.55 NLG/kg, the Net Present Values decrease with increasing size of the fish-hold and all values are negative; (they are only listed in table 3.1-3).

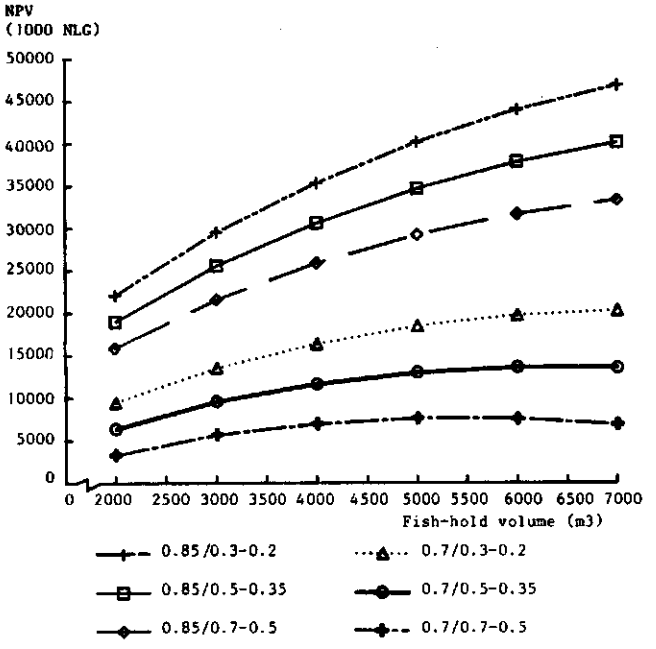

Figure 3.1 Estimated Next Present Values of stern freezer trawlers with fish-hold volumes ranging from 2000 to 7000 m3, at average fish prices of 0.85 NLG/kg and 0.70 NLG/kg and three fuel price levels

The Net Present Value Index reflects profit in relation to investment. Curves of NPVI are drawn in figure 3.2. The two groups of curves are of roughly the same tendency: first rising then falling with increasing size of the fish-hold, like rough parabolas arched up. The maxima lie near the centre, at the cases with 4000 m3 fish-hold volume. The values of NPVI are positive when fish prices are not substantially lower than 0.7 NLG/kg.

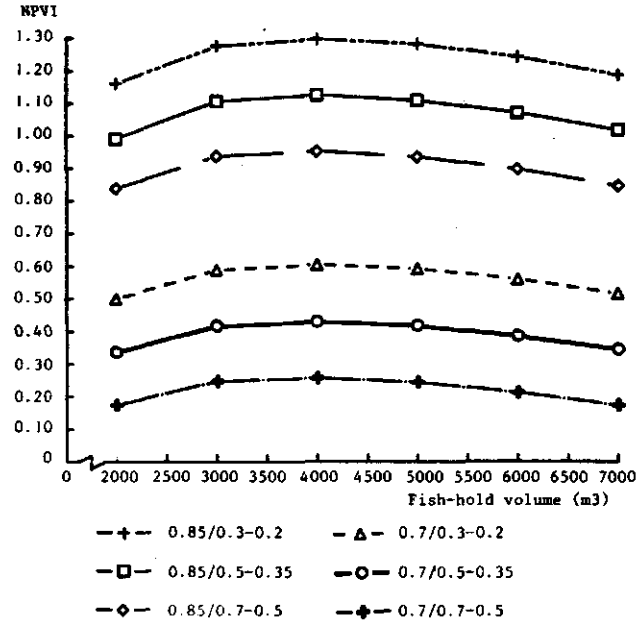

Figure 3.2 Estimated Net Present Value Indices of stern freezer trawlers with fish-hold volumes ranging from 2000 to 7000 m³, at average fish prices of 0.85 NLG/kg and 0.70 NLG/kg and three fuel prices levels

Under this condition fishing is profitable with these vessels. If the level of fish prices goes down to 0.55 NLG/KG, it will be disadvantageous to invest in stern freezer trawlers within this range of technical parameters, as such investment would produce negative Net Present Values.

From the point of view of the profit per unit of investment (NPVI), a clear conclusion can be obtained that stern freezer trawlers with medium dimensions (3000-5000 m3 fish-hold) can get better economic results than those with other sizes in this range of fish-hold volumes.

The values of Internal Rate of Return (IRR) are depicted in figure 3.3, while values smaller than the normal interest rate (0.1) are only given in tables 3.1-3.

These graphs are similar to those of NPVI, like parabolas arched up, dropping from the centre to both sides. The highest values are 0.143...0.293, reached at the cases with 4000 m3 fish-hold volume. Like with NPVI, the conclusion can be obtained that the stern freezer trawlers with medium dimensions can get better economic results. Similarly, the curves for lower fuel price levels lie higher, showing a better economic result.

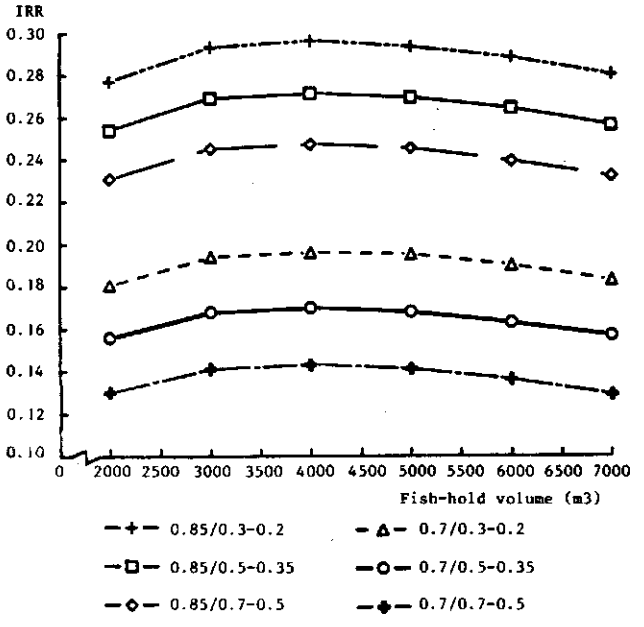

Figure 3.3 Estimated Internal Rates of Return of stern freezer trawlers with fish-hold volumes ranging from 2000 to 7000 m³, at average fish prices of 0.85 NLG/kg and 0.70 NLG/kg and three fuel price levels

The shorter the Pay Back Period is, the better the economic result. The curves given in figure 3.4 make clear that the better economic results are to be expected from vessels with medium dimensions (3000-5000 m3 fish-hold), as they give a shorter PBP. The lowest points lie at the 4000 m3 fish-hold, going up towards both sides. When the fish price is on the levels of 0.7 and 0.85 NLG/kg, the shortest PBP is 4.22 years and the longest is 12.15 years, which is shorter than the vessels normal life span (15 years). However, when the fish price drops to or below 0.55 NLG/kg, the PBP would be longer than 15 years, which is of course unacceptable.

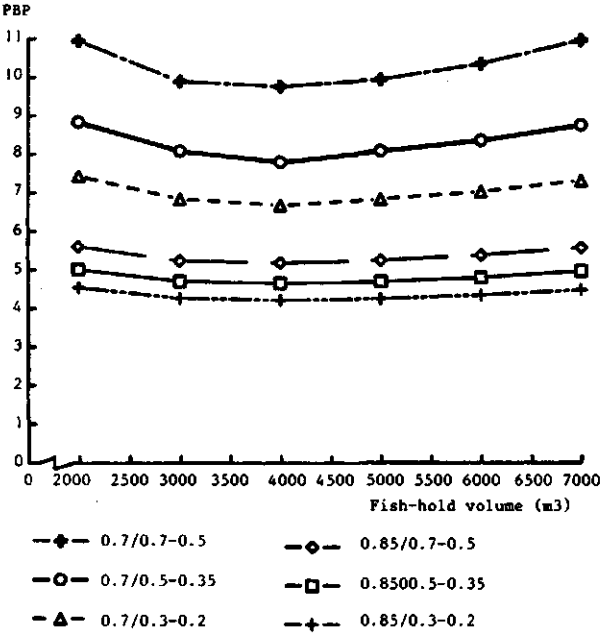

Figure 3.4 Estimated Pay Back Periods (in years) of stern freezer trawlers with fish-hold volumes ranging from 2000 to 7000 m³, at average fish prices of 0.85 NLG/kg and 0.70 NLG/kg and three fuel price levels

4. Conclusions

A conclusion can be clearly obtained that the investment in stern freezer trawlers within a range of technical parameters (from 2000 to 7000 m3 fish-hold) can be profitable when fish prices are equal to, or higher than the level of 0.70 NLG/kg, while it is disadvantageous when fish prices are equal to, or lower than 0.55 NLG/kg.

The best economic results are of course in the cases with highest level of fish price and lowest level of fuel price. These results reflected in economic criteria are: NPV (46.8 mil.NLG) found for the largest vessel size (7000 m3 fish-hold), and NPVI (1.29), IRR (0.296) and PBP (4.22) found at medium vessel size (4000 m3 Fish-hold).

It can not always be said that the bigger the fishing vessels are, the better the economic results, from these economic criteria given above. By comparing carefully all data on the economic performance of the Dutch stern freezer trawlers from 1980 to 1987, it is found that the average value of filling-coefficient, which indicates the relation between the fish-hold and the actual catch, is 0.718 in the case of 1950 m3 fish-hold, and are getting smaller to 0.574 in the case of 4450 m3 fish-hold. This indicates that on average the holds were only filled with fish for about two thirds. Similarly, the average values of freezing-percentage are getting smaller with increasing size of the fish-hold (from 0.658 to 0.458 in the above range of fish-hold). It shows that fishing (= filling) time for stern freezer trawlers only accounts for 55% of time at the fishing grounds, and the proportion is getting smaller with increasing fish-hold. Therefore, it is not economically justified to build stern freezer trawlers of ever larger size if these vessels are mainly meant for fishing in Northern North Sea or the seas around the United Kingdom and Ireland. This conclusion reflects the observed economic results in recent years, when the smaller stern freezer trawlers showed better results than the larger ones (De Jager, 1989). However, we think, the picture of the economic results should change for vessels fishing in the seas far away from the Netherlands, as is practised nowadays in waters of the United States, the Falkland Islands and West Africa.

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