A STOCHASTIC SIMULATION ANALYSIS OF A SMALL-SCALE CATFISH PROCESSING PLANT

William Branch and Daniel S. Tilley

Abstract

Stochastic simulation was used to analyze revenues and costs for a small-scale catfish processing plant under various combinations of operating capacity utilization and price paid for live fish. The probability for a positive level of daily net income ranged from 11 to 100 percent depending on the price paid for live fish and level of operating capacity utilized. Daily average total cost per pound of live fish processed changed by 2.10 percent given a 10 percent change in live fish processed. Short-term cyclical patterns in revenues and costs suggest a need for financial planning to provide for possible year-end revenue shortfalls.

Key words: stochastic simulation, catfish processing

The farm-raised catfish industry has developed into one of the leading sectors of new growth in United States agriculture. While the industry is centered in the Delta region of Mississippi, interest in the establishment of new production and processing markets exists throughout much of the southern United States. However, geographical expansion of the industry has been hindered due to the closure of several small-scale regional fish processors. The exit of these processors and instability in the sector create a source of risk for producers and marketers who depend on processors as a market for live fish and for a stable supply of processed fish products, respectively.

A growing volume of information pertaining to the production, processing, and marketing activities associated with farm-raised catfish is available (Branch and Tilley; Fuller et al.; Garrard et al.; Keenum and Waldrop 1988a; Keenum and Waldrop 1988b; Keenum and Waldrop 1988b; Miller, et al. 1981a and b; Fuller and Dillard; Kinnucan et al.). This information is based primarily on comparative statics analyses of the production and processing practices of large, Delta-based operations, excluding smaller regional operations.

The objective of this paper was to determine how variability caused by demand and supply seasonality affects the flow of revenues and costs in a small-scale catfish processing operation. The results provide small-scale processors with information concerning capacity utilization and input price levels that assists in evaluating the likelihood of continued plant operation.

To address the objective, a stochastic simulation model of plant operation was used to analyze the sources and financial consequences of risk on small-scale processors. The model was based on an economic-engineering analysis of the costs of processing for a small (16,000 lbs. per day) Mississippi-based plant with a fixed production mix (Garrard). The Garrard algorithm was adapted to a Lotus 1-2-3[1] spreadsheet leaving the daily level of live fish processed, output mix, processed product sales, and prices open to modeler discretion. This information was supplied to the model in the form of subjective probability distributions based on the modeler's expectations or past data. The spreadsheet was used to generate and summarize distributions of daily revenues and costs for stochastic analysis as well as sensitivity analyses of alternative processing scenarios.[2] In the analyses presented, the spreadsheet was used to perform a breakeven analysis of the distributional means of daily processing net income. This analysis used 1990 historical data from the catfish

[1] Lotus and 1-2-3 are registered trademarks of Lotus Development Corporation.

[2] Sensitivity analysis is assumed to involve the changing of parameters and/or relationships within the model and studying how these changes affect the results generated by the model. Sensitivity analysis does not imply that the changed parameters or relationships are stochastic nor does it imply that any of the parameters, relationships, or variables within the model are stochastic. Stochastic analysis is assumed to involve the use of stochastic parameters, relationships, and/or variables within the model to determine how the stochastic structure of such factors affect the results generated by the model and in turn, how such risk affects the processor's decision making process.

William Branch is a former Assistant Researcher and Daniel S. Tilley is a Professor in the Department of Agricultural Economics at Oklahoma State University. The authors wish to thank the three anonymous *SJAE* reviewers for their helpful comments, and acknowledge the funding support provided by the Agricultural Marketing Service under the USDA Cooperative Agreement 12-25-G-0016. This study also appears as Journal Article J-6192 of the Agricultural Experiment Station, Division of Agriculture of Oklahoma State University.

industry. A second analysis of the distributional properties of the average monthly net income generated from processing subject to cyclical patterns in yearly live-fish availability, wholesale demand, and input and output prices is also presented.

The Garrard model is briefly outlined in the Model section of this paper as are the modifications made to adapt the model to a stochastic spreadsheet. In the third section, the analyses and results are reported. Finally, the last section presents a brief summary of the paper.

MODEL

Garrard synthesized a small-scale catfish processing plant based on the economic-engineering approach assuming prevailing levels of technology. Operating costs were identified for four stages in catfish processing (receiving, dressing, processing, handling and storage) as were ownership and overhead costs related to the production process as a whole. These costs were totaled to derive an estimate of the cost of processing for a plant with a production capacity of 16,000 pounds of live fish per day.

The economic and engineering relationships defined by Garrard were reproduced in a Lotus spreadsheet model. The model can replicate Garrard's results or it can be used to analyze any scenario within the general bounds of the model structure given the redefinition of specific variables and/or values. Furthermore, specific engineering relationships may be modified to more accurately simulate a desired plant structure. It should be noted, however, that such changes should be made mindful of the fixed economic and engineering relationships established in the model.

Through the use of a Lotus add-on software package, @RISK,[3] uncertain model variables can be defined as individual subjective probability distributions, functions of any of a number of subjective probability distributions, fixed values, correlated relationships, or a combination of all four. Once defined, @RISK allows for the iterative simulation of the model by successively sampling the subjective input distributions, recalculating the spreadsheet, and producing a set of estimated distributions for specified output variables based on the economic and engineering relationships established in the model. Thus, simulation with @RISK produces distributions of possible outcomes rather than a single valued result. In turn, these stochastic results provide an understanding of how uncertainty affects the operation of the processing plant and the processor's decision-making process (Antle).

The model provides daily summaries of the financial and quantitative aspects of a small processing plant. Daily operating costs are compiled based on the amount of fish (live-weight) processed. These costs are combined with a proportional share of yearly ownership (depreciation, interest [opportunity cost on investment], insurance, taxes, and repairs) and overhead (administration, sales, and wages) costs to yield an estimate of the daily level of total cost of operations. Ownership and overhead costs are prorated based on the daily level of live fish processed in proportion to an estimated level of total live fish processed during the year (48 five-day weeks, single shift).

Daily revenues are based on the sales and associated price distributions of six processed products. Revenues and the estimated total costs of operation are combined to provide an estimate of net income for the day's operation.

In reality most of the input and output variables associated with a catfish processing plant are stochastic, as are many of the economic and engineering relationships. The stochastic properties modeled for the analyses in this paper present a relatively basic picture of the stochastic properties of such a plant. Daily levels of live fish processed, processed product sales, the prices associated with these quantities, dressing percentages, product mix, and electricity usage were considered stochastic for the analyses reported. All the variables were assumed to be normally distributed.[4] The means and standard deviations of the price distributions and the standard

[3] @RISK is a trademark of Palisade Corporation.

[4] USDA data for prices and quantities associated with live fish purchased for processing and the sales of processed fish products were transformed and tested for normality using Shapiro and Wilk's W-Test. The natural log of each data series was differenced to remove time trends and six and twelve month production and seasonal processed demand cycles in the data (Branch). Tests for the period January 1986 to October 1991 indicated no evidence of non-normality for all price and quantity variables at the 50 percent point or higher for the null distribution with the exceptions of the price paid for live fish, the price paid for processed whole frozen fish, and the sales of fresh fillets. These three series showed no evidence of non-normality at the 10 percent point for the null distribution. Results of the testing for normality led to the hypothesis that prices and quantities associated with live fish purchased for processing and the sales of processed fish products were log-normally distributed. Results of simulations with the model assuming log-normally distributed prices for both live fish purchased for processing and processed fish products sold did not indicate a meaningful difference between the means and standard deviations of the revenue, fixed cost, variable cost, and net income distributions generated in these simulations as compared to those generated under the assumption of normally distributed live fish and processed fish product prices.

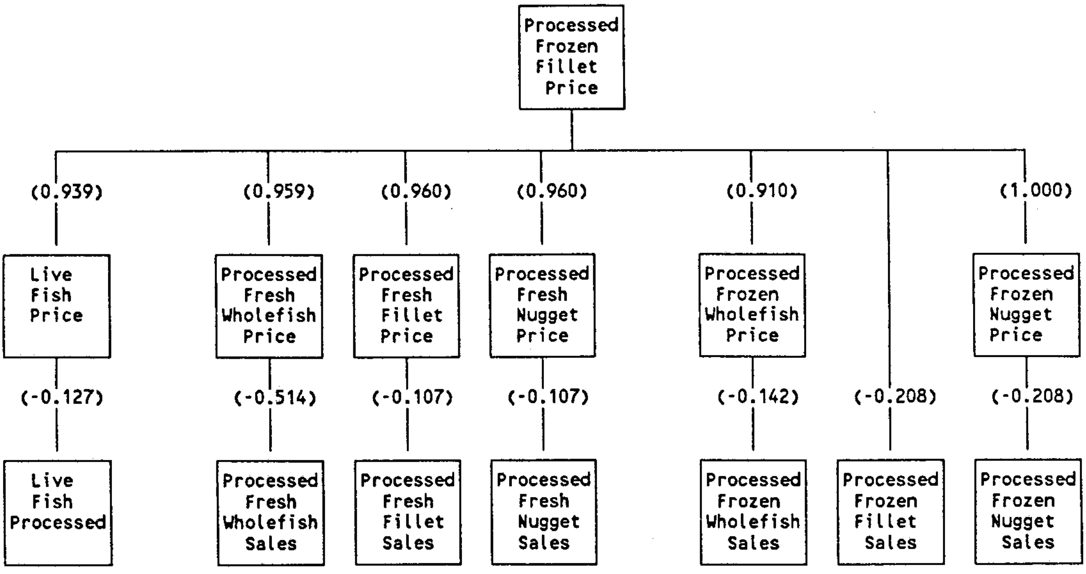

Figure 1. Flowchart Showing Correlation of Live Fish Prices and Other Processed Product Prices to Processed Frozen Fillet Prices and the Correlation of Prices to Quantity of Each Product Sold. Correlations are Shown in Parentheses

deviations of the quantity distributions were based on 1990 industry averages. Means and standard deviations of the other processing distributions and the means of the quantity distributions were based on Garrard and the past experience of the researchers.

Multivariate correlation between price and quantity variables was modeled using the @INDEP (independence) and @DEP (dependence) functions available with @RISK. With @RISK, independence implies that the stochastic component of a variable is unaffected by the stochastic component of any other variable in the model, whereas dependence implies that a variable's stochastic component is correlated to the stochastic component of one or more other stochastic variables in the model (@RISK: user's guide).[5] Frozen processed fillets were assumed to be the principle product processed with the prices of all other processed products and the price paid for live fish positively correlated to the price of frozen processed fillets (Figure 1). Price and quantity variables were assumed to be negatively correlated, with prices being the independent variable and quantities the dependent variable. The correlations represent the basic price-quantity relationships assumed to exist between the price of live fish and prices for processed products, and the processor's demand for live fish and level of processed product sales, respectively. The assumed magnitude of correlation between the variables was based on the actual correlation between prices and quantities for industry data from the period January 1986 to January 1991.[6]

ANALYSES

Initially, the model was used to generate data for a breakeven analysis of the distributional means of daily processing net income. This analysis was based on the historical distribution of prices paid by

[5] Palisade Corporation has released a new version of @RISK (ver. 2.0) that more accurately models multiple correlated random variables. Results presented in this paper were generated using @RISK (ver. 1.02) which tends to upwardly bias the correlation between random variables generated by the program.

[6] The assumption of downward sloping demand curves in the live fish and processed fish markets may alter the risk associated with the cost of live fish and the revenues from the sale of processed fish. A downward sloping demand curve implies less risk in terms of variance in revenues (output demand) or costs (factor demand) than does a perfectly elastic demand curve, given a change in quantity demanded. Thus the assumption of a non-competitive output market for the processing firm implies less risk in sales revenues than would be the case for a perfectly competitive output market. Additionally, the use of industry data in deriving correlation coefficients for the processing plant's price-quantity relationships may improperly portray the firm's input cost and sales revenue variances. The industry factor demand correlation may imply a more elastic factor demand at the firm level than actually exists. This would increase the variance associated with factor costs of the firm. The industry output demand correlation may imply less elastic output demand at the firm level than actually exists. This would decrease the variance associated with sales revenues of the firm.

processors for live fish in 1990 and an array of processing capacity levels. The results from this study provide an indication of the minimum input-price/processing-level relationships that must exist for the processing plant to continually maintain operations over the long run.

In the second analysis, the distributional properties of average monthly net income generated from processing were evaluated given the cyclical patterns in yearly live-fish availability, wholesale processed product demand, and input and output prices. This analysis extended the results of the first analysis to gain an understanding of the short-term dynamics of the probability of catfish processing profitability.

Breakeven Analysis

Firm profitability was examined in a breakeven analysis over a range of plant operating levels and live fish prices. Operating levels varied from 70 to 100 percent of plant capacity while live fish prices in the range of 0.60 to 0.75 dollars per pound of fish were considered. Other assumptions concerning processing level and live fish price variability, processed product sales, sales prices, and product mix are presented in Table 1.

Table 2 presents the estimated daily sales revenue, operating costs, and net income given the assumptions presented in Table 1. The means of the sales revenue distributions generated ranged from $12,852 to $18,361 per day depending upon the level of fish processed and sold, while operating cost distributions with means over the range of $11,335 to $17,526 per day were generated depending on the percentage of operating capacity used and the price paid for live fish. The means for the sales revenue distributions were above the means for the operating cost distributions for a major portion of the range of input-price/processing-level combinations analyzed. Average daily revenues exceeded operating costs at a processing level of 70 percent of capacity (11,200 pounds) per day given a price for live fish of 0.73 dollars per pound or less. Sales revenues exceeded operating costs over the entire range of live fish prices at processing levels of 77.5 percent of capacity (12,400 pounds) and above. Thus, a range of input prices and processing levels existed at which the processing plant could operate and cover operating costs with a relatively high degree of probability, at least in the short run.

This range was contracted when the total cost of operations was considered. In this case, processing at the 70 percent level of daily capacity (11,200 pounds) must have been accompanied by a price for live fish below 0.68 dollars per pound to yield a positive level of daily net income on average. Daily sales revenues exceeded total costs of operations over the entire range of live fish prices at processing levels of 96.25 percent of capacity (15,400 pounds) and above. The probability for a positive level of daily net income in the input-price/processing-level range extended from 11 percent at a price for live fish of 0.75 dollars per pound to unity for a price of 0.60 dollars per pound.

A 50 percent or higher probability of a positive level of net income existed for live fish prices below 0.68 dollars per pound for all levels of processing capacity utilization. The price paid for live fish averaged 0.77 dollars per pound during 1990. While this price was well above the range of prices considered in this analysis, it should be noted that live fish prices fell to 0.68 dollars per pound on average for the first half of 1991 and fell below 0.60 dollars per pound later in 1991. If a non-artificially sustained live fish price (either by large-scale processors or by fish producers) can stabilize at or below 0.68 dollars per pound, a profitable input cost structure may exist for small-scale processors.

An average total cost per pound curve for live fish processed, based on a live fish price of 0.65 dollars per pound is presented in Figure 2. Data for the curve were derived from the breakeven analysis data presented in Table 2 along with fixed cost information.[7] The curve implies that economies of size existed for the small-scale processing plant with an average total cost of 1.03 dollars per pound at the assumed full capacity level of operation. Average total cost per pound processed changed by 2.10 percent given a 10 percent change in live fish processed at 92.5 percent of processing capacity.

Production Cycle Analysis

Breakeven analysis gives an indication both of the average price level for live fish and of operating capacity and sales necessary for the continued operation of the processing plant. However, desirable

[7]The fitted average total cost curves are: Breakeven Analysis Average Total Cost = 1.57 - 5.56E - 5*X + 1.40E - 9*X^2
(18.79) (12.67)

Production Cycle Analysis Average Total Cost = 1.43 - 3.79E - 5*X + 9.0E - 10*X^2
(1.02) (0.69)

where: x = pounds of live fish processed.
t-values are presented in parentheses.

Table 1. Breakeven and Yearly Production Cycle Analyses: Distribution Assumptions and Correlations for Processing, Sales, and Associated Prices[a]

Variable	Distribution, Mean, Standard Deviation, and Correlations (if any)					
	Processed Fresh			Processed Frozen		
	Wholefish	Fillets	Nuggets	Wholefish	Fillets	Nuggets
Dressing Percentage[b]						
Distribution	Normal	Normal	Normal	Normal	Normal	Normal
Mean	60.6%	38.6%	6.8%	60.6%	38.6%	6.8%
Standard Deviation	3%	2%	0.3%	3%	2%	0.3%
Correlation[c]						
Relationship	—	—	—	—	—	—
Coefficient	—	—	—	—	—	—
Product Mix[b]						
Distribution	Normal	Normal	Normal	Normal	Normal	Normal
Mean	20%	50.5%	4.5%	20%	50.5%	4.5%
Standard Deviation	1%	1.5%	1.5%	1%	1.5%	1.5%
Correlation						
Relationship	—	—	—	—	—	—
Coefficient	—	—	—	—	—	—
Processed Fish Prices[d]						
Distribution	Normal	Normal	Normal	Normal	Normal	Normal
Mean	1.62	2.75	2.75	1.72	2.70	2.70
Standard Deviation	0.026	0.042	0.042	0.043	0.035	0.035
Correlation						
Relationship	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	—	FnSFNBp
Coefficient	0.959	0.960	0.960	0.910	—	1.000

	Price of Live Fish							
Price of Live Fish[d]								
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.67
Standard Deviation	0.017	0.017	0.017	0.017	0.018	0.018	0.018	0.018
Correlation								
Relationship	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp
Coefficient	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	0.68	0.69	0.70	0.71	0.72	0.73	0.74	0.75
Standard Deviation	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.021
Correlation								
Relationship	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp
Coefficient	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939

	Daily Processing Level (lbs. of live fish per day)								
	11,200	11,800	12,400	13,000	13,600	14,200	14,800	15,400	16,000
Daily Processing Level									
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	11,200	11,800	12,400	13,000	13,600	14,200	14,800	15,400	16,000
Standard Deviation	829	874	918	962	1,007	1,051	1,096	1,140	1,184
Correlation									
Relationship	FARMp	FARMp	FARMp	FARMp	FARMp	FARMp	FARMp	FARMp	FARMp
Coefficient	-0.127	-0.127	-0.127	-0.127	-0.127	-0.127	-0.127	-0.127	-0.127
Daily Processed Fish Sales[e]									
Fresh Wholefish									
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	1,357	1,430	1,503	1,576	1,648	1,721	1,794	1,866	1,939
Standard Deviation	134	141	148	155	163	170	177	184	191
Correlation									
Relationship	FhWNBp	FhWNBp	FhWNBp	FhWNBp	FhWNBp	FhWNBp	FhWNBp	FhWNBp	FhWNBp
Coefficient	-0.514	-0.514	-0.514	-0.514	-0.514	-0.514	-0.514	-0.514	-0.514

Table 1. Continued

	Daily Processing Level (lbs. of live fish per day)								
	11,200	11,800	12,400	13,000	13,600	14,200	14,800	15,400	16,000
Daily Processed Fish Sales[e]									
Fresh Fillets									
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	1,298	1,368	1,437	1,507	1,576	1,646	1,715	1,785	1,854
Standard Deviation	125	132	139	145	152	159	165	172	179
Correlation									
Relationship	FhSFNBp	FhSFNBp	FhSFNBp	FhSFNBp	FhSFNBp	FhSFNBp	FhSFNBp	FhSFNBp	FhSFNBp
Coefficient	-0.107	-0.107	-0.107	-0.107	-0.107	-0.107	-0.107	-0.107	-0.107
Daily Processed Fish Sales[e]									
Fresh Nuggets									
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	229	241	254	266	278	290	303	315	327
Standard Deviation	22	23	25	26	27	28	29	30	32
Correlation									
Relationship	FhNNBp	FhNNBp	FhNNBp	FhNNBp	FhNNBp	FhNNBp	FhNNBp	FhNNBp	FhNNBp
Coefficient	-0.107	-0.107	-0.107	-0.107	-0.107	-0.107	-0.107	-0.107	-0.107
Daily Processed Fish Sales[e]									
Frozen Wholefish									
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	1,357	1,430	1,503	1,576	1,648	1,721	1,794	1,866	1,939
Standard Deviation	122	128	135	141	148	154	161	167	174
Correlation									
Relationship	FnWNBp	FnWNBp	FnWNBp	FnWNBp	FnWNBp	FnWNBp	FnWNBp	FnWNBp	FnWNBp
Coefficient	-0.142	-0.142	-0.142	-0.142	-0.142	-0.142	-0.142	-0.142	-0.142
Daily Processed Fish Sales[e]									
Frozen Fillets									
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	1,298	1,368	1,437	1,507	1,576	1,646	1,715	1,785	1,854
Standard Deviation	116	123	129	135	141	148	154	160	166
Correlation									
Relationship	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp	FnSFNBp
Coefficient	-0.208	-0.208	-0.208	-0.208	-0.208	-0.208	-0.208	-0.208	-0.208
Daily Processed Fish Sales[e]									
Frozen Nuggets									
Distribution	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Mean	229	241	254	266	278	290	303	315	327
Standard Deviation	21	22	23	24	25	26	27	28	29
Correlation									
Relationship	FnNNBp	FnNNBp	FnNNBp	FnNNBp	FnNNBp	FnNNBp	FnNNBp	FnNNBp	FnNNBp
Coefficient	-0.208	-0.208	-0.208	-0.208	-0.208	-0.208	-0.208	-0.208	-0.208

[a]Definition of terms:
FARMp - Price paid by processor for live fish.
FhWNBp - Propcessed fresh wholefish price.
FhSFNBp - Processed fresh fillet price.
FhNNBp - Processed fresh nugget price.
FnWNBp - Processed frozen wholefish price.
FnSFNBp - Processed frozen fillet price.
FnNNBp - Processed frozen nugget price.
[b]Percentage of live fish weight.
[c]Correlation relationships show the variables with which the variables listed in the first column are assumed to be correlated and the size of the correlation coefficient.
[d]Dollars per pound.
[e]Pounds per day of processed products.

Table 2. Results of Breakeven Analysis Based on 1990 Historical Data: 50 Iterations

Live Fish Price ($/lb.)	Daily Processing Level (lbs. of live fish per day)								
	11,200	11,800	12,400	13,000	13,600	14,200	14,800	15,400	16,000
Daily Sales Revenues									
	12,852	13,546	14,233	14,928	15,610	16,293	16,996	17,677	18,361
	(315)[a]	(312)	(371)	(323)	(418)	(432)	(464)	(459)	(501)
Daily Operating Costs									
0.60	11,335	11,786	12,248	12,727	13,180	13,637	14,117	14,564	15,041
	(514)	(524)	(542)	(593)	(608)	(631)	(656)	(688)	(714)
0.61	11,435	11,912	12,379	12,845	13,322	13,789	14,272	14,728	15,205
	(497)	(536)	(566)	(567)	(640)	(629)	(674)	(689)	(723)
0.62	11,544	12,024	12,497	12,981	13,471	13,944	14,426	14,896	15,378
	(512)	(545)	(551)	(600)	(614)	(661)	(698)	(689)	(733)
0.63	11,670	12,154	12,629	13,123	13,598	14,085	14,580	15,053	15,540
	(527)	(555)	(584)	(615)	(647)	(645)	(673)	(724)	(739)
0.64	11,789	12,274	12,767	13,259	13,745	14,237	14,718	15,221	15,691
	(520)	(551)	(575)	(613)	(647)	(676)	(709)	(739)	(763)
0.65	11,902	12,392	12,899	13,374	13,882	14,384	14,875	15,374	15,865
	(534)	(556)	(581)	(617)	(624)	(684)	(706)	(729)	(762)
0.66	12,021	12,514	13,019	13,510	14,038	14,526	15,209	15,540	16,037
	(535)	(567)	(620)	(635)	(657)	(707)	(726)	(736)	(761)
0.67	12,136	12,635	13,133	13,660	14,172	14,674	15,181	15,690	16,197
	(543)	(560)	(605)	(612)	(662)	(677)	(721)	(732)	(781)
0.68	12,246	12,765	13,276	13,787	14,304	14,822	15,333	15,845	16,357
	(553)	(569)	(613)	(24)	(661)	(706)	(769)	(785)	(767)
0.69	12,362	12,894	13,401	13,941	14,437	14,959	15,499	16,011	16,526
	(540)	(598)	(634)	(642)	(665)	(691)	(735)	(764)	(810)
0.70	12,486	13,003	13,531	14,066	14,574	15,120	15,651	16,173	16,698
	(547)	(600)	(608)	(677)	(679)	(727)	(748)	(775)	(786)
0.71	12,591	13,125	13,655	14,189	14,731	15,258	15,792	16,328	16,860
	(588)	(584)	(626)	(669)	(698)	(732)	(770)	(802)	(831)
0.72	12,713	13,249	13,795	14,341	14,881	15,416	15,950	16,475	17,011
	(582)	(618)	(668)	(662)	(705)	(747)	(758)	(779)	(844)
0.73	12,834	13,371	13,908	14,463	15,001	15,555	16,099	16,624	17,181
	(596)	(606)	(662)	(691)	(703)	(743)	(779)	(787)	(859)
0.74	12,937	13,482	14,044	14,589	15,145	15,706	16,269	16,811	17,360
	(603)	(630)	(668)	(678)	(700)	(775)	(792)	(804)	(818)
0.75	13,052	13,612	14,177	14,718	15,297	15,849	16,433	16,967	17,526
	(595)	(617)	(649)	(692)	(731)	(735)	(832)	(845)	(873)
Daily Net Income									
0.60	878	1,121	1,346	1,561	1,791	2,017	2,240	2,473	2,680
	(580)	(593)	(634)	(702)	(700)	(728)	(928)	(855)	(933)
	{94%}[b]	{97%}	{98%}	{99%}	{99%}	{100%}	{99%}	{100%}	{100%}
0.61	778	995	1,216	1,443	1,649	1,864	2,085	2,310	2,517
	(589)	(616)	(782)	(649)	(658)	(804)	(736)	(894)	(856)
	{91%}	{95%}	{94%}	{99%}	{99%}	{99%}	{100%}	{100%}	{100%}
0.62	669	883	1,097	1,307	1,500	1,709	1,931	2,142	2,344
	(631)	(659)	(699)	(826)	(672)	(775)	(894)	(799)	(819)
	{86%}	{91%}	{94%}	{94%}	{99%}	{99%}	{98%}	{100%}	{100%}
0.63	543	752	965	1,166	1,373	1,568	1,777	1,985	2,182
	(621)	(595)	(703)	(698)	(808)	(761)	(886)	(867)	(960)
	{81%}	{90%}	{91%}	{95%}	{96%}	{98%}	{98%}	{99%}	{99%}
0.64	424	633	828	1,030	1,226	1,417	1,638	1,817	2,031
	(653)	(698)	(604)	(720)	(829)	(830)	(855)	(838)	(935)
	{74%}	{82%}	{91%}	{92%}	{93%}	{96%}	{97%}	{99%}	{99%}

Table 2. Continued

Live Fish Price ($/lb.)	Daily Processing Level (lbs. of live fish per day)								
	11,200	11,800	12,400	13,000	13,600	14,200	14,800	15,400	16,000
Daily Net Income									
0.65	311	514	695	914	1,089	1,270	1,482	1,663	1,856
	(580)	(686)	(757)	(693)	(749)	(783)	(898)	(807)	(980)
	{71%}	{77%}	{82%}	{91%}	{93%}	{95%}	{95%}	{98%}	{97%}
0.66	193	392	576	778	933	1,128	1,328	1,498	1,684
	(596)	(634)	(721)	(631)	(805)	(783)	(846)	(871)	(834)
	{63%}	{73%}	{79%}	{89%}	{88%}	{93%}	{94%}	{96%}	{98%}
0.67	77	271	462	628	799	979	1,176	1,347	1,524
	(609)	(704)	(787)	(753)	(790)	(847)	(816)	(934)	(886)
	{55%}	{65%}	{72%}	{80%}	{84%}	{88%}	{93%}	{93%}	{96%}
0.68	-33	142	318	501	667	831	1,024	1,193	1,364
	(665)	(618)	(743)	(846)	(874)	(841)	(919)	(899)	(931)
	{48%}	{59%}	{67%}	{72%}	{78%}	{84%}	{87%}	{91%}	{93%}
0.69	-149	12	193	347	534	695	857	1,027	1,196
	(713)	(644)	(689)	(701)	(724)	(901)	(841)	(865)	(967)
	{42%}	{51%}	{61%}	{69%}	{77%}	{78%}	(85%)	{88%}	{89%}
0.70	-273	-96	64	222	397	533	706	865	1,024
	(656)	(706)	(658)	(772)	(792)	(926)	(809)	(845)	(869)
	{34%}	{44%}	{54%}	{61%}	{69%}	{72%}	{81%}	{85%}	{88%}
0.71	-34	141	317	500	666	831	1,023	1,192	1,363
	(623)	(781)	(672)	(805)	(857)	(729)	(860)	(911)	(867)
	{27%}	(39%)	{46%}	{55%}	{61%}	{71%}	{75%}	{78%}	{84%}
0.72	-500	-343	-201	-53	90	237	406	563	711
	(630)	(720)	(798)	(758)	(940)	(829)	(933)	(990)	(962)
	{21%}	{32%}	{40%}	{47%}	{54%}	{61%}	{67%}	{72%}	{77%}
0.73	-621	-464	-314	-174	-30	99	258	414	540
	(684)	(741)	(684)	(711)	(792)	(954)	(997)	(972)	(999)
	{18%}	{26%}	{32%}	{41%}	{48%}	{54%}	{60%}	{67%}	{71%}
0.74	-724	-575	-450	-300	-174	-53	88	227	362
	(800)	(833)	(803)	(709)	{799}	(896)	(900)	(1,012)	(958)
	{18%}	{25%}	{29%}	{34%}	{41%}	{48%}	{54%}	{59%}	{65%}
0.75	-839	-705	-583	-429	-326	-196	-77	71	196
	(672)	(690)	(784)	(877)	(805)	(912)	(899)	(987)	(1,023)
	{11%}	{15%}	{23%}	{31%}	{34%}	{42%}	{46%}	{53%}	{58%}

[a]Standard deviations are presented in parentheses.
[b]Probabilities of positive values are presented in brackets.

average input prices and processing levels do not guarantee firm success. The dynamic structures of the supply and demand for both live fish and processed fish products along with their respective prices, affect the flow of costs and revenues to the firm throughout the year. It is the proper management of these flows in terms of cash availability, debt payment, receivables collections, and operations financing that is necessary to insure continued firm operation. A second analysis was made to study the short-term (yearly) production cycle dynamics of catfish processing costs and revenues given an assumed level of average firm profitability.

Distributions of daily sales revenue, fixed costs, operating costs, and net income were generated for each month of the year based on an average yearly price for live fish of 0.65 dollars per pound, the availability of live fish to process and sell at a mean of 92.5 percent (14,800 pounds) of processing capacity, the assumed product mix and dressing per-

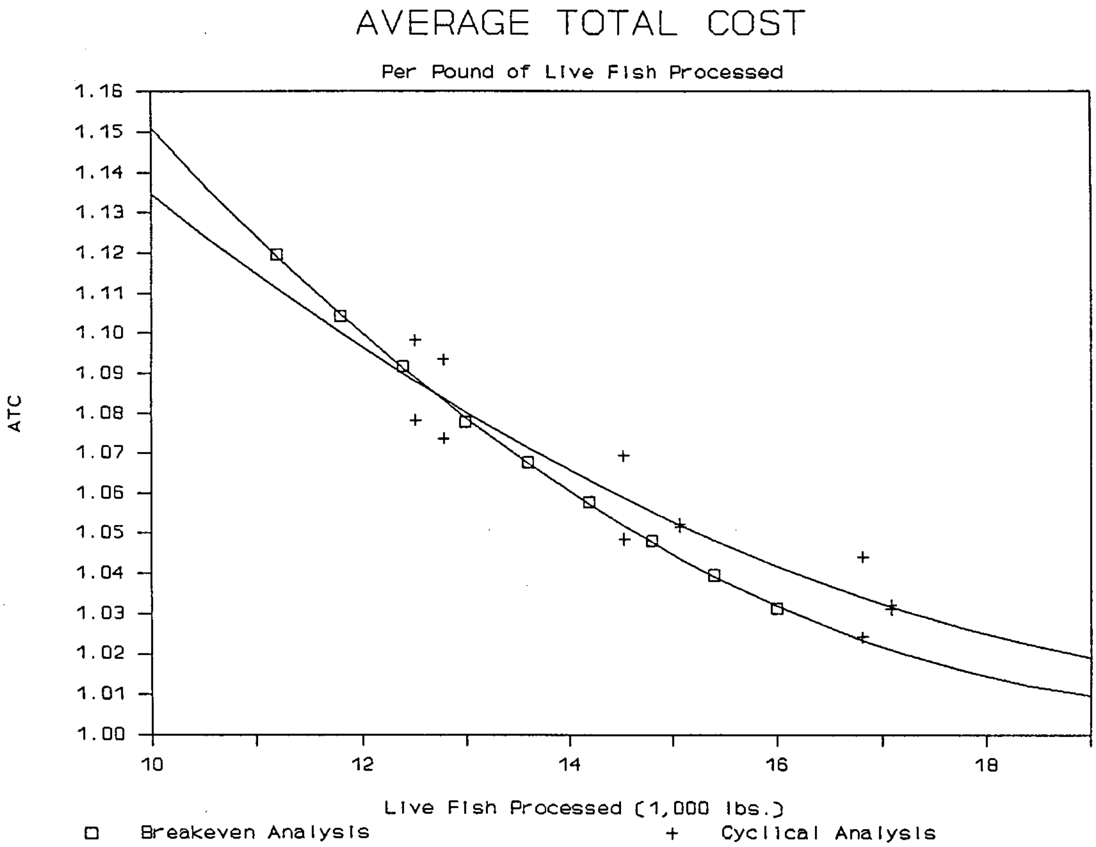

Figure 2. Average Total Cost per Pound of Live Fish Processed

centages outlined in Table 1, and a set of hypothesized cyclical patterns in live fish prices, processed product prices, live fish processed, and processed products sales. These cyclical patterns were based on cyclical patterns estimated by Branch for the United States catfish marketing system. A six-month harvest cycle was assumed to influence the level of live fish processed and live fish prices. A 12-month wholesale demand cycle, in addition to the six-month harvest cycle, was assumed to influence processed product sales and associated prices. The hypothesized input data for live fish prices, processed product prices, live fish processed, and processed product sales are presented in Table 3.

Figure 3 shows a monthly comparison of the means of the average quantity of live fish processed and the average total quantity of processed fish sold for all types of processed products, in live fish equivalents (the amount of live fish processed to attain the specified amount of processed product). Sales were expected to peak in March and April during the Lenten period and reach a minimum in November and December during the Thanksgiving and Christmas holidays. Local troughs and peaks in sales occur in early and late summer, respectively. Processing peaks occur in late summer at the end of the primary growing season and in February and March prior to Lent. Processing troughs occur in early summer following Lent and in late fall following the end of the primary growing period and harvest.

Total cost of operations are also cyclical as shown in Figure 4. On average, sales revenues exceeded operating costs by $2,036 per day for each month of the year. This implies that the firm will continue to operate, at least in the short run, because revenues are being generated to cover a portion of fixed costs. However, while sales revenues over operating costs were positive on average, the variability associated with this income was quite large (standard deviation of $830). Indeed, in certain months, daily revenues are expected to be less than operating costs, particularly from November through January (Table 4). During this period, the probability of a positive level of daily net income did not exceed 11 percent, while in October the probability was only 52 percent. For the remainder of the year, the probability for a positive level of daily net income ranged from a low of 70 percent in February to certainty in March to July. For the entire year, the average probability of a

Table 3. Yearly Production Cycle Analysis: Distributional Assumptions for Monthly Processing, Sales, and Associated Prices

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
Live Fish Processed[a]													
	14,529	16,810	17,082	15,071	12,790	12,518	14,529	16,810	17,082	15,071	12,790	12,518	14,800
	(1,075)[c]	(1,244)	(1,264)	(1,115)	(946)	(926)	(1,075)	(1,244)	(1,264)	(1,115)	(946)	(926)	(1,095)
Processed Fish Sales[a]													
Fresh -													
Whole	1,616	2,122	2,358	2,182	1,821	1,635	1,753	1,963	1,945	1,625	1,270	1,237	1,794
	(159)	(209)	(233)	(215)	(180)	(161)	(173)	(194)	(192)	(160)	(125)	(122)	(177)
Fillet	1,476	1,821	2,069	2,054	1,846	1,672	1,678	1,794	1,822	1,652	1,398	1,297	1,715
	(142)	(176)	(200)	(198)	(178)	(161)	(162)	(173)	(176)	(159)	(135)	(125)	(165)
Nugget	279	314	338	337	316	299	299	311	314	297	271	261	303
	(27)	(30)	(33)	(33)	(31)	(29)	(29)	(30)	(30)	(29)	(26)	(25)	(29)
Frozen -													
Whole	1,696	1,866	1,925	1,861	1,783	1,799	1,901	1,971	1,902	1,717	1,556	1,549	1,794
	(152)	(168)	(173)	(167)	(160)	(162)	(171)	(177)	(171)	(154)	(140)	(139)	(161)
Fillet	1,334	1,723	1,951	1,932	1,831	1,856	2,027	2,140	1,980	1,566	1,167	1,073	1,715
	(120)	(155)	(175)	(173)	(164)	(166)	(182)	(192)	(178)	(140)	(105)	(96)	(154)
Nugget	265	304	327	325	315	317	334	345	329	288	248	239	303
	(24)	(27)	(29)	(29)	(28)	(28)	(30)	(31)	(30)	(26)	(22)	(21)	(27)
Processed Sales Live Fish Equivalent[a]													
	11,865	14,625	16,178	15,706	14,289	13,675	14,434	15,410	14,790	12,828	10,513	10,011	13,709
Live Fish Price[b]													
	0.66	0.66	0.65	0.65	0.64	0.64	0.64	0.64	0.65	0.65	0.66	0.66	0.65
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Processed Fish Prices[b]													
Fresh -													
Whole	1.60	1.65	1.68	1.66	1.62	1.60	1.62	1.64	1.64	1.60	1.57	1.56	1.62
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Fillet	2.73	2.76	2.79	2.78	2.76	2.75	2.75	2.76	2.76	2.74	2.72	2.71	2.75
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Nugget	2.73	2.76	2.79	2.78	2.76	2.75	2.75	2.76	2.76	2.74	2.72	2.71	2.75
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Frozen -													
Whole	1.71	1.73	1.73	1.73	1.72	1.72	1.73	1.74	1.73	1.71	1.70	1.70	1.72
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Fillet	2.66	2.70	2.72	2.72	2.71	2.71	2.73	2.74	2.73	2.69	2.65	2.64	2.70
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)
Nugget	2.66	2.70	2.72	2.72	2.71	2.71	2.73	2.74	2.73	2.69	2.65	2.64	2.70
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)

[a]Pounds per day.
[b]Dollars per pound.
[c]Standard deviations are presented in parentheses.

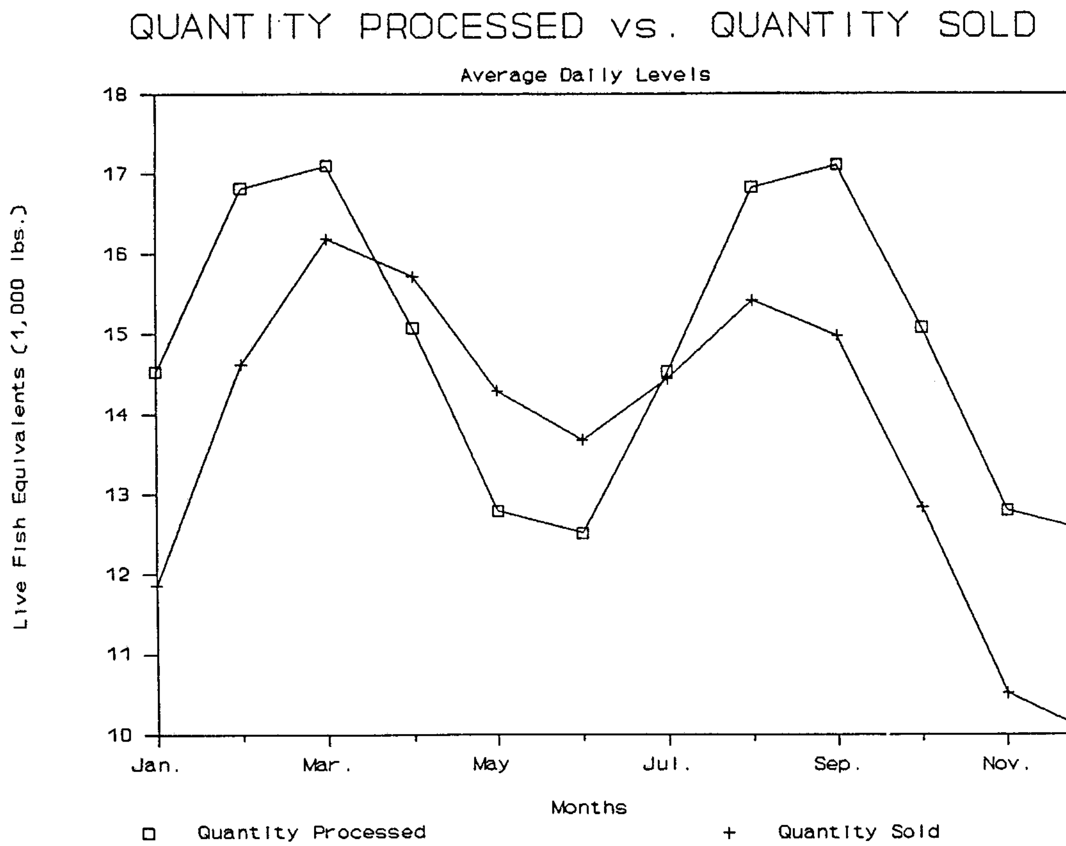

Figure 3. Comparison of Average Daily Quantity Processed and Quantity Sold in Live Fish Equivalent Units

positive level of daily net income in any given month was 69 percent.

An average total cost per pound curve for live fish processed based on monthly average total cost from the production cycle analysis is also presented in Figure 2, with the breakeven analysis average total cost curve. Data for the curve were derived from the production cycle analysis data presented in Table 4. The curve implies that economies of size exist for the small-scale processing plant as did the breakeven analysis average total cost curve. Average total cost was 1.04 dollars per pound, based on the production cycle curve at the assumed full capacity level of operation. Average total cost per pound processed changed by 1.73 percent given a 10 percent change in live fish processed at 92.5 percent of processing capacity.

It is cyclical patterns in revenue and cost generation that are of great concern to processors when considering cash-flow management, debt structuring, and financial planning. Results from the year-long production cycle analysis of the small-scale processing plant's revenue and cost structure suggest a need for financial planning to provide for possible year-end revenue shortfalls. Also, for the potential firm, the timing of initial processing and sales greatly influences the firm's early solvency and survival. The late winter and early spring may be a more suitable period to begin initial operations rather than in a low processed product demand period such as summer and fall. In order to evaluate cash flow, it would be necessary to make assumptions about the timing of payments and receipts, lines of credit, loan payment schedules, and cash balances at the beginning of the period. The variability in revenues and costs could then be used to calculate expected monthly cash-flow and the variability of cash flow.

SUMMARY

A Lotus spreadsheet model based on an economic-engineering analysis by Garrard of the costs of production for a small-scale (16,000 lbs. per day) catfish processing plant was presented. The model was used initially in a breakeven analysis of daily net income from processing in light of historically-based price distributions for live fish. A second analysis of the dynamic structure of the average monthly net income generated by the processing plant subject to cyclical patterns in yearly live fish availability, wholesale demand, live fish prices, and

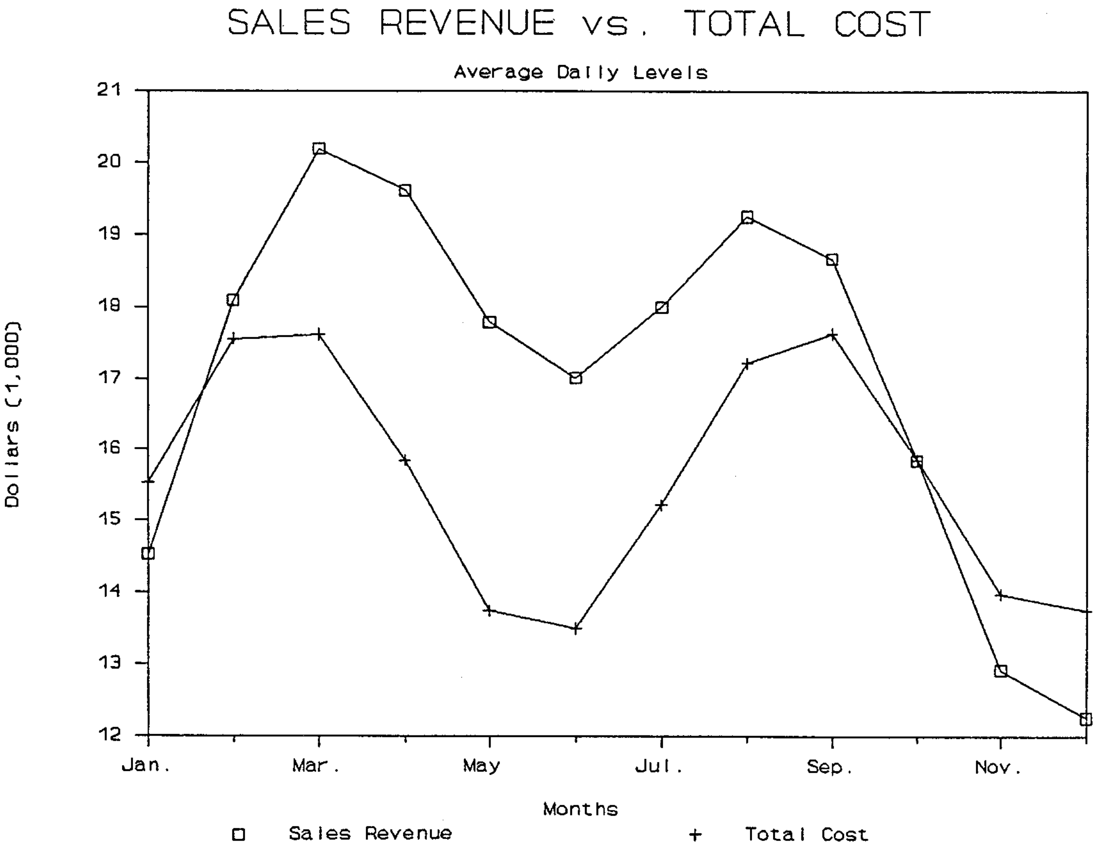

Figure 4. Average Daily Sales Revenue-Operating Cost Comparison

processed product prices was also presented. Input variables were defined by subjective probability distributions through the use of a Lotus add-on software package (@RISK). An iterative simulation of the model was performed by successively sampling the subjective input distributions and recalculating the model to generate a set of estimated output variable distributions based on the economic and engineering relationships of the model.

Breakeven analysis showed that under combinations of operating capacity utilization (70 to 100 percent) and price paid for live fish (0.60 to 0.75 dollars per pound) the firm was able to generate revenues greater than its operating costs given an associated set of processed product sales and prices received for processed products based on 1990 average industry prices. The probability for a positive level of daily net income in this input-price/processing-level range extended from 11 percent at a price for live fish of 0.75 dollars per pound to 100.0 percent at a price of 0.60 dollars per pound depending on the daily level of processing. The average total cost curve per pound of live fish processed based on a live fish price of 0.65 dollars per pound implies that economies of size exist for the small-scale processing plant. Average total cost per pound at full processing capacity was 1.03 dollars. Additionally, average total cost per pound changed by 2.10 percent given a 10 percent change in live fish processed at 92.5 percent of processing capacity.

In the second analysis, the short-term production cycle dynamics of catfish processing costs and returns were examined given an assumed level of average firm profitability. Total costs of operations were shown to be cyclical but exhibited a lower degree of variability compared to sales revenues; this lower variablitiy was due to the relative stability in the quantity of fish processed during the year compared to the quantity of processed product sold. As a result, daily revenues were expected to be less than total operating costs (average probability of 93 percent from November to January) for certain months. This was despite an expected positive level of daily sales net income on average for the year as a whole.

Cyclical patterns in revenue and cost generation in conjunction with conditions of uncertainty suggest the need for a financial planning strategy to be implemented by the processor to assist in decision making. Such planning will aid the processor in dealing with the constant change that persists in the economic environment and provide for the continuation of plant operations in the future.

Table 4. Results of Yearly Production Cycle Analysis: 150 Iterations

Month	Average Daily Sales Revenue	Average Daily Fixed Costs	Average Daily Operating Costs	Average Daily Net Income
Jan.	14,530	627	14,910	-1,008
	(380)[a]	(37)	(714)	(858)
				{11%}[b]
Feb.	18,096	726	16,832	538
	(419)	(42)	(811)	(906)
				{70%}
Mar.	20,199	737	16,881	2,581
	(518)	(43)	(796)	(1,005)
				{100%}
Apr.	19,623	650	15,202	3,770
	(517)	(36)	(746)	(871)
				{100%}
May	17,792	552	13,181	4,059
	(454)	(31)	(606)	(745)
				{100%}
Jun.	17,017	541	12,957	3,519
	(423)	(31)	(583)	(713)
				{100%}
Jul.	18,006	627	14,609	2,770
	(410)	(36)	(680)	(735)
				{100%}
Aug.	19,264	726	16,496	2,043
	(475)	(42)	(812)	(930)
				{97%}
Sep.	18,676	738	16,896	1,041
	(461)	(43)	(821)	(914)
				{86%}
Oct.	15,860	651	15,213	-4
	(437)	(36)	(715)	(861)
				{52%}
Nov.	12,927	552	13,435	-1,060
	(298)	(31)	(642)	(753)
				{8%}
Dec.	12,260	540	13,209	-1,489
	(323)	(33)	(623)	(699)
				{3%}
Average	17,021	639	14,985	1,397
	(426)	(37)	(712)	(833)
				{69%}

[a]Standard deviations are presented in parentheses.
[b]Probabilities of a positive value are presented in brackets.

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