Apples, Processed

ECONOMICS RESEARCH REPORT

AN ECONOMIC ANALYSIS OF ALTERNATIVE INVESTMENT OPPORTUNITIES IN APPLE PROCESSING

JORGE GUTIERREZ-VILLARREAL,
RICHARD A. KING,
GENE A. MATHIA AND NORMAN MILLER

ECONOMICS RESEARCH REPORT NO. 24
DEPARTMENT OF ECONOMICS
NORTH CAROLINA STATE UNIVERSITY AT RALEIGH
ERR 24
MARCH 1973

AN ECONOMIC ANALYSIS OF ALTERNATIVE INVESTMENT OPPORTUNITIES IN APPLE PROCESSING

Jorge Gutierrez-Villarreal, Richard A. King,
Gene A. Mathia and Norman Miller

Economics Research Report No. 24
Department of Economics
North Carolina State University
Raleigh, North Carolina
March 1973

ABSTRACT

The objective of this study was to evaluate the profitability of several alternatives for processing North Carolina apples. The investment alternatives include the production of canned slices, sauce, frozen slices, juice, vinegar, concentrate and essence, and butter. Small, medium and large size plants operating for three different lengths of season were evaluated in which only one of the products was produced. Other plants were designed to process two or more of the products.

The plants were compared in terms of the internal rates of return expected from each operation. Many of the basic plants yielded rather high rates of return although some lines were ruled out either because they required a high proportion (greater than 18 percent) of the total North Carolina crop or because output levels represented a large proportion (greater than 10 percent) of the national market for that product. The juice plant was the most profitable. All the combined-product plants were profitable, yielding rates of return greater than 20 percent at base prices. The plant producing juice and sauce was the most profitable combined-product plant.

The profitability of apple processing was very sensitive to change in raw product and final product prices. The conversion rate from raw to finished product also greatly affected the profitability of each plant.

Potential investors in processing facilities should find this study useful in planning their investment activities. Investment costs, equipment designs and specifications, and operating costs provide valuable background data for the industry. This information will assist investors in choosing among products and product combinations, sizes of plant, lengths of season, and prices required to attract an adequate raw product supply.

TABLE OF CONTENTS

	Page
INTRODUCTION	5
Objectives and Investment Criterion	7
Data Generation and Assumptions	9
PROCESSING COSTS	17
Overhead Costs for Group I and Group II Plants	17
Building and Pallet Costs	17
Equipment Costs	19
Other Costs	19
Operating Costs for Group I and Group II Plants	22
Raw Product	22
Direct Labor	22
Cans, Cases and Labels	24
Other Miscellaneous Costs	24
Overhead Costs for Group III Plants	25
Buildings, Equipment and Pallets	25
Other Overhead Costs	27
Operating Costs for Group III Plants	27
Total Costs	27
Processing Plant Revenues	29
ECONOMIC ANALYSIS OF MODEL PLANTS	32
Group I and Group II Plants	32
Slice Plant	32
Sauce Plant	34
Frozen Slice Plant	34
Juice Plant, Base Situation	34
Juice Plant, Alternative Situations	37
Concentrate and Essence Plant	39
Vinegar Plant	42
Butter Plant	42
Group III Plants	45
SUMMARY AND CONCLUSIONS	47
LIST OF REFERENCES	50

ACKNOWLEDGEMENTS

The authors wish to acknowledge the helpful editoral suggestions received from the reviewers of this manuscript. Special appreciation is due R. Charles Brooks, E. C. Pasour, Jr. and E. A. Proctor of the Department of Economics, Maurice W. Hoover of the Department of Food Science, and Melvin H. Kolbe of the Department of Horticultural Science.

AN ECONOMIC ANALYSIS OF ALTERNATIVE INVESTMENT OPPORTUNITIES IN APPLE PROCESSING

Jorge Gutierrez-Villarreal, Richard A. King,
Gene A. Mathia and Norman Miller*

INTRODUCTION

The North Carolina apple industry has been fresh market oriented for many years. There are several reasons for this fresh market orientation. One of the most important is that apples are ready for market during a period of time when fresh market prices are favorable relative to prices for other outlets. In most years, the North Carolina crop has been harvested and marketed before competing states to the north and northwest have marketed sufficient quantities to greatly depress prices. As a result of this favored position with respect to the fresh market, the North Carolina apple trade has expressed interest primarily in developing alternative marketing outlets for cull and juice grade apples.

The interest in developing new outlets reaches a peak when nature either deals a blow to the apple crops (hail, wind damage, etc.) which render them less desirable for fresh market or when ideal growing conditions prevail in which a large crop is produced resulting in fresh market prices near the price for processing apples. Unfavorable conditions in one or two of the five North Carolina areas seem to occur once

---

*Jorge Guiterrez-Villarreal is a former graduate student, Richard A. King and Gene A. Mathia are Professors of Economics, Norman Miller is associate Professor in the Food Science Department, North Carolina State University, Raleigh.

in every three to five seasons but very seldom in consecutive years. A normal or good growing season usually follows an unfavorable season. Thus, the urge to develop alternative outlets dwindles until another unfavorable year occurs.

Apple production in North Carolina has increased rapidly during the last several years. The U. S. Department of Agriculture (10) estimated 1972 commercial production of apples in North Carolina at 250 million pounds or nearly 6 million (42-pound) cartons. A study by Pasour and Mathia (8) provided estimates of total North Carolina production in 1974 which exceed 7 million bushels. This 7 million bushel estimate would represent an increase in total production between the 1968-71 period and 1974 of around 50 percent.

The trade has shown some interest in extending the marketing season for fresh apples by storing. However, experience by those few investors in storage facilities and results of economic analyses indicate that delayed merchandising by storing does not offer North Carolina growers a very profitable alternative to immediate fresh market sales.[1] These analyses have demonstrated that prices of North Carolina apples at peak harvest in most years are greater than post-harvest prices of apples less the costs of storing and grade-out. There is little evidence that this situation will change very much for the next few years. Therefore, the search for marketing outlets must continue in other directions.

Another logical alternative outlet is processing. Apple varieties are classed as "fresh market," "dual purpose," and "processing," according to their utilization. Most of North Carolina apples are of the fresh market and dual purpose varieties which have not been considered very desirable for processing. During most seasons, however, about 20 percent of total production is not acceptable for fresh market purposes. The low economic value of these cull apples in the fresh market and technological developments in processing these into certain apple products have created the interest in developing processing facilities.

Although prices of the "processing" varieties are much lower than prices for fresh varieties, it still may be profitable to grow "processing" varieties since in North Carolina they have a higher yield per tree or

[1] See Mathia (6) and Mathia and Pasour (7).

per acre. In fact, several plantings of dual purpose varieties have been made which can go either to the fresh or processing markets. The cost of producing "processing" varieties is usually lower than the cost of producing "fresh" varieties because they require less spraying, pruning, and harvesting labor. Also, the costs of packing, grading and marketing are less.

In the past, only cull apples and apples of relatively low fresh market quality have been processed. They have been processed into many products including slices, sauce, pie filling, dried slices, dehydro-frozen slices, frozen slices, cider, vinegar, concentrate, essence and butter. Most of these have been shipped to processing plants located in other states. Therefore, the degree of grower control of the product is reduced by selling to out-of-state processors. The possibility of increasing the market value of apples by reducing transfer costs has created interest in exploring the possibility of establishing processing facilities in North Carolina.

Objectives and Investment Criterion

A decision to invest in an apple processing plant cannot be made objectively until information is available to answer several questions. The following questions are particularly critical:

1. What are the potential market demand conditions for processed apples and do North Carolina apples make an acceptable market product?
2. What are the investment costs of processing apples in alternative types of plants?
3. What are the requirements and costs of the raw product and other inputs?
4. What are the most profitable product lines and expected rates of return from efficiently operated plants?

The general objective of the study is to generate information required to answer the above questions. Specifically, the objectives are to:

1. Determine the costs of constructing various types of apple processing plants.
2. Determine the costs of operating these plants at various lengths of season, raw and finished product prices and rated capacities.

3. Determine internal rates of return from operating these plants under various conditions.

The profitability of the investment alternatives for the different plants was evaluated by computing and comparing rates of return to the investment. Computation of rates of return required estimates of the present values of the total revenue, total cost and net revenue streams as expressed in the three following expressions:

$$(1)\quad PV_{TR} = \frac{R_1}{1+i} + \frac{R_2}{(1+i)^2} + \ldots\ldots\ldots\ldots\ldots + \frac{R_n}{(1+i)^n} + \frac{S_n}{(1+i)^n}$$

$$(2)\quad PV_{TC} = C_o + \frac{C_1}{1+i} + \frac{C_2}{(1+i)^2} + \ldots\ldots\ldots\ldots + \frac{C_n}{(1+i)^n}$$

$$(3)\quad PV_{NR} = -C_o + \frac{R_1 - C_1}{1+i} + \frac{R_2 - C_2}{(1+i)^2} + \ldots\ldots\ldots + \frac{R_n - C_n}{(1+i)^n} + \frac{S_n}{(1+i)^n}$$

Where:

PV_{TR} = present value of the total revenue stream

PV_{TC} = present value of the total cost stream

PV_{NR} = present value of the net revenue stream

R_j = annual revenue in the jth year

C_o = initial capital investment

C_j = annual cost in the jth year

S_n = salvage value of the investment in year n

i = interest rate

j = 1, 2, ... n

The internal rate of return is the rate of interest that will make the present value of the total revenue stream (1) equal to the present value of the total cost stream.[2] In other words, it is the

[2]For further discussion of investment theory, see Lutz and Lutz (5).

interest rate that will make the present value of the net returns (3) equal to zero. The general decision rule for this criterion is to select alternatives with internal rates of return greater than the opportunity costs of capital.

Comparisons of internal rates of return from alternative investments are not affected by the size of the investment or by the duration of the project. Another important feature is that no arbitrary interest rate has to be chosen beforehand. A special case occurs when two projects with different lengths of life are compared and the internal rate of return for the project with the shorter life is higher than the rate of return for the other project. The decision in this case must be made on the basis of the opportunities available for using the funds during the period between the end of the short-life alternative and the end of the longer-life alternative.

Data Generation and Assumptions

A list of major apple products was constructed to investigate the investment alternatives in processing North Carolina apples. Those selected for analysis are classified into three groups based on input requirements. Group I plants include slices (A), sauce (B), and frozen slices (C).[3] Group II plants include cider or juice (F), concentrate and essence (G), vinegar (H), and butter (I). The raw product requirements and output obtained in each plant are presented in Table 1. Group III included those plants producing the following product combinations: slices-vinegar (J), sauce-cider (K), slices-sauce-cider (L), sauce-cider-vinegar (M) and slices-sauce-cider-concentrate-essence-vinegar (N). Input requirements for these plants are presented in Table 2. Other plant options were evaluated but are not summarized in this report.[4]

The sequence of apple processing in model plants is shown in Figure 1. The flow of raw material from the receiving of the raw apples through the

---

[3] Letters in parentheses represent plant code.

[4] A complete reporting of other alternative situations was presented in an unpublished Ph.D. dissertation entitled: "Investment alternatives in the Processing of North Carolina Apples" by Jorge Gutierrez-Villarreal (4).

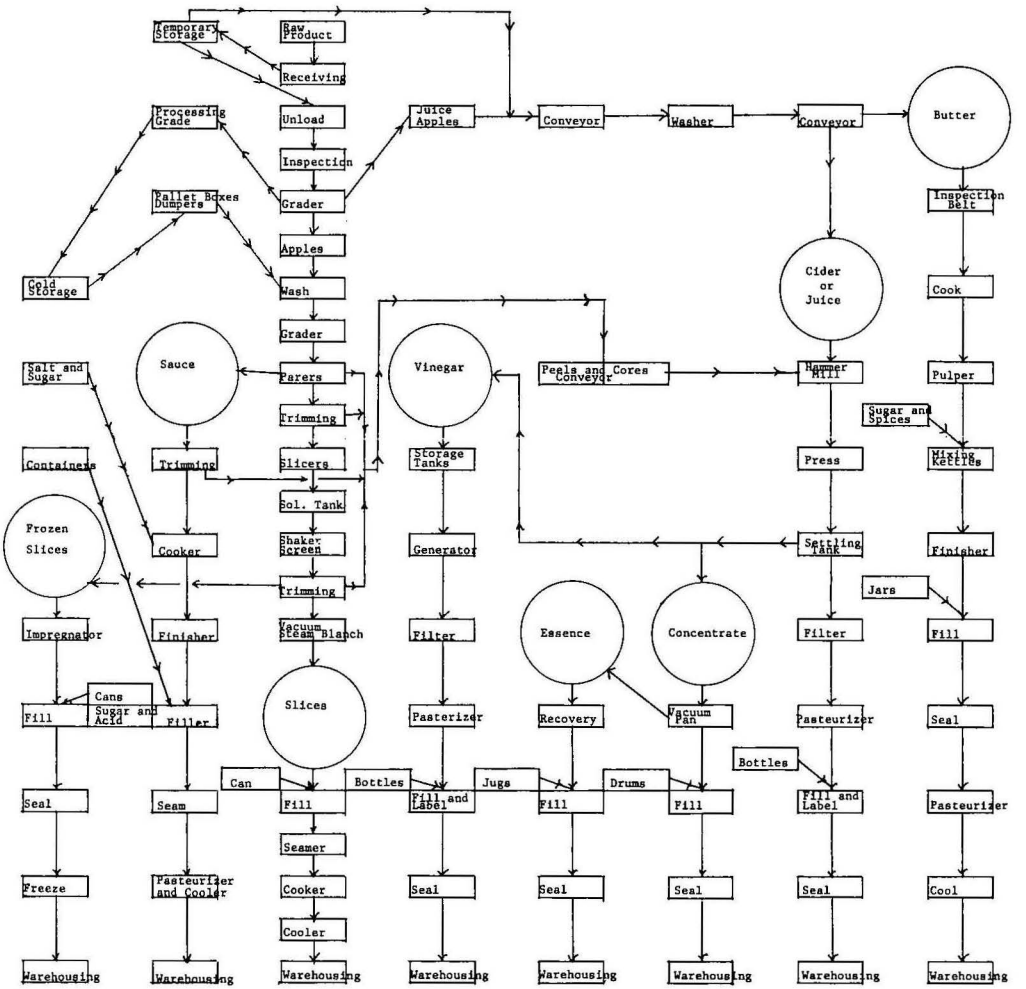

Figure 1. Flow chart for canning apple products

Table 1. Input requirements and output obtained in Group I and Group II plants

Type of plant	Unit	Input requirements for 450 hours			Output obtained for 450 hours		
		Size of plants			Size of plants		
		Small	Medium	Large	Small	Medium	Large
		(1,000 cwt.)			(1,000 units)		
Group I		60	120	180			
Slices (A)	6/10 cans				90[a]	180[b]	270[c]
Sauce (B)	6/10 cans				30[a]	60[b]	90[c]
Frozen slices (C)	pounds				4,320[a]	8,640[b]	12,960[c]
Group II		40	80	120			
Cider or juice (F)	12/3 cans				60	120	180
	12 quarts				30	60	90
Concentrate and essence (G)	gallons concentrate				45	90	135
	gallons essence				3.725	7.470	11.205
Vinegar (H)	gallons				360	720	1,080
Butter (I)	12/quarts				130	260	390

[a]In addition, 3.6 thousand cwt. of culls were produced during each 450 hours of operation.

[b]In addition, 363,720 gallons of juice were produced during each 450 hours of operation.

[c]In addition, 545,580 gallons of juice were produced during each 450 hours of operation.

Table 2. Input requirements and output obtained in Group III plants[a]

Plants[b]	Apples used		Volume of production by type and size of container							
	Processing apples[c]	Culls	Slices	Sauce		Cider		Concentrate	Essence	Vinegar
	(1,000 cwt.)		(6/10's)	(6/10's)	(24/303's)	(12/3's)	(12/qt)		(gallons)	(gallons)
J	240	240	360,000							2,887,440
K	360	240		180,000	870,750	541,860	270,930			
L	360	240	180,000	120,000	580,500	541,860	270,930			
M	360	240		180,000	870,750	361,860	180,930			1,080,000
N	360	240	180,000	120,000	580,500	180,620	90,310	135,465	11,240	1,083,720

[a]Same conversion rates as for Group I and Group II plants.

[b]Product combinations for each plant are: (J) slices-vinegar; (k) sauce-cider; (L) slices-sauce-cider; (M) sauce-cider-vinegar; and (N) slices-sauce-cider-concentrate-essence-vinegar.

[c]Six percent of these apples are used as culls. This is because they are not suitable for being processed into sauce or slices.

major steps of processing is illustrated. It also shows the stages followed in processing each product. The different products are denoted with a circle. Each product may be produced by itself or in combination by using common equipment.

Model plants were designed to study the profitability of each product and each product mix. Model plants for each of the products were designed so that a broad range of production possibilities could be considered. Three capacities for each plant were considered. These capacities are referred to as small, medium and large. Table 1 presents the input requirements and output obtained from these plants operating at 450 hours per season.

Group III plants were selected after examining the profitability of each of the Group I and Group II options. The relationship between the product mix was also taken into consideration, that is, if they were joint, complementary, supplementary or competitive in the use of resources. All Group III plants were designed with at least one product from each of Group I and Group II. The quantity of processing apples and culls required by the Group III plants was also considered since the availability of processing apples and culls was one of the constraints considered in this study.

Table 2 shows the total production and utilization of apples for Group III plants. The conversion rate of raw product into finished product was the same as the one used for the Group I and Group II basic plants. However, the total production of juice, concentrate and essence, and vinegar may be different from the production levels indicated for these products when they were considered in the basic plants. This is because the culls, peels, and cores of the processing apples processed into sauce or slices may be used to produce juice, concentrate and essence, and vinegar.

It was assumed that the culls, peels, and cores of the processing apples were used to produce vinegar in the slice-vinegar plant (J). All others except the slice-sauce-cider-concentrate-essence-vinegar plant (N) used them in the production of juice. This plant used them in three equal amounts to produce juice, concentrate and essence, and vinegar.

Since the investment alternatives are interdependent, costs of any of the Group III plants cannot be estimated by adding up the cost for

each of the individual alternatives. Data were generated for each of the Group III plants in the same way as for the basic plants.

The analysis assumes that only certain plant choices are feasible options. The decision as to which choice provides the best opportunity for investors must be made from these possibilities. Plants were assumed to operate at 95 percent of their engineer rated capacity. It was assumed that the necessary quantities of raw products and other factor inputs are available.

Another assumption refers to the amount of capital, raw apples, and the desired production of each product. The maximum amount of capital available for any plant was established at 4 million dollars. The maximum amounts of processing apples and culls for any given plant were taken to be 18 and 12 percent (36.7 and 24.5 million pounds, respectively) of the annual production of apples in North Carolina for the 1969-71 period. The production desirable for each product was established as a maximum of 10 percent of the U. S. production for each product as shown in Table 3.

A riskless environment for the operation of each plant was assumed. Initially, complete certainty was assumed with respect to the total costs and revenue streams for each plant. Furthermore, the supply of all inputs was assumed to be unchanging with respect to price over the quantity ranges considered. Other assumptions were related to the conversion rates of apples into each product, the cost of operating capital, and the length of life and salvage value for the durable goods. These will be stated as they become relevant for the analysis. In subsequent analyses, prices of raw and finished products were varied 10 percent above and below the base prices. Limitations on raw product supply were also considered.

An economic-engineering approach was used to estimate the overhead and operating costs corresponding to each of the model plants using data obtained from food processing specialists, apple processing firms, equipment companies, and government agencies. Factor prices were obtained from the suppliers of the different inputs.

Total revenues were estimated according to plant production and product prices. Information with respect to product prices was obtained from several sources including the Almanac of the Canning, Freezing, Preserving Industries (1), fruit brokers, and apple processing plant managers.

Table 3. Maximum output assumed for selected apple products[a]

Product	Unit	Quantity
Slices	cases (6#10)	347,000[b]
Sauce	cases (24#303)	2,640,958[b]
Frozen slices	lbs.	11,237,000[b]
Juice	cases (12#3)	832,830[b]
Butter	cases (12 qt.)	177,916[c]
Vinegar	gal.	d
Concentrate	gal.	d
Essence	gal.	d

[a]Sources: Almanac of the Canning, Freezing, Preserving Industries (1), Brunk et al. (2), U. S. Department of Agriculture (11), and Dalrymple and Twigg (3).

[b]10 percent of the U.S. average annual output for the 1967-69 period.

[c]10 percent of the U.S. production for 1967.

[d]The U.S. output was not available.

Overhead and operating costs for each of the model plants were estimated. Overhead costs consist of buildings, equipment, complementary equipment, pallet boxes, pallets and truck. Operating costs and other costs measured on an annual basis include permanent labor, property taxes, insurance, interest on operating capital, office and sales expenditures, and outlays for variable inputs. All of these costs will be discussed in detail in the following sections.

PROCESSING COSTS[a]

Overhead Costs for Group I and Group II Plants

Building and Pallet Costs

A summary of buildings, pallet boxes and pallet costs is presented in Table 4. The cost of buildings was obtained by estimating the building requirements for warehouse, processing area, rest rooms, quality control laboratories and boiler room, and cold storage rooms. In general, costs of the processing area, offices, rest rooms, quality control laboratories and boiler room are a function of plant size. The costs of the warehouse, pallets, pallet boxes, and cold storage area are a function of both the length of season and plant size.

The costs of the structure for frozen slices were greater than the costs for the other products. The need for refrigerated storage accounts for much of the difference in costs. Less warehouse space is required for concentrate and essence, and thus, cost of the structure is considerably less than for any of the other lines. Costs of complementary equipment to process culls, peels, and cores into juice for the medium and large plants for Group 1 are also included in Table 4. In addition, 15 percent of the costs of complementary equipment was included to cover delivery and installation.

Buildings were assumed to be used for processing over a period of 30 years. The value at the end of 10 years was assumed to be equal to two-thirds of the initial investment. Pallet boxes and pallets were assumed to have a useful life of 5 years with zero salvage value at the end of this period. These costs are included in Table 4.

---

[a]Detailed requirements and estimates of costs are included in the unpublished Ph.D. dissertation by Jorge Gutierrez-Villarreal (4).

Table 4. Summary of building and pallet costs for Group I and Group II plants by rate of output and length of season[a]

Plant	Length of season and plant size								
	450 hours			900 hours			1,350 hours		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	($1,000 dollars)								
Group I									
Slices (A)	325.23	514.98	741.48	509.19	948.69	1350.69	745.71	1429.96	2034.96
Sauce (B)	339.98	531.48	787.48	534.74	992.74	1401.74	784.76	1487.26	2112.26
Frozen slices (C)	692.03	923.22	1116.27	1198.97	1705.96	2157.14	1694.66	2501.86	3162.34
Group II									
Juice (F)	114.73	192.98	264.73	143.24	296.74	434.74	175.96	403.71	611.96
Concentrate Essence (G)	88.03	149.98	209.98	91.24	217.74	337.74	102.21	288.71	468.71
Vinegar (H)	133.63	215.13	298.75	162.89	340.64	499.39	216.63	462.13	698.63
Butter (I)	114.38	202.38	274.13	142.74	315.24	361.64	171.71	428.71	636.96

[a]Source: Gutierrez-Villarreal (4).

Equipment Costs

A summary of equipment costs for all plants is presented in Table 5. These costs are basically a function of plant size but some additional equipment is required as length of season is extended. Equipment costs are presented on the basis of a 450-hour season for all plants. The numbers in parentheses represent costs of additional equipment required for the 900 to 1,350 hour season. Table 5 shows some economies of scale as the length of season and/or the rate of output doubles and triples. For example, the costs of equipment per case of slices for a given rate of output decreased as the length of operating season increased, as shown in Figure 2. The equipment cost per case for the small slice plant operating 450 hours was $2.81. As the length of operating season was increased to 900 and 1,350 hours, the cost per case for equipment decreased to $1.50 and $1.00, respectively.

Also for a given length of season, the cost per case decreased as the rate of output was increased. The cost per case for the small slice plant operating 450 hours per season decreased from $2.81 to $1.97 and $1.88 as the rate of output doubled and tripled, respectively.

It also can be seen in Figure 2 that certain quantities of output (180,000 to 540,000 cases) may be produced by more than one plant size. In all the overlapping cases, the lowest equipment cost per case was shown by the smaller plant. Equipment costs per case of output for plants producing other products also decreased as the length of operating season and plant size increased.

The equipment was assumed to have a life of 10 years with zero salvage value. Corrosion due to the apple acids is the main determinant of this expected life. Costs of transportation and installation for each plant were estimated as 15 percent of the total equipment costs.

Other Costs

A truck is necessary to take the pomace obtained from the culls, peels and cores to a sanitary land fill. A 10-ton truck with a value of $10,000 was included in the cost of all plants except in the case of the small plants A, B, and C. These plants were designed to sell

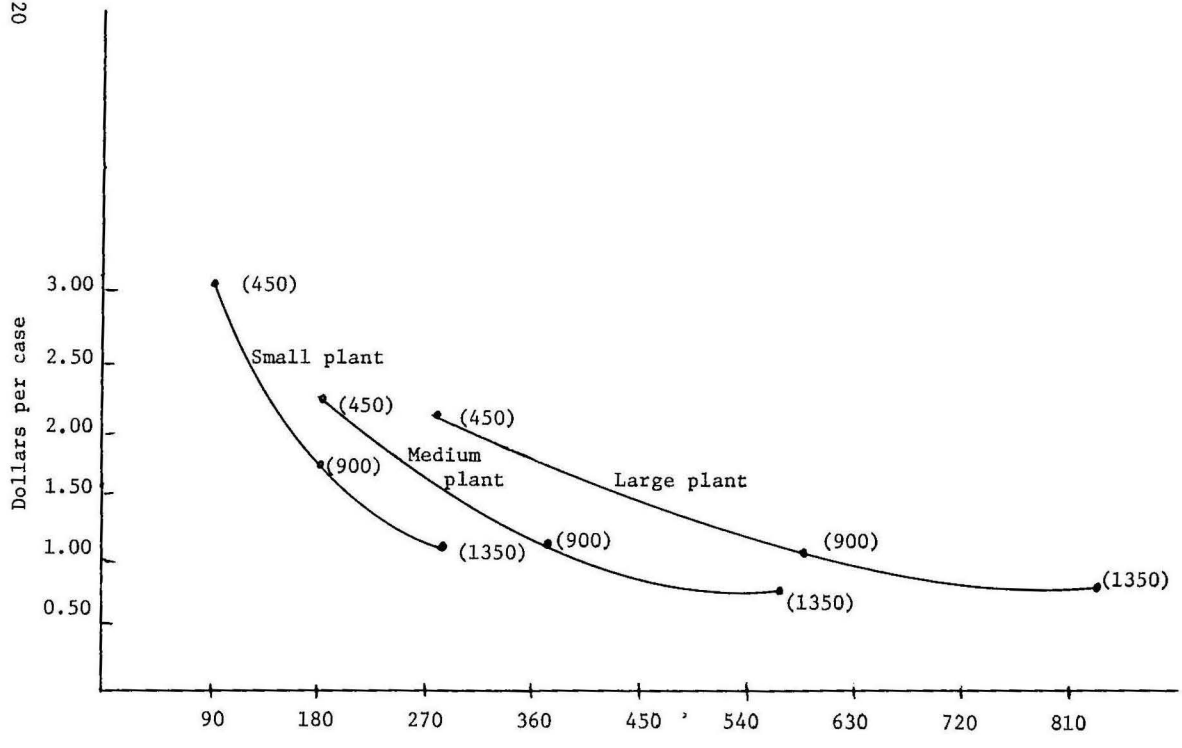

Figure 2. Average costs of equipment to produce apple slices in Plant A*

*Numbers in parentheses are lengths of season in hours.

Table 5. Summary of equipment costs for Group I and Group II plants by rate of input at the 450-hour length of season[a]

Plant	Plant size		
	Small	Medium	Large
		(dollars)[c]	
Group I[b]			
Slices (A)	252,834 (16,951)	395,174 (13,984)	571,205 (20,769)
Sauce (B)	247,746 (17,224)	378,923 (13,984)	540,998 (0)
Frozen slices (C)	126,035 (16,951)	230,644 (13,984)	318,447 (20,769)
Group II			
Juice (F)	165,278 (10,638)	173,903 (19,263)	250,091 (17,250)
Concentrate and essence (G)	283,269 (10,638)	291,894 (19,263)	413,097 (17,250)
Vinegar (H)	197,909 (66,436)	235,057 (167,428)	355,675 (193,670)
Butter (I)	106,975 (10,638)	136,473 (19,262)	189,657 (17,250)

[a]Source: Gutierrez-Villarreal (4).

[b]Includes investment in complementary equipment.

[c]Numbers in parentheses represent additional investment costs required for either 900 or 1,350 hours of operation per season.

culls to other processing plants but peels and cores had no value or costs of destruction. A truck was not included for the butter plants either since no pomace is obtained in the processing of this product. A life of 5 years for the truck with a salvage value of one-fourth of its original value at the end of five years was assumed.

Permanent labor refers to employees such as a manager, assistant manager, secretaries, a janitor, a quality control supervisor, a field man, and a maintenance chief. This staff was the same for all plants. An allowance of 10 percent of the cost of permanent labor was added as fringe benefits. Annual costs of permanent labor for these plants were 68,530, 81,730 and 100,210 dollars for the small, medium and large plants, respectively.

Property taxes vary by plant location. For the purposes of this study, one percent of the initial costs of buildings, pallet boxes, pallets (Table 4) equipment (Table 5) and truck was assumed.

Operating Costs for Group I and Group II Plants

A summary of variable costs including the raw product and direct labor for Group I and Group II plants is presented in Table 6. Input requirements are related to the quantity of raw product received, the quantity of product suitable for canning and the number of units produced. Methods of calculating requirements and costs of variable inputs are discussed below.

Raw Product

The total quantity of raw apples for each plant depends upon the plant size, length of season and the product being produced. Input requirements for Group 1 plants were 133, 267, and 400 cwt. of processing grade apples per hour. The value of processing apples was assumed to be 3.25 dollars per cwt. Requirements for Group 2 plants were 89, 178, and 267 cwt. per hour for the three plant sizes. A value of $1.00 per cwt. of cull apples was assumed.

Direct Labor

Input of direct labor for all plants was estimated according to the equipment of each plant and the plant size. Costs of labor were

Table 6. Summary of variable costs for group I and group II plants by product, rate of output and length of season[a/]

Plant	Length of Season and Rate of Output								
	450 Hours			900 Hours			1350 Hours		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	(dollars/hour)[b/]								
Group I									
Slices (A)	907.00	1717.41	2560.01	895.76	1696.26	2531.88	890.12	1687.46	2519.24
Sauce (B)	1114.29	2140.51	3211.81	1103.37	2120.44	3185.56	1097.83	2111.98	3173.58
Frozen Slices (C)	1367.66	2666.33	3972.68	1364.38	2655.57	3960.42	1361.39	2650.21	3953.07
Group II									
Juice (F)	425.09	754.78	1130.66	416.47	747.98	1118.95	412.55	743.70	1113.11
Concentrate and Essence (G)	217.11	334.65	498.04	201.07	320.44	476.09	194.68	313.69	466.78
Vinegar (H)	396.33	739.44	1102.37	391.37	725.22	1095.11	388.66	718.47	1088.58
Butter (I)	943.40	1835.63	2740.85	939.17	1831.90	2733.65	936.70	1828.64	2729.32

[a/] Source: Gutierrez-Villarreal, Jorge, Investment Alternatives in the Processing of North Carolina Apples, Unpublished Ph.D. Dissertation, North Carolina State University, Raleigh.Table 8, and Appendix A Tables: 26-33.

[b/] Includes direct labor costs.

based upon wages for the various labor skills. Unskilled labor was priced at the 1970 minimum wage of $1.60. Semiskilled and skilled workers were priced at levels typically observed in the Southeast. These wage rates may vary by location and over time.

Cans, Cases and Labels

The number of cans was estimated according to the weight or contents in each can size and the yield of apples. An allowance of 5 percent was made for bent and damaged cans. Cases are determined by the production of cans and the number of cans per case. A 5 percent allowance was made for damaged cases.

The requirement for labels is the same as the requirement for cans except that the labeling machine has a higher loss rate. It was estimated that 15 percent of the labels are damaged in that operation.

Other Miscellaneous Costs

It was estimated that 100 pounds of salt per day of operation for the small slice plant were necessary. Medium and large plants used 200 and 300 pounds per day of operation, respectively.

Fuel oil is required for boilers generating steam. The requirements were estimated as 100 gallons per hour of operation for each boiler in the plant.

Apple processing plant operators estimate that 100 kilowatts of electrical power is needed for each 100 gallons of fuel. This rate was used for all plants.

Requirements of water for washing, peeling and steam generation were estimated to be 100 gallons for each case of slices (6/10's).

Gasoline required for fork-lift trucks handling and storing the finished product was estimated at 2 gallons per hour for each fork-lift truck. The variable repairs and maintenance costs were estimated at 6.5 percent of the total equipment and truck costs.

The cost of treating waste and its disposal depends upon the quantity of biochemical oxygen demand (BOD) in the water and the quantity of water used. It was estimated that 1,680 pounds BOD in a million pounds of water result from the processing of apples. The cost of waste disposal for each plant was estimated at a cost of $80 per thousand BOD.

Waste material costs depend upon the quantity of pomace to be taken to a sanitary land fill, the length of the trip from the plant to the sanitary land fill and the unloading fee at the sanitary land fill. It was estimated that 17.3 pounds of pomace for each cwt. of cull apples and 5.9 pounds of pomace from the peels and cores of each cwt. of apples used in the main operation would have to be trucked to the land fill. A 10-mile round trip to a sanitary land fill for each load and a 15-cent per mile operating costs were assumed. A 25-cent per load charge was allowed as the fee for unloading the waste at a sanitary land fill. No truck operation costs were estimated for the small plants on the assumption that no costs would be incurred in disposing of waste materials.

Fire insurance cost was estimated to be 1.5 percent of the initial cost of all equipment, buildings, pallet boxes, pallets, and value of average inventory.

Since sales were assumed to be spread out during the year, it is necessary to use short-term credit for operating capital not only for the period of time that the processing plants operate but for the whole year. Therefore, interest on short-term credit was estimated according to the average value of inventory. A 10 percent interest rate was assumed to be the cost of operating capital.

Office expenditures such as telephone, office supplies, and licenses were estimated to be 2 percent of the total sales. Sales expenditures were considered to be 6 percent of total sales.

Overhead Costs for Group III Plants

Buildings, Equipment and Pallets

A summary of building, equipment and pallets is presented in Table 7. These costs apply to all three lengths of season. A certain output schedule for each product was selected. The slice-vinegar plant (J) was designed to produce slices during the first 900 hours of operation and vinegar for 1,350 hours. The sauce-juice plant (K) produced sauce and cider for 1,350 hours. The slice-sauce-juice plant (L) produced sauce for the first 900 hours of operation (0-900), slices for the next 450 hours (901-1,350), and juice for 1,350 hours. The sauce-

Table 7. Summary of overhead costs for Group III plants by product[a]

Plant	Item[b]			
	Building	Equipment	Pallets and pallet boxes	Total
			(1,000 dollars)	
Group III				
Slices-vinegar (J)	1,280	910	240	2,430
Sauce-juice (K)	1,273	531	440	2,244
Slices-sauce-juice (L)	1,839	705	440	2,984
Sauce-juice-vinegar (M)	1,631	739	457	2,827
Slices-sauce-juice-concentrate-essence-vinegar (N)	1,850	1,134	465	3,449

[a]Source: Gutierrez-Villarreal (4, Tables 31-36 and 38).

[b]Investment costs apply for 450-, 900-, and 1,350-hour seasons.

juice-vinegar plant (M) was designed to produce slices, juice and vinegar for 1,350 hours. The slice-sauce-juice-concentrate-essence-vinegar plant (N) produced sauce and slices as did plant (L) and juice concentrate and essence, and vinegar for a period of 450 hours each.

Other Overhead Costs

Property taxes, insurance, interest, and office and sales expenditures were considered on the same basis as they were considered for the Group I and Group II plants. Each of the Group III plants also included a 10-ton truck with a value of $10,000.

Cost of the permanent labor force was estimated at 100,210 dollars per year per plant except for plant n. This plant required two additional secretaries to handle the large business volume which increased the cost by 10,560 dollars per year.

Operating Costs for Group III Plants

A summary of operating costs by length of season for Group III plants is presented in Table 8. These costs include direct labor, raw product, and other operating costs. It should be noted that these plants were designed to operate under very selective conditions. For example, the hourly costs of operating the slice-sauce-juice-concentrate-essence and vinegar plant are greater for a 450-hour season than 900- and 1,350-hour seasons because of product scheduling rather than for economies of size.

Total Costs

Annual total costs for all plants were estimated for a period of 10 years. The cost stream included the investment cost for building, equipment, complementary equipment, pallet boxes, pallets and truck. Overhead costs are incurred before the first year of the plant's operation. Additional overhead costs were incurred at the end of the fifth year to replace pallet boxes, pallets and truck. Other costs computed on an annual basis were variable costs, permanent labor, property taxes, insurance and cost of operating capital. Office and sales expenditures were subtracted from total sales.

Table 8. Summary of variable costs for Group III plants by length of season[a]

Plant[b]	Length of season		
	450 hours	900 hours	1,350 hours
	(dollars per hour)[c]		
Group III			
Slices-vinegar (J)	82.05	1727.00	809.70
Sauce-juice (K)	-----	-------	3044.67
Slices-sauce-juice (L)	665.11	1088.57	1982.11
Sauce-juice-vinegar (M)	------	-------	3127.32
Slices-sauce-juice-concentrate-essence-vinegar (N)	1939.75	1159.37	1301.16

[a]Source: Gutierrez-Villarreal (4, Table 39).

[b]Size of plant varies by product and product line.

[c]Includes direct labor costs.

The present value of the cost stream for each plant was computed by the use of a computer program using the following expression:

$$PV_{TC} = C_{01} + \frac{C_{02}}{(1+i)^3} + \sum_{j=1}^{10} \frac{C_j}{(1+i)^j}$$

where:

PV_{TC} = present value of total cost

C_{01} = B + E + CE + PB + P + T

C_{02} = PB + P + T

i = interest rate

j = year (1, 2....10)

B = initial investment in buildings

E = initial investment in equipment

CE = initial investment in complementary equipment

PB = initial investment in pallet boxes

P = initial investment in pallets

T = new truck cost

$$C_j = V + L + T_x + I \pm P_2A$$

V = annual variable cost

L = annual cost of permanent labor

T_x = annual property taxes

I = annual cost of insurance

P_2 = interest rate charged on operational capital

A = annual average value for finished product inventories (P_1D)

P_1 = finished product price

D = annual average inventories of finished product

Processing Plant Revenues

Total revenue for each plant was calculated using total production and the assumed prices for each product. Table 9 shows the base prices used for each of the apple products studied. This table also shows the prices for a + percent change in the base price for the finished products. The net price in Table 9 shows the gross price minus office and sales expenditures estimated as 8 percent of the gross price.

Table 9. Finished product prices for selected apple products used in estimating rates of return[a]

Product	Unit	Price per unit					
		Gross price			Net price[b]		
		Base	+10%	-10%	Base	+10%	-10%
		(dollars per unit)					
Slices	6#10	5.75	6.325	5.175	5.290	5.819	4.761
Sauce	6#10	4.75	5.225	4.275	4.370	4.807	3.933
Sauce	24#303	3.35	3.685	3.015	3.082	3.390	2.774
Juice	12#3	3.55	3.905	3.195	3.266	3.593	2.939
Juice	12 qt.	2.80	3.080	2.520	2.576	2.834	2.318
Butter	12 qt.	3.78	4.158	3.402	3.478	3.825	3.130
Vinegar	gal.	0.74	0.814	0.666	0.681	0.749	0.613
Concentrate	gal.	2.00	2.20	1.80	1.840	2.024	1.656
Essence	gal.	7.00	7.770	6.30	6.440	7.084	5.796
Juice (bulk)[c]	gal.	0.20	-	-	0.184	-	-

[a]Sources: Almanac of the Canning, Freezing, Preserving Industries (1) and selected processors and food brokers.

[b]Gross price minus office and sales expenditures assumed to be 8 percent of gross price.

[c]No change in price was considered for bulk juice.

The total revenue streams included the salvage value of trucks, buildings and equipment. The present value of the total revenue stream was derived by a computer program using the following expression:

$$PV_{TR} = \sum_{j=1}^{10} \frac{(P_1 - 0.08P_1)Q_j}{(1+i)^j} + \sum_{j=1}^{10} \frac{(P_3 - 0.08P_3)C_i}{(1+i)^j}$$

$$+ \sum_{j=1}^{10} \frac{(P_4 - 0.08P_4)B_j}{(1+i)^j} + \frac{K}{(1+i)^5} + \frac{K+S}{(1+i)^{10}}$$

where:

PV_{TR} = present value of total revenue

i = interest rate

j = year (1, 2, ... 10)

$(P_1-.08P_1)$ = price of the finished product less office and sales expenses

Q_j = quantity of finished product produced in year j

$(P_3-.08P_3)$ = price of culls less office and sales expenses

C_j = culls sold in year j

$(P_4-.08P_4)$ = price for bulk juice less office and sales expenses

B_j = bulk juice sold in year j

K = salvage value of truck

S = salvage value of building

ECONOMIC ANALYSIS OF MODEL PLANTS

Group I and Group II Plants

The information about the expected cost and revenue streams for each of the investment alternatives was estimated as discussed in the last section. The internal rates of return were estimated by equalizing the present value of the revenue stream (1) to the present value of the cost stream (2) for each investment alternative and solving for "1." This was done by using a high-speed computer program. These internal rates of return are presented separately for each type of product. It was assumed that no plant would be constructed unless the internal rate of return exceeded 6 percent. In many situations, a substantially higher rate of return would be necessary to attract investors.

Slice Plant

Most of the investment alternatives for the slice plant showed positive internal rates of return except for the small plant operating at 450 and 900 hours per season as shown in Table 10. Five of the nine investment alternatives for the slice plant showed rates of return greater than 6 percent. However some of these alternatives which showed exceedingly high rates of return would be ruled out because they exceeded the bounds of the production constraint established in this study.

Table 10 also shows how sensitive rates of return for the slice plant are to changes in prices. When the price for the finished product was decreased by 10 percent, only three investment alternatives showed rates of return greater than 6 percent. None of the alternatives showed rates of return greater than 6 percent when this decrease in the price for finished products was combined with an increase in the price for raw apples by 10 percent, as shown in Table 10. However, when the price for the finished product is increased by 10 percent, all the alternatives except the small plant operating for 450 hours showed rates

Table 10. Slice plant: Internal rates of return and their sensitivity to changes in finished product and raw apple prices*

Plant size	Raw apple price	Length of season: 450 hours, Product price: Base	450 hours, Product price: +10%	450 hours, Product price: -10%	900 hours, Product price: Base	900 hours, Product price: +10%	900 hours, Product price: -10%	1,350 hours, Product price: Base	1,350 hours, Product price: +10%	1,350 hours, Product price: -10%
		(internal rate of return in percent)								
Small	Base	a	a	a	a	7.99	a	0.51	15.55	a
	+10%	a	a	a	a	2.10	a	a	9.55	a
	-10%	a	a	a	a	13.55	a	7.02	21.31	a
Medium	Base	5.25	18.42	a	19.29	34.15	2.83	26.26[b]	42.29[b]	8.96[b]
	+10%	a	12.94	a	12.54	27.92	a	19.17[b]	35.61[b]	0.86[b]
	-10%	11.16	23.68	a	25.76	40.26	10.16	33.14[b]	48.87[b]	16.51[b]
Large	Base	9.81	23.46	a	23.19[b]	38.19[b]	6.08[b]	30.52[c]	47.39[c]	12.47[c]
	+10%	3.27	17.75	a	16.15[b]	32.24[b]	a[b]	23.10[c]	40.34[c]	4.12[c]
	-10%	15.90	28.98	1.09	29.97[b]	45.24[b]	13.68[b]	37.74[c]	54.36[c]	20.32[c]

*The underlined entries identify the base price situations.

[a]Negative internal rate of return.

[b]Output is greater than 10 percent of U. S. production of canned slices.

[c]Output is greater than 10 percent of U. S. production and raw product requirement of processing apples is greater than 18 percent of North Carolina production.

of return greater than 6 percent. The small slice plant showed negative rates of return at all price levels.

Sauce Plant

The internal rates of return for the sauce plants were very similar to the rates shown by the slice plant as shown in Table 11. It can also be noted that the rates of return for the small sauce plant were very low. Two of these rates were negative. However, this plant showed higher rates of return as the plant size was increased. Five of the nine investment alternatives for the sauce plant showed rates of return greater than 6 percent, ranging from 9.40 to 30.15 percent. The most favorable rate of return was produced by the large plant operating for 1,350 hours. However, this alternative was ruled out because it required more than the assumed supply of raw apples.

A decrease in the price for the finished product by 10 percent affected the internal rates of return so adversely that only 2 of the investment alternatives for this plant showed rates of return greater than 6 percent (Table 11). When this change in price was combined with a 10 percent increase in the price for raw apples, none of the investment alternatives showed a positive rate of return. On the other hand, when the price for the finished product was increased by 10 percent, all the alternatives showed rates of return greater than 6 percent, except the small plant operating 450 hours.

Frozen Slice Plant

The frozen slice plant showed negative rates of return for all the designed plant sizes and average prices as shown in Table 12. When the price for the finished product was increased by 10 percent, only the large plant operating at 1,350 hours showed a positive internal rate of return. When an increase in product price was combined with a decrease in the raw apple price, 4 alternatives showed positive internal rates of return but only one was greater than 6 percent.

Juice Plant, Base Situation

All the investment alternatives for the juice plant showed very high internal rates of return at base prices except for the small plant

Table 11. Sauce plant: Internal rates of return and their sensitivity to changes in finished product and raw apple prices*

Plant size	Raw apple price	Length of season: 450 hours, Product price: Base	450 hours, Product price: +10%	450 hours, Product price: -10%	900 hours, Product price: Base	900 hours, Product price: +10%	900 hours, Product price: -10%	1,350 hours, Product price: Base	1,350 hours, Product price: +10%	1,350 hours, Product price: -10%
		(internal rate of return in percent)								
Small	Base	a	a	a	a	11.87	a	2.73	19.85	a
	+10%	a	a	a	a	6.31	a	a	14.24	a
	-10%	a	0.40	a	1.07	17.18	a	8.86	25.29	a
Medium	Base	5.68	21.20	a	19.57	37.12	a	26.91	45.94	6.10
	+10%	a	15.92	a	12.99	31.09	a	19.97	39.43	a
	-10%	11.46	26.31	a	25.90	43.06	7.17	33.66	52.38	13.68
Large	Base	9.40	25.67	a	22.64	41.23	1.82	30.15[b]	50.23[b]	8.35[b]
	+10%	2.94	20.11	a	15.70	34.83	a	22.86[b]	43.35[b]	a[b]
	-10%	15.43	31.07	a	29.33	47.55	9.58	37.25[b]	57.05[b]	16.27[b]

*The underlined entries identify the base price situations.

[a]Negative rate of return.

[b]Output is greater than 10 percent of U. S. production and raw product requirement of processing apples is greater than 18 percent of North Carolina production.

Table 12. Frozen slice plant: Internal rates of return and their sensitivity to changes in finished product and raw apple prices*

Plant size	Raw apple price	Length of season: 450 hours, Product price: Base	450 hours, Product price: +10%	450 hours, Product price: -10%	900 hours, Product price: Base	900 hours, Product price: +10%	900 hours, Product price: -10%	1,350 hours, Product price: Base	1,350 hours, Product price: +10%	1,350 hours, Product price: -10%
		(internal rate of return in percent)								
	Base	a	a	a	a	a	a	a	a	a
Small	+10%	a	a	a	a	a	a	a	a	a
	-10%	a	a	a	a	a	a	a	a	a
	Base	a	a	a	a	a	a	a	a	a
Medium	+10%	a	a	a	a	a	a	a	a	a
	-10%	a	a	a	a	0.42	a	a	5.71	a
	Base	a	a	a	a	a	a	a	2.81	a
Large	+10%	a	a	a	a	a	a	a	a	a
	-10%	a	a	a	a	3.13	a	a	8.94	a

*The underlined entries identify the base price situations.

[a]Negative rate of return.

operating for 450 hours (Table 13). As was the case for other types of plants, internal rates of return increased as the plant size increased. They ranged from negative returns for the small plant to 89.94 percent for the large plant. The 4 alternatives for the medium and large plants showed rates of return greater than 50 percent. These plants are very large. Three of these plants separately produced between 5 and 10 percent of the total U. S. production of juice. The large plant alternative was ruled out since it was beyond the bounds for the specified raw apples constraint.

When the price for the finished product was decreased by 10 percent, only 3 of the 9 investment alternatives for the juice plant showed rates of return lower than 6 percent. An increase of 10 percent in the price of raw apples combined with this decrease in the price for the finished product affected the rates of return but still only those same 3 alternatives showed rates of return lower than 6 percent. The investment alternative for the small plant showed negative internal rates of return for all price situations.

Juice Plant, Alternative Situations

The juice plant showed very high rates of return and was selected to test the sensitivity of the internal rates of return to changes in several other assumptions.

Buildings were planned for processing apples over a period of 30 years. Since the production period used in this study covers only 10 years, a salvage value equal to two-thirds of the investment value was estimated. However, if these buildings are used for processing apples only for a period of 10 years, their salvage value at the end of this period may be much less.

Rates of return were calculated at a salvage value of 25 percent of the investment value. Plant F_2 in Table 14 shows the rates of return for the juice plant when this lower value was assumed. It can be observed that the rates of return changed very little. It also can be observed that the larger the plant the smaller the change in this rate due to the change in salvage value.

Apple processing plants were assumed to operate at 95 percent of their engineer rated capacity. This implied that the necessary raw

Table 13. Juice plant: Internal rates of return and their sensitivity to changes in finished product and raw apple prices*

Plant size	Raw apple price	Length of season: 450 hours, Product price: Base	450 hours, Product price: +10%	450 hours, Product price: -10%	900 hours, Product price: Base	900 hours, Product price: +10%	900 hours, Product price: -10%	1,350 hours, Product price: Base	1,350 hours, Product price: +10%	1,350 hours, Product price: -10%
		(internal rate of return in percent)								
Small	Base	a	a	a	14.86	30.80	a	33.84	52.62	13.68
	+10%	a	a	a	12.25	28.46	a	30.92	49.83	10.38
	-10%	a	a	a	17.41	33.12	a	36.73	55.41	16.89
Medium	Base	23.55	40.75	4.01	55.28	76.63	33.33	76.15	101.28	50.72
	+10%	20.76	38.17	0.51	51.98	73.39	29.87	72.33	97.50	46.82
	-10%	26.30	43.32	7.32	58.57	79.87	36.76	79.96	105.07	54.59
Large	Base	33.40	52.01	13.10	64.79	88.03	41.12	84.94[b]	111.87[b]	57.80[b]
	+10%	30.43	49.19	9.62	61.22	84.49	37.41	80.86[b]	107.80[b]	53.65[b]
	-10%	36.34	54.82	16.45	68.36	91.56	44.79	89.02[b]	115.93[b]	61.93[b]

*The underlined entries identify the base price situations.

[a]Negative rate of return.

[b]Raw product requirement of cull apples is greater than 12 percent of total North Carolina production.

materials are available as required for these plants. However, it may happen that raw products or other inputs are not available as required. If this is the case, the plants will have to operate at a lower capacity which affects the rate of return. In order to measure the effects of reduced input supplies, it was assumed that each juice plant would operate only for 80 percent of the designed lengths of the operating season. Under this assumption, the rates of return decreased as shown by plant F_3 in Table 14. The effects can be identified by comparing situations F_1 and F_3. Rates of return decreased considerably due to the change in level of operation.

A rate of conversion of raw apples into juice was assumed to be 9 gallons per cwt. of apples. However, according to Tressler and Joslyn (9) the rate of conversion of raw apples into juice may vary from 7.5 to 9 gallons of juice per hundredweight of apples. If a conversion rate of 7.5 gallons of juice per hundredweight of apples is assumed, the rates of return for the juice plant may decrease as shown by plant F_4 in Table 14. The small juice plant operating for 900 hours originally showed a rate of return of 14.86 percent. However, with the change in the yield conversion rate, the rate of return became negative.

The rates of return for plant F_5 in Table 14 show what happens if all these conditions occur simultaneously. The conditions are (1) salvage value of buildings is equal to 25 percent of the investment value, (2) plants operate at only 80 percent capacity, and (3) the rate of conversion is only 7.5 gallons per hundredweight of apples. Only four investment alternatives for plant F_5 showed rates of return greater than 6 percent. The large plant operating for 1,350 hours exceeds the assumed raw product restraint.

Concentrate and Essence Plant

Most of the investment alternatives for the concentrate and essence plant showed negative rates of return (Table 15). Only the two alternatives corresponding to the medium and large plants showed rates of return greater than 6 percent. However, only one of these alternatives was considered feasible. The large plant was ruled out because its production was greater than the raw apples constraint specified in this study.

Table 14. Internal rates of return for juice plants with different salvage values of buildings, raw product availability and rates of conversion

Plant size	Length of season	Plant situation[a]				
		F_1	F_2	F_3	F_4	F_5
	(hours)	(internal rate of return in percent)				
Small	450	Neg.	Neg.	Neg.	Neg.	Neg.
	900	14.86	13.96	3.99	Neg.	Neg.
	1350	33.84	33.38	21.54	13.28	0.94
Medium	450	23.55	22.98	9.72	3.97	Neg.
	900	55.28	55.12	39.22	33.18	19.81
	1350	76.15	76.08	57.12	50.83	35.64
Large	450	33.40	33.09	18.92	12.72	Neg.
	900	64.79	64.69	47.41	40.98	27.11
	1350[b]	84.94	84.89	69.10	57.47	41.94

[a]The plant situations are defined as follows:

F_1: Original plant with a conversion rate of 9 gallons per hundredweight of apples, apples available as required and salvage value of buildings equal to two-thirds of investment value.

F_2: Same as plant F_1, but assuming a salvage value of buildings equal to 25 percent of investment value.

F_3: Same as plant F_1, but assuming that apples available are 80 percent of the apples required. Operates 80 percent of the time indicated in length of season.

F_4: Same as plant F_1, but assuming that the conversion rate is 7.5 gallons of juice per hundredweight of apples.

F_5: Combines the effects of F_2, F_3 and F_4.

[b]Raw product requirement of cull apples is greater than 12 percent of total North Carolina production.

Table 15. Concentrate and essence plant: Internal rates of return and their sensitivity to changes in finished products and raw apple prices*

Plant size	Raw apple price	Length of season: 450 hours, Product price: Base	450 hours, Product price: +10%	450 hours, Product price: -10%	900 hours, Product price: Base	900 hours, Product price: +10%	900 hours, Product price: -10%	1,350 hours, Product price: Base	1,350 hours, Product price: +10%	1,350 hours, Product price: -10%
		(internal rate of return in percent)								
Small	Base	a	a	a	a	a	a	a	a	a
	+10%	a	a	a	a	a	a	a	a	a
	-10%	a	a	a	a	a	a	a	a	a
Medium	Base	a	a	a	a	6.75	a	10.87	22.03	a
	+10%	a	a	a	a	2.63	a	6.23	17.83	a
	-10%	a	a	a	0.18	10.65	a	15.31	26.11	3.37
Large	Base	a	a	a	2.47	13.66	a	16.52[b]	28.12[b]	3.67[b]
	+10%	a	a	a	a	9.48	a	11.76[b]	23.74[b]	a[b]
	-10%	a	a	a	7.04	17.65	a	21.10[b]	32.43[b]	8.85[b]

*The underlined entries identify the base price situations.

[a]Negative internal rate of return.

[b]Raw product requirement of cull apples is greater than 12 percent of total North Carolina production.

None of the alternatives for this plant showed rates of return greater than 6 percent when the prices for the finished products were decreased by 10 percent, as shown in Table 15. On the other hand, when the base price for the finished product was increased by 10 percent, four alternatives for the large plant showed rates of return greater than 6 percent.

Vinegar Plant

Most of the alternatives for the vinegar plant showed positive rates of return (Table 16). Six of these alternatives corresponding to the medium and large plants showed rates of return greater than 6 percent. The rates of return for the large plant ranged from 9.35 for the 450-hour season to 37.21 for the alternative at the 1,350-hour season. This alternative was ruled out since it required more apples than the quantity assumed available. No data were available with respect to the U. S. production of vinegar. For this reason, it was not possible to fix the bounds for the output constraint of this plant.

A decrease of 10 percent in the price for the finished product decreased the rates of return for all the investment alternatives. Only 4 alternatives showed rates of return greater than 6 percent (Table 16). These were the alternatives for the medium and large plants operating for 900 and 1,350 hours per season. When the finished product price decrease was combined with an increase of 10 percent in the price of raw apples, three of these alternatives still showed rates of return greater than 6 percent. However, when the price of the finished product was increased by 10 percent, all the alternatives showed internal rates of return greater than 10 percent except for the small plant.

Butter Plant

Only two of the investment alternatives for the apple butter plant showed positive internal rates of return (Table 17). The levels of output of these alternatives were greater than 10 percent of the total U. S. output of butter except for the small plant operating for 450 hours per season.

The rates of return for the butter plant alternatives were very sensitive to changes in prices. When the price for the finished product

Table 16. Vinegar plant: Internal rates of return and their sensitivity to changes in finished product and raw apple prices*

Plant size	Raw apple price	Length of season: 450 hours, Product price: Base	450 hours: +10%	450 hours: -10%	900 hours: Base	900 hours: +10%	900 hours: -10%	1,350 hours: Base	1,350 hours: +10%	1,350 hours: -10%
		(internal rate of return in percent)								
	Base	a	a	a	a	12.81	a	11.57	24.72	a
Small	+10%	a	a	a	a	10.74	a	9.18	22.60	a
	-10%	a	a	a	2.13	14.84	a	13.89	26.82	a
	Base	2.14	17.00	a	21.94	35.73	6.63	33.18	48.20	17.22
Medium	+10%	a	14.62	a	19.48	33.44	3.74	30.58	45.71	14.35
	-10%	4.92	19.33	a	24.36	38.00	9.42	35.76	50.69	20.02
	Base	9.35	24.05	a	26.90	41.73	10.70	37.21[b]	53.33[b]	20.22[b]
Large	+10%	6.55	21.65	a	24.27	39.26	7.67	34.43[b]	50.64[b]	17.19[b]
	-10%	12.04	26.41	a	29.49	44.19	13.62	39.97[b]	56.00[b]	23.19[b]

*The underlined entries identify the base price situations.

[a]Negative internal rate of return.

[b]Raw product requirement of cull apples is greater than 12 percent of total North Carolina production.

Table 17. Butter plant: Internal rates of return and their sensitivity to changes in finished product and raw apple prices*

Plant size[a]	Raw apple price	Length of season: 450 hours, Product price: Base	450 hours, Product price: +10%	450 hours, Product price: -10%	900 hours, Product price: Base	900 hours, Product price: +10%	900 hours, Product price: -10%	1,350 hours, Product price: Base	1,350 hours, Product price: +10%	1,350 hours, Product price: -10%
		(internal rate of return in percent)								
Small	Base	b	b	b	b	4.86	b	b	25.38	b
	+10%	b	b	b	b	1.43	b	b	21.85	b
	-10%	b	b	b	b	8.17	b	b	28.85	b
Medium	Base	b	b	b	b	34.69	b	9.12	65.67	b
	+10%	b	b	b	b	30.96	b	3.06	60.77	b
	-10%	b	b	b	b	38.39	b	14.86	70.57	b
Large	Base	b	16.83	b	b	45.10	b	13.82	64.59	b
	+10%	b	12.69	b	b	41.07	b	8.64	60.12	b
	-10%	b	20.83	b	2.30	49.11	b	18.81	69.04	b

*The underlined entries identify the base price situations.

[a]The output of apple butter exceeded 10 percent of total U. S. production for plant situations except the small plant operating 450 hours per season. In addition, the large plant operating for 1,350 hours per season exceeds the raw product restraint.

[b]Negative rate of return.

was increased by 10 percent, 6 of the 9 alternatives showed rates of return greater than 6 percent. These were the large plant alternatives. When this change in price was combined with a decrease of 10 percent in the price for raw apples, an additional alternative showed a rate of return greater than 6 percent.

Group III Plants

The internal rates of return for the Group III plants were estimated using the expected cost and revenue streams. The same procedure was followed as in the previous analysis.

The internal rates of return and the initial capital investment for these plants are shown in Table 18. All the Group III alternatives yielded internal rates of return greater than 6 percent. Rates of return ranged from 27 percent for plant N to 64 percent for plant K.

If the entrepreneur's decision is to invest in this type of plant, returns to capital would be maximum if he selected the sauce-juice plant. Although this alternative showed very high returns, the production of sauce and juice in this plant exceeds the maximum quantities established by the raw product and finished product constraints.

A large capital investment is required in a plant producing these product combinations. Plant (N) producing all products required an initial investment of 3.5 million dollars. Although this plant showed a lower rate of return than other Group III plants, it provides greater flexibility in product choice.

The sensitivity of the internal rates of return for Group III plants to a $\pm$ 10 percent change in the level of prices of the finished products and/or the price of raw apples is also shown in Table 18. All plants except Plant N showed rates of return greater than 6 percent when prices for the finished products were decreased by 10 percent and the price of raw apples increased by 10 percent.

Table 18. Sensitivity of internal rates of return to changes in the level of prices of finished products and raw apples for multiple line plants*

Raw apple price	Plant J[a] Product price			Plant K[b] Product price			Plant L[c] Product price			Plant M[d] Product price			Plant N[e] Product price		
	Base	+10%	-10%	Base	+10%	-10%	Base	+10%	-10%	Base	+10%	-10%	Base	+10%	-10%
	(internal rate of return in percent)														
Base	<u>34.48</u>	50.66	17.36	<u>64.50</u>	90.50	37.80	<u>44.33</u>	63.38	24.52	<u>43.05</u>	63.79	21.29	<u>27.02</u>	42.35	10.49
+10%	29.93	46.24	12.34	58.04	84.17	31.02	39.36	58.55	19.20	37.78	58.68	15.53	22.44	38.01	5.29
-10%	38.97	55.00	22.20	70.91	96.84	44.46	49.25	68.20	29.71	48.27	68.88	26.87	31.51	46.64	15.44

*The underlined entries identify the base price situations.

[a]Production of the slices-vinegar plant represents 23.5 percent of all N. C. apples and 10.3 percent of total U. S. output.

[b]Production of the sauce-juice plant represents 29.4 percent of all N. C. apples and 4.4 to 8.6 percent of total U. S. output.

[c]Production of the slices-sauce-juice plant represents 29.4 percent of all N. C. apples and 2.9 to 8.6 percent of total U. S. output.

[d]Production of the sauce-juice-vinegar plant represents 29.4 percent of all N. C. apples and 4.4 to 5.8 percent of total U. S. output.

[e]Production of the slices-sauce-juice-concentrate-essence-vinegar plant represents 29.4 percent of all N. C. apples and 2.9 to 5.2 percent of total U. S. output.

SUMMARY AND CONCLUSIONS

The objective of this study was to analyze the profitability of several alternatives in North Carolina apple processing. The investment alternatives include the production of canned slices, sauce, frozen slices, juice, vinegar, concentrate and essence, and butter. The profitability of processing these products was analyzed for different plant sizes operating for different lengths of season.

Basic plants were designed to operate at three capacities referred to as small, medium, and large. Three lengths of operating season for each plant were considered. These were 450, 900, and 1,350 hours per season. Plants were evaluated under specified restrictions on the amount of capital, raw product available, and output restrictions for each product. Other assumptions were a riskless environment for the operation of the plants, specified prices for raw inputs and finished products, conversion rates of raw apples into finished product and the operation of the plants at 95 percent of their rated capacity. The sensitivity of these assumed conditions was treated for the juice plant by selected alternative levels of prices, capacity rate, and raw product conversion.

Combined product plants were designed on the basis of the results of the basic plant analyses. The levels of internal rates of return for the basic plants were used to select combined product plants. Several alternatives that showed relatively high rates of return were ruled out because of several assumed restrictions specified for the study.

In Table 19, all plants yielding internal rates of return greater than 6 percent were ranked. Thirty plant situations showed internal rates of return greater than 6 percent.

Of the five most profitable plants, four were the medium or large specialized juice plants operating for 900 or 1,350 hours per season. The sauce-juice plant was the fourth most profitable with a rate of return of 64.5 percent. It is interesting to note that four of the five Group III plant alternatives were ranked in the top nine. The capital

Table 19. Basic plants with internal rates of return higher than six percent, arranged in descending order of rate of return, with initial capital investment, raw product required and share of U. S. output

Plant[a]	Capital investment	Internal rate of return	Raw product		Finished product share of U. S. output
			Quantity required	Share of N.C. production	
	(thousand dollars)	(percent)	(thous. cwt.)	(percent)	(percent)
F3c	889	84.94	360	17.6	8.6
F2c	636	76.15	240	11.8	5.8
F3b	685	64.79	240	11.8	5.8
K	2,259	64.50	600	29.4	4.4 to 8.6
F2b	500	55.28	160	7.8	3.8
L	2,999	44.33	600	29.4	2.9 to 8.6
M	2,843	43.05	600	29.4	4.4 to 5.8[c]
H3c	1,382	37.21	360	17.6	b
J	2,430	34.48	480	23.5	10.3[c]
F1c	444	33.84	120	5.9	2.9
F3a	443	33.40	120	5.9	2.9
H2c	1,000	33.18	240	11.8	b
A3c	2,637	30.52	540	26.5	23.3
B3c	2,684	30.15	540	26.5	6.6
N	3,457	27.02	600	29.4	2.9 to 5.2[c]
B2c	1,911	26.91	360	17.6	4.4
H3b	1,025	26.90	240	11.8	b
A2c	1,879	26.26	360	17.6	15.6
F2a	331	23.55	80	3.9	1.9
A3b	1,992	23.19	360	17.6	15.6
B3b	1,953	22.64	360	17.6	4.4
H2b	753	21.94	160	7.8	b
B2b	1,396	19.57	240	11.8	2.9
A2b	1,368	19.29	240	11.8	10.3
F1b	375	14.86	80	3.9	1.9
13c	818	13.92	360	17.6	65.8
H1c	640	11.57	120	5.9	b
A3a	1,182	9.81	180	8.8	7.8
B3a	1,192	9.40	180	8.8	2.2
H3a	579	9.35	120	5.9	b
12c	496	9.12	240	11.8	43.8

[a]The capital letters refer to plant type as defined in the text, numbers refer to plant size (1=small, 2=medium and 3=large) and lower case letters refer to length of season (a=450 hours, 6=900 hours, and c=1,350 hours).

[b]U. S. output was not available.

[c]Does not include vinegar since the U. S. output of vinegar was not available.

required for Group III plants exceeded 2 million dollars in all cases. Many of the basic plants required less than 1 million dollars but ranged as high as 2.7 million dollars.

The fifth column of Table 19 suggests that the raw product requirements are relatively large for many plants. This is particularly true for the Group III plants which require almost 30 percent of total North Carolina apple production. Several basic plants require around 18 percent of the North Carolina crop.

The last column of Table 19 also suggests that some lines would produce a relatively large share of total U. S. production. This would mean that the sales of the finished product could become a critical problem for the firm. The problem is not as critical for the Group III plants as for several of the basic plants.

Some of the assumptions regarding the investment alternatives were changed to test the sensitivity of the rates of return to these changes. Prices for the finished products and the raw apples were allowed to change by $\pm$ 10 percent to take into account part of the risks faced by the entrepreneur. Internal rates of return were found to be very sensitive to these price changes.

The juice plant was selected to test the sensitivity of the internal rates of return to changes in other assumptions. A change in the salvage value of buildings to 25 percent of the original investment value showed little effect in the rates of return. A 20 percent decrease in the availability of apples lowered the rates of return by several percentage points. A decrease in the conversion rate from 9 to 7.5 gallons per hundredweight of cull apples also lowered the rates of return very sharply. When these three changes were assumed to occur simultaneously, only four of nine investment alternatives for the juice plant showed internal rates of return higher than 6 percent.

LIST OF REFERENCES

Almanac of the Canning, Freezing, Preserving Industries. 1971. Edward E. Judge, Publisher, Westminister, Maryland.

Brunk, M. E., B. A. Dominick, D. A. Call and O. D. Forker. 1967. Profile and prospects in apple products, 1967-1975. American Can Company, New York, New York.

Dalrymple, D. G. and B. A. Twigg. 1966. Processing an expanding apple crop. University of Maryland, College Park, Maryland.

Gutierrez-Villarreal, Jorge. 1972. Investment alternatives in the processing of North Carolina apples. Unpublished Ph.D. dissertation, The Graduate School, North Carolina State University, Raleigh, North Carolina.

Lutz, F. and V. Lutz. 1951. The Theory of Investment of the Firm. Princeton University Press, Princeton, New Jersey.

Mathia, Gene A. 1967. Costs of storing North Carolina apples. Economics Information Report No. 5, Department of Economics, North Carolina State University, Raleigh, North Carolina.

Mathia, Gene A. and E. C. Pasour, Jr. 1968. An analysis of apple marketing and storage: North Carolina market area. Economics Research Report No. 6, Department of Economics, North Carolina State University, Raleigh, North Carolina.

Pasour, E. C., Jr. and G. A. Mathia. 1967. Estimates of 1974 apple production in North Carolina -- A comparison of three predictive procedures. Economic Research Report No. 1, Department of Economics, North Carolina State University, Raleigh, North Carolina.

Tressler, D. K. and M. A. Joslyn. 1961. Fruit and Vegetable Juice Processing Technology. The Avi Publishing Company, Inc., Westport, Connecticut.

U. S. Department of Agriculture. 1970. Fruit situation. TFS-152, Economic Research Service, Washington, D. C.

U. S. Department of Agriculture. 1973. Crop production, 1972 annual summary. CRPR 2-1, Crop Reporting Board, Statistical Reporting Service, Washington, D. C.

Agricultural Experiment Station

North Carolina State University
at Raleigh

J. C. Williamson, Jr., Director of Research

Bulletins of this station will be sent free to all citizens who request them.