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Techno-Economic Analysis of E-commerce Business for Tropical Fruit Ice Cream Manufacturing

Nantawut Sriariyawat

Industrial Engineering Department, Faculty of Engineering at Sriracha, Kasetsart University, Sriracha Campus, Chonburi, Thailand

nantawut@eng.src.ku.ac.th

Sirang Klankamsorn*

Industrial Engineering Department, Faculty of Engineering at Sriracha, Kasetsart University, Sriracha Campus, Chonburi, Thailand

sirang@eng.src.ku.ac.th

Abstract

Customer habits nowadays have changed from out-of-home to at-home consumption. Therefore, the frozen food distribution channel requires an E-commerce platform to achieve business success. This research proposes a Techno-Economic Analysis for setting up the tropical fruit ice cream factory with seasonal limitations in quantity and price using the E-commerce business model. The tropical fruits that are popular for making ice cream are durian, pineapple, passion fruit, coconut, mango, lychee, watermelon and santol. A Techno-Economic Analysis consists of 1) a marketing or demand analysis, 2) a technical analysis, and 3) a financial analysis. A marketing analysis uses the 4 Ps method, which considers the product, price, place and promotion. A technical analysis proposes the production processes of tropical fruit ice cream. A financial analysis presents the financial metrics related to production operations. The results show that the net present value is 83,960 $, the internal rate of return is 25%, and the payback period is 3 years and 4 months. It can be concluded that the project is a worthwhile business investment.

Keywords: techno-economic analysis, e-commerce, tropical fruit, ice cream

1 INTRODUCTION

Tropical fruit is a fruit that requires high temperatures throughout the year, such as durian, mango, and pineapple. Subtropical fruit is a fruit that needs cool, dry air to inhibit leaf growth and stimulate flowering, but it also needs warm and humid air, for example, lychees and grapes. These fruits are delicious and have various benefits for the body. During the harvest season, the amount of fruit is sufficient to supply domestic and export markets. So food processing is required as soon as possible to prevent the fruit from rotting. The government and private sectors promote fruit-flavoured ice cream as processed products that can generate income for the community. This tropical fruit is then made into ice cream ingredients for sale in restaurants, department stores and online.

E-commerce is a growing force in the modern economy. Retail e-commerce is increasingly diversifying the sale of ice cream and frozen desserts. The interesting topic is how to set up an ice cream manufacturing factory for an e-commerce business. An important characteristic of the business is the ability to manage production volumes based on seasonal changes in fruit prices and the use of natural ingredients for the ice cream. Research related to the use of natural ingredients and fruits for ice cream production was found in [1]. The paper showed that recent years have seen rapid growth in the consumption of the better-for-you" (BFY) category of ice cream and frozen desserts. The manufacturer should produce naturally sweetened or minimal sweeteners of ice cream.

Meanwhile, [2] suggested that a stronger driver of ice cream preference among consumers is the flavour variety, which is more important than portion size. In [3], a new family of ice cream formulations is recommended using aromatic fats or di□erent watery parts (fruit juices, broths, mushroom water, etc.) instead of a dairy mix. The growth of the plant-based protein ice cream market was proposed in [4], in which gluten- and lactose-free, plant-based yogurt-like yogurt is the main ingredient of the ice cream. The addition of raisin and grape molasses in the ice cream led to synergistic effects in terms of chocolate flavour and creaminess-related sense stimuli [5]. However, the original flavour of ice cream uses dairy and cheese ingredients [6]. The eco-consumers tend to select healthy food products with plant-based ingredients that have less environmental impact [7]. In addition, the perception of health and nutritional enrichment of ice cream can be used as an effective marketing strategy [8].

The Techno-Economic Analysis is a kind of project feasibility study for any manufacturing business. The purpose of the method is to assess the economic performance of industrial processes, products, and services. The Techno-Economic Analysis relates to the marketing analysis, technical requirements, economic feasibility, environment assessment, organization structure, research development, quantifying uncertainty and risk, etc. Research involving the financial analysis of ice cream manufacturing was found in [9-12]. Most papers proposed the investment costs, operating costs, administrative costs and revenue to determine the net present value, internal rate of return, profitability index, payback period, etc. The selling price, raw material cost and energy cost have an impact on the ice cream business.

The objective of this research is to apply the Techno-Economic Analysis to set up the tropical fruit ice cream factory. The study consists of 1) a marketing or demand analysis, 2) a technical analysis, and 3) a financial analysis. The business aims to produce tropical fruit-flavoured ice cream by selling the product through the e-commerce system. The investment decisions will consider the worthiness of the investment using the financial metrics, which are the net present value, the internal rate of return and the payback period.

2 RELATED THEORIES OF ECONOMIC ANALYSIS

The following financial metrics [13, 14] are involved in the Techno-Economic Analysis to make decisions for the investment.

2.1 Net present value

In project management and investment planning, the net present value or NPV is used to analyze the profitability of a projected investment. The NPV aims to determine the current value of a future stream of payments or expected financial gains of a project that will outweigh the present-day investment. The NPV is the difference between the present value of cash inflows and cash outflows. If the project is worthwhile, the NPV is positive, and the rate of return will be above the discount rate, which equals the minimum acceptable rate of return. Equation (1) shows the NPV formula.

$$NPV = -C_0 + \sum_{t=1}^{T} \frac{NCF_t}{(1+i)^t} \quad (1)$$

Whereas,

T = number of periods, when $t = 1,...,T$

i = discount rate or internal rate of return

C_0 = initial investment

NCF_t = net cash flow at t = cash inflow at t - cash outflow at t

2.2 Internal rate of return

The internal rate of return (IRR) is a financial metric used to estimate the investment return or profitability of the projects over time. The IRR is a discount rate that makes the NPV equal to zero or a project's returns equal to its initial investment. It can also be considered a break-even point where the total cash inflows completely meet the total cash outflow. If the IRR is greater than or equal to the minimum required rate of return, the decision-making of project investment can be accepted. The formula used to determine the IRR is shown in equation (2).

$$NPV = 0 = -C_0 + \sum_{t=1}^{T} \frac{NCF_t}{(1+i)^t} \quad (2)$$

2.3 Payback period

The payback period is the expected period or number of years in which the cumulative cash inflow equals the cash outflow in the form of an annuity. The payback period is the time to reach a breakeven

point or to recover the initial investment, for which a shorter payback period is required. In case the cash flow of all years is equal, the formula of the payback period is shown in equation (3).

$$PP = \frac{C_0}{ACF_t} \quad (3)$$

PP = payback period
C_0 = initial investment
ACF_t = annual cash flow at t

The time unit of the payback period is expressed in years and fractions of years.

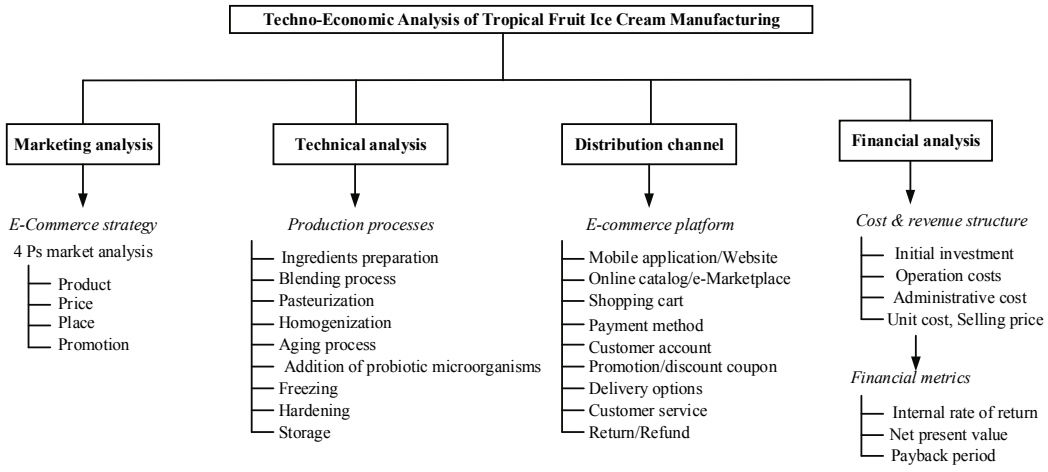
3 RESEARCH METHODOLOGY

The methodologies of this research are proposed as follows:

3.1 The problem statement

The important research question is how an ice cream business made from tropical fruit can be successful in terms of marketing, production, and distribution through the E-commerce system, with results measured in the form of a financial index. This research then proposed the Techno-Economic Analysis of the tropical fruit ice cream business, in which the components of the research are depicted in Figure 1.

Picture 1: Components of Techno-Economic Analysis of the Tropical Fruit Ice Cream Manufacturing



3.2 E-Commerce marketing analysis

E-commerce of the ice cream business is a B2C (Business to Consumer), which means doing business directly between entrepreneurs and consumers. Ice cream business through E-commerce is to sell goods and services through electronic media, a computer network system or the internet. The advantage is that there is a low cost of sales because there is no need to have a shop, hire a salesperson and pay the rental fee for the shop. Customers can order products 24 hours a day. The transportation is via temperature-

controlled refrigerated vehicles. The 4 Ps market analysis, which is composed of product, price, place and promotion, is integrated into the study.

3.3 Technical analysis

The technical analysis steps are shown below.

3.3.1 Calculating ice cream ingredients

The tropical fruit flavours of ice cream in this research are durian, pineapple, passion fruit, coconut, mango, lychee, watermelon and santol. An example of the calculation of the weight of ice cream contents (for 20 kilograms of ice cream) of the case study is shown as follows.

Milkfat (12.5%)	= 0.125 * 20	= 2.5	kilograms
Milk solids-not-fat (12%)	= 0.12 * 20	= 2.4	kilograms
Sugar (14.5%)	= 0.145 * 20	= 2.9	kilograms
Emulsifier (0.35%)	= 0.0035 * 20	= 0.07	kilograms
Stabilizer (0.45%)	= 0.0045 * 20	= 0.09	kilograms

The fat content comes from melted butter, which is 85% of fat. Thus,

Melted butter	= 2.5 / 0.85	= 2.94	kilograms

The milk solids-not-fat is derived from skim milk powder for 96%. Thus,

Skim milk powder	= 2.4 / 0.96	= 2.50	kilograms

The remaining weight = 20 – 2.94 – 2.50 – 2.9 – 0.07 – 0.09 = 11.50 kilograms. This amount is composed of 65% of water and 35% of fruit pulp.

Water	= 0.65 * 11.50	= 7.47	kilograms
Fruit pulp	= 0.35 * 11.50	= 4.02	kilograms

3.3.2 Preparing ice cream ingredients

Preparation of ingredients begins with heating liquid ingredients such as milk, cream and syrup to a temperature of approximately 50-55 degrees Celsius. Then, the dry ingredients, for example, milk solids-not-fat and stabilizer, are added to the mixture.

3.3.3 Blending process

The blending process uses the blender machine to mix all ingredients with shear force. So the solids are being dispersed in the liquid mixture.

3.3.3Pasteurization

In general, the pasteurization of ice cream ingredients uses the method of high temperature-short time or HTST, where the temperature is approximately 80-85 degrees Celsius for at least 25-30 seconds. The purpose is to destroy disease-causing microorganisms in the ingredients. The ice cream pasteurization temperature affects the flavour and texture of ice cream by causing the ingredients, such as sugar and stabilizers, to dissolve easily. Then, the quick cooling process is performed at temperatures below 5 °C.

3.3.4 Homogenization

Homogenization is a process that causes the fat to break down and become smaller, approximately 1-2 microns. The fat will be dispersed in the ice cream texture. The results are to decrease the amount of constant substance and to prevent the separation of the ice cream layer.

3.3.5Aging process

The temperature of the aging process is set at 4 °C for 24 hours. The fat in the mixture is then melted to be a solid state, and the occurrence of the absorption of protein and emulsifier. So, the viscosity of the ice cream mixture is increased and the ice cream texture is softer and creamier.

3.3.6 Addition of probiotic microorganisms

The culture media, which is an artificially prepared nutrient for the growth of microorganisms, is used to produce the probiotic through the incubation process at the right temperature and time; the maximum amount of probiotics will be obtained. The probiotic is then centrifuged at 4 °C and the probiotic cells are washed with peptone solution before adding to the ice cream.

3.3.7 Freezing

The ice cream maker uses the impeller to make the air infiltration into the ice cream texture. So, the volume of ice cream is increased to be the soft-serve ice cream.

3.3.8 Hardening

Hardening should be operated quickly to prevent large ice crystals resulting a smoother ice cream. The temperature of hardening process should be lower than 18 °C (approximately -25 to -30 °C). In this hardening process, the ice cream's water content is increased, causing the concentration of the water solution to be increased.

3.3.9 Storage

Ice cream is stored in temperature-controlled refrigerators, waiting to be sold within 1-2 weeks or immediately sold to customers.

3.4 Distribution channel

Firstly, the initial investment is considered in setting up the factory. The main cost components of initial investment are the construction and installation costs for machines and equipment. Then, the operation costs are proposed along with the proportion of sub-costs in percentage terms. The operation costs are occurred during the project life, which is assumed to be 10 years. Examples of operation costs are raw material costs, transportation costs and factory rental costs. The administrative cost that is necessary to support the business including the manager, salesperson, etc.

3.5 Financial analysis

Firstly, the initial investment is considered in setting up the factory. The main cost components of initial investment are the construction and installation costs for machines and equipment. Then, the operation

costs are proposed along with the proportion of sub-costs in percentage terms. The operation costs are occurred during the project life, which is assumed to be 10 years. Examples of operation costs are raw material costs, transportation costs and factory rental costs. The administrative cost that is necessary to support the business including the manager, salesperson, etc.

The financial plan assumptions for projections and strategy of ice cream manufacturing in this research are shown in Table 1. The financial index for making investment decisions includes the net present value, internal rate of return and payback period.

Table 1: Financial assumptions for tropical fruit ice cream manufacturing

Lists	Details
Project life	10 years
Corporate income tax rate	20 % on net profit
Sources of project financing	The proportion of the project owner is 30 % Loan from financial institutions is 70 %
Interest rates for long-term business loan	MRR+5% or equal to 11.5 % per year

4 EXPERIMENTS AND RESULTS

This section presents the experiments and related results.

4.1.1 Resulting of 4 Ps marketing analysis

The business model for setting up a tropical fruit ice cream factory uses an E-commerce system to reduce the rental cost of a retail store. Deciding between renting and buying land for the construction of the ice cream shop isn't always worthwhile for a new business. The reason is the increase in investment expenses, for example, higher rental costs in the department store or higher land prices in the city area. Therefore, an E-commerce business is an effective strategy to sell products to general customers or restaurants that order large quantities of ice cream. The production volume of ice cream products from tropical fruits depends on the season. Prices of raw materials vary according to the quantity and quality available in the market and the farmers' cultivation areas. In e-commerce, customers can pre-order ice cream to allow manufacturers to efficiently prepare seasonal fruits. The results of the 4 Ps marketing analysis for tropical fruit ice cream manufacturing are shown in Table 2.

Table 2: Resulting of 4 Ps marketing analysis for tropical fruit ice cream manufacturing

4 Ps	Marketing strategies
Product	safe for health, no potentially toxic element contamination, various tropical fruit flavours, eco-friendly products, biodegradable products
Price	suitable price promotion policy, cost-based pricing strategies, bulk pricing
Place	marketing distribution channels, for example, the official website, Facebook, online marketplaces, social media
Promotion	festival discounts, coupons & promo codes

4.1.2 The initial investment for tropical fruit ice cream manufacturing

The initial investment is the amount of money required to start the tropical fruit ice cream business in the planning stages. The important initial costs comprise the construction of the factory building, temperature-controlled cold storage rooms, and the installation costs for machinery and equipment and machines used to produce the ice cream. The initial investment for tropical fruit ice cream manufacturing is shown in Table 3.

Table 3: Initial investment for tropical fruit ice cream manufacturing

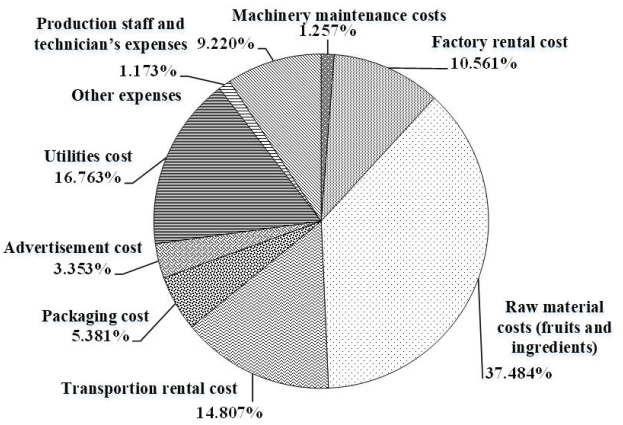
Lists	Quantity	Unit cost ($)	Total cost ($)
Factory construction cost		24,657.53	24,657.53
Construction cost of temperature-controlled cold storage rooms		10,410.96	10,410.96
Installation costs for machinery and equipment related to the factory, such as electrical wires, water pipes, compressed air pipes, vacuum pipes, air pumps, etc.		27,397.26	27,397.26
Mixer machine	1 unit	726.03	726.03
Blending machine	2 units	4,109.59	8,219.18
Storage machine	2 units	8,219.18	16,438.36
Homogenizer	1 unit	873.97	873.97
Pasteurization machine	1 unit	1,287.67	1,287.67
Freezer	3 units	482.19	1,446.57
Marketing and public relations expenses		1,369.86	1,369.86
Fees for setting up a factory		301.37	301.37
Net working capital		13,698.63	13,698.63
		Total initial investment	**106,827.39**

4.1.3 The operation costs for tropical fruit ice cream manufacturing

Table 4. shows the operation costs for tropical fruit ice cream manufacturing. The highest operation cost is the raw material costs, which are mostly the fruits and ingredients. Generally, the fluctuation of fresh fruit prices is subject to seasonal patterns. The second highest operation cost is the utilities expense, which is the cost incurred by using electricity and water for production processes. The third highest operation cost is the transportation cost, which is the temperature-controlled vehicles. The other

main operation costs are the factory rental cost and production staff and technician's expenses. The E-commerce expenses are paid with a small amount of money in the ice cream business. As shown in Figure 1, the E-commerce expenses is the development cost of mobile application or website for selling the ice cream.

Table 4: Operation costs for tropical fruit ice cream manufacturing

Lists	Total cost ($/Year)	
Machinery maintenance costs	2,465.75 (1.257%)	
Factory rental cost	20,712.33 (10.561%)	
Raw material costs (fruits and ingredients)	73,514.38 (37.484%)	
Transportation cost	29,040.71 (14.807%)	
Packaging cost	10,553.42 (5.381%)	
Advertisement cost	6,575.34 (3.353%)	
Utility expenses	32,876.71 (16.763%)	
E-commerce expenses	2,301.37 (1.173%)	
Production staff and technician's expenses	18,082.19 (9.220%)	
Total operation costs	**196,122.20 (100%)**	

4.1.4 The administrative costs for tropical fruit ice cream manufacturing

The expenses for managing the ice cream business include the general manager, accountants, customer service staff, salesperson, administrative staff and sales and marketing expenses. For sales and marketing expenses for E-commerce, there are 2 components of expenses in this research, which are 1) the 32% of E-commerce commission and 2) the 7% of value added tax. The E-commerce commission is the payment to the online platform's service fees. Whereas the value-added tax is the payment to the government sector, which is the Revenue Department. Table 5 shows the administrative costs for tropical fruit ice cream manufacturing.

Table 5: Administrative costs for tropical fruit ice cream manufacturing

Lists	Quantity	Cost/month ($)	Annual cost ($)
General manager	1 person	821.91 ($/person/month)	9,862.92
Accountants	1 person	493.15 ($/person/month)	5,917.81
Customer service staff	1 person	602.72 ($/person/month)	9,205.48
Salesperson	2 persons	602.72 ($/person/month)	9,205.48
Administrative staff	1 person	602.72 ($/person/month)	4,273.97
Sales and marketing expenses (E-commerce commission + Value added tax)		3,287.67 ($/month)	3,287.67
		Total administrative costs	**34,849.32**

4.1.5The unit cost and selling price for tropical fruit ice cream manufacturing

The calculation of the production cost uses the principles of cost accounting by considering raw material costs, labour costs, and manufacturing overhead costs. The cost of raw materials, which are fruits, varies according to the harvest season. Then, the cost per unit is calculated by dividing the total cost by the production quantity. The selling price is determined by cost plus the profit percentage desired by the business. In determining the product price, the business must consider such factors as profit from sales, acceptance by buyers, comparison with competitors' prices, etc.

Table 6: Unit cost and selling price for tropical fruit ice cream manufacturing

Fruits / Harvest season		Selling price ($/unit)	Unit cost ($/unit)	Production quantity (unit/year)	Revenue ($/year)
Durian (April-September)		0.93	0.85	40,350	37,525.50
Pineapple (All year round)		0.93	0.85	20,175	18,762.75
Passion Fruit (October-January)		0.93	0.85	20,175	18,762.75
Coconut (All year round)		0.93	0.85	60,525	56,288.25
Mango (All year round)		0.93	0.85	40,350	37,525.50
Lychee (May-June)		0.93	0.85	40,350	37,525.50
Watermelon (All year round)		0.93	0.85	40,350	37,525.50
Santol (January-February)		0.93	0.85	20,175	18,762.75
			Total	**282,450**	**262,678.50**

The entrepreneur which is the case study company in this research sets the selling price at approximately 10 percent of the production cost. The production quantity of each fruit ice cream flavour depends on market analysis and customers' advance online orders. Table 6. shows the selling price, unit cost, production quantity and annual revenue of each fruit ice cream flavour. Coconut ice cream is the most popular and best-selling. The next best-selling are durian, mango, lychee and watermelon ice cream.

4.1.6 The financial results for tropical fruit ice cream manufacturing

The basis and steps of Techno-Economic analysis for tropical fruit ice cream production are as follows:

Determine the production capacity and cost of each type of tropical fruit that is available in the harvest season.

Calculate the initial investment including the tangible fixed asset (factory building, machines, equipment, etc.,), pre-operating expenses and net working capital.

Calculate the annual operation costs as shown in Table 4.

Calculate the administrative costs as shown in Table 5.

Calculate the total cost and unit cost. The selling price is then set approximately 10% higher than the unit cost. The results are shown in Table 7.

The revenue is then calculated by using the equation (4). Table 6. shows the unit cost, selling price and revenue.

Revenue by selling the ice cream through an online platform (4)

= sales – (commission + marketing support cost+7% value added tax)

the net cash flow for 10 years of project life is used to determine the financial measures, which are the weighted average cost of capital (or WACC), net present value (NPV), internal rate of return (IRR) and payback period (PB), to make decisions for the ice cream business investment.

From Table 1., the financial funding indicates that the proportion of the project owner is 30 %, and the loan from financial institutions is 70 %. These proportions are used to determine the WACC, which is the metric in the discounted cash flow (DCF) analysis. The WACC formula involves the rate of return required by shareholders, shareholders' equity, total debt and average interest rate on debt incurred. From the financial statement of the case study company, the WACC is 8.84%, the net present value is 83,960 $, the internal rate of return is 25%, and the payback period is 3 years and 4 months. The internal rate of return is larger than the WACC, so the project is an acceptable or worthwhile investment.

Table 7: Financial results for tropical fruit ice cream manufacturing

Assessment criteria	Value	Decision criteria	Decision results
WACC(%)	8.84%		
NPV($)	83,960 $	>0	Worthwhile investment
IRR(%)	25%	> WACC	Worthwhile investment
PB(Year)	3 years 4 months	Less than the project period	Worthwhile investment

5 CONCLUSIONS

E-commerce has been growing consistently nowadays. E-commerce is the online sale of goods and services via websites, social media sites and third-party marketplaces. The dessert product such as ice cream can be sold directly to consumers by ordering via the internet. The advantage of an E-commerce business is to reduce costs from investment in opening a store. An important point in running an online ice cream business is marketing analysis. The 4Ps marketing analysis shows that the ice cream should have various tropical fruit flavours at a suitable price. The consumers accept the online marketplaces and coupons & promo codes. In manufacturing aspects, the initial investment is focused on the production site, machinery and ice cream production equipment to meet food production standards.

Whereas, the operation costs for tropical fruit ice cream manufacturing are mainly on the raw material costs, which are subject to seasonal patterns. The sales and marketing expenses of the ice cream E-commerce business in this research are the E-commerce commission and value-added tax. The financial analysis shows that the net present value is 83,960 $, the internal rate of return is 25%, and the payback period is 3 years and 4 months. The investment is acceptable. The business model in this research can be further applied to other types of frozen food products.

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