1. Supply Chain Management
2. Operation Research Management

SINGLE-VENDOR SINGLE-BUYER MODEL FOR FOOD COLD ITEM UNDER FINITE LIFETIME INVOLVING ADVANCE PAYMENT

A THESIS

Submitted in Partial Fulfillment of the Requirement for the Degree of Bachelor of Engineering in Industrial Engineering

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INTERNATIONAL INDUSTRIAL ENGINEERING PROGRAM

DEPARTMENT OF INDUSTRIAL ENGINEERING

FACULTY OF INDUSTRIAL TECHNOLOGY

UNIVERSITAS ATMA JAYA YOGYAKARTA

YOGYAKARTA

2020

IDENTIFICATION PAGE

A THESIS ON

SINGLE-VENDOR SINGLE-BUYER MODEL FOR FOOD COLD ITEM UNDER FINITE LIFETIME INVOLVING ADVANCE PAYMENT

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DECLARATION OF RESEARCH ORIGINALITY

I certify that the research entitled “SINGLE-VENDOR SINGLE-BUYER MODEL FOR FOOD COLD ITEM UNDER FINITE LIFETIME INVOLVING ADVANCE PAYMENT” in this thesis has not already been submitted for any other degree.

I certify that to the best of my knowledge and belief, this thesis which I wrote does not contain the works of parts of the works of other people, except those cited in the quotations and bibliography, as a scientific paper should.

In addition, I certify that I understand and abide the rule stated by the Ministry of Education and Culture The Republic of Indonesia, subject to the provisions of Peraturan Menteri Pendidikan Nasional Republik Indonesia Nomor 17 Tahun 2010 tentang Pencegahan dan Penanggulangan Plagiat di Perguruan Tinggi.

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ACKNOWLEDGEMENTS

I want to express my deepest gratitude to Jesus Christ because of His Blessings I can complete my thesis with the title ”Single-Vendor Single-Buyer Model For Food Cold Item Under Finite Lifetime Involving Advance Payment”. This thesis is submitted as the fulfillment of the requirement for the degree of Bachelor of Engineering in Industrial Engineering, Faculty of Industrial Technology, Universitas Atma Jaya Yogyakarta.

The completion of my thesis is being supported by many parties. I am going to say my sincere gratitude to:

1. Mr. Dr. Teguh Siswantoro, M.Sc. as the Dean of Faculty of Industrial Technology Universitas Atma Jaya Yogyakarta.

2. Ms. Ririn Diar Astanti, D. Eng. as the Head of Industrial Engineering Department Universitas Atma Jaya Yogyakarta.

3. Mr. Yosef Daryanto, Ph.D. and Prof. Wenyih Lee, Ph.D. as my Supervisor 1 and Supervisor 2 who have guided me on writing and finishing this thesis.

4. Prof. Dah Chuan Gong, Ph.D. and Prof. Wenyih Lee, Ph.D. who have given this research topic and allowed me to write this thesis at Chang Gung University, Taiwan.

5. Bapak and Ibu who have given their support and their prayers for me on finishing this thesis.

6. My closest friends William and Vera who have always give me advice and support on finishing this thesis.

7. My friends from TIKI 16 and IAESTE Indonesia members who always given their support in finishing this thesis.

I hope this thesis is useful and can be expanded for the reader and the next researcher.

Taoyuan, July 20th, 2020

Jude Septayana

HALAMAN PENGESAHAN

Tugas Akhir Berjudul

SINGLE-VENDOR SINGLE-BUYER MODEL FOR FOOD COLD ITEM UNDER FINITE LIFETIMEINVOLVING ADVANCE PAYMENT

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Yogyakarta, 28 Juli 2020

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ABSTRACT

In today's competition, market, and industry management competing to collaborate,and forms the supply chain.. The food cold chain is one of the supply chains with special characteristics preserving the goods by controlled temperature. Besides, food cold items limited lifetimes that make them perishable. The vendor may request the buyer advance payments before the goods deliveryto secure the payment.

This research studies a single-vendor single-buyer model for food cold items under finite lifetime involving advance payment. The motivation of this research is to extend previous researches by applying the lifetime product and advance payment on vendor-buyer collaboration. This paper also gives numerical examples to illustrate the model and get some insight to minimize the cost. The proposed model optimizes the cycle time that will minimize the total costs, also the result shows that the advance payment significantly effect the total cost of vendor and buyer for food cold items and need to make agree in terms of the period for advance payment.

Keywords: Single-vendor single-buyer, food cold item, deteriorating items, finite lifetime, advance payment.

CHAPTER 1
INTRODUCTION

1.1. Background

In today's competition, market, and industry management competing to collaborate which becomes the most important activity that forms the supply chain. In a conventional vendor-buyer collaboration, a buyer must capable of managing their inventory, in terms of calculating the optimum order quantity, and time replenishment receive from the vendor. On the other hand, the vendor has to prepare the goods available until it is delivered to the buyer or customer including the internal operations and transportation to deliver the goods to the buyer. In today's industries, the vendor has no other preference but to offer consignment stock arrangements to preserve their own business, and the buyer also has no authority to takes ownership of the goods sold. However, based on Verheijen (2010), there are three strategic benefits of collaboration with a vendor. First, improve the strategic position in the vendor-buyer collaboration to increase and take customer interest. Second, information gathering will be easier and more detailed from buyers to a vendor to increase marketing knowledge on proper usage and purchases of the products produced that costumer needed. Last, the advantage of collaboration is reducing the workload that causing the buyer's administrative or internal process of order management and buyer's overhead.

The most critical goods in today market and important for the human is food. The food industry plays an important role to provide the necessities for supporting every human activity (Cooper and Ellram, 1993). Therefore to increase the awareness in today's global market of food logistics', the food industry needs to recognize the cold storage or cold room to maintain food safety. When the safety of food quality is on the risk and not reported, it will cause foodborne diseases for the costumers. According to a report of the scientific and technical information department of The International Institute of Refrigeration (IIR) in Paris, they estimated the foodborne diseases cost more than $50 billion particularly in the United States, including more than 120,000 patients that have been hospitalized in which results in 3,000 deaths cases.

In Taiwan, food cold items becoming the trends and most critical to maintaining. Therefore, to maintain the fresh and food quality, the term Food Cold Chain (FCC) or also called cold item was introduced. Lan (2009) described Food Cold Chain

(FCC) as one of the supply chains with special characteristics, FCC preserves the temperature of cold products' in fit temperature to take care of the product's quality in the long term. It is applied in the whole operations including preparation, packaging, cold storage, distribution, until being consumed by the end customer. It maintains the chilled or frozen foods to decrease the deteriorating rate from raw material to final product or consumption, and one of the solutions is by coordinating production and inventory to match food and material cycle with market demands.

Cold items including food cold chains always identical to deteriorating. Based on Yang and Wee (2001), deterioration is the decay and damage including the loss of utility or loss of marginal value that results in decreasing use and quality from the original form. Deteriorating with finite lifetime also deals with food cold that will slowly shrink continuously due time. Moreover, Liu et al (2005) said the finite lifetime generally can be categorized into two categories, those are common or fixed finite lifetime models and random finite lifetime models. Items with common category usually referring to evaporated items, then items with fixed lifetime involving random finite lifetimes such as fresh products, food cans, or medicine. In this research, the study focuses on the deteriorating with shelf life which is involving the finite lifetime where the period of a product can be more specific in terms of the day, month, or years. This condition inspires this study concern about food products that store in cold storage like pudding. This product has a short period in term of resistance, and one of the causes of short period or lifetime product is the radiation of electronic components like storage which contains the radioactive that make the food become more perish.

In a trend of the cold item, the goods have finite lifetimes and always deteriorate each time. Therefore, in today's competitive market, Teng et al. (2016) proposed the advance payment method instead of permissible delay for payment. The advance payment can be paid partially before the products are received from the seller. It secures the payment of the order, hence, the advance payment becomes a popular type of payment.

This research studies a single-vendor single-buyer model for food cold items under finite lifetime involving advance payment. The motivation of this research is to extend previous researches by applying the lifetime product and advance payment on vendor-buyer collaboration. The problem formulation, scope, and objective of the research will be explained in Sub-chapter 1.2, 1.3, and 1.4.

1.2. Problem formulation

Based on the background, a problem occurs in vendor-buyer collaboration when the vendor or seller requesting the buyer advance payments before the goods arrive because the goods have a finite lifetime and always deteriorate each time. So, the problem formulation of this research is:

a. What is the mathematical model for a single-vendor single-buyer food cold items under finite lifetime involving advance payment?
b. What is the optimum cycle length formula for the food cold item under finite lifetime involving advance payment?
c. Do the costs from the vendor and buyer perspective be the same? How does the model parameters affect the total cost?

1.3. Scope

a. The research considers a single-vendor and single-buyer considering single item product and single set up.
b. The demand rate is deterministic
c. No shortage allowed
d. Data which are related to this research are based on assumptions

1.4. Research Objective

a. Optimize the quantity of product a buyer need to order
b. Optimize the replenishment time for vendor and buyer
c. Calculate the profit percentage of vendor and buyer
d. Identify changes in costs as product life, demand, and pre-payment change.

CHAPTER 2
LITERATURE REVIEW & THEORETICAL BACKGROUND

2.1. Literature Review

Bozorgi et al. (2014) considered an inventory model in which a cold product is supplied from a warehouse to a distribution center and climate-controlled freezers and trucked are utilized in the supply chain. Two main objection functions: a cost function consisting of inventory holding and transportation costs and an emission function are proposed. This model was later extended by Bozorgi (2016) to deal with multiple types of cold products.

To wider the scope of the research area, research on inventory models involving the collaboration between a vendor and a buyer has been done. Pan and Yang (2002) conducted an integrated vendor-buyer production inventory model considering the lead time in under control with order's lot is delivered by multiple shipments or distribution. Also, in the same year, Huang (2002) proposed the model by involving the calculation of the imperfect quality items under the identical delivery quantity that will be sent to each buyer's shipment. He also extended the model from Ha and Kim (1997) by including the imperfect item's model into the inventory model of production and then redo again by Lo et al. (2007) by assuming the rate of various deterioration involving partial back ordering, inflation, unclear production processes with several consignments, then he generated an integrated production and inventory model for both side views including the manufacturer side and retailer side. In next two years, Cárdenas-Barrón (2009) also conducted an economic production quantity (EPQ) inventory model involving the planned backorders for under economic production amount and a lot size of backorders for a single item in a single manufacturing process that will raise the yield of good grade and evaporated goods that can be re-evaluated at the same cycle life. Hsu & Hsu (2012) conducted a single-vendor single-buyer involving inspection error relation with imperfect quality. Khan et al. (2015) proposed the single-vendor single-buyer involving screening cost under stochastic lead time. Astanti et al. (2018) conducted a comparison of two buyers involving the different demand behavior and how the vendor is dealing with that.

Extended the model from Pan and Yang in deteriorating literature, Ben-Daya and Hariga (2004) add the model by involving an account and including linear production and nonproduction conditions. Ouyang et al. (2004) also contribute to

developing the single vendor buyer with controllable lead time and stochastic demand and then involving the cost of quality improvement (Ouyang et al. 2007) and then extended by Vijayashree and Uthayakumar (2015a, 2015b) with involving multiple deliveries from vendor location to buyer location during production time. Involving stochastic demand is conducted by Chaharsooghi & Heydari (2010) to obtain the motivation for both vendor buyer to participate in the collaboration. In the next three years, Bahri and Tarokh (2012) researched by exploring the vendor buyer under exponential function lead time and then extended by Lin (2013) to learn an integrated model under imperfect condition under production involving the screening cost after buyer accepts the product. Another research with vendor buyer topic also being conduct from Yang and Wee (2001) by involving deteriorating item under fixed demand for multiple buyers, then the research continuous together with Daryanto and Wee (2018) for single vendor single buyer considering with carbon emission including transportation cost and tax emission from the government.

Involving the food cold chain, Sinha (2019) explained that every food industry obligated to preserve its inventory storage. History of research involving food inventory was initiated from Goyal (1977) by calculating the integration solution procedure and comparing the output to individual solutions which did not consider the production rate. The research work was followed by Banerjee (1986) which is developing the Joint Economic Lot Size (JELS) and Joint Total Relevant cost (JTLC) with assumptions that the vendor produces products as per the order received from the purchaser on a lot-for-lot with the deterministic condition. Ha, and Kim (1997) also developed and explore the integration analysis for buyer and vendor perspective by generating a mathematical model of the inventory cost of the vendor by derived it beyond noncontinuous saw-tooth inventory level model function. Salin and Nayga (2003) researched food cold chain by considering the network of food exports to developing the business relation new markets including in developing countries by using pricing strategies that will involve the quality and most likely affecting the availability of the third party and also with considered the advantages of buyers habit to reduce for individual incentives investment and also providing the services in new developing markets country. Kuo and Chen (2009) conducted model development involving multi temperatures. Wei (2011) also researched to find out how the supermarket handles the food cold chain to improve the effectiveness involving third party logistics. Lan et al. (2014) also conducted

the food cold chain in equilibrium condition to analyze based on collaborative replenishment policy with supply chain member that involved on his research including from supplier, retailer until the customer in the non-cooperative game to increase customer satisfaction together with performing the sensitivity analysis to show the overall profit over costumers' demand while the condition of customer satisfaction will decrease to some point whenever food deterioration rate and shortage increasing. Zhang and Liu (2018) conducted the simulation and optimization of food cold items using a dynamic simulation method to find the carbon emission impact and improve the loading rate, appropriate freight transportation, and delivery routes. Interesting research also has been done by Joshi et al. (2011) and Raut et al. (2019). Joshi et al. (2011) conducted the research involving inhibitors model of food cold chain and using the Fuzzy Interpretive Structure Modelling (FISM) method to find the interrelation that will be affecting the growth of the economy in India that require high attention. Then on a journal that was written from Raut et al. (2019), he proposed an Improvement in the food damage such as star fruit and cabbage under the perspective of a logistic distributor approach. His journal also described that India had produced sufficient food to fulfill the demand of its entire nation's population, on the other hand, that country is claimed as the second-highest grower of fruits and vegetables.

Considered the expiration and lifetime product, several types of research have done from previous researches, like Kreng and Tan (2011) with their proposed on generating the economic quantity model with delay payment decision. Extended their research, Wu and Chan (2014) developed the scope of their research by involving the retailer's system of credit risks for short period products to calculate the revenue and increasing the profit. In the previous year of Wu and Chan (2014), Dye (2013) also conducted similar research with Kreng and Tan (2011) with analyzing the investment of technology effect for a product with an expiration date. The latest research conducted by Muriana (2014) and Pal et al. (2017) involving stochastic production with the shortage is allowed in that research to illustrate the production inventory activity habits of a product lifetime. Ndraha et al. (2018) explored the issues and challenges for food cold chain involving time temperature.

In advance payment research, almost no research that related to advance payment appears in the business domain, which is indicated suggest of the tax domain with a higher interest in advance payments and appropriate refunds or repay over lower payments and appropriate additional payments. Ayers et al. (1999) demonstrate

the hypothetical condition. Their research stated that 43% of Management and Business students encounter a predicted tax liability which is more preferred to generating advance payments bigger than the minimum amount required. Jones (2012) also conducted and analyze the original data of taxpayers and conclude that the taxpayers on the advance payment method need 23% of performing the payment method after the minimum amount of qualification is decreased. In the latest research involving advance payment in the inventory, the model was generated by Teng et al. (2016). Their research illustrates the condition of retailer inventory with prepayment agreement considering the deteriorating items, and on their analysis without shortage and shortage being concluded that whenever the cost is calculated, it can enhance retailer's shortcoming by incorporating the deterioration rate slowly closes 100% as the expiration date and it won't affect the order quantity.

2.2. Theoretical Background

2.2.1. Supply Chain

Supply Chain is the teamwork of the network that consists of all parties involved including the manufacturer and suppliers, warehouses, retailers, and the customer directly or not also involved to fulfill the customer request and increasing the customer satisfaction, to be noted also that supply chain is always dynamic in term of time and concerns a steady flow of information, product, and funds among different stages.

Supply Chain consists of stages that each of the stages is always related through the flow of products, information and money that showed in Figure 2.1 below

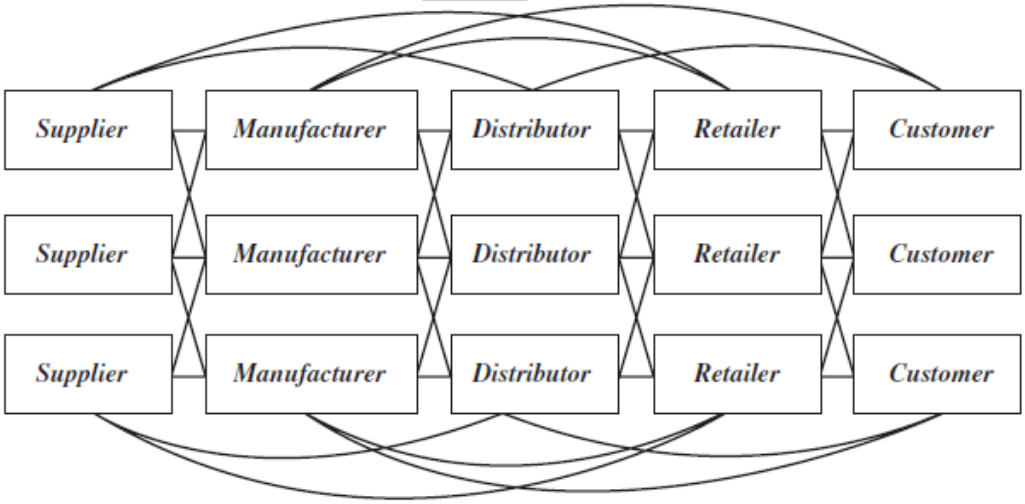

Figure 2.1. Supply Chain Stages

In a supply chain system, there are 3 types of flow, namely material flow, money flow, and information flow. All three types of flow have different flow directions. Material flow in the form of raw materials, components and finished products comes from upstream to downstream, the flow of money in the form payments come from downstream to upstream and information flow in the form of capacity, status delivery, quota, technical information, stock, sales and RFQ that can flow from upstream to downstream and vice versa. Figure 2.2 illustrates customer demand and value flow in a supply chain.

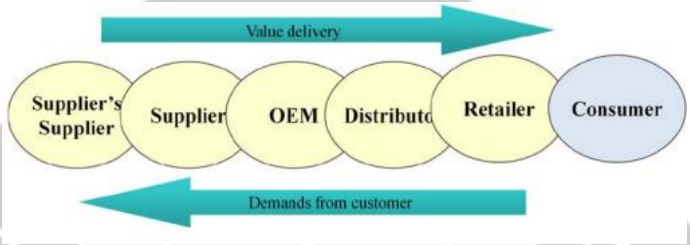

Figure 2.2. Basic Supply Chain Model

2.2.2. Cold Chain

Term of cold chain implemented to preserve a product within a low specified temperature distance. In Supply Chain, it is an uninterrupted series of cold storage or refrigerators of productions, and distribution activities together with associated equipment and logistics, which preserves the desired low-temperature range. The elements of a cold chain involve:

a. Cooling systems. Carrying goods such as food to the proper temperature for processing, storage, and transportation.
b. Cold storage. Providing facilities for the storage of goods due a lifetime and waiting to be delivered to a market that far from shipping location.
c. Cold transport. Having a carriage or vehicle that available to move and bring goods while preserving the fit and stable temperature and right humidity to keep protecting the goods safely.
d. Cold processing and distribution. Providing and supplying facilities for the transformation and processing of goods as well to make sure the sanitary perfect conditions by doing consolidating and deconsolidation loads which is can unmerge and re-assemble again such as crates, boxes, pallets for distribution.

2.2.3. Deteriorating finite lifetime

In the Introduction, deterioration is defined as the decay and damage including loss of utility or loss of marginal value from the original form (product or goods) that results slowly decreasing of durability and quality from the original form. In the mathematical model, the deteriorating items will slowly deteriorate due the time, and cannot be sold when time or date limit exceeds the expiration time. The basic deteriorating finite lifetime from Wang et al. (2014) and Chen & Teng (2014) is

$$\theta(t) = \frac{1}{1 + y - t}, \quad 0 \le t \le T \le y \tag{2.1}$$

Where θ is the deterioration rate, y is the maximum lifetime or expiration date, t is the time where $0 \le t \le T$, which T equal to the length of cycle inventory time.

Table 2.1. Company Advance Payment Offer Report (Schulz et al., 2015)

	Company	APS offered?	Optional or mandatory?	Name	Incentive provided to switch to APS?
France	EDF	Yes	Optional	Direct debit	Yes
	ENI	Yes	Optional	Automatic payment	No
	GDF Suez	Yes	Optional	Automatic payment	Yes
	Poweo Direct Energie	Yes	Optional	Automatic payment	Yes
	Eon Fr	No	–	–	–
Germany	EnBW	Yes	Mandatory	Anticipated payment	–
	Eon Germany	Yes	Mandatory	Anticipated payment	–
	EWE	Yes	Mandatory	Anticipated payment	–
	RWE	Yes	Mandatory	Anticipated payment	–
	Vattenfall Europe	Yes	Mandatory	Anticipated payment	–
Italy	Acqua Gas Azienda Municipale	No	–	–	–
	Aem	No	–	–	–
	Edison SpA	No	–	–	–
	Enel	No	–	–	–
	Hera Group	No	–	–	–
Spain	EDP Renováveis	No	–	–	–
	Endesa	Yes	Optional	Bills with estimated consumption	No
	Eon Spain	No	–	–	–
	Gas Natural	Yes	Optional	Plan with fixed payments	No
	Iberdrola	Yes	Optional	Fixed rate	No
UK	EDF Energy	Yes	Optional	Direct debit	Yes
	Eon UK	Yes	Optional	Direct debit	No
	National Grid	Yes	Optional	Direct debit	Yes
	RWE npower	Yes	Optional	Direct debit	Yes
	Scottish and Southern Energy	Yes	Optional	Direct debit	Yes
US	AES	Yes	Optional	Budget billing	No
	Duke Energy	Yes	Optional	Budget billing	No
	Exelon	Yes	Optional	Budget billing	No
	Pacific Gas & Electric	Yes	Optional	Balanced payment plan	No
	Southern Company	Yes	Optional	Budget billing	No

2.2.4. Advance Payment

Advance payment is a generic payment for general utility services, such as gas, water, and electricity specially Europe and United States. Even though they are creating different names such as direct debit, automatic payment, budget billing, balanced payment plan, etc. Table 2.1 from Schulz et al. (2015) shows the consumption of advance payment methods between the biggest five of most uses

as a utility of services companies in Europe and the United States. Payment by this method is originally obligated in Germany but in another country, it has become an alternative payment for whole countries in the world.

Advance payment also gives a range of advantages to big companies and customers, then the usual or conventional payment method. Big industry and company can reduce the risks because of customer action such as unresponsible pay, also the payment happens before usage, costumers do not need to be afraid costs will fail to pay. Customers can make their planning on managing their budgets preferable, because the payments in a monthly method are more fixed and consistent, which is also becomes a benefit for the company whenever they communicate with customers. In addition, advance payment potentially can reduce the operating costs together with other additional costs and overhead costs such as billing, and customer services.

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CHAPTER 6
CONCLUSION

In today's market and industry management, collaboration becomes the most important activity that forms a supply chain. To maintain the freshness and quality of food, food cold items become a popular method. However, the food cold supply chain must consider deterioration conditions because the food is slowly damaged or perish due to time, hence, affecting the inventory. The food cold item is typically has a finite lifetime, hence the vendor may request the buyer an advance payment. This method also uses as protection against non-payment conditions.

This research extends the single-vendor single-buyer model for food cold items by considering a finite lifetime involving advance payment. The proposed model optimizes the cycle time that will minimize the total costs. The numerical example and model implementation illustrate that the developed model provides different cost percentage to the buyer and vendor. Further, both the vendor and the buyer must set the agreement of prepayment to maintain the cost percentage because the sensitivity analysis shows that the cost is significantly different when the number of installments changes.

For further research, the proposed model can be extended by involving environment cost, quantity discount, limitation of expired date, order lot size or considering multi-items.To be more illustrates the real condition, next reserach also will consider the *Economic Engineering* by applying the fluctuating market condition.

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