MANAGING CORPORATE FINANCIAL RISKS WITH FINANCE INSTRUMENTS IN SUPPLY CHAINS

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Managing Corporate Financial Risks with Finance Instruments in Supply Chains

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CERTIFICATE OF ORIGINALITY

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Abstract

Due to the high research and development investment and high production costs, many upstream suppliers are often constrained by limited initial capital when producing and supplying products, with some suppliers struggling to get funding from banks because they lack guarantees and credit histories. To solve this problem, Supply Chain Management (SCM) practitioners and scholars are paying attention to Supply Chain Finance (SCF), which can help cash-strapped suppliers obtain funds through supply chain cooperation. In the current situation, pre-shipment financing is worth studying, and is based on purchase orders rather than invoices, and credit risk is relatively highly based on trust between buyers and sellers. Therefore, how to effectively use pre-shipment financing tools to tackle the problem of the working capital constraints of suppliers in supply chains and manage the financial risks of corporates has become an important research topic.

Salvage value is the amount received for the disposal of unsold inventory at the end of the selling season. For perishable products with salvage value, due to the uncertainty of market demand and the existence of many invisible factors, downstream retailers may purchase more goods from suppliers than market demand before the selling season, thus facing the problem of excess inventory after the season. However, in many previous SCF studies, to simplify the calculation, the salvage value was ignored or set to zero in short-term financing. Therefore, it is important to study the influence of different salvage values on supply chain operation and financing decisions.

The existing research on SCF is rarely applied to specific industries. Scholars should consider the application of SCF in various industries, such as high-tech industries. In addition, when previous studies focused on Green Supply Chain (GSC) and environmental sustainability, they mainly discussed how enterprises make optimal decisions according to different carbon sources, policies, and carbon emission costs. However, few studies have considered the combination of GSC and SCF to help the supplier solve the problem of capital constraints, so as to produce more green products that are more environmentally friendly, which is worth studying.

Therefore, the thesis studies the impact of various salvage values on the operation and financing decisions of participants under different financing instruments in capital-constrained supply chains, filling in the research gaps above. The main contributions are as follows:

1. The supplier can be funded by pre-shipment financing instruments. Advance Payment Discounted (APD) financing, also a form of cash in advance with a discount, to alleviate the financial stress before product delivery. Furthermore, Buyer-Backed Purchase Order Financing (BPOF) is also a pre-shipment financing tool to deal with this problem where a financial institution provides loans according to a reliable buyer purchase order before product delivery. Two other financing mechanisms, Buyback Support Buyer-Backed Purchase Order Financing (BSBPOF) and Buyback Support Advance Payment Discount (BSAPD) are also considered to ease the supplier's financial pressures, which indicate that the supplier promises to buy back unsold products after the normal sale season.

2. This research focuses on considering various salvage values (e.g., positive and negative salvage values, supplier-responsible salvage values, time-varying salvage values) when using SCF to solve the supplier funding constraints. First, whether positive and negative salvage influence operation and financing decisions under APD and BPOF are examined. Further, the influence of the difference between the buyback price and salvage value under BSBPOF and BSAPD on the participants' decisions and the financing equilibrium is studied. This study also studies how time-varying salvage values influence the decisions under APD and BPOF and uses mean-variance theory to study the profit risk of the supply chain.

3. This research considers the application of SCF in the mobile phone and TV industries to solve the financing difficulties of the suppliers. In particular, to reduce environmental pollution and promote sustainable development, the supplier can be committed to producing more eco-friendly televisions through a GSC system.

To sum up, the analytical modeling approach is adopted with the integration of numerical study for the observations from industrial practice in various industries. This thesis begins with a comprehensive literature review on SCM, SCF, capital constraint issues for managing the buyers and the suppliers, perishable goods with salvage values, and the application of various financing instruments. Then the mathematical models are used to analyze the problems. Finally, in-depth numerical studies are conducted to verify the research results. The management insights generated in this study are of benefit to the suppliers, the retailers, the financial institutions, and the whole industrial spectrum.

Publications

Journal articles (in reverse chronological order)

Wu, S. M., Chan, F. T. S., & Chung, S. H. (2020). The influence of positive and negative salvage values on supply chain financing strategies. Annals of Operations Research. (Under Review)

Wu, S. M., Chan, F. T. S., & Chung, S. H. (2021). The impact of buyback support on financing strategies for a capital-constrained supplier in a mobile phone supply chain. International Journal of Production Economics. (Under Major Revision)

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List of Abbreviations

SCM: Supply Chain Management

GSCM: Green Supply Chain Management

GSC: Green Supply Chain

SCF: Supply Chain Finance

SMEs: Small and Medium-Sized Enterprises

APD: Advance Payment Discount

BPOF: Buyer-Backed Purchase Order Financing

BSAPD: Buyback Support Advance Payment Discount

BSBPOF: Buyback Support Buyer-Backed Purchase Order Financing

POF: Purchase Order Financing

SF: Supplier Financing

SI: Supplier Investment

TV: Television

IGFR: Increasing Generalized Failure Rate

CHAPTER 1 Introduction

In this chapter, the research background is briefly discussed in Section 1.1, followed by the objectives, scope, contribution, and significance of this research in Section 1.2, Section 1.3, Section 1.4, Section 1.5, respectively. Lastly, the organization of this thesis is elaborated in Section 1.6.

1.1 Research Background

The chapter commences with a statement of the background of the study, which focuses mainly on describing the following four aspects: the transformation of corporate relations, Supply Chain Finance (SCF) and capital constraints of enterprises, perishable goods with salvage value and Green Supply Chain Management (GSCM), respectively.

1.1.1 The transformation of corporate relations

The world economy has recently undergone fundamental changes, and the needs of customers have also changed a lot, from the practical needs of the past to the personalized and diversified needs of today. All this has led to a shift in corporate strategy. Therefore, enterprises not only need to pay attention to their operation and management but also urgently need to find strategic partners to build a competitive supply chain to meet diversified customer needs. As is well known, the supply chain is an enterprise system mainly composed of suppliers, manufacturers, distributors, retailers, and customers. Although each company's decision-makers are different, their goal is to maximize their profits. However, in the past, the decisions made by enterprises from their own perspective are not necessarily the best decisions of the whole supply chain, which requires enterprises to fully cooperate to maximize the profit of the supply chain. As a result, business relationships are gradually transformed into partnerships to establish a competitive supply chain and gain a large enough market share to achieve high corporate profits.

Further, the global financial market turmoil in recent years has led to an overall increase in corporate financing costs. For the largest number of capital-constrained enterprises, due to their low credit level and lack of effective asset mortgage, receiving loan financing from banks or other financial institutions becomes difficult, so their financial difficulties have a serious impact on their production and operation. At the micro-level, the transaction settlement method in the supply chain also influences the capital flow of enterprises. For example, under a commercial credit contract, the retailer is unable to pay for goods until 30-90 days after receiving a delivery from the supplier, so the supplier's sales revenue cannot be converted into cash flow into the enterprise's cash account in time. The supplier may also run into cash flow difficulties, as the disposable cash cannot meet the funding needs of daily business activities, such as production and orders. The interaction of material and capital flows in the production and operation of enterprises makes researchers realize the value that Supply Chain Management (SCM) can be changed from the traditional decentralized decision-making mode to the joint decision-making mode. How to use the working capital of the firms to optimize the benefit of the supply chain and enhance the coordination of enterprises has become the focus of the industry, academia, and governments around the world.

1.1.2 Supply chain finance and capital constraints of enterprises

SCM is concerned with the combination of materials, information, and capital flows, so it is reasonable for researchers to study the impact of joint financial and operational decisions on SCM (Babich and Sobel 2004; Buzacott and Zhang 2004). Since supply chain parties often faced the ordering and production decisions of working capital constraints, to solve the problem of capital shortage, an innovative financing service supply chain financing at the beginning of the 21st century, can be defined as a tool for enterprises to solve the working capital issues in the management, planning, and control of all cash flow related trading activities. This is a financial model that makes use of the high-quality credit resources of the core firms to help other enterprises obtain funds. Nowadays, various SCF models have been proposed and applied in the steel, automobile, construction machinery, home appliances, and other industries (Chen et al. 2017). When liquidity is tight, companies need short-term financing to operate their businesses. Combining and effectively using external and internal sources of funds to solve the supply chain working capital constraints becomes a significant research topic. Trade credit usually takes the form of the supplier's early payment discount. A retailer can pay interest to suppliers free of charge for a pre-specified period, such as 30, 60, or 90 days. Nevertheless, early payment can be encouraged by offering discounts on the wholesale price. The discount can also be viewed as the amount of interest on deferred payment. When both parties have limited working capital, it may make sense to consider bank loans to address these restrictions.

Furthermore, with the increase of orders, the production cost of suppliers also increases. For suppliers constrained by production capital, they are unable to produce the optimal order quantity due to capital constraints. When the above situation occurs, retailers and suppliers have two choices. One is to order or produce according to the existing funds, however, this is bound to fail to achieve the optimal performance, thus reducing the profits. The second is to order the optimal quantity through financing. In real life, financing is not easy due to the problems of the lending enterprises themselves and the influence of third-party financial institutions, which is mainly reflected in the following: (1) The problems existing in loan enterprises themselves. Many enterprises are labor-intensive small and medium-sized enterprises, and they lack effective management methods and advanced technical levels. In the increasingly competitive market environment, there is a huge risk of competition and bankruptcy. At the same time, in terms of financial management, many enterprises do not have standardized relevant systems, which often bring greater transaction risks to third-party financial institutions. (2) There are no strong guarantee agencies and no adequate mortgages. Companies that are constrained by capital tend to have lower credit ratings. To reduce the transaction risk of financing, third-party financial institutions often require enterprises to prove their solvency, but the loan enterprises cannot obtain strong security and lack sufficient valuable tangible assets as a guarantee. (3) The cost of financing is high, and the process is complex. The financing process is more complex and often causes greater losses for companies with high timeliness requirements. In addition to the above factors, the reasons for enterprises' financing difficulties include monetary policy, information asymmetry, and lack of strong policy support. Therefore, how to establish an effective financing channel and solve the problem of the capital constraint of enterprises has become a major problem facing today's society. A buyer can finance the supplier through Advance Payment Discounted (APD) means, also a form of cash in advance, to alleviate the financial stress before product delivery. The unit discount provided by the supplier can also be viewed as the amount of interest on deferred payment which encourages the retailer to pay upfront. However, there is sparse literature on how to solve the problem of supply chain working capital constraints through APD, most of which are solved via bank financing and trade credit. Furthermore, Buyer-Backed Purchase Order Financing (BPOF) is an external financing tool to deal with the capital-constrained supplier’s problem. A financial institution provides loans according to a reliable buyer purchase order before product delivery. However, there is little information on BPOF despite it emerging as a financial instrument. Hence, this paper focuses on both APD and BPOF to deal with the financial stress of the supplier.

1.1.3 Perishable goods with salvage values

Perishable products were originally viewed as agricultural products that lost their sale value once they spoiled. However, with the development of information technology, as well as the changing needs of customers to personalized and diversified service, the speed of product substitution is accelerating which makes more and more products in the current life begin to have certain characteristics of perishable products. Specifically, the perishable goods supply chain has the following characteristics: 1) Short product life cycle. Product life cycle length mainly depends on market demand and market competition. With the trend of consumer demand diversification, the development ability of perishable goods manufacturers is also improving unceasingly, and the development cycle of new products is greatly shortened. For example, mobile phones, one of the most competitive products, have an average life cycle of fewer than 10 months in many places. 2) Uncertain market demand. Perishable products have a short life cycle and a wide variety, which makes it difficult to accurately predict product demand. Besides, many perishable products are innovative products. Because there are no relevant historical sales data for these products to refer to, it makes it more difficult to predict the market demand, which brings huge risks to the operation and management of enterprises at each node of the supply chain. 3) Diversified products. Due to the diversification of consumer demand, production enterprises continue to introduce new varieties to better meet the needs of consumers. In addition, some popular products aim to provide customers with personalized choices, thus increasing the added value of the products. For example, for the same product, they provide rich colors, varieties, and styles to attract more customers to buy. 4) Short delivery time. The contemporary market competition is more and more fierce, and the pace of economic activities is intensified. As a result, every enterprise realizes that the customers' expectations and demands are greatly increasing. The customer not only requests the manufacturer to deliver the goods on schedule but also requests the delivery time to be shorter. These perishable products have occupied an increasing proportion on the shelves of shops and supermarkets. Since the perishable goods supply chain has the above characteristics, the retailers are likely to face overstocking. Salvage value is a crucial aspect, and it is common practice for retailers to clear inventory by the salvage value. Therefore, the study of perishable goods with salvage value has gradually become an important aspect in the field of SCM.

In many previous works of SCF (Yan et al. 2018; Feng et al. 2014), in order to simplify the calculation, many researchers ignored the salvage value in short-term financing and implicitly or explicitly believe that the salvage value has little influence on the model; thus the salvage value of unsold products is set to zero in their studies. However, the positive and negative properties of salvage values are an important subject worthy of study. Besides, according to the available literature, it is clear that the majority of the research assumed that the salvage value was fixed. But some scholars and empirical evidence indicated that the salvage value was variable (Cachon and Kök 2007; Alan and Gaur 2018), and no researchers have yet to investigate the time-varying salvage value.

1.1.4 Green supply chain management

The Green Supply Chain (GSC) is the integration of environmental factors in the process of SCM. It is a modern management mode that comprehensively considers the environment, resources, and benefits. It makes products more environmentally friendly and is a way to improve the market competitiveness of products. With the development of the GSC, a green product also has its definition, that is, such a product cannot harm human health, or even damage the natural environment, but also can be effectively recycled and reduce the waste of resources. Chin et al. (2015) believe that the concept of GSCM is to integrate environmental thinking into SCM, so GSCM is also conducive to sustainable development. To some extent, the GSC depends more on the cooperation between the enterprises of the supply chain, but it also needs every member to achieve the objective of sustainable development. The management system of the GSC can be represented by a relatively intuitive structure, as shown in Figure 1.1 below:

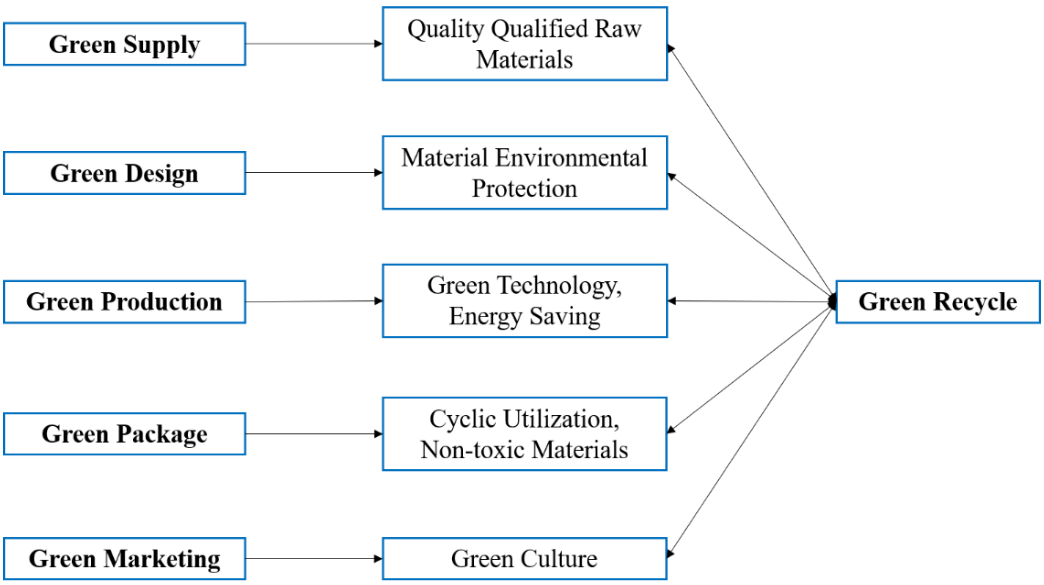

Figure 1.1 The management system of the green supply chain.

(1) Green supply. The key to green supply is the purchase of raw materials, that is, raw materials must be purchased to ensure that they meet the specified quality standards, the purchase cost of materials must be optimal, and they must have the attribute of green environmental protection (Bowen et al. 2006).

(2) Green design. If in the process of green design, ecological environmental

protection, product quality assurance, cost reduction, and other requirements are given priority, then energy consumption and recycling will be effectively reduced. In other words, effective green design can reduce the damage to the ecological environment and avoid the excessive consumption of resources (Zhang et al. 1997).

(3) Green production. Green production mainly concerns in the whole production process of a product to save energy, reduce consumption, and reduce pollution as the core standards, and to reduce the negative impact on people's health and ecological natural environment (Leff 1995).

(4) Green packaging. Green packaging requires that products produced in the green production link are packaged with materials that are not harmful to the public health and ecological natural environment, and these packaging materials can be reused, recycled, and degraded many times (Rabnawaz et al. 2017).

(5) Green marketing. Green marketing means that enterprises take the impact of products on the ecology and natural environment as the main marketing strategy. A company should focus on conveying the concept of a green environmental protection culture which helps the company effectively establish a green image in the eyes of consumers (Peattie and Charter 2003).

(6) Green recycling. Green recycling mainly refers to the secondary recycling and re-utilization of waste materials on the basis of the principle of being eco-friendly to the natural environment, so as to achieve the maximum value with the minimum cost (Meshram et al. 2020).

To sum up, GSCM essentially refers to the integration of green and environmental protection ideas into traditional SCM.

1.2 Research Objectives

This thesis explores how to use financial instruments to manage corporate financial risks in supply chains. The objectives for this research are established as follows:

1. To establish an SCF system by applying two pre-shipment financing strategies in order to explore whether the existence of a positive or negative salvage value affects: 1) the optimal decisions of the participants under both APD and BPOF; 2) the profits of supply chain participants; 3) the threshold of the retailer's asset level under a single financing condition.

2. To develop a newsvendor model in a mobile phone supply chain with consideration of the integration of two pre-shipment financing strategies and a buyback policy. This enables examination of the impact of a mobile phone's buyback price and the difference between the buyback price and salvage value on the decision makings of the participants under Buyback Support Buyer-Backed Purchase Order Financing (BSBPOF) and Buyback Support Advance Payment Discount (BSAPD), as well as to characterize the financing equilibrium between BSAPD and BSBPOF.

3. To investigate a green TV supply chain by considering time-varying salvage values in which the supplier can adopt pre-shipment financing strategies (APD and BPOF) for the smooth production of new, greener products, so as to analyze the effect of the TV time-vary salvage value on the decision makings of the participants, as well as to measure the retailer's risk level under different financing schemes in the GSC.

1.3 Research Scope

The scope of this research concerns the interface of operations and finance, taking into account various salvage values (e.g., positive and negative salvage values, variable salvage values), rather than assuming zero or ignoring the importance of salvage values. Pre-shipment financing instruments are applied for mitigating the financial distress of suppliers rather than using post-shipment financing instruments.

Therefore, the buyer's capital constraints and post-shipment financing instruments are not discussed here. In addition, this research focuses on investigating the importance of the difference between the buyback price and salvage value, rather than studying supply chain coordination by using a buyback contract. This study also considers how to help suppliers solve the problem of capital constraint so as to produce more environmentally friendly green products, rather than discussing how enterprises make optimal decisions according to different carbon sources, policies, carbon emission costs. Finally, this research emphasizes the application of SCF in high-tech industries is explained, rather than the theoretical model.

1.4 Research Contributions

In this sub-chapter, the contributions of this research to the literature are summarized from the following aspects:

1. The main contributions in Chapter 4 are in the following aspects: 1) The positive and negative salvage values affect the optimal order quantity. The buyer orders more products with a positive salvage value than those without any salvage value and reduces orders for items with a negative salvage value; 2) Different salvage values affect the profits of the buyer and the overall supply chain, since buying products with a positive salvage value reduces the retailer’s losses; 3) the positive and negative salvage values affect the threshold of the retailer's asset level under a single financing condition. Specifically, a positive salvage value creates more inventory risk to the retailer compared with no salvage value and a negative salvage value, so the retailer should have a higher level of assets to ensure adequate funding for the supplier through APD.

2. A newsvendor model in an SCF system is developed in Chapter 5, where a mobile phone supplier with limited funds sells products to a retailer facing uncertain demand. Two major contributions are as follows: 1) It is the first study that characterizes the financing equilibrium between BSAPD and

BSBPOF, as well as studying the impact of both buyback price and salvage value on the equilibrium. The smaller the difference between buyback price and salvage value, the higher the capacity level, and the higher the supplier's profit. In BSAPD, with a higher difference, the supplier should offer a lower discount rate to maintain a higher purchase price for the buyer, thus reducing the financing costs and risks. While in BSBPOF, a financial institution's interest rate increases with the difference, and BSBPOF is preferred when the buyback price is above a certain level and the difference is small. Otherwise, BSAPD should be encouraged; 2) The insights presented in this chapter are novel and contribute to the understanding of common but underexplored issues in the financing of mobile phone manufacturing enterprises.

3. Chapter 6 mainly makes the following contributions: 1) This chapter focuses on sustainability and green issues and presents a GSC model concerned with green TVs; 2) Two effective financing instruments (APD and BPOF) are applied here to help the financially constrained supplier produce green TVs smoothly; 3) The salvage value of a TV varies according to the clearance time, and the impact of the time-varying salvage value on the decision making of the participants under APD and BPOF are analyzed. The clearance time has an impact on the retailer's optimal order quantity, the supplier's discount rate, and the financial institution's interest rate; 4) This chapter characterizes the financing equilibrium and the financing equilibrium is BPOF when the clearance time is below a certain threshold or when the retailer's internal asset level is below a certain level, and the threshold of the asset level is inversely proportional to the clearance time; 5) A profit-risk analysis of different financing schemes is carried out to obtain more insights. The results show that the profit risks of the TV retailer under APD and BPOF are increasing with the order quantity and the clearance time. The profit risks of the retailer and the entire supply chain via two financing instruments are equal, which implies that the retailer's profit risks determine the whole supply chain's risks.

In general, this research contributes not only to the academic community but also to industry with managerial insights: firstly, it provides accurate mathematical models that can be used as benchmarks for supply chain operations and financing decisions when products with different salvage values can be considered; secondly, it provides new ideas for the application of SCF in specific industries; thirdly, it not only provides useful management insights to suppliers but also provides decision-making advice to other participants, such as retailers and third party financial institutions; finally, it is also important to focus on green and sustainable development in supply chain financing.

1.5 Research Significance

Recently, scholars in the field of management science have attached great importance to research on the combination of operation management and financing decisions, but there have been few systematic studies on the joint decision-making of operation and financing under the financial constraints of suppliers. The supplier may obtain financing through different channels, and in this study, the supplier is financed through pre-shipment finance instruments. Further, many researchers implicitly or explicitly assume that the salvage value has no influence on the model and ignore the salvage value in short-term financing in order to simplify the calculation. However, combining SCF with various salvage values is an important topic that is worth studying. Therefore, this topic has the following theoretical and practical significance:

1. Theoretical significance

The existing literature mainly discusses the operation and financing decisions of the downstream enterprises of the supply chain under the financial constraint, and rarely involves systematic studies on the financial constraint of upstream suppliers. The scope of this research is subordinate to the operation and financial joint decision-making problem in operation management. On the basis of systematically studying the joint decision of business operation and financing under supplier capital constraints, the study improves the existing literature system for supplier's financial constraints. What's more, in the literature of SCF, many researchers ignored the salvage value in short-term financing and assumed the salvage value of unsold products was zero. However, in practice, there are positive and negative salvage values, as well as time-varying salvage values. Therefore, the second theoretical significance of this research is that it is the first time the related research in the field of operation and finance has been expanded by considering various salvage values, and the problems of the influence of the salvage value for the participants' operations and financing decisions have been proved. Thirdly, this research focuses on investigating the importance of the difference between the buyback price and salvage value when the supplier is responsible for the unsold products with the salvage value based on the buyback contract. This research also provides references for helping suppliers solve the capital constraint problem so as to produce more environmentally friendly green products.

2. Practical significance

In practice, how to finance capital-constraint enterprises is a worldwide problem. This study investigates the optimization of operation and financing joint decisions and discusses the best choices with various financing strategies in the environment of perishable goods with salvage values, to provide a reference for the decision-making of enterprises in practice. For instance, the research findings provide a reference for choosing different financing modes for products with positive and negative salvage values, salvage values responsible for the upstream supplier, as well as time-varying salvage values. Hence this study is able to help core enterprises stabilize the supply and marketing channels, improve market competitiveness and strengthen the relationship with suppliers to ensure the number of products without financial difficulties. Lastly, the model can be applied in a variety of industries that produce goods with salvage value, such as high-tech industries, high-end clothing, and other products that require disposal costs when discarded.

1.6 Thesis Organization

The chapters of the thesis are organized as follows:

Chapter 1. Introduction: the current chapter.

Chapter 2. Literature Review: This part provides a literature review on the related works in the field, including SCM, SCF, managing capital constraint of the buyer and the supplier, perishable goods with salvage values, and application of financing instruments.

Chapter 3. Problem Description: the research problem is described in detail including problem background and problem statements.

Chapter 4. The Influence of Positive and Negative Salvage Values on Supply Chain Financing Strategies: problem statements and model descriptions are first introduced and the models considering both positive and negative salvage values are presented. Then, some comparisons regarding the profits of the enterprises are made. Finally, the study verifies the results via a numerical analysis and obtains some managerial insights.

Chapter 5. The Impact of Buyback Support on Financing Strategies for a Capital-Constrained Supplier in a Mobile Phone Supply Chain: problem statements and model descriptions are introduced at first and then the models about BSAPD, BSBPOF, and financing equilibrium are presented. The results are verified via a numerical analysis and some managerial insights are obtained.

Chapter 6. Green Television Supply Chain Under Capital Constraint Considering Time-Varying Salvage Value: this chapter first shows problem statements and model descriptions. Then the models regarding APD, BPOF, and financing equilibrium with considering time-varying salvage value are presented. Moreover, profit risks are analyzed by a mean-variance method. The results are verified via a numerical analysis and some managerial sights are generated.

Chapter 7. Conclusions and Further Research: The thesis is concluded, and the limitations and directions of future work are illustrated. Figure 1.2 shows the structure of the research.

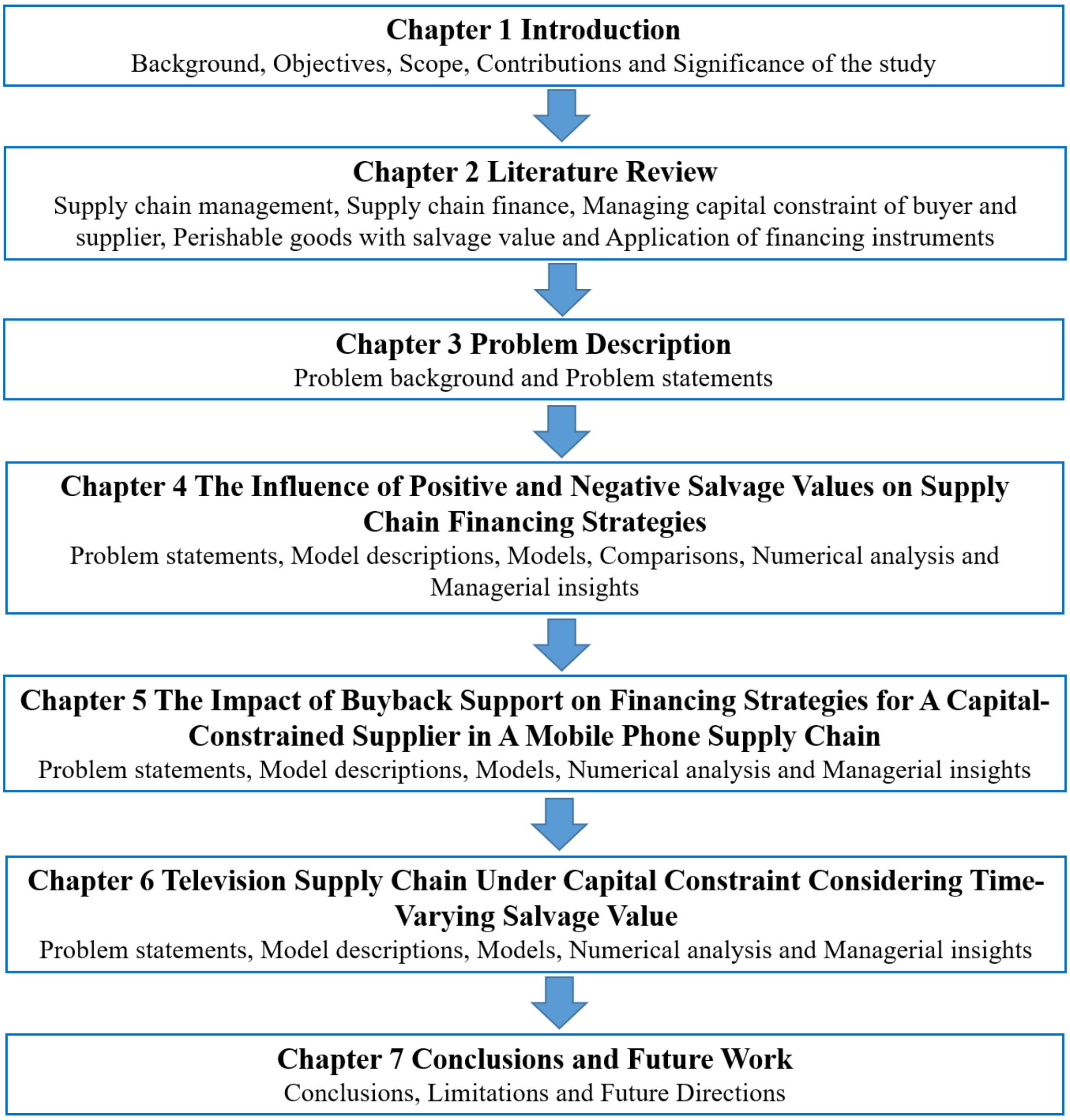

Figure 1.2 Structure of the research.

CHAPTER 2 Literature Review

2.1 Supply Chain Management

In this chapter, a systematic literature review on SCM is firstly demonstrated in Section 2.1. The introduction with recent literature of SCF is provided in Section 2.2. Then the related literature on managing capital constraint of the buyer is presented in Section 2.3, mitigating financial distress of the supplier, perishable goods with salvage values, and the application of financing instruments in Sections 2.4, 2.5, and 2.6. In Section 2.7, the research gaps are presented in detail.

2.1.1 Overview of supply chain management

Nowadays, the competition among corporates has evolved into the competition among various supply chains of enterprises, rather than the competition between individual enterprises. A "supply chain" is a logistics network consisting of raw materials, inventories, and finished goods moving between facilities such as suppliers, production centers, warehouses, distribution centers, and retailers. Hence the supply chain refers to the steps taken to deliver an item or service from its initial state to its delivery to a customer (Kozlenkova et al. 2015). Each entity in the supply chain is independent, and each economic entity has its own behavior, which may have an influence on the operation and benefit. An important means to improve the competitiveness of modern enterprises is to promote the supply chain's operational efficiency, which is also of great concern to modern enterprises.

SCM is an important process since an efficient supply chain is conducive to lower costs and faster production cycles. Hence, to promote the supply chain to run effectively, the supply chain must be well managed. Cooper and Ellram (1993) defined SCM by using integrated thinking so as to manage the whole business process of the distribution channel from the supplier to the final customer. Simchi-Levi et al. (2008) put forward that SCM is to integrate suppliers, manufacturers, warehouses, and distributors effectively so that goods can be produced and distributed in the right quantity at the right time and in the right place to meet customers' requirements and mitigate the total costs. SCM embodies an integration of the supply chain so that all members share risks and benefits, design and control the cash flow, logistics flow, and information flow to effectively improve the whole system's efficiency, reduce costs, and achieve the purpose of a win-win situation.

Three important factors are in the process of supply chain operation: information flow, logistics, and capital flow. Only by properly coordinating the three factors can the supply chain's overall efficiency be better improved, and the competitiveness is enhanced. The supplier processes the raw materials and makes the finished products and sells them to the downstream retailers, who then sell the items to the customers. This is the process of information flow and the logistics in the supply chain being transferred from node to node. Money flows in the opposite direction of logistics, from users to retailers to distributors to manufacturers to suppliers. As capital intermediaries and credit intermediaries, banks will meet the risk avoidance and financing needs of enterprises in all links. With the support of information flow, capital flow and logistics can move, so information flow is a two-way flow. If the information flow is not smooth, there will be severe and serious information asymmetry between supply chain participants, thus reducing the supply chain's operating efficiency.

2.1.2 Supply chain contract

Supply chain contracts are provisions that ensure coordination between buyers and sellers so as to optimize supply chain performance via providing appropriate information and incentives. Pasternack (1985) put forward the concept of the supply chain contract and studied the optimal wholesale price and return policy of perishable goods. Supply chain contract design mainly solves two problems: the double marginal effect and the bullwhip effect caused by information asymmetry. Here, the "double marginalization effect" was first put forward by Spengler (1950), which means that the marginal cost of retailers in decentralized decision making is often higher than that in centralized decision making, and results in lower order quantity or higher retail price of retailers and lower total profits. Supply chain coordination is an important part of SCM. Danese et al. (2004) defined it as the mode of planning, controlling, and adjusting materials, parts, services, information, funds, and personnel effectively. In the decentralized supply chain, each member enterprise is accustomed to make decisions with the consistent aim of maximizing his or her interests, which leads to the fact that the performance of the whole supply chain cannot reach the optimal state in the centralized supply chain. To eliminate the "double marginalization effect", the core enterprise may choose a contract to coordinate the behavior of each member. Therefore, research on supply chain contract coordination is of great significance in that it aims to change the relationship between enterprises through various mechanisms and methods, eliminate the conflicts, and make every corporation strive to maximize the profits. The objectives of the coordination contracts are (Arshinder et al. 2008): 1) optimize the total profit of the supply chain; 2) minimize the salvage costs related to inventory (excess inventory) and goodwill costs (shortage); 3) share the risks. Each independent economic individual who pursues his or her maximum profits leads to incongruence. The aim of coordination is to decide on each supply chain member in a decentralized condition consistent with the overall decision of the centralized system so as to realize the maximum total profits of the system and to reasonably distribute the profits. Members should choose appropriate contracts according to their own advantages, market information, benefit objectives, and other conditions to stimulate and restrict the behavior of other members in order to coordinate the supply chain.

Many types of supply chain contracts are studied (Saha and Goyal 2015), and several contracts are described in detail below. Firstly, the wholesale price contract is the most common in practice, which means that suppliers sell goods to retailers at a certain wholesale price, and retailers determine their order quantity to maximize profits. It is easy to execute with low operating costs, and the market risk is entirely borne by the retailers, and the suppliers do not need to bear the risk, so it is favored by the suppliers. However, Lariviere and Porteus (2001) proved that this contract could be coordinated only when the wholesale price is equal to the cost of the products. The supplier's profit is equal to zero, which is impossible, resulting in a “double marginalization effect”. Secondly, the revenue sharing contract means that at the beginning, suppliers sell commodities to distributors at a lower wholesale price. After the sales cycle, a certain proportion of the proceeds of products to suppliers are distributed. Through revenue sharing, suppliers can share part of the risks caused by market uncertainty, and profits of the supply chain can be redistributed among different members to achieve coordination (Li et al. 2019). Thirdly, the options elastic quantity contract refers that the retailers use the wholesale price to order some products from suppliers and allow the suppliers to pay a fee for purchases in the future. Under this contract, the retailer could purchase goods at a fixed price in the future. Barnes et al. (2002) conducted a systematic study on option elastic quantity contracts. Fourthly, the sales rebate contract has two forms: one is a linear rebate, in which the supplier pays a certain proportion according to the final sales quantity of the retailer after the sales season; The other is an incremental rebate. Only when the retailer's sales quantity reaches a certain value can the supplier give a certain proportion of rebate to the excess part. This contract type was studied by Netemeyer et al. (2004) and Taylor (2002). Fifthly, the quantity flexibility contract is that the retailer sets an order number before the sales season, and can then adjust the previous order quantity according to the market demand (Tsay and Lovejoy 1999). Sixthly, the quantity discount contract gives different discounts based on the retailer's order quantity (Nie and Du 2017). The last one is the buyback contract, which is an agreement for the manufacturer to buy back unsold products at a certain price at the end of the sales period if the retailer has unsold products. The purpose of the buyback contract is to promote the retailer to order more and ultimately improve the revenue. With the buyback contract, the risk of uncertain market demand is shared by the cooperative enterprises (Pasternack 1985; Xue, Hu, and Chen 2018). This contract is very common in perishable goods supply chains. Figure 2.1 shows some supply chain contracts.

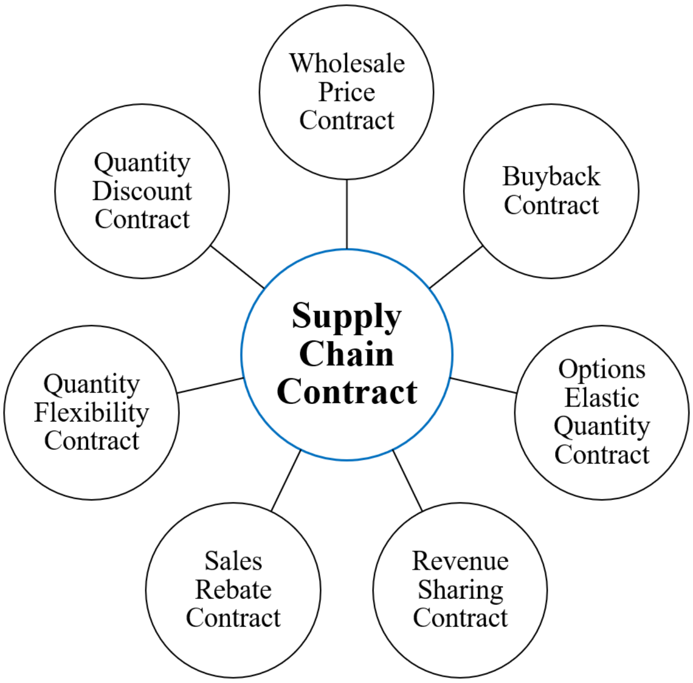

Figure 2.1 Common supply chain contracts.

Under the buyback contract, retailers return unsold products to sellers after the sales season. The buyback contract not only motivates the retailer to order more and further increase the market share but also loses the supplier's brand image and reputation due to product shortage. The buyback contract has been widely studied by researchers. For instance, Marvel and Peck (1995) studied the impact of the buyback contract on retailers' inventory and retail price decision-making process. When suppliers provided retailers with higher buyback subsidies, retailers can be encouraged to maintain high inventory levels in response to high market demand. Katok and Wu (2009) investigated the performance of three different contracts including the buyback contract, and the individual rational buyback contract was designed by Devangan et al. (2013). Xue et al. (2018) studied the value of the buyback contract and presented the effects of uncertainty of demand, level of competition, and processing cost of the contract on the profits. A "capital-constrained news supplier" problem in the SCF system was studied by Shi et al. (2020), in which the manufacturer provided a buyback contract that compensates lenders if the retailer defaults. Wang et al. (2021) studied the signaling effect of repurchase contracts when retailers did not know the manufacturer's reliability in fulfilling its repurchase commitments or the market potential of its products.

2.1.3 Green supply chain management

The costs of global warming are getting higher and higher, affecting economies around the world. One of the main causes of the greenhouse effect is that more carbon dioxide is being released into the atmosphere (Gleick et al. 2010). GSCM aims to encourage suppliers and retailers to consider energy conservation and emission reduction when making business decisions, in an attempt to solve the pollution problems caused by industrial development (Bhatia and Gangwani 2020; Rinaldi et al. 2021). Because of the increasing awareness of the significance of environmental protection, researchers have paid more and more attention to solve the pollution problem caused by industrial development in SCM. Many studies have included sustainability and environmental concepts into GSCM (Sheu et al. 2005).

Cheah and Phau (2011) observed that consumers have an environmentally friendly attitude when purchasing products. Cheah and Phau (2011) investigated the relationship between consumers' knowledge of environmental pollution and their purchase intention regarding green products. Zhao et al. (2012) found that improving the environmental performance of enterprises can increase economic profits. Subsequently, Zhang and Liu (2013) established a GSC coordination model with three levels where customer demand depends on product greenness. Recently, Jamali and Barzoki (2018) discussed the revenue sharing contract in the GSC model. Gao et al. (2020) investigated the dual-channel GSC with the eco-label policy. Agi et al. (2020) made a systematic review in GSCM. Bhatia and Gangwani (2020) reviewed the empirical research on GSCM and discussed its current status. Zou et al. (2021) put forward a risk standard evaluation system of GSC, and the correlation degree among supply chain risk factors was clarified by using the grey correlation analysis method.

2.2 Supply Chain Finance

2.2.1 Overview of supply chain finance

Research on SCF dates back to the 1970s and the impact of the changes on policies related to trade credit and inventories were reviewed by Budin and Eapen (1970). De Boer et al. (2015) first used the term "Supply Chain Finance", believing that SCF represents the control and optimization of capital flow caused by material flow. In the beginning, it did not arouse much recognition among researchers, but after the financial crisis in September 2008, SCF, as a new financing strategy, has attracted more and more attention. One of the most important reasons for the rise of SCF is that it provides convenient and reliable financial services to the supply chain enterprises through the core enterprise in the supply chains. It can effectively release the overall supply chain operation cost, mitigate and prevent operating risks, realize mutually beneficial coexistence of enterprises and financial institutions, and promote the sustainable development of industrial ecology. SCF generally has three aspects (Steeman 2014; Templar et al. 2016; Zhao and Huchzermeier 2018b), as shown in Figure 2.2. First of all, the SCF refers to the optimization planning, management, and control of the supply chain cash flow to promote the efficient material flow in the supply chain (Wuttke et al. 2013). Secondly, the SCF is a collection of financial instruments to improve the efficiency of capital flows in the supply chain. Pfohl and Gomm (2009) defined financing optimization and financing process integration among customers, suppliers, and service providers. Thirdly, the SCF can simply describe Supplier Financing (SF) as a retailer-driven accounts payable solution, where the lender purchases receivables only from retailers with specific information transparency (Klapper 2005).

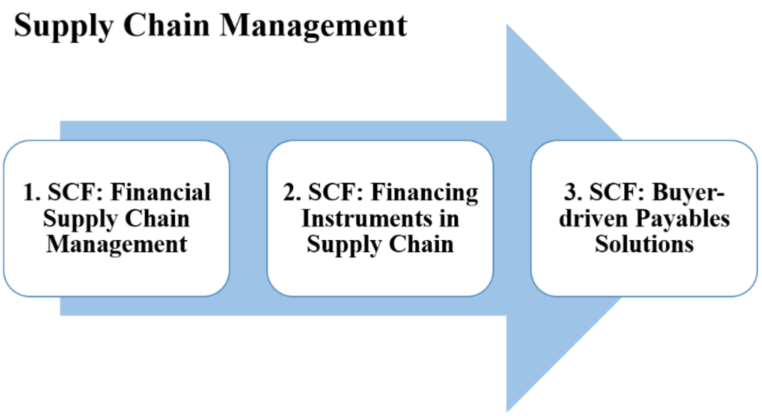

Figure 2.2 Aspects of SCF.

The major benefit of SCF programs is to reduce financing costs for suppliers or buyers. These programs further strengthen supply chain relationships, increase the negotiating power of its members, and improve financial services (Lekkakos et al. 2016; Zhao and Huchzermeier 2018b). Specifically, the supplier can immediately access cash, improve cash flow visibility, lower financing costs and there is no debt on the balance sheet; the retailer can lower the cost of goods sold, decrease supply chain risks, and use financing strength as a competitive advantage; the bank earns income from financing, have new customers-suppliers who gain financing. What's more, for the whole supply chain, costs and risks are lowered and working capital is optimized for all parties. Figure 2.3 shows the benefits of SCF for each party (Zhao and Huchzermeier 2018b).

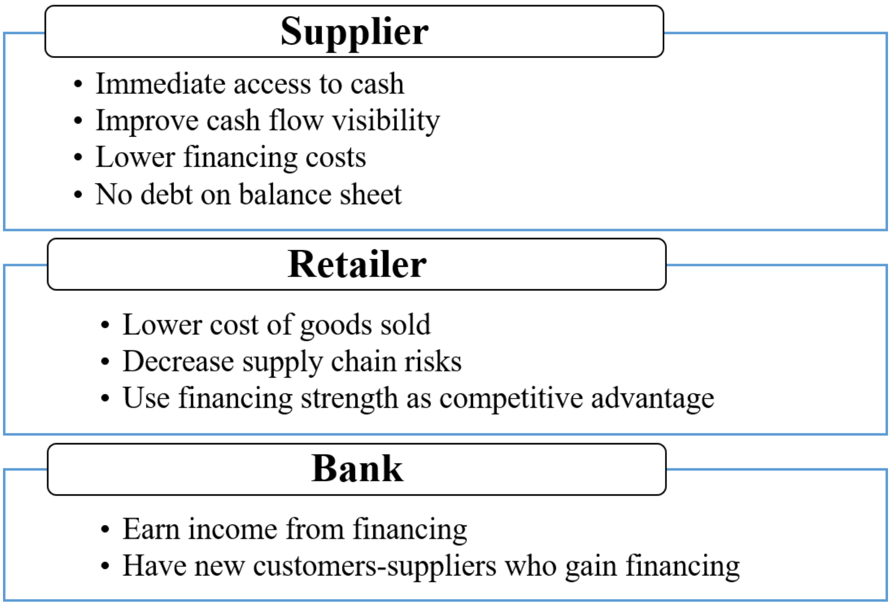

Figure 2.3 Supply chain finance benefits.

2.2.2 Classification of supply chain finance

SCF is divided into different categories. On one hand, regarding the time dimension, SCF instruments can be classified into three classes: pre-shipment financing, in-transit financing, and post-shipment financing (Zhao and Huchzermeier 2018b), as illustrated in Figure 2.4.

a) Pre-shipment financing. This refers to funds advanced to a supplier to support the cost of activities carried out before the shipment of the product (i.e., purchase costs, labor costs, and other overhead costs, etc.) and to provide additional working capital. Credit risk is relatively high because pre-shipment financing is based on purchase orders rather than invoices and it is based on the trust relationship between the buyer and the seller. Therefore, the interest rate is usually high, although it can be lowered according to the creditworthiness of an established retailer. The release of a new product can serve as an example application for such SCF. Here, suppliers need working capital to meet capacity investments in new production facilities, and then retailers (banks or financial institutions) start financing suppliers.

b) In-transit financing. This approach offers a loan from a bank or financial institution based on products or inventory currently being shipped or embedded in other logistics processes. The risk is less than the first financing situation.

c) Post-shipment financing. This enables the capital demander to obtain working capital from the bank or financial institutions based on accounts receivable. In this case, the collateral is an invoice, shipping document, or a draft on the retailer. Consequently, the risks are lower than the first two types.

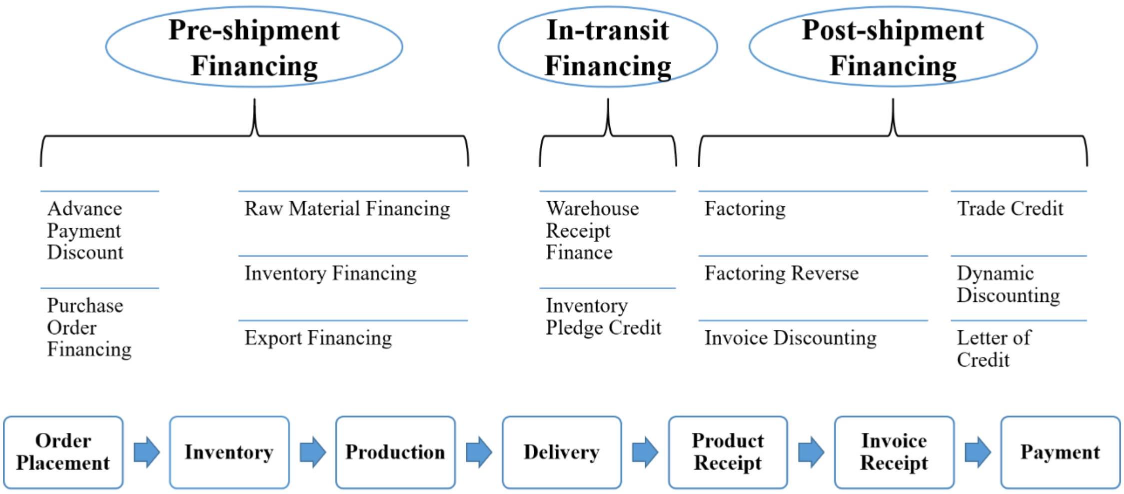

Figure 2.4 Timing-based classification of SCF.

On the other hand, based on the availability of collateral, SCF can be divided into arm's length financing and relationship financing (Navas-Alemán et al. 2012; Zhao and Huchzermeier 2018b), as shown in Figure 2.5.

d) The arm’s-length financial instrument is based on verifiable information or tangible collateral, such as invoices, bills of exchange, purchase orders, and so on, so they are related to enforcement mechanisms in the case of non-delivery or non-payment. Therefore, financial institutions can more accurately estimate and control the credit risk on the basis of the verifiable collateral.

e) Relationship financing relies on the trust relationship established between the buyer and the seller, rather than a binding contractual relationship, as a result, there is rarely any tangible collateral. Supply chain financial service providers are typically members or platform service providers in supply chain operations. They fully understand the borrower's credit status, transaction history and supply chain operation ability, and can accurately assess the borrower's credit status, so as to make financing decisions.

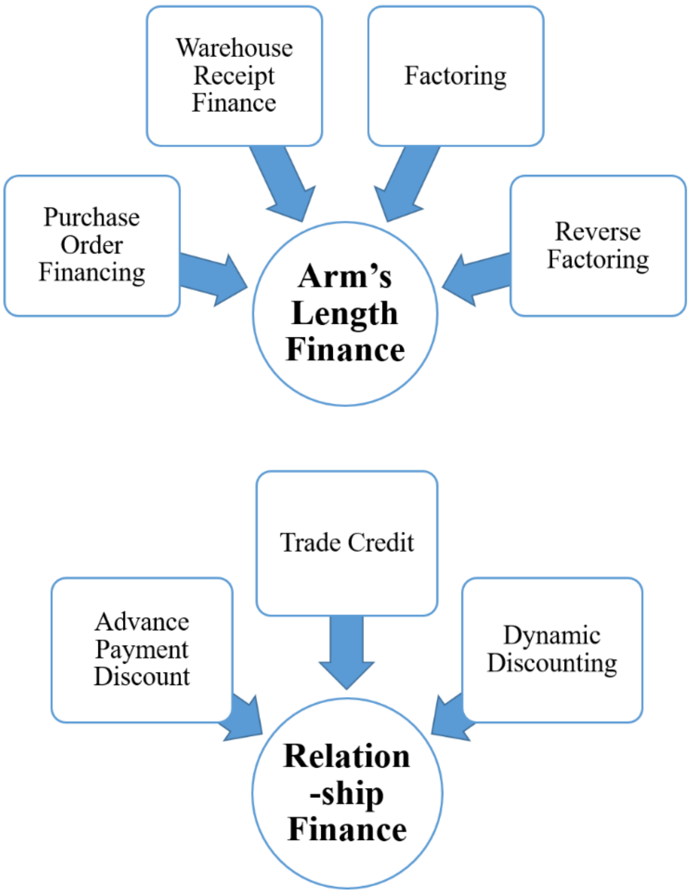

Figure 2.5 Classification of SCF based on the availability of collateral.

2.2.3 Supply chain financing instruments

The characteristics of SCF instruments based on the collateral, beneficiaries, sum financed and credit guarantee providers, and payment timing are reviewed (Zhao and Huchzermeier 2018b), as shown in Table 2.1.

Table 2.1. An overview of SCF instruments.

SCF instrument	Collateral	Financier	Beneficiary	Credit guarantee	Payment timing
Advance payment discount	Purchase order	Buyer	Supplier and buyer	Buyer	Pre-shipment
Purchase order financing	Purchase order	Bank	Supplier	Supplier	Pre-shipment
Buyer-backed purchase order financing	Validated purchase order	Bank	Supplier	Buyer	Pre-shipment
Warehouse receipt financing	Warehouse receipt	Bank	Supplier	Warehouse	In-transit
Inventory pledged financing	Pledged inventory	Bank	Borrower	Borrower	In-transit
Trade credit	Invoice	Supplier	Buyer	Supplier	Post-shipment
Dynamic discounting	Invoice	Supplier	Buyer	Supplier	Post-shipment
Recourse factoring	Invoice	Bank	Supplier	Supplier	Post-shipment
Non-recourse factoring	Invoice	Bank	Supplier	Supplier and buyer	Post-shipment
Reverse factoring	Validated invoice	Bank	Supplier	Buyer	Post-shipment
Letter of credit	Bill of lading	Bank	Supplier	Buyer	Post-shipment

Specific financing instruments are introduced as follows:

f) Advance payment discount: The buyer pays at the unit discount prior to delivery, which is discussed in more detail later.

g) Purchase order financing: The bank purchases accounts receivable from the supplier before shipment according to the purchase order.

h) BPOF: The bank purchases supplier receivables guaranteed by the buyer under the purchase order, and the buyer's credit rating is particularly important in this form of financing

i) Warehouse receipt financing: This financing is known as the “warehouse receipt pledge financing, warehouse financing”, and refers to the applicant having full ownership of the goods stored in its commercial bank's designated storage company and issued by the parties on warehouse receipt pledge in the bank (Mahanta 2012).

j) Inventory pledged financing: This refers to the business activities in which the enterprise (the borrower) in need of financing pledges its inventory to the fund provider (the lender) and meanwhile transfers the inventory to the logistics enterprise with the legal inventory storage qualification for safekeeping to obtain the loan from the lender. It is the chattel pledge business with the participation of the logistics enterprise. (Song et al. 2016).

k) Trade credit: The retailer is offered a discount for advance payment. Interest is charged on deferred payments. In other words, it is a financial instrument that gives buyers a discount when they pay within a specified period. If the buyer remits later, he or she will have to pay the wholesale price in addition to the pre-specified interest (Giannetti et al. 2011).

l) Dynamic discounting: The retailer is offered a discount based on the time it takes to receive the payment. Interest rates depend entirely on the credit ratings of suppliers and buyers (Gelsomino et al. 2018).

m) Recourse factoring: The seller sells accounts receivable at a discount for immediate payment to a bank or a financial institution with recourse. In recourse factoring, the financier is entitled to require the supplier to pay any unpaid invoice amount (Auboin et al. 2016).

n) Non-recourse factoring: This refers to factoring taking over the receivables of the debtor and providing bad debt guarantee liability from the supplier within the credit line according to the debtor's approved credit line provided by the supplier. (Auboin et al. 2016).

o) Reverse factoring: In this, the buyer of the accounts receivable bought by the factoring is a company with a high credit level. Therefore, the bank evaluates the credit risk to implement factoring, and the credit recovery flow is also directly from the buyer. Small suppliers with financing difficulties can use their receivables of large buyers for working capital financing and reduce the financing cost of small suppliers by replacing the high credit risk of small suppliers with the low credit risk of large buyers (Van der Vliet et al. 2015).

p) Letter of credit: a bank or financial institution guarantees that the buyer makes payment to the supplier. The buyer makes the payment within the specified date upon presentation of the documents. The beneficiary can transfer the credit to another company upon mutual agreement, which then has the right to use the credit. The bank issuing the letter of credit usually needs to pledge securities or documents (such as bills of lading) as collateral (Ahn and Sarmiento 2019).

Moreover, supply chain companies are increasingly concerned about environmental and social sustainability. Nestle, for instance, cooperated with the local government and a local bank to provide financial support to farmers to solve the shortage of funds for dairy farmers. It embraced the principle of "creating shared value" as part of its sustainability strategy. (Gong et al. 2017). Nevertheless, few studies have examined the correlation among GSC, sustainability, and SCF. Therefore, it is worth studying how SCF promotes the sustainable development of the supply chain and produces more environmentally friendly green products. For instance, Dye and Yang (2015) examined sustainable trade credit and supplementary decisions with considering carbon emission regulations. Therefore, combining GSC and SCF is becoming a fertile area for SCM research.

2.3 Managing Capital Constraint of Buyer

One of the most important decisions cash-strapped buyers face is how to raise working capital. In response to the financial constraints of buyers, trade credit and bank finance are two common financing methods to solve the problem. Generally speaking, bank finance requires enterprises to have sufficient collateral and a good credit record, while trade finance is more flexible, which is an important channel for enterprises, particularly for Small and Medium-Sized Enterprises (SMEs), to derive financing. Many sellers are willing to offer trade credits to their buyers so that the retail channel can operate sustainably. With this credit, the buyer can defer payment until the product is sold.

Trade credit is a very common way of financing in business activities. Jing et al. (2012) detected financing balance between bank credit and trade credit when a retailer had limited capital. Kouvelis and Zhao (2012) analyzed the importance of trade credit, and a novel model with trade credit was proposed by Zhong et al. (2018) in order to optimize the location, transportation, inventory, and financing costs of the system. Alan and Gaur (2018) explored the importance of inventory in both bank financing and trade credit. The interaction between financial decisions and operational decisions for a retailer with limited capital under a carbon cap-and-trade mechanism was studied by Cao and Yu (2018), and trade credit financing was used to tackle the issue of lack of funds. In order to achieve good coordination and maximize the profit of each member, Ghosh et al. (2021) proposed a strategy (manufacturers provide trade credit to the retailer, and provide prepaid wholesale price discounts to the financially strong retailer). In fact, many academics have shown that trade credit is benefit to finance capital-constrained buyers (Jing et al. 2012; Jing and Seidmann 2014; Kouvelis and Zhao 2012). Moreover, Yang et al. (2017) examined the impact of equity financing on the optimal decisions of one supplier and two capital-constrained retailers and the supply chain performance. Yan et al. (2018) explored two SCF options for capital-constrained retailers: SF and Supplier Investment (SI), and found that supply chain participants preferred SI over SF if the retailer was very capital-constrained. Huang et al. (2019) established a two-tier game model in which the retailer could receive financing from a bank via supplier credit guarantee loan. Luo et al. (2020) studied the optimal purchasing decision of a two-level GSC under SF and bank financing and found that whether SF or bank financing, the benefits of the participants were higher than the benefits in the benchmark model, and cleaner production would benefit more to supply chain participants. Therefore, the above studies are mainly based on post-shipment financing to deal with the downstream buyer’s financial constraints.

2.4 Mitigating Financial Distress of Supplier

Another category of the relevant literature focuses on the effects of mitigating financial constraints on upstream suppliers. Suppliers need to have sufficient working capital in order to maintain production and other business operations, but in some cases, many suppliers may not have sufficient working capital. When suppliers supply downstream retailers, for example, they often have to endure long payment delays after delivery. As a result, suppliers, especially those of SMEs, need cash and capital to maintain their operations. In addition, many cash-strapped suppliers had to abandon lucrative orders because they did not have the money to complete the production of the orders. However, small and medium-sized suppliers struggle to get cheap financing because they lack credit histories and collateral of sufficient value. Some suppliers often resort to high-interest loans, taking on too much economic burden, increasing the overall cost and reducing the supply chain efficiency.

To address suppliers’ financial distress, besides bank financing and reverse factoring, some enterprises provide financing to suppliers directly through various means, such as advance payment for each order, establishing a common financing plan for suppliers, or even buying suppliers’ inventory to relieve their financial pressure. This financial method has aroused wide concern (Van der Vliet et al. 2015). Tanrisever et al. (2015) studied how reverse factoring created value for enterprises, as well as the impact of the spread of exogenous financing cost, working capital policy, payment term extension, and risk-free interest rate determined by the bank on the value. Rui and Lai (2015) discussed supplier deferred payment as a way to encourage the supplier to invest in improving product quality. They showed that deferred payment could improve investment and compared its effectiveness with buyer's product inspection. Huang et al. (2018) indirectly supported small suppliers by using BPOF with a reputable buyer and two capital-constrained suppliers, where the buyer provided a partial or full guarantee to share the financing risks of the bank, thus assisting SMEs in applying for loans. Reindorp et al. (2018) used Purchase Order

Financing (POF) to solve the financial constraint problem of a supplier and showed that the retailer might be inclined to ease the financial constraints of the supplier by adjusting the wholesale price or combining the wholesale price with commitments. Tang et al. (2018) considered information asymmetry in both buyer direct financing and POF and showed that if the supplier had severe capital constraints, superior information made buyer direct financing more attractive. Other works on various seller financing solutions can be found in Xiao and Zhang (2018), Tunca and Zhu (2018), Zhao and Huchzermeier (2018a), Yang et al. (2019), and others.

The study is based on the recent literature on reducing financial constraints by APD and BPOF and the literature on the integration of SCF into green supply chains.

1. APD

Some scholars have begun to study the field of operations management in advance payment (Fisher and Raman 1996; Maiti et al. 2009). For example, a supply chain with one supplier and several retailers was studied by Thangam (2012) to provide advance payment discounts for customers with two-level trade credit. He also compared the interest earned from prepaid, immediate, and deferred payment plans. A real coded genetic algorithm was used by Gupta et al. (2009) to solve the mixed-integer constrained optimization problem with APD. Chen et al. (2017) analyzed the effectiveness of early payment financing with a cash-strapped manufacturer as well as a cash-rich retailer in a pull supply chain. Qin et al. (2019) used the game theory analysis method to test the value of APD to carbon emission reduction and production and found that in the absence of financial constraints, prepayment financing with a low-price discount could increase profits. Khan et al. (2019) described the effect of early-payment financing on supply decisions for perishable goods and showed that the demand depended on price and inventory. The advance payment policy was also studied by Li et al. (2019), Zhang et al. (2016), Khan et al. (2020), Manna et al. (2020).

2. BPOF

To satisfy the financing needs of the suppliers, POF has recently emerged, secured by tangible assets, and repayment of POF loans is subject to the supplier successfully delivering the relevant purchase order. When there is no buyer guarantee, the interest rate on such financing relies on the credit rating of the supplier. Wu (2017) analyzed POF and financial subsidies and showed the impact of loan interest rates on buyers' purchasing and financing decisions. To solve the problem of direct financing by the buyer and order financing without buyer's guarantee in the signal game, Tang et al. (2018) studied the influence of information asymmetry on cost. Reindorp et al. (2018) presented the effect of a POF scheme, and Tang et al. (2018) considered information asymmetry in both buyer direct financing and POF and showed that if the supplier had severe capital constraints, superior information made buyer direct financing more attractive. When the POF loan is guaranteed by the buyer with good credit, the financing rate of the supplier depends on the buyer's credit. This arrangement is known as BPOF. This variant allows the suppliers to sign a larger number of orders based on external funding from banks, or other financial institutions. Cao et al. (2019) used BPOF to help alleviate the financial difficulties of the suppliers and increase the income of the retailer. Besides, they demonstrated how the initial capital of suppliers and inventory risks of supply chain members affected the optimal decision.

3. Integration of SCF into green supply chains

The research of Zhan et al. (2018) showed that advance payment and reverse factoring could promote the supply chain’s sustainability and efficiency. A green inventory model was developed by Tiwari et al. (2019) to help the enterprise maximize annual total profits under different trade credit policies and reduce the environmental impact. Xu and Fang (2020) developed an emission-dependent model with partial credit guarantee and trade credit. Ghosh et al. (2021) focused on GSCM and developed a strategy based on advanced payment policies for manufacturers and trade credit facilities for retailers. Abdel Basset et al. (2020), Zhao et al. (2020), Lin and He (2019), Luo et al. (2020), and Li et al. (2021) also integrated SCF with green supply chains.

2.5 Perishable Goods with Salvage Values

With the rapid development of science and technology and the economy, more and more new products are being frequently launched. With the increasing number of these new products, some companies eliminate the old products as soon as they launch the new products. After new products are launched, the market share of the old perishable goods drops rapidly and may not be fully sold in the normal selling season. Retailers often clear excess inventory through the salvage value approach (Wang and Webster 2009). Salvage value is the amount received by selling unsold products at the end of the sales season. For assets with significant secondary market value, such as vehicles, earth-moving equipment, or assets with significant scrap value, such as ships, the salvage value may be a key factor in the replacement decision because it involves cash flow (Adkins and Paxson 2017). Based on the final value, perishable goods with salvage value can be broadly classified into two types—positive salvage value and negative salvage value. The details are as follows.

1. Perishable goods with a positive salvage value

Perishable goods with positive salvage value mainly fall into the following categories. First of all, high-tech products usually have a positive salvage value. At the end of the market life cycle, there are a lot of unsold products, especially in high-tech industries such as smartphones, tablets, and wearables. These products remain fully functional after the sales period. In other words, a product with a high salvage value means that its market value disappears quickly, but the use value of the product does not decline sharply over time and can be maintained for a certain period of time. The second is to focus on the brand value of high-end products. High-end products in showcases are expensive because the price of these products is related to the brand value. At some point, a high-end product may be completely unwanted in the next season. For example, expensive fashions designed by famous fashion designers will be out of fashion in the second year, and sellers are also reluctant to cut prices to protect their brands. Mauer and Ott (1995) interpreted salvage value and depreciation as functions of stochastic operating costs, while Dobbs (2004) embedded salvage values in the single-factor model. Yu and Xiang (2016) studied the optimal yield and expected profits of a manufacturer with different salvage value channel structures. Yang et al. (2014) studied two competing retailers with revenue targets and found that positive and non-positive salvage values could result in varying outcomes. A salvage value contract was designed by Castañeda et al. (2019) under which the United Nations World Food Programme would purchase the remaining stock from the manufacturer at salvage value.

2. Perishable goods with a negative salvage value

When the salvage value is negative, it means that it constitutes an expense. For many industries, dealing with products with negative salvage value is a critical problem. This is because, with increasing concern for the environment, regulated companies cannot simply discard out-of-season products, some of which produce harmful substances in the process. As a result, they may have to spend additional processing costs to make them safe and protect the environment, thus leading to negative salvage value (Welke 1988). These include goods such as unsold over-the-counter medicines, chemicals. Most previous research on perishable goods considered a positive salvage value case, and few studies also incorporated a negative salvage value into the model. Yang et al. (2011) studied a single price-setting newsvendor approach and assumed the salvage value strictly positive. Keren and Pliskin (2006) obtained the first-order condition of optimality of the expected utility maximization problem with risk aversion and pointed out that the salvage value could even be less than zero. Zhang et al. (2019) showed that when the net salvage value was negative, implementing a Money-Back Guarantee was not a great choice for the manufacturer.

In addition, it is clear that the majority of the research assumed that the salvage value was fixed. But some scholars and empirical evidence pointed out that the salvage value was variable (Cachon and Kök 2007; Alan and Gaur 2018), and no researchers have yet investigated the time-varying salvage value.

As far as we know, there are few papers in the field of SCM that consider both the salvage value and financing scheme. Chen et al. (2018) presented that the salvage value affected the fairness-concerned seller's optimal order quantity via buyback guarantee financing mode. Lekkakos et al. (2016) suggested that operation decisions and SMEs' performance were affected by reverse factoring and assumed that any leftover products could be salvaged at the unit production cost.

2.6 Application of Financing Instruments

In some specific industries, such as manufacturing or retailing, SCF is more worthy of researchers' attention. Klapper (2006) illustrated the benefits of reverse factoring and POF through the Nafin project in Mexico. Filbeck et al. (2016) explored the influence of supply chain disruptions on rivals in the automotive industry. Chen et al. (2019) took Jingdong, a large Chinese e-commerce platform, as an example, and studied the role of SCF in improving the competitive advantage of online retail firms and determined the motivation and contributing factors for adopting SCF. The mobile phone supply chain is worth studying, and Wang et al. (2019) considered a single mobile service operator and examined how fairness affects pricing, subsidies, and channel selection between unlocked channels and bundled channels in the field of SCM. Besides, most SCF studies focus on retailers' capital constraints, with little discussion of supplier capital constraints (Yan et al. 2020; Tang et al. 2018; Tunca and Zhu 2018). Moreover, existing SCF research fails to apply financing tools to the mobile phone and television industries for solving the financing difficulties of suppliers and in mitigating financing risks.

2.7 Research Gaps

The research gaps are stated as follows:

1. Post-shipment financing has received a lot of attention. However, pre-shipment financing is also critical for both trade and emerging markets. Credit risk is relatively high in pre-shipment financing is based on a purchase order rather than an invoice and it relies on the trust relationship between the buyer and the seller. Therefore, pre-shipment financing is worth

studying. Furthermore, there is sparse literature on how to solve the problem of supply chain working capital constraints through APD and BPOF, most of which are solved via bank financing, trade credit, and reverse factoring.

2. Most research models assume the salvage value of unsold products to be zero or negligible. However, in real life, the salvage value of unsold goods can be positive or negative based on the end of the quarter value. Hence, the positive or negative salvage value is an important topic worth studying. Up to now, there has been no systematic study reported in the SCF literature as to whether the existence of positive and negative salvage values affects the operations and financing decisions. Moreover, it is clear that most of the research assumed that the salvage value was fixed. However, some scholars and empirical evidence pointed out that the salvage value was variable (Cachon and Kök 2007; Alan and Gaur 2018), and no researchers have yet to investigate the time-varying salvage value, that is, the later the clearance, the smaller the salvage value.

3. Typically, if there are some unsold goods after the sales quarter, retailers are assumed to dispose of those items themselves in most studies, but in real life, retailers can return the unsold inventory to the suppliers. Buyback policy means that the supplier buys back unsold products at a certain price from the retailer, however, there is sparse literature on integrating the salvage value and the SCF under buyback policy, although this problem is faced by practitioners. Investigating how the difference between the buyback price and salvage value affects the optimal operational decisions in supply chains is important.

4. When previous studies focused on GSC and environmental sustainability, they mainly discussed how enterprises make optimal decisions according to different carbon sources, policies, carbon emission costs. However, few studies have considered the relationship between GSC and SCF, and how to help suppliers solve the problem of capital constraint to produce more environmentally friendly green products need studying.

5. Existing research on SCF is seldom applied in specific industries. Therefore, scholars can consider the application of SCF in various industries, such as high-tech industries. Therefore, it is very meaningful to apply financing tools to the mobile phone and TV supply chains to solve the financing problems of suppliers.

To fill the above research gaps, this thesis investigates the use of pre-shipment financing to help cash-constrained upstream suppliers for producing products smoothly rather than post-shipment financing to finance the downstream buyers. Various salvage values such as positive and negative salvage values and time-dependent salvage values are considered in the models. Besides, this research contributes to previous research by examining the impact of the difference between the buyback price and the salvage value on operating decisions and financing issues. This study also helps to bring management significance to players in the mobile phone and TV fields and helps the supplier to produce more environmentally friendly green goods.

CHAPTER 3 Problem Description

In this Chapter, firstly the problem background is introduced in Section 3.1. Section 3.2 presents the problem statements.

3.1 Problem Background

In the 21st century, the world has gradually entered a new industrial revolution, and the competition in the manufacturing industry has intensified, which has brought new opportunities and challenges to suppliers. However, the existence of many suppliers often hinders the realization of an efficient supply chain due to financial constraints and financing difficulties. This is a capital-constrained supply chain, which refers to the supply chain with insufficient working capital of upstream and/or downstream enterprises. Therefore, how to deal with the ubiquitous corporate financial constraints and financing problems has become a key issue. In addressing this problem, SCF is a significant approach that optimizes the working capital of the supply chain's participants. This financial mode makes use of the high-quality credit loan resources of the core companies to help capital-constrained enterprises obtain funds. In the past few years, various SCF models have been proposed and applied in the steel, automobile, construction machinery, household appliances, and other industries (Chen et al. 2017). Effectively using external and internal sources of funds to solve the supply chain parties' working capital constraints is a significant research field. A buyer can finance the supplier through APD to alleviate the financial stress before product delivery. The unit discount provided by the supplier can also be viewed as the amount of interest on deferred payment which encourages the retailer to pay upfront. However, there is sparse literature on how to solve the problem of supply chain working capital constraints through APD. Furthermore, considering external financing instruments to address the financial problems is also important. BPOF is an external financing tool to deal with the capital-constrained supplier's problem. A financial institution provides loans according to a reliable buyer purchase order before product delivery. However, there is little information on BPOF despite it emerging as a financing instrument. Hence, Chapter 4 and Chapter 6 of this study focus on both

APD and BPOF to deal with the financial stress of the supplier. Furthermore, in real life, retailers can return the unsold inventory to the suppliers. Motivated by this fact, in Chapter 5, two financing options are studied to address the shortage of funds of a smartphone supplier under a buyback policy where the unsold phones can be bought back by the handset vendor. To be specific, one option is BSAPD, which specifies that the downstream retailer pays in advance while the supplier offers a unit discount on the wholesale price, and the supplier buys back unsold products with salvage value after the sales season. The other option is BSBPOF, whereby a financial institution offers the supplier loans guaranteed by the downstream retailer before product delivery, and the unsold items will be bought back by the supplier after the normal sales season.

Further, with the progress of science and technology and the intensification of market competition, the product life cycle is shortened, and the replacement of products is accelerated. An increasing number of products (such as electronic products, personal computers, information products, toys, cosmetics and perfumes, and fashion items) have the typical characteristics of perishable products, which are seasonal or short-lived (Tsay 2001). Due to the uncertainty of market demand, buyers may purchase more goods from suppliers before the beginning of the sales season than the market demand, so they may face the problem of excess inventory. In practice, retailers can clear excess inventory using the salvage value (Wang and Webster 2009). Salvage value is the amount gained by processing unsold inventory after the selling season. The salvage value of these goods still exists and is positive (still valuable) or even negative (generating processing costs). In many previous works in the literature on SCF (Tang et al. 2018; Cao and Yu 2018; Tunca and Zhu 2018), the salvage value was ignored in short-term financing in order to simplify the calculation; thus, the salvage value of unsold products was set to zero in such studies. Most previous research on perishable goods considered a positive salvage value case, and few studies also incorporated a negative salvage value as well into the model. There has been no systematic study in the SCF literature as to whether the existence of positive and negative salvage values affects the operations and financing decisions. Hence the positive or negative salvage value in Chapter 4 is an important topic that needs studying. In addition, in real life, the salvage value can the responsibility of the suppliers since the retailers can return the unsold inventory to the suppliers, hence in Chapter 5, this phenomenon is studied. Moreover, some scholars and empirical evidence pointed out that the salvage value was variable (Alan and Gaur 2018; Cachon and Kök 2007), and no researchers have yet investigated the time-varying salvage value. In Chapter 6, the salvage value is a function of time, that is, all remaining stock is cleared at time-dependent salvage value, and the later the clearance time, the lower the salvage value.

Further, in some specific industries, such as the mobile phone and television industries, SCF is more worthy of researchers' attention. Firstly, smartphones have developed rapidly in recent years. According to Statista, the number of smartphone users worldwide now exceeds 3.8 billion, which means that around 45% of the global population owns a smartphone. That is a big increase from the 2.5 billion users in 2016 (Statista, 2020). In many countries with dense populations, the smartphone market still has great potential. However, due to the large investment in mobile phone research and development and the high production cost, some mobile phone suppliers are often restricted by the lack of funds in the process of product production and supply. When these suppliers are short of funds, the downstream buyers will be at risk of a shortage of goods, which may influence the normal operation of the buyer enterprises, as well as the whole supply chains, even the suppliers themselves, may be on the verge of bankruptcy. For example, Gionee, once China's largest handset maker, declared bankruptcy in 2018 due to a breakdown in its funding chain, after owing 648 creditors about $3 US billion. In addition to the ubiquity of mobile phones, the smartphone industry is updating more frequently than ever before, ranging from a year to a few months (Liu et al. 2019). Except for Apple, which releases a phone every year, other manufacturers such as Samsung, Huawei, OPPO, Xiaomi, and Vivo release new models within a few months. Retailers also stock up on new phones to meet growing consumer demand. The study of this industry is set out in Chapter 5. Secondly, television is now an indispensable part of any family in modern society. According to the Statista Research Department (2021), about 229 million televisions (TVs) were sold in 2017 alone, of which Asia was the largest buyer, accounting for one-third of all TV sales in 2018. Since 2010, the number of households with TVs worldwide has increased by hundreds of millions. Of the 128 million households in the United States, more than 90% have at least one TV set. With the advancement of electronics technology, especially the rapid development of semiconductor technology, technological innovation in the TV field has accelerated significantly. Over the years, televisions have undergone tremendous changes in appearance, size, shape, image quality, design, and viewing methods. Figure 3.1 gives a brief overview of the key technologies and capabilities of TVs from 1924 to 2020 (TAB-TV, 2020; Wikipedia, 2021). The rapid renewal of a TV is not only due to the public's attention to the upgrading of TV technology, but also the idea of environmental issues becoming more and more important in the development of TV. Recently, there has been an increasing demand for green TVs, and the function and fashionable appearance are no longer the main factors that impress buyers.

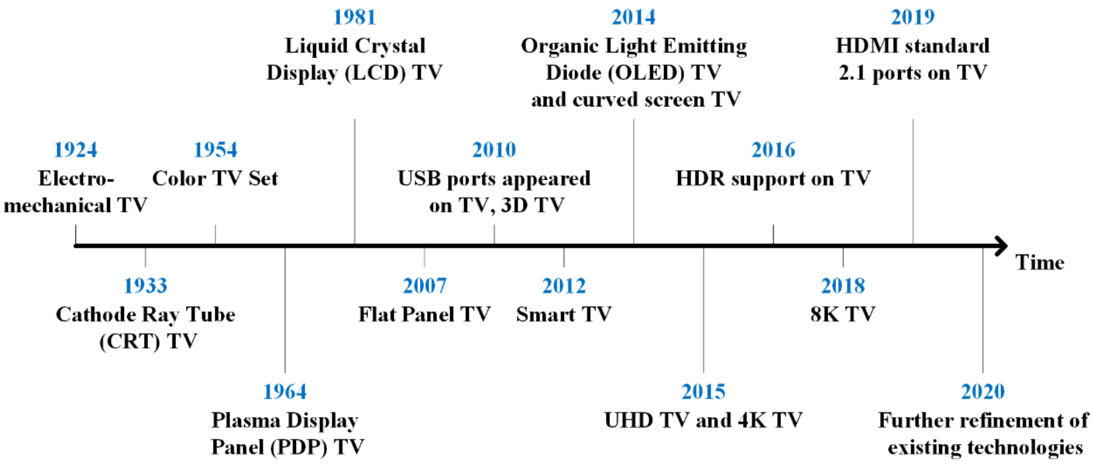

Figure 3.1 Overview of the key technologies and capabilities of TVs from 1924 to 2020.

Green TV is mainly reflected in two aspects. Firstly, it is reflected in televisions becoming more energy-saving, with low energy consumption characteristics. Table 2.2 compares the power consumption of LED, LCD, CRT, and plasma TVs (Energy Use Calculator. 2019). As can be seen from Table 3.1, energy conservation and environmental protection have become the development trends in the TV market, and green technology is developing rapidly. It is found that big-screen TVs consume more energy than small-screen TVs, and new TVs consume less energy than old TVs. The most famous brands, such as Samsung, LG, and Sharp, all use the most energy-efficient TV technology and lead the market. On the other hand, the selection of raw materials for electronic products has been identified as a crucial global environmental problem by many scholars (e.g., Awasthi et al. (2018); Ikhlayel (2018); Gollakota et al. (2020)). A growing number of TV suppliers have upgraded their raw materials to reduce or eliminate harmful substances, including eliminating the use of environmentally harmful heavy metals such as lead and mercury and using new materials that can be recycled. For instance, a TV from LG (55E9 55-inch E9 OLED 4K) won sustainability and eco-design awards at the Consumer Electronics Show in January 2019, mainly because the TV is made of environmentally friendly and recyclable materials, including natural glass (Vertatique, 2019). Furthermore, in 2019, the European Union passed a ban on the use of all organic halogen flame retardants in electronic product enclosures. More than a dozen major TV brands, such as Hisense, LG, Samsung, and Sony, protect their customers by producing safer TVs that do not contain harmful flame retardants. The TV market has been experiencing a wave of replacement sets in recent years as an increasing number of people pursue green TVs.

Table 3.1. Electricity power use by TV type.

Screen Size (Inches)	Electricity Power Use (Watts)			
	LED TV	LCD TV	CRT TV	Plasma TV
15	15	18	65	---
20	24	26	90	---
24	40	50	120	---
30	50	60	---	150
37	60	80	---	180
50	100	150	---	300

Therefore, due to the continuous renewal of green TV, more and more off-season products that are less environmentally friendly cannot be sold during the sales season. Hence the management of out-of-season TVs with time-varying salvage value has become a significant issue that can not only reduce the profit loss of the retailers' remaining inventory but also benefits the development of global sustainable development and environmental protection. The TV sets that are eliminated during the peak sales season can be resold to remote areas of the country or other economically poor, developing countries. As a result, TVs in these regions have also been upgraded to be more environmentally friendly than their previous TVs in that they consume less energy and use more environmentally friendly materials. By selling unsold TVs to such places, the study promotes sustainable development and reduces environmental pollution. In combination with SCF, the TV industry is studied in Chapter 6.

Based on the above facts, the problem issues are introduced from the following three aspects:

1) Participants: In the study, the supply chains comprise four participants. A capital-constrained supplier (seller) provides products to a retailer (buyer), and then the buyer delivers the product to the final customer (see Figure 3.2). These parties collaborate with the financing provider to raise funds by using various supply chain financing strategies. The supplier can raise a loan from a financial institution. It is noted that the financial institution only plays a role in BPOF and BSBPOF. Each party is risk neutral. Before delivery, both the supplier and retailer have limited amounts of internal capital, and they may bear the financial risks before shipment, according to whether internal assets are sufficient to pay for their loans.

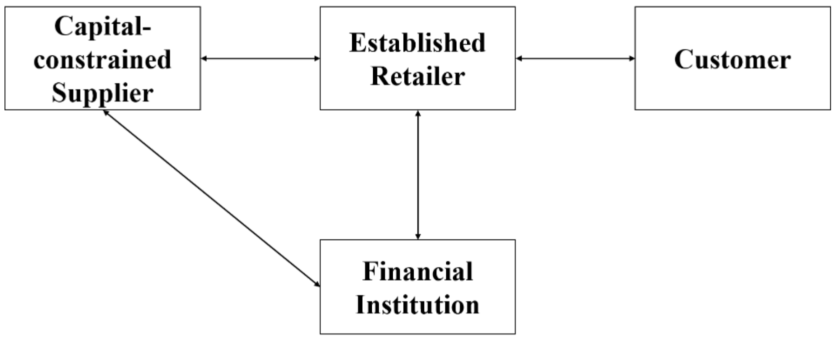

Figure 3.2. Participants in the research.

2) Operation environment and product market: The retailer orders q units of a product from a supplier at a wholesale price w at the beginning of the sales period. After receiving the order, the goods are produced. The supplier has capacity K, and the unit production cost is c_p, and the unit capacity cost is c_k. Customer demand D is stochastic and is realized only after the order is completed. The demand probability density function and the demand cumulative distribution function can be presented by *f(D)* and *F(D)*, respectively. The demand cumulative distribution function is absolutely continuous with density. The complementary cumulative distribution function is defined as $\bar{F}(D) = 1 - F(D)$, hazard rate as $h(D) = f(D)/\bar{F}(D)$ increasing in *D* and generalized failure rate as $H(D) = Dh(D)$ which is monotonically increasing in *D*, see Cachon (2004) for details. Suppose that *F* has a strictly Increasing Generalized Failure Rate (IGFR), and $h(D) = Df(D)/(1 - F(D))$. The risk-free interest rate r_f is zero (Jing et al. 2012).

3) Capital structure and financial market: The supplier is capital-constrained experiencing financial distress in the business and has internal assets *As* and short-term debt *Ls*. *As* is stochastic and not realized until the selling season (Babich 2010; Yang et al. 2015). Its cumulative distribution function is Φ(A_s), and the probability density function is φ(A_s), where $A_s \in \left[\underline{A}_s, \bar{A}_s\right]$ for $0 \le \underline{A}_s < \bar{A}_s \le \infty$ (Babich 2010; Zhao and Huchzermeier 2018a). *Ls* is certain and will expire before the sales peak. The established retailer's credit rating for financial institutions is higher. If the downstream retailer provides financing to the supplier, the retailer can also experience financial difficulties. It is assumed that the capital market is imperfect. If a firm fails to pay its debts, it can either be liquidated or negotiate with creditors in an expensive restructuring process (Zhao and Huchzermeier 2018a). In continuation or restructuring, the retailer pays the financial institutions the principal and interest of the loan and then transfers the balance to the supplier. However, in liquidation, the financial institution accepts the supplier's current assets, and the retailer pays the defined part of the loss of financial institutions (δ), being the credit guarantor. Therefore, in the liquidation, the cost of financial default is a proportion $1-\gamma$ ($0<\gamma<1$) of the firm value. In the reorganization, the cost of financial distress is a proportion $1-\alpha$ ($0<\alpha<1$) of the raised capital (Leland 1994; Gamba and Triantis 2014; Zhao and Huchzermeier 2018a). Moreover, following the convention in SCF literature (Cai et al. 2014; Jing et al. 2012), information asymmetry is not considered.

3.2 Problem Statements

This Ph.D. research study mainly solves the following problems:

First, the focus is on the important positive and negative salvage values (presented in Chapter 4), tackling the following questions.

1) How does the positive or negative salvage value affect the optimal decisions of the participants, under both APD and BPOF?

2) Whether the positive or negative salvage value affects the profits of the participants and even the whole supply chain under both APD and BPOF?

3) How do the positive and negative salvage values affect the threshold of the retailer's asset level under a single financing condition?

Second, under a buyback policy, the following questions (presented in Chapter 5) are addressed.

1) How do an unsold mobile phone’s buyback price and the difference between the buyback price and salvage value affect the optimal operational decisions under BSAPD and BSBPOF (such as the supplier’s capacity level, the discount rate under BSAPD, and the financial institution’s interest rate under BSBPOF)?

2) What is the financing equilibrium when both financing instruments (BSAPD and BSBPOF) are feasible for the capital-constrained supplier?

Third, regarding a green TV supply chain, the following problems are investigated:

1) How to build a green TV supply chain model and what is the effect of the TV

time-vary salvage value on the supply chain participants’ decisions under pre-shipment financing strategies?

2) Which financial strategy, APD or BPOF, should the retailer select to help the supplier obtain funds to produce green products?

3) How to measure potential risks in the green TV supply chain under different financing schemes in the GSC?

CHAPTER 4 The Influence of Positive and Negative Salvage Values on Supply Chain Financing Strategies

In Chapter 4, the influence of positive and negative salvage values on participants' operational and financing decisions is examined. Firstly, the problem statements are described in detail in Section 4.1. Section 4.2 presents the model descriptions. Section 4.3 presents benchmark and base case models, the model of APD, the model of BPOF, and the financing equilibrium in single financing, respectively. The comparisons between the proposed models with positive and negative salvage values and models without considering salvage value are shown in Section 4.4. Numerical experiments are described in Section 4.5. Managerial insights and a summary are given in Section 4.6 and Section 4.7.

4.1 Problem Statement

This chapter focuses on the important positive and negative salvage values. For the positive salvage value, it indicates that the commodities still have value after the selling season. For the negative salvage value, it is a cost is incurred to dispose of the excess inventory, such as products containing materials which are harmful to the environment (Yang et al. 2014). If the salvage value of leftover products is zero, it indicates that the model is built without considering salvage value. Hence in this chapter, the following questions are tackled.

1) How does the positive or negative salvage value affect the optimal decisions of the participants, under both APD and BPOF?

2) Whether the positive or negative salvage value affects the profits of the participants and even the whole supply chain, under both APD and BPOF?

3) How do the positive and negative salvage values affect the threshold of the retailer's asset level under a single financing condition?

To achieve these aims, a newsvendor model in an SCF system is adopted, where a seller with limited funds sells products to a buyer facing uncertain demand. The credit rating of the retailer in the financial institution is higher than that of the SME supplier, which is due to the need to study the guarantee provided by the retailer for the supplier in BPOF. The seller can seek financing support from a financial institution via BPOF and/or directly raise financing from the downstream retailer through prepayment of orders by the retailer.

4.2 Model Descriptions

4.2.1 Notations and assumptions

For convenience, the notations (summarized in Table 4.1) are as follows:

Table 4.1. Summary of notations

Notation	Description
π	Expected profit
A	Asset level
L	Short-term debt
D	Product demand
p	Unit selling price
α	Proportional distress cost
γ	Proportional liquidation cost
δ	The portion of financial institution's loss reimbursed by retailer
c_p	Unit production cost
c_k	Unit capacity cost
r	The interest rate of BPOF
s	Unit salvage value of the item
K	Supplier's capacity
q	Order quantity
w	Unit wholesale price
d	Discount rate under APD
β	A portion of orders under BPOF in dual financing

λ	The portion of purchase order value financed by a financial institution

The salvage value is expressed as s (s>0, s<0 *and* s=0), and p>w. In BPOF, the supplier will receive the λwq loan through a contract $(\bar{\lambda}, r)$ from the financial institution. Here $\lambda \in [0, \bar{\lambda}]$ and r represent the borrowing level and the interest rate, respectively. In the case of liquidation, the retailer, as credit guarantor, pays the previously defined part of the loss of financial institutions (δ). In APD, the supplier offers the discount rate d and ensures $w(1-d) > c_p + c_k$ for profitability. Moreover, the lending market is highly competitive and the financial institution's expected profit is zero, as in Zhao and Huchzermeier (2018a). Throughout this chapter, subscripts "s", "r", and "c" indicate the supplier, the retailer, and the financial institution. Similarly, "csc", "dsc", "bc", "df", "bpof" and "apd" are used to express the centralized supply chain, decentralized supply chain, base case, dual financing, BPOF, and APD respectively. Subscript "0" is that model without considering salvage value, while subscript "1" is for a model with positive or negative salvage value.

4.2.2 Model framework

As mentioned above, there are three key participants in the approach: a capital-constraint supplier (seller), a retailer (buyer), and a financial institution. The buyer purchases goods from the seller. Then, the buyer deliveries the goods to the final market. According to the number of orders and requirements, the retailer may be in stock for the end of the sales season, and must deal with a predetermined salvage value. These parties in this supply chain collaborate with each other to deal with the supplier's financial stress by using two supply chain financing strategies (APD and BPOF). Firstly, the BPOF strategy means that the supplier obtains funds from a financial institution on the basis of a purchase order with the established downstream retailer's guarantee in order to fulfill on-time delivery to the buyer. Secondly, by using APD, the retailer can finance financially troubled suppliers by pre-paying for products at a discount before delivery. In other words, the supplier obtains early payment ("cash in advance") from the retailer for production. Figure 4.1 displays a sequence of events in the two financing instruments (Zhao and Huchzermeier 2018b).

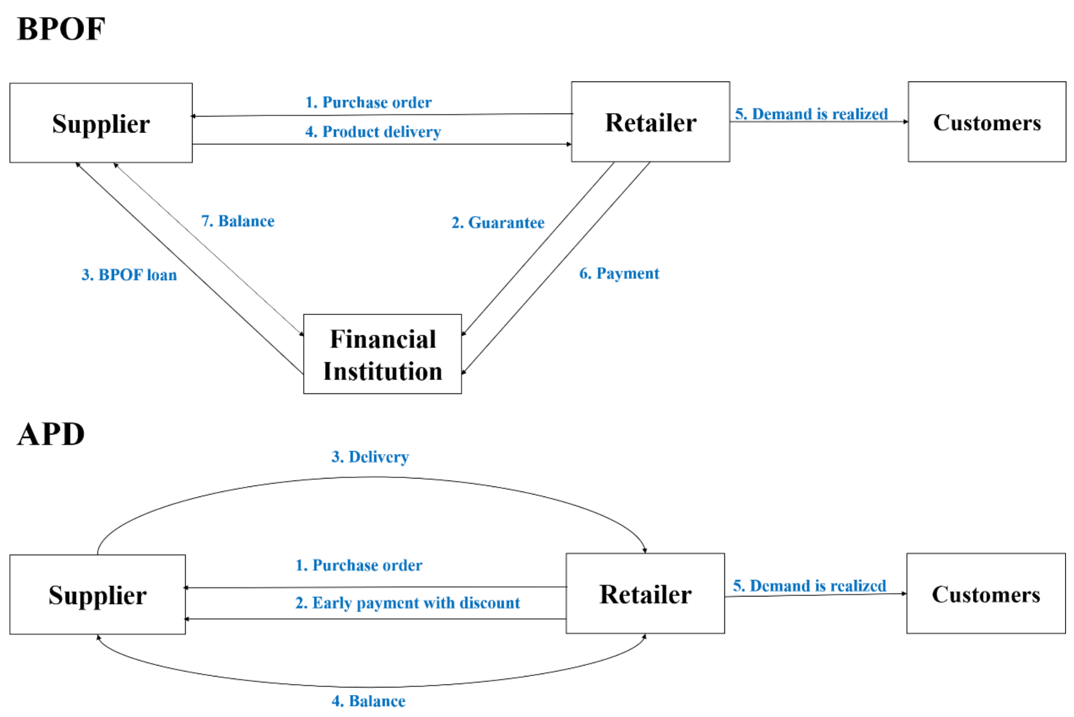

Figure 4.1. The sequence of events of two financing instruments.

4.2.3 Sequence of events

There are two stages in the progress: financing, in which the retailer chooses a financing strategy to reduce the supplier's financial stress; and executing: both parties complete the business. The timeline of events is shown in Figure 4.2, which is based on the study of Zhao and Huchzermeier (2018a).

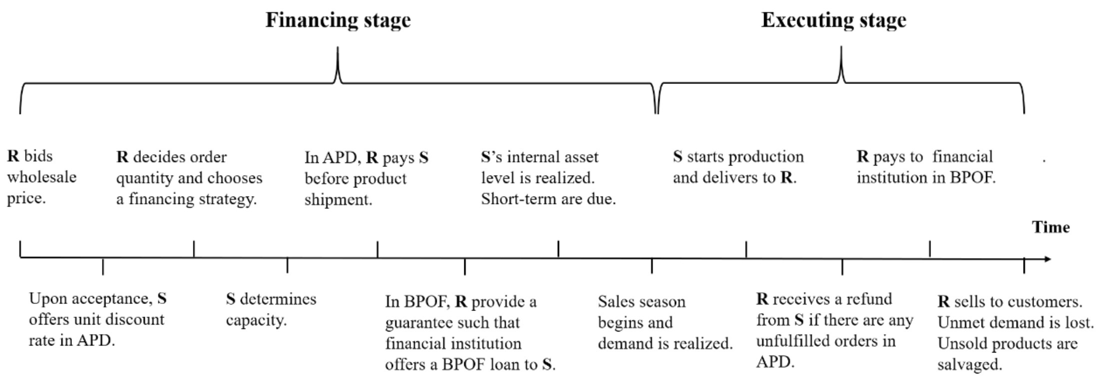

Figure 4.2. Timeline of events.

Specifically, (1) the wholesale price w is set firstly; (2) the supplier decides whether to accept w based on the allocation of its assets, taking into account the possibility of financial hardship and default. Once accepted, the supplier should offer a discount d on w. If not accepted, the deal is over; (3) the retailer plans on q and selects a financing strategy; (4) the supplier determines K which depends on q and how much will support the working capital can provide. (5) once APD is selected, the retailer will pay before the products are shipped. (6) once the retailer selects the BPOF, the financial institution provides financing. At this time, the supplier selects a borrowing level λ and then obtains λwq; (7) short-term debts mature; (8) the sales season begins, and the demand is realized; (9) products are delivered to the retailer; (10) the retailer pays the supplier in the base case. For any outstanding pre-paid orders, the retailer will refund the supplier in APD; (11) If the supplier continues to operate or restructure in BPOF, the retailer pays the full amount of the order to the financial institution. For liquidation, the financial institution will seize the supplier's current assets, and the retailer will pay the agreed-upon portion of the financial institution's losses as the loan guarantor; (12) The retailer sells to the customer at a market-determined unit price of p; (13) The retailer undertakes the salvage value of all unsold commodities.

4.3 Models

4.3.1 Benchmark and base case with salvage values

This section first considers two special settings in which there are no financing instruments: centralized benchmark without capital constraints, and decentralized benchmark without any financing. Then, a base case in which both the participants may be financially constrained is formulated. Further, positive and negative salvage values are considered in the models. When $s>0$, it indicates a positive salvage value; while $s<0$, represents the negative value. The formulas in this section are as follows.

Firstly, the integrated enterprise's expected profit function is

$$\pi^{\mathrm{csc}}(K) = (p - c_p)\mathrm{E}\min(K, D) - c_k K + s(K - D)^+. \tag{4.1}$$

For this concave profit function, the optimal capacity level satisfies $K^{\mathrm{csc}*} = F^{-1}(\frac{p - c_p - c_k}{p - c_p - s})$.

Secondly, participants maximize their decision-making objectives in a decentralized decision-making environment. The retailer's expected profit is:

$$\pi_{r1}{}^{dsc} = p\mathrm{E}\min[D, \min(q, K)] - w\min(q, K) + s[\min(q, K) - \mathrm{D}]^+. \tag{4.2}$$

This function is concave, and $q_1{}^{dsc*} = F^{-1}(\frac{p - w}{p - s})$.

The supplier's expected profit in the decentralized decision-making environment is:

$$\pi_{s1}{}^{dsc} = (w - c_p)\min(q, K) - c_k K. \tag{4.3}$$

Then, the entire supply chain's profit is expressed as:

$$\begin{aligned} \pi_{sc1}{}^{dsc} &= \pi_{s1}{}^{dsc} + \pi_{r1}{}^{dsc} \\ &= p\mathrm{E}\min[D, \min(q, K)] - c_p \min(q, K) - c_k K + s[\min(q, K) - \mathrm{D}]^+. \end{aligned} \tag{4.4}$$

It can be observed that $\pi_{sc1}{}^{dsc}$ increases with s due to $[\min(q, K) - \mathrm{D}]^+ > 0$. Hence, if there is unsold inventory, the greater salvage value, the greater the benefit to the entire supply chain.

Thirdly, under the base case, no financing instruments are viable, and the retailer's profit can be presented as:

$$\pi_{r1}^{bc} = p\mathrm{E}\min[D, \min(q, K)] - w^{bc}\min(q, K) + s[\min(q, K) - \mathrm{D}]^{+}. \tag{4.5}$$

The retailer's profit function in the base case is concave, and $q_1^{bc*} = F^{-1}(\frac{p-w}{p-s})$.

Proposition 4.1 The increase of *s* eases the financial distress of the retailer and increases the expected profit of the retailer. Further, the optimal order quantity q_1^{bc*} increases with *s*, i.e., $q_1^{bc*}(s<0) < q_1^{bc*}(s=0,\ \text{no salvage value}) < q_1^{bc*}(s>0)$.

Proposition 4.1 demonstrates that q_1^{bc*} and π_{r1}^{bc} are affected by the positive and negative salvage values. The retailer prefers to order more goods with positive salvage values so as to reduce losses and earn more money in the transaction.

If a supplier fails to pay its debts before the sales season, it goes through reorganization (financial default cost is $1-\gamma$ of enterprise value) or liquidation (financial hardship cost is $1-\alpha$ of raised funds).

Hence, the supplier's expected profit is

$$\pi_{s1}^{bc} = (w - c_p)\min(q, K) - c_k K - (1-\alpha)(L_s - A_s + c_k K)^{+} \tag{4.6}$$

Hence, the entire supply chain's profit with considering salvage value is:

$$\pi_{\text{sc1}}^{bc} = \begin{cases} p\mathrm{E}\min[D, \min(q, K)] - c_p\min(q, K) - c_k K \\ +s[\min(q, K) - \mathrm{D}]^{+} & \text{Continuation} \\ p\mathrm{E}\min[D, \min(q, K)] - c_p\min(q, K) - c_k K \\ +s[\min(q, K) - \mathrm{D}]^{+} - (1-\alpha)(L_s - A_s + c_k K) & \text{Reorganization} \end{cases} \tag{4.7}$$

In the base case, note that π_{sc1}^{bc} increases with *s*. Hence, if there exists unsold inventory, with the growth of the salvage value, the whole supply chain's profit increases. As a result, ordering items with positive salvage values is more attractive to the entire supply chain.

4.3.2 APD with salvage values

By adopting APD, the retailer pays the supplier $wq^{apd}(1-d)$ before product delivery. If any quantity ordered is not completed, the retailer will receive a refund after delivery. If the supplier fails to pay its debts before the sales season, it goes through reorganization (financial default cost is $1-\gamma$ of enterprise value) or liquidation (financial hardship cost is $1-\alpha$ of raised funds). The supplier's profit and capacity with considering salvage value in APD is

$$\pi_{s1}{}^{apd} = [w(1-d)-c_p]\min(q,K) - c_k K - (1-\alpha)(L_s - A_s + c_k K - w(1-d)q)^+ . \quad (4.8)$$

The retailer's expected profit function with considering salvage value is:

$$\begin{aligned}\pi_{r1}{}^{apd} &= p\mathrm{E}\min[D,\min(q,K)] - w(1-d)\min(q,K) \\ &\quad + s[\min(q,K)-D]^+ - (1-\alpha)[L_r - A_r + w(1-d)q]^+\end{aligned} \quad (4.9)$$

Under APD, $q_1{}^{apd*}$ satisfies $(p-s)\bar{F}(q_1{}^{apd*}) + s = w(1-d)$ in continuation and in the reorganization, $q_1{}^{apd*}$ satisfies $(p-s)\bar{F}(q_1{}^{apd*}) + s = w(1-d)(2-\alpha)$. The retailer balances the marginal effect of APD against the unit financial distress cost.

Proposition 4.2 Under APD, the higher the salvage value of the product is, the buyer will order more, which will bring higher profits and low financial risk, i.e., $q_1{}^{apd*}(s<0) < q_1{}^{apd*}(s=0,\ \text{no salvage value}) < q_1{}^{apd*}(s>0)$.

Proposition 4.2 indicates that products with positive high salvage values are more attractive to the retailer who can order more products to earn more money. Conversely, for goods with negative salvage values, the order quantity is less than that without any salvage value.

If the retailer can provide the supplier with sufficient working capital via APD, then $K^{apd*}=q^{apd*}$. Hence, the entire supply chain's profit is:

$$\pi_{sc1}^{apd}=\begin{cases} p\mathrm{E}\min[D,\min(q,K)]+s[\min(q,K)-D]^{+} \\ -(1-\alpha)[L_r-A_r+w(1-d)q]^{+}-c_p\min(q,K)-c_kK & \text{Continuation} \\ p\mathrm{E}\min[D,\min(q,K)]+s[\min(q,K)-D]^{+}-c_p\min(q,K)-c_kK \\ -(1-\alpha)[L_r-A_r]^{+}-(1-\alpha)(L_s-A_s+c_kK) & \text{Reorganization} \end{cases} \tag{4.10}$$

In APD, π_{sc1}^{apd} increases with s. Hence, when the retailer has more inventory than the customer demands, a higher salvage value of unsold products leads to fewer losses and a greater gain for the overall supply chain.

4.3.3 BPOF with salvage values

Under, BPOF, the retailer offers a loan guarantee to the financial institution to help the supplier obtain funds, and the supplier determines the borrowing level according to the capital level and the orders. If the supplier fails to pay its debts before the sales season, it goes through reorganization (financial default cost is $1-\gamma$ of enterprise value) or liquidation (financial hardship cost is $1-\alpha$ of raised funds).

Hence, the supplier's profit considering salvage value is

$$\pi_{s1}^{bpof}=(w-c_p)\min(q,K)-c_kK-\lambda wqr-(1-\alpha)(L_s-A_s-\lambda wq+c_kK)^{+}. \tag{4.11}$$

The retailer's expected profit considering salvage value is:

$$\begin{aligned}\pi_{r1}^{bpof} &= p\mathrm{E}\min[D,\min(q,K)]-w\min(q,K)+s[\min(q,K)-D]^{+}- \\ &\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq-\gamma\left[(w-c_p)\min(q,K)-c_kK-\lambda wqr+A_s-L_s\right]\right\}\phi(A_s)dA_s.\end{aligned} \tag{4.12}$$

Hence, the optimal order quantity in BPOF is $q_1^{bpof*}=F^{-1}(\frac{p-w-(\delta\lambda w-\delta\gamma w+\delta\gamma c_p+\delta\gamma\lambda wr)[\Phi(\tilde{A}_S)-\Phi(\underline{A}_S)]}{p-s})$.

Proposition 4.3 In BPOF, both π_{r1}^{bpof} and q_1^{bpof*} increase with the salvage value. That is, $q_1^{bpof*}(s<0)<q_1^{bpof*}(s=0,\ \text{no salvage value})<q_1^{bpof*}(s>0)$.

Proposition 4.3 indicates that if the retailer's order quantity exceeds the market demand, there is surplus inventory. Items having high salvage values will encourage the retailer to order more products because a high salvage value can help reduce losses and maximize profits.

The profit of the whole supply chain, considering the salvage value is:

$$\pi_{\mathrm{sc1}}^{bpof}=\begin{cases} pE\min[D,\min(q,K)]+s[\min(q,K)-D]^{+}-c_p\min(q,K)-c_kK \\ -\lambda wqr-\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq-\gamma\begin{bmatrix}(w-c_p)\min(q,K)\\ -c_kK-\lambda wqr+A_s-L_s\end{bmatrix}\right\}\phi(A_s)dA_s \\ \qquad\qquad\qquad\qquad\qquad\qquad\text{Continuation} \\ pE\min[D,\min(q,K)]+s[\min(q,K)-D]^{+}-c_p\min(q,K)-c_kK \\ -\lambda wqr-\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq-\gamma\begin{bmatrix}(w-c_p)\min(q,K)\\ -c_kK-\lambda wqr+A_s-L_s\end{bmatrix}\right\}\phi(A_s)dA_s \\ -(1-\alpha)(L_s-A_s-\lambda wq+c_kK)\qquad\qquad\text{Reorganization} \end{cases}. \quad (4.13)$$

In the BPOF, $\pi_{\mathrm{sc1}}^{bpof}$ increases with *s*. Therefore, processing unsold goods with positive salvage values brings more benefit than those with a non-positive salvage value for the entire supply chain.

4.3.4 Financing equilibrium with salvage values

If either of the two financing instruments is able to satisfy the upstream supplier's financial requirements, the downstream buyer will select one of them in the single financing condition. Here, if the buyer is unfamiliar with both, it is assumed that the buyer selects APD over BPOF.

Theorem 4.1 In single financing, a unique threshold of the retailer's internal asset level ω_{r1} exists, which makes the buyer more inclined to BPOF if and only if $A_r < \omega_{r1}$. Otherwise, APD is preferred. Besides, the value ω_{r1} is in direct proportion to *s*. That is, $\omega_{r1}(s>0) > \omega_{r1}(s=0) > \omega_{r1}(s<0)$.

Theorem 4.1 reveals that the threshold of asset level of the retailer with positive salvage value is higher than the threshold of the asset level of the retailer with no salvage value and negative salvage value. The reason is that goods with high positive salvage value motivate the retailer to have more orders, and at the same time, the increase of the order quantity will bring inventory risks to the retailer, making the inventory in the backlog state. Therefore, if the retailer buys goods with a positive high salvage value, the buyer's asset level should be higher, so the retailer can have sufficient funds to provide APD financing to the supplier.

4.4 Comparisons

4.4.1 Benchmark and base case without considering salvage value

(1) Comparisons among the integrated firm's expected profits

The expected profit of an integrated enterprise without salvage value is $\pi_0^{csc}(K) = (p - c_p)\mathrm{E}\min(K, D) - c_k K$. Then, given *w, p, K*,

$$\pi_0^{csc} - \pi^{csc} = -s[\min(q, K) - \mathrm{D}]^+. \tag{4.14}$$

a) When s>0, and $[\min(q, K) - \mathrm{D}]^+ > 0$, $\pi_0^{csc} < \pi^{csc}$.

b) When s<0, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{0}{}^{dsc}>\pi^{dsc}$.

(2) Comparisons among the retailer's expected profits in a deconcentrated benchmark

The retailer's expected profit without salvage value is

$\pi_{\mathrm{r0}}{}^{dsc}=p\mathrm{E}\min[D,\min(q,K)]-w\min(q,K)$. Then,

$$\pi_{\mathrm{r0}}{}^{dsc}-\pi_{\mathrm{r1}}{}^{dsc}=-s[\min(q,K)-\mathrm{D}]^{+}. \tag{4.15}$$

a) When s>0, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{r0}}{}^{dsc}<\pi_{\mathrm{r1}}{}^{dsc}$.

b) When s<0, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{r0}}{}^{dsc}>\pi_{\mathrm{r1}}{}^{dsc}$.

(3) Comparisons among the supplier's expected profits in a deconcentrated benchmark

Since the salvage value does not affect the supplier's profit $\pi_{s1}{}^{dsc}$, $\pi_{\mathrm{s0}}{}^{dsc}-\pi_{\mathrm{s1}}{}^{dsc}=0$, and the results are the same ($\pi_{\mathrm{s0}}{}^{dsc}=\pi_{\mathrm{s1}}{}^{dsc}$), no matter whether the salvage value is positive, negative, or even zero.

(4) Comparisons among the entire supply chain's expected profits in a deconcentrated benchmark

Since the entire supply chain's profit without considering salvage value is $\pi_{\mathrm{sc0}}{}^{dsc}=p\mathrm{E}\min[D,\min(q,K)]-c_{p}\min(q,K)-c_{k}K$. Then,

$$\pi_{\mathrm{sc0}}{}^{dsc}-\pi_{\mathrm{sc1}}{}^{dsc}=-s[\min(q,K)-\mathrm{D}]^{+}. \tag{4.16}$$

a) Since s>0, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{sc}0}{}^{dsc}<\pi_{\mathrm{sc}1}{}^{dsc}$.

b) Since s<0, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{sc}0}{}^{dsc}>\pi_{\mathrm{sc}1}{}^{dsc}$.

The comparison results are presented in Table 4.2.

Table 4.2. Comparisons among expected profits in benchmarks.

Profits	***s*>0**	***s*<0**
Integrated firm's profit	$\pi_0{}^{csc}<\pi^{csc}$	$\pi_0{}^{csc}>\pi^{csc}$
Retailer's profit	$\pi_{\mathrm{r}0}{}^{dsc}<\pi_{\mathrm{r}1}{}^{dsc}$	$\pi_{\mathrm{r}0}{}^{dsc}>\pi_{\mathrm{r}1}{}^{dsc}$
Supplier's profit	$\pi_{\mathrm{s}0}{}^{dsc}=\pi_{\mathrm{s}1}{}^{dsc}$	$\pi_{\mathrm{s}0}{}^{dsc}=\pi_{\mathrm{s}1}{}^{dsc}$
Supply Chain's profit	$\pi_{\mathrm{sc}0}{}^{dsc}<\pi_{\mathrm{sc}1}{}^{dsc}$	$\pi_{\mathrm{sc}0}{}^{dsc}>\pi_{\mathrm{sc}1}{}^{dsc}$

(1) Comparisons among the retailer's expected profits in the base case

Since $\pi_{r0}{}^{bc}=p\mathrm{E}\min[D,\min(q,K)]-w\min(q,K)$,

$$\pi_{\mathrm{r}0}{}^{bc}-\pi_{\mathrm{r}1}{}^{bc}=-s[\min(q,K)-\mathrm{D}]^{+}. \tag{4.17}$$

a) Since s>0 and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{r}0}{}^{bc}<\pi_{\mathrm{r}1}{}^{bc}$.

b) Since s<0 and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{r}0}{}^{bc}>\pi_{\mathrm{r}1}{}^{bc}$.

(2) Comparisons among the supplier's expected profits in the base case

The supplier's expected profits without salvage value are

$$\pi_{s0}{}^{bc} = \begin{cases} (w-c_p)\min(q,K)-c_kK & \text{Continuation} \\ (w-c_p)\min(q,K)-c_kK-(1-\alpha)(L_s-A_s+c_kK) & \text{Reorganization} \\ 0 & \text{Liquidation} \end{cases}.$$

Hence $\pi_{s0}{}^{bc}-\pi_{s1}{}^{bc}=0$, the results are the same no matter whether the salvage value is positive or non-positive.

(3) Comparisons among the supply chain's expected profits in the base case

The entire supply chain's profit without considering salvage value is:

$$\pi_{sc0}{}^{bc} = \begin{cases} p\mathrm{E}\min[D,\min(q,K)]-c_p\min(q,K)-c_kK & \text{Continuation} \\ p\mathrm{E}\min[D,\min(q,K)]-c_p\min(q,K)-c_kK & \text{Reorganization} \\ -(1-\alpha)(L_s-A_s+c_kK) & \end{cases}.$$

$$\pi_{sc0}{}^{bc}-\pi_{sc1}{}^{bc}=-s[\min(q,K)-\mathrm{D}]^{+}. \tag{4.18}$$

a) When s>0, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{sc0}{}^{bc}<\pi_{sc1}{}^{bc}$.

b) When s<0, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{sc0}{}^{bc}>\pi_{sc1}{}^{bc}$.

The comparison results of the base case are shown in Table 4.3.

Table 4.3. Comparisons among expected profits in the base case.

Profits	***s*>0**	***s*<0**
Retailer's profit	$\pi_{r0}{}^{bc}<\pi_{r1}{}^{bc}$	$\pi_{r0}{}^{bc}>\pi_{r1}{}^{bc}$
Supplier's profit	$\pi_{s0}{}^{bc}=\pi_{s1}{}^{bc}$	$\pi_{s0}{}^{bc}=\pi_{s1}{}^{bc}$

Supply Chain's profit	${\pi_{sc0}}^{bc} < {\pi_{sc1}}^{bc}$	${\pi_{sc0}}^{bc} > {\pi_{sc1}}^{bc}$

4.4.2 APD without considering salvage value

(1) Comparisons among the retailer's expected profits

The retailer's expected profit function without considering salvage value is ${\pi_{r0}}^{apd} = p\mathrm{E}\min[D, \min(q,K)] - w(1-d)\min(q,K) - (1-\alpha)[L_r - A_r + w(1-d)q]^{+}$. Hence,

$$ {\pi_{r0}}^{apd} - {\pi_{r1}}^{apd} = -s[\min(q,K) - D]^{+}. \tag{4.19}$$

a) When $s>0$, and $[\min(q,K) - \mathrm{D}]^{+} > 0$, ${\pi_{r0}}^{apd} < {\pi_{r1}}^{apd}$.

b) When $s<0$, and $[\min(q,K) - \mathrm{D}]^{+} > 0$, ${\pi_{r0}}^{apd} > {\pi_{r1}}^{apd}$.

(2) Comparisons among the supplier's expected profits

The results are the same (${\pi_{s0}}^{apd} = {\pi_{s1}}^{apd}$), no matter whether the salvage value is positive or negative.

(3) Comparisons among the supply chain's expected profits

The profit of the whole supply chain without considering salvage value is

$$ {\pi_{sc0}}^{apd} = \begin{cases} p\mathrm{E}\min[D, \min(q,K)] - c_p \min(q,K) & \text{Continuation} \\ -c_k K - (1-\alpha)[L_r - A_r + w(1-d)q]^{+} & \\ p\mathrm{E}\min[D, \min(q,K)] - c_p \min(q,K) & \text{Reorganization} \\ -c_k K - (1-\alpha)[L_r - A_r]^{+} - (1-\alpha)(L_s - A_s + c_k K) & \end{cases}. $$

$$ {\pi_{sc0}}^{apd} - {\pi_{sc1}}^{apd} = -s[\min(q,K) - D]^{+}. \tag{4.20}$$

a) Since $s>0$, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{sc}0}{}^{apd}<\pi_{\mathrm{sc}1}{}^{apd}$.

b) Since $s<0$ and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{sc}0}{}^{apd}>\pi_{\mathrm{sc}1}{}^{apd}$.

The comparison results under APD are shown in Table 4.4.

Table 4.4. Comparisons among expected profits in APD.

Profits	***s*>0**	***s*<0**
Retailer's profit	$\pi_{\mathrm{r}0}{}^{apd}<\pi_{\mathrm{r}1}{}^{apd}$	$\pi_{\mathrm{r}0}{}^{apd}>\pi_{\mathrm{r}1}{}^{apd}$
Supplier's profit	$\pi_{\mathrm{s}0}{}^{apd}=\pi_{\mathrm{s}1}{}^{apd}$	$\pi_{\mathrm{s}0}{}^{apd}=\pi_{\mathrm{s}1}{}^{apd}$
Supply Chain's profit	$\pi_{\mathrm{sc}0}{}^{apd}<\pi_{\mathrm{sc}1}{}^{apd}$	$\pi_{\mathrm{sc}0}{}^{apd}>\pi_{\mathrm{sc}1}{}^{apd}$

4.4.3 BPOF without considering salvage value

(1) Comparisons among the retailer's expected profits

The retailer's expected profit without considering salvage value is

$$\pi_{r0}{}^{bpof}=p\mathrm{E}\min[D,\min(q,K)]-w\min(q,K)-\int_{\underline{A}_S}^{\bar{A}_S}\delta\left\{\lambda wq-\gamma\begin{bmatrix}(w-c_p)\min(q,K)-c_kK-\\-\lambda wqr+A_s-L_s\end{bmatrix}\right\}\phi(A_s)dA_s.$$

Then,

$$\pi_{\mathrm{r}0}{}^{bpof}-\pi_{\mathrm{r}1}{}^{bpof}=-s[\min(q,K)-D]^{+}. \tag{4.21}$$

a) When $s>0$, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{r}0}{}^{bpof}<\pi_{\mathrm{r}1}{}^{bpof}$.

b) When $s<0$, and $[\min(q,K)-\mathrm{D}]^{+}>0$, $\pi_{\mathrm{r}0}{}^{bpof}>\pi_{\mathrm{r}1}{}^{bpof}$.

(2) Comparisons among the supplier's expected profits

The supplier's profit without considering salvage value is
$$\pi_{s0}^{bpof} = \begin{cases} (w-c_p)\min(q,K) - c_k K - \lambda wqr & \text{Continuation} \\ (w-c_p)\min(q,K) - c_k K - \\ (1-\alpha)(L_s - A_s - \lambda wq + c_k K) - \lambda wqr & \text{Reorganization} \\ 0 & \text{Liquidation} \end{cases}.$$

Hence, the results are the same ($\pi_{s0}^{bpof} = \pi_{s1}^{bpof}$), no matter whether the salvage value is positive, negative, or even zero.

(3) Comparisons among the supply chain's expected profits

The profit of the whole supply chain without considering salvage value is
$$\pi_{sc0}^{bpof} = \begin{cases} pE\min[D,\min(q,K)] - c_p\min(q,K) - c_k K - \lambda wqr \\ -\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq - \gamma\begin{bmatrix}(w-c_p)\min(q,K) - c_k K \\ -\lambda wqr + A_s - L_s\end{bmatrix}\right\}\phi(A_s)dA_s & \text{Continuation} \\ pE\min[D,\min(q,K)] - c_p\min(q,K) - c_k K - \lambda wqr \\ -(1-\alpha)(L_s - A_s - \lambda wq + c_k K) \\ -\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq - \gamma\begin{bmatrix}(w-c_p)\min(q,K) - c_k K \\ -\lambda wqr + A_s - L_s\end{bmatrix}\right\}\phi(A_s)dA_s & \text{Reorganization} \end{cases}.$$

$$\pi_{sc0}^{bpof} - \pi_{sc1}^{bpof} = -s[\min(q,K) - D]^{+}. \tag{4.22}$$

a) Since s>0, and $[\min(q,K)-\mathrm{D}]^{+} > 0$, $\pi_{sc0}^{bpof} < \pi_{sc1}^{bpof}$.

b) Since s<0 and $[\min(q,K)-\mathrm{D}]^{+} > 0$, $\pi_{sc0}^{bpof} > \pi_{sc1}^{bpof}$.

The comparison results under BPOF can be seen in Table 4.5.

Table 4.5. Comparisons among expected profits in BPOF.

Profits	*s*>0	*s*<0
Retailer's profit	$\pi_{r0}^{bpof} < \pi_{r1}^{bpof}$	$\pi_{r0}^{bpof} > \pi_{r1}^{bpof}$
Supplier's profit	$\pi_{s0}^{bpof} = \pi_{s1}^{bpof}$	$\pi_{s0}^{bpof} = \pi_{s1}^{bpof}$
Supply Chain's profit	$\pi_{sc0}^{bpof} < \pi_{sc1}^{bpof}$	$\pi_{sc0}^{bpof} > \pi_{sc1}^{bpof}$

To sum up, from the comparison results in the above tables, it can be seen that in all the above five cases, the salvage value affects the profits (retailer's and entire supply chain) but does not influence the profit of the supplier. To be specific, when the salvage value is greater than 0, the profits are greater than the profits without considering any salvage value. In contrast, when the salvage value is negative, the profits of the buyer and the entire supply chain are less than the profits without considering any salvage value.

4.5 Numerical Analysis

The effects of different salvage values on partner decisions and supply chain performance are examined through some computational experiments, and comparisons are determined in the case without salvage value. According to the parameters set by Zhao and Huchzermeier (2018a) and Gamba and Triantis (2014), p=60, ck=cp=10, α= 0.85, γ= 0.9, and D obeys a normal distribution N(1000,100). In this section, the salvage value s is set between -10 and 25, in increments of 5.

4.5.1 Impact of *s* on profits under APD and BPOF

The impact of the salvage value on the expected profits of the retailer and the entire supply chain is shown in Figure 4.3 and Figure 4.4. Both figures show that the profits increase with s. That is, when there is unsold inventory, if the salvage value of these traded items is high, the buyer and the entire supply chain will have more benefits. The reason is that ordering items with a positive salvage value can reduce the risk of loss during the clearance period compared to orders with no salvage value, which leads to more gains for the buyer and the overall supply chain. On the contrary, orders with negative salvage value will increase losses, resulting in lower profits.

However, the difference in these two cases is that the expected profit of the buyer obviously rises, while the profit in Figure 4.4 increases steadily. This is mainly because the change of salvage value has no effect on the seller's expected profit, and only affects the buyer's profit.

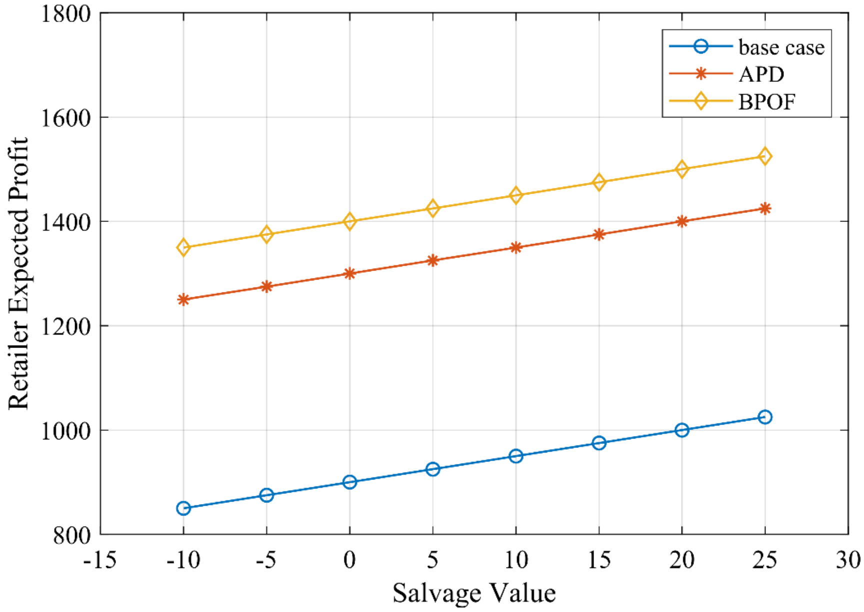

Figure 4.3. Impact of salvage value on retailer's expected profit.

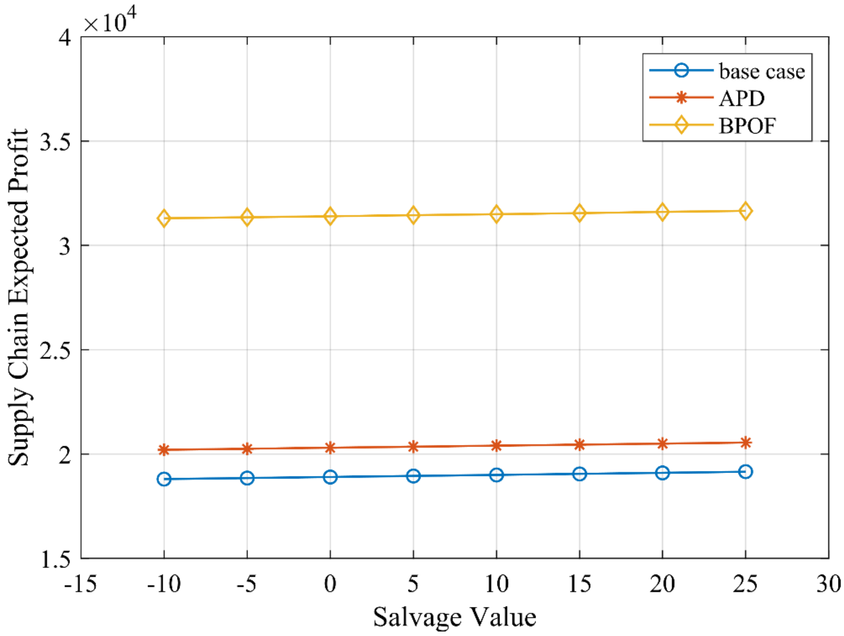

Figure 4.4. Impact of salvage value on supply chain's expected profit.

4.5.2 Impact of *s* on retailer's optimal order quantity under APD and BPOF

From the results shown in Figure 4.5, when the salvage value of all items increases, the retailer's optimal order quantity increases in both APD and BPOF conditions. Disposal of products with high positive salvage values during the clearance period can avoid excessive losses on the part of the retailer. Thus, an increase in salvage value lowers the risk related to random customer demand. The retailer does not have to worry about losing a lot of inventory, which motivates the retailer to order more to meet market demand.

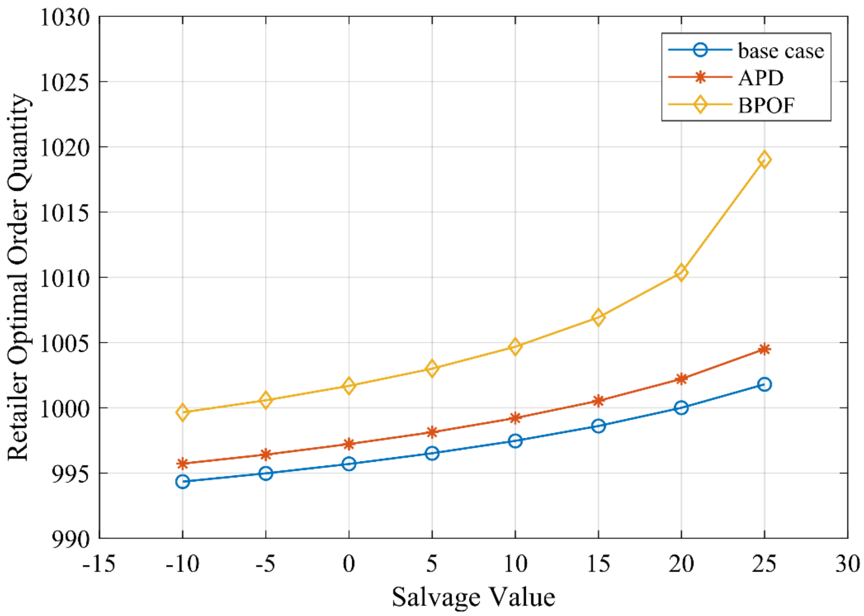

Figure 4.5. Impact of salvage value on retailer's optimal order quantity.

4.5.3 Impact of *s* on the threshold of the retailer's asset level

The buyer's short-term liabilities Lr are unchanged at 30,000 here. From Figure 4.6, it can be seen that the unique threshold ω_{r1} is more than 55,500 when the salvage value is 25, while for the negative salvage value ($s=-10$), ω_{r1} is about 53,000 which is lower than that in case of no salvage value. Hence, the result $\omega_{r1}(s>0)>\omega_{r1}(s=0,\ \text{no salvage value})>\omega_{r1}(s<0)$ is verified. Figure 4.6 demonstrates that the salvage value has a significant influence on the threshold ω_{r1} in single financing. The underlying reason is that items with a high positive salvage value increase q^* which increases the inventory risk, thus tending to make the inventory overstocked. Therefore, to ensure that the retailer has sufficient money to provide APD financing to the supplier, the buyer should have a higher asset level compared with the case without considering salvage value if the retailer buys positive salvage value commodities. In contrast, a negative salvage value makes the retailer order fewer products, reducing the overstock risk, thus lowering the threshold of the internal asset level of the retailer under single financing.

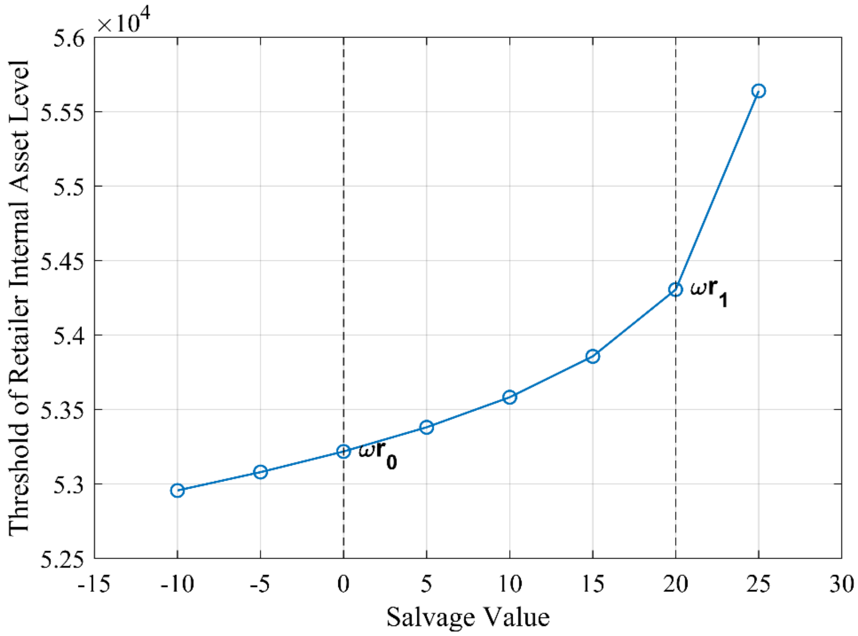

Figure 4.6. Impact of salvage value on the threshold of the retailer's asset level.

4.6 Managerial Insights

In this chapter, suggestions for practicing managers are provided in many different industries to make operation and financial decisions when ordering items from a capital-constrained supplier and is selecting the optimal financing strategy, considering various salvage values. The details are as follows.

Firstly, the model is applicable for industries that involve perishable goods with high positive salvage values (i.e., $c<s<w$). These kinds of products have the following distinct characteristics: (a) High-tech products and core components of the products with reuse value. Compared with traditional labor-intensive products, products with constantly innovative technologies are updated more quickly, resulting in faster market obsolescence, a short product maturity period, and a fast decline period, especially in high-tech industries such as smartphones, laptops, and wearable devices. After the end of the selling season, some of parts of these products still have reuse value. These items can be sold to liquidators like TechLiquidators who offer items in bulk to resellers. At the same time, the core components (old parts contained in these

unmarketable products) can be disassembled, refurbished, or reused for producing new products after testing or modification (Zink et al. 2014). (b) High-end products. These products are distinguished by large profits and high salvage values, because that the price of the products is related to the brand value, and it cannot fall below a certain threshold to maintain the brand value. In a sense, a high-end seasonal product may not make sense in the next sales season. Take clothing designed by a prestigious designer as an example, it will be out of fashion by the next year. If there are stocks left, people who follow fashion will not buy such items. Sellers, however, are reluctant to cut prices too much to protect their brands. At this point, these products with higher salvage values can be disposed of at a price between the cost price and the wholesale price. In the United States, TJ Maxx, an off-price seller, founded in 1976, is now the largest discount clothing and grocery store, selling surplus clothes and daily necessities after a sale season for 20-60% less than department stores (Nwalozie 2011). Based on the above practical application cases, when the high positive salvage value is taken into account, dealing with such unsold products can help the retailer cut losses, thus reducing the retailer's capital constraints. Compared with products with no salvage value, the retailer earns more profit and prefers to order more products with high positive salvage value in this situation. Eventually, the supply chain's profit also increases. Furthermore, with fewer financial difficulties, the retailer is more likely to adopt APD as the optimal financing instrument.

Secondly, the model can be used in industries that involve perishable goods with low positive salvage value (i.e., $0<s<c$). These products have lower prices and low-profit margins due to fierce competition and are generally purchased by price-sensitive customers who believe that good quality and reasonable price are more important than style or uniqueness. After the selling season, these commodities are cleared at a very low price (lower than the cost, possibly to get rid of them) until they run out; examples are toys, books, holiday baskets, low-end clothing, and other daily-use products. However, they are still valuable ($s>0$), and the retailer can reduce the loss to some extent, thus getting more benefit than the case without considering the salvage value. As the salvage value is below the cost, the seller only gains a small profit. Besides, the retailer's order quantity also increases, but not by much, as well as the probability of the retailer adopting APD as the optimal financing instrument.

Thirdly, the model can be applied to goods industries with a negative salvage value (that is, $s<0$). For many industries, dealing with products with negative salvage values is a critical problem. This is because, with increasing concern for the environment, regulated companies cannot simply discard out-of-season products, some of which produce harmful substances in the process. As a result, they may have to spend additional processing costs to make them safe and protect the environment, thus leading to negative salvage (Welke 1988). These include goods such as unsold over-the-counter medicines, chemicals. Therefore, if there are products with a negative salvage value, the buyer and the whole supply chain increase the loss compared with products with positive salvage value. This is because clearing the unsold inventory requires the extra money to process them. In this case, retailers are under greater financial pressure and will choose BPOF to fund suppliers to ensure the completion of orders and secure the product quantity without causing financial distress. Besides, to avoid huge losses from overstocking, retailers will reduce orders. Products with negative salvage values also provide gains for the buyer and make the overall supply chain smaller than a product with no salvage value and positive salvage values.

Therefore, managers should not ignore the combination of the financing strategy and the positive or negative salvage values when making key decisions. Instead, they should take both of them into account and identify their effects on the order quantity, supply chain participants' profits, and the change in financing equilibrium. This chapter confirms the result that a higher salvage value increases the number of orders and the overall profits. Furthermore, if the retailer buys many positive salvage value commodities, the buyer should have a higher asset level compared with the case without considering the salvage values so as to ensure having sufficient money to provide APD financing to the supplier.

4.7 Summary

A cash-strapped supplier, a creditworthy retailer as well as a financial institution are considered in this chapter. The optimal decision-making and financing strategies considering the positive and negative salvage values are analyzed. Moreover, the supplier was able to use BPOF and APD to address the financial distress. Although there is a large amount of literature on SCF, there is little on the combination of APD and BPOF. Hence, the effect of different salvage values on the operational decisions and profits in various financing situations (no capital constraints, capital constraints without financing, APD, and BPOF, respectively) are investigated, and a comparison and analysis with the case of no salvage value have been built.

Some significant results and managerial insights were derived from the analysis. Firstly, under different salvage values, the optimal order quantities of the retailer in different financing scenarios varied. Specifically, ordering items with a positive salvage value can reduce the risk of loss compared to orders with no salvage value, which leads to more gains for the buyer, and the overall supply chain, while orders for items with negative salvages increase losses, resulting in lower profits. Thus, the retailer prefers to order products with high positive salvage values from the supplier in the SCF system. Furthermore, the higher salvage values would bring more inventory risks for the retailer, so the buyer should have a higher asset level to ensure the availability of sufficient capital to provide APD financing to the supplier.

The main contributions are in three aspects. First, the positive and negative salvage values affect the optimal order quantity. The buyer orders more products with a positive salvage value than those without any salvage value and reduces orders for items with a negative salvage value. Second, different salvage values affect the profits of the buyer and the overall supply chain, since buying products with a positive salvage value reduces the retailer’s losses compared with orders without any salvage value, which leads to higher profits. Conversely, ordering items with a negative salvage value increases the loss, resulting in lower profits. Third, the positive and negative salvage values affect the threshold of the retailer's asset level under a single financing condition. Specifically, a positive salvage value creates more inventory risk to the retailer compared with no salvage value and a negative salvage value, so the retailer should have a higher level of assets to ensure adequate funding for the supplier through APD.

CHAPTER 5 The Impact of Buyback Support on Financing Strategies for A Capital-Constrained Supplier in A Mobile Phone Supply Chain

In this Chapter, newsvendor models are presented to solve the impact of buyback support on financing strategies in a mobile phone supply chain. Detailed problem statements and model descriptions are presented in Section 5.1 and Section 5.2. The models, including BSAPD, BSBPOF, and the financing equilibrium between BSAPD and BSBPOF, are given in Section 5.3. Section 5.4 presents the numerical experiments. The managerial insights are provided in Section 5.5, followed by a summary of the chapter in Section 5.6.

5.1 Problem Statements

This chapter establishes a mobile phone supply chain and pre-shipment financing strategies (BSAPD and BSBPOF) that can be adopted for the smooth production of cellphones. To be specific, BSAPD is the downstream retailer who pays the supplier in advance with a unit discount, and the supplier promises to buy back unsold products with salvage value after the sales season. BSBPOF refers to a financial institution offering the supplier loans guaranteed by the downstream retailer before product delivery, with the unsold items being bought back by the supplier. This chapter deals with the following research questions:

1) How do an unsold mobile phone's buyback price and the difference between the buyback price and the salvage value affect the optimal operational decisions under BSAPD and BSBPOF (such as the supplier's capacity level, the discount rate under BSAPD, and the financial institution's interest rate under BSBPOF)?

2) What is the financing equilibrium when both financing instruments (BSAPD and BSBPOF) are feasible for the capital-constrained supplier?

To address these issues, a SCF model based on newsvendor is proposed, where a mobile phone seller with limited funds sells products to a buyer facing uncertain demand. The salvage value of the phone is the responsibility of the supplier.

5.2 Model Descriptions

5.2.1 Notations and assumptions

The notations are presented in Table 5.1.

Table 5.1. Summary of notations.

Notation	Description
π	Expected profit
A	Asset level
L	Short-term debt
D	Product demand
p	Unit mobile phone selling price
α	Proportional distress cost
γ	Proportional liquidation cost
δ	The portion of financial institution’s loss reimbursed by retailer
c_p	Unit mobile phone production cost
c_k	Unit mobile phone capacity cost
r	The interest rate of BPOF
s	Unit salvage value of the mobile phone, $s>0$
b	Unit buyback price of the unsold mobile phone, $s<b<w$
K	Supplier’s capacity
q	Order quantity of mobile phones
w	Unit wholesale price
d	Discount rate under APD
λ	The portion of purchase order value financed by a financial institution

Some general assumptions of this chapter are given as follows. A1. The supplier has limited working capital. If the supplier fails to repay the short-term debt before the start of the sales season, it will be liquidated or reorganized at a cost. A2. All supply chain participants are information symmetric. A3. A backup supplier is not available, and the out-of-stock cost is not considered. A4. The lending market is highly competitive. Unsold phones after the sales season will be bought back by the supplier at a buyback price b, and $s<b<w$. In BSBPOF, the supplier will receive a λwq loan through a contract $(\bar{\lambda},\ r)$ from the financial institution. Here $\lambda \in [0, \bar{\lambda}]$ and r represent the borrowing level and the interest rate, respectively. In liquidation, the retailer, as credit guarantor, pays the previously defined part of the loss of financial institutions (δ). In BSAPD, the supplier provides the unit discount rate d. The terms "bsbpof" and "bsapd" are used to express BSBPOF and BSAPD financing modes respectively.

5.2.2 Model framework

The SCF system with a capital-constrained handset provider, a reputable retailer, as well as a financial institution, are all risk-neutral. Without sufficient working capital, the supplier has to use additional funds (BSAPD financing or BSBPOF financing) to carry out operations. Under BSAPD, the retailer pays in advance before shipment, while under BSBPOF, the retailer acts as the guarantor for the loan, and the financial institution provides financial support to the supplier according to a certain percentage of the value of the purchase order. All short-term debts will be due. The selling season begins, demand is met, and the seller produces and delivers products to the buyer, who sells them to customers. Unmet demand is lost. In both cases, the supplier buys back unsold phones after the sales season at a buyback price b. Figure 5.1 and Figure 5.2 show the sequence of BSAPD and BSBPOF, as well as the specific payment process.

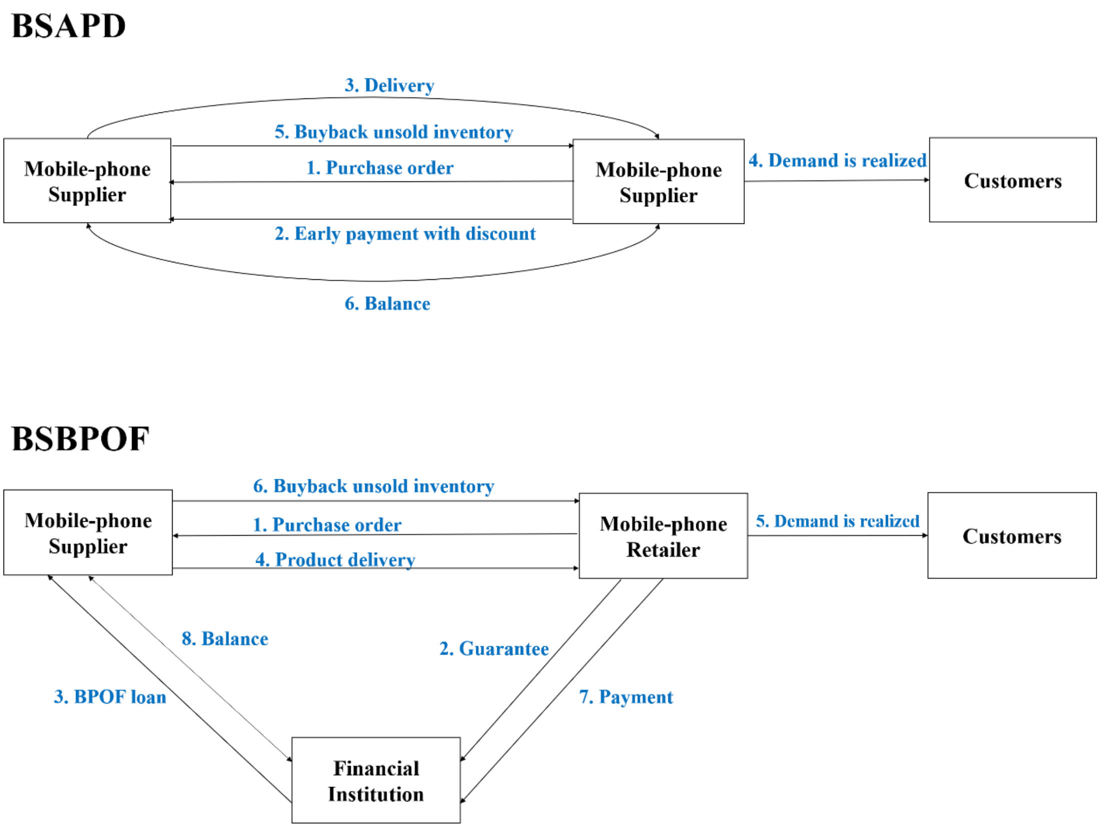

Figure 5.1. The sequence of events in BSAPD and BSBPOF.

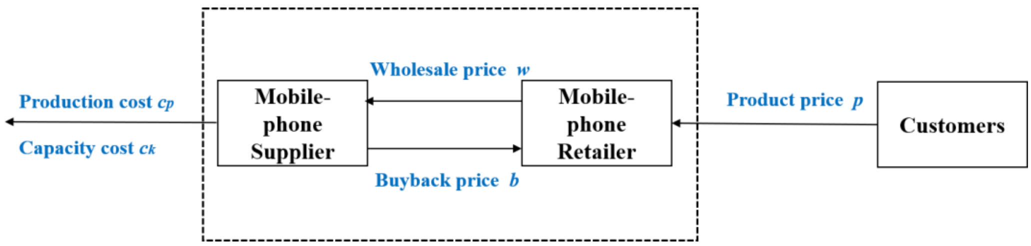

Figure 5.2. Pay flowchart of Supplier-Retailer-Customer.

5.2.3 Sequence of events

Two stages are included in the process. Specifically, 1) Financing stage: the retailer chooses a financing strategy to reduce the supplier's financial stress; 2) Executing stage: both parties complete the business, and the unsold products are bought back by the cellphone supplier with the buyback policy. The timeline of events is presented in Figure 5.3 which is based on the study of Zhao and Huchzermeier

(2018a).

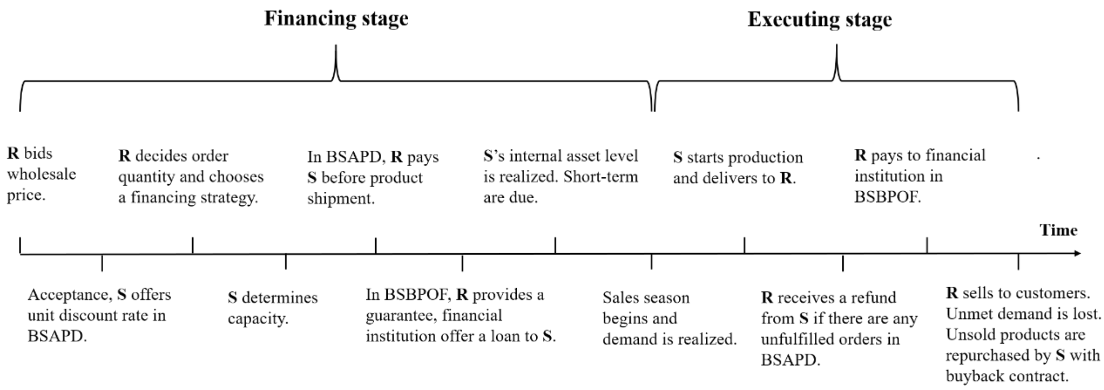

Figure 5.3. Timeline of events.

Specifically, (1) the wholesale price w is set firstly; (2) the supplier decides whether to accept w based on the allocation of its assets, taking into account the possibility of financial hardship and default. Once accepted, the supplier should offer a discount d on w. If not accepted, the deal is over; (3) the retailer plans on q and selects a financing strategy; (4) the supplier determines K which depends on q and how much the working capital support. (5) once BSAPD is selected, the retailer will pay before the products are shipped. (6) once the retailer selects the BPOF, the financial institution provides financing. At this time, the supplier selects a borrowing level and then obtain a λwq; (7) short-term debts mature; (8) the sales season begins, and the demand is realized; (9) the products are delivered to the retailer; (10) the retailer pays the supplier. For any outstanding pre-paid orders, the retailer will refund the supplier in BSAPD; (11) If the supplier continues to operate or restructure in BSBPOF, the retailer will pay the full amount of the order to the financial institution. For liquidation, the financial institution will seize the supplier's current assets, and the retailer will pay the agreed-upon portion of the losses, being the loan guarantor; (12) The products are sold to the customer at p; (13) After the sales season, if there are unsold goods with salvage value, under the buyback contract, the supplier is responsible for this salvage value.

5.3 Models

5.3.1 BSAPD with salvage value

When only BSAPD is adopted, the retailer will pay the supplier for the order at the price (*1-d*)*w* before shipment. During the sales period, if the customer demand *D* is less than the delivered quantity min(*q,K*), the retailer will give back any leftover inventory to the upstream supplier at buyback price *b*. If the supplier fails to pay its debts before the sales season, it goes through reorganization (financial default cost is $1-\gamma$ of enterprise value) or liquidation (financial hardship cost is $1-\alpha$ of raised funds). The supplier's expected profit is

$$\begin{aligned}\pi_s^{bsapd} =& [w(1-d)-c_p]\min(q,K)-c_k K-(b-s)[\min(q,K)-D]^+ \\ & -(1-\alpha)[L_s - A_s + c_k K - w(1-d)q]^+ .\end{aligned} \tag{5.1}$$

This chapter follows the approach of Cachon (2004), p. 227, and obtains the supplier's inverse demand curve $w(q)=p-(p-b)F(q)$. For liquidation, the optimal capacity $K^{bsapd*}=0$ otherwise K^{bsapd*} satisfies the first-order conditions:

$$\begin{aligned}&(1-d)[p-(p-b)F(K^{bsapd*})][1-h(K^{bsapd*})]=c_p+c_k+(b-s)F(K^{bsapd*}) \\ &\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{Continuation} \\ &(1-d)[p-(p-b)F(K^{bsapd*})][1-h(K^{bsapd*})]=c_p+(2-\alpha)c_k+(b-s)F(K^{bsapd*}) \, . \\ &\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{Reorganization}\end{aligned} \tag{5.2}$$

Here the seller's probability of continuing to operate is $\Pr(c)=\bar{\Phi}(\hat{A}_s)$,

$\hat{A}_s \triangleq L_s + c_k K - w(1-d)q$; the probability of liquidation is $\Pr(l)=\Phi(\tilde{A}_s)$,

$$\tilde{A}_s = L_s + c_k K - w(1-d)q - \frac{[w(1-d)-c_p]\min(q,K)-c_k K-(b-s)[\min(q,K)-D]^+}{1-\alpha},$$

and the probability of reorganization is $\Pr(r)=\Phi(\hat{A}_s)-\Phi(\tilde{A}_s)$.

Under BSAPD, the retailer's expected profit is

$$\pi_r^{bsapd} = p\mathrm{E}\min[D,\min(q,K)] - w(1-d)\min(q,K) + b[\min(q,K)-\mathrm{D}]^{+}. \qquad (5.3)$$

If BSAPD is sufficient to support the supplier's financial needs, the retailer's optimal order quantity q^{bsapd*} meets $p-(p-b)F\left(q^{bsapd*}\right)=(1-d)w$ in continuation and $p-(p-b)F\left(q^{bsapd*}\right)=(2-\alpha)(1-d)w$ in reorganization.

Proposition 5.1. Under BSAPD, (1) The value of *b-s* has a negative impact on π_s^{bsapd} and K^{bsapd*} decreases with *b-s*; (2) π_r^{bsapd} and q^{bsapd*} are not irrelevant to *s*, but only are positively related to *b*.

Proposition 5.1 first demonstrates that the expected profit and the capacity level are affected by the difference between the buyback price and the salvage value when customer demand is smaller than the shipped quantity. The supplier prefers to install few goods with a higher difference so as to decrease the losses under the buyback policy. This proposition also shows that the buyer's expected profit and the optimal order quantity are not irrelevant to the salvage value of unsold mobile phones, while they are positively affected by the buyback price since the retailer returns the products at a buyback price and the salvage value is not handled by the retailer.

Proposition 5.2. Given *w, p, K*, the discount rate *d* is decreasing with *b-s*.

Proposition 5.2 indicates that in BSAPD, the higher the difference, the smaller the discount rate offered by the supplier. This means that the difference between the buyback price and the salvage value of the surplus phones is high, and the more adverse to the supplier, that is, the greater the financial risks. Therefore, in the face of high repurchase costs, the supplier should offer the buyer a lower discount rate to maintain a higher buyer purchase price (wholesale price), thus reducing financing costs.

Theorem 5.1. To ensure that both the upstream seller and the downstream buyer benefit from BSAPD and choose it, the buyback price is met for $\eta_r^{bsapd*} < b$, and the difference between buyback price and salvage value should satisfy $b - s < \eta_s^{bsapd*}$, where $\eta_r^{bsapd*} \triangleq \dfrac{p\mathrm{E}\min(D, q^{bsapd*}) - w(1-d)q^{bsapd*}}{(q^{bsapd*} - D)^+}$,

and $\eta_s^{\mathrm{bsapd*}} \triangleq \dfrac{[w(1-d) - c_p]\min(q^{bsapd*}, K^{bsapd*}) - c_k K^{bsapd*}}{[\min(q^{bsapd*}, K^{bsapd*}) - D]^+}$.

Theorem 5.1 shows that to ensure that participants benefit from the BSAPD financing model, the supplier should set the buyback price within a certain range. The financing mode decision for the retailer is related to the buyback price. A higher return at a buyback price above a certain value would prompt the retailer to provide BSAPD financing. The difference between buyback price and salvage value should be lower than a threshold value to enable the supplier to have profits under BSAPD, otherwise, the excessive difference will not benefit the operation of the supplier and bring great financial risks.

5.3.2 BSBPOF with salvage values

In this case, BSBPOF is initiated in that the financial institution provides a loan. After the sales season is over, the borrower will refund the principal and interest of the loan to the financial institution. Thus, the supplier’s profit is:

$$\begin{aligned}\pi_s^{bsbpof} &= (w - c_p)\min(q, K) - c_k K - (b - s)[\min(q, K) - D]^+ - \lambda wqr \\ &\quad - (1-\alpha)[L_s - A_s + c_k K - \lambda wq]^+.\end{aligned} \tag{5.4}$$

If the supplier's internal assets fall below the threshold $\tilde{A}_s = L_s + c_k K - \lambda wq - \dfrac{(w - c_p)\min(q, K) - c_k K - (b - s)[\min(q, K) - D]^+ - \lambda wqr}{1-\alpha}$, the supplier liquidates, and the probability of liquidation is $Pr(l) = \Phi(\tilde{A}_s)$. For liquidation, the supplier's optimal capacity $K^{bsbpof*}=0$. Otherwise, $K^{bsbpof*}$ satisfies

$$\begin{aligned}
&[p-(p-b)F(K^{bsbpof*})][1-h(K^{bsbpof*})]=c_p+c_k+(b-s)F(K^{bsbpof*}) \\
&\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{Continuation} \\
&[p-(p-b)F(K^{bsbpof*})][1-h(K^{bsbpof*})]=c_p+(2-\alpha)c_k+(b-s)F(K^{bsbpof*}). \\
&\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{Reorganization}
\end{aligned} \tag{5.5}$$

Further, the retailer maximizes the profit:

$$\begin{aligned}
\pi_r^{bsbpof} &= p\mathrm{E}\min[D,\min(q,K)]-w\min(q,K)+b[\min(q,K)-D]^+ - \\
&\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq-\gamma\begin{bmatrix}(w-c_p)\min(q,K)-c_kK- \\ (b-s)[\min(q,K)-D]^+-\lambda wqr+A_s-L_s\end{bmatrix}\right\}\phi(A_s)dA_s.
\end{aligned} \tag{5.6}$$

The profit function is concave, and

$$q^{bsbpof*}=F^{-1}\left(\frac{p-w-(\delta\lambda w-\delta\gamma w+\delta\gamma c_p+\delta\gamma\lambda wr)[\Phi(\tilde{A}_S)-\Phi(\underline{A}_S)]}{p-b+\delta\gamma(b-s)[\Phi(\tilde{A}_S)-\Phi(\underline{A}_S)]}\right).$$

Proposition 5.3. Under BSBPOF financing, both π_s^{bsbpof} and $K^{bsbpof*}$ decrease with *b-s*. Moreover, π_r^{bsbpof} and $q^{bsbpof*}$ are not irrelevant to *s*, but only are positively related to *b*.

Proposition 5.3 suggests that π_s^{bsbpof} and $K^{bsbpof*}$ are affected by the buyback price and the salvage value. If there is surplus stock, a higher value of *b-s* incentivizes the supplier to install less capacity, increasing the losses and reducing the profit. Thus, applying a buyback strategy brings more risks for the supplier which cuts the margins. For the retailer, the order quantity and expected profit are affected by the buyback price. If there is surplus stock, a higher buyback price from the supplier incentivizes the retailer to place more orders, reducing the retailer's losses and maximizing the profit. Regardless of whether the item has the salvage value, the retailer's order quantity and profit are not correlated with the salvage value but are only positively related to the buyback price since all unsold items are subject to repurchase by the supplier.

Now, let us determine the financial institution's optimal interest rate. Since the supplier and the retailer can repay the entire debt, the financial institution's profit can be written as

$$\pi_c = \lambda wqr\bar{\Phi}(\tilde{A}_s) + \int_{\underline{A}_s}^{\tilde{A}_s} (1-\delta)\{\gamma \begin{bmatrix} (w-c_p)\min(q,K) - c_k K - \lambda wqr \\ -(b-s)[\min(q,K)-D]^+ + A_s - L_s \end{bmatrix} - \lambda wq\}\phi(A_s)dA_s. \tag{5.7}$$

The financial institution has zero expected returns because the capital market is competitive. Hence, the financial institution's optimal interest rate is:

$$r = \frac{(1-\delta)\bar{\Phi}(\tilde{A}_s)\lambda wq - \int_{\underline{A}_s}^{\tilde{A}_s} (1-\delta)\gamma \begin{bmatrix} (w-c_p)\min(q,K) - c_k K - \\ (b-s)[\min(q,K)-D]^+ + A_s - L_s \end{bmatrix} \phi(A_s)dA_s}{\lambda wq[\bar{\Phi}(\tilde{A}_s) - (1-\delta)\Phi(\tilde{A}_s)\gamma]}. \tag{5.8}$$

Proposition 5.4. In BSBPOF, with buyback price $b>s$, the interest rate r obtained increases with the value of b-s.

Proposition 5.4 demonstrates that for the financial institution, the optimal interest rate is correlated with the expected earnings of the financial institution when the supplier defaults and liquidates. When there is excess inventory, the greater the difference between the buyback price and the salvage value, the lower the financial institution's profitability in liquidation. Therefore, to protect against excessive losses and to avoid risks, a higher interest rate is offered by the financial institution when the difference in the supply chain is greater.

Theorem 5.2. To ensure that both participants in the supply chain are willing to choose BSBPOF, the buyback price and the salvage value can be met for $\eta_r^{bsbpof*} < b$,

$$b - s < \eta_s^{bsbpof*}, \text{ where } \eta_s^{bsbpof*} \triangleq \frac{\begin{array}{c}(w-c_p)\min(q^{bsbpof*}, K^{bsbpof*}) - c_k K^{bsbpof*} - \\ \lambda w q^{bsbpof*} r - (1-\alpha)(L_s - A_s - \lambda w q^{bsbpof*} + c_k K^{bsbpof*})\end{array}}{[\min(q^{bsbpof*}, K^{bsbpof*}) - D]^+},$$

and

$$\eta_r^{bsbpof*} \triangleq \frac{p\mathrm{E}\min(D, q^{bsbpof*}) - wq^{bsbpof*} - \int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq - \gamma\begin{bmatrix}(w-c_p)q^{bsbpof*} - c_k K^{bsbpof*} \\ -(b-s)(q^{bsbpof*} - D)^+ \\ -\lambda w q^{bsbpof*} r + A_s - L_s\end{bmatrix}\right\}\phi(A_s)dA_s}{(q^{bsbpof*} - D)^+}.$$

Similar to Theorem 5.1, Theorem 5.2 also indicates that to ensure that both the seller and the buyer prefers to choose the financing mode of BSBPOF, the buyback price and the salvage value should be within a range so that both of them benefit from the financing.

5.3.3 Financing equilibrium between BSBPOF and BSAPD

So far, the respective optimal decisions under BSBPOF and BSAPD have been derived. Whereas, when either of the two financing instruments is chosen, it is necessary to describe the unique equilibrium under a single-financing mode. That is, which financing scheme should be chosen in equilibrium if either BSAPD or BSBPOF alone is sufficient to meet the financial needs of the supplier? Without loss of generality, if the buyer is unfamiliar with both, it is assumed that the buyer selects BSAPD over BSBPOF, and analyzed it from the perspective of both the buyer and the seller.

(1) Retailer’s perspective: BSBPOF versus BSAPD

In a single financing mode, when both BSPOF and BSAPD are feasible, backward induction is applied to derive the optimal strategy of each channel member.

Theorem 5.3. Under single financing, if the supplier's buyback price b is over a unique threshold μ_r ($b > \mu_r$) such that BSBPOF is preferred by the buyer because $\pi_r^{bsbpof*} > \pi_r^{bsapd*}$.

Here,

$$\mu_r \triangleq \frac{\begin{array}{l} p[\mathrm{E}\min(D,q^{bsapd*}) - \mathrm{E}\min(D,q^{bsbpof*})] + w[q^{bsbpof*} - (1-d)q^{bsapd*}] \\ + \int_{\underline{A}_S}^{\bar{A}_S} \delta \left\{ \lambda w q^{bsbpof*} - \gamma \begin{bmatrix} (w-c_p)q^{bsbpof*} - c_k K^{bsbpof*} \\ -(b-s)(q^{bsbpof*} - D)^+ - \lambda w q^{bsbpof*} r + A_s - L_s \end{bmatrix} \right\} \phi(A_s) dA_s \\ +(1-\alpha)[L_r - A_r + w(1-d)q^{bsapd*}]^+ - (1-\alpha)[L_r - A_r + w(1-d)q^{bsapd*}]^+ \end{array}}{(q^{bsbpof*} - D)^+ - (q^{bsapd*} - D)^+}.$$

Otherwise, BSAPD is the best choice because $b \le \mu_r$ if and only if $\pi_r^{bsapd*} \ge \pi_r^{bsbpof*}$.

Theorem 5.3 reveals that the retailer's financing decision depends on whether the supplier's buyback price exceeds a certain threshold. That is, even if the retailer pays less in BSAPD than in BSBPOF, the risk of potential financial distress before shipping must be undertaken and the risk of increased inventory after shipping is due to the larger orders. BSBPOF is preferred by the retailer over BSAPD in exceptional cases where the supplier's buyback price is extremely high and there is no financial distress. This is because the high buyback price reduces the retailer's losses, and the expected profit is higher than the low buyback price, reducing the financing risks. Hence, the retailer is more motivated to use his or her own capital to finance the supplier (BSAPD financing) with the lower threshold μ_r.

(2) Supplier's perspective: equilibrium conditions

Considering that the income of BSBPOF is determined by the financing contract provided by the creditor, in the BSAPD-only strategy, the supplier can optimize the expected income. Therefore, the supplier selects the minimum discount rate, making BSAPD more profitable than BSBPOF.

Theorem 5.4. Under single financing, (1) the difference between the buyback price and the salvage value *b-s* should be below a certain threshold μ_s ($b-s<\mu_s$) to ensure $\pi_s^{bsbpof*} > \pi_s^{bsapd*}$.

Here,

$$\mu_s \triangleq \frac{[w(1-d)-c_p](q^{bsapd}-q^{bsbpof})-c_k(q^{bsapd}-q^{bsbpof})+\lambda w q^{bsbpof} r}{\{[q^{bsapd}-D]^+-[q^{bsbpof}-D]^+\}}$$
$$-\frac{(1-\alpha)[L_s-A_s+c_k q^{bsapd}-w(1-d)q^{bsapd}]^+ +(1-\alpha)[L_s-A_s+c_k K-w(1-d)q^{bsbpof}]^+}{\{[q^{bsapd}-D]^+-[q^{bsbpof}-D]^+\}}.$$

Otherwise, BSAPD is the best choice; (2) the seller provides an advance payment discount contract $(w,\tilde{d})$ in equilibrium, and

$$\tilde{d} \in \frac{(w-c_p-c_k)(q^{bsapd}-q^{bsbpof})+(b-s)\{[q^{bsbpof}-D]^+-[q^{bsapd}-D]^+\}+\lambda w q^{bsbpof} r}{w q^{bsapd}}.$$

Hence, the supplier prefers BSAPD over BSBPOF because $\pi_s^{bsapd*} > \pi_s^{bsbpof*}$.

Theorem 5.4 states that for a capital-constrained supplier, the difference between the buyback price and the salvage value can influence the financing decision. The difference should be less than a fixed value, making BSBPOF more favored by the supplier than BSAPD. This theorem also implies that the supplier chooses a minimum discount rate to maximize the profit, which ensures that BSAPD is more profitable than BSBPOF, otherwise the supplier may choose to cancel BSAPD.

5.4 Numerical Analysis

The impact of a key parameter, the difference between the buyback price and the salvage value, is investigated regarding the decisions of both the mobile phone supplier and the financial institution through an extensive numerical study in the smartphone industry. The benchmark parameter values include p=600 US dollars, c_k=c_p=100 US dollars, α=0.85, and γ=0.9. The demand D is normally distributed and can be expressed as N(1000,100). When adjusting the difference between the buyback price and the salvage value, the difference varies between 0 and 150, in increments of

15.

5.4.1 Impact of *b-s* on supplier's decisions

In this section, we first examine how the difference between the buyback price and the salvage value affects the capacity levels under both BSAPD and BSBPOF and the supplier's setting on the discount rate under BSAPD. These impacts are shown in Figure 5.4 and Figure 5.5. Figure 5.4 first demonstrates that the capacity level of the supplier is affected by the difference when customer demand is under the shipped quantity. The supplier prefers to produce fewer goods with a larger difference so as to decrease the losses under the buyback policy. When b-s is relatively small (i.e., b-s =15), there is a larger capacity level for the supplier (K=1022 under BSAPD and K=1034 under BSBPOF). In other words, when the seller sells products through BSAPD and BSBPOF, the smaller the difference between the buyback price and the salvage value, the smaller the financial risks the seller will face. The supplier makes more profits under the buyback policy with low b-s than with a high b-s due to the cost. Moreover, with the increase of b-s, the supplier's capacity level in BSBPOF decreases, which also makes the profits of the supplier drop to a lower level. From Figure 5.4, the difference between the buyback price and the salvage value has a greater impact on BSBPOF and the decrease is more obvious as the wholesale price in BSAPD is lower and the supplier prefers to prepare less capacity before shipment. Thus, the supplier would rather lend money from adopting BSBPOF to maximize the profits. When b-s takes a large value (i.e., b-s = 150), the two capacity levels under BSAPD (K=1005) and BSBPOF (K=1010) are smaller than when taking a small b-s. Although the supplier's capacity level under BSBPOF decreases to a certain extent as b-s increases, because too much loss can be avoided by reducing the supply, the two financing strategies still bring profits to the supplier.

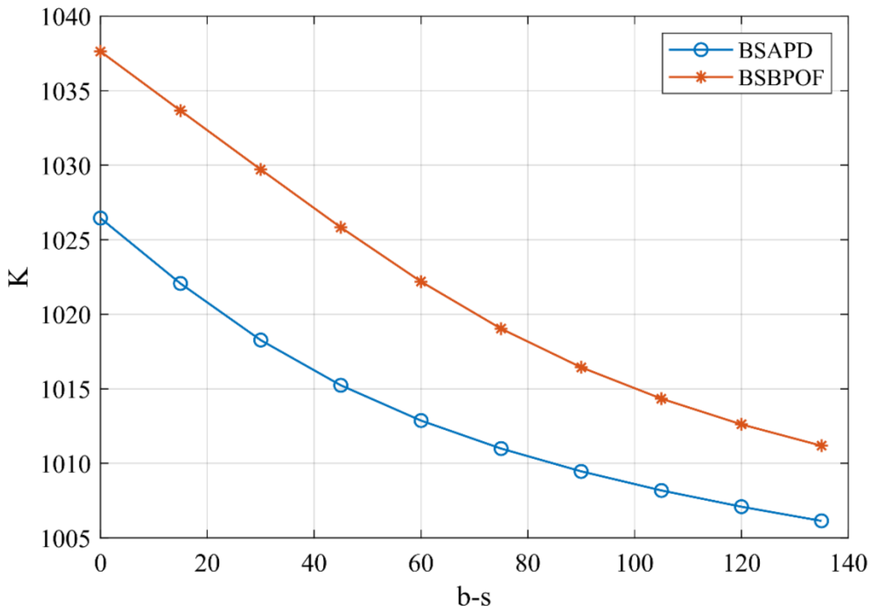

Figure 5.4. Impact of *b-s* on supplier's capacity level.

Figure 5.5 indicates that in BSAPD, the discount rate of the wholesale price decreases as the difference between the buyback price and the salvage value increases. For instance, when b-s is relatively small (i.e., b-s = 45), the offered discount rate is 0.31, while for b-s increasing (i.e., b-s = 120, b-s = 135), the discount is significantly reduced (d=0.12 and 0.09, respectively). This reflects the fact that the higher the difference, the more adverse effects on the supplier, that is, the greater the risks; hence, in the face of high repurchase costs, the supplier should offer the buyer a lower discount rate to maintain a higher wholesale price, because an increase in the repurchase price will cause the product risks to be borne by the supplier, thus reducing the financing costs and keeping a higher return.

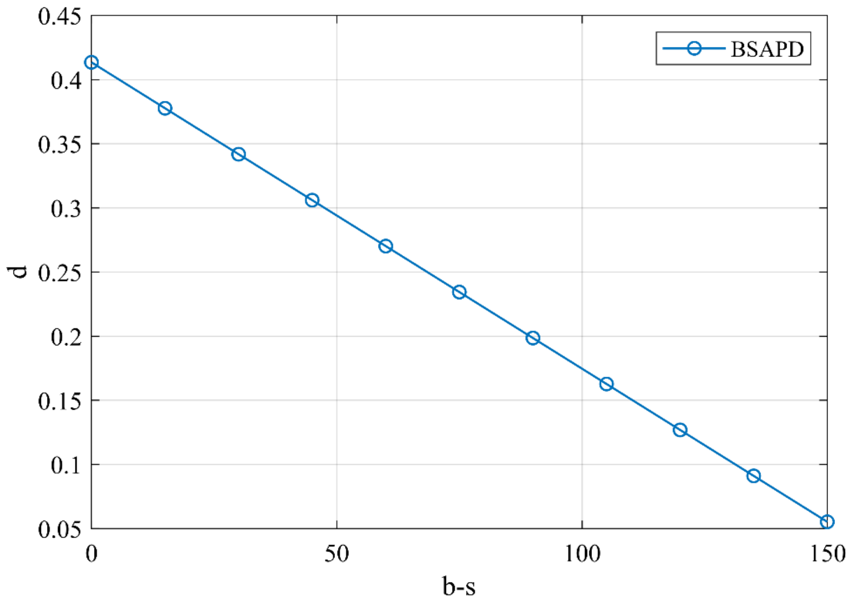

Figure 5.5. Impact of *b-s* on the discount rate.

5.4.2 Impact of *b-s* on financial institution's decision

Figure 5.6 illustrates comparisons of the financial institution's interest rate with the difference between the buyback price and the salvage value (the parameters include *b-s* =0, *b-s* =15, …, *b-s* =150). It is clear that the financial institution provides a lower interest rate when *b-s* is relatively small (i.e., *b-s* = 15). For the financial institution, the optimal strategy of the interest rate is related to the financial institution's expected income when the supplier defaults and liquidates. A small *b-s* means that the loss suffered by the supplier is small if there is a return of unsold products, and the supplier is less likely to liquidate, thus the financial institution's profitability in liquidation becomes lower, which in turn ensures the financial institution's profit. In order to protect against excessive losses and to avoid risks, the financial institution offers a higher interest rate when the difference in the supply chain is greater.

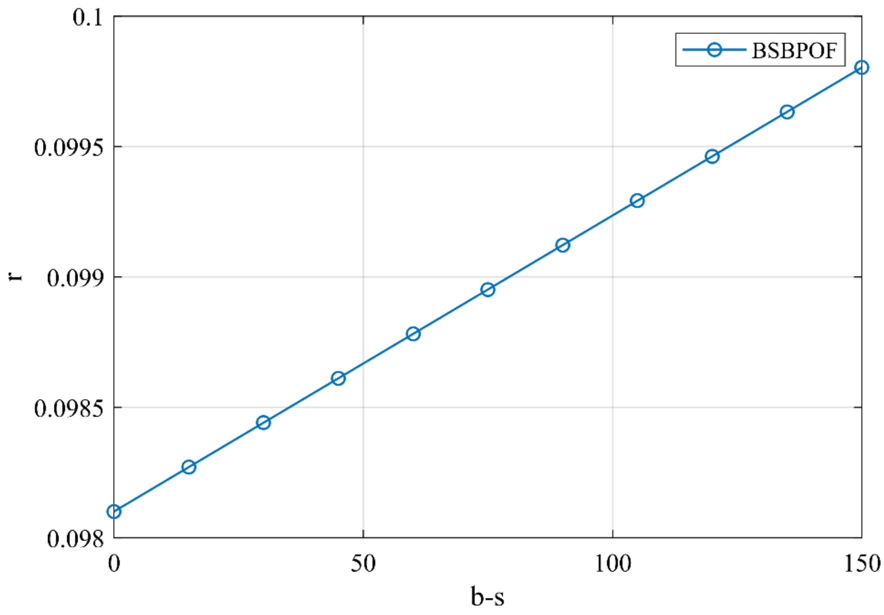

Figure 5.6. Impact of *b-s* on financial institution's interest rate.

5.5 Managerial Insights

As mobile phones are highly innovative products with short life cycles, manufacturers are constantly introducing novel products, some of which fail to catch on due to uncertain customer demand. In real life, smartphone retailers often order more phones before the selling season than the market demands, and they have to clear them out when the selling season ends. These unsold phones have a relatively high salvage value and are still valuable after the sales season and are of a type that market researchers should consider in SCF research. For instance, in many developed countries and even some developing countries, with the gradual maturity of 5G mobile phone technology and the gradual laying of network communication infrastructure, 5G mobile phone users are gradually increasing. The market is expected to see a wave of replacement phones in the next few years. Unsold and still valuable 4G or even 3G phones from the fast-growing market can be exported to slow-growing countries. In this regard, this chapter provides several management insights.

Firstly, for the mobile phone supplier, the approach solves the shortage of the working capital problem and ensures that orders can be filled. However, under both BSAPD and BSBPOF, the gap between the buyback price and the salvage value of mobile phones will affect the capacity level and the supplier’s profit. The smaller the difference between the buyback price and the salvage value of the mobile phone, the higher the capacity level and the lower the losses for the supplier. Besides, in BSAPD financing, when the difference is higher, the supplier should provide a lower discount rate to keep the buyer's purchase price higher, because an increase in the repurchase price will cause the risks to be borne by the supplier.

Secondly, for the retailer, the two financing strategies described in this chapter can alleviate the supply shortage caused by the supplier's financial difficulties. It is worth noting that under the buyback policy, the salvage value of the mobile phone does not affect the retailer’s operational decisions, because it is the responsibility of the supplier, and the profit and the order quantity are positively associated with the buyback price. After the sales season, the upstream seller can buy back the unsold goods to help the retailer reduce losses, thus reducing financial risks.

Thirdly, for the financial institution, the loan interest rate increases along with the difference between the buyback price and salvage value. If the difference increases, the handset supplier's losses will increase, readily leading to liquidation. Therefore, when adopting BSBPOF financing, if the difference between the repurchase price and the salvage value of mobile phones is large, it is suggested that the financial institution set a higher interest rate to reduce the loan amount of the supplier, so as to avoid losses and to reduce the financing risks.

Besides, compared with the two pre-shipment financing modes, BSBPOF and BSAPD, the only financing equilibrium is BSBPOF when the buyback price is higher than a certain level and the difference between the buyback price and the salvage value is small. Here, the BSBPOF strategy can provide triple benefits to the supplier, the buyer, and the financial institution. By comparison, BSAPD can allow the coordination of channels by moving money from voluntary sources to constrained locations in the supply chain.

5.6 Summary

At present, there are many studies on post-shipment financing instruments and solving the shortage of funds of the retailers but less research on solving the problem of the supplier's capital constraints by applying pre-shipment financing modes. Moreover, the salvage value of commodities is usually handled by the buyer. However, in real life, the supplier often buybacks unsold products with high salvage value, such as mobile phones. At this time, the supplier is responsible for the salvage value. Because of the short replacement cycle of mobile phones, the mobile phone supplier needs to have sufficient working capital to produce and keep up with the pace of new product launches. Thus, we investigate the optimal financing strategy and analyze how the difference between the salvage value and the buyback price affects operation management in a mobile phone supply chain.

Two novel pre-shipment mechanisms (BSBPOF and BSAPD) are developed to finance the capital-constrained supplier. It is found that the difference between the buyback price and the salvage value of unsold mobile phones affects the capacity level, the discount rate under BSAPD, and the interest rate of financial institutions under BSBPOF. To be specific, the higher the difference is, the less the supplier is encouraged to produce more phones, so as to avoid the losses caused by excessive purchases. On the contrary, the larger the difference is, the more unfavorable it is for the supplier. The supplier bears the risk of excessive inventory and will pay high buyback costs. Therefore, the supplier should have a low-capacity level before the sales season to reduce the financing costs. In addition, under BSAPD financing, with a higher difference, the supplier should offer a lower discount rate to maintain a higher purchase price for the buyer, thus reducing the economic burden and financial risks. Moreover, under BSBPOF financing, a financial institution's interest rate increases with the difference. The financial institution offers a higher interest rate when the difference is relatively large so as to prevent excessive losses. Furthermore, when both financing instruments are available, the only equilibrium is BSBPOF when the buyback price is above a certain level and the difference is less than a certain range. Otherwise, BSAPD should be selected.

CHAPTER 6 A Study on Green Supply Chain Under Capital Constraint Considering Time-Varying Salvage Value

In this chapter, a green television supply chain under capital constraint with time-varying salvage values is studied. Firstly, the problem statements are presented in detail in Section 6.1. The model descriptions are shown in Section 6.2. Models including APD and BPOF with time-varying salvage values, the financing equilibrium, and a profit risk analysis are formulated in Section 6.3. Section 6.4 presents the numerical experiments. Some managerial insights are provided in Section 6.5, with a summary in Section 6.6.

6.1 Problem Statements

This chapter concerns a green TV supply chain in which the retailer sells unsold TVs with time-varying salvage values, and the supplier can adopt pre-shipment financing strategies for the smooth production of new, greener products. Regarding a green TV supply chain, the following research questions in this chapter are investigated:

1) How to build a green TV supply chain model and what is the effect of the TV time-vary salvage value on the decision making of the participants under pre-shipment financing strategies?

2) Which financial strategy, APD or BPOF, should the retailer select to help the supplier obtain funds to produce green products?

3) How to measure potential risks in the green TV supply chain under different financing schemes in the GSC?

Therefore, to help the TV supplier with capital constraints obtain financing to produce more green products, a GSC model via APD and BPOF is established and the impact of the time-varying salvage value on the operational and financing decisions is studied. In addition, the profit risk level was modeled. Some novel managerial insights are presented and contribute to the current literature.

6.2 Model Descriptions

6.2.1 Notations and assumptions

For convenience, the notations summarized in Table 6.1 have been used in the development of the proposed model.

Table 6.1. Summary of notations.

Notation	Description
π	Expected profit
A	Asset level
L	Short-term debt
D	Product demand
p	Unit television selling price
α	Proportional distress cost
γ	Proportional liquidation cost
δ	The portion of financial institution's loss reimbursed by retailer
c_p	Unit television production cost
c_k	Unit television capacity cost
r	The interest rate of BPOF
$s(t)$	Unit salvage value of the television at time t
K	Supplier's capacity level of televisions
q	Order quantity of televisions
w	Unit wholesale price
d	Discount rate under APD
λ	The portion of purchase order value financed by a financial institution

After the sales season ends, any leftover inventory $[min(q,K)\text{-}D]^+$ is salvaged at s.

The time-dependent salvage value is in the form of *s(t)=a-bt* where *a* and *b* are constant. Here *a* is the initial (maximum) salvage value, and *b* is the sensitivity of price to the time ($b \geq 0$). In BPOF, the supplier will receive a λwq loan through a contract $(\bar{\lambda},\ r)$ from the financial institution. Here $\lambda \in [0, \bar{\lambda}]$ represents the borrowing level and *r* is the interest rate. In liquidation, the retailer, as the credit guarantor, pays the previously defined part of the loss of financial institutions (δ). The lending market is highly competitive and the financial institution's expected profit is zero (Zhao and Huchzermeier 2018a). In APD, the supplier provides the unit discount rate *d* a. Moreover, a backup television supplier is not available.

6.2.2 Model framework

There are three key participants: a green TV supplier (seller) with financial constraints, a TV retailer (buyer) with high credibility, and a financial institution, all of whom are risk neutral. Such parties in this supply chain collaborate to deal with the TV supplier's financial stress by using two financing strategies (APD and BPOF). The BPOF strategy means that the supplier obtains funds from the financial institution with the established downstream retailer's guarantee to deliver to the buyer on time. By using APD, the retailer can finance the financially troubled supplier by pre-paying for TVs at a discount before delivery. That is, the supplier obtains early payment from the retailer for production.

Figure 6.1 displays the sequence of events of the two financing instruments (Zhao and Huchzermeier 2018b).

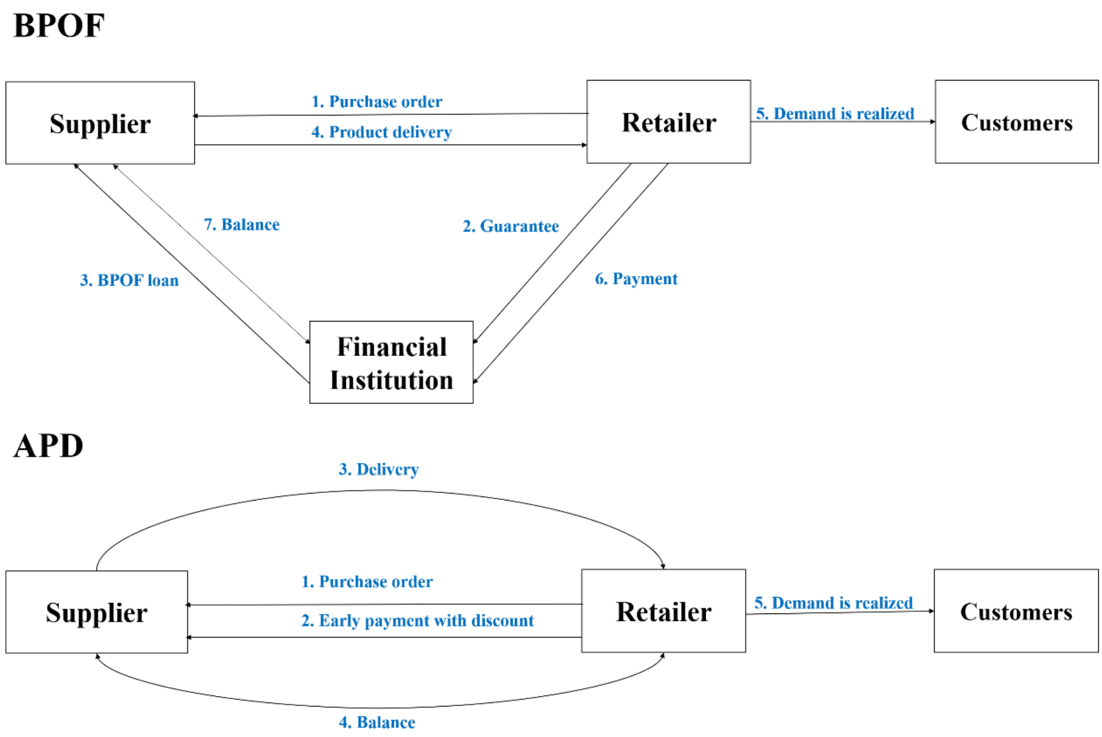

Figure 6.1. The sequence of events of two financing instruments.

6.2.3 Sequence of events

Moreover, there are three stages in the process: 1) financing, in which the retailer chooses a financing strategy to reduce the green TV supplier's financial stress; 2) executing: both parties complete the business; 3) salvage processing stage: unsold TVs are salvaged. The timeline of events is shown in Figure 6.2, which is based on the study of Zhao and Huchzermeier (2018a). To be specific, the model has two periods: a normal sales period (executing stage) where TVs are sold at a predetermined price p (Pasternack 1985; Wang and Webster 2009), and a clearance sales period (salvage processing stage) where TVs are settled at a time-varying salvage value s.

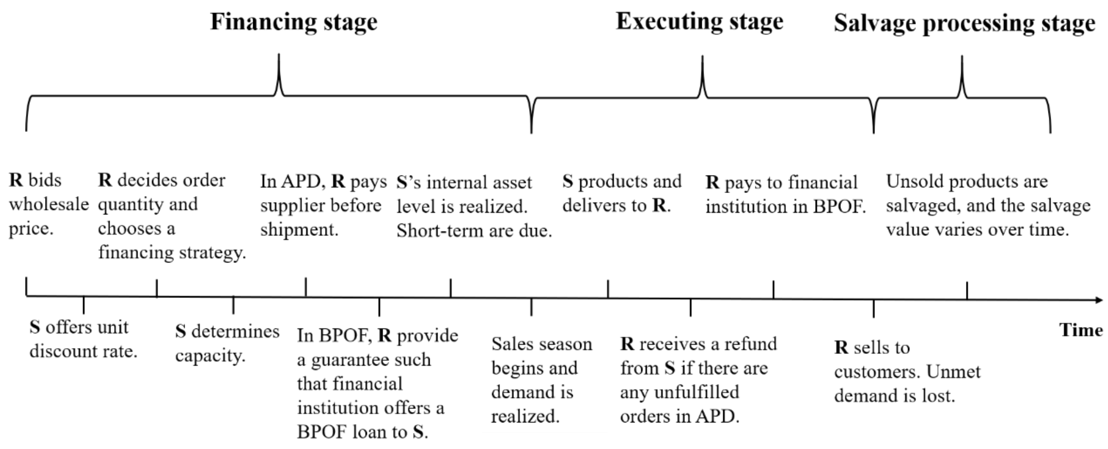

Figure 6.2. Timeline of events.

Specifically, (1) the wholesale price *w* is set firstly; (2) the TV supplier decides whether to accept *w* based on the allocation of its assets, taking into account the possibility of financial hardship and default. Once accepted, the supplier should offer a discount *d* on *w*. If not accepted, the deal is over; (3) the TV retailer plans on *q* and selects a financing strategy; (4) the TV supplier determines *K* which depends on *q* and how much working capital support there is. (5) once APD is selected, the retailer will pay before the products are shipped. (6) once the retailer selects the BPOF, the financial institution provides financing to the supplier. At this time, the TV supplier selects a borrowing level and then obtains a λwq; (7) short-term debts mature; (8) the sales season begins, and the demand is realized; (9) the products are sent to the retailer; (10) the retailer pays for the TVs. For any outstanding pre-paid orders, the retailer will refund the supplier in APD; (11) If the supplier continues to operate or restructure in BPOF, the retailer pays the full amount of the order to the financial institution. For liquidation, the financial institution will seize the supplier's current assets, and the retailer will pay the agreed-upon portion of the losses, being the loan guarantor; (12) The products are sold to the customer at *p*; (13) After the sales season, if there are unsold goods with salvage value, the salvage value of the TV is determined based on time.

6.3 Models

6.3.1 APD with time-varying salvage values

The supplier's profit function is:

$$\pi_s^{apd} = [w(1-d)-c_p]\min(q,K) - c_k K - (1-\alpha)[L_s - A_s + c_k K - w(1-d)q]^+ . \tag{6.1}$$

When $L_s - A_s + c_k K - w(1-d)q \le 0$, it means that the TV supplier's current assets can meet the liabilities and so can continue to operate. Otherwise, the TV supplier enters the reorganization or liquidation stage. The supplier will go into liquidation only if the cost of the financial distress exceeds the operating profit of the restructured company (Yang et al. 2015). For liquidation, the optimal capacity $K^{apd*} = 0$, otherwise K^{apd*} satisfies the first-order conditions:

$$\begin{aligned} &(1-d)[p-(p-a+bt)F(K^{apd*})][1-h(K^{apd*})] = c_p + c_k && \text{Continuation} \\ &(1-d)[p-(p-a+bt)F(K^{apd*})][1-h(K^{apd*})] = c_p + (2-\alpha)c_k && \text{Reorganization.} \end{aligned} \tag{6.2}$$

The retailer's profit in APD is found as follows:

$$\begin{aligned} \pi_r^{apd} = {} & p\mathrm{E}\min[D,\min(q,K)] - w(1-d)\min(q,K) \\ & + (a-bt)[\min(q,K)-D]^+ - (1-\alpha)[L_r - A_r + w(1-d)q]^+ . \end{aligned} \tag{6.3}$$

The buyer's expected profit function in APD is:

$$\begin{aligned} E(\pi_r^{apd}) = {} & [p-w(1-d)]\min(q,K) - (p-a+bt)\int_0^{\min(q,K)} F(x)dx \\ & -(1-\alpha)[L_r - A_r + w(1-d)q]^+ . \end{aligned} \tag{6.4}$$

Under APD, the buyer balances the marginal effect of APD against the unit financial distress cost, and if the supplier's working capital is sufficient to support APD, the retailer’s optimal order quantity q^{apd*} is:

$$\begin{aligned} &p-(p-a+bt)F\left(q^{apd*}\right)=w(1-d) && \text{Continuation} \\ &p-(p-a+bt)F\left(q^{apd*}\right)=w(1-d)(2-\alpha) && \text{Reorganization.} \end{aligned} \quad (6.5)$$

Proposition 6.1. Under APD, π_r^{bsapd} and q^{bsapd*} are relevant to the time-varying salvage value, and they are negatively related to time *t*.

Proposition 6.1 shows that the buyer’s expected profit and the optimal order quantity are affected by the salvage value of the TV, while they are negatively affected by time, since a TV with a high salvage value is more attractive to the buyer, allowing the ordering more products and make more money. In contrast, for a TV with a low salvage value, the order quantity and the profit of the retailer are less than those with a high salvage value.

Proposition 6.2. Given *w, p, K,* the discount rate *d* is decreasing with *t*.

Proposition 6.2 shows that in APD, the later the TVs are sold during the clearance period, the lower the discount rate offered by the supplier. This is because the salvage value of the TV is greatly affected by the selling time during the clearance period. The later the clearance time, the lower the salvage value will be. When the time-varying salvage value of the TV is low, it harms the retailer’s profit, that is, the retailer's financial risks become high. Therefore, in the face of the high financial risks of the retailer, the TV supplier should provide the retailer with a lower discount rate to maintain a higher buyer's purchase price (wholesale price), thus reducing the financial risks.

Theorem 6.1. To ensure that the downstream buyer benefits from APD and chooses it, the time of the time-varying salvage value is met $t<\eta_r^{apd*}$ where

$$\eta_r^{apd*} \triangleq \frac{a}{b} - \frac{w(1-d)\min(q,K) - p\mathrm{E}\min[D,\min(q,K)] + (1-\alpha)[L_r - A_r + w(1-d)q]^+}{b[\min(q,K)-D]^+}.$$

Theorem 6.1 shows that to ensure that participants benefit from the APD financing model, the clearance time should be within a certain range. The financing mode decision for the retailer is related to the clearance time. A higher return at a clearance time below a certain value would prompt the retailer to apply APD financing. Otherwise, a late clearance time will lead to a low salvage value of the TV, affecting the profit of the retailer which brings great financial risks.

6.3.2 BPOF with time-varying salvage values

The supplier’s profit under BPOF is:

$$\pi_s^{bpof} = (w-c_p)\min(q,K) - c_k K - \lambda wqr - (1-\alpha)(L_s - A_s + c_k K - \lambda wq)^+. \quad (6.6)$$

The TV supplier continues to operate on the condition that the supplier pays off short-term debt before delivery (that is $L_s - A_s + c_k K - \lambda wq \le 0$). Conversely, the TV supplier goes into bankruptcy. If the supplier's internal assets fall below the threshold $\tilde{A}_s = L_s + c_k K - \lambda wq - \dfrac{(w-c_p)\min(q,K) - c_k K - \lambda wqr}{1-\alpha}$, the supplier liquidates, and the probability of liquidation is $Pr(l) = \Phi(\tilde{A}_s)$. For liquidation, $K^{bpof*} = 0$, otherwise K^{bpof*} satisfies:

$$\begin{aligned} &[p-(p-a+bt)F(K^{bpof*})][1-h(K^{bpof*})] = c_p + c_k && \text{Continuation} \\ &[p-(p-a+bt)F(K^{bpof*})][1-h(K^{bpof*})] = c_p + (2-\alpha)c_k && \text{Reorganization.} \end{aligned} \quad (6.7)$$

In BPOF, the retailer’s profit is:

$$\pi_r^{bpof} = pE\min[D,\min(q,K)] - w\min(q,K) + (a-bt)[\min(q,K)-D]^+ - \int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq - \gamma\left[(w-c_p)\min(q,K) - c_k K - \lambda wqr + A_s - L_s\right]\right\}\phi(A_s)dA_s. \tag{6.8}$$

The expected profit of the retailer in BPOF is

$$E(\pi_r^{bpof}) = (p-w)\min(q,K) - (p-a+bt)\int_0^{\min(q,K)} F(x)dx - \int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq - \gamma\left[(w-c_p)\min(q,K) - c_k K - \lambda wqr + A_s - L_s\right]\right\}\phi(A_s)dA_s. \tag{6.9}$$

Hence, the optimal order quantity under BPOF can be derived as $q^{bpof} * = F^{-1}(\dfrac{p-w-(\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)[\Phi(\tilde{A}_S)-\Phi(\underline{A}_S)]}{p-a+bt})$.

Proposition 6.3. Under BPOF, both π_r^{bpof} and q^{bpof*} are affected by the time-varying salvage value. The longer TVs that are not sold at the end of the season are stored, the lower π_r^{bsbpof} and q^{bpof*}.

Proposition 6.3 suggests that if there is surplus stock, a shorter clearance time incentivizes the retailer to place more orders, reducing the losses and maximizing the profit because the salvage value of the unsold inventory is greater. Besides, regardless of whenever the TV is sold out during the clearance period, the supplier's capacity level and profit are not correlated with the time-varying salvage value because all unsold TVs are handled by the retailer.

Since the supplier and the retailer can repay the entire debt, the financial institution's profit is

$$\pi_c = \lambda wqr\bar{\Phi}(\tilde{A}_s) + \int_{\underline{A}_S}^{\tilde{A}_S} (1-\delta)\{\gamma\begin{bmatrix}(w-c_p)\min(q,K)-c_k K \\ -\lambda wqr + A_s - L_s\end{bmatrix} - \lambda wq\}\phi(A_s)dA_s. \tag{6.10}$$

Since the capital market is competitive, the financial institution has zero expected returns. Hence, the financial institution's optimal interest rate is:

$$r=\frac{(1-\delta)\bar{\Phi}(\tilde{A}_s)\lambda wq-\int_{\underline{A}_S}^{\tilde{A}_S}(1-\delta)\gamma\left[(w-c_p)\min(q,K)-c_kK+A_s-L_s\right]\phi(A_s)dA_s}{\lambda wq[\bar{\Phi}(\tilde{A}_s)-(1-\delta)\Phi(\tilde{A}_s)\gamma]}. \tag{6.11}$$

Proposition 6.4. Under BPOF, the financial institution's optimal interest rate r is positively affected by the time-varying salvage value.

Proposition 6.4 suggests that if if there is surplus stock, the time-dependent salvage value will affect the financial institution's interest rate. The reason is that the shorter the clearance time, the higher the salvage value, and the retailer prefers to order more products because the inventory risk of products with high salvage value is low. Moreover, since the retailer has collateral liability in BPOF financing, he/she may also face financial distress. As a result, as the retailer orders more, the retailer faces greater financial risks, and the financial institution should offer a higher interest rate to avoid possible losses and reduce financing risks when the clearance time is shorter.

Theorem 6.2. To ensure that the downstream buyer benefits from BPOF and choosing it, the time of the time-varying salvage value is met for $t<\eta_r^{bpof*}$ where

$$\eta_r^{bpof*}\triangleq\frac{a}{b}-\frac{w\min(q,K)-p\min[D,\min(q,K)]+\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq-\gamma\begin{bmatrix}(w-c_p)\min(q,K)-\\c_kK-\lambda wqr+A_s-L_s\end{bmatrix}\right\}\phi(A_s)dA_s}{b[\min(q,K)-D]^+}.$$

Theorem 6.2 ensures that the retailer benefits from the BPOF financing model, and the clearance time should be within a certain range. An early clearance time will lead to high salvage value which brings more profits to the retailer and few financial risks.

6.3.3 Financing equilibrium with time-varying salvage values

When either of the financing instruments is sufficient to meet the working capital demand of the supplier, the retailer will choose one of these two financing strategies.

Theorem 6.3. Under a single financing condition, a unique threshold of the retailer's internal asset level ω_r exists, which makes the retailer more inclined to BPOF if $A_r < \omega_r$. Otherwise, APD is preferred. Besides, the value ω_r is inversely proportional to the clearance time.

Theorem 6.3 reveals that considering the time-varying salvage value, ω_r is to ensure that the buyer prefers to apply BPOF. The reason is that the earlier the clearance time, the greater the salvage value of the TVs which encourages the retailer to order more, while the increase of order quantity increases the inventory risk and makes the inventory tend to be overstocked. Therefore, the TV buyer should have a higher asset level if the clearance period is too long so that the retailer has sufficient funds to provide APD financing for the supplier.

Theorem 6.4. Under a single financing condition, a unique threshold of the clearance time ω_t exists, which makes the buyer more inclined to BPOF if $t < \omega_t$. Otherwise, APD is preferred.

Theorem 6.4 reveals that the threshold of clearance time exists to ensure that the buyer prefers to apply BPOF. The reason is that the later the clearance time, the smaller the salvage value which decreases the order quantity and reduces the risk of excess inventory. Under BPOF, the retailer only needs to pay part of the losses of the financial institution as compensation when the supplier is in a liquidation state, while under APD financing mode, the retailer needs to have sufficient funds to finance the TV supplier. Therefore, if the clearance time is late (at the time when the salvage value is low), the retailer will order less and suffer fewer losses and should choose APD financing due to having more funds to finance the supplier. If the clearance time is early, BPOF has a relative advantage. This is because the retailer may order more and therefore might not have sufficient money to finance the supplier, and BPOF is the better choice.

6.3.4 Profit risk analysis

The retailer's profit risks under the time-varying salvage value scenarios are analyzed by conducting a mean-variance analysis (Choi et al. 2008). The variance of the retailer's profit under APD is:

$$V(\pi_r^{apd}) = \mathrm{E}[(\pi_r^{apd})^2] - [\mathrm{E}(\pi_r^{apd})]^2 \tag{6.12}$$

Putting (6.3) & (6.4) into (6.12), we have

$$V(\pi_r^{apd}) = (p-a+bt)^2[2\min(q,K)n - 2\int_0^{\min(q,K)} xF(x)dx - n^2] \tag{6.13}$$

where $n = \int_0^{\min(q,K)} F(x)dx$. For $\frac{dV(\pi_r^{apd})}{dq} = 2(p-a+bt)^2[1-F(\min(q,K))]n \geq 0$, and $\frac{dV(\pi_r^{apd})}{dt} = 2(p-a+bt)b \geq 0$, $V(\pi_r^{apd})$ is a monotone increasing function of q^{apd} and t.

The variance of the retailer's profit under BPOF is:

$$V(\pi_r^{bpof}) = \mathrm{E}[(\pi_r^{bpof})^2] - [\mathrm{E}(\pi_r^{bpof})]^2 \tag{6.14}$$

Putting (6.8) & (6.9) into (6.14), we have

$$V(\pi_r^{bpof}) = (p-a+bt)^2[2\min(q,K)n - 2\int_0^{\min(q,K)} xF(x)dx - n^2] \tag{6.15}$$

where $n = \int_0^{\min(q,K)} F(x)dx$. For $\frac{dV(\pi_r^{bpof})}{dq} = 2(p-a+bt)^2[1-F(\min(q,K))]n \geq 0$, and

$\frac{dV(\pi_r^{bpof})}{dt} = 2(p-a+bt)b \geq 0$. Thus, $V(\pi_r^{bpof})$ is a monotone increasing function of q^{bpof} and t.

The profit of the entire supply chain in APD financing mode is

$$\begin{aligned}\pi_{sc}^{apd} = {} & p\mathrm{E}\min[D, \min(q,K)] + (a-bt)[\min(q,K)-D]^+ - c_p\min(q,K) - c_k K \\ & -(1-\alpha)[L_r - A_r + w(1-d)q]^+ - (1-\alpha)[L_s - A_s + c_k K - w(1-d)q]^+.\end{aligned} \tag{6.16}$$

The entire supply chain's expected profit under APD is:

$$\begin{aligned}E(\pi_{sc}^{apd}) = {} & (p-c_p)\min(q,K) - (p-a+bt)\int_0^{\min(q,K)} F(x)dx \\ & -(1-\alpha)[L_r - A_r + w(1-d)q]^+ - (1-\alpha)[L_s - A_s + c_k K - w(1-d)q]^+.\end{aligned} \tag{6.17}$$

Hence the variance of the entire supply chain's profit under APD is:

$$V(\pi_{sc}^{apd}) = (p-a+bt)^2[2\min(q,K)n - 2\int_0^{\min(q,K)} xF(x)dx - n^2] \tag{6.18}$$

where $n = \int_0^{\min(q,K)} F(x)dx$.

The profit of the entire supply chain in the BPOF financing mode is:

$$\begin{aligned}\pi_{sc}^{bpof} = {} & p\mathrm{E}\min[D, \min(q,K)] + (a-bt)[\min(q,K)-D]^+ - c_p\min(q,K) \\ & -c_k K - \lambda wqr - \int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq - \gamma\begin{bmatrix}(w-c_p)\min(q,K) \\ -c_k K - \lambda wqr + A_s - L_s\end{bmatrix}\right\}\phi(A_s)dA_s \\ & -(1-\alpha)(L_s - A_s - \lambda wq + c_k K)^+\end{aligned} \tag{6.19}$$

The entire supply chain's expected profit under BPOF is

$$
\begin{aligned}
E(\pi_{\mathrm{sc}}{}^{bpof}) = {} & (p-c_p)\min(q,K)-(p-a+bt)\int_0^{\min(q,K)}F(x)dx-\lambda wqr-c_kK \\
& -\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq-\gamma\begin{bmatrix}(w-c_p)\min(q,K)-c_kK\\ -\lambda wqr+A_s-L_s\end{bmatrix}\right\}\phi(A_s)dA_s \\
& -(1-\alpha)(L_s-A_s-\lambda wq+c_kK)^+
\end{aligned} \tag{6.20}
$$

Therefore, the variance of supply chain profit under BPOF is:

$$
V(\pi_{\mathrm{sc}}{}^{bpof}) = (p-a+bt)^2[2\min(q,K)n-2\int_0^{\min(q,K)}xF(x)dx-n^2] \tag{6.21}
$$

where $n=\int_0^{\min(q,K)}F(x)dx$.

Comparing the variances of the retailer's profits and the entire supply chain's profits under both APD and BPOF, the findings are concluded in Proposition 6.6.

Proposition 6.6. (a) $V(\pi_r^{apd})$ and $V(\pi_r^{bpof})$ are increasing functions of q^{apd} and q^{bpof}. (b) $V(\pi_r^{apd})$ and $V(\pi_r^{bpof})$ are increasing with *t*. (c) $V(\pi_r^{apd})=V(\pi_{sc}^{apd})$, $V(\pi_r^{bpof})=V(\pi_{sc}^{bpof})$.

Proposition 6.6 identifies the relationship of profit risks with the order quantity and the clearance time. To be specific, Proposition 6.6(a) illustrates that the profit risks of the retailer under APD and BPOF are increasing with the order quantity, that is, the higher order quantity leads to higher profit risks. Proposition 6.6(b) implies that the retailer’s profit risks under APD and BPOF are related to the clearance time, that is, the earlier the retailer clears the inventory after the normal selling season, the lower the profit risk. Proposition 6.6(c) shows that the profit risks of the retailer and the profit risks of the entire supply chain under APD and BPOF are equal, which implies the retailer’s profit risks determine the risks of the whole supply chain.

6.4 Numerical Analysis

Some numerical experiments are used to verify the theoretical analysis above.

The basic parameter settings are listed below: (1) the demand D is normally distributed and can be expressed as N (1000,100). (2) For cost-revenue parameter: p = 580 US dollars, c_k=c_p=120 US dollars. (3) α=0.85, and γ=0.9 (Gamba and Triantis 2014; Dedrick et al. 2011). (4) The time-varying salvage value for the TV is $s(t)=a-bt$ where initial (maximum) salvage value a is 300, and the sensitivity of price to the time b is 10. When adjusting the clearance time, it varies between 0 and 30.

6.4.1 Impact of *t* on retailer's optimal order quantity under APD and BPOF

Figure 6.3 demonstrates that the clearance time t influences the retailer's optimal order quantity. For example, when t is relatively small (i.e., t =3), there is a larger order quantity (q=1001 under APD financing mode, q=1010 under BPOF financing mode). When t takes a large value (i.e., t=27), the two optimal order quantities under APD (q=995) and BPOF (q=999) are smaller than when taking a small t (i.e., t =3). Thus, under both financing strategies, the retailer prefers to order more goods with an earlier clearance time. The reason is that the products with a high salvage value (when the clearance time is early) can help the retailer avoid excessive losses and have higher inventory levels because the remaining TVs are still valuable. This can encourage more TVs to be ordered from the supplier. Thus, an earlier clearance time lowers the risks related to random customer demand. The retailer does not have to worry about losing a lot of inventory, which allows the retailer to increase the number of orders to meet market demand.

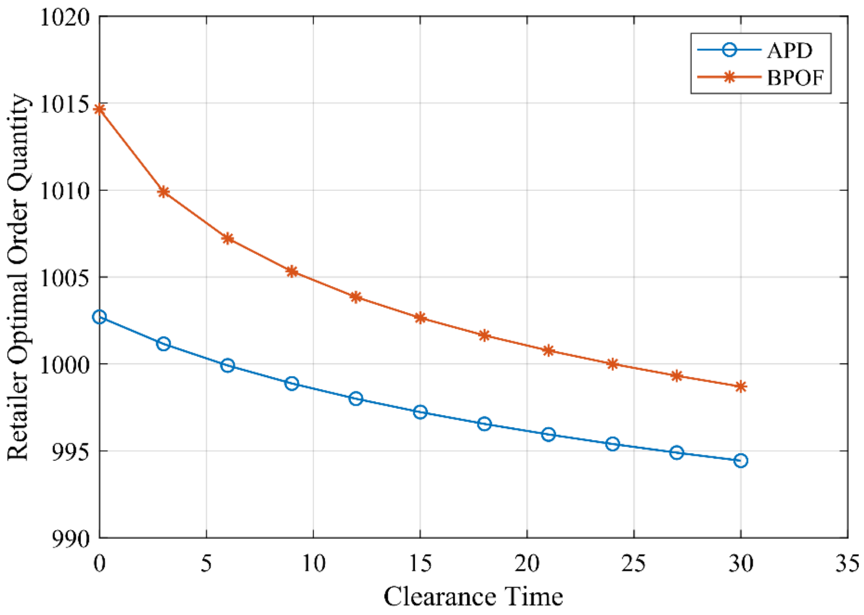

Figure 6.3. Impact of *t* on retailer's optimal order quantity under APD and BPOF.

6.4.2 Impact of t on supplier's setting on discount rate under APD

The study now examines how the clearance time of the TVs with the salvage value affects the supplier's setting on the discount rate under APD financing mode. The results are shown in Figure 6.4, and the figure indicates that in APD, the discount rate decreases as t increases. For instance, when t is relatively small (i.e., $t = 6$), the offered discount rate is 0.41, while as t increases (i.e., $t = 24$, $t = 27$), the discount is significantly reduced (d=0.23 and 0.19, respectively). This reflects the fact that the later the clearance time, the more adverse the effect on the TV retailer, that is, the greater the financial risks of the retailer; hence, in the face of high financial risks of the retailer, the TV supplier should offer the buyer a lower discount rate to maintain a higher wholesale price in order, thereby reduce the financial risks and maintain a higher return.

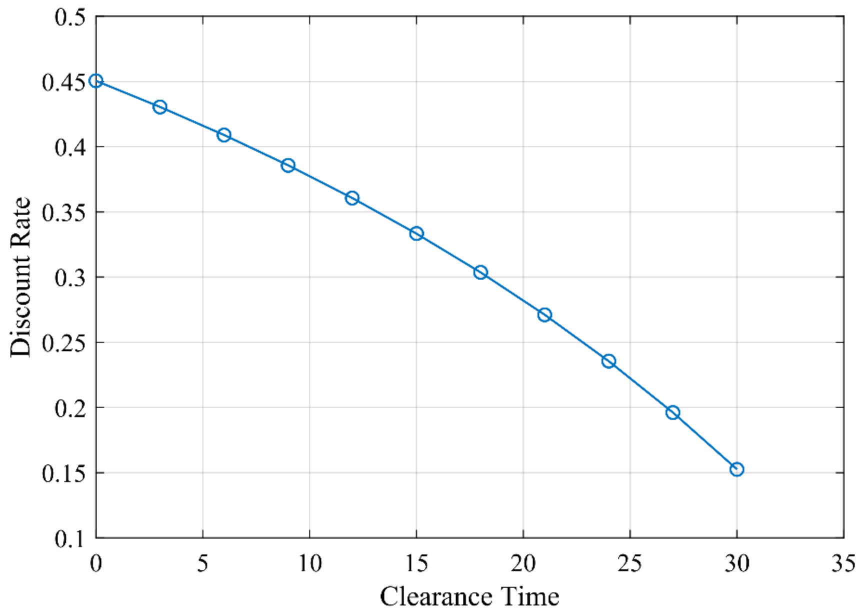

Figure 6.4. Impact of *t* on supplier's discount rate.

6.4.3 Impact of *t* on financing equilibrium

The relationship between ω_r and t is investigated (see Figure 6.5), and ω_t is shown in Figure 6.6. From Figure 6.5, it can be seen that the unique threshold ω_r is more than 5.32×10^5 when the clearance time is 9. While a later clearance time (t=24), ω_r is about 5.25×10^5 which is lower than that in the case of early clearance time. It's obvious that the clearance time has a significant effect on the threshold ω_r in single financing. The underlying reason is that the earlier the clearance time, the greater the salvage value of the TVs. This promotes the retailer to order more, while the increase of order quantity increases the inventory risk and makes the inventory tend to be overstocked, thereby increasing the cost of inventory backlog. Therefore, the buyer should have a higher asset level if the clearance period is too long so that the retailer has sufficient funds to provide APD financing for the seller.

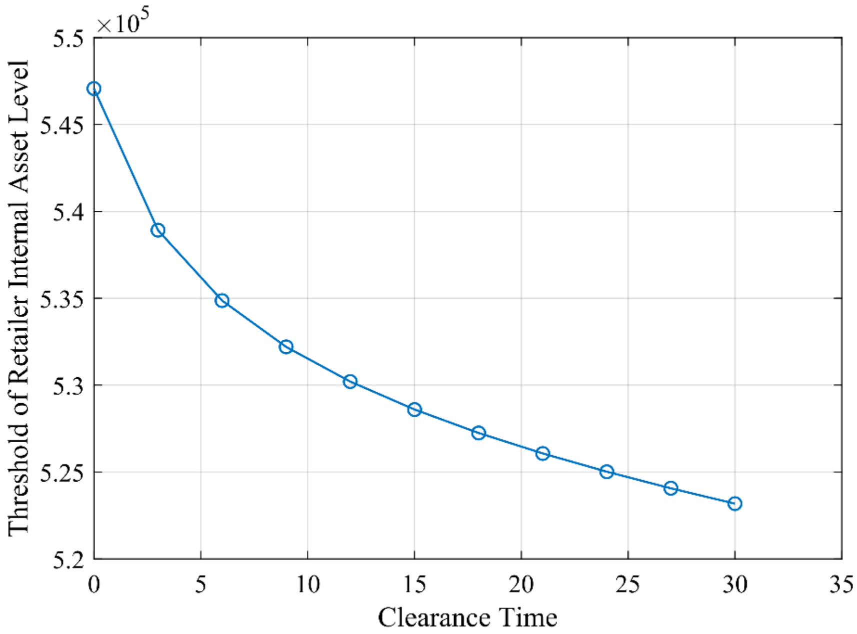

Figure 6.5. Impact of *t* on ω_r .

Figure 6.6 illustrates that there is a unique threshold of clearance time which ensures the buyer prefers to apply BPOF mode. The retailer prefers BPOF when the clearance time is relatively early (i.e., if $\omega_t < 12.97$); otherwise, APD is preferred. If the clearance time is sufficiently late, APD dominates BPOF. Therefore, BPOF dominates APD in financing equilibrium when the clearance time is below a certain threshold. The reason is that the later the clearance time, the smaller the salvage value of the TV, thus reducing the retailer's order quantity, reducing the risk of excess inventory, and reducing the losses. Therefore, APD financing should be chosen because of having more funds to finance the supplier. If clearance is early, BPOF has a comparative advantage, as the retailer is likely to order more and therefore does not have sufficient funds to subsidize the capital-constrained supplier, hence the supplier can obtain the funds from the financial institution.

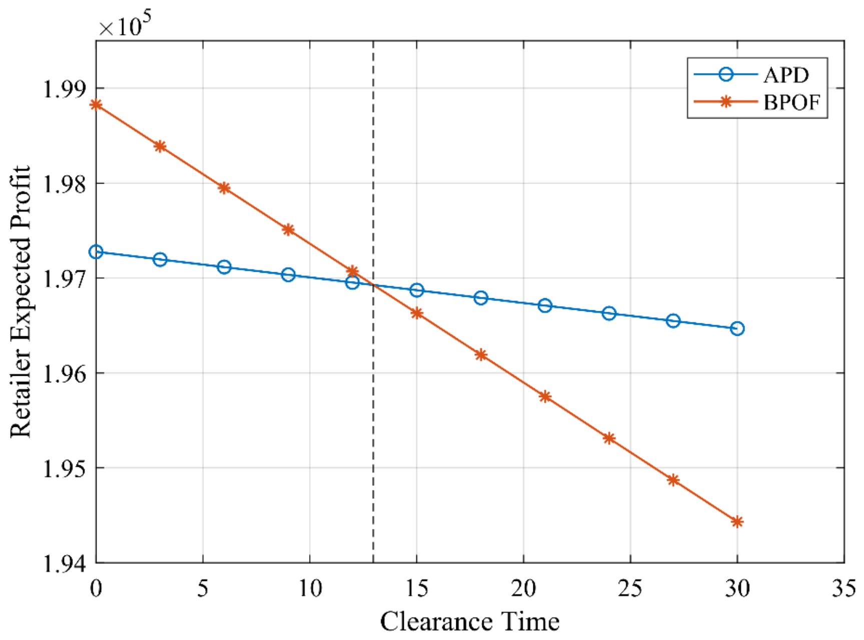

Figure 6.6. The unique threshold of clearance time.

6.5 Managerial Insights

In the 21st century, all industries attach great importance to green environmental protection, including the television industry. TV suppliers strive to produce products that are more environmentally conscious and have less impact on the environment. To achieve this ambitious goal, TV suppliers are adopting a green product strategy. Since TV sets are innovative products with a short life cycle, TV suppliers are constantly introducing new products, some of which may not be popular because their functions and appearance may not meet the current market demand. They have to clear out all the unsold TV sets after the normal sales season. However, these unsold TVs have a relatively high salvage value and remain valuable beyond the selling season. Unsold but still valuable out-of-season TVs, smart or not, can be sold at salvage value to remote areas of their home economies or exported to slow-growing developing countries. The less developed areas can promote environmental sustainability by replacing TV sets that are more environmentally friendly than before. It's worth noting that the salvage value of these TV sets varies over time, with a lower value the later they are cleared. Thus, by addressing the financial constraints of the TV supplier, more environmentally friendly TVs are produced, thus promoting environmental sustainability. In summary, this chapter provides the consequent management insights.

First of all, for a cash-strapped upstream TV supplier, seeking financing to increase working capital is a good choice to produce more green TVs, which can not only reduce pollution and protect the environment but also maintain the economic benefits of all members of the GSC. Besides, since the retailer needs to dispose of excess TVs, the time-varying salvage value of unsold TVs does not affect the supplier's capacity level and expected profits. When applying the APD financing instrument, if the time-varying salvage value is lower, it is suggested that a lower discount rate should be provided by the supplier to keep the purchase price higher to maintain a higher return, because an increase of the repurchase price will result in the financial risks being borne by the supplier.

Secondly, for a downstream retailer, the supply shortage caused by the supplier's financial difficulties can be alleviated via supply chain financing, so that the retailer can receive green TVs as far as possible to meet the order quantity. Under both APD and BPOF modes, the time-varying salvage value affects the optimal order quantity and the expected profits of the retailer. The earlier the clearance time, the higher the order quantity and the lower the losses for the retailer. Therefore, for the unsold TVs with time-varying salvage values, if the clearance time is early, a high salvage value can help the retailer avoid excessive losses and achieve a higher inventory level. The retailer should attach importance to the clearance time and should deal with those unsold inventories as soon as possible to reduce the losses caused by overordering. Moreover, the profit risks of the retailer are increasing with the order quantity and the clearance time, that is, a higher order quantity and a later clearance time will cause a higher level of profit risks. The retailer's profit risks determine the entire supply chain's profit risks.

Furthermore, compared with the two pre-shipment financing modes, the only financing equilibrium is BPOF when the retailer's internal asset level is below a certain level, and the threshold is inversely proportional to the clearance time. Therefore, the retailer should have a higher asset level if the clearance period is too long in order to have sufficient funds to provide APD. Furthermore, if the retailer's clearance time is earlier than a certain time, the retailer is likely to apply BPOF, as there is an incentive to order more when the TV's salvage value is large. Therefore, the retailer does not have sufficient money to subsidize the supplier, and hence the funds can be obtained from the financial institution via BPOF.

6.6 Summary

In the face of the new challenges and requirements of consumers in regard to TV environmental protection, TV developers all over the world are taking "Green" and " Energy conservation and emission reduction" as their themes and carrying out appropriate research and development. Since TV sets are innovative products with a short life cycle, TV suppliers are constantly introducing new products, some of which are not popular because their functions and appearance may no longer meet customer demand. After the sales season, there are unsold TV sets. However, these unsold inventories still have value beyond the selling season and have relatively high salvage values, which are time-dependent, becoming lower the later they are cleared. Therefore, in the TV industry, the time-varying salvage value is an important issue. This chapter aims to help the TV supplier with capital constraints obtain financing to produce more green products, so a GSC model via APD and BPOF has been established and the impact of the time-varying salvage value on the operation and financing decisions of GSC participants was studied. In addition, the supply chain system's level of risk was modeled.

Some significant outcomes have resulted from the work in this chapter: 1) A supply chain system related to green TV is proposed; 2) The TV supplier is financially constrained and can obtain funds via two effective financing instruments (APD and BPOF) to produce green TVs smoothly. 3) The salvage value of a TV varies according to clearance time, and the clearance time affects the retailer's optimal order quantity, the supplier's decision on the discount rate under APD and the financial institution's interest rate; 4) the financing equilibrium is BPOF when the clearance time is below a certain threshold or the retailer's internal asset level is below a certain level and the threshold of the asset level is inversely proportional to the clearance time; 4) The profit risks of the retailer under APD and BPOF increase with the order quantity and the clearance time, and the profit risks of the retailer and the entire supply chain are equal, which implies that the retailer's profit risks determine the risks of the whole supply chain.

CHAPTER 7 Conclusions and Future Work

Based on the previous work, this chapter summarizes the research outcomes, analyzes the shortcomings existing in the current research, and looks into future research work.

7.1 Conclusions

In order to meet the changing needs of customers, enterprises have to speed up the upgrading of their products and use innovative and functional modules to integrate into new products. Under such a competitive environment, the life cycle of each generation of products in the market is constantly shortened, so after the normal selling season, a large number of unsold products with various salvage values are produced. In addition, in the context of SCF, from the perspective of a capital-constrained supplier and a reputable retailer, this thesis explores the impact of financing on the operational and financing decisions of participants and the financial risks with considering various salvage values of the perishable products. Chapter 2 describes a detailed literature review regarding SCM, SCF, managing capital constraint of the buyer and the supplier, perishable goods with salvage value, and application of financing instruments. The research problem is described in detail in Chapter 3 including problem background and problem statement. To be specific, this research studied the influence of positive and negative salvage values on supply chain financing strategies, the impact of buyback support on financing strategies in a mobile phone supply chain, and a green television supply chain with time-varying salvage values respectively, and meaningful research results were obtained, as shown below.

In Chapter 4, based on the significant research gaps identified regarding the combination of positive and negative salvage values and SCF, under different salvage values, the optimal order quantities of the retailer in different financing scenarios varied, with the retailer willing to order products with high positive salvage values from the supplier. Further, different salvage values affect the profits of the buyer and the overall supply chain, and ordering items with a negative salvage value increases the loss, resulting in lower profits. Moreover, the retailer should have a higher level of assets to ensure adequate funding for the supplier through APD with a higher salvage value. Finally, this chapter made some comparisons, and numerical analyses are made to verify the results and obtained some managerial insights.

In addition, in Chapter 5, two novel pre-shipment mechanisms (BSBPOF and BSAPD) for financing the capital-constrained supplier have been developed, and the importance of integrating the buyback policy with the salvage value into the model has been highlighted. Moreover, the application of SCF in the mobile phone industry has been comprehensively explained, which provides solid theoretical and practical support for this research. It is found that the difference between the buyback price and the salvage value of unsold mobile phones affects the supplier's capacity level, the discount rate under BSAPD, and the interest rate of financial institutions under BSBPOF. The higher the difference is, the less the supplier is encouraged to produce more phones. With a higher difference, the supplier should offer a lower discount rate to maintain a higher purchase price for the buyer, thus reducing the economic burden and financial risks. Moreover, the financial institution is suggested to provide a higher interest rate when the difference between the buyback price and salvage value is relatively large so as to prevent excessive losses. Furthermore, when both financing instruments are available, the only equilibrium is BSBPOF when the buyback price is above a certain level and the difference between the buyback price and the salvage value is less than a certain range. The results are verified via numerical analysis and some managerial insights are obtained.

Afterward, in Chapter 6, to realize the goal of green environmental protection and sustainable development and to help the TV supplier with capital constraints obtain financing to produce more green products, a GSC model has been established via APD and BPOF for studying the impact of the time-varying salvage value on the operation and financing decisions of GSC participants. In addition, mean-variance theory is applied to conduct risk analysis in this research, which results in many crucial managerial insights. It is found that the time-vary salvage value affects the retailer's optimal order quantity, the supplier's decision on the discount rate under APD and the financial institution's interest rate under BPOF. Under both APD and

BPOF modes, the earlier the clearance time, the higher the order quantity and the lower the losses for the retailer, and when applying the APD mode, if the time-varying salvage value is lower, it is suggested that the supplier should provide a lower discount rate to keep the buyer's purchase price higher to maintain a higher return. In addition, the financing equilibrium is BPOF when the clearance time is below a certain threshold or the retailer’s internal asset level is below a certain level and the threshold of the asset level is inversely proportional to the clearance time. Moreover, the profit risks of the retailer under APD and BPOF increase with the order quantity and the clearance time, and the profit risks of the retailer and the entire supply chain are equal, which implies that the retailer’s profit risks determine the risks of the whole supply chain. The results are verified via numerical analysis, generating significant managerial sights.

In conclusion, how to manage corporate financial risks with various financing instruments in supply chains has been analytically studied by considering different salvage values and investigated the operations and financing decisions for the participants in various supply chains.

7.2 Limitations and Future Directions

This thesis suggests a number of research directions.

First, in the model, all supply chain participants are assumed to be risk neutral. However, in reality, some participants are risk averse. Hence, it is worth considering risk aversion in-depth.

Second, in this thesis, it is assumed that the distribution of demand, the production cost and capacity cost of the supplier, and the self-owned capital level of both participants are common information. Therefore, information asymmetry is not considered in the model of this thesis. Under the SCF model, the cooperation between the enterprises of the supply chain is closer and information sharing is more common. Therefore, the hypothesis of this paper is reasonable. However, in practice, the information between the supplier, the retailer, and consumers are asymmetric. Therefore, in future research, information asymmetry can be included in the model, and be combined with specific practical cases to build more practical models.

Third, the single-cycle two-stage supply chain consisting of one supplier and one retailer is analyzed and studied in this thesis, but in practice, complex multi-stage and multi-cycle supply chains are common. Hence, future research may consider the complex supply chain structure consisting of multiple suppliers and multiple retailers. Moreover, the competition between multiple suppliers or retailers in the model can be investigated. The number of participants can also be increased, studying the three-level supply chain including the retailer, the distributor, and the supplier.

Furthermore, this thesis explores various pre-shipment financing options, such as APD, BPOF, BSAPD, and BSBPOF, when suppliers are short of funds. Future research can consider other pre-shipment financing tools to solve the capital shortage and financing problems of enterprises and provide a decision-making basis for relevant supply chain members.

Lastly, this research has explored the supply chain of green TV. To further verify the feasibility and practicability of the presented model, more complex studies on other green products can be carried out to obtain equally important results.

Appendix A All Proofs for Chapter 4

Proof of Proposition 4.1

The retailer's expected profit can be written as

$$\pi_{r1}^{\mathrm{bc}}(q,w) = (p-s)\int_0^q xf(x)dx + (p-s)\int_q^\infty qf(x)dx - (w-s)q \qquad \text{(A1)}$$

Taking the first-order and second-order partial derivative of q, we have

$$\frac{\partial \pi_{r1}^{bc}}{\partial q} = (p-s)\bar{F}(q) - w + s$$

$$\frac{\partial^2 \pi_{r1}^{bc}}{\partial q^2} = \frac{\partial\{(p-s)[1-F(q)] - w + s\}}{\partial q} = -(p-s)f(q) < 0 \qquad \text{(A2)}$$

$$\frac{\partial^2 \pi_{r1}^{bc}}{\partial q \partial s} = 1 - \bar{F}(q) = F(q) > 0$$

From the first-order condition: $\frac{\partial \pi_r^{\mathrm{bc}}}{\partial q_1^{\mathrm{bc*}}} = 0$, we derive $q_1^{\mathrm{bc*}} = F^{-1}(\frac{p-w}{p-s})$.

Furthermore, the first derivative with respect to s follows:

$$\frac{dq}{ds} = \frac{\partial^2 \pi_{r1}^{bc} / \partial q \partial s}{-\partial^2 \pi_{r1}^{bc} / \partial q^2} = \frac{F(q)}{(p-s)f(q)} > 0 \qquad \text{(A3)}$$

Hence, $q_1^{bc}*$ and π_{r1}^{bc} increase with the salvage value, that is,

$q_1^{bc*}(s<0) < q_1^{bc*}(s=0,\ \text{no salvage value}) < q_1^{bc*}(s>0)$. □

Proof of Proposition 4.2

From Equation (4.9), the order quantity q_1^{apd*} in continuation satisfies the first-order condition $\frac{\partial \pi_{r1}^{apd}}{\partial q^{apd*}} = 0$, then we have $(p-s)\bar{F}\left(q_1^{apd*}\right) = w\left(1-d\right) - s$. Hence,

$q_1^{apd*} = F^{-1}(\frac{p-(1-d)w}{p-s})$.

In the case of reorganization, from Equation (4.9) and the first-order condition: $\frac{\partial \pi_{r1}{}^{apd}}{\partial q^{apd*}} = 0$, we derive $(p-s)\overline{F}(q) = (2-\alpha)(1-d)w - s$. Hence, the optimal order quantity is $q_1^{apd*} = F^{-1}(\frac{p-(2-\alpha)(1-d)w}{p-s})$.

To sum up, from the first-order condition: $\frac{\partial \pi_{r1}{}^{apd}}{\partial q^{apd*}} = 0$, we have

$$
\begin{cases}
q_1^{apd*} = F^{-1}(\frac{p-(1-d)w}{p-s}) & \text{Continuation} \\
q_1^{apd*} = F^{-1}(\frac{p-(2-\alpha)(1-d)w}{p-s}) & \text{Reorganization}
\end{cases}.
$$

Under APD, from Equation (4.9), taking the first-order and second-order partial derivative of q, we have

$$\frac{\partial \pi_{r1}{}^{apd}}{\partial q} = (p-s)\overline{F}(q) - (2-\alpha)(1-d)w + s \tag{A4}$$

$$\frac{\partial^2 \pi_{r1}{}^{apd}}{\partial q^2} = -(p-s)f(q) < 0 \tag{A5}$$

Then we can obtain that

$$\frac{\partial^2 \pi_{r1}{}^{apd}}{\partial q \partial s} = 1 - \overline{F}(q) = F(q) > 0 \tag{A6}$$

$$\frac{dq}{ds} = \frac{F(q)}{(p-s)f(q)} > 0 \tag{A7}$$

Hence, q^{apd*} and $\pi_{r1}{}^{\text{apd}}$ increase with the salvage value, that is,

$q_1^{apd*}(s<0) < q_1^{apd*}(s=0,\ \text{no salvage value}) < q_1^{apd*}(s>0)$. □

Proof of Proposition 4.3

Under BPOF, based on Equation (4.12), the problem of the retailer can be expressed as:

$$\pi_{r1}^{bpof} = [\int_0^q xf(x)dx + \int_q^{\infty} qf(x)dx](p-s)$$
$$- q[w - s + \int_{\underline{A}_S}^{\tilde{A}_S} (\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)\phi(A_s)dA_s] \quad \text{(A8)}$$
$$- \int_{\underline{A}_S}^{\tilde{A}_S} (\delta\gamma c_k K - \delta\gamma A_s + \delta\gamma L_s)\phi(A_s)dA_s$$

Taking the first-order and second-order partial derivative of π_{r1}^{bpof}, we have

$$\frac{\partial \pi_{r1}^{bpof}}{\partial q} = (p-s)\overline{F}(\text{q}) - [w - s + \int_{\underline{A}_S}^{\tilde{A}_S} (\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)\phi(A_s)dA_s] \quad \text{(A9)}$$

$$\frac{\partial^2 \pi_{r1}^{bpof}}{\partial q^2} = -(p-s)f(q) < 0 . \quad \text{(A10)}$$

Moreover,

$$\frac{\partial^2 \pi_{r1}^{bpof}}{\partial q \partial s} = 1 - \overline{F}(q) = F(q) > 0 \quad \text{(A11)}$$

Accordingly,

$$\frac{dq}{ds} = \frac{\partial^2 \pi_{r1}^{bpof} / \partial q \partial s}{-\partial^2 \pi_{r1}^{bpof} / \partial q^2} = \frac{F(q)}{(p-s)f(q)} > 0 \quad \text{(A12)}$$

Hence, $q^{bc}*$ and π_{r1}^{bpof} increase with the salvage value. That is,

$q_1^{bpof*}(s<0) < q_1^{bpof*}(s=0,$ no salvage value$) < q_1^{bpof*}(s>0)$.

In addition, from the first-order condition: $\frac{\partial \pi_{r1}^{bpof}}{\partial q^{bpof*}} = 0$, we have

$$(p-s)\overline{F}(q) = w - s + (\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)[\Phi(\tilde{A}_S) - \Phi(\underline{A}_S)]$$
$$\overline{F}(q) = \frac{w - s + (\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)[\Phi(\tilde{A}_S) - \Phi(\underline{A}_S)]}{p-s}$$
$$F(q) = 1 - \frac{w - s + (\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)[\Phi(\tilde{A}_S) - \Phi(\underline{A}_S)]}{p-s} \quad \text{(A13)}$$
$$= \frac{p - w - (\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)[\Phi(\tilde{A}_S) - \Phi(\underline{A}_S)]}{p-s}$$

Therefore, $q_1^{bpof*} = F^{-1}(\frac{p - w - (\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)[\Phi(\tilde{A}_S) - \Phi(\underline{A}_S)]}{p-s})$. □

Proof of Theorem 4.1

The financing strategy chosen by the retailer will bring a greater expected profit: ${\pi_{r1}}^{bpof*} > {\pi_{r1}}^{apd*}$ iff

$$p\mathrm{E}\min(D, q_1^{bpof*}) - wq_1^{bpof*} + s(q_1^{bpof*} - D)^+$$
$$-\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq_1^{bpof*} - \gamma\left[(w - c_p)q_1^{bpof*} - c_k K - \lambda wq_1^{bpof*} r + A_s - L_s\right]\right\}\phi(A_s)dA_s$$
$$> p\mathrm{E}\min(D, {q_1}^{\mathrm{apd*}}) - w(1-d){q_1}^{\mathrm{apd*}} + s({q_1}^{\mathrm{apd*}} - D)^+ - (1-\alpha)[L_r - A_r + w(1-d){q_1}^{\mathrm{apd*}}]^+ \tag{A14}$$

where the threshold value of the retailer's internal assets:

$$\begin{aligned}
\omega_{r1} &= L_r + w(1-d)\,{q_1}^{apd*} \\
&\quad - \frac{p\mathrm{E}\min(D, {q_1}^{apd*}) - w(1-d){q_1}^{apd*} + s({q_1}^{apd*} - D)^+ - p\mathrm{E}\min(D, q_1^{bpof*}) + wq_1^{bpof*} - s(q_1^{bpof*} - D)^+}{1-\alpha} \\
&\quad + \frac{\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq_1^{bpof*} - \gamma\left[(w - c_p)q_1^{bpof*} - c_k K - \lambda wq_1^{bpof*} r + A_s - L_s\right]\right\}\phi(A_s)dA_s}{1-\alpha} \\
&= L_r + w(1-d)\,{q_1}^{apd*} \\
&\quad - \frac{p\mathrm{E}\min(D, {q_1}^{apd*}) - w(1-d){q_1}^{apd*} - p\mathrm{E}\min(D, q_1^{bpof*}) + wq_1^{bpof*} + s[({q_1}^{apd*} - D)^+ - (q_1^{bpof*} - D)^+]}{1-\alpha} \\
&\quad + \frac{\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq_1^{bpof*} - \gamma\left[(w - c_p)q_1^{bpof*} - c_k K - \lambda wq_1^{bpof*} r + A_s - L_s\right]\right\}\phi(A_s)dA_s}{1-\alpha}
\end{aligned} \tag{A15}$$

Since there exist $s[({q_1}^{\mathrm{apd*}} - D)^+ - (q_1^{bpof*} - D)^+]$ and $q_1^{bpof*} > {q_1}^{\mathrm{apd*}} > D$, the value of ω_{r1} is in direct proportion to the salvage value: $\omega_{r1}(s > 0) > \omega_{r0}(s = 0,\ no\ salvage\ value) > \omega_{r1}(s < 0)$. □

Appendix B All Proofs for Chapter 5

Proof of Proposition 5.1

Since $w'(K) = -\dfrac{w(K)}{vK}$, the first-order condition of the supplier's revenue is $\dfrac{d\,\mathrm{Re}venue}{dK} = (1-d)w(K)[1-h(K)] = (1-d)[p-(p-b)F(K)][1-h(K)]$. The first-order condition of the cost is $\dfrac{dCost}{dK} = c_p + c_k + (b-s)F(K)$. When marginal revenue equals marginal cost, we obtain:

$$(1-d)[p-(p-b)F(K^{bsapd*})][1-h(K^{bsapd*})] = c_p + c_k + (b-s)F(K^{bsapd*}) \qquad \text{(B1)}$$

Then, we have $K^{bsapd*} = F^{-1}\left(\dfrac{(1-d)[1-h(K^{bsapd*})]p - c_p - c_k}{(1-d)[1-h(K^{bsapd*})](p-b)+b-s}\right)$. Since b-s>0, π_s^{bsbpof} and $K^{bsbpof*}$ decrease with b-s obviously.

Similarly, from the retailer's expected profit equation, we can get $\dfrac{\partial \pi_r}{\partial q} = p-(p-b)F(q)-(1-d)w = 0$, $q^{bsapd*} = F^{-1}\left(\dfrac{p-(1-d)w}{p-b}\right)$, $\dfrac{\partial \pi_r}{\partial b} > 0$, $\dfrac{\partial q}{\partial b} > 0$. Hence, both π_r^{bsbpof} and $q^{bsbpof*}$ increase with *b,* and they are not affected by the salvage value. □

Proof of Proposition 5.2

In APD financing mode, $1-d = \dfrac{c_p + c_k + (b-s)F(K^{bsapd*})}{p-(p-b)F(K^{bsapd*})[1-h(K^{bsapd*})]}$, the discount rate *d* is obviously decreasing with the difference between the buyback price and the salvage value *b*-*s*. □

Proof of Theorem 5.1

In order to satisfy both $\pi_s^{bsapd*} > 0$ and $\pi_r^{bsapd*} > 0$, we can derive

$b < \eta_s^{bsapd*} \triangleq \dfrac{[w(1-d)-c_p]\min(q^{bsapd*}, K^{bsapd*}) - c_k K^{bsapd*}}{[\min(q^{bsapd*}, K^{bsapd*}) - D]^+} + s$, and

$b > \eta_r^{bsapd*} \triangleq \dfrac{p\mathrm{E}\min(D, q^{bsapd*}) - w(1-d)q^{bsapd*}}{(q^{bsapd*} - D)^+}$. Hence, the buyback price should satisfy $b \in (\eta_r^{bsapd*}, \eta_s^{bsapd*})$. □

Proof of Proposition 5.3

According to Equation (5.4), the first-order condition of the retailer's profit under BSBPOF is

$$\frac{d\pi_r^{bsbpof}}{dq^{bsbpof}} = -(p-b)F(q) + (p-w) - \int_{\underline{A}_S}^{\tilde{A}_S} \delta \begin{Bmatrix} [\lambda w - \gamma w + \gamma c_p + \gamma\lambda wr \\ +\gamma(b-s)F(q)] \end{Bmatrix} \phi(A_s)dA_s\}. \quad \text{(B2)}$$

then we have $q^{bsbpof*} = F^{-1}(\dfrac{p - w - (\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)[\Phi(\tilde{A}_S) - \Phi(\underline{A}_S)]}{p - b + \delta\gamma(b-s)[\Phi(\tilde{A}_S) - \Phi(\underline{A}_S)]})$.

Since b-s>0, $[\min(q^{bsbpof*}, K^{bsbpof*}) - D]^+ > 0$, $-(b-s)[\min(q^{bsbpof*}, K^{bsbpof*}) - D]^+ < 0$. Hence, both π_r^{bsbpof} and $q^{bsbpof*}$ increase with *b*.

Similarly, the derivative of π_s^{bsbpof} with respect to *K* is equal to 0, and we can get the optimal capacity $K^{bsbpof*} = F^{-1}(\dfrac{p - c_p - c_k - ph(K^{bsbpof*})}{(p-b)(1-h(K^{bsbpof*})) + b - s})$. Obviously, since b-s>0, π_s^{bsbpof} and $K^{bsbpof*}$ decrease with *b*-*s*. □

Proof of Proposition 5.4

Since the financial institution has zero expected returns, we have

$$\lambda wqr[\bar{\Phi}(\tilde{A}_s) - (1-\delta)\Phi(\tilde{A}_s)\gamma] + \int_{\underline{A}_S}^{\tilde{A}_S} (1-\delta)\gamma \begin{bmatrix} (w-c_p)\min(q,K) - c_k K \\ -(b-s)[\min(q,K)-D]^+ + A_s - L_s \end{bmatrix} \phi(A_s)dA_s$$
$$= (1-\delta)\phi(\tilde{A}_s)\lambda wq. \quad \text{(B3)}$$

Then the financial institution's optimal interest rate can be obtained, which can be expressed as:

$$r = \frac{(1-\delta)\bar{\Phi}(\tilde{A}_s)\lambda wq - \int_{\underline{A}_S}^{\tilde{A}_S} (1-\delta)\gamma \begin{bmatrix} (w-c_p)\min(q,K) - c_k K - \\ (b-s)[\min(q,K)-D]^+ + A_s - L_s \end{bmatrix} \phi(A_s) dA_s}{\lambda wq[\bar{\Phi}(\tilde{A}_s) - (1-\delta)\Phi(\tilde{A}_s)\gamma]}. \square$$

Proof of Theorem 5.2

Similar to the proof of Theorem 5.1, to ensure $\pi_r^{bsbpof*} > 0$ and $\pi_s^{bsbpof*} > 0$, we have

$$b > \eta_r^{bsbpof*},$$

$$\eta_r^{bsbpof*} \triangleq \frac{p\mathrm{E}\min(D, q^{bsbpof*}) - wq^{bsbpof*}}{(q^{bsbpof*} - D)^+} - \frac{\int_{\underline{A}_S}^{\tilde{A}_S} \delta \left\{ \lambda wq - \gamma \begin{bmatrix} (w-c_p)q^{bsbpof*} - c_k K^{bsbpof*} + A_s - L_s \\ -(b-s)(q^{bsbpof*} - D)^+ - \lambda wq^{bsbpof*} r \end{bmatrix} \right\} \phi(A_s) dA_s}{(q^{bsbpof*} - D)^+}, \tag{B4}$$

and

$$b < \eta_s^{bsbpof*},$$

$$\eta_s^{bsbpof*} \triangleq \frac{(w-c_p)\min(q^{bsbpof*}, K^{bsbpof*}) - c_k K^{bsbpof*} - \lambda wq^{bsbpof*} r}{[\min(q^{bsbpof*}, K^{bsbpof*}) - D]^+}. - \frac{(1-\alpha)(L_s - A_s - \lambda wq^{bsbpof*} + c_k K^{bsbpof*})}{[\min(q^{bsbpof*}, K^{bsbpof*}) - D]^+} + s. \tag{B5}$$

Hence, the buyback price of the unsold mobile phones should be met $\eta_r^{bsbpof*} < b < \eta_s^{bsbpof*}$. □

Proof of Theorem 5.3

The retailer selects the financing strategy with higher expected profit:

$\pi_r^{bsbpof*} > \pi_r^{bsapd*}$ if and only if

$$p\mathrm{E}\min(D, q^{bsbpof*}) - wq^{bsbpof*} + b(q^{bsbpof*} - D)^+ - \int_{\underline{A}_S}^{\tilde{A}_S} \delta \left\{ \lambda wq - \gamma \begin{bmatrix} (w-c_p)q^{bsbpof*} - c_k K^{bsbpof*} - \lambda wq^{bsbpof*} r \\ -(b-s)(q^{bsbpof*} - D)^+ + A_s - L_s \end{bmatrix} \right\} \phi(A_s) dA_s$$

$$> p\mathrm{E}\min(D, q^{bsapd*}) - w(1-d)q^{bsapd*} + b(q^{bsapd*} - D)^+ - (1-\alpha)[L_r - A_r + w(1-d)q^{bsapd*}]^+.$$

Then, the threshold value of the retailer's internal asset is

$$\omega_r = L_r + w(1-d)q^{bsapd*} - \frac{p\mathrm{E}\min(D,q^{bsapd*}) - w(1-d)q^{bsapd*} - p\mathrm{E}\min(D,q^{bsbpof*}) + wq^{bsbpof*}}{1-\alpha}$$

$$-\frac{\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq^{bsbpof*} - \gamma\left[(w-c_p-c_k)q^{bsbpof*} - \lambda wq^{bsbpof*}r + A_s - L_s\right]\right\}\phi(A_s)dA_s}{1-\alpha}$$

$$-\frac{b[(q^{bsapd*}-D)^+ - (q^{bsbpof*}-D)^+] + \int_{\underline{A}_S}^{\tilde{A}_S} \delta\gamma(b-s)(q^{bsbpof*}-D)^+\phi(A_s)dA_s}{1-\alpha}. \tag{B6}$$

Since $b \geq 0$, $(q^{bsbpof*}-D) > 0, (q^{bsbpof*}-D)^+ > 0, \int_{\underline{A}_S}^{\tilde{A}_S} \delta\gamma(q^{bsbpof*}-D)^+\phi(A_s)dA_s > 0$,

ω_r is inversely proportional to the value of *b*. □

Proof of Theorem 5.4

To satisfy $\pi_s^{bsbpof*} > \pi_s^{bsapd*}$, we have

$$[w(1-d)-c_p]q^{bsapd} - c_k q^{bsapd} - (b-s)[q^{bsapd}-D]^+ - (1-\alpha)[L_s - A_s + c_k q^{bsapd} - w(1-d)q^{bsapd}]^+ <$$
$$(w-c_p)q^{bsbpof} - c_k q^{bsbpof} - (b-s)[q^{bsbpof}-D]^+ - \lambda wq^{bsbpof}r - (1-\alpha)[L_s - A_s + c_k K - w(1-d)q^{bsbpof}]^+.$$

Then, we can obtain:

$$b-s \leq \mu_s,$$

$$\mu_s \triangleq \frac{[w(1-d)-c_p](q^{bsapd}-q^{bsbpof}) - c_k(q^{bsapd}-q^{bsbpof}) + \lambda wq^{bsbpof}r}{\{[q^{bsapd}-D]^+ - [q^{bsbpof}-D]^+\}}$$
$$-\frac{(1-\alpha)[L_s - A_s + c_k q^{bsapd} - w(1-d)q^{bsapd}]^+ + (1-\alpha)[L_s - A_s + c_k K - w(1-d)q^{bsbpof}]^+}{\{[q^{bsapd}-D]^+ - [q^{bsbpof}-D]^+\}}. \tag{B7}$$

The seller provides an advance payment discount contract $(w,\tilde{d})$ in equilibrium, and where

$$\tilde{d} \in \frac{(w-c_p-c_k)(q^{bsapd}-q^{bsbpof}) + (b-s)\{[q^{bsbpof}-D]^+ - [q^{bsapd}-D]^+\} + \lambda wq^{bsbpof}r}{wq^{bsapd}},$$

the supplier prefers BSAPD over BSBPOF. □

Appendix C All Proofs for Chapter 6

Proof of Proposition 6.1

From Equation (6.4), we can obtain that

$\frac{\partial \pi_r^{apd}}{\partial q} = p - w(1-d) - [p-(a-bt)]F(q) > 0$. The optimal order quantity q^{apd*} in the case of continuation satisfies the first-order condition and can be derived from

$p-(p-a+bt)F\left(q^{apd*}\right) = w(1-d)$. Hence, $q^{apd*} = F^{-1}(\frac{p-(1-d)w}{p-a+bt})$.

In the same way, we can also derive that in the reorganization, the optimal order quantity under APD is $q^{apd*} = F^{-1}(\frac{p-(2-\alpha)(1-d)w}{p-a+bt})$.

To sum up, we have

$$q^{apd*} = \begin{cases} F^{-1}(\frac{p-(1-d)w}{p-a+bt}) & \text{Continuation} \\ F^{-1}(\frac{p-(2-\alpha)(1-d)w}{p-a+bt}) & \text{Reorganization} \end{cases} \tag{C1}$$

Moreover, we can derive that

$$\frac{\partial^2 \pi_r^{apd}}{\partial q^2} = -[p-(a-bt)]f(q) < 0$$

(C2)

$$\frac{\partial^2 \pi_r^{apd}}{\partial q \partial t} = -bF(q) < 0 \tag{C3}$$

$$\frac{dq}{dt} = \frac{-bF(q)}{[p-(a-bt)]f(q)} < 0 \tag{C4}$$

Hence, $q^{apd}*$ and π_r^{apd} decrease with the clearance time. □

Proof of Proposition 6.2

Under APD, since $d = 1 - \frac{c_p + c_k}{[p-(p-a+bt)F(K^{apd*})][1-h(K^{apd*})]}$, and $\frac{\partial d}{\partial t} < 0$.

The discount rate d is decreasing with the clearance time. □

Proof of Theorem 6.1

To ensure that the downstream buyer benefits from APD and chooses it ($\pi_r^{apd} > 0$), we can derive that:

$$\begin{aligned}(a-bt)[\min(q,K)-D]^{+} > w(1-d)\min(q,K) - p\mathrm{E}\min[D,\min(q,K)] \\ +(1-\alpha)[L_r - A_r + w(1-d)q]^{+}\end{aligned} \tag{C5}$$

Then, the clearance time should satisfy:

$$t < \eta_r^{apd*} \triangleq \frac{a}{b} - \frac{w(1-d)\min(q,K) - p\mathrm{E}\min[D,\min(q,K)] + (1-\alpha)[L_r - A_r + w(1-d)q]^{+}}{b[\min(q,K)-D]^{+}} \tag{C6}$$

. □

Proof of Proposition 6.3

Taking the first-order and second-order partial derivative of π_r^{bpof}, we have

$$\frac{\partial \pi_r^{bpof}}{\partial q} = (p-a+bt)\overline{F}(q) - [w-a+bt+\int_{\underline{A}_S}^{\tilde{A}_S}(\delta\lambda w - \delta\gamma w + \delta\gamma c_p + \delta\gamma\lambda wr)\phi(A_s)dA_s] \tag{C7}$$

$$\frac{\partial^2 \pi_r^{bpof}}{\partial q^2} = -(p-a+bt)f(q) < 0 \tag{C8}$$

$$\frac{\partial^2 \pi_r^{bpof}}{\partial q \partial t} = -bf(q) < 0 \tag{C9}$$

Accordingly,

$$\frac{dq}{dt} = \frac{\partial^2 \pi_r^{bpof} / \partial q \partial t}{-\partial^2 \pi_r^{bpof} / \partial q^2} = \frac{-bf(q)}{(p-a+bt)f(q)} < 0 \tag{C10}$$

Hence, $q^{bpof}*$ and π_r^{bpof} increase with the salvage value.

From the first-order condition: $\dfrac{\partial \pi_r^{bpof}}{\partial q^{bpof*}} = 0$, we have

$$(p-a+bt)\overline{F}(q)=w-a+bt+(\delta\lambda w-\delta\gamma w+\delta\gamma c_p+\delta\gamma\lambda wr)[\Phi(\tilde{A}_S)-\Phi(\underline{A}_S)]$$

$$\overline{F}(q)=\frac{w-a+bt+(\delta\lambda w-\delta\gamma w+\delta\gamma c_p+\delta\gamma\lambda wr)[\Phi(\tilde{A}_S)-\Phi(\underline{A}_S)]}{p-a+bt}$$

$$F(q)=\frac{p-w-(\delta\lambda w-\delta\gamma w+\delta\gamma c_p+\delta\gamma\lambda wr)[\Phi(\tilde{A}_S)-\Phi(\underline{A}_S)]}{p-a+bt}$$

Therefore, $q^{bpof*}=F^{-1}(\frac{p-w-(\delta\lambda w-\delta\gamma w+\delta\gamma c_p+\delta\gamma\lambda wr)[\Phi(\tilde{A}_S)-\Phi(\underline{A}_S)]}{p-a+bt})$. □

Proof of Theorem 6.2

To satisfy $\pi_r^{bpof}>0$, we can derive that:

$$p\min[D,\min(q,K)]-w\min(q,K)+(a-bt)[\min(q,K)-D]^+ -\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq-\gamma\left[(w-c_p)\min(q,K)-c_kK-\lambda wqr+A_s-L_s\right]\right\}\phi(A_s)dA_s>0 \tag{C11}$$

Then, the threshold of the clearance time can be obtained from

$$a-bt>\frac{w\min(q,K)-p\min[D,\min(q,K)]+\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq-\gamma\begin{bmatrix}(w-c_p)\min(q,K)-\\ c_kK-\lambda wqr+A_s-L_s\end{bmatrix}\right\}\phi(A_s)dA_s}{[\min(q,K)-D]^+}.$$

Hence,

$$t<\eta_r^{bpof*}\triangleq\frac{a}{b}-\frac{w\min(q,K)-p\min[D,\min(q,K)]+\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq-\gamma\begin{bmatrix}(w-c_p)\min(q,K)-\\ c_kK-\lambda wqr+A_s-L_s\end{bmatrix}\right\}\phi(A_s)dA_s}{b[\min(q,K)-D]^+}.$$

□

Proof of Theorem 6.3

The financing strategy chosen by the retailer will bring a greater income: $\pi_r^{bpof*}>\pi_r^{apd*}$ if and only if

$$pE\min(D,q^{bpof*})-wq^{bpof*}+(a-bt)(q^{bpof*}-D)^+ -\int_{\underline{A}_S}^{\tilde{A}_S}\delta\left\{\lambda wq^{bpof*}-\gamma\left[(w-c_p)q^{bpof*}-c_kK-\lambda wq^{bpof*}r+A_s-L_s\right]\right\}\phi(A_s)dA_s > pE\min(D,q^{apd*})-w(1-d)q^{apd*}+(a-bt)(q^{apd*}-D)^+-(1-\alpha)[L_r-A_r+w(1-d)q^{apd*}]^+ \tag{C12}$$

where the threshold value of the retailer's internal assets:

$$\begin{aligned}
\omega_r =& L_r + w\left(1-d\right)q^{apd*} \\
&-\frac{p\mathrm{E}\min(D,q^{apd*}) - w(1-d)q^{apd*} + (a-bt)(q^{apd*}-D)^{+} - p\mathrm{E}\min(D,q^{bpof*})}{1-\alpha} \\
&-\frac{wq^{bpof*} - (a-bt)(q^{bpof*}-D)^{+}}{1-\alpha} \\
&+\frac{\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq^{bpof*} - \gamma\left[(w-c_p)q^{bpof*} - c_k K - \lambda wq^{bpof*}r + A_s - L_s\right]\right\}\phi(A_s)dA_s}{1-\alpha} \\
=& L_r + w\left(1-d\right)q^{apd*} \\
&-\frac{p\mathrm{E}\min(D,q^{apd*}) - w(1-d)q^{apd*} - p\mathrm{E}\min(D,q^{bpof*}) + wq^{bpof*}}{1-\alpha} \\
&-\frac{(a-bt)[(q^{apd*}-D)^{+} - (q^{bpof*}-D)^{+}]}{1-\alpha} \\
&+\frac{\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq^{bpof*} - \gamma\left[(w-c_p)q^{bpof*} - c_k K - \lambda wq^{bpof*}r + A_s - L_s\right]\right\}\phi(A_s)dA_s}{1-\alpha}
\end{aligned} \tag{C13}$$

Since there exist $(a-bt)[(q^{apd*}-D)^{+} - (q^{bpof*}-D)^{+}]$ and $q^{bpof*} > q^{apd*} > D$, the value ω_r is in inverse proportion to the clearance time. □

Proof of Theorem 6.4

The financing strategy chosen by the retailer will bring a greater expected profit: ${\pi_r}^{bpof*} > {\pi_r}^{apd*}$ if and only if

$$\begin{aligned}
& p\mathrm{E}\min(D,q^{bpof*}) - wq^{bpof*} + (a-bt^{bpof*})(q^{bpof*}-D)^{+} \\
& -\int_{\underline{A}_S}^{\tilde{A}_S} \delta\left\{\lambda wq^{bpof*} - \gamma\left[(w-c_p)q^{bpof*} - c_k K - \lambda wq^{bpof*}r + A_s - L_s\right]\right\}\phi(A_s)dA_s \\
& > p\mathrm{E}\min(D,q^{apd*}) - w(1-d)q^{apd*} + (a-bt^{apd*})(q^{apd*}-D)^{+} - (1-\alpha)[L_r - A_r + w(1-d)q^{apd*}]^{+}
\end{aligned} \tag{C14}$$

where the threshold value of the clearance time is:

$t < \omega_t$,

$$\omega_t \triangleq \frac{a}{b} - \frac{p\mathrm{E}\min(D,q^{apd*}) - w(1-d)q^{apd*} - (1-\alpha)[L_r - A_r + w(1-d)q^{apd*}]^{+} - p\mathrm{E}\min(D,q^{bpof*}) + wq^{bpof*}}{b[(q^{bpof*}-D)^{+} - (q^{apd*}-D)^{+}]}.$$ □

References

Abdel Basset, Mohamed, Rehab Mohamed, Karam Sallam, and Mohamed Elhoseny. 2020. "A novel decision-making model for sustainable supply chain finance under uncertainty environment." *Journal of Cleaner Production* 269: 122324.

Adkins, Roger, and Dean Paxson. 2017. "Replacement decisions with multiple stochastic values and depreciation." *European Journal of Operational Research* 257 (1):174-84.

Agi, Maher AN, Sohrab Faramarzi-Oghani, and Öncü Hazır. 2020. "Game theory-based models in green supply chain management: A review of the literature." *International Journal of Production Research*:1-20.

Ahn, JaeBin, and Miguel Sarmiento. 2019. "Estimating the direct impact of bank liquidity shocks on the real economy: Evidence from letter-of-credit import transactions in Colombia." *Review of International Economics* 27 (5):1510-36.

Alan, Yasin, and Vishal Gaur. 2018. "Operational investment and capital structure under asset-based lending." *Manufacturing & Service Operations Management* 20 (4):637-54.

Arshinder, Arun Kanda, and S. G. Deshmukh. 2008. "Supply chain coordination: Perspectives, empirical studies and research directions." *International Journal of Production Economics* 115 (2):316-35.

Auboin, Marc, Harry Smythe, and Robert Teh. 2016. "Supply chain finance and SMEs: Evidence from international factoring data." CESifo Working Paper Series No. 6039, Available at SSRN: *https://ssrn.com/abstract=2845280*.

Awasthi, Abhishek Kumar, Mengmeng Wang, Zhishi Wang, Mrigendra Kumar Awasthi, and Jinhui Li. 2018. "E-waste management in India: A mini-review." *Waste Management Research* 36 (5):408-14.

Babich, Volodymyr. 2010. "Independence of capacity ordering and financial subsidies to risky suppliers." *Manufacturing & Service Operations Management* 12 (4):583-607.

Babich, Volodymyr, and Matthew J Sobel. 2004. "Pre-IPO operational and financial decisions." *Management Science* 50 (7):935-48.

Barnes Schuster, Dawn, Yehuda Bassok, and Ravi Anupindi. 2002. "Coordination and flexibility in supply contracts with options." *Manufacturing Service Operations Management* 4 (3):171-207.

Bhatia, Manjot Singh, and Kishore Kumar Gangwani. 2020. "Green supply chain management: Scientometric review and analysis of empirical research." *Journal of Cleaner Production*:124722.

Bowen, Frances, Paul Cousins, Richard Lamming, and Adam Faruk. 2006. "Horses for courses: Explaining the gap between the theory and practice of green supply." *Greening the supply chain*, 151-72.

Budin, Morris, and AT Eapen. 1970. "Cash generation in business operations: Some simulation models." *The Journal of Finance* 25 (5):1091-107.

Buzacott, John A, and Rachel Q Zhang. 2004. "Inventory management with asset-based financing." *Management Science* 50 (9):1274-92.

Cachon, Gérard P. 2004. "The allocation of inventory risk in a supply chain: Push, pull, and advance-purchase discount contracts." *Management Science* 50 (2):222-38.

Cachon, Gérard P., and A. Gürhan Kök. 2007. "Implementation of the newsvendor model with clearance pricing: How to (and how not to) estimate a salvage value." *Manufacturing & Service Operations Management* 9 (3):276-90.

Cai, Gangshu George, Xiangfeng Chen, and Zhiguo Xiao. 2014. "The roles of bank and trade credits: Theoretical analysis and empirical evidence." *Production and Operations Management* 23 (4):583-98.

Cao, Erbao, and Man Yu. 2018. "Trade credit financing and coordination for an emission-dependent supply chain." *Computers & Industrial Engineering* 119:50-62.

Cao, Yuan, Ji-Hong Zhang, and Xiao-Yu Ma. 2019. "Optimal Financing and Production Decisions for a Supply Chain With Buyer-Backed Purchase Order Financing Contract." *IEEE Access* 7:119384-92.

Castañeda, Jaime Andrés, Mark Brennan, and Jarrod Goentzel. 2019. "A behavioral investigation of supply chain contracts for a newsvendor problem in a developing economy." *International Journal of Production Economics* 210:72-83.

Cheah, Isaac, and Ian Phau. 2011. "Attitudes towards environmentally friendly products: The influence of ecoliteracy, interpersonal influence and value orientation." *Marketing Intelligence Planning* 29 (5):452-72.

Chen, Jianxin, Yongwu Zhou, and Yuanguang Zhong. 2017. "A pricing/ordering model for a dyadic supply chain with buyback guarantee financing and fairness concerns." *International Journal of Production Research* 55 (18):5287-304.

Chen, Kegui, Xinyu Wang, Min Huang, and Wai-Ki Ching. 2018. "Compensation plan, pricing and production decisions with inventory-dependent salvage value, and asymmetric risk-averse sales agent." *Journal of Industrial & Management Optimization* 14 (4):1397-422.

Chen, Xiangfeng, Chuanjun Liu, and Shuting Li. 2019. "The role of supply chain finance in improving the competitive advantage of online retailing enterprises." *Electronic Commerce Research and Applications* 33.

Chin, Thoo Ai, Huam Hon Tat, and Zuraidah Sulaiman. 2015. "Green supply chain management, environmental collaboration and sustainability performance." *Procedia Cirp* 26:695-9.

Choi, Tsan Ming, Duan Li, and Houmin Yan. 2008. "Mean–variance analysis of a single supplier and retailer supply chain under a returns policy." *European Journal of Operational Research* 184 (1):356-76.

Cooper, Martha C, and Lisa M Ellram. 1993. "Characteristics of supply chain management and the implications for purchasing and logistics strategy." *The international journal of logistics management* 4 (2):13-24.

Danese, Pamela, Pietro Romano, and Andrea Vinelli. 2004. "Managing business processes across supply networks: the role of coordination mechanisms." *Journal of Purchasing Supply Management* 10 (4-5):165-77.

De Boer, Ronald, Matthijs van Bergen, and MA Steeman. 2015. "Supply chain finance, its practical relevance and strategic value." *The Supply Chain Finance Essential Knowledge Series*:1-66.

Dedrick, Jason, Kenneth L. Kraemer, and Greg Linden. 2011. "The distribution of value in the mobile phone supply chain." *Telecommunications Policy* 35 (6):505-21.

Devangan, Lokendra, R. K. Amit, Peeyush Mehta, Sanjeev Swami, and Kripa Shanker. 2013. "Individually rational buyback contracts with inventory level dependent demand." *International Journal of Production Economics* 142 (2):381-7.

Dobbs, Ian M. 2004. "Replacement Investment: Optimal Economic Life Under Uncertainty." 31 (5-6):729-57.

Dye, Chung-Yuan, and Chih-Te Yang. 2015. "Sustainable trade credit and replenishment decisions with credit-linked demand under carbon emission constraints." *European Journal of Operational Research* 244 (1):187-200.

Energy Use Calculator, 2019. Electricity usage of an LCD/LED display or TV screen. *http://energyusecalculator.com/electricity_lcdleddisplay.htm*.

Feng, Yi, Yinping Mu, Benyong Hu, and Arun Kumar. 2014. "Commodity options purchasing and credit financing under capital constraint." *International Journal of Production Economics* 153:230-7.

Filbeck, Greg, Sanjay Kumar, Jiangxia Liu, and Xin Zhao. 2016. "Supply chain finance and financial contagion from disruptions-evidence from the automobile industry." *International Journal of Physical Distribution & Logistics Management* 46 (4).

Fisher, Marshall, and Ananth Raman. 1996. "Reducing the cost of demand uncertainty through accurate response to early sales." *Operations Research* 44 (1):87-99.

Gamba, Andrea, and Alexander J. Triantis. 2014. "Corporate risk management: Integrating liquidity, hedging, and operating policies." *Management Science* 60 (1):246-64.

Gao, Jingzhe, Zhongdong Xiao, Haixiao Wei, and Guanghui Zhou. 2020. "Dual-channel green supply chain management with eco-label policy: A perspective of two types of green products." *Computers & Industrial Engineering* 146:106613.

Gelsomino, Luca Mattia, Antonella Moretto, Federico Caniato, and Michiel Steeman. 2018. Innovative supply chain finance schemes: An exploratory study of dynamic discounting. *The Academy of Management Proceedings* 1:18089.

Ghosh, Prasanta Kumar, Amalesh Kumar Manna, Jayanta Kumar Dey, and Samarjit Kar. 2021.

"Supply chain coordination model for green product with different payment strategies: A game theoretic approach." *Journal of Cleaner Production* 290:125734.

Giannetti, Mariassunta, Mike Burkart, and Tore Ellingsen. 2011. "What you sell is what you lend? Explaining trade credit contracts." *The Review of Financial Studies* 24 (4):1261-98.

Gleick, Peter H, RM Adams, RM Amasino, E Anders, DJ Anderson, WW Anderson, LE Anselin, MK Arroyo, B Asfaw, and FJ Ayala. 2010. "Climate change and the integrity of science." *Science* 328 (5979):689-90.

Gollakota, Anjani RK, Sneha Gautam, and Chi Min Shu. 2020. "Inconsistencies of e-waste management in developing nations–Facts and plausible solutions." *Journal of Environmental Management* 261:110234.

Gong, Y, F Jia, S Brown, and L Koh. 2017. "Supply chain learning of sustainability in multi-tier supply chains: a resource orchestration perspective." *International Journal of Operations & Production Management*.

Gupta, R. K., A. K. Bhunia, and S. K. Goyal. 2009. "An application of genetic algorithm in solving an inventory model with advance payment and interval valued inventory costs." *Mathematical and Computer Modelling* 49 (5-6):893-905.

Huang, Boray, Andy Wu, and David Chiang. 2018. "Supporting small suppliers through buyer-backed purchase order financing." *International Journal of Production Research* 56 (18):6066-89.

Huang, Jing, Wensheng Yang, and Yiliu Tu. 2019. "Supplier credit guarantee loan in supply chain with financial constraint and bargaining." *International Journal of Production Research* 57 (22):7158-73.

Ikhlayel, Mahdi. 2018. "An integrated approach to establish e-waste management systems for developing countries." *Journal of Cleaner Production* 170:119-30.

Jamali, Mohammad Bagher, and Morteza Rasti Barzoki. 2018. "A game theoretic approach for green and non-green product pricing in chain-to-chain competitive sustainable and regular dual-channel supply chains." *Journal of Cleaner Production* 170:1029-43.

Jing, Bing, Xiangfeng Chen, and Gangshu George Cai. 2012. "Equilibrium Financing in a Distribution Channel with Capital Constraint." *Production and Operations Management* 21 (6):1090-101.

Jing, Bing, and Abraham Seidmann. 2014. "Finance sourcing in a supply chain." *Decision Support Systems* 58:15-20.

Katok, Elena, and Diana Yan Wu. 2009. "Contracting in supply chains: A laboratory investigation." 55 (12):1953-68.

Katok, Elena, and Diana Yan Wu. "Contracting in supply chains: A laboratory investigation." *Management Science* 55.12 (2009): 1953-1968.

Keren, Baruch, and Joseph S. Pliskin. 2006. "A benchmark solution for the risk-averse newsvendor problem." *European Journal of Operational Research* 174 (3):1643-50.

Khan, Md Al Amin, Ali Akbar Shaikh, Ioannis Konstantaras, Asoke Kumar Bhunia, and Leopoldo Eduardo Cárdenas Barrón. 2020. "Inventory models for perishable items with advanced payment, linearly time-dependent holding cost and demand dependent on advertisement and selling price." *International Journal of Production Economics* 230:107804.

Khan, Md Al Amin, Ali Akbar Shaikh, Gobinda Chandra Panda, Ioannis Konstantaras, and Leopoldo Eduardo Cárdenas-Barrón. 2019. "The effect of advance payment with discount facility on supply decisions of deteriorating products whose demand is both price and stock dependent." *International Transactions in Operational Research* 27 (3):1343-67.

Klapper, Leora. 2005. "The role of factoring for financing small and medium enterprises." *Policy Research Working Papers: The World Bank.*

Klapper, Leora. 2006. "Export financing for SMEs: The role of factoring." *World Bank Group, Trade Note* 29.

Kouvelis, Panos, and Wenhui Zhao. 2012. "Financing the newsvendor: supplier vs. bank, and the structure of optimal trade credit contracts." *Operations Research* 60 (3):566-80.

Kozlenkova, Irina V, G Tomas M Hult, Donald J Lund, Jeannette A Mena, and Pinar Kekec. 2015. "The role of marketing channels in supply chain management." *Journal of Retailing* 91 (4):586-609.

Lariviere, Martin A., and Evan L. Porteus. 2001. "Selling to the newsvendor: An analysis of price-only contracts." *Manufacturing & Service Operations Management* 3 (4):293-305.

Leff, Enrique. 1995. *Green production: toward an environmental rationality*: Guilford Press New York.

Lekkakos, Spyridon Damianos, Hofmann, Erik Mark Johnson, and Alejandro Serrano. 2016. "Supply chain finance for small and medium sized enterprises: The case of reverse factoring." *International Journal of Physical Distribution & Logistics Management* 46 (4):367-92.

Leland, Hayne E. 1994. "Corporate debt value, bond covenants, and optimal capital structure." *The Journal of Finance* 49 (4):1213-52.

Li, Ping, Congjun Rao, Mark Goh, and Zuqiao Yang. 2021. "Pricing strategies and profit coordination under a double echelon green supply chain." Journal of Cleaner Production 278:123694.

Li, Ruihai, YuPing Liu, Jinn Tsair Teng, and Yu Chung Tsao. 2019. "Optimal pricing, lot-sizing and backordering decisions when a seller demands an advance-cash-credit payment scheme." *European Journal of Operational Research* 278 (1):283-95.

Li, Tao, Rong Zhang, Senlin Zhao, and Bin Liu. 2019. "Low carbon strategy analysis under revenue-sharing and cost-sharing contracts." *Journal of Cleaner Production* 212:1462-77.

Lin, Qiang, and Jinying He. 2019. "Supply chain contract design considering the supplier's asset structure and capital constraints." *Computers Industrial Engineering* 137:106044.

Liu, Jingchen, Xin Zhai, and Lihua Chen. 2019. "Optimal pricing strategy under trade-in program in the presence of strategic consumers." *Omega* 84:1-17.

Luo, Ying, Qiang Wei, Qihui Ling, and Baofeng Huo. 2020. "Optimal decision in a green supply chain: Bank financing or supplier financing." *Journal of Cleaner* Production 271:122090.

Mahanta, Devajit. 2012. "Review of warehouse receipt as an instrument for financing in India." *International journal of scientific technology research* 1 (9):42-5.

Maiti, A. K., M. K. Maiti, and M. Maiti. 2009. "Inventory model with stochastic lead-time and price dependent demand incorporating advance payment." *Applied Mathematical Modelling* 33 (5):2433-43.

Manna, Amalesh Kumar, Barun Das, and Sunil Tiwari. 2020. "Impact of carbon emission on imperfect production inventory system with advance payment base free transportation." *RAIRO-Operations Research* 54 (4):1103-17.

Marvel, Howard P., and James Peck. 1995. "Demand uncertainty and returns policies." *International Economic Review* 36 (3):691-714.

Mauer, David C., and Steven H. Ott. 1995. "Investment under uncertainty: The case of replacement investment decisions." *Journal of Financial and Quantitative Analysis* 30 (4):581-605.

Meshram, Pratima, Abhilash Mishra, and Rina Sahu. 2020. "Environmental impact of spent lithium ion batteries and green recycling perspectives by organic acids–A review." *Chemosphere* 242:125291.

Navas-Alemán, Lizbeth, Carlo Pietrobelli, and Marco Kamiya. 2012. "Inter-firm linkages and finance in value chains." *IDB Working Paper Series*.

Netemeyer, Richard G, Balaji Krishnan, Chris Pullig, Guangping Wang, Mehmet Yagci, Dwane Dean, Joe Ricks, and Ferdinand Wirth. 2004. "Developing and validating measures of facets of customer-based brand equity." *Journal of Business Research* 57 (2):209-24.

Nie, Tengfei, and Shaofu Du. 2017. "Dual-fairness supply chain with quantity discount contracts." *European Journal of Operational Research* 258 (2):491-500.

Nwalozie, Chinemerem. 2011. "All About the TJX Companies." *Available at SSRN 1872210*.

Pasternack, Barry Alan. 1985. "Optimal pricing and return policies for perishable commodities." *Marketing Science* 4 (2):166-76.

Peattie, Ken, and Martin Charter. 2003. "Green marketing." *The marketing book* 5:726-55.

Pfohl, Hans-Christian, and Moritz Gomm. 2009. "Supply chain finance: Optimizing financial flows in supply chains." *Logistics research* 1 (3-4):149-61.

Qin, Juanjuan, Yuqing Han, Guangming Wei, and Liangjie Xia. 2019. "The value of advance payment financing to carbon emission reduction and production in a supply chain with game theory analysis." *International Journal of Production Research*:1-20.

Rabnawaz, M, I Wyman, R Auras, and S Cheng. 2017. "A roadmap towards green packaging: The current status and future outlook for polyesters in the packaging industry." *Green Chemistry* 19 (20):4737-53.

Reindorp, Matthew, Fehmi Tanrisever, and Anne Lange. 2018. "Purchase order financing: Credit, commitment, and supply chain consequences." *Operations Research* 66 (5):1287-303.

Rinaldi, Marta, Mario Caterino, Marcello Fera, Pasquale Manco, and Roberto Macchiaroli. 2021. "Technology selection in green supply chains-the effects of additive and traditional manufacturing." *Journal of Cleaner Production* 282:124554.

Rui, Huaxia, and Guoming Lai. 2015. "Sourcing with deferred payment and inspection under supplier product adulteration risk." *Production Operations Management* 24 (6):934-46.

Saha, S, and SK Goyal. 2015. "Supply chain coordination contracts with inventory level and retail price dependent demand." *International Journal of Production Economics* 161:140-52.

Sheu, JiuhBiing, YiHwa Chou, and ChunChia Hu. 2005. "An integrated logistics operational model for green-supply chain management." *Transportation Research Part E: Logistics Transportation Review* 41 (4):287-313.

Shi, Jinzhao, Qiang Du, Feng Lin, Yi Li, Libiao Bai, Richard Y. K. Fung, and Kin Keung Lai. 2020. "Coordinating the supply chain finance system with buyback contract: A capital-constrained newsvendor problem." *Computers & Industrial Engineering* 146:106587.

Simchi-Levi, David, Philip Kaminsky, Edith Simchi-Levi, and Ravi Shankar. 2008. "Designing and managing the supply chain: concepts, strategies and case studies." *Tata McGraw-Hill Education*.

Song, Zhilan, Huan Huang, Wenxue Ran, and Sen Liu. 2016. "A study on the pricing model for 3PL of inventory financing." *Discrete Dynamics in Nature Society* 6489748.

Spengler, Joseph J. 1950. "Vertical integration and antitrust policy." *Journal of Political Economy* 58 (4):347-52.

Statista, 2020. "Smartphone users worldwide 2016-2021." *https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/*, 2020.

Statista Research Department, 2021. "TV unit sales worldwide 2012-2017." *https://www.statista.com/statistics/461316/global-tv-unit-sales/*.

Steeman, Michiel. 2014. "The power of supply chain finance: How companies can apply collaborative finance models in their supply chain to mitigate risks and reduce costs." *Hogeschool Windesheim*.

TAB-TV, 2020. "The history of TVs 2010-2020." *https://en.tab-tv.com/?p=14041*.

Tang, Christopher S., S. Alex Yang, and Jing Wu. 2018. "Sourcing from suppliers with financial constraints and performance risk." *Manufacturing & Service Operations Management* 20 (1):70-84.

Tanrisever, Fehmi, Hande Cetinay, Matthew Reindorp, and Jan C Fransoo. 2015. "Reverse factoring for SME finance." Available at SSRN: *https://ssrn.com/abstract=2183991*.

Taylor, Terry A. 2002. "Supply chain coordination under channel rebates with sales effort effects." *Management Science* 48 (8):992-1007.

Templar, Simon, Charles Findlay, and Erik Hofmann. 2016. "Financing the end-to-end supply chain: A reference guide to supply chain finance." *Kogan Page Publishers*.

Thangam, A. 2012. "Optimal price discounting and lot-sizing policies for perishable items in a supply chain under advance payment scheme and two-echelon trade credits." *International Journal of Production Economics* 139 (2):459-72.

Tiwari, S., W. Ahmed, and B. Sarkar. 2019. "Sustainable ordering policies for non-instantaneous deteriorating items under carbon emission and multi-trade-credit-policies." *Journal of Cleaner Production* 240.

Tsay, Andy A. 2001. "Managing retail channel overstock: Markdown money and return policies." *Journal of Retailing* 77 (4):457-92.

Tsay, Andy A, and William S Lovejoy. 1999. "Quantity flexibility contracts and supply chain performance." *Manufacturing Service Operations Management* 1 (2):89-111.

Tunca, Tunay I., and Weiming Zhu. 2018. "Buyer intermediation in supplier finance." *Management Science* 64 (12):5631-50.

Van der Vliet, Kasper, Matthew J. Reindorp, and Jan C. Fransoo. 2015. "The price of reverse factoring: Financing rates vs. payment delays." *European Journal of Operational Research* 242 (3):842-53.

Vertatique, 2019. "Green ICT: Sustainable communications & information technology." *https://www.vertatique.com/finding-greenest-television*.

Wang, Charles X., and Scott Webster. 2009. "Markdown money contracts for perishable goods with clearance pricing." *European Journal of Operational Research* 196 (3):1113-22.

Wang, Ningning, Zhi-Ping Fan, and Xu Chen. 2019. "Effect of fairness on channel choice of the mobile phone supply chain." I*nternational Transactions in Operational Research* 28(4):2110-38.

Wang, Shouqiang, Haresh Gurnani, and Upender Subramanian. 2021. "The informational role of buyback contracts." *Management Science* 67 (1):279-96.

Welke, William R. 1988. "Accounting for “negative salvage”." *Journal of Accounting Education* 6 (2):325-9.

Wikipedia, 2021. *https://en.wikipedia.org/wiki/History_of_television*.

Wu, Andy. 2017. "A supportive pricing model for suppliers with purchase order financing." *International Journal of Production Research* 55 (19):5632-46.

Wuttke, David A., Constantin Blome, and Michael Henke. 2013. "Focusing the financial flow of supply chains: An empirical investigation of financial supply chain management." *International Journal of Production Economics* 145 (2):773-89.

Xiao, Yongbo, and Jihong Zhang. 2018. "Preselling to a retailer with cash flow shortage on the manufacturer." *Omega* 80:43-57.

Xu, Song, and Lei Fang. 2020. "Partial credit guarantee and trade credit in an emission-dependent supply chain with capital constraint." *Transportation Research Part E: Logistics and*

Transportation Review 135:101859.

Xue, Weili, Yulin Hu, and Zhiyuan Chen. 2018. "The value of buyback contract under price competition." *International Journal of Production Research* 57 (9):2679-94.

Yan, Nina, Xiuli He, and Ye Liu. 2018. "Financing the capital-constrained supply chain with loss aversion: supplier finance vs. supplier investment." *Omega* 88:162-78.

Yan, Nina, Yang Liu, Xun Xu, and Xiuli He. 2020. "Strategic dual-channel pricing games with e-retailer finance." *European Journal of Operational Research* 283 (1):138-51.

Yang, Honglin, Wenyan Zhuo, and Lusheng Shao. 2017. "Equilibrium evolution in a two-echelon supply chain with financially constrained retailers: The impact of equity financing." *International Journal of Production Economics* 185:139-49.

Yang, Hui, Fei Sun, Jing Chen, and Bintong Chen. 2019. "Financing decisions in a supply chain with a capital-constrained manufacturer as new entrant." *International Journal of Production Economics* 216:321-32.

Yang, S. Alex, John R. Birge, and Rodney P. Parker. 2015. "The supply chain effects of bankruptcy." *Management Science* 61 (10):2320-38.

Yang, Shilei, Chunming Victor Shi, and Xuan Zhao. 2011. "Optimal ordering and pricing decisions for a target oriented newsvendor." *Omega* 39 (1):110-5.

Yang, Shilei, Chunming Shi, Yibin Zhang, and Jing Zhu. 2014. "Price competition for retailers with profit and revenue targets." *International Journal of Production Economics* 154:233-42.

Yu, Dennis Z., and Chen Xiang. 2016. "A manufacturer's production and pricing strategies with a salvage channel." *International Journal of Production Research* 55 (2):347-57.

Zhan, Jizhou, Shuting Li, and Xiangfeng Chen. 2018. "The impact of financing mechanism on supply chain sustainability and efficiency." *Journal of Cleaner Production* 205:407-18.

Zhang, Chengtang, and Liping Liu. 2013. "Research on coordination mechanism in three-level green supply chain under non-cooperative game." *Applied Mathematical Modelling* 37 (5):3369-79.

Zhang, Hong C, Tsai C Kuo, Huitian Lu, and Samuel H Huang. 1997. "Environmentally conscious design and manufacturing: A state-of-the-art survey." *Journal of manufacturing systems* 16 (5):352-71.

Zhang, Qinhong, Dali Zhang, Yu Chung Tsao, and Jianwen Luo. 2016. "Optimal ordering policy in a two-stage supply chain with advance payment for stable supply capacity." *International Journal of Production Economics* 177:34-43.

Zhang, Rong, Jiatong Li, Zongsheng Huang, and Bin Liu. 2019. "Return strategies and online product customization in a dual-channel supply chain." *Sustainability* 11 (12).

Zhao, Lima, and Arnd Huchzermeier. 2018a. "Managing supplier financial distress with advance payment discount and purchase order financing." *Omega* 88:77-90.

Zhao, Lima, and Arnd Huchzermeier. 2018b. "Supply chain finance." *Supply Chain Finance*, 105-19. Springer.

Zhao, Rui, Gareth Neighbour, Jiaojie Han, Michael McGuire, and Pauline Deutz. 2012. "Using game theory to describe strategy selection for environmental risk and carbon emissions reduction in the green supply chain." *Journal of Loss Prevention in the Process Industries* 25 (6):927-36.

Zhao, Xin, Yuemei Xue, and Lili Ding. 2020. "Implementation of low carbon industrial symbiosis systems under financial constraint and environmental regulations: An evolutionary game approach." Journal of Cleaner Production 277:124289.

Zhong, Yuanguang, Jia Shu, Wei Xie, and Yongwu Zhou. 2018. "Optimal trade credit and replenishment policies for supply chain network design." *Omega* 81:26-37.

Zink, Trevor, Frank Maker, Roland Geyer, Rajeevan Amirtharajah, and Venkatesh Akella. 2014. "Comparative life cycle assessment of smartphone reuse: repurposing vs. refurbishment." *The International Journal of Life Cycle Assessment* 19 (5):1099-109.

Zou, Zhiqin, Arash Farnoosh, and Tom McNamara. 2021. "Risk analysis in the management of a green supply chain." *Strategic Change* 30 (1):5-17.