國立臺灣大學工學院工業工程學研究所

博士論文

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供應鏈端至端整合的分析案例
An Analysis of End-to-end Integration in Supply Chains

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本論文係羅伯特君（學號 D04546011）在國立臺灣大學工業工程學研究所完成之博士學位論文，於民國 112 年 5 月 22 日承下列考試委員審查通過及口試及格，特此證明

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"He who began a good work will persevere in it till completion. On the road, stress from jobs, commitments, and difficulties can make us depressed and impair our thinking. Remember that we are in the Lord's hands, confident that he will never forsake us since we are his treasure."

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Abstract

The main subjects of this study are the supply chain and retail channel integration mechanisms. This study aims to provide structures for configuring intra-chain coordination mechanisms. We focus on two key areas: building two-part tariff contracts as an integration mechanism in the supply chain and developing a flow-based end-to-end supply chain integration model. The overall cost of ownership, US-China commerce and technological competition, and the COVID-19 pandemic are driving a significant restructuring of global supply chains that will soon alter the economy and business internationally. For premium agri-food goods, end-to-end integrated supply chains have become a new business model. This study looks at how they work, pinpoints the production and business conditions required for their growth, and introduces a flow-based model to explain the interactions between supply chain stakeholders. We investigate a

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premium supply chain that consists of a single integrator company, many small farms that grow bananas, and many retail establishments. We connect business and industry data using a flow-based approach that starts with farmers and moves via integrators, retailers, and wholesalers. We employ economic research to shed light on the stakeholders' conduct in making decisions and cross-check the findings with an expert in the field. Contract farming, capacity planning, and business robustness are the three key decision factors that we have identified.

Contracts are typically used in supply chains in addition to those already mentioned to coordinate the connections between distributors and suppliers. However, a new economy focused on services has recently evolved; in this economy, there are some circumstances where the variable cost is virtually negligible. New contracts must be created that adapt to modern realities because of the changes brought on by technological advancement. First, it's important to think about the kind of contract that works for hundreds or thousands of suppliers who distribute their goods via an online retailer platform, making thousands or millions of products accessible. Second, a lot of contract types do not take quasi-fixed expenses into account. Therefore, it is crucial to create systems for this kind of expense. Specifically, how to handle these quasi-fixed costs, consider them in the context of the supplier's relationship with the e-commerce platform, and use them to facilitate coordination between suppliers and distributors in a supply chain. A coordination method for two-part tariff contracts is suggested in this dissertation that considers a number of performance criteria, including service intensity.

Keywords: End-to-end integration, supply contract design, premium products, flow-based model, two-part tariff, sponsored advertising, value network, e-commerce retailer, online retailer, quasi-fixed cost.

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Chapter 1 Introduction

1.1 Problem definition

The movement of commodities via several organisations makes up the supply chain, from a producer of raw materials to a distributor or a final customer (La Londe & Masters, 1994). The supply chain is a flow that develops different value-creation activities between other actors; this set of different actors is part of a much more complex system, which is subject to being managed and synchronized (Lummus & Vokurka, 1999). In the supply chain, there are generally more than two main actors involved in the flow of products and services, which use information resources, and financial resources, so that the product reaches a consumer (Mentzer et al., 2001).

The interactions carried out in the supply chain, which includes different actors, are intended to generate value for other organizations and a final customer. Because the conception of value is subjective, the customer must be part of the co-creation of value; this co-creation of value is studied within the axioms of the service-dominant logic (Vargo & Lusch, 2016). In supply chains, the flows of materials, services, and resources are constant. Supply chains vary; some consider this flow from the supplier's supplier to the client's client. The co-creation of value is being developed within these different entities or organizations. The interaction between various organizations requires a management philosophy, practices and tools throughout the supply chain flow (Cooper et al., 1997). Supply chain management arises from the need to coordinate the interaction between different organizations and the responsibility of managing other flows, for example, materials, products and services (Stevens, 1989). Supply chain management considers multiple actors, businesses, customers, resources, and value drivers that must be

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coordinated and managed to manipulate the value and stay in the market for a long time (Mentzer et al., 2001).

Integration logic must be utilised in handling supply chains. Integration can be horizontal or vertical. In vertical integration, organizations of the same type create alliances to work in a coordinated way. In vertical integration, different organizations of different types are coordinated, such as a supplier, with the transport service and the distributor. Integration seeks to make the supply chain more competitive; this requires coordination of the choices and activities made throughout the supply chain. The integration of the supply chain needs to be managed, searching within that management for coordination and collaboration mechanisms that allow the flow of valid and complete information that may be utilised to make decisions. Integrating the supply chain requires working on tools that will enable the creation of strategic alliances within the chain vertically. These alliances should focus on the search for strategic partners. The collaboration between different strategic partners is oriented towards permanence in the market and the search for new business opportunities (Bowen, 2019). Supply chain management must include different actors. These actors coordinate due to shared interests. Supply chain participants usually belong to other sectors of the economy, for example, producers of raw materials, the transport service industry, the manufacturing sector, the distribution sector and the advertising service sector. Within an integrated system, supply chain management must seek strategic mechanisms that allow it to compete with other supply chains. Therefore, the strategic vision with tactical work must enhance the overall value chain's performance; it must have a long-term idea that allows all chain members to obtain value for themselves within a system. Prosperous. Therefore, the strategic mechanisms must seek the continuous improvement of the entire system, called the supply chain or integrated supply chain. For the different organizations to remain

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motivated, they must receive benefits that allow them to be prosperous, for which the client is key by incorporating resources within the chain to receive value from a product or service (Mentzer et al., 2001).

To manage the entire supply chain, the organizations that comprise it must consider how to align strategies and daily operations to supply chain objectives. The chain members must ensure that each task, activity and process contributes to fulfilling the goals. Part of the management includes the development of initiatives that allow us to know the market situation; the market must be listened to. Supply chain participants necessarily require the development of beneficial relationships for the entire chain, seen as a system that adjusts to the market's needs. The story of the supply chain requires a global vision, a vision of a system which works in a coordinated manner, in which the decisions made favouring the whole supply chain, constantly measuring its performance as an indicator of coordination and working towards common goals (Lummus & Vokurka, 1999).

Coordination in supply chains requires a balance in which organizations are comfortable because their actions are optimal. This balance does not require a more significant change of activities; this balance is known as Nash equilibrium (Cachon, 2003). Coordination within the supply chain can be classified as centralized and decentralized. In centralized coordination, there is an organization that is the one that makes the decisions. In decentralized coordination, several organizations make decisions; these two decision-making scenarios from one actor or several actors can be present at different stages or links in the supply chain (Giannoccaro & Pontrandolfo, 2004). Incentives management is a component of supply chain leadership. The incentives can motivate the chain actors to maintain a system aligned with common objectives. However, incentives can also cause distortions when they are not appropriately managed. Incentives allow organizations to be rewarded based on their performance within the supply chain

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(Simatupang, Wright & Sridharan, 2002). The incentives must be focused on supporting the achievement of the objectives through constant daily work of value creation from the different processes of the supply chain. The incentives must necessarily respond to a global performance that shows that the supply chain is concentrated on resource creation and value design (Simatupang & Sridharan, 2002). Incentives are part of the coordination mechanisms within supply chains; they seek to make organizations focus on the customer, who is the one who ultimately provides the economic resources to maintain the proper functioning throughout the entire supply chain (Lee, 2000).

The competition within the chains is no longer individual from each organization. The competition now is between supply chains. The challenges to which supply chains are subjected and the changes in the environment motivate research focused on improving coordination mechanisms in supply chains and distribution channels so that the members that structure them benefit from them and share the risks. Coordination within the supply chain brings benefits. These benefits are achieved thanks to good performance globally, which brings with it the generation of resources for the co-creation of value between the organizations that make up the supply chain and customers. However, most organisations find it challenging to face the relationship between coordination mechanisms and supply chain problems (Narayanan & Raman, 2004). Through this research, we want to contribute to understanding integration mechanisms and supply chain performance.

This research aims to determine strategic mechanisms that allow the integration of end-to-end supply chains considering different coordination mechanisms within the internal configuration of supply chains. To determine strategic mechanisms of supply chains, we ask ourselves the following questions: From a tactical standpoint, what is required to integrate the supply chain from beginning to end or also called end-to-end? Within the new technological trends, such as electronic commerce platforms, how to

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coordinate the interaction between providers and the platform to generate strategic decision mechanisms regarding the level of service of the electronic platforms?

The specific objectives of this study are:

- Identify theoretical constructions at a strategic level that explain the chain's behaviour within a logic from end-to-end.
- To present a strategic methodological mechanism to configure different aspects regarding the relationship between suppliers and e-commerce platforms using two-part tariff contracts to configure different service levels.

1.2 Intra-chain economic behaviour

The integrated supply chains for premium produce have emerged from the traditional supply chains as a new business model. These chains are integrated within an end-to-end logic, which includes not only the farmers but also the different links that can be present until they reach the customer, such as a transport intermediary, a wholesale centre, a retail centre, or supermarket chains. This study aims to discover theoretical constructs that can be used to explain the intra-chain economic behaviour of their stakeholders. This study is based on industry and business data of premium bananas and analytic deduction of insights. An agricultural supply chain usually comprises farm producers, factors, processors, distributors, wholesalers, and retailers. Research problems include farmers' suppliers, customers, auction institutions and logistics firms. Agri-food supply systems are usually fragmented in structure, and past research works have focused chiefly on tactical or operational issues rather than on strategic issues such as integration and collaboration (Tsolakis et al., 2014). Despite the fact that there are many studies that promote group work in a coordinated manner, in the agricultural sector, many times these cooperative relationships are limited solely to the relationship of the farmer or farm with

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the transport system or logistics system that collect the products on the farms. Many times the farmer does not know the destination of his production (Matopoulos et al., 2007). There are many research papers on supply chain integration in dyadic or triadic settings, such as dual sourcing, but minimal on end-to-end integration. However, the benefits of end-to-end integration can be substantial and strategic. For example, you can compete in a traditionally very volatile market or even propose a new business in a market that has not been explored (Bowen & Burnette, 2019). It is also possible that a new market can be created, such as the case of Dole Food and 7-11 chain stores collaboration that will be the focus of this study. End-to-end integration is more complicated than dyadic and triadic integration. Therefore, end-to-end integration needs to be studied to comprehensively understand how such systems form and work and realise their potential economic benefits. Our understanding of supply chain management theories appears limited and does not provide valuable guides to end-to-end integration. Those who do qualitative and qualitative research related to the supply chain do not have enough scientific articles to examine the supply chain leadership's difficulties in a comprehensive way (Gligor et al., 2019).

This research includes a global problem within agri-food systems. Integration issues with the agricultural and food supply chain are mainly at a strategic level, so it is essential to develop research in this area that allows knowing theoretical constructs that, in turn, allow progress in the understanding of better strategies for supply chain management. In a lot of poor nations, the producers of perishable produce are usually small farm operators. They face significant limitations in resources, technology and market information, agricultural services, and awareness of regulations and environmental concerns (Delgado, 2010). As a result, critical supply chain players control profit allocation while farmers carry much of the production and market risks. As a result, many communities are

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intensely interested in improving the farmers' economic situation and the agri-food supply chains. The solution approaches include product differentiation, networking and cooperation, and supply chain integration.

Implementing exemplary practices that promote quality standards are increasingly demanded within the food industry (Henson & Reardon, 2005). Many research studies have identified networking and cooperation as a strategic approach for the well-being of small agri-food producers (Lawson et al., 2008; Beuchelt & Zeller, 2012). Networking within agri-food systems allows for overcoming the disadvantages of a small product since it benefits from a more robust agri-food chain; however, despite remaining within the system, it continues to maintain its independence as a small farmer. Beuchelt and Zeller (2012) studied coffee grower cooperatives, in which they found that there is no positive relationship between implementing certification and increased profits. The restrictions of the coffee sector, such as the lack of credits, lack of subsidies, and operating with inadequate infrastructure, make competing internationally very complex. To succeed, cooperatives need to be united, collaborate among themselves, and be integrated with other members within a supply chain.

Supply chain management using vertical integration in agri-food systems, which considers farmers, industry and distributors under a quality-based scheme, is a field of study that can be further developed (Delgado, 2010). Bhuyan (2005) generates evidence that allows us to know how agri-food systems can undergo vertical integration with his studies within the United States of America's food manufacturing sector. His research shows that some transaction cost factors and potential monopolies drive vertical integration. For example, Dole Food Company Inc. partners with farmers and 7-11 chain stores to sell premium bananas in Taiwan's convenience stores. Dole Food is the integrator of this supply chain; the farmers are the primary producers under contract. Tell

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et al. (2016) studied different agricultural industries and proposed some models for supply chain management. They point out the shortcomings of a producer-centric perspective and suggest that entrepreneurs should engage in business model innovation. Business model innovation typically integrates seed, production, or logistic technologies with institutional innovation such as vertical integration, contract farming, and community-supported agriculture. That the agri-food supply system is fragmented implies that it is fertile ground for developing new business models. However, as described above, the agri-food problems are so complicated that the outcomes of various solution approaches are not always predictable. The integration within the agri-food chains requires further studies that allow us to know the real effects of its implementation. Although, therefore, there is a need to study and promote the development of different models and theories to manage simple and complex agricultural systems from the perspective of two organizations and more, it is essential to emphasize that agri-food systems are vital for the proper development of societies.

1.2.1 Proposed scheme

The structure suggested in this dissertation starts with the analysis of a case in which an agri-food system is examined using a supply chain integration method from beginning to finish (end-to-end). To show the relevant industry and business data of the case analysed and to use it to calibrate the model. To derive an intra-chain supply/demand function by profit maximisation. To analyse under what conditions the supply chain integration is considered and how the contracts are used as a coordination mechanism by one of the actors in the chain. To define decision points regarding contract farming, capacity strategy, and business resilience.

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1.2.2 Contribution

This study aims to develop conceptual bases that allow a greater comprehension of the functioning of agri-food supply chains and thus contribute to developing management theories with an end-to-end integration approach. We develop an economic model for analysing the economic behaviour of the actors in the integrated chain of premium bananas about Dole Food and 7-11 convenience stores. To fine-tune our economic model, we gather company and industry data. We contribute to developing theoretical constructs for supply chain management by deriving insights.

1.3 Configuring two-part tariff contracts

As online retailing evolves to more complex forms of multi- and omnichannel retailing, it offers a fertile field for business model innovation in which supply chain integration has become crucial. A two-part tariff (TPT) contract comprises an established sum or rate and a variable rate for each unit traded. TPT is an essential type of contract that distributors use as a mechanism to co-create value with suppliers. However, the fixed fee is usually treated as an exogenous variable, impairing the full capability of the contract. In addition, in the emerging business model of sponsored search advertising in online retailing, the cost-per-click fee is neither a fixed fee nor a variable commission but a quasi-fixed fee. The variable rate can be negotiated on the units sold or on the income generated depending on the business environment, electronic commerce platforms usually have thousands of suppliers and thousands or millions of products, so it is a challenge to coordinate this type of supply chain considering their particularities, this can be done using two-party contracts. However, we find no methods of this capability. This research presents a method for configuring contracts with a fixed or quasi-fixed fee and a variable rate charged on revenue or quantity. In addition, each supply chain member

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can use a strategic orientation mechanism, which includes the variations of the different parameters studied for the types of contracts mentioned.

The success of the distributors that operate under electronic commerce affects the traditional retail channels since the platforms have a greater reach and an increasing reception by the target audience; this has caused a transformation in the retail trade, generating new contact mechanisms with customers that are, exploring various sales channels including a multichannel or omnichannel environment (Piotrowicz et al., 2014; Verhoef et al., 2015). These migrations are driven by new technologies and are accompanied by strategic business model changes. The study of a computer retailer proposed by Cao (2014) suggests retailers should develop co-creation value with stakeholders, re-optimize their channel activities in channel integration, and revamp their organization to facilitate the strategic shift. The created value may come from developing new products, synchronizing the merchandizing across channels, and offering new services to consumers and suppliers. There are substantial research works analyzing and predicting consumers' purchasing behaviour on the demand side since the early days of online retailing. Kim and Kim (2004) aim to identify critical transactional and demographic attributes and develop predictors for purchasing intention in the garment industry. Using a logit model, Van den Poel and Buckinx (2005) propose a prediction mechanism that considers when the next sale will be made on an electronic platform. Furthermore, they determined the number of clicks on a website to predict the next sale as the prediction mechanism within the model. Supply-side problems have recently become a crucial part of online business strategies, so they have received increasing interest in research. Gallino and Moreno (2014) investigate how sharing inventory information between dual channels affects cross-selling, new demand generation, and customer migration.

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Wollenburg et al. (2018) study how customers can be steered across channels by configuring the fulfilment processes to improve customer services and the returns on investment. This research will address a contract design problem upstream of the supply side. Within electronic platforms, you usually work with hundreds or thousands of suppliers and thousands or millions of products. Each product can generally have more than one supplier. This research considers the case in which a dominant electronic distributor market seeks to generate the best incentive mechanisms for business and interaction with suppliers. The combination of suppliers and distributor constitute a supply chain. In this scenario, TPT contracts are a coordination mechanism to generate value co-creation. It is possible to incorporate incentives within the supplier-distributor relationship within the contracts. The contracts literature indicates that contracts can coordinate when those who submit to them are in a state where they do not intend to change their decisions; the contract becomes the best decision; we know this state as an equilibrium of Nash. We know many contract types, and many industries use many contract types.

The main types of contracts can be summarized as two-part tariff contracts, contracts based on a discount based on quantity, contracts based on profit, contracts flexible with the amount traded, and agreements in which the product unsold is returned to the supplier. In addition, coordination mechanisms within contracts have been subjected to different mathematical studies. Cachon (2003) and the studies of Tsay et al. (1999) have written an in-depth and extensive review of significant contract types. They analyze whether a particular contract can coordinate supply chains, business settings where it cannot coordinate supply chains, and comparative studies between contracts when contract parameters are appropriately set. This research focuses on the scenario of a dominant distributor part of electronic commerce, which has suppliers who are considered followers,

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and the type of contract used is a two-part rate. Remember that two-part rate contracts comprise a fixed payment amount and another variable payment amount, usually depending on the sold amount of units. The fixed part of the contract can have different mechanisms. For example, it may be a one-time payment such as a membership; it may be having stores with specific particular characteristics, remodelling the store, carrying out marketing campaigns, or opening new stores. The fixed part is generally used to segment potential partners, to have capital and later use the improved mechanism to operate the business and redistribute value. This fixed mechanism generates links between the supply chain participants that take part in the sector; this mechanism improves the efficiency within the supply chain and allows it to operate more comfortably (Mukherjee & Tsai, 2015).

Even though the TPT contract is simple, using mathematical optimization is not so simple since when considering the profit of the fixed rate to derive it, the first-order rate disappears as a result of a first-order condition. Later we will address this situation and propose a mechanism to deal with the fixed and variable rates. Gabriel and Sorgard (1998) indicate that a TPT contract is adequate to treat the scenario between two producers and a monopolistic distributor, meaning that this contract has a positive effect. A linear model can be a collusive mechanism in a system where a supplier has several substitute products, such as an infinitely repeated equilibrium mechanism. His model employs a non-negative condition which becomes a constraint on the fixed rate.

A TPT contract is a coordination mechanism in the supply chain under a complete information scenario in which one of the participating organizations receives no profits, or these are limited to external opportunities (Corbett et al., 2004). Under information asymmetry, TPT cannot coordinate supply chains in the traditional upstream-downstream chain structure. These deficiencies can be addressed with contracts managed by a strong

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retailer, such as an e-commerce retailer, which seeks different mechanisms to benefit its suppliers by applying agreements that benefit them. Wu, Li, and Shi (2017) study TPT under asymmetric information on the heterogeneity of customers in a supplier-dominated chain. They use a linear city representation of customer distribution and transportation cost in an adverse selection model. The resultant kinked demand function and private transportation cost allow the retailer to seek additional profits. They show that coordination is achievable with positive profits for the dominated firm. In their model, however, binding constraints of individual rationality and incentive compatibility are utilized to establish bounds on the fixed fee.

The cost-per-click is not considered a fixed rate, but neither is it a variable; it is regarded as a quasi-fixed rate; the offer per click is related to the intensity of visibility mechanisms within an electronic commerce platform; this parameter is considered a quasi-fixed cost. Online marketplaces are less constrained by geographical boundaries than traditional retail channels. A more intensive advertisement will reach more potential customers, thus expanding the nominal market size. This new business model that considers the cost per click on the advertising displayed on a platform managed as sponsored advertising requires that the different conventional models be reviewed, especially the TPT contracts. This is the second research issue that motivates this study. Because an online retailer must interact with thousands of heterogeneous product suppliers, there is a need to be able to configure various types of TPT contracts.

1.3.1 Proposed scheme

To describe the problem and research method. To analyze two TPT models, one of which considers the variable rate and the other income model that considers the number of sales. To present a method for determining the variable rate and using the quasi-fixed

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fee to influence suppliers' advertising intensity. To perform numerical simulation and effects of contract parameters.

1.3.2 Contributions

We will first use a simple model to illustrate why most studies treat the fixed fee as an exogenous variable before defining our research problem. Regarding supply chain management, the coordination challenge is usually modelled as a Stackelberg game of two stages. The analyzed scenario consists of a leader retailer and two suppliers. The providers are considered the followers. In this scenario, the retailer takes the first step, which defines the fixed rate f_i and the variable r_i. The second step consists of the competition between the two suppliers who compete based on the most attractive price for the retailer based on the first step, where f_i and r_i were fixed. This model might look reasonable initially but lacks a coordination mechanism between upstream and downstream firms.

1.4 Dissertation framework

In this investigation, four chapters are considered. In chapter two, we begin with a review of the literature, including the main concepts used in this research, such as control and coordination, incentive alignment, supply chain contracts, two-part tariff, premium agri-food products and end-to-end integration. Chapter three describes an end-to-end integration of supply chains for high-end products using a flow-based methodology; introduces a business economic analysis of the integrator; shows decision points regarding contract farming, capacity strategy, and business robustness. In chapter four, the TPT contract model is addressed, which addresses the problem of two suppliers with

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a leading retailer, then the revenue model called the MR model is addressed, later the quantity-based model called the MQ model is analyzed and solved, later an exercise is addressed in which the two models are unified, that is, the MR model and the MQ model, numerical simulations are used to know the effect of modifying different parameters of the models addressed. Finally, in chapter five, the main conclusions of this research are drawn up, and a few ideas for future investigation are proposed.

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Chapter 2 Literature review

To understand the relationship between a two-part tariff as a coordination mechanism and the development of a supply chain with end-to-end integration, in this section, we will explore a sample of literature concerning the main ideas in control and coordination and its mechanisms, incentive alignment, two-part tariff contact design and finally end-to-end integration.

2.1 Control and coordination

Although supply chain members share a common interest in improving their performance through collaborative mechanisms, a supply chain member may perceive its performance impeded by other chain members. This situation between the chain members creates discontent due to differences that affect the maximum potential profit. The supply chain involves different issues such as control, pricing, structure, information, operations, inventory, competition, reward, policy and risk (Munson, Rosenblatt & Rosenblatt, 1999).

Management is related to planning, organizing, coordination, motivation, control, etcetera. An example related to control within the supply chain is that it becomes a mechanism that allows execution according to the planned objectives; in organizations, it includes various processes, some performed daily in operations (Anthony, Dearden & Bedford, 1989). The interaction between the supply chain members entails a series of control areas, including control over price, information, structure, inventory and operations (Munson et al., 1999). Control within the supply chain is studied within two areas, mainly management control or management control systems, which are reviewed by Anthony and Govindarajan (2007). Part of management is control, which refers to keeping operations under planned standards. There is a term that covers the particularities

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of power: the Management Control System (MCS); this system seeks to contribute to the organisational objectives of the activities. Organisations increasingly use control mechanisms, especially in complex systems that must maintain parameters aligned with common goals. The new organisations linked to systems, networks or integrated, for example, within a supply chain, require management control systems more strongly (Strauß & Zecher, 2013). The management control systems consist of several components, including analysing the organisational structure, rethinking the strategy used, reviewing the corporate culture, implementing information management systems and finally, own control mechanisms (Herath, 2007).

A crucial role is played by the supply chain's integration as a uniting mechanism for the different actors in the supply chain; for the integration of the supply chain, it is necessary to have coordination mechanisms that facilitate interaction, group work and the achievement of common objectives (Simatupang, Sandroto & Lubis, 2004). Therefore, successful companies will integrate a coordinated system and manage across all nodes in an entire supply chain network, optimising the overall performance (Lummus & Vokurka, 1999).

Control and coordination are supply chain and retail channel mechanisms looking to generate higher profits. In the literature, there are different mechanisms for control and coordination. Table 2.1 shows some elements to consider when addressing coordination as part of supply chain management. These elements include logistical aspects, information, incentives and mechanisms that allow for generating feedback for the supply chain.

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Table 2.1 Elements for coordination (Simatupang et al., 2002)

	Complementarity	*Coherency*
Operational	Logistics synchronisation	Information sharing
Organisational	Incentive alignment	Collective learning

Coordination in the supply chain seeks to reduce, diminish or eliminate the distortion caused by the lack of communication. Lee et al. (1997) studied a distortion mechanism within supply chains, such as the bullwhip effect. The bullwhip impact must be managed strategically within the organization. Decisions within the organization must be made rationally, with information at hand and with knowledge of where the organization is going within the supply chain. To control the adverse effects of the bullwhip effect, it is essential to understand what causes it, what the results would be for the organization, develop strategies to deal with it, use mechanisms such as information systems to know what the market wants, what the chain contributes to the market and what contributes each partner within the supply chain. Information flows better in organizations that maintain good business relationships, in chains that have implemented incentive systems, and in designs that measure whether the performance of each organization is on par with the system's objectives.

Bastl, Johnson and Finne (2019) propose a theory based on coordination and control by studying three organizations. This study suggests an initial approximation of the control and coordination mechanisms. Bastl et al. (2019) offer a theoretical approach which deals with the control and coordination mechanisms within service provider organizations; the main conclusion is that the responsibility for control and coordination should not fall on a single organization but on a group of these. In addition, it proposes some mechanisms that contribute to management and coordination: the predisposition to risk by the client, the presence of substitute products in the market, the design of contracts

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that ensure all parties, and the mechanisms to promote more fruitful relationships. It also proposes a division between the mechanisms that contribute to the control and the tools that contribute to coordination by comparing different tools that can be presented within the supply chain:

- Mechanisms for exerting control: contracts; structural position; power; information monitoring; etcetera.
- Mechanisms for exerting coordination: information sharing; mutual adjustment; decision-making, and feedback mechanisms.

It is essential to review what forms of agreements are permitted in the supply chain by analyzing the control and coordination mechanisms and having as background that a coordination mechanism is contracted.

2.1.1 Supply chain contracts

Contracts are the coordination mechanisms used within supply chains. These help business conditions to be maintained in a clear and documented way; the use of contracts generates much more effective business relationships; in this way, each actor in the chain knows what to do and what to focus on and, ultimately, helps achieve the supply chain's overall goal (Simchi-Levi, Chen & Bramel, 2010). Contracts are coordination mechanisms in which a supplier generates favourable conditions so that a distributor is encouraged to order a maximum capacity, as the order capacity is complete, in the same way, the income for the supply chain (Elahi, Lamba & Ramaswamy, 2013). Some authors explore different coordination mechanisms through contracts approached from an experimental point of view (Ho & Zhang, 2008; Katon & Wu, 2009; Elahi, Lamba & Ramaswamy, 2013; Davis, 2015).

A considerable amount of literature focuses on contracts as coordination

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mechanisms for supply chains. However, warranties do not express their full potential as coordination mechanisms, causing coordinated decisions in the supply chain not to be the most appropriate or optimal (Elahi et al., 2013; Katon & Wu, 2009). The literature also includes cases in which contracts do not synchronise the supply chain (Elahi et al., 2013). Although the literature on contracts is considerable, there is still much work to be done, and coordination mechanisms through contracts become an area subject to review, improvement and expansion (Simchi-Levi et al., 2010).

Coordination mechanisms within the supply chain have been studied by different authors, who have classified them, broken them down into their coordination mechanisms, and expanded their theoretical basis, facilitating their adaptation to different scenarios (Hezarkhani & Kubiak, 2010; Cachon, 2003). However, contracts in the supply chain settings have developed in many directions. In addition, there is a need to expand and, in many cases, update the coordination mechanisms used by each type of contract according to current business requirements, particularly the mathematical models for optimising inventory addressed in operations research and operations management (Tsay, Nahmias & Agrawal, 1999).

The use of contracts within supply chains entails an agreement between the parties, so the contract must include all the necessary parameters for the supply chain to work; for example, quantities, prices, responsibilities, and mechanisms must be specified. Payment, dates, incentives, risks, penalties, policies, and other tools clarify the contractual relationship (Simchi-Levi, Chen & Bramel, 2010). Organizations should consider working with other organizations under a contractual coordination scheme before considering other coordination mechanisms. This is because implementing the contracts is relatively easy and fast, and the utility within the chain is sufficient to generate a coordination mechanism (Narayanan & Raman, 2004). Elahi, Lamba and Ramaswamy

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(2013) propose mechanisms that should be considered within contracts, mainly in contracts that share revenue and repurchase contracts:

- A new kind of contract combines buyback and revenue-sharing features.
- The tendency to select contracts under risk aversion.
- The use of "gifts" by the supplier.
- The results of giving the retailer information in a graphic style.
- Scenario information under different conditions, e.g. different quantities ordered.

Elahi et al. (2013) focus on the quantities that retailers should order within a supply chain so that that order maximizes supply chain revenue. We find the following types of arrangements within the literature that studies contracts (1) wholesale price, (2) revenue-sharing, (3) quantity discount, (4) quantity flexibility, (5) buy-back, (6) sales rebate, and (7) two-part tariff contracts (Sluis & De Giovanni, 2016).

- A coordinating mechanism for the wholesale price contract is the wholesale price regardless of the quantity a retailer orders (Keser & Paleologo, 2004). This type of contract causes the retailer to collect the minimum amount of products (Elahi et al., 2013; Katok & Wu, 2009).
- Revenue-sharing contract manages lower prices with the condition that the retailer splits a portion of its earnings (Cachon & Lariviere, 2005; Katok & Wu, 2009).
- The retailer lowers its average costs in a quantity discount contract by buying more units (Ho & Zhang, 2008).
- Flexible quantity contract. In this type of contract, a quantity of orders is fixed over time with a margin of flexibility (Tsay & Lovejoy, 1999).
- Repurchase contract, in this type of contract, there is a commitment that if the product is not sold, whoever provided it will repurchase it with a price penalty (Padmanabhan & Png, 1995; Katok & Wu 2009).

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- Sales reimbursement contract in this type of contract, each unit sold results in an extra payment from the producer to the seller (Wong, Qi & Leung 2009).
- A two-part contract establishes an initial fixed price and a variable rate based on each item used or unit purchased (Ho & Zhang, 2008).

2.2 Incentive alignment

Incentives are mechanisms that motivate people to achieve specific objectives. Finding the right incentive mechanisms can facilitate integration and coordination inside the supply chain. The coordination mechanism in the supply chain must consider how to generate and distribute those resources among its members. The distribution of incentives in an equitable way within the supply chain will indeed allow its members to find themselves associated with and work to accomplish common intentions. For the supply chain to distribute benefits, it must be able to generate them in sufficient quantity. Incentives motivate the actors in the supply chain; therefore, these incentives must be appropriately planned, generated and distributed. Incentives allow people to stay motivated and continue to achieve common goals. Working on shared objectives brings with it different benefits and is a mechanism that allows for aligning common interests.

In the same way, incentives are distributed, the actors in the chain must be willing to assume situations that involve risk, cost or even losses. In addition, the supply chain's goals being in harmony with the incentives helps to make the relations of the chain members fairer. Fair compensation seeks mechanisms in which the benefit distribution is equitable to the worker performed, always aligned, thus maintaining a productive and profitable supply chain incentive alignment focuses on organisational linkages and is a complementarity mechanism for coordination. Table 2.3 shows a classification of incentive alignment.

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Table 2.2 Classification of incentive alignment

		Correspondent	
		Compensation fairness	*Self-enforcement*
Organisational linkages	*Benefits* *Risks* *Costs*	Pay-for-production	Pay-for-attempt

Whereas incentive alignment is capable of motivating supply chain members by meeting their needs and increasing profits, it can also be disappointing when they work together but feel differences in the configuration of what they do—incentives that are not correctly aligned, which does not allow them to obtain the expected benefit. Incentive alignment is critical to developing different incentive schemes for other supply chain members. The correct alignment of incentives seeks that the supply chain members collaborate successfully by implementing benefit-sharing mechanisms. The alignment of incentives should motivate supply chain members to contribute to shared objectives, which in turn benefit all members. An incentive scheme is usually built to reward the performance of supply chain members, in which individual benefits are perceived before expected benefits are achieved. However, effective collaboration in the supply chain must also consider the configuration of incentives, which must balance the use and the risk and provide the stimuli based on the contributions made by each organisation in the supply chain.

The incentive scheme must be strong enough to attract, motivate and retain supply chain members. The system must be designed so that the decisions are aligned with the supply chain's activities along with the expected benefits. The supply chain must be able to design incentives to maximize the benefits of supply chain members (Barua & Whinston, 1998). High profits within the supply chain make it possible to generate significant incentives and maintain members' interest in caring for successful performance. Furthermore, the alignment of incentives motivates the chain members to

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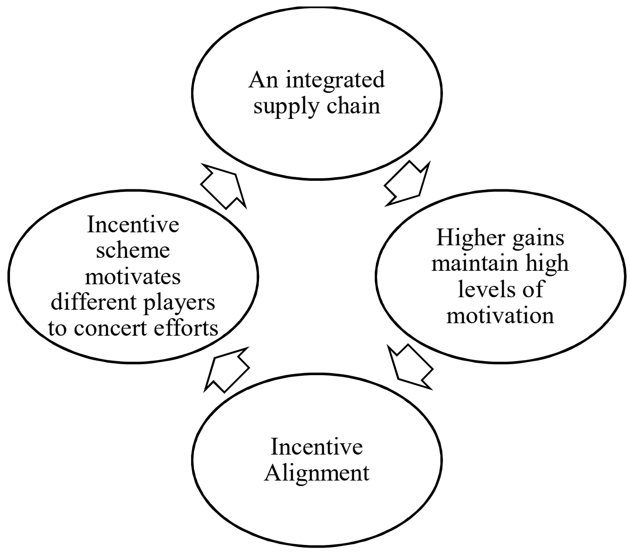
optimize their processes so that savings are generated because of coordination efforts. Figure 2.1 shows an incentive alignment loop of motivation.

Figure 2.1 The incentive alignment loop of motivation

(Adapted from Simatupang, Wright & Sridharan, 2002)



Incentive alignment provides mechanisms to spread the benefits associated with optimization across logistics and other operations. In addition, the use of incentives creates an atmosphere in which members feel recognized for their efforts, which motivates them to provide better customer service (Lee, 2000). Logistics synchronization and optimization also determine the need to share information and are the basis for aligning incentives. Logistics synchronization requires independent partners to coordinate decisions at the tactical level. Taken together, aligning incentives with information sharing provides better supply chain outcomes.

Synchronization within the supply chain allows members to stay motivated for the long term with a productive supply chain. On the contrary, incentives that have not been adequately implemented as a strategic issue of the supply chain bring with them a series of losses due to waste of time, inventory, unnecessary movements, and poor customer

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service (Narayanan & Raman, 2004). A broad field of study is the correct definition of incentives, seeing these as aligned incentives which must provide benefits for all the actors involved; this allows, within the research possibilities, mathematical models of optimization of supply chain alignment decisions to be considered (Clemons & Row, 1993).

With the arguments presented, it is seen to investigate more about mechanisms that allow the generation of incentive alignment schemes. The incentives must consider the production of the complete supply chain but also the achievement of each supply chain member. For example, equitable mechanisms for splitting the rise in profit or cost cuts among chain members need further attention (Lee et al., 1997). As in any conflict resolution mechanism, once the central problem has been defined, the causes can be known, and in this way generate strategies that seek to overcome the issues and incorporate incentive mechanisms within the chain, thereby seeking to improve competitive conditions for all member organizations of the supply chain (Narayanan & Raman, 2004).

2.3 End-to-end integration in premium product supply chains

An extensive transformation is taking place in global supply networks. In-house manufacturing has received due consideration based on the dynamic capacities of companies and the overall cost of ownership as the 1980s-era trend of outsourcing has halted (Gyarmathy et al., 2020). Supply chain restructuring is further fueled by the US-China trade and technological rivalry as well as the COVID-19 pandemic. Global business and economics will soon be drastically changed by these factors.

The connection of decisions and actions among firms of the same chain is known as supply chain integration, SCI (Du Toit & Vlok, 2014). It is a significant type of supply

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chain restructuring that makes it easier to reduce the chains in order to increase their economic and environmental sustainability (Malak-Rawlikowska et al., 2019). The actions, responses, and qualities of supplier-buyer relations, such as fairness, trust, etc., are what determine whether supply chain strategies are implemented successfully (Hingley, 2005). The prominent theories in the SCI literature (Perdana et al., 2019) that explain the incentives for integration and point out areas for development include transaction cost economics, resource-based concerns, and learning organisations. Functional, logistical, informational, and process integration are the subcategories of SCI at the operational level. Additionally, integration typically covers 0–1–2 firms in an upward or downward direction (Frohlich & Westbrook, 2001). Upstream streamlining, downstream integration, and improving internal effectiveness are the most prominent approaches (Childerhouse & Towil, 2011). For inventory, scheduling, fulfilment, and retail pricing decisions, dyadic and triadic models are commonly used in studies (Alcívar-Espín et al., 2021; Matopoulos et al., 2007).

The demand for quality among consumers (Henson & Reardon, 2005) and ecologically responsible business practises (Miceikiene et al., 2021) have led to the emergence of premium agri-food items as a new retail food category in recent years. By implementing safety practises moral norms, and process-based certification, new categories, such as organic food and foods that comply with safety criteria, have been formed (Higgins et al., 2008). Different supply chains must be built for some premium agri-food goods, unlike standard manufacturing chains where the same facility can produce two grades of the same product (Raynolds, 2004).

A large farm owned by one company might serve as the sole producer and distributor of a premium agri-food product in accordance with the traditional producer-centric paradigm. The vertical integration of small producers, processing companies, and

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marketers is an alternate strategy, according to Delgado (2010). When consumption patterns must be gradually understood while seed and production technologies are being experimented with, vertical integration is most advantageous and is a significant determinant of enterprises' innovation behaviour (Karantininis et al., 2010). In a review of business model innovations, Tell et al. (2016) highlight the drawbacks of the conventional producer-centric strategy and advise entrepreneurs to use production technology and institution innovation to develop new business models. Utilising small farmers through vertical integration also enhances social welfare when small farm operators are economically disadvantageous in the traditional agri-food supply networks.

The fullest range of integration, known as end-to-end integration, includes both the production and the market ends. Compared to dyadic and triadic integration, its advantages are greater, more strategic, and more difficult to achieve. A company might, for instance, enter markets that might have seemed too volatile under a conventional non-integrated chain (Bowen & Burnette, 2019), or it might proactively develop a new market. Nestlé Nespresso is a standout example, as it created a new premium coffee business centred on capsule coffee makers and a multi-party supply network (Alvarez et al., 2010). On the supply side, Nestlé offers assistance, guarantees for bank loans, and production inputs to small farmers while paying them more than average. Nestlé maximises the usage of regional materials by operating small operations near its market. The Dole Food Company, in the scenario examined in this study, supplies quality bananas to thousands of convenience stores (the 7-11 chain) in Taiwan. Small farmers are the major contract producers, with Dole Food acting as the integrator. Dole Food also manages post-processing facilities for ripening unripe bananas in a temperature- and humidity-controlled environment. Bananas can be purchased by the piece or in packages at convenience stores for a significant premium above typical retail outlets.

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Perishable goods and non-perishable basic foods each have their own supply chain in the agri-food sector. The first is what this essay concentrates on. The typical agri-food supply chain is made up of farm producers, factors, processors, distributors, wholesalers, and retailers. These supply chains differ from manufacturing supply chains in a number of ways, such as weather conditions, environmental concerns, the presence of multiple stakeholders, perishable products, and complicated food safety regulations. Small farm operators are primarily responsible for producing perishable goods, and they have varying views on the advantages of networking, human resources, and standard propagation for clusters (Haviernikova et al., 2019). The structure of many agri-food supply chains is, therefore, fragmented. In this dissertation, we investigate the positive effects of premium product supply chain end-to-end integration (referred to as premium chains) on integrators' proactive participation in starting new firms.

The literature on vertical integration typically focuses on providing answers to the questions of what and why, or what the integration does and what its goals are, whereas we are interested in providing answers to the questions of how or how a premium chain can be developed, and what the proactive implications are for business development. Our motivation comes from Fernández-Olmos et al. (2016), who argue that minimising opportunism and managing unanticipated circumstances must be addressed in integration efforts, as well as from our knowledge of the significance differences in products as a predictor of vertical integration. Agri-food items that are distinct for retailing, a sizable number of small producers, and the creation of new businesses from a disjointed supply system are the characteristics of the end-to-end challenge that we study. Learn how a premium chain and its integrator may accommodate all stakeholders in this article. In a case study of the banana supply chain for an expensive commodity, we create a flow-

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based model to analyse their economic behaviour. The approach includes aspects of vertical integration, open bidding, parallel supply chains, and contractual agreements.

2.4 Two-part tariff contract design for a supplier base

Coordinating the supply chain (SCC) aims to synchronise the actions made by supply chain participants to be able to accomplish the performance outcome of an integrated organisation. Contractual applications in SCC often refer to dyadic interactions where the dominant party benefits from swaying the decisions of the less dominant party or from using asymmetric knowledge. However, this study investigates how they are used in networks and supply chains that involve several partners. In order to better understand the value networks' and value generation's "service-dominant logic", we use a metatheoretical framework (Vargo & Lusch, 2018). In contrast to dyadic coordination, value networks allow for the efficient utilisation of other parties' services by one party by easing their stress. That is to say, value is produced through assisting service providers in providing better services to service recipients, and act-react cycles are the hallmark of value generation. The integrated company, which serves as the foundation for coordination analysis, cannot be easily characterised as a value network in contrast to dyadic coordination. The distinctions are shown with an instance of internet commerce. Walmart informs its suppliers about demand, alleviating them of order swings and allowing it to compete with cheaper supply costs. There may be several suppliers for each item that online merchants offer, and each supplier may distribute their goods through a variety of online or offline channels. The goals, sizes, and business practises of the providers may probably vary. For instance, small sellers who are product makers or resellers may find it difficult to pay the set price required by an online retailer like Walmart. Therefore, it is impossible to categorise the retailer and its supplier base as an

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integrated organisation, and it takes tremendous work to gather the data on all suppliers required for rigorous coordination.

Despite the fact that the standard SCC falls short of completely embracing the fundamental idea of a mutually beneficial cycle of enabling and alleviating actions that provide value (Lusch, 2011), expanded SCC concepts have advanced our knowledge of value networks. The steady growth of the supply chain vertical structure into networks as well as the incorporation of new dynamics and decisions, are described below. Studies of various SCC supply agreements have been conducted (Cachon, 2003). Their impacts on coordination and contract equivalence were initially examined. However, the equivalence is not always valid in the circumstances like pricing decision rights, voluntary compliance, and asymmetric knowledge, for example. For instance, Cachon and Lariviere (2005) demonstrated that buy-back contracts and revenue-sharing (RS) contracts were equal under fixed retail prices. Contracts for buy-back, quantity flexibility, and sales rebates cannot synchronise the chain. RS contracts, however, can provide the newsvendor or retailer with a way to select the retail price.

More complex issue situations that include proactive actions, like green innovation, marketing, and cooperative advertising, have recently been researched for SCC (Ghadimi et al., 2013; Li et al., 2017). Using two-part tariff contracts to synchronise the chain, Zhang et al. (2017) looked at how green innovation investments affected supply chain profitability. Retailers will benefit more from a consignment contract than a wholesale pricing contract. Lu et al. (2017) presented a dynamic control approach to decide how to best direct advertising efforts. The manufacturer's top choice would be moderated, though, by the efficiency and delay of promotion. Changing contract types were investigated by Zhang and Zhang (2018) as stochastic production costs were discovered over time. Each period's producer and retailer had the option of selecting the TPT contract or the linear

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pricing contract, leading to variations of contracts. The writers also spoke about whether it was possible to come to an agreement on the best sorts of contracts in order to recognise legal contracts. Many providers now offer their goods for sale through both physical and online platforms. Zhang and Zhang (2020) looked at how demand information sharing affected contract choice and the decision of a supplier to enter a different conventional channel in this multi-channel environment.

There are two effects on contract design from adding additional dynamics and decisions to the network. First of all, it presents the potential for different act-react loops for value production. For instance, depending on the product categories and business strategies of the parties involved in the supply chain, the online advertising choice may be taken either before or after the price decision. Second, the creation of increasingly complex corporate procedures and decision-making models may be based on contracts. Companies do not only trade with other companies. When a supplier seeks to team up with a less capable retailer in order to compete against a robust retailer (Zhang et al., 2018), the supplier must assess the contract within a larger framework for business decision-making. A negotiating mechanism may also be used in conjunction with contracts (Basak & Wang, 2016).

In this study, the scenario of a retailer creating two-part tariff contracts for a supplier base is taken into consideration. Prior to proposing a unifying framework, we first discuss typical two-part tariff variations as well as recent variations in online shopping. One important sort of supply contract is a two-part tariff (TPT), which can take many different forms and consists of a lump-sum set charge and a commission per unit. A store within a store, launching additional stores, or marketing initiatives are just a few examples of how the set charge could appear. The per-unit compensation might be based on sales or volume. On an individual supplier basis, physical retail channels often bargain different fees and

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rates. By product and provider, the variable rate often varies.

Table 2.4 compiles research on two-part tariff (TPT) agreements in supplier chains, department shops, royalties, and internet shopping. Each part of a TPT contract affects other things outside the SCC function (Cachon, 2003). According to Pashgian and Gould (1998), the principal implications of the variable rate on SCC are those that affect the ultimate price in general. The retailer is able to vet potential suppliers and disperse earnings throughout its supply chain when they are paid in one single payment. The set charge might increase social welfare and supply chain efficiency by allowing parties in the chain to share information (Mukherjee & Tsai, 2015). Additionally, if a separate factor, like a per-unit commission, is specified for the suppliers, changing one element may still enable the upstream duopolies to turn a profit (Griva & Vettas, 2015).

Table 2.3 TPT problems in a variety of contexts

Problem setting	Research problem	Research conclusion
Supply chains (Gabriel & Sorgard, 1998)	Are two-part tariffs more advantageous than linear tariffs?	A two-part tariff promotes competition, but a linear tariff may be used as a collusive tool.
Supply chains (Griva & Vettas, 2015)	Examine the consequences of the two TPTs' parts.	Rivalry in only one area changes the nature of the rivalry and unintentionally adds a component of product differentiation, which can enable businesses to make money.
Department stores (Pashigian & Gould, 1998)	Should anchor retailers receive separate two-part tariffs than non-anchor stores?	For anchor retailers, the basic rent is often cheaper, and the commission rate is greater.
Royalty payment (Martin & Saracho, 2015)	Is it better to base the variable pricing on value or quantity?	Depending on the degree of difference and whether the products are complementary or replacements.
Online retailing (Chen et al., 2018)	Examine the relative merits of wholesale versus agency pricing.	Online retailers should switch to a TPT with no fixed costs once consumer loyalty is high enough.

According to Rifkin in his 2014 book, The Zero Marginal Cost Society, manufacturing expenses are typically divided into fixed and variable costs; however, the advent of communication and digital technology has led to a period in which many goods

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and services now have almost zero variable costs. Examples include 3D printing, renewable energy, digital products and services, and massive open online courses (MOOCs) (Lozic, 2019). In the modern era, where variable costs are playing a smaller role, quasi-fixed expenses are becoming more significant. Global supply networks and internet shopping are also impacted by this development. These days, contract manufacturers compete for business based on services like quick production engineering, quality control, many short-chain facilities, and international shipping. The associated expenses are almost set.

Conventional retail channels and supply chains are changing as a result of e-commerce. By means of its Fulfilment by Amazon (FBA) programme, Amazon offers fee-based logistic services and grants preferred locations in product comparisons and searches on the internet to the registered item providers. In order to boost their products' reputation, suppliers may decide to create brand stores on Amazon's website. In order to have information about their products and websites shown alongside online search results, suppliers may also pay for Sponsored Search Advertising (SSA). The standard payment method for SSA is cost-per-click, which is based on a bidding procedure or auction for ad placements. According to Ghose and Yang (2009) and Chen & He (2011), product distinctiveness and landing page quality often have an impact on cost-per-click costs. They are largely fixed. TPT contracts now have a new version brought about by essentially set service fees, which have developed into a sizable source of income for internet companies.

Alternative strategies are required to address the issues of plurality and dynamics, such as providing each provider with a set of contracts and allowing them to select the one that best suits their needs. This strategy adheres to the core idea that the customer, not the provider, determines the value of the service (Vargo & Lusch, 2018). The

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performance results of several contracts must be similar in order to build a set of agreements for a supplier group, and no contract may provide unfair, inherent benefits for the retailer. So that the TPT versions have equivalent performance results, we propose and evaluate a suitable technique for the contract parameter set in this study. In classic SCC, it is not required to demonstrate that all contracts are precisely equal because many are not.

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Chapter 3 A Flow-Based Model of End-To-End Integration

This chapter is rewritten mainly from the paper by Alcívar-Espín et al. (2023).

3.1 An end-to-end premium chain case study using a flow-based approach

For our case study of an end-to-end premium banana chain in Taiwan, we offer our flow-based model in this part. The premium chain and its surrounding system's structures are shown in Figure 3.1. There are two official avenues of distribution: regular and premium. Three parties are involved in the premium channel: a network of retail outlets, an integrator, and independent small farmers. In addition to a distribution agreement with the management of the retail establishments, the integrator also establishes supply agreements with several farmers. Large wholesalers have long controlled the conventional distribution route, but in recent years, Taiwan's government has established public auction agencies to boost market efficiency, which greatly benefits small farmers. The contract farms, in this case study, have an area of one hectare. The supply contract agreements define a contract price p_c and a contract quantity q_c, where N represents the total number of contract farms. Farms that produce less than q_c are not fined.

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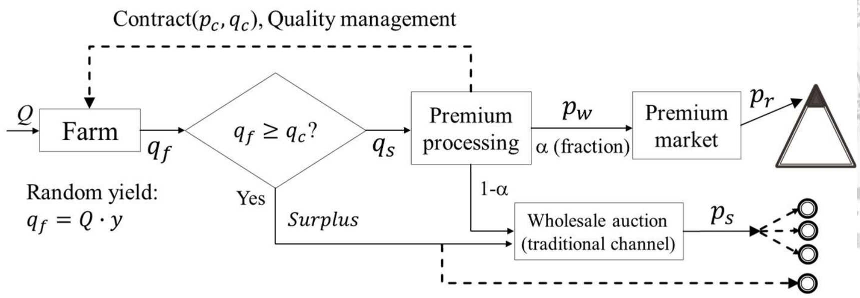

Figure 3.1 Premium supply chain with ties to conventional channels
Note. Adapted from Tsao (2019)

There is just one production stage and one processing step for the premium channel. A farm's intake is denoted by Q, its output is denoted by q_f, and its yield rate is denoted by y. A farm is denoted by the subscript *f*. If the actual output exceeds q_c, the surplus is sold via the conventional route in a public auction, commonly known as the secondary market, for a price of p_s. q_s. The terms $q_s = \min(q_f, q_c)$ refer to the actual amount sent to the processing step (ripening, quality screening, packaging, etc.). We refer to the retail chain stores as the premium marketplace because the bananas need to be premium grade. We denote the portion of q_s transmitted to chain stores using the parameter $\alpha, 0 < \alpha < 1$, and the portion sent to the conventional channel using (1-α)q_s.

The growers can also sell their bananas in their own stores, independently owned businesses, and neighbourhood shops. They could get bigger net earnings depending on the state of the market. We do not include the outside opportunism of these farmers in our model since we view it as a tertiary arena. In Figure 3.1, the tertiary venues are shown by the bottom dotted line.

We refer to our concept as a flow-based model as the agricultural outputs from the supply base are delivered to the processing facility annually rather than on a monthly or seasonal basis. The processed goods are sent to the secondary and premium markets separately. In order to protect the premium market from the erratic nature of agricultural

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output and farmers' opportunism, the parameter α serves as the lever for regulating the amount of product sent to the premium market.

Public auctions serve as the focal point of the conventional channel. The secondary market price p_s is made available online by a governmental organisation. We write p_r for the premium market retail price and p_w for the purchase price paid by the retailer. The retailer's gross profit equals the difference $p_r - p_w$. We use an exponential function to model market demand q_r so that it declines with price more quickly than it would with a linear function,

$$q_r = M \cdot \exp(-\lambda \cdot p_r), \tag{1}$$

where the price parameter is λ. According to the research, this function of demand is a popular willingness-to-pay model (Huang et al., 2013). The integrator's profit function, shown by the subscript *m*, is equal to the unit cost of premium processing, where *k*,

$$\pi_m = p_w \alpha q_s + p_s(1-\alpha)q_s - (p_c + k)q_s.$$

For every farmer, the revenue function is

$$\pi_f = p_c \cdot q_s + p_s \max\{q_f - q_c, 0\} - cQ,$$

when the cost of farming as a unit of produce is *c*. The marginal production cost, c, is assumed to be zero since the total production cost *cQ* is a sunk cost and is thus irrelevant to our study. We presume that farmers are not penalised for production shortfalls on their farms.

3.2 Dataset and analysis

Banana manufacturing in Taiwan dates back a long time (Hwang & Ko, 2004). The Taiwan Banana Research Institute and the Agriculture and Food Agency are two government organisations that gather and disseminate data on the production and yield of

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other agricultural goods as well as bananas. From the Agriculture and Food Agency database, we extract the panel data for bananas for five producing counties from 1997 to 2017. We must take into account agricultural regions with various planting seasons since quality bananas are provided to the market throughout the entire year. To estimate the random yield rate, we use the panel data.

Three of the five major counties' yield rate distributions were subjected to statistical tests, the findings of which are presented in Table 3.1. The yield data from the five counties and four candidate probability distributions were subjected to the K-S test, and the test's P-value is shown in Table A-1 of Appendix A.

Table 3.1 Parameters of yield rate distributions

	Gamma distribution	Normal distribution	Beta distribution
County P	α=16.57, β=0.034	μ=0.56, σ=0.12	α=9.41, β=7.34
County KS	α=34.94, β=0.015	μ=0.53, σ=0.09	α=17.89, β=16.04
County N	α=98.27, β=0.004	μ=0.39, σ=0.04	α=60.81, β=93.56

The three counties' average yield rates, when read from the warmer south to the cooler north, are 0.56, 0.53 and 0.39, respectively, as shown by the normal distribution column. The standard deviation supports the widespread perception of the erratic nature of Taiwan's agricultural output. Contrary to the gamma and normal distribution, which could produce extreme values beyond the interval [0, 1], the beta distribution function's support is the range [0, 1], which is particularly ideal for directly estimating the yield rate. In this study, the beta distribution is used. However, we maintain the breadth of our analysis process.

The retail pricing data from the shelf tag that was gathered every day for 15 months is displayed in Figure 3.2 below. From the wholesale trading database kept by the

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Agriculture and Food Agency, we retrieved the secondary market pricing. Prices are lower in the summer than in the winter for both time series of $p_r(t)$ and $p_s(t)$, which is consistent with Chadwick and Nieuwoudt (1985). Although the range of changes is comparable, the $p_r(t)$ lags behind the $p_s(t)$ significantly. The premium market should respond to the seasonal supplies of the general market later than expected. The prices are $\overline{p}_r$≈120 and $\overline{p}_s$=24.6 on average. Approximately 9589 kilogrammes (kg) are sold per day.

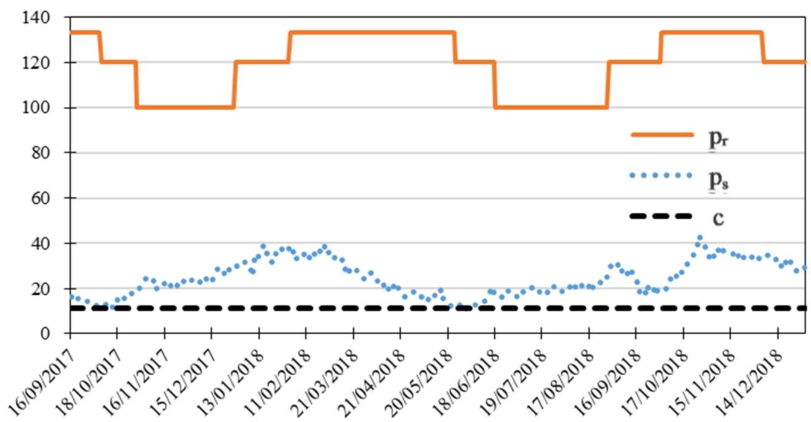

Figure 3.2 Premium retail price, secondary market price, and production cost

Note. Adapted from Tsao (2019)

According to Chadwick and Nieuwoudt (1985), the estimate of banana price elasticity under limited supply typically ranges between 1.42 and 1.52. We calibrate Equation 1's demand function as follows by assuming a price elasticity of 1.5.

$$\frac{dp_r}{dq_r} = -\frac{F_{q_r}}{F_{p_r}} = \frac{-1}{\lambda \cdot M \cdot e^{-\lambda p_r}} \quad \text{(Implicit function law)}$$

$$\text{price elasticity } \epsilon = \frac{dQ/Q}{dP/P} = \lambda \cdot M \cdot e^{-\lambda p_r} \cdot \frac{p_r}{q_r},$$

and using the average price of 120, the number of sales of 9589, and $\epsilon = 1.5$, we determine M and λ.

$$\epsilon = 1.5 = \lambda M e^{-\lambda \cdot 120} \cdot \frac{120}{9589},$$

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$$Me^{-\lambda \cdot 120} = 9589$$

and discover $M = 42975$ and $\lambda = 0.0125$.

The wholesale pricing is decided upon through business-to-business agreements between the integrator and the retailer, and both parties modify the price whenever there are significant changes in the market. Due to the chain shops' extensive selection of both food and non-food items, industry standard requires that the gross profit margins of the product mix be managed. Based on the publicly accessible financial statements of the Taiwan 7-11 chain, our case study's retail chain locations had gross profit margins of 32.3%, 32.8%, and 33.2% from 2015 to 2017, respectively. The price difference between wholesale and retail is known as the markup. The following information, obtained from the Taiwan Banana Research Institute, is used as our reference figure for markup and is based on the average gross profit margin: Q, a production input, is equal to 45,000 per hectare; the premium processing was priced at k = 14.0/kg; c = 11.37 per kilogramme for agricultural produce.

3.3 Analysis of the integrator's business and economy

Data from Taiwan's banana sector, as well as the stakeholders' decision rationale, are incorporated into our model. The yield rate *y* is a crucial variable, as previously said; thus we allow it to follow a probability distribution with a density function $f(y)$ and cumulative distribution function $F(y)$. For a farming hectare, we'll let q_c determine the contract quantity. By translating the contract quantity, q_c, to a target yield rate, y_c, on the fixed input, Q, we may define $y_c = q_c/Q$, where y_c is the normalised q_c. We characterise each farm's supply as follows:

$$q_s = min(q_f, q_c) = min(Qy, q_c) = Q \cdot min(y, y_c).$$

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We let $y_s = \min(y, y_c)$. The supply's anticipated value is expressed as

$$E[q_s] = Q \cdot E[\min(y, y_c)] = Q \cdot E[y_s], \tag{2}$$

where q_s has been normalised, or y_s. The Leibniz integration rule and the definition both state that

$$E[y_s] = [1 - F(y_c)]y_c + \int_0^{y_c} y f(y) dy = y_c - \int_0^{y_c} F(y) dy, \tag{3}$$

The final (integral) term is a decrease in yield rate as a result of a subpar harvest. The average supply per farm under a random yield may be determined using Equation 2. It should be noted that Equation 3 illustrates how the contract quantity affects the projected supply per unit of cropland, i.e., q_c is implicit in $E[y_s]$.

The integrator in our case study purchases bananas from the contracted small farmers. If there is just one harvest each year, the integrator only requires N minimum farmers to supply the market.

$$N = \frac{\text{average daily sale} \cdot 365}{E[q_s] \cdot \alpha}.$$

The demand and supply equation is solved to arrive at the market-clearing price.

$$M \cdot \exp(-\lambda p_r) \cdot 365 = E[q_s] \cdot \alpha \cdot N, \tag{4}$$

where supply is a function of q_c and N and demand is a function of the retail price p_r on the right-hand side. The market-clearing price is by rewriting Equation 4:

$$p_r = \frac{1}{\lambda}[\ln(365M) - \ln(\alpha N) - \ln E[q_s]]. \tag{5}$$

The integrator's yearly profit, Π_m, is equal to the revenue from selling each farm's supply multiplied by the number of farms covered by the contract.

$$E(\Pi_m) = E(\pi_m)N = [\alpha m p_r + (1 - \alpha)p_s - p_c - k]E[q_s]N$$

$$= \left[\frac{\alpha m}{\lambda}(\ln 365M - \ln(\alpha N) - \ln E[q_s]) + (1 - \alpha)p_s - p_c - k\right] E(q_s)N.$$

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One feature of end-to-end integrated chains is that the two aspects of the supply contract are not independent. One can therefore be derived from the other. We derive the profit-maximizing contract quantity for each given N from the required condition $\partial E(\pi_m)/\partial q_c = 0$ (see Appendix B),

$$\ln(365M) - \ln(\alpha N) - \ln E(q_s) = \frac{\lambda}{\alpha m}[p_c + k - (1-\alpha)p_s] + 1.$$

After being simplified,

$$E[q_s{}^*] = \frac{365 \cdot M}{\alpha N} \cdot e^{\frac{-\lambda[p_C + k - (1-\alpha)p_S]}{\alpha m} - 1}, \quad (6)$$

It connects the contract's two criteria. Equation 6 gives a trajectory of the ideal contract arrangements for each q_c since we can find a matching p_c and vice versa. The trajectory depicts every ideal contract resolution. This is the outcome of the integrator maximising profit. The trajectory is designated as an implicit function $OC(p_c, q_c) = 0$ and is referred to as the optimal contract (OC). Equation 6 is universal for all yield rate distribution functions in numerical example 1 below, and we use it to describe the beta distribution.

3.3.1 Numerical example 1: balancing supply and demand

The yield rate follows the beta distribution beta (9,7) in numerical example 1. A 16-degree polynomial function will be the final formula for the $E[y_s]$ in Equation 3. However, regression by a second-degree polynomial, with R^2=0.9961 (see Appendix C), is a decent approximation.

$$E[y_s] = -0.811{y_c}^2 + 1.399y_c - 0.0321.$$

Equation 6 may be solved for by entering this formula for $E[y_s]$

$$-0.811{y_c}^2 + 1.399y_c - 0.0321 = \frac{365M}{\alpha NQ} \cdot e^{\frac{-\lambda[p_C + k - (1-\alpha)p_S]}{\alpha m} - 1} \quad (7)$$

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then figure out an ideal contract price for every contract amount using Equation 7. The OC and two additional demand functions are plotted in Figure 3.3 below at various supply chain levels. We set the parameters to α = 0.8, m = 0.7, p_s = 24.6, and N = 200. In the price-quantity space, the functional connections are likewise depicted in Figure 3.3. The market demand function, or $p_r(q_r)$, is shown by the top curve; the connection between p_w and q_r, or $p_w = m \cdot p_r$; and the OC are represented by the middle and bottom curves, respectively. For each contract amount, the predicted profit of the integrator may be plotted using the right axis, and this demonstrates that the integrator's profit is concave and rises with the contract quantity, however, at a decreasing pace.

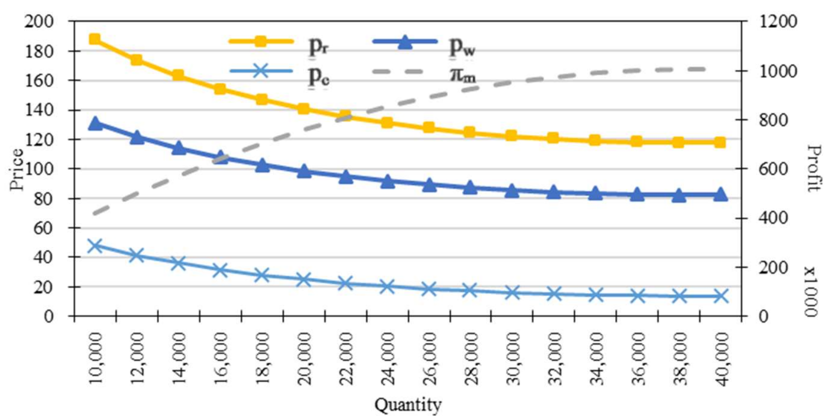

Figure 3.3 Intra-chain demand functions

Note. Adapted from Tsao (2019)

Next, we describe the last three curves. Given that a supply chain with numerous stages is made up of a series of durable demand-supply connections, one for every step, we express each relationship by a demand function or inverse demand function. A horizontal market, often known as a duopoly or oligopoly, is made up of all the companies at each level. The market structures of horizontal markets can vary. The horizontal markets in a supply chain that is not integrated are more or less autonomous, but in a chain that is integrated, they are closely connected. Figure 3.3 displays the three curves

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that depict the intra-chain demand functions between the production end and the market end of the supply chain. The premium market sets the top curve, but the integrator must select how big the premium market should be by managing supply. High markups show strong market power; they are calculated as the distance between the top and centre curves. The planning area for defining the farm contract has a ceiling imposed by the centre curve as well. The bottom OC curve in this space is determined by the integrator's profit-maximizing behaviour. Farmers and integrators must agree on a certain spot on the curve that serves their respective needs. The relationships between the stakeholders are characterised by the three intra-chain demand functions, and the distance between them indicates the possibility of allocating profits.

3.4 Decision points include capacity planning, contract farming, and business resilience.

Which supply contract clause is better at settling disputes throughout the negotiating process? That is the question we are asking. We must thus inquire as follows: Which should be prioritised in the supply contract arrangements: contract quantity or contract price? What regulations are necessary for the integrator to employ a supply base of several small farms or a smaller number of large farms? What steps should the integrator take if a new rival enters the market? Does the premium chain provide significant profits? We examine the three cases' decision points below. A single farmer is the subject of Section 3.4.1, many farms are the subject of Section 3.4.2, and modifying the parameters of λ and α is the subject of Section 3.4.3.

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3.4.1 Choices involving single farmers and contract farming

Without a premium chain, farmers are more likely to sell their agricultural products largely to the secondary market. H and L are shorthand for the premium and secondary markets, respectively. The farmers' earnings from the premium and secondary markets are represented by $\pi_{f,H}$ and $\pi_{f,L}$, respectively. In a similar manner, $\pi_{m,H}$ and $\pi_{m,L}$ represent the integrator's respective gains from the two marketplaces.

When using Equation 7, we take into account a variety of contract pricing. The OC function is used to calculate the contract quantity for each price, and Equation 5 is used to get the retail price. The two profit curves for the farmers and the two profit curves for the integrator are shown in Figure 3.4 below. Without sacrificing generality, we presumptively have zero marginal production costs. As a result, $\pi_{f,H} = p_c E[q_s]$. The two profit functions for the integrator decline as the contract price increases, which is in line with what we anticipated. The cost of the integrator grows as the contract price rises, and a rising contract price is followed by a falling contract quantity. Consequently, less merchandise is sold to the secondary market. The earnings from L represent a minor portion of the overall profit and are less significant to the integrator than the profits from H.

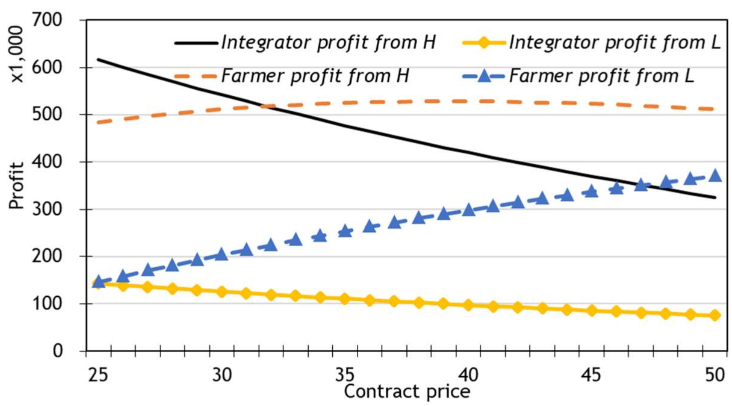

Figure 3.4 Premium and secondary market profits

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Intriguing are the two profit roles for the farmers. Farmers' $\pi_{f,H}$ for the H market is concave and does not grow continuously with contract price; instead, it initially levels out and then slightly declines. Over a wide range of contract prices, farmers that serve the H market make roughly the same earnings. In other words, the profitability is independent of the contract price. Due to an increase in the amount supplied to the secondary market for the L market, the farmers' $\pi_{f,L}$ rises with the contract price. It should be noted that while farmers benefit financially from the H market, there is also potential to increase earnings in the L market. The integrator's profit-maximizing OC is to blame for this. The farmers have limited space for manoeuvring because all possibilities of $(p_{c,}q_c)$ pairings provide the same reward for the integrator. The farmers may initially want a high contract price, but in this instance of an integrated chain, selling to the H market will not provide higher profits than selling the surplus—that is, the production less the contract quantity—to the L market. The farmers can also sell their excess product to secondary markets. A smaller contract quantity is associated with a higher contract price, which increases the surplus quantity. Although a lump-sum profit is guaranteed by the supply contract, the farmer's main worry and economic driver is probably surplus production.

3.4.2 Decisions about the capacity of many farms

The integrator can sign up either fewer farmers with a higher contract quantity or more farmers with a lower contract quantity if the premium chain generates more earnings, which is a type of economic surplus. Don't forget that the supply variables q_c and N define the overall maximum supply to the H market. The two factors each have a distinct impact. The yield is unpredictable, therefore q_c has a declining influence on predicted supply, whereas N has a proportionate impact. The earnings of the integrator and N farmers are shown across the q_c-N space in Figure 3.5. The integrator profit

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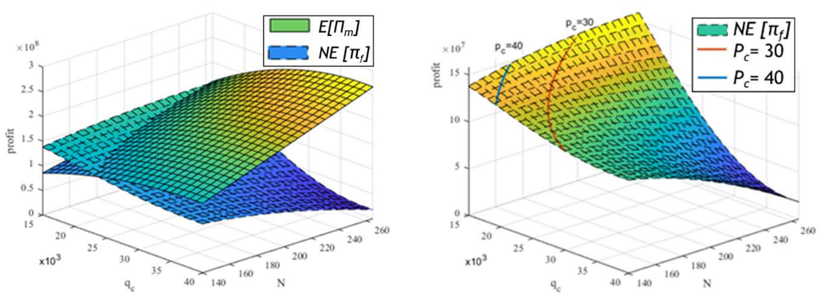
$E[\Pi_m]$ is represented by the top surface in Fig. 4.5a, and the total profit $N \cdot E[\pi_f]$ of N farms is represented by the other surface. Two isoquant curves for p_c=30 and 40 are used in 4.5b to denote the farmers' profit function. When N = 250 and q_c = 40,000, the overall profit of the N farms equals around 7.5% of the integrator's profit. As a result, farmers make less money when there is an excess of supply. The retail and contract prices fall when the supply is increased, and the farmers' overall earnings fall more quickly (Figure 3.3 also shows the effect). According to Figure 3.5a, N has a more dramatic impact on the two supply variables than q_c. If an equitable profit distribution between the integrator and farmers is desired, the integrator should resist the urge to select a N that is bigger than is required.



(a) All farmers' and the integrator's profits (b) The contract price's iso curves

Figure 3.5 All farmers' and the integrator's profits and the contract price's iso curves

The outcomes of this example suggest that both farmers and integrators could want a high contract price. The integrator wants a high contract price, which is an intriguing observation. While a higher p_c is undesirable for the integrator, a higher p_c is costly for the farmers since the related q_c suggests a bigger excess production at their disposal. However, for the integrator, a higher p_c is linked to a lower q_c, which in turn permits a greater N. The marginal contribution of N is greater than that of q_c, therefore the integrator benefits more from a higher contract price than $\pi_{f,H}$'s optimiser. The false

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assumptions that people often have regarding contract prices and the real reasons for both parties' actions are compiled in Table 3.2. The rates paid between any two supply chain nodes, or "transfer prices," are a common source of conflict in supply chain planning and contract negotiations. This is also true for our premium chain. By taking into consideration the farmers' surplus output and the size of the integrator's supply base independently, both parties might agree on a certain high value of p_c. Table 3.2 suggests that it would be ideal for each side to investigate how the friction point affects the other.

Table 3.2 False assumptions and beliefs on contract pricing at the optimiser of $\pi_{f,H}$ or higher

	Common beliefs	False assumptions	True intentions
Individual Farmer	Will increase earnings, which is desirable	Profits are comparable and are controlled by the OCs curve	Farmers can market their increased excess to other nearby marketplaces
Integrator	Unfavourable: will drive up the cost of sourcing	Similar expenses are ensured by the OCs curve	Low contract amounts with specific farms result in an increase in contract farms

A consensus is more likely to be reached when the interests of the two parties do not directly contradict. The farmers won't protest, and the price will lessen their opportunism, for example, if we set the contract price to the highest historical secondary market price, or $p_c = \max\{p_s(t), \forall t\} = 40$. In Figure 3.5b, an iso-quant curve is indicated for each combination of (q_c-N) that supports this pricing. The formula below demonstrates the two components of each farmer's profit.

$$E[\pi_f] = p_c \cdot E[q_s] + p_s \cdot (QE[y] - E[q_s]) = (p_c - p_s)E[q_s] + p_s \cdot QE[y].$$

Each farmer would make $p_s \cdot QE[y]$ in total profit in the absence of our premium market. The economic surplus (ES) from the H market, which is produced when there is a premium market, increases. Thus,

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$$\mathrm{ES} = \pi_{f,H} = (p_c - p_s)E[q_s].$$

As the ratio of ES to q_c, we refer to unit economic surplus (UES) as

$$UES = \pi_{f,H}/q_c.$$

For each value of N, we exhibit the ES from the H market, q_c, and the UES in Figure 3.6. Farm count is shown on the horizontal axis. All farmers are focused on quantity, but because their outside opportunities may differ, they are likely to have different opportunistic tendencies. To ascertain the value of N, the integrator must enlist sufficient numbers of cooperative farmers. The integrator could treat q_c as a restricting factor because of its declining impact on the UES. The constricting impact is reflected in the UES's curvature. Finding enough interested farmers will become more challenging even as the integrator's profit rises with N. We suggest using the UES as a criteria for determining N's value.

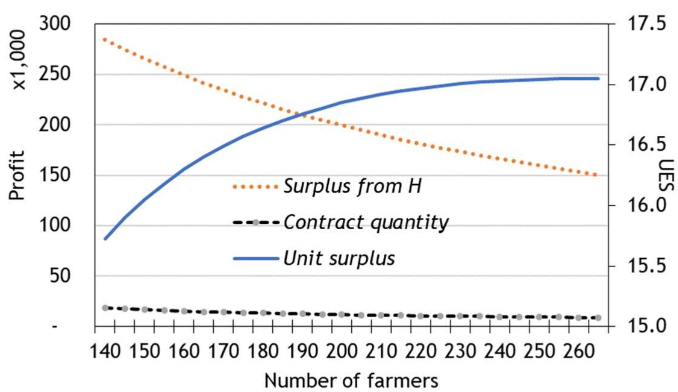

Figure 3.6 Unit economic surplus and farmer income from the H market

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3.4.3 Business resilience

Price elasticity has something to do with the price parameter λ, a variable that might fluctuate over time. The demand quantity drops if λ rises while the price remains the same. Therefore, λ, which stands for the general customer's selection, also has an impact on the H market's size. Profit is a crucial factor in company planning, hence we consider our premium chain sustainable if changes in λ have little effect on the integrator's overall profit. This competence pertains to managing demand through flexible supply chains (Yuan et al., 2017).

We worry about the stability of our premium chain when the market has a brief change in λ because as grows, the entire profit lowers. The profit function of the integrator is rewritten as

$$E(\Pi_m) = \left[\frac{\alpha m}{\lambda}[\ln 365M - \ln \alpha - \ln(E[q_s]N)] + (1-\alpha)p_s - p_c - k\right] E[q_s]N.$$

We see the supply $E[q_s]N$ as fixed in the short term, perhaps within a year, for example. We will use the formula $r = [E(\Pi_m\ )/E(q_s\ )N] + p_c + k$ to represent the revenue contribution per unit of product. Both α and λ have an impact on how the r behaves. We get the following by rephrasing the previous query,

$$r = f(\alpha,\ \lambda) = \frac{\alpha m}{\lambda}[\ln 365M - \ln \alpha - \ln(E[q_s]N)] + (1-\alpha)p_s. \quad (8)$$

Assign the brief term λ the symbol $\tilde{\lambda}$. In the equation above, if $\tilde{\lambda}$ above, if is substituted,

$$\frac{r}{m}\tilde{\lambda} = \alpha\left[\ln 365M - \ln \alpha - \ln(E[q_s]N) - \frac{p_s}{m}\tilde{\lambda}\right] + \frac{p_s}{m}\tilde{\lambda}.$$

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In order to achieve the same unit profit, we are interested in discovering a new α for each $\tilde{\lambda}$. The following equality must be satisfied in order for the solution α, denoted as $\tilde{\alpha}$, to exist.

$$\tilde{\alpha}\ln\tilde{\alpha} - \left[\ln 365M - \ln(E[q_s]N) - \frac{p_s}{m}\tilde{\lambda}\right]\tilde{\alpha} + \frac{r-p_s}{m}\tilde{\lambda} = 0, \quad (9)$$

$x\,ln\,x + bx + c = 0$ is the form that Equation 9 takes. Where W is the Lambert W function and its general solution is the exponential function $x = exp(-b + W(-c \cdot e^{b}))$.

3.4.3.1 Changing λ and α in the second numerical example

Our lookup Table 3.3, is predicated on the starting values λ = 0.0125, α = 0.70, and p_r = 164.9 in the centre column. Equation 9 changes when other constants are used.

$$\tilde{\alpha}\ln\tilde{\alpha} - (1.705 - 35.14 \cdot \tilde{\lambda})\tilde{\alpha} + 90.86 = 0.$$

Because it would be computationally expensive to calculate the Lambert W function's value, we solved for $\tilde{\lambda}$ each possible value of $\tilde{\alpha}$ and built this lookup table.

Table 3.3 Reaction to changes in λ

	smaller λ ←–– ––		Original value	larger λ –– ––→	
$\tilde{\lambda}$	0.01188	0.01221	λ = 0.0125 α = 0.70 p_r = 164.9	0.01275	0.01297
$\tilde{p}_r$	173.6	168.9		161.7	159.0
α^*	0.5998	0.6494		0.7500	0.7999
${p_r}^*$	186.6	175.0		156.3	148.7

The value of λ rises and the price falls, as shown in Table 3.3, if a competitive product enters the H market or if buyers in retail stores start becoming pickier. It would be sensible to move the firm to a smaller specialty area of the H market given the logic of our premium product profit and the H market, but doing so would reduce the integrator's

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overall profit. Instead, in order to retain its current profit level, the integrator should raise the overall supply by adapting α to a greater (and a lower price). You should be aware that parameter α may also be used as a lever for controlling the H market's profitability.

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Chapter 4 Establishing a Two-Part Tariff Contract

This chapter is largely rewritten from the paper by Alcívar-Espín et al. (2022).

4.1 Problem description and definition

In this study, we first introduce our fundamental concept and then utilise a basic variation of a TPT to illustrate why certain TPT kinds are resistant to mathematical optimisation. When there is no ambiguity, on sometimes, we omit the variable subscripts for brevity. A supply chain with two upstream providers is one example, suppliers 1 and 2, and one downstream retailer, Retailer *d*. A duopoly between the two providers exists. Assume the demand for supplier $i,\ i \in \{1,2\},$ has the standard linear form,

$$q_1 = M - \beta p_1 + \theta(p_2 - p_1) \tag{1}$$

$$q_2 = \alpha M - \beta p_2 + \theta(p_1 - p_2) \tag{2}$$

$$0 \le \theta \le 1,\ 0 < \alpha < 1,$$

where M is the nominal demand for supplier 1, αM is the nominal demand for supplier 2, θ is a cross-price elasticity measure, q_i is the demand, p_i is the product price, and β is the slope of the demand function, which also serves as a unit conversion factor. The supplier is given the option of signing a TPT contract with the retailer, who will charge a variable commission rate based on sales. The retailer's and suppliers' profit functions are described as follows:

$$\underset{p_i}{\pi_i} = p_i q_i - f_i - r_i p_i q_i \quad i \in \{1,2\} \tag{3}$$

$$\underset{f_i, r_i}{\pi_d} = f_1 + f_2 + r_1 p_1 q_1 + r_2 p_2 q_2, \tag{4}$$

where the variable rate is r_i and the fixed charge is f_i. Despite the fact that we refer to this model as our baseline model, it is not the main model we use for analysis. It serves

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as an example for a crucial future decision-making difficulty. After that, we give a description of our basic model, which includes fixed and quasi-fixed expenses.

As a Stackelberg game between two states, we simulate supply chain cooperation. Upstream suppliers are viewed as the followers and the downstream retailer as the leader. The consignment model stipulates that the retailer sets the fixed fee f_i and variable rate r_i, after which the two suppliers face off on selling prices based on the established f_i and r_i. In order to solve Stackelberg games, one often applies backward induction by first figuring out the price in equilibrium and then the best options for *f* and *r*. Even while our fundamental model appears to be solvable at first sight, it is not. Despite the fact that we can get the equilibrium costs determined by the profit functions above by concurrently solving the optimal response functions of the first-order conditions (FOC) $\mathrm{d}\pi_1/\mathrm{d}p_1 = 0$ and $\mathrm{d}\pi_2/\mathrm{d}p_2 = 0$,

$$p_1 = \frac{2(\theta+1)+\alpha\theta}{4(\theta+1)^2-\theta^2}M, \quad p_2 = \frac{\theta+2\alpha(\theta+1)}{4(\theta+1)^2-\theta^2}M,$$

the factors *f* and *r* are not present in the equilibrium pricing. Additionally, lacking the *f* and *r* are the demand values from equations (1) and (2). In the FOC of maximising π_d with regard to *f* and *r*, both *f* and *r* disappear as a result. Simply put, in this Stackelberg game model, the contract variables *f* and *r* and equilibrium prices have no connection. Therefore, the TPT contract cannot be used by the retailer as a means of influencing the suppliers' price decisions through *f* and *r*. The set split between the retailer and the suppliers (i.e., $p \cdot q$) of the sales profits is to blame for this deficit. The best choice made by the store will guide the choices made by the suppliers. Although our baseline model doesn't include a coordination mechanism, however, when the retailer is the dominant party, it is advantageous.

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MR and MQ, two extensions of our basic model, are used to calculate the profit functions for suppliers and retailers in Table 4.1. In MR, where the letter R stands for revenue, the variable commission rate is assessed; in MQ, where the letter Q stands for quantity, the variable commission rate is assessed. As a percentage in MR and a per-unit rate in MQ, respectively, the rate *r* has different connotations in the two models. The basic service price f_i and the service level s_i are used to represent the quasi-fixed fee as $s_i f_i$. The services that online retailers provide to their suppliers include logistics and warehousing, branded shops, cross-border consultation, sponsored search advertising, etc. These suppliers then compete on the level of service quality. A supplier's service expense will drop to the fixed charge of the base model if they select $s_i = 1$. If $s_i > 1$, the part of service costs above f_i is quasi-fixed. Budgets are created by each provider for their service costs. Due to the bidding process used in sponsored search advertising, the cost is variable and discretionary, based on the level of competition, the state of the market, and other elements. The marginal production cost in our two extended models is zero, and the service intensity or level is indicated by the notation s_i. The baseline service charge is determined by the merchant, and the suppliers choose the level of service.

Table 4.1 The retailer´s and suppliers´ profit models

Model MR r charged on Revenue	Model MQ r charged on Quantity
$\pi_i = p_i q_i - r_i p_i q_i - s_i f_i$	$\pi_i = p_i q_i - r_i q_i - s_i f_i$
$\pi_d = \sum_i (s_i f_i + r_i p_i q_i)$	$\pi_d = \sum_i (s_i f_i + r_i q_i)$

Note. Adapted from Huang (2018)

We use the following linear demand functions, taking into account platform service features and tailored advertising:

$$q_1 = s_1 M - \beta p_1 + \theta(p_2 - p_1) \tag{5}$$

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$$q_2 = s_2 \alpha M - \beta p_2 + \theta(p_1 - p_2), \quad (6)$$

where the variable for service intensity is $s_i \in \{\underline{s}, \overline{s}\}$. Online tailored advertising may reach a more niche audience than traditional media and significantly increases the size of the possible market. The nominal market size is shown as $s_i \alpha M$. The normalised value of α for supplier 1 is 1. Retail pricing and nominal markets both contribute to the needs in different ways. Similar demand functions with an additional term for goodwill are used to determine the distribution channels to use (Zhang et al., 2018). The intensity level has an upper bound $\overline{s}$ and a lower bound $\underline{s}$ = 1. $s_i = 1$ causes MR to decrease to our basic model.

According to Huang et al. (2013), power functions—which show that advertising costs rise as returns decrease—are extensively employed in studies on the advertising industry. However, because many new items have limited shelf lives, internet-based promotion lowers the waste that comes with conventional types of promoting. A suitable estimate of power functions for the growth phase is thus a nominal market size assumption of linearity with an upper constraint. Internet advertising is also moving away from pay-per-impression pricing methods and towards pay-per-action mechanisms, where marketers only pay for measurable consumer behaviours (Dellarocas, 2012; Mahdian & Tomak, 2008). With the transition from pay-per-click to pay-per-call and pay-per-sale strategies for advertising efficiency, linear functions will increasingly resemble quasi-fixed service charges and nominal demand sizes.

We evaluate and solve the MR and MQ models in Sections 4.2 and 4.3, respectively.

4.2 Revenue model MR

Once more, we model the information flow between the provider and retailer as a two-stage Stackelberg game. The retailer establishes the fundamental charge f_i and

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variable rate r_i in the initial phase. The providers choose the service intensity s_i and the product pricing p_i in the second stage's subgame. We state the order of events as (f, r)→(s, p), with the choice s coming before the pricing p, for two reasons.

Some providers of well-known brands may first establish their pricing in conventional retailing and then rely on marketing to sell their goods. Price changes are uncommon, with the exception of end-of-reason sales or model closeouts. In this situation, we argue that choosing a service comes before cost. Price fluctuations and short product lifespans are common in online retailing platforms, nevertheless. A budget for search-based advertising must be specified by suppliers before a product may be sold on the platforms. Every product has a list price, but the actual pricing decision is dependent on the discount price, which is highly flexible and affected by competitors' actions and market conditions. In this instance of internet purchasing, we assert that providers' judgements about service come first. The latter instance is the subject of this study.

Although it takes the form of a functional dependency between s_i and p_i, the second explanation is connected to the first explanation. The intensity s_i has an impact on demand quantity q_i and price p_i, as shown in the formulation of the demand functions. s_i. is unaffected by p_i, in contrast.

The following characteristics of the model MR solution are derived via backward induction:

- The price at equilibrium p_i is the best one.
- Convex in s_i is the profit function π_i. For the providers, the minimiser is not the best option.
- The suppliers' pricing decisions cannot be used to determine the best rates, ${r_1}^*$ and ${r_2}^*$, for any given s_1 and s_2.

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As shown in Appendix D, the optimum response functions are used to derive the equilibrium price.

$$p_1 = \frac{2(\theta+1)Ms_1+\theta\alpha Ms_2}{4(\theta+1)^2-\theta^2} \;\; ; \;\; p_2 = \frac{\theta Ms_1+2(\theta+1)\alpha Ms_2}{4(\theta+1)^2-\theta^2}.$$

The derivative of profit π_i for s_i is obtained by substituting prices into each profit function:

$$\frac{d\pi_1}{ds_1} = -f_1 + \frac{4(1-r_1)(\theta+1)^2M}{[4(\theta+1)^2-\theta^2]^2}[2(\theta+1)Ms_1+\theta\alpha Ms_2]$$

$$\frac{d\pi_2}{ds_2} = -f_2 + \frac{4(1-r_2)(\theta+1)^2\alpha M}{[4(\theta+1)^2-\theta^2]^2}[\theta Ms_1+2(\theta+1)\alpha Ms_2]$$

$$\frac{\mathrm{d}^2\pi_i}{ds_i{}^2} > 0 \;\text{ for }\; i = 1,2,$$

where the derivatives' first component, $-f_i$, is negative and their second term, $-f_i$, is positive and monotonically growing in s_1 and s_2, respectively. As a result, the value of f_i affects the derivatives' sign. All profit functions, however, are convex. Because of this, the intensity determined by solving the FOC is not the best option for each provider, and they would be better served by selecting the boundary value $\underline{s}$ or $\overline{s}$ rather than the minimiser. For simplicity, we still refer to the minimiser as $\tilde{s}_i$. Furthermore, it is not clear that $\tilde{s}_i$ always lies inside the range $[\underline{s},\ \overline{s}]$. s_i is therefore uncertain.

There is no equilibrium in $s_i's$ since one provider lacks complete knowledge about the other supplier's s_i and the s_i is unknowable. As a result, the retailer is unable to internalise the suppliers' second-stage judgements about the first-stage contract variables that were optimised for profit. The retailer's business strategy mandates categorising the suppliers according to the service level they have selected, utilising service level s_i as a stand-in measure for segmenting the providers. Even if the retailer thinks that s_i belongs to any certain service class c_i, the issue still exists as:

$$p_1 = \frac{2c_1(\theta+1)M+c_2\alpha\theta M}{4(\theta+1)^2-\theta^2}, p_2 = \frac{c_1\theta M+2c_2\alpha(\theta+1)M}{4(\theta+1)^2-\theta^2},$$

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$$q_1 = c_1 M - \beta p_1 + \theta(p_2 - p_1),\ q_2 = c_2 \alpha M - \beta p_2 + \theta(p_1 - p_2).$$

In this case, p_i and q_i are not both functions of r_i. It is positive and equal to $p_i q_i$ for the derivative of π_d with regard to r_i. Consequently, the retailer is free to set the commission rates as high as feasible (i.e., to collect all profits or to provide the suppliers earnings equivalent to their outside prospects).

Typically, the two TPT factors are viewed as control levers or variables, but under model MR, the retailer is not allowed to utilise them to affect the choices of the suppliers. The event sequence $(f, r|s_i = c_i) \rightarrow (s, p)$, where r is conditioned on provided $s_i = c_i$, cannot be carried out. When using the vertical bar | is to express a condition. The proposition is as follows.

PROPOSITION 1 The dominant position of the retailer in allocating profits and segmenting the supplier base into two clusters, one choosing the highest quality of service and the other the least, is reinforced by Model MR, which has little of an impact on coordination. There is no system in place to empower the suppliers.

Justification: The retail and each supplier receive equal shares of the variable portion of the revenue, which is divided in the ratio of r_i to $(1 - r_i)$. In order to maximise $(1 - r_i) p_i q_i$ for the retailer for each given r_i, each supplier must maximise $r_i p_i q_i$. The suppliers' choices would not stray from the retailer's ideal decision at the global level. Therefore, neither a positive nor negative influence of the variable rate can be shown on the providers' pricing methods. While *f* and *r* have no impact on the suppliers' pricing, they do have an impact on their profit functions and minimisers, which inadvertently encourages them to select $\underline{s}$ or $\overline{s}$. The supplier base is thus divided into two groups.

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4.3 Quantity model MQ

We evaluate the viability of the $(f, r) \to (s, p)$ event sequence for model MQ. In order to assess whether or not model MQ can be solved, we employ the sequence $(f_i, r_i | s_i = c_i) \to (s_i, p_i)$. We determine the equilibrium pricing by backward induction:

$$p_1 = \frac{2(\theta+1)Ms_1 + \alpha M\theta s_2 + 2(\theta+1)^2 r_1 + \theta(\theta+1)r_2}{4(\theta+1)^2 - \theta^2} \quad (7)$$

$$p_2 = \frac{\theta M s_1 + 2(\theta+1)\alpha M\ _2 + \theta(\theta+1)r_1 + 2(\theta+1)^2 r_2}{4(\theta+1)^2 - \theta^2} \quad (8)$$

By increasing the service standards, we achieve:

$$\frac{d\pi_1}{ds_1} = -f_1 + \frac{2(\theta+1)^2 M}{[4(\theta+1)^2 - \theta^2]^2}[2\theta\alpha M s_2 + 2\theta^2 r_1 + (4Ms_1 + 2\theta r_2)(\theta+1) - 4(\theta+1)^2 r_1]$$

$$\frac{d\pi_2}{ds_2} = -f_2 + \frac{2\alpha(\theta+1)^2 M}{[4(\theta+1)^2 - \theta^2]^2}[2\theta M s_1 + 2\theta^2 r_2 + (4\alpha M s_2 + 2\theta r_1)(\theta+1) - 4(\theta+1)^2 r_2]$$

$$\frac{d^2\pi_1}{ds_1{}^2} > 0 \text{ and } \frac{d^2\pi_2}{ds_2{}^2} > 0.$$

It is not in the suppliers' best interest to pick the minimiser $\tilde{s}_i$ since the second order derivative demonstrates that each profit function is convex in s_i. Consequently, the backward induction process is stopped. Backward induction continues to the first step if the retailer supplies a notional value $\mathrm{s_i^n}$ for s_i, $\underline{s} \le \mathrm{s_i^n} \le \overline{s}$ and knows in advance the service level each provider has chosen. In contrast to model MR, p_i and q_i are now both functions of r_i. We modify the retailer's profit function as follows:

$$\pi_d = s_1^n f_1 + s_2^n f_2 + r_1[s_1 M - p_1 + \theta(p_2 - p_1)]$$
$$+ r_2[s_2 \alpha M - p_2 + \theta(p_1 - p_2)].$$

By resolving the first-order criteria (see Appendix E) and taking into account that π_d is concave in r_1 and r_2, we are able to determine the ideal variable rates.

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$$r_1{}^* = \frac{M(s_1^n+\theta s_1^n+\alpha\theta s_2^n)}{2(2\theta+1)} \text{ and } r_2{}^* = \frac{M(\alpha s_2^n+\theta s_1^n+\alpha\theta s_2^n)}{2(2\theta+1)}. \tag{9}$$

Model MR does not predict this result. Using the service class information provided by its suppliers, the downstream retailer may determine the best variable rate, as seen in the example below.

Numerical Example 1

Suppose that s_1^n = 2 and s_2^n = 1.

Recall that $\pi_d = 2f_1 + f_2 + r_1q_1 + r_2q_2$, $q_1 = 2M - p_1 + \theta(p_2 - p_1)$ and $q_2 = \alpha M - p_2 + \theta(p_1 - p_2)$.

These are the equilibrium pricing according to equations (7) and (8):

$$p_1 = \frac{4M(\theta+1)+\alpha\theta M+r_2\theta(\theta+1)+2r_1(\theta+1)^2}{4(\theta+1)^2-\theta^2}$$

$$p_2 = \frac{2\theta M+2\alpha M(\theta+1)+r_1\theta(\theta+1)+2r_2(\theta+1)^2}{4(\theta+1)^2-\theta^2}.$$

Profit function π_d has a concave shape. These are the ideal variable rates:

$$r_1{}^* = \frac{M(2+2\theta+\alpha\theta)}{2(2\theta+1)} \;;\; r_2{}^* = \frac{M(\alpha+2\theta+\alpha\theta)}{2(2\theta+1)}. \qquad \square$$

The final option is f_i for the retailer. The profit of the suppliers may be calculated across the $s_1 -$ s_2 domain with a specified f_i. The following example shows how to solve the equation $s_i^n \to r_i^* | s_i^n, f_i \to \pi_i$.

Numerical Example 2

Consider the exogenous variables to be M = 5000, $\theta = 0.5$, and $\alpha = 0.5$. We set the basic fixed cost proportional to the size of the provider to prevent unneeded complexity from utilising unrelated f_1 and f_2. With k equal to 1000, let $f_1 = 6125k$ and $f_2 = \alpha f_1$,. The best rates are, assuming the store believes $s_1^n = s_2^n = 1$, as follows:

$$r_1{}^* = \frac{M(1+\theta+\alpha\theta)}{2(2\theta+1)} \text{ and } r_2{}^* = \frac{M(\alpha+\theta+\alpha\theta)}{2(2\theta+1)}.$$

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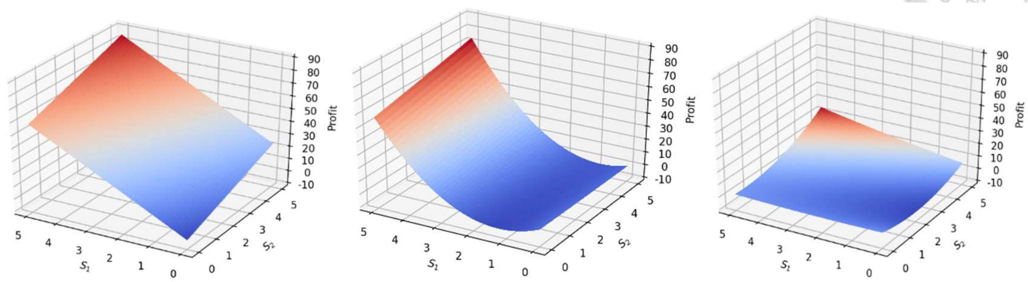
The supply chain's earnings in the $s_1 -\ s_2$ domain are depicted in Figure 4.1 as units in a million. The profit functions of the suppliers are convex in s_i, and the profit function of the retailer grows with s_i.



(a) Retailer's profit (b) Supplier 1's profit (c) Supplier 2's profit

Figure 4.1 Profits in the $s_1 -\ s_2$ domain and the impact of service intensity

Note. Adapted from Huang (2018)

The value of the minimiser $\tilde{s}_i$ is dependent on f_i, as can be seen from the first-order derivatives $d\pi_1/ds_1$ and $d\pi_2/ds_2$. The minimiser may leave the domain $[\underline{s}, \overline{s}]$ of s_i's undefined or split the domain into two halves. The suppliers will choose either border value since their profit function is convex. $s_i{}^*$ thus equals $\underline{s}$ or $\overline{s}$. The proposition is as follows.

PROPOSITION 2 For the event sequence $(f_i, r_i | s_i = s_i^n) \rightarrow (s_i{}^*, p_i{}^*)$, where s_i^n is any specified degree of service intensity in the domain $[\underline{s}, \overline{s}]$, model MQ offers a workable solution.

Justification: The fundamental set charge f_i acts as a brake on the providers' choices for s_i. The optimal service level is either $\underline{s}$ or $\overline{s}$ depending on the disparity in revenues between the two boundary levels.

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4.4 Combining the variable rates in the models MR and MQ

As you can remember from Proposition 1, model MR does not provide an executable solution technique since the variable rate cannot be derived via backward induction. In order to solve this issue, we take the best variable rate from the MQ model and divide it by the associated sale price. Three phases make up the solution procedure:

- The equilibrium prices, quantities, and commission rates are solved using MQ. They should be written as p_i^{MQ}, q_i^{MQ}, and r_i^{MQ}, where the superscripts denote the model that was utilised.
- Use MR to find the prices and quantities at equilibrium. Assign the solutions the letters p_i^{MR} and q_i^{MR}.
- Create a virtual commission rate by dividing $r_i^{MR} p_i^{MR} q_i^{MR}$. $r_i^{MR} = r_i^{MQ} / p_i^{MQ}$ together make up the entire commission.

This paradigm is known as the executable MR (EMR). The shop shouldn't be penalised for utilising the MQ or the EMR models as far as profit maximisation is concerned. It should be permitted to freely provide different TPT contract types to its suppliers. We define the MQ and EMR models as similar if they yield equivalent financial results. We simply need to take into account the total variable commission when comparing the results because MQ and EMR both have the same quasi-fixed cost. In order to compute supply chain profits throughout the range of supplier sizes and price elasticities (α-θ), the entire variable commission is denoted by the letter v. The results are as follows:

$$v_i^{EMR} - v_i^{MQ} = \left[1 - \frac{r_i^{MQ}}{p_i^{MQ}}\right] p_i^{MR} q_i^{MR} - \left(p_i^{MQ} - r_i^{MQ}\right) q_i^{MQ} \quad i = 1,2 \tag{10}$$

$$v_d^{\mathrm{EMR}} - v_d^{\mathrm{MQ}} = \frac{r_1^{\mathrm{MQ}}}{p_1^{\mathrm{MQ}}} p_1^{\mathrm{MR}} q_1^{\mathrm{MR}} + \frac{r_2^{\mathrm{MQ}}}{p_2^{\mathrm{MQ}}} p_2^{\mathrm{MR}} q_2^{\mathrm{MR}} - \left(r_1^{\mathrm{MQ}} q_1^{\mathrm{MQ}} + r_2^{\mathrm{MR}} q_2^{\mathrm{MR}}\right). \tag{11}$$

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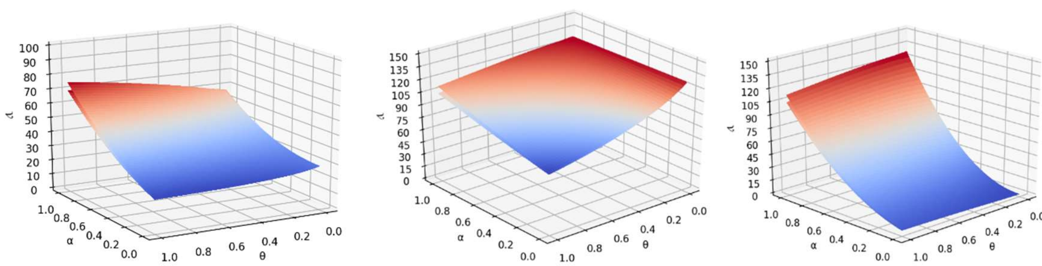
We illustrate the resultant difference in variable commission with a numerical example.

Numerical Example 3

Let M be 5000, f_1 be 6,250k, f_2 be αf_1, and ${s_1}^n = {s_2}^n$ be 5. The percentage difference is equal to $\delta = (v^{MR} - v^{MQ})/v^{MQ}$. Over the exogenous domain of α-θ, where 0<α<1 and 0<θ<1, we depict the reaction surfaces of the commission. We determine the δ value for each point in the grid, known as a scenario, by dividing the α and θ axes into 1000 equally spaced intervals. Figure 4.2 demonstrates how closely the two response surfaces are related and how little the variation in *v* between the two models. The retailer's average δ is -1.50%, Supplier 1's average δ is -2.88%, and Supplier 2's average δ is -6.90%. The absolute difference would be much lower when comparing the overall earnings since v does not take into account the quasi-fixed cost. □



Average δ -1.50% -2.88% -6.90%

(a) Retailer (b) Supplier 1 (c) Supplier 2

Figure 4.2 Total commissions in the α-θ domain that differ between MR and MQ

Note. Adapted from Huang (2018)

The minimal discrepancy between the MQ and EMR models across such a large region of α-θ shows that the performance results are similar. As a consequence, the retailer may use MQ and EMR to create the TPT contracts before distributing them to its supplier base. The response surface's slope in Figure 4.2 provides crucial data. Supplier 2's size in relation to supplier 1 is shown by the parameter α. The parameter θ measures

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how easily a product may be replaced. For aggregated or conglomerated scenarios, the retailer can predict the supplier's decision-making behaviour and may subsequently develop plans to manage its supplier base. According to Table 4.2, which offers the best strategies, supplier 1, the main supplier, is better off pursuing product differentiation, while supplier 2, the secondary supplier, is better off obtaining market share. Promoting similar market shares among its suppliers is an appropriate tactic since the overall profit of the downstream retailer rises with α. This result lends credence to the premise that the retailer should classify its suppliers in accordance with their objectives, sizes, and business practises.

Table 4.2 The best strategies

Supplier 1	Incorporate a difference in the products
Supplier 2	Increase share of the market
Retailer	Encourage suppliers to have similar market shares

4.5 Effects of contract parameters and numerical simulation

The computing process, including the minimiser $\tilde{s}_i$ for EMR, is demonstrated via a numerical simulation. The profit functions, including the variable commission and $f_i s_i$, are rewritten as follows:

$$\pi_i^{\text{EMR}} = \left(1 - r_i^{\text{MR}}\right) p_i^{\text{MR}} q_i^{\text{MR}} - s_i f_i \quad i = 1,2$$

$$\pi_d^{\text{EMR}} = \sum_i \left(r_i^{\text{MR}} p_i^{\text{MR}} q_i^{\text{MR}} + s_i f_i\right).$$

Because of their convex profit functions, suppliers pick boundary values for s_i, which leads to a bipolar supplier base. The minimiser only splits the whole domain of $s_i > 0$ into a maximum of three segments. The position or value of the minimiser with regard to the upper and lower boundaries influences the size of each pole. There are 3 steps in the simulation. We'll set $\underline{s}$ and $s_i{}^n$ in both to 1.

- Find the area of the domain of s_i where minimiser $\tilde{s}_i$ falls. (I) $\tilde{s}_i < \underline{s}$, (II) $\underline{s} \leq$

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$\tilde{s}_i < \overline{s}$, and (III) $\overline{s} \le \tilde{s}_i$ make up the three segments.

- Choice of the supplier $s_i = \begin{cases} \overline{s} & \text{if } \tilde{s}_i < \underline{s} \\ \underline{s} \text{ or } \overline{s} & \text{if } \underline{s} \le \tilde{s}_i < \overline{s} \\ \underline{s} & \text{if } \overline{s} \le \tilde{s}_i \end{cases}$
  - It would be easier for you to choose the value for segment II if you compare the consequent profit at the two boundary levels. Pick the s_i value that results in the most profit. Let's say each provider believes that its rival will select a basic level, $s_i = \underline{s}$.
- Calculate $\pi_i(s_1, s_2)$ for i=1,2 in the participation test. A supplier's profit must be positive in order for them to participate. In the event that neither provider participates, the duopoly does not develop, the contract is deemed void, and π_d does not exist.

The process may be stated as follows: $p_i^* \to s_i^n \to r_i^* | s_i^n \to s_i{}^* | f_i$, where * denotes an ideal solution.

After that, the method is applied to three levels of f_1 and three levels of $\overline{s}$. To distinguish the combined impacts of $s_i f_i$ this time, we decrease the value of f_i and extend the range of s_i. The level of f_1 is represented by a fraction of 6,250k, called m. 0.1, 0.3, and 0.5 are the three values of m, while 2, 4, and 6 are the three levels of $\overline{s}$.

The numerical computation includes the exogenous variable α-θ domains of 0<α<1 and 0<θ<1, respectively. As a result, the size of supplier 2 fluctuates from being extremely small to almost as big as supplier 1. The percentage data of each supplier's (non)participation and service level across the grid are shown in Table 4.3. The three segments into which minimiser $\tilde{s}_i$ falls are listed in the Segm column. The percentages of each supplier choosing $s_i = \underline{s} = 1$, $s_i = \overline{s}$, or not participating (Non-particip) are shown in the final two broad columns. The symbol # indicates scenarios that the decision

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logic of step (2) disallows. The provider will always select $\bar{s}$, for instance, if the minimiser belongs to segment I.

Table 4.3 The quasi-fixed cost´s capacity to be controlled

f_1 level (m)	$\bar{s}$	Segm	Supplier 1 % Non-particip	Supplier 1 % with s_1=1	Supplier 1 % with $s_1=\bar{s}$	Supplier 2 % Non-particip	Supplier 2 % with s_2=1	Supplier 2 % with $s_2=\bar{s}$
0.1	2	I	0.0	#	100	0.87	#	87.1
		II	0.0	0.0	0.0	2.57	4.52	0.98
		III	0.0	0.0	#	0.65	3.34	#
	4	I	0.0	#	100	0.0	#	87.9
		II	0.0	0.0	0.0	1.74	3.95	4.7
		III	0.0	0.0	#	0.18	1.51	#
	6	I	0.0	#	100	0.0	#	87.9
		II	0.0	0.0	0.0	1.09	3.27	6.65
		III	0.0	0.0	#	0.09	0.96	#
0.3	2	I	0.0	#	100	24.7	#	38.9
		II	0.0	0.0	0.0	24.2	0.0	0.0
		III	0.0	0.0	#	10.8	1.31	#
	4	I	0.0	#	100	0.21	#	63.5
		II	0.0	0.0	0.0	27.8	0.0	3.35
		III	0.0	0.0	#	3.82	1.32	#
	6	I	0.0	#	100	0.0	#	63.7
		II	0.0	0.0	0.0	20.1	0.0	13.0
		III	0.0	0.0	#	1.94	1.32	#
0.5	2	I	63.5	#	36.5	34.2	#	5.24
		II	0.0	0.0	0.0	40.4	0.0	0.0
		III	0.0	0.0	#	19.5	0.70	#
	4	I	0.0	#	100	1.02	#	38.4
		II	0.0	0.0	0.0	47.3	0.0	4.59
		III	0.0	0.0	#	7.91	0.70	#
	6	I	0.0	#	100	0.0	#	39.5
		II	0.0	0.0	0.0	34.2	0.0	20.9
		III	0.0	0.0	#	4.76	0.70	#

Regarding the impact of the quasi-fixed charge, we note the following:

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1. Supplier 2's choice of whether or not to participate is significantly influenced by fee $s_i f_i$. Think back to Table 4.2's best-case scenario for the store. The store will benefit more from assisting supplier 2 in growing its market share. An operational tool for carrying out such plan is the quasi-fixed charge f_i.
2. As $\bar{s}$ rises, provider 2 is more likely to take part and choose for the highest intensity.
3. Both suppliers' likelihood of participation decreases as f_i rises.

In configuring f_i and s_i levels, observations 2 and 3 indicate portfolio optimisation. As already stated, in order to participate, the suppliers must make a profit. A TPT contract is seen as enough if both providers participate and as insufficient if just one does. The proportion of legally binding contracts and the supply chain's typical earnings are shown in Table 4.4.

Table 4.4 Average revenue and participation rate

f_1 level (m)	$\bar{s}$	Average π_1	Average π_2	Average π_d	Participation rate (%)
	2	20,913	2,636	21,521	95.9
0.1	4	83,769	10,333	85,566	98.1
	6	188,586	23,091	192,157	98.8
	2	22,873	4,538	27,260	40.3
0.3	4	87,973	13,909	97,302	68.2
	6	195,098	28,364	209,912	78.0
	2	24,639	6,636	31,017	5.3
0.5	4	91,535	17,644	107,945	43.7
	6	200,598	33,637	226,153	61.1

We also highlight new findings.

- As seen in Table 4.4, s_i has a stronger impact than f_i. While for the same f_i, the effect of f_i is positive but less pronounced, the profits will grow dramatically with $\bar{s}$. Accordingly, while setting up the TPT contracts, the store should prioritise s_i over f_i. There is little reason to raise the amount of the basic fixed charge. Instead, the retailer has to increase the service intensity of the providers.
- The average profits made by each party significantly rise as $\bar{s}$ rises.

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- The percentage of participating suppliers declines as f_i rises (Table 4.3), while average earnings for the store and participating suppliers rise.

Conclusion: The store may exercise control and the two suppliers benefit from a TPT contract with a quasi-fixed charge.

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Chapter 5 Conclusions

For premium agri-food goods, end-to-end integrated supply chains have replaced the old supply chain as a new business model. These chains connect the farm to the shop space. In this study, we looked at end-to-end integration, its purpose, and the production and business environments needed to launch premium products onto the market and foster their sustained growth. In the agri-food supply chain, new business models are quickly formed. We proposed a novel multiple-route flow-based model, which considers both the primary and secondary channels. To balance the interests of the integrator and the contracted farms, we identified three critical decision-making factors: contract farming, capacity plan, and business robustness.

We discover that negotiating contracts based on price as opposed to quantity makes it easier to balance the interests of the integrator and farmers. A possible source of contention during contract talks is the contract price, which serves as a transfer fee for both parties. We discover that both sides should think about the impact of the friction point on the other side rather than relying on market power or game-theoretic optimisation. In our example study, an agreement might be established by taking into account both the size of the integrator's supply base and the farmers' surplus output. In order to maximise capacity, the integrator should purchase raw materials from several small farms as opposed to fewer but larger farms. This will allow it to make money from the supply base as a whole rather than at the expense of the profits of individual farmers. To maintain its business and secure comparable profitability, the integrator needs to modify its supply in response to shifting market circumstances and new rivals. Finally, end-to-end integration of premium chains raises the level of retail sector distinctiveness. In addition to fostering new enterprises centred around new food categories, the suggested flow-based model

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increases our understanding of how premium chains operate in supply networks and the field of industrial engineering.

In a value network setting, this research presents structures to configure contract design intra-chain coordination methods to guarantee equivalent performance outcomes for many TPT versions. The creation of novel variants based on choice sequences and quasi-fixed costs allowed for the creation of two-part tariff contracts. Some TPT variations and decision sequences are mathematically challenging, but the approach gets around this. We provide information on the impact of contract specifications and strategic focus for each chain link. The simulation findings show that by allowing a variety of suppliers with various goals, sizes, and business practises to select the contract types they want, the suggested technique significantly simplifies the administration of the retailer's supplier base. It eliminates the requirement to create a single contract for all suppliers or a separate contract for every supplier in order to construct different types of TPT contracts that are advantageous to the chain participants. The supply chain participants co-create value through the contract that coordinates supply chain choices.

The quasi-fixed costs that are common in online selling are addressed by the suggested technique. According to the results of the simulation, a downstream retailer should manage its supplier base using the set fee and service level as control levels rather than the variable rate. The findings also imply that the shop might benefit from lowering the fixed price and increasing the service offerings $\bar{s}$.

Future research will focus on the models for screening and self-revelation that the new value network requires. The supply chain stakeholders who possess decision rights in act-react loops are likely to use a variety of decision processes. Self-revelation models might let each provider pick the contract that best suits its goals, scale, and operational procedures. Value networks could be able to operate natively and distributedly if

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screening methods are used to help the offeror weed out bad providers. Future studies will also examine how well different supply contract forms can handle a broad range of suppliers. The establishment of f_i and s_i values for a supplier base is another area of future TPT contract research that could be optimised. Future studies should also focus on how to include small producers in supply chains to raise their standard of living, lessen poverty, and expand the market for high-end goods.

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Appendix

Appendix A. Source of the data and yield rate dispersion

The Agriculture and Food Agency website may be accessed at https://agr.afa.gov.tw/afa/afa_frame.jsp to get production and yield data.

You may download auction prices from the website:

http://amis.afa.gov.tw/fruit/FruitChartProdTransPriceVolumeTrend.aspx

Table A-1. The K-S test on yield rate distributions' P-value

	Gamma	Normal	Uniform	Beta
County P	0.141	0.273	0.0	0.26
County K	0.380	0.536	0.092	0.54
County Ch	0.785	0.648	0.459	0.69
County N	0.651	0.670	0.3809	0.87
County H	0.508	0.333	0.0306	0.37

Appendix B. Best-case scenario contract options with a fixed N

$$E[q_s] = q_c - Q \cdot \int_0^{q_c/Q} F(y)dy$$

$$\frac{d}{dq_c}E[q_s] = 1 - Q \cdot \left[F\left(\frac{q_c}{Q}\right) \cdot \frac{1}{Q}\right] = 1 - F\left(\frac{q_c}{Q}\right)$$

$$p_r = \frac{1}{\lambda}[\ln(365 \cdot M) - \ln(\alpha N) - \ln E[q_s]]$$

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$$\frac{dE[\Pi_m]}{dq_c} = \left[\frac{\alpha m}{\lambda}\left(ln\left(\frac{365M}{\alpha N}\right) - ln\,E[q_s]\right) + (1-\alpha)p_s - p_c - k\right]\left[1 - F\left(\frac{q_c}{Q}\right)\right] \cdot N$$

$$+ \left[\frac{\alpha m}{\lambda} \cdot \frac{-\left[1 - F\left(\frac{q_c}{Q}\right)\right]}{E[q_s]}\right] E[q_s] \cdot N$$

$$= \left[\frac{\alpha m}{\lambda}\left(ln\left(\frac{365M}{\alpha N}\right) - ln\,E[q_s] - 1\right) + (1-\alpha)p_s - p_c - k\right]\left[1 - F\left(\frac{q_c}{Q}\right)\right] \cdot N$$

Using the FOC,

$$\frac{d^2E[\Pi_m]}{dq_c^2} = \frac{\alpha m}{\lambda} \cdot \frac{-\left[1 - F\left(\frac{q_c}{Q}\right)\right]}{E[q_s]}\left[1 - F\left(\frac{q_c}{Q}\right)\right] \cdot N + 0 \cdot \left[-f\left(\frac{q_c}{Q}\right)\right] < 0$$

There is an ideal solution since the profit function is concave.

Appendix C. Beta distribution analysis for yield rate

The Beta distribution´s CDF is described as $F(x;\alpha,\beta) = \frac{B(x;\alpha,\beta)}{B(\alpha,\beta)}$,

Where $B(x;\alpha,\beta)$ is the incomplete beta function and $B(\alpha,\beta)$ is the beta function.

Furthermore, $B(\alpha,\beta) = \frac{\Gamma(\alpha)\Gamma(\beta)}{\Gamma(\alpha+\beta)} = \frac{(\alpha-1)!\ (\beta-1)!}{(\alpha+\beta-1)!}$ as well as $B(x;\alpha,\beta) = \int_0^x t^{\alpha-1}(1-t)^{\beta-1}dt$.

If the beta distribution represents how the yield rate behaves, then

$$E(y_s) = y_c - \int_0^{y_c} F(y)dy = y_c - \frac{(\alpha+\beta-1)!}{(\alpha-1)!\ (\beta-1)!}\int_0^{y_c} B(y;\alpha,\beta)dy,$$

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During which $B(y;\alpha,\beta)=\int_0^y t^{\alpha-1}(1-t)^{\beta-1}dt$

is a function of a high order polynomial. We employ a second-order function to approximate since high-order polynomial functions could lead to computation issues. The mathematical formula for Beta (9, 7) is

$$\int_0^y t^8(1-\mathrm{t})^6dt=\frac{3003y^{15}-1930\quad{}^{14}+51975y^{13}-7507\quad{}^{12}+61425y^{11}-27027y^{10}+5005\quad{}^{9}}{45045}$$

$$\int_0^{y_c} B(y;\alpha,\beta)dy$$

$$=\frac{1}{45045}(187.6875{y_c}^{16}-1287{y_c}^{15}-3712.5{y_c}^{14}-5775{y_c}^{13}$$

$$+5118.75{y_c}^{12}-2457{y_c}^{11}+500.5{y_c}^{10})$$

$$\frac{(\alpha+\beta-1)!}{(\alpha-1)!\ \ (\beta-1)!}=\frac{15!}{8!\,6!}=45045$$

$$\mathrm{E}(y_s)=-187.6875{y_c}^{16}+1287{y_c}^{15}-3712.5{y_c}^{14}+5775{y_c}^{13}-5118.75{y_c}^{12}$$

$$+2457{y_c}^{11}-500.5{y_c}^{10}+y_c$$

R^2=0.9961 indicates that the high-order polynomial function is roughly approximated by the second-order polynomial function.

$$\mathrm{E}(y_s)=-0.8112{y_c}^2+1.399y_c-0.0321$$

Appendix D. The best response function for the MR model

$$\frac{d\pi_1}{dp_1}=(1-r_1)[s_1M-2p_1+\theta p_2-2\theta p_1]=0$$

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$$\frac{d\pi_2}{dp_2} = (1 - r_2)[s_2\alpha M - 2p_2 + \theta p_1 - 2\theta p_2] = 0$$

Appendix E. A given s_i conditions the best r_i for the MQ model

We shorten the following by using s_i rather than s_i^n.

$$p_1 - p_2 = \frac{(\theta+2)}{4(\theta+1)^2-\theta^2}[M(s_1 - \alpha s_2) + (\theta + 1)(r_1 - r_2)]$$

$$\frac{\partial\pi_d}{\partial r_1} = s_1M - \frac{2s_1M(\theta+1)+\alpha s_2\theta M+r_2\theta(\theta+1)+2r_1(\theta+1)^2}{4(\theta+1)^2-\theta^2} -$$

$$\theta\frac{(\theta+2)[(r_1-r_2)(\theta+1)+M(s_1-\alpha s_2)]}{4(\theta+1)^2-\theta^2} + r_1\left[\frac{-2(\theta+1)^2}{4(\theta+1)^2-\theta^2} - \theta\frac{(\theta+2)(\theta+1)}{4(\theta+1)^2-\theta^2}\right] + r_2\left[\frac{-\theta(\theta+1)}{4(\theta+1)^2-\theta^2} +\right.$$

$$\left.\theta\frac{(\theta+2)(\theta+1)}{4(\theta+1)^2-\theta^2}\right] = s_1M - \frac{2s_1M(\theta+1)+\alpha s_2\theta M}{4(\theta+1)^2-\theta^2} - \theta\frac{(\theta+2)M(s_1-\alpha s_2)}{4(\theta+1)^2-\theta^2} - \frac{2r_2\theta(\theta+1)+4r_1(\theta+1)^2}{4(\theta+1)^2-\theta^2} -$$

$$\frac{2\theta(\theta+2)[(r_1-r_2)(\theta+1)]}{4(\theta+1)^2-\theta^2}$$

After being simplified, $\frac{\partial\pi_d}{\partial r_1} = \frac{s_1[2M(\theta+1)^2]+s_2[\alpha\theta(\theta+1)M]}{4(\theta+1)^2-\theta^2} -$

$$\frac{(\theta+1)[r_1(4+8\theta+2\theta^2)-2r_2\theta(\theta+1)]}{4(\theta+1)^2-\theta^2}$$

$$\frac{\partial^2\pi_d}{\partial {r_1}^2} = -\frac{(\theta+1)(4+8\theta+2\theta^2)}{4(\theta+1)^2-\theta^2}$$

$$\frac{\partial^2\pi_d}{\partial r_1\partial r_2} = -\frac{-2\theta(\theta+1)^2}{4(\theta+1)^2-\theta^2}$$

$$\frac{\partial\pi_d}{\partial r_2} = s_2\alpha M - \frac{s_1\theta M+2\alpha s_2M(\theta+1)+r_1\theta(\theta+1)+2r_2(\theta+1)^2}{4(\theta+1)^2-\theta^2} +$$

$$\theta\frac{(\theta+2)[(r_1-r_2)(\theta+1)+M(s_1-\alpha s_2)]}{4(\theta+1)^2-\theta^2} + r_1\left[-\frac{\theta(\theta+1)}{4(\theta+1)^2-\theta^2} + \theta\frac{(\theta+2)(\theta+1)}{4(\theta+1)^2-\theta^2}\right] +$$

$$r_2\left[-\frac{2(\theta+1)^2}{4(\theta+1)^2-\theta^2} - \theta\frac{(\theta+2)(\theta+1)}{4(\theta+1)^2-\theta^2}\right] = s_2\alpha M - \frac{s_1\theta M+2\alpha\ {}_2M(\theta+1)}{4(\theta+1)^2-\theta^2} +$$

$$\theta\frac{(\theta+2)M(s_1-\alpha s_2)}{4(\theta+1)^2-\theta^2} - \frac{2r_1\theta(\theta+1)+4r_2(\theta+1)^2}{4(\theta+1)^2-\theta^2} + \frac{2\theta(\theta+2)(r_1-r_2)(\theta+1)}{4(\theta+1)^2-\theta^2}$$

After being simplified, $\frac{\partial\pi_d}{\partial r_2} = \frac{s_1[(\theta+1)\theta M]+s_2[2\alpha(\theta+1)^2M]}{4(\theta+1)^2-\theta^2} -$

$$\frac{(\theta+1)[r_2(4+8\theta+2\theta^2)-2r_1\theta(\theta+1)]}{4(\theta+1)^2-\theta^2}$$

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and $\frac{\partial^2 \pi_d}{\partial {r_2}^2} = -\frac{(\theta+1)(4+8\theta+2\theta^2)}{4(\theta+1)^2-\theta^2}$.

The profit function is concave since $|H| > 0$ and $\frac{\partial^2 \pi_d}{\partial {r_i}^2} < 0$. The initial circumstances are as follows:

$$\begin{cases} \alpha\theta M s_2 + 2(\theta+1)M s_1 - (4+8\theta+2\theta^2)r_1 + 2\theta(\theta+1)r_2 = 0 \\ \theta M s_1 + 2(\theta+1)\alpha M s_2 - (4+8\theta+2\theta^2)r_2 + 2\theta(\theta+1)r_1 = 0. \end{cases}$$

The ideal variable rates are obtained when the two equations are concurrently solved.

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