Risk, Incentives and Coordination Costs in Agro-Food Chains in the Presence of Futures Markets

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Abstract

This thesis focuses on developing conceptual models to examine the role of futures markets for risk-shifting, incentives and coordination costs in the context of commodity marketing channels. The empirical analysis is conducted for different marketing channel structures (two-stage and three-stage marketing channels) and for different situations regarding the availability of a futures market (i.e., with and without futures markets). The conceptual models have been applied to the Dutch potato marketing channel.

We model and empirically examine incentives, coordination costs, and risk-shifting in the Dutch ware potato marketing channel that includes producers and marketing firms (e.g., retailers), when these marketing channel members (MCMs) are allowed to trade on spot markets only. We apply the classic agency model to investigate risk shifting in the Dutch ware potato marketing channel, using time-series analysis. We show that, if the principal (marketing firm) is risk neutral and the agent (producer) is risk averse instead of risk neutral, a linear contract can still be optimal if the fixed payment is negative. The empirical results over the period 1946 - 2003 indicate that, while fixed payments to farmers (agents) have decreased over time since the 1980s to become more and more negative, the incentive intensity has approximately doubled, and the risk premium that farmers demand has remained considerable. Moreover, since the mid 1960s, risk has shifted from retailers to farmers. We argue that this shift could be the consequence of chain reversal, i.e., the transformation of the traditional supply chain into a demand-oriented chain. From the mid 1980s on, potato growers have had to pay an increasing amount of fixed compensation to the marketing firms. As a percentage of output value at consumer prices, as received by the marketing firms, this compensation has increased from -43% in 1948 to 23% in 1998. This value, however, decreased to 15% in 2003. Nevertheless, together with the rise in the output-value sharing rate (i.e., incentive intensity), farmers became less risk averse. Furthermore, the empirical results reveal that as a consequence of increases in incentives to producers, the coordination costs of the marketing channel decreased considerably.

Next, we model the contractual relationships in the Dutch ware potato marketing channel, while allowing risk-averse producers to use futures contracts in order to manage their increasing income risk. The principal-agent model is extended to include a futures market, in order to assess risk shifting between the principal (retailers) and the agent (producers). We compare the case with a futures market for the risk-averse producers to the case without futures trade. The empirical results show that risk shifted from retailers to farmers, possibly as
a consequence of chain reversal, and that this risk can be managed by farmers if they use futures contracts. This demonstrates the hedging role of futures contracts (futures markets) as a risk-shifting, mediating market institution. Furthermore, as a result of increases in incentives from retailers to producers, the coordination costs of the marketing channel have decreased considerably, both with and without producers’ futures trade. The coordination costs are much lower in the scenario with futures use than without futures trade, showing the price-discovery (informational) role of the futures markets. Having obtained the results that producers can manage their increasing income risk by hedging in the futures market, the level of hedging becomes of interest. Therefore, we also model and empirically estimate the optimal time-varying hedge ratio for these risk-averse producers. We use the classic agency model to derive a time-varying optimal hedge ratio for low-frequency, time-series data: the type of data used by crop farmers when deciding about their production and about their hedging strategy. Rooted in the classic agency framework, the proposed hedge ratio reflects the context of both the producer’s decision and the producer’s contractual relationships in the marketing channel. The empirical illustration for the Dutch ware potato sector and its futures market in Amsterdam over the period 1971 - 2003 reveals that the time-varying optimal hedge ratio decreased from 0.21 in 1971 to 0.15 in 2003. On average these optimal ratios led to a risk reduction through hedging of 39%.

The modelling and the empirical investigations in the previous studies in this thesis include only producers and retailers. The intermediary in this marketing channel, i.e., the wholesaler has been ignored so far. Hence, we model and empirically examine a three-stage, principal-agent, marketing-channel model that includes producers, wholesalers, and retailers. We assess incentives, coordination costs, and risk shifting when the MCMs (i.e., producers, wholesalers, and retailers) trade on the spot market only. The empirical application shows that during the period 1961 - 2002, the retailers were able to provide more incentives to the wholesalers and producers, and, as a consequence, the costs of coordination in the supply chain decreased considerably. This study provides insight into the role of incentives in reducing the coordination costs of the marketing channel. Furthermore, it provides insight into the role of the wholesaler regarding risk shifting in the marketing channel. Moreover, the concentration of retailers in food marketing channels and the resulting bargaining power imbalance is evident here, as risks are shifted from retailers to producers and wholesalers.

To obtain more insight into the results, we specify a three-stage, principal-agent, supply-chain model that includes producers, wholesalers, and retailers, as well as a futures market. We compare the situation with and without a futures market. The empirical results for
the Dutch ware potato marketing channel over 1971 - 2003 reveal that the coordination costs of the marketing channel decreased considerably as a result of increased incentives to producers and wholesalers, both with and without futures trade. The coordination costs of the marketing channel are lower in the scenario with futures markets than without futures, demonstrating the informational (i.e., price discovery) role of the futures markets. The futures market enables producers and wholesalers to manage the increasing variability in their incomes, thus demonstrating its role as a price-risk management instrument. Furthermore, as a consequence of the decreasing degree of risk aversion among producers and wholesalers, the optimal dynamic hedge ratio for wholesalers decreased from 14% in 1971 to 10% in 2003, while that of producers decreased from 38% in 1982 to 18% in 2002.

Hence, the overall results are the following. Incentives reduce the coordination costs in food marketing channels, but at the cost of increasing the risk for those MCMs who obtain these incentives. Consequently, the MCM who provides the incentives faces a trade-off between giving more incentives (i.e., lower coordination costs) on the one hand and having to pay a higher risk-premium to the risk-averse MCMs who receive the incentives. The futures market, however, provides the risk-averse MCMs a risk-management instrument so that they can manage more risk and hence, are able to deal with more incentives than without a futures market. What we observe is that income risks shifted from retailers to producers and wholesalers, and we argue that this risk shift could be the consequence of chain reversal (i.e., the transformation of traditional supply-oriented chains into demand-oriented chains). The futures market enables MCMs to reduce their increasing income risks so that they can handle more incentives for market orientation.
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CHAPTER 1
Introduction
1.1 General Introduction

The liberalisation of agricultural food markets all over the world, particularly in fulfillment of the World Trade Organisation (WTO) agreements and Structural Adjustment Programs of national governments, has increased price risk for producers in agri-food chains. In line with these developments, changes within the Common Agricultural Policy (CAP) of the European Union (EU), as part of the proposed reductions in financial support to farmers, have caused price volatility in the European agricultural industry. This \textit{price volatility} is increased by the uncertainty in agricultural production, thereby creating income uncertainty for producers. This uncertainty is caused by uncontrollable elements, such as weather conditions and crop/animal diseases. Also as a consequence of long production lags, production decisions have to be made far in advance and, as a result, the market price for the output is typically not known at the time decisions have to be made (Moschini and Hennessy, 2000). This is particularly true for agricultural markets which are volatile (\textit{e.g.}, Brorsen \textit{et al.}, 1987) because of demand fluctuations, which are particularly important when a sizable proportion of the output is destined for the export market. Production uncertainty influences price uncertainty, as the price adjusts in relation to the amount of produce on the market. Not only agricultural producers face income uncertainty; also other members of the marketing channel (\textit{i.e.}, processors, wholesalers, and retailers) are exposed to income uncertainties caused by uncertainties in their input costs and output prices.

Currently, many agricultural marketing channels are facing a transition from using open-market mechanisms for coordinating the various stages of value adding (\textit{e.g.}, production, wholesale, and retail) to negotiated coordination, involving governance forms such as joint ventures, contracts, franchising agreements, and vertical integration (\textit{e.g.}, Boehlje \textit{et al.}, 1999). A driving force behind this integration is the need to coordinate the timing and quality of purchases and deliveries along the supply chain. Vertical coordination
through contracting can be seen as an organisational response to an increased demand for quality among increasingly discerning consumers (Wolf et al., 2001). The present drive for market orientation in agricultural and food markets implies that producers and all other channel members (e.g., processors) should adjust production processes and products in order to respond to specific consumer demands and market signals and trends.

In many agricultural marketing channels wholesalers and processors are important economic actors that link producers with consumers’ demands, as articulated by retailers. To be successful as a link, they need to solve the problems of information asymmetry and incentive incompatibility among marketing channel members (MCMs). Producers have more information about their own effort than the wholesalers and the retailers, and if they obtain a fixed wage, they may want to keep costs down at the expense of quality and/or product differentiation. The latter will create a problem if wholesalers and retailers ask for quality and differentiated products to satisfy consumers' needs. These developments lead to contracts between retailers/wholesalers and producers, shifting of financial (returns) risks among marketing channel members. As a consequence, risk shifting has become an important topic of study, all the more since increasingly large processors and supermarket chains seem able to dictate the terms of trade and transfer the market-level risk to farmers (e.g., Weaver and Kim, 2000).

Transferring risk to farmers, who have fewer opportunities to spread risk than marketing firms will make risk bearing in the marketing channel more costly and reduces the gains from trade. Instead, marketing firms might prefer to bear the risk themselves and extract the gains from this by lowering the price they pay to farmers.

Since this study is on risk shifting in agro-food chains we focus on contracts that align incentives, while at the same time addressing monitoring issues. In order to address the issues of risk, incentives, and coordination in an agricultural marketing channel we employ the
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principal-agent theory from the agency-theory framework. The key idea within agency theory is that principal-agent relationships should reflect efficient information and risk-bearing costs, incentive alignments, and the contract as the unit of analysis (e.g., Cook and Barry, 2004). An agency problem arises if a risk-averse agent (e.g., producer) is assigned decision (or control) rights (e.g., regarding production) that affect the principal's (e.g., retailer) wealth or utility function. The principal cannot fully observe the effort of the agent and, hence, is not sure whether or not the agent acts according to the principal’s best interest when the goals of the principal and the agent conflict. Yet another issue is that of risk sharing. This arises when the principal and the agent have different attitudes towards risk, and when the agent’s risk position changes through alternative incentive arrangements in the contract.

Given agency problems, we cannot expect a supply chain to function as well economically as it would if all information were shared without any cost involved or if the incentives of principal and agent were cost aligned. This shortfall is called agency costs (Cook and Barry, 2004). Those costs may include ex ante search costs (associated with adverse selection (hidden information) problems) and/or ex post monitoring and enforcement costs (associated with moral hazard (hidden action) problems) (e.g., Sykuta and Cook, 2001; Douma and Schreuder, 2002). Incentives are crucial in aligning the goals of the principal and agent (e.g., Laffont and Martimort, 2002; Sappington, 1991). Principal-agent relationships are evident in food marketing channels where production contracts are dominant and incentives enhance contractual relationships among MCMs. However, the literature on incentives in food marketing channels is scanty (e.g., Heuth et al., 1999) and the incentives underlying production contracts are not currently well understood (Goodhue, 1999). To understand the role of incentives in improving coordination efficiency in food marketing channels, this thesis not only examines risk and risk shifting, it also investigates the role of incentives in reducing the coordination costs in a food marketing channel.
In employing the classic principal-agent model to examine the above-mentioned issues, this thesis does make both theoretical and empirical contributions. The theoretical contribution lies in the fact that application of agency theory to this type of problems has been extended to the case of a three-stage channel while research from the past in this field was restricted to a two-stage channel (e.g., Androkovich, 1989). Furthermore, we extend the two-stage and three-stage principal-agent model by including a futures market. The empirical contribution lies in the fact that we assess how complete contracting, as provided by the classic principal-agent model, influences risks, incentives, and coordination costs in a food marketing-channel setting, by making use of time series analysis.

Among the instruments available to traders of many agricultural commodities to reduce risk are futures and options markets. Futures markets provide risk-management tools that channel members can use to hedge their risks in the spot markets. Hedging may affect risk shifting in the marketing channel, as it enables marketing-channel members to transfer some risk to speculators. Note that speculators accept the risk of price changes in order to make profits in the futures markets (Working, 1967). In this thesis, we examine the influence of the use of futures contracts on risk shifting, incentives and coordination costs in the Dutch ware potato marketing channel. In general, high incentives are associated with high risk. Therefore, channel members will hedge, using futures contracts, whenever they obtain high incentives, in order to reduce the risks. Next, due to the price-discovery function of futures markets, we argue that the coordination costs will decrease when channel members trade futures contracts. A futures contract (i.e., futures) is an agreement to deliver a specific amount of a commodity (asset) at a specified future time, at a specific price, and at a specific location. Futures contracts are standardised, which facilitates their trading at organised exchanges. As futures contracts are commitments to trade in the future, actual delivery and payment are not required until the contract matures. A primary use of futures involves shifting risk from a firm that
desires less risk (the hedger) to a party who is willing to accept the risk in exchange for an expected profit (the speculator). For example, crop producers can protect themselves from declines in prices of expected outputs by selling futures contracts at the beginning of the growing period and buying back futures at the time their product is ready to be sold in the spot market. As futures and spot prices are positively correlated, losses and gains in the two markets tend to offset each other, leaving the hedger with a return close to what was expected (e.g., Working, 1953; Ederington, 1979).

Yield variability reduces the risk-reduction capacity of hedging for producers, making it advisable for them, however, to sell futures up to a quantity less than the expected harvest (e.g., Moschini and Lapan, 1995). Moreover, although futures and spot prices tend to move in parallel, these movements are not usually identical; this results in basis risk (where basis is defined as the local spot price minus the futures price). As can be demonstrated by the minimum-variance criterion, this is also why the optimal hedge ratio (i.e., the futures position divided by the spot position) can be less than 1. Consequently, for crop producers and all channel members wishing to reduce risk by hedging with futures contracts, the hedge ratio is of critical importance (e.g., Dawson et al., 2000; Harwood et al., 1999). This study contributes to the understanding of hedge ratios by modelling the time-varying optimal hedge ratios for risk-averse producers and wholesalers and estimating these ratios for the Dutch ware potato marketing channel.

Having provided an introduction and motivations of the thesis, we specify the research questions and objectives as follows.

1.2 Research Question and Research Objectives

This section states the research objectives and the research question of the thesis.
1.2.1 Research Question

Based on the recent developments in agricultural marketing channels outlined in the general introduction, we address the following research question: How do members of a commodity marketing channel, with and without the presence of a futures market, deal with risk shifting, incentive provision, and coordination costs, respectively?

1.2.2 Research Objectives

The general objective of this thesis is to develop conceptual models to examine risk shifting, incentives, and coordination costs in the context of commodity marketing channels in situations with and without futures markets.

This general research objective is elaborated as follows:

(a) To develop a model to assess risk shifting in a marketing channel that includes producers and retailers, and to examine the impact of incentives on the coordination costs of that marketing channel (see Chapter 2).

(b) To develop a model by which we derive and empirically estimate time-varying hedge ratios for risk-averse producers, while taking their spot-market contractual relationships and production horizons into account. This model also investigates the impact of incentives on the coordination costs of the marketing channel in the presence of a futures market (see Chapter 3).

(c) To develop a model in order to assess risk shifting and the role of incentives in reducing the coordination costs of a three-stage marketing channel that includes producers, wholesalers, and retailers (see Chapter 4).

(d) To develop a model that includes a futures market in order to assess incentives, risk, and coordination costs in a three-stage marketing channel involving producers, wholesalers, and retailers (see Chapter 5).
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(e) To develop a model in order to derive and empirically estimate time-varying hedge ratios for risk-averse producers and wholesalers simultaneously, while taking their spot-market contractual relationships and production horizons into account (see Chapter 5).

As mentioned before, we employ the classic principal-agent model to achieve the above-mentioned objectives, as this framework meets the following criteria: (i) reflects spot market transactions; (ii) can include futures markets; (iii) considers the risk preferences of MCMs; and (iv) captures the risk premium for the risk-averse MCMs.

1.3 Research Design and Empirical Domain

This section describes the research design and the empirical domain.

1.3.1 Research Design

Figure 1.1 describes the research design of analysing risk shifting, incentives, and coordination costs in a systematic way. This is by varying the number of stages in the marketing channel, and simultaneously with and without a futures market. Such a design allows us not only to investiage the role of intermedairies in the marketing channel, but also to assess the role of futures markets in these marketing channels.

Chapter 2 (the top left panel) assesses risk shifting and coordination costs in a two-stage, principal-agent, marketing-channel that includes producers and retailers, where none of these channel members trade futures. In Chapter 3 (the top right panel) a two-stage principal-agent marketing-channel model is introduced that includes producers and retailers, and, in contrast to Chapter 2, also a futures market. We allow producers to use futures and we examine producers’ risk management through the use of futures and the optimal time-varying hedge ratio for these producers. The latter is empirically estimated. Furthermore, this chapter
Chapter 1. Introduction

examines the influence of the incentives for the producers on the coordination costs of this marketing-channel setting.

A comparison of the analysis in Chapter 2 (*top left panel*) and Chapter 3 (*top right panel*) shows the impact of the futures market on the variables of interest in this thesis: risk shifting, incentive provision, and the coordination costs of the marketing channel. In Chapters 2 and 3, no intermediary between the producer and the retailer is considered.

Figure 1.1: Research Design: A Two-Stage and Three-Stage Principal-Agent Marketing-Channel Model with and without Futures Markets
Therefore, Chapters 4 and 5 (*bottom panels*) extend the models by introducing an intermediary (a wholesaler). Chapter 4 (*the bottom left panel*) deals with a three-stage, principal-agent marketing channel (*i.e.*, involving producers, wholesalers, and retailers), without a futures market.¹ Chapter 5 (*the bottom right panel*) concerns a three-stage, principal-agent, marketing channel (including producers, wholesalers, and retailers), in which producers and wholesalers can use futures contracts. As in the two-stage principal-agent models, a comparison of the variables of interest in the three-stage marketing channel models sheds light on the role of the futures market. Furthermore, comparing the models with and without an intermediary (wholesaler) explains the role of the wholesaler regarding risk shifting and coordination costs in the marketing channel.

### 1.3.2 Empirical Domain

We apply our models to the Dutch potato industry. In what follows we provide a brief overview of this industry. In the Netherlands potatoes are usually produced on family farms. The annual production amounts to about eight million tonnes. About 50% of the potatoes are ware potatoes,² 20% seed potatoes, while the remaining 30% are grown for starch (NIVAP Holland, 2002). The Dutch ware potato industry is characterised by high price volatility, as indicated by the relatively high coefficient of variation of 0.69 (based on annual prices over the period 1946-2003), which is significantly higher than for wheat (0.18), and sugar beet (0.14). The high price variability in the potato sector can be explained by the fact that there is no government intervention in the potato markets: in contrast to such crops as cereals and sugar beets, potatoes are not EU-regulated crops. Moreover, Dutch potato prices are to a large

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¹ The two-stage, principal-agent, marketing-channel model shows a contractual relationship between the producer (*i.e.*, agent) and the retailer (*i.e.*, principal). The three-stage principal-agent marketing channel model shows two contractual relationships: the contractual relationship between the producer (*i.e.*, agent) and the wholesaler (*i.e.*, principal); and the contractual relationship between the wholesaler (*i.e.*, agent) and the retailer (*i.e.*, principal). Hence, in the three-stage, principal-agent, marketing-channel model, the position of the wholesaler changes depending on the contract (trading) partner.
extent determined by export demand. The Netherlands exports about two-thirds of its ware potatoes produced annually, and as a result market prices of Dutch ware potatoes are influenced by potato yields and planted areas in countries importing Dutch potatoes (e.g., Germany, Belgium). This leads to high price volatility in the potato sector. Being one of the most volatile crop markets in Europe, we have chosen the Dutch ware potato market for our empirical domain. Furthermore, the Dutch potato marketing channel has an interesting structure, as there is heterogeneity in the size of the companies at the various stages of the marketing channel. There are many farmers in this industry who each produce a small proportion of the total output. However, there are small numbers of wholesalers, processors, and retailers. The theory of perfect competition suggests that these farmers can hardly influence prices in the spot market, implying that they possess less bargaining power than the marketing firms.

The Dutch potato marketing channel has another feature that makes it the perfect research domain: a potato futures market has existed in Amsterdam since 1958. The General Foundation of Futures Trade (AST) was established in 1958. The Clearing House (NLKKAS) for these futures markets already existed, it was established in 1888. The Clearing House acts as a guarantee for honoring the contracts traded, if a trading partner liquidates his/her position by offsetting. The Clearing House delivers whenever a seller of futures contracts fails to deliver, and takes delivery of the commodity whenever a buyer of futures contracts fails to take delivery of the commodity. In 1992, the AST established the Amsterdam Agricultural Commodity Exchange (ATA). In 1997, the ATA was taken over by the Amsterdam Exchange (AEX), and since then it was called AEX Agricultural Futures Markets (AAT). In 2000, Amsterdam Exchanges merged with exchanges in Brussels, London, Lisbon and Paris.

2 Ware potato is the type of potato sold to consumers fresh or in processed form.
3 In line with Helmberger and Chavas (1996, p.134), we classify processors, wholesalers, and retailers as marketing firms, i.e., firms that transform raw farm produce into finished consumer goods by performing a set of marketing functions, such as collection, cleaning, processing, transportation, and retailing.
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forming Euronext. In 2001, Euronext took over the London International Financial Futures Exchange (LIFFE). As a result, coffee, sugar, and cocoa futures contracts were listed, in addition to the then-existing commodities in London. Since 2001, the AEX Agricultural Futures Markets (AAT) in Amsterdam has been called Euronext.Liffe.

Though the agricultural commodity futures market in Amsterdam is not very liquid compared to large commodity exchanges like the Chicago Board of Trade or the Chicago Mercantile Exchange, the volume of potato futures contracts traded (i.e., the number of purchases or sales of a commodity (potato) futures contract made during a specific period, e.g., a year) increased in the past. In recent years, however, the volume of potato futures contracts has decreased. For instance, the volume of futures contracts traded increased from 22,184 in 1971 to 100,446 in 1995, only to decrease to 14,223 in 2003. However, the volumes were as high as 716,220, 693,574, 722,144, and 533,207 in 1996, 1997, 1998, and 1999, respectively. Figure 1.2 shows the volume of futures contracts traded at the Amsterdam Commodity Exchange over the period 1971-2003.

Euronext intends to close down the potato futures markets at the Amsterdam Commodity Exchange after June 2006. The only potato futures market left in Europe will be that of the Hannover Commodity Exchange (WTB) in Germany. Hence, Dutch potato farmers and other channel members can still trade potato futures contracts.

Notable studies of the potato futures market at the Amsterdam Commodity Exchange were conducted by Pennings and Meulenberg (1997a,b) and Pennings et al. (1998). These studies examined the hedging effectiveness of the potato futures contracts, the liquidity of these markets, and the implications of these findings for the management of the Commodity Futures Exchange. Our study focuses on risk, incentives and coordination costs in the Dutch ware potato marketing channel, while taking the potato futures markets into account.
1.4 Outline of the thesis

This thesis consists of six chapters. **Chapter 1** forms the introduction to the thesis.

In **Chapter 2**, we model and empirically estimate incentives, coordination costs, and risk shifting in a food marketing channel that includes producers and retailers, when these MCMs are allowed to trade on spot markets only. This provides insights into the coordination of risk management in the marketing channel, when channel members trade on the spot markets. The question that arises is whether or not channel members need risk-management tools to manage their risks.

Consequently, in **Chapter 3**, we model the contractual relationships between producers and retailers (*i.e.*, marketing firms), while allowing risk-averse producers to sell futures contracts of their outputs, in order to manage the increasing risk in their revenues/incomes. Next, given that hedging in the futures markets reduces risk shifting and that channel members can better coordinate risk management, the optimal hedge level needs to be
established. We model and empirically estimate the optimal time-varying hedge ratio for the risk-averse producer.

In Chapter 4, we develop and empirically estimate a model for a three-stage, principal-agent, marketing-channel that includes wholesalers, producers, and retailers. We assess incentives, coordination costs, and risk shifting, when MCMs trade on the spot market only. This chapter provides insights into the role of incentives in reducing the coordination costs of the marketing channel. Furthermore, it provides insights into the role of the wholesaler regarding risk shifting in the marketing channel.

Chapter 5 specifies and empirically estimates a model for a three-stage, principal-agent, marketing-channel consisting of producers, wholesalers and retailers in the presence of a futures market. It addresses the question how the futures market impacts the risk-shifting role of the wholesaler. Another question being investigated is how the futures market affects the degree of incentive, and the coordination costs in this three-stage marketing channel. What is the hedge ratio for the risk-averse producers vis-à-vis the wholesalers, when, in addition to their respective contractual relationships, they also trade futures, and how does this hedge ratio differ from the one obtained in the two-stage marketing channel model (i.e., including only producers and retailers)?

Finally, Chapter 6 contains a summary, discussion, implications of the major findings, and conclusions, as well as suggestions for further research.
CHAPTER 2
Time-Series Analysis of a Principal-Agent Model to Assess Risk Shifting in Agricultural Marketing Channels: An Application to the Dutch Ware Potato Marketing Channel*

Abstract

We apply the classic agency model to investigate risk shifting in an agricultural marketing channel, using time-series analysis. We show that if the principal is risk neutral and the agent is risk averse instead of risk neutral, a linear contract can still be optimal if the fixed payment is negative. Empirical results for the Dutch potato marketing channel over the period 1946 - 2003 indicate that, while fixed payments to farmers (agents) have decreased since the 1980s to become more and more negative, the incentive intensity has approximately doubled, and the risk premium asked by the farmers has remained considerable. Moreover, since the 1960s, risk has shifted from wholesalers, processors, and retailers to farmers. We argue that this shift could be the consequence of chain reversal, i.e., the transformation of the traditional supply chain into a demand-oriented chain. Furthermore, the empirical results have shown that the coordination costs of the marketing channel decreased considerably, from 1.72 billion Euros in 1948 to 0.96 billion Euros in 2003 as a result of increases in the producers’ incentive intensity.

Keywords: risk shifting, agency theory, agricultural marketing channels, chain reversal, time series analysis

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2.1 Introduction
Marketing firms that convert raw farm products into finished consumer goods by performing a set of marketing services, such as collection, cleaning, processing, transportation, and retailing (see Helmerber and Chavas, 1996, p. 134), have become much larger than farms. Hence, risk shifting has become an important topic of study for agricultural economists and policy makers. In spite of marketing co-operatives, concern is growing that the increasingly large processors and supermarket chains will be able to dictate the terms of trade and transfer the market-level risk to farmers (e.g., Weaver and Kim, 2000).

However, if marketing firms can dictate the terms of trade, they will do so to maximise profit. Transferring risk to farmers, who have fewer opportunities to spread risk compared with marketing firms, and therefore find it more costly to bear risk, simply reduces the gains from trade. Rather, marketing firms prefer to bear the risk themselves, thereby cutting the risk-bearing costs paid to farmers in the form of a risk premium, included in the overall price paid to farmers, ultimately reducing the price they pay to farmers. Thus, whenever marketing firms transfer market-level risk to farmers, there must be another reason for doing so than mere risk aversion.

In this chapter we examine risk shifting in an agricultural marketing channel, using time-series analysis. We argue that the classic agency model (e.g., Gibbons, 2005; Furubotn and Richter, 1997; Milgrom and Roberts, 1992; Valimaki, 2001) provides a tool to investigate risk shifting in agricultural marketing channels. The usefulness of this model for indicating risk shifting in a food marketing channel is tested using sector-level, time-series data.

Originating in economics literature, agency theory has been the backbone of research on corporate governance (Jensen and Meckling, 1976; Fama and Jensen, 1983; Schleifer and Vishny, 1997). It has been applied to, amongst others, budget control in business research (Demski and Feltham, 1978), domestic franchising (Rubin, 1978; Mathewson and Winter,
1985; Brickley and Dark, 1987), retail sales compensation (Eisenhardt, 1988), and supplier–
(distributor relationships (Lassar and Kerr, 1997). In this chapter we apply the agency theory
to assess risk shifting in a food marketing channel. Knoeber and Thurman (1995) applied the
agency model to assess risk shifting in the US broiler industry. However, they used contract-
specific information instead of the widely available data used in this chapter, where a more
indirect approach is followed by using sector-level, time-series data.

The classic model in agency theory is based on the concept of the principal–agent
relationship. The agent performs a task for the principal, and the principal values the agent’s
output and pays him compensation, as specified in a contract. To generate the output required
and/or desired by the principal, the agent has to put in effort. As well as on the effort invested,
an agent's output depends on a random component: unexpected events that are beyond his
control. While the principal is observing the agent's output, he does not usually have access to
the know-how necessary to make the agent’s effort; but even if the principal does get hold of
the necessary know how, he may not have the ability to interpret it. This information
asymmetry in the principal–agent relationship is not a problem per se. However, it does
become a problem when the principal and agent have or develop different goals, creating a
moral hazard on the part of the agent in the supply of effort. The principal might consider a
contract that allows for a trade-off between incentives and insurance in order to obtain an
optimal relationship with the agent. This is particularly valid if an agent is risk averse,
preferring a certain reward over an uncertain one.

Receiving a fixed salary, independent of the output realised, would provide the agent
with full insurance but no incentive. Receiving a percentage of the output value obtained by
the principal would give the agent full incentive, yet no insurance. It may be hypothesised that
the optimal contract lies somewhere between these extremes, consisting of a fixed payment
plus a bonus rate of the value received by the principal for the agent's output. Such a mixed
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*share-wage contract* or *share contract* is consistent with Stiglitz’s (1974) theory from tenancy literature, in which the distribution of the output in a sharecropping context is based on the trade-off between the landlord’s (i.e., principal’s) need to provide both incentives and insurance to his tenants (i.e., agents). This trade-off is the core of the principal–agent problem and provides a useful framework from which Knoeber (1999) reviews the literature on agricultural contracting.

The agency model offers a possible explanation for why marketing firms (the principal) wish to transfer risk to farmers (the agent), in spite of the higher risk-bearing costs. These higher risk-bearing costs might not outweigh the higher profits the supply chain achieves when farmers are given more incentives to meet the delivery conditions that enable marketing firms to increasingly produce high value-added products in addition to the mainstream homogeneous products. This phenomenon, whereby traditional supply-oriented chains are transformed into demand-oriented chains, can be denoted as "chain reversal" (cf. Boehlje's (1996) "industrialization of agriculture"). Chain reversal has been growing in importance now that consumer food markets in the western world have become saturated, international competition is growing by the day, and agro-food companies must concomitantly meet the rising demand for product differentiation and deal with the stiffer competition in their markets. On top of this, consumers and governments expect improvements in production quality and environmental care.

Given that the marketing firms are eclipsing the farmers because of the need to produce more products with greater added value, it is important to note that although the fixed payment can be thought of as equivalent to the reservation wage (i.e., the wage that an agent receives for an alternative job without risk), the classic agency model shows that a Pareto-optimal solution is not inevitable (e.g., Valimaki, 2001, p. 35). Upon reflection, solutions with a negative fixed payment can be Pareto optimal. In such cases, the agent's degree of risk
aversion allows for a *mixed share-rent contract*. This entails the agent paying a fixed amount to the principal for the opportunity to perform for the principal, in exchange for a percentage of the total value that the principal receives for the agent’s actual output. In these cases, the agent has no insurance, despite his risk aversion. Such a contract implies shifting the risk from the marketing firm to the farmer, to increase the latter’s incentive — possibly to involve the farmer more in the investments of the marketing firm that has to develop products that better satisfy consumer needs.

In line with the classic agency model, we have chosen a linear contract, because it corresponds to real-world settings. Holmstrom and Milgrom (1987) have shown that the optimal compensation scheme for providing incentives over time to an agent with a constant absolute risk aversion is a linear function of the end-of-period results, such as revenues, costs, or profits. This result is based on the fact that a linear contract provides more uniform incentives. In contrast, if, for instance, we consider the annual output as the result of many small daily actions performed by the agent, a non-linear contract may create unintended or non-uniform incentives for the agent in the course of the year, depending on the agent’s performance so far (Gibbons, 2005).

Below, we will outline the classic agency model and its consequences for risk shifting and incentive transfer. We will then explain how the model can be applied to time-series data. Subsequently we will present an empirical application of the time-series-based principal–agent model, using data from the Dutch marketing channel for ware potatoes. Finally, we will discuss the main conclusions of our analysis and propose an avenue for future research.

2.2 The Classic Agency Model

Performance in the classic model of principal and agent is assumed to satisfy
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\[ x = e + \varepsilon \]  

where \( x \) is the value obtained by the principal for the agent’s realised performance, \( e \) the value of the agent’s actual level of effort at the expected output price, and \( \varepsilon \) the events in the performance process that are beyond the agent's control (i.e., "noise"). The random term \( \varepsilon \) is assumed to be normally distributed with zero mean and variance \( \sigma^2 \).

The costs incurred by the agent to perform for the principal are described by a cost function \( C(e) \), such that \( dC/de > 0 \) and \( d^2C/de^2 > 0 \), i.e., cost is a convex function of \( e \).

Without loss of generality for the main conclusions, the following specification is adopted

\[ C(e) = 0.5ce^2 \]  

where \( c \) is a positive parameter.

The principal pays the agent a compensation \( w \) according to the linear function

\[ w = \alpha x + \beta \]  

where \( \alpha \) and \( \beta \) are the variable (i.e., uncertain) and fixed (i.e., certain) compensation components, respectively, and \( \alpha \) represents the output-value sharing rate, such that \( 0 \leq \alpha \leq 1 \). The function in (2.3) is referred to as a linear incentive contract if \( \alpha > 0 \). The magnitude of \( \alpha \) measures the strength of the incentives. Absence of incentives, i.e., \( \alpha = 0 \), reduces (2.3) to a fixed-wage contract. A mixed share-wage contract is obtained if \( 0 < \alpha < 1 \) and \( \beta > 0 \).
In the classic agency model, the principal is assumed to be risk neutral, while the agent is risk averse. This assumption is based on the observation that the principal can usually diversify, while the agent cannot. The agent's utility function is

\[ U(w,e) = -\exp\{-\rho[w - C(e)]\} \]  

(2.4)

where \( \rho > 0 \) is the agent's coefficient of constant absolute risk aversion implying \( \rho = -[d^2U/de^2]/[dU/de] \). Consequently, a principal trying to maximise his expected payoff will solve

\[ \max_{e,\alpha,\beta} [(x - w) | I] \]  

(2.5)

subject to

\[ E(-\exp\{-\rho[w - C(e)]\} | I) \geq U(\bar{w}) \]  

(2.5a)

and

\[ e \in \arg\max_{e} E(-\exp\{-\rho[w - C(e)]\} | I) \]  

(2.5b)

where \( \bar{w} \) is the certain monetary equivalent, so that (2.5a) represents the agent's participation constraint and (2.5b) reflects the agent's incentive compatibility constraint.\(^1\) The expectations

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\(^1\) The participation constraint suggests that the agent derives a minimum level of expected utility from his/her contractual relationship with the principal; hence this is an inequality constraint. The incentive compatibility constraint reflects the restriction that the principal can observe the agent’s output but not the agent’s action or effort. In this sense the effort exerted by the agent is optimal from his/her own point of view.
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are conditional on the information set $I$. We assume that both principal and agent have information $I$, except that the principal cannot observe the actual effort of the agent (asymmetric information problem). Therefore, although we assume that the principal always predicts exactly the actual effort of the agent (i.e., perfect foresight), we also assume that the principal does not know this simply because the principal cannot observe the actual effort of the agent. Hence, the principal will always be apprehensive of moral hazard on the part of the agent. Thus, the principal uses the observable $x$ to partly determine the agent’s compensation.

Let us first consider (2.5b). If we assume that the agent's net payoff $w - C(e)$ is a normally distributed random variable, then the certainty equivalent $\hat{w}$ of $w - C(e)$ under constant absolute risk aversion (CARA) preferences, i.e.,

$$U(\hat{w}) = E[U[w - C(e)] | I]$$  \hspace{1cm} (2.6)

has a particularly simple form, namely

$$\hat{w} = E[(w - C(e)) | I] - 0.5 \rho \text{var}[(w - C(e)) | I]$$  \hspace{1cm} (2.7)

where the difference between the mean of the random net payoff, i.e. $E[(w - C(e)) | I]$, and its certain equivalent $\hat{w}$ is referred to as the risk premium: $0.5 \rho \text{var}[(w - C(e)) | I] = E[(w - C(e)) | I] - \hat{w}$. Working out $E[(w - C(e)) | I]$ using equations (2.1), (2.2), and (2.3), and given that, in the finance literature, the risk of a random variable is usually measured by the variance, conditional on the available information, the agent’s risk can be expressed as:

$$\text{var}[(w - C(e)) | I] = \alpha^2 \sigma^2$$  \hspace{1cm} (2.8)
Equation (2.8) shows that the optimization problem of the agent in equation (2.5b) is equivalent to

$$\max_e \{ \alpha e + \beta - 0.5ce^2 - 0.5\rho \alpha^2 \sigma^2 \}$$  \hspace{1cm} (2.9)$$

which yields

$$e = \alpha / c$$  \hspace{1cm} (2.10)$$

Equation (2.10) is called the incentive constraint and must be satisfied by any feasible contract. It says that the agent will exert his effort level in such a way that his marginal gains from more effort (\emph{i.e.}, \(\alpha\)) equal his marginal personal cost of effort (\emph{i.e.}, \(ce\)).

Inserting (2.10) into the participation constraint (2.5a) yields

$$\alpha(\alpha / c) + \beta - 0.5c(\alpha / c)^2 - 0.5\rho \alpha^2 \sigma^2 = \overline{w}$$  \hspace{1cm} (2.11)$$

from which the following expression for the fixed compensation \(\beta\) results

$$\beta = \overline{w} + 0.5\rho \alpha^2 \sigma^2 - 0.5\alpha^2 / c$$  \hspace{1cm} (2.12)$$

Substituting the expressions for \(e\), see (2.10), and \(\beta\), see (2.12), into (2.5), where

$$E(x - w|I) = e - \alpha e - \beta,$$

which can be derived from (2.1) and (2.3), the principal solves

$$\max_{\alpha} \{ \alpha / c - \alpha^2 / c - (\overline{w} + 0.5\rho \alpha^2 \sigma^2 - 0.5\alpha^2 / c)\}$$  \hspace{1cm} (2.13)$$
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of which the first-order condition yields

\[ \alpha = \frac{1}{1 + \rho c \sigma^2} \]  

(2.14)

Equation (2.14) can be referred to as the incentive-intensity principle and shows that since \( \rho \), \( c \), and \( \sigma^2 \) are positive, the optimal incentive parameter \( \alpha \) is between zero (full insurance) and one (full incentive). Furthermore, \( \alpha \) is smaller if the agent is more risk averse (\( \rho \) is higher), if the marginal cost of effort increases more quickly (\( c \) is higher), or if there is more uncertainty in production (\( \sigma^2 \) is higher).

Now that the optimal incentive parameter is determined in (2.14), the fixed part of the agent's compensation can be derived by substituting (2.14) into the participation constraint (2.12), giving

\[ \beta = \bar{w} + 0.5(\rho \sigma^2 - 1/c)/(1 + \rho c \sigma^2)^2 \]  

(2.15)

Equation (2.15) reveals that \( \beta \) should not necessarily be positive, since \( \rho \sigma^2 - 1/c \) can be smaller than zero, such that \( \left| 0.5(\rho \sigma^2 - 1/c)/(1 + \rho c \sigma^2)^2 \right| > \bar{w} \). Moreover, this situation may occur while still having \( \rho \sigma^2 > 0 \). In other words, the classic agency model allows for a contract in which the principal obtains \( x - w = (1 - \alpha)x - \beta \), and hence is exposed to income risk given by

\[ \text{var}[(x - w) | I] = (1 - \alpha)^2 \sigma^2 \]  

(2.16)

where the negative \( \beta \) represents the lump sum of \( x \) (i.e., rent) received by the principal and \( (1 - \alpha)x \) is the variable amount assigned to the principal, leaving the agent with a variable
compensation of $\alpha x$ minus the lump sum taken by the principal. Such a contract is called a mixed share-rent contract and provides the agent with no insurance, even though the agent is risk averse.

Next, from equation (2.10) and (2.14), the agent’s (i.e., producers’) risk parameter is derived as

$$\rho = \frac{1}{c^2 \sigma^2} \frac{(1 - ce)}{ce}$$

(2.17)

To assess the importance of the producers’ risk parameter for the performance of the marketing channel, we determine the coordination (agency) costs ($AC$) of the whole marketing channel involving producers and marketing firms. The coordination costs of the marketing channel are determined as the difference between the first-best optimal solution and the second-best optimal solution. The first-best solution is the expectation of the total profits of the marketing channel when both producers and marketing firms are risk neutral. The second-best optimal solution is the expectation of the total profits of the marketing channel when producers are risk averse, while marketing firms are risk neutral. Note that the terms first-best optimal solution and first-best situation are used interchangeably in this chapter. The terms second-best optimal solution and second-best situation are also used interchangeably. The coordination costs can be expressed as:

$$AC = E[(\pi_m^* + \pi_p^*) \mid I] - E[(\pi_m + \pi_p) \mid I]$$

(2.18)

---

2 Coordination (agency) costs may include ex ante information search costs associated with adverse selection (hidden information) problems and/or ex post monitoring and enforcement costs associated with moral hazard problems. These costs are believed to be the main reasons for which the marketing channel cannot achieve the first-best optimal solution. We examine the role of incentives in reducing coordination costs of the marketing channel.
where \( \pi_m = x - w \), see (2.5), and \( \pi_p = w - C(e) \), see (2.6). The first-best optimal solution of the marketing channel, \( E[(\pi_m^* + \pi_p^*) | I] \) is obtained by setting the producers’ risk-aversion coefficient in equation (2.17) to zero \((\rho = 0)\), where \( \pi_m^* \) and \( \pi_p^* \) are the first-best optimal profits of marketing firms and producers, respectively. In this sense, both producers and the marketing firms are considered risk neutral, and information flows among producers and marketing firms are obtained at zero cost. With the above-mentioned condition for the first-best optimal solution, equation (2.14) yields \( \alpha = 1 \); equation (2.15) yields \( \beta = (\bar{W} - 0.5\alpha^2 / c) \); and equation (2.10) yields \( e = (1/c) \). These derivations are then substituted into the respective profits of producers and marketing firms in order to obtain their respective first-best optimal profits.

On the contrary, the second-best optimal solution of the marketing channel \( E[(\pi_m + \pi_p) | I] \) is obtained when the respective profit functions for producers and marketing firms take account of the risk aversion of these channel members, and of the fact that the derived risk-aversion coefficient, \( \rho \) in (2.17), is used in estimating the producers’ profits. Thus, the respective derivations for \( \alpha \) in (2.14), \( \beta \) in (2.15), and \( e \) in (2.10) are used in obtaining the profits of producers and marketing firms.

### 2.3 Econometric Considerations

The solutions of the game-theoretic model in the previous section are given by the expressions for \( \alpha \) in (2.14) and \( \beta \) in (2.15). The unknowns in the expression for \( \alpha \) are \( \rho \), \( c \) and \( \sigma^2 \). If we consider these unknowns as constant parameters over time, then \( \alpha \) will be a constant as well. However, according to the incentive constraint given by (2.10), \( \alpha \) is equal to \( ce \). Although we may consider \( c \) as time invariant, this cannot be imposed on \( e \). Hence, in terms of time-series variables, the incentive constraint implies \( \alpha \) to be time varying:
\( \alpha_t = ce_t \) \hspace{1cm} (2.10')

where the index \( t = 1, \ldots, n \) refers to observations through time.

For annual data, to be used in the empirical part of this research, it can typically be assumed that \( \sigma^2 \), \textit{i.e.,} \( \text{var}(x-e) \), is constant in the food supply chain where the farmers are the agent and the marketing firms are the principal.\(^3\) Consequently, in order to comply with the time-varying behavior of \( \alpha \), the other time-varying coefficient in (2.14) must be \( \rho \):

\[
\alpha_t = \frac{1}{1 + \rho_t c \sigma^2}
\] \hspace{1cm} (2.14')

From this and the fact that \( \pi \) can be considered to be time varying as well, it can also be expected that \( \beta \) is time varying:

\[
\beta_t = \frac{w_t}{\sigma_t} + 0.5(\rho_t \sigma^2 - 1/c)\frac{1}{1 + \rho_t c \sigma^2}
\] \hspace{1cm} (2.15)

Now given that \( w \) and \( x \) are also time-varying variables, substituting (2.14') and (2.15') into (2.3) and using

\[
\rho_t = \left[ \frac{1/c \sigma^2}{(1 - ce_t)/ce_t} \right]
\] \hspace{1cm} (2.17')

as can be derived from (2.10') and (2.14'), we obtain the following equation

\(^3\) A negative relationship exists between the frequency of data and the constancy of the variance of the distribution of those data over time. Thus, for example, we expect annual data to have a fairly constant variance over time, as compared to daily, weekly, or monthly data.
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\[
(w_i - \bar{w}_i - 0.5e_i) = ce_i (x_i - e_i) \tag{2.19}
\]

in which \( c \) is the single unknown parameter. Before \( c \), as parameter of interest, can be estimated, it should first be identified (cf. Ackerberg and Botticini, 2002). If \((w_i - \bar{w}_i - 0.5e_i)\) and \(e_i(x_i - e_i)\) are stationary, then the estimation model

\[
(w_i - \bar{w}_i - 0.5e_i) = d(t) + ce_i (x_i - e_i) + u_t \tag{2.19'}
\]

in which \( u_t \) is an unobserved component, and \( d(t) \) is a linear function of deterministic components, including a constant and linear trend which might be necessary to be added to equation (2.19) to complete the empirical specification of the cost function, does not typically allow for simple OLS estimation. This is because \( e_i(x_i - e_i) \) and \( e_i \) could well be correlated, in particular with \( e_i \) included on both sides of (2.19). This problem, however, will not occur when \((w_i - \bar{w}_i - 0.5e_i)\) and \(e_i(x_i - e_i)\) are co-integrated (Engle and Granger, 1987). But if these variables, as well as \((w_i - \bar{w}_i)\) and \(e_i\), are stationary, we may test for the absence of simultaneity bias by performing the omitted variable version of the Hausman (1978) test, as in

\[
(w_i - \bar{w}_i - 0.5e_i) = d(t) + \hat{\alpha}e_i (x_i - e_i) + \gamma \hat{v}_t + u_t^* \tag{2.19''}
\]

to test the null hypothesis \( \gamma = 0 \), i.e., \( e_i(x_i - e_i) \) is exogenous, by a \( t \) test, where \( \hat{v}_t \) are the residuals of the second equation in the bivariate VAR(\( k \)) (including \( d(t) \)) for \((w_i - \bar{w}_i - 0.5e_i)\) and \(e_i(x_i - e_i)\), with \( k \) being much smaller than the sample size.

Suppose that we have been able to estimate \( c \). Then, from (2.10'), we obtain the estimate of \( \alpha_j \), denoted as \( \tilde{\alpha}_j \). Next, we can derive \( \tilde{\rho}_j \) from (2.17'), and then \( \tilde{\beta}_j \) from (2.15') (adding
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d(t) to the right-hand side of equation (2.15')). Finally, substituting $\tilde{\alpha}_t$ and $\tilde{\beta}_t$ in (2.3), $w_t$ can be estimated as

$$w_t = \alpha_t x_t + \beta_t$$

(2.3')

and compared with the actual values of $w_t$. This comparison evaluates the validity of the model. If it is valid and the empirical model shows a situation in which $\tilde{\alpha}_t$ (and hence, $\tilde{\alpha}_t^2 \tilde{\sigma}^2$) have been increasing over time, $\tilde{\beta}_t$ has been decreasing to (more) negative values, whereas $\rho_t$ has always remained positive, it can be concluded that, although farmers are risk averse, marketing firms still find it optimal to increase farmers’ rent instead of reducing the risk farmers have to be compensated for. This allows hypothesising that marketing firms need farmers in the marketing channel for more than just supplying the primary produce: as sales and profit tend to become a responsibility of the chain as a whole in reversed chains, marketing firms also need farmers to finance some of the activities they want to initiate (or they want farmers to initiate) to successfully process and market the final consumer goods. By way of example, with respect to the empirical case of the Dutch ware potato marketing channel outlined in the next section, it is known that farmers have increasingly become involved in storing the raw potatoes they produce.

2.4 Empirical Application

Every year, some eight million tons of potatoes are produced in the Netherlands, mainly on family farms. About half are ware potatoes, approximately 20 percent are seed potatoes, while the remaining 30 percent are potatoes grown for starch (NIVAP Holland, 2002). Most ware potatoes are sold to wholesalers. A negligible amount is sold directly by the farmer to the processor or retailer (De Graaff, 1981; Smidts, 1990; ZLTO and LLTB, 2002; Baltussen and
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Van Asseldonk, 2005). The basic marketing problem facing wholesalers is how to optimise the supply of potatoes in terms of time (storage), quantity and quality (assembly and sorting), and place (transport), so as to meet the requirements of the different users. Most of the wholesale trade has become concentrated in relatively few hands. The major users, particularly the large retailers, processors, and export markets, demand large quantities with tight specifications, which only the larger wholesalers can meet. Because of this development in the market, the need has arisen to procure potatoes before harvest. Hence, a number of different arrangements to do so have emerged, with fixed-price contracts and pooling contracts being the most important (e.g., Young, 1977; De Graaff, 1981; Smidts, 1990; ZLTO and LLTB, 2002; Baltussen and Van Asseldonk, 2005).

The fixed-price contract involves selling a net amount of potatoes at a fixed contract price. This marketing strategy entails transferring the entire price risk from the farmer to the wholesale company. In the pooling-contract system, the potatoes delivered by the farmers are sold by wholesalers throughout the season. The resulting gross returns from these sales, minus the wholesalers' expenses, are distributed across the producers, proportional to the amount of potatoes delivered. Non-fixed price arrangements, such as the pooling-contract system, have been adopted by farmers, because wholesalers wish to retain their core suppliers by offering them contracts that bear some relation to the market price. Note that this complies with the concept of chain reversal and, more specifically, the fact that potato farmers have increasingly invested in storage facilities on their farms, in order to be able to anticipate on the highest prices in the marketing season.

For the empirical analysis of the Dutch ware potato marketing system, Statistics Netherlands provided us with annual data over the period 1946-2003, for the following variables: the farm and retail prices (Euro/kg) of ware potatoes, both deflated by the consumer
price index (1990 = 1.00), the area planted (1000 ha), the yield per hectare (100 kg/ha), and the rent price of land (Euro/ha), deflated by the consumer price index.

From these variables, we derive the following variables of interest. First, the output value at consumer prices (billion Euro), \( i.e., x_t \), is computed as the retail price times the yield per hectare times the area planted (divided by \( 10^4 \)). Next, for the estimation of \( e_t \) (\( i.e., \) the expected output value at consumer prices) and the variance of the random component of the output value \( \sigma^2 \), see the appendix at the end of this thesis. Lastly, \( w_t \) (billion Euro) is computed as the farm price times the yield per hectare times the area planted (divided by \( 10^4 \)), and for \( \bar{w}_t \) (billion Euro), we take the rent price of land times the area planted (divided by \( 10^6 \)). In the computation of \( x_t \) and \( w_t \) (\( \bar{w}_t \)), we divide by \( 10^4 \) (\( 10^6 \)) each time, to ensure uniformity in the units of measurements of the components that made up each of these variables.

Before estimating \( c \) in (2.19'), we first investigate the order of integration of the time series of \( (w_t - \bar{w}_t - 0.5e_t) \) and \( e_t(x_t - e_t) \). It appears that the graphs of these two time series show a downward trend in such a way that it is difficult to decide whether or not these series are trend stationary. However, Johansen's co-integration test (Johansen and Juselius, 1990; Osterwald-Lenum, 1992) rejects all hypotheses according to which the rank of matrix \( \Pi \) is not full in the model

\[
\Delta X_t = \Pi X_{t-1} + \sum_{j=1}^{\ell-1} \Gamma_j \Delta X_{t-j} + \mu_t + \varepsilon_t \tag{2.20}
\]

where \( X_t = [(w_t - \bar{w}_t - 0.5e_t), e_t(x_t - e_t)]' \), \( \mu_t \) captures the deterministic terms, and \( \{\varepsilon_t\} \) is Gaussian white noise. These test results are presented in Table 2.1, where the trace statistic

\[\text{Suppose that } X_t \text{ is a } (g \times 1) \text{ vector of variables. Given that } \Delta X_t \text{ is stationary, then, if the matrix } \Pi \text{ is full rank, } X_t \text{ is already stationary and has no unit root. If } \Pi \text{ is the null matrix, then there are } g \text{ unit roots, and hence the proper specification of (2.20) is one without the term } \Pi X_{t-j}. \text{ If there are } h \text{ cointegrating relations } (0 < h < g), \text{ we}\]
has been computed for the case where the linear trend is restricted to be included only in the cointegrating space and \( k = 1 \), as selected by the Akaike Information Criterion (AIC) for a VAR with a linear trend and pre-specified upper bound of order five. Moreover, we tested for the absence of the linear trend in case \( \text{rank}(\Pi) = 2 \) and found a value of 30.62 for the likelihood ratio test statistic. The asymptotic distribution of the test statistic is \( \chi^2(2) \), of which the 95% quantile equals 5.99. Thus, the value of the test statistic is highly significant. Based on these results, we conclude that \((w_t - \bar{w}_t - 0.5e_t)\) and \(e_t(x_t - e_t)\) are trend stationary.

### Table 2.1: Testing \( \text{rank}(\Pi) \) when \( X_t = [(w_t - \bar{w}_t - 0.5e_t), e_t(x_t - e_t)]' \)

<table>
<thead>
<tr>
<th>Rank (( \Pi ))</th>
<th>Trace Statistics</th>
<th>5% Critical Value(^a)</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 0</td>
<td>90.71</td>
<td>25.87</td>
<td>0.00</td>
</tr>
<tr>
<td>( \leq 1 )</td>
<td>40.25</td>
<td>12.51</td>
<td>0.00</td>
</tr>
</tbody>
</table>

\(^a\) Critical values are obtained from MacKinnon et al. (1999).

We now estimate \( c \) in (2.19\(^\prime\)) by the following regression model

\[
(w_t - \bar{w}_t - 0.5e_t) = c_0 + c_1 t + ce_t(x_t - e_t) + u_t
\]  

(2.19\(^{\prime\prime}\))

where the deterministic component \( c_0 + c_1 t \) is considered an extension of the cost function specification in (2.2):

\[
C(e_t) = 0.5ce_t^2 + c_0 + c_1 t
\]  

(2.2\(^{\prime}\))

can decompose \( \Pi \) into \( \varphi \delta' \), where \( \varphi \) and \( \delta \) are \((g \times h)\) matrices of full column rank, such that \( \delta'X_t \) are \( h \) linearly independent combinations of variables in \( X_t \) that are stationary in spite of the non-stationarity of \( X_t \). Johansen’s trace statistic tests for the rank of \( \Pi \).
However, before we are allowed to use the estimate of $c$ obtained from applying OLS to (2.19'''), we first have to find out whether or not $e_t(x_t - e_t)$ is exogenous. For this, we add the residuals from the VAR(1) equation of $e_t(x_t - e_t)$ obtained above as a regressor to (2.19'''), in order to apply the omitted variable version of the Hausman (1978) test, as in

$$(w_t - \bar{w}_t - 0.5e_t) = \kappa_0 + \kappa_1 t + \delta e_t(x_t - e_t) + \gamma \hat{e}_{2t} + u^*_t$$

where $\hat{e}_{2t}$ are the residuals of second equation of the bivariate VAR(1) in (2.20) (rank($\Pi$) = 2, $k = 1$). Testing the restriction $\gamma = 0$, we find that the $p$ value of the $t$ test is 0.62 and, hence, we conclude that $e_t(x_t - e_t)$ is exogenous. Therefore, we now arrive at estimating (2.19'''').

The OLS estimates in (2.19''') are $c_0 = 0.155$ ($t$ value = 4.079; $p$ value = 0.0002), $c_1 = -0.011$ ($t$ value = -9.429; $p$ value = 0.000), and $c = 0.262$ ($t$ value = 3.184; $p$ value = 0.0024). The negative coefficient of the linear trend complies with the cost-reducing technological advances in agriculture. Furthermore, the $R^2 = 0.64$, the Jarque-Bera statistic testing for normality of the residuals has a $p$ value of 0.32, after omitting four vertical outliers that did not lead to dramatic changes in the estimates and significance of the coefficients, and the $F$ version of the $LM$ statistic testing for the absence of first-order (fourth-order) autocorrelation in the residuals has a $p$ value of 0.95 (0.65). Based on these diagnostic test results, and the results of the specification tests with regard to (2.19''''), we conclude that $\{u_t\}$ is Gaussian white noise and uncorrelated with $\{e_t(x_t - e_t)\}$. In what follows, we graphically show and discuss the relevant estimation results obtained from the empirical and estimated time series, the OLS parameter estimates, and the relationships implied by the theoretical model.
Using the estimate of \( c \), we obtain the following graph of \( \tilde{\alpha} \) from (2.10'), see Figure 2.1. Note that the first-best situation is when \( \alpha_i = 1 \). The graph shows a decreasing trending pattern from 1948 to the early 1960s according to which \( \tilde{\alpha}_t \) (incentive intensity) decreased from 0.25 to 0.20. Thereafter, \( \tilde{\alpha}_t \) increased to 0.38 in 2002. The model is internally consistent in the sense that the rise in \( \tilde{\alpha}_t \) implies a decrease in \( \tilde{\rho}_t \), see (2.14'), as shown in Figure 2.2, i.e., less risk aversion among farmers. Nevertheless, at the same time, the risk premium \( 0.5\tilde{\rho}_t\hat{\sigma}^2 \) decreased from about 0.34 billion Euro in 1948 to 0.29 billion Euro in the late 1950s, only to increase to 0.41 billion Euro in 2003. The sum of producers’ total cost, the risk premium and the reservation wage \( \{ \tilde{C}(e_t) + 0.5\tilde{\rho}_t\hat{\sigma}^2 + \bar{w}_t \} \) seems to perform reasonably well as an expectation of the producer’s actual wage \( w_t \), conditional on the information set available at time \( t - 1 \), see Figure 2.3.

Consequently, in spite of the results that the producers are still asking for a positive risk premium, which, compared with the total production cost \( \tilde{C}(e_t) \) and compensation \( w_t \), is considerable, the fixed compensation \( \tilde{\beta}_t \), computed as

\[
\tilde{\beta}_t = \bar{w}_t + 0.5(\tilde{\rho}_t\hat{\sigma}^2 - 1/\hat{\sigma})/[(1 + \tilde{\rho}_t\hat{\sigma}\hat{\sigma}^2)^2] + \hat{c}_0 + \hat{c}_1t \tag{2.15''}
\]

where \( \hat{c}_0 + \hat{c}_1t \) originates from (2.2') and estimated in (2.19''), declines steadily and has become more and more negative since the beginning of the 1980s. However, the first-best situation shows that \( \tilde{\beta}_t \) has been negative throughout the period of study, see Figure 2.4. In addition, Figure 2.5 reveals that the model explains producers’ wage \( w_t \), quite well for many of the years studied. Conditional on this and Figure 2.6, in which the income risks of producers (see (2.8)) and marketing firms (see (2.16)) are displayed, it can be concluded that risk has shifted from marketing firms to producers. This shift indicates that, instead of
Figure 2.1: Producers’ Incentive Intensity (ALPHA = $\alpha_i$)

Figure 2.2: Constant Absolute Risk Aversion Coefficients (RP = $\rho_i$)
Risk, Incentives and Coordination Costs

Figure 2.3: Wage Compensation ($WP = w_i$), Producers’ Total Cost + Risk Premium + Reservation Wage ($TCRW = \tilde{C}(e_i) + 0.5\tilde{\rho}_i\tilde{\alpha}_i^2\tilde{\sigma}^2 + \tilde{w}_i$), and the Producers’ Risk Premium ($RISKP = 0.5\tilde{\rho}_i\tilde{\alpha}_i^2\tilde{\sigma}^2$)

Figure 2.4: Producers’ Fixed Compensation under Risk Aversion ($BETA = \tilde{\beta}$), and Producers’ Fixed Compensation under Risk Neutrality ($BETARN$)
Chapter 2. Time-Series Analysis of a Principal-Agent Model

Figure 2.5: Wage Compensation ($W = w_t$), Estimated Wage Compensation ($WPE = \tilde{w}_t$), the Variable (Uncertain) Wage Compensation ($\text{ALPHAX} = \tilde{\alpha} x_t$), and the Fixed (Certain) Wage Compensation ($\text{BETA} = \tilde{\beta}_t$).

Figure 2.6: Producers’ Profit Risk ($\text{VARP} = \tilde{\alpha}_i^2 \sigma^2$, see (2.8)), and Marketing Firms’ Profit Risk ($\text{VARM} = (1-\tilde{\alpha}_i)^2 \sigma^2$, see (2.16)).
receiving a lump-sum payment, farmers have to transfer an increasing amount of such a payment to the marketing firms, even though the risk premium they ask for is still considerable. It is the marketing firms, however, who have been able to compensate their expenses without risk. They have done so by steadily increasing the proportion of the output value at consumer prices obtained without risk: from −43% in 1948 to 23% in 1998. This proportion, however, decreased to about 15% in 2003 (see Figure 2.7).

![Figure 2.7: Part of Output Value of Potatoes at Consumer Prices Received by Marketing Firms Without Risk (PROX = −β_i / x_i)](image)

Given that the marketing firms can be assumed to be risk neutral, they might be expected to behave differently and bear all the risk themselves, so as to reduce the risk-bearing costs of the farmers. This would also be in their own interest, since it would allow them to lower the price they pay to the farmers. The above results, however, suggest that farmers play a crucial role in the process of chain reversal, as they seem to be the ones who have to finance some of the activities desired by marketing firms to meet consumers’ needs.
and demands in the increasingly saturated consumer food market, amidst growing competition and globalization. The fact that growers have become more involved in storing potatoes is a clear example of this development.

Regarding the influence of the producers’ risk parameter for the performance of the marketing channel, the results show that, as a consequence of increases in the producers’ incentive intensity, the coordination costs of the marketing channel (see (2.18)) decreased considerably from about 1.07 billion Euros in 1948 to 0.86 billion Euros in 2003, see Figures 2.8 and 2.9. Figure 2.8 shows the profit of the marketing channel in both the first-best situation (producer risk neutrality) and the second-best situation (when producers are risk averse). The graphs show that the difference between the first-best optimal profit and the second-best optimal profit decreased over time, indicating decreases in coordination (agency) cost of the marketing channel, as depicted in Figure 2.9.

![Figure 2.8: The Expectation of Profit of the Marketing Channel with Risk Aversion (EPSB = \( \hat{E}(\pi_{mt} + \pi_{pt} | I_{t-1}) \)), and Profit of the Marketing Channel with Risk Neutrality (EPFB = \( \hat{E}(\pi_{mt}^* + \pi_{pt}^* | I_{t-1}) \))](image-url)
Figure 2.9: The Coordination Cost of the Marketing Channel Involving Producers and Retailers (\(CCOST = AC_i\), see (2.18))

In order to actually evaluate the validity of the model, we examine how the estimated payments explain the actual wages for producers. A regression of the actual wages on the estimated wages and fixed-wage components for producers shows that the estimated wages are efficient predictions and explain about 33% of the actual wages, see Figure 2.10 and the results tabulated in Table 2.2. The model does provide an unbiased and significant prediction, as we can see from performing a regression of \(w_t\) (producer’s actual wages) on a constant, \(\tilde{\alpha}_i x_i\) (producer’s estimated variable wages) and \(\tilde{\beta}_i\) (producer’s estimated fixed wages), see Table 2.2, and consider the results of the following coefficient tests: testing the joint hypothesis of a zero constant and unit coefficients of both \(\tilde{\alpha}_i x_i\) and \(\tilde{\beta}_i\) leads to non rejection (\(p\)-value = 0.188), and testing the joint hypothesis of zero coefficients of both \(\tilde{\alpha}_i x_i\) and \(\tilde{\beta}_i\) leads to a firm rejection (\(p\)-value = 0.000). Furthermore, we conducted normality tests regarding the distributional assumption (in applying the certainty equivalent approach) of producer profits. The result of the test, while omitting three outlying observations (i.e., 1976, 1983, and 1994), show that the profits of the producers, computed with the costs estimated by
the model (obtaining $\tilde{w}_{pt} = w_i - \tilde{C}(e_t)$), are normally distributed ($p$ value of the Jarque-Bera statistic is 0.148). This justifies the application of the certainty-equivalent approach in this chapter.

Table 2.2: Parameter Estimates in the Regression of the Actual Payment ($w_i$) on the Variable- and Fixed-Compensation Components Estimated by the Agency Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient Estimate</th>
<th>Std. Error</th>
<th>$t$ Value</th>
<th>$p$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.184</td>
<td>0.069</td>
<td>2.680</td>
<td>0.009</td>
</tr>
<tr>
<td>$\tilde{\alpha}_t x_t$</td>
<td>0.449</td>
<td>0.196</td>
<td>2.290</td>
<td>0.026</td>
</tr>
<tr>
<td>$\tilde{\beta}_t$</td>
<td>0.666</td>
<td>0.153</td>
<td>4.345</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Sample: 1948 - 2003; Number of Observations = 56; $R^2 = 0.33$; $R^2_{adj} = 0.30$; Std. Error Resid = 0.13; Sum Squared Resid = 0.94; Durbin-Watson = 2.03

Figure 2.10: Producers’ Actual Wage ($W = w_i$) and Producers’ Estimated Wage ($WPE = \tilde{w}_t$, see (2.3'))
2.5 Conclusion and Discussion

In this chapter, the classic agency model is applied to shed light on risk shifting and chain reversal in a food marketing channel. The model involves a mixed share-wage/rent contract with a time-varying fixed wage/rent and output-value sharing rate. It can be tested on sector-level, time-series data that are widely available. To perform this test, we have outlined how to take the time-series properties of the data into account, in relation with the simultaneity problem regarding the parameter of interest to be estimated. If the model complies with the data, it can be used to detect risk shifting as a possible indication of a marketing channel changing from a traditional supply-oriented chain into a demand-oriented chain. The estimates may then reveal a situation where the fixed wage becomes an implicit rent, while the risk premium that the agents demand remains considerable. Further, we apply the model to investigate the role of incentives in reducing the marketing channel’s coordination costs.

The empirical application to the Dutch marketing channel of ware potatoes has shown that risk has shifted from the marketing firms to the producers. From the beginning of the 1980s on, ware potato producers have been paying an increasing amount of fixed compensation to marketing firms. This compensation expressed as a percentage of total output value at consumer prices as received by the marketing firms, has increased from \(-43\%\) in 1948 to 23\% in 1998. This value, however, decreased to about 15\% in 2003. Nevertheless, together with the rise in the output-value sharing rate the producers became less risk-averse. This finding contributes to the debate on whether risk attitude is a stable concept (e.g., Pennings and Garcia, 2001). The results also show that increases in producers’ incentives considerably reduce the coordination costs of the marketing channel (from 1.72 billion Euros in 1948 to 0.96 billion Euros in 2003).

The method used in this paper differs from the procedure in Knoeber and Thurman (1995). Knoeber and Thurman (1995) already knew which contracts were used in the course
of time. Using simulation methods along with production and payment data from a panel of individual farmers, they measured the risk shift between principal and agent, based on these contracts. By estimating the parameter of interest, the method presented here is also able to reveal how the contracts have changed over time. However, for this purpose it uses only sector-level data on prices and quantities that are widely available.

Knoeber and Thurman (1995) applied their method to the U.S. broiler industry, where the agents are the growers and the principals are the integrator firms. They concluded that risk had shifted from the agents to the principals. In contrast to their study, the current application to the Dutch marketing channel of ware potatoes includes the retail sector among the principals. The results show risk shifting from principals to agents. In our view, the differences in the results can be attributed to the differences in market structures for the two market situations: the US broiler industry and the Dutch ware potato industry. The US broiler industry is highly integrated compared to the Dutch ware potato industry, where production, wholesaling, and retailing are distinct activities. The above argument is consistent with Pennings and Wansink (2004), who have shown that in different marketing channel structures risk and risk attitudes play different roles.

Our empirical result regarding risk shifting is consistent with the fact that retailers have become a powerful player in the marketing channel (e.g., Kuiper and Meulenberg, 2002). As a result, they can force processors and wholesalers to better fit the needs and wants of the consumer which, in turn, processors and wholesalers can only do with the farmers’ support. The difference in the results shows the importance of extending the classic agency model to more than two stages in the marketing channel. It also indicates a future avenue of research: the possibility of testing for different strategic interactions between these stages.
CHAPTER 3

Time-Varying Hedge Ratios: A Principal-Agent Approach

Abstract

In this chapter we use the classic agency model to derive a time-varying optimal hedge ratio for low-frequency time-series data: the type of data used by crop farmers when deciding about production and about their hedging strategy. Rooted in the classic agency framework, the proposed hedge ratio reflects the context of both the crop producer’s decision and the crop producer’s contractual relationships in the marketing channel. An empirical illustration for the Dutch ware potato sector and its futures market in Amsterdam over the period 1971 - 2003 reveals that the time-varying optimal hedge ratio decreased from 0.21 in 1971 to 0.15 in 2003. The average hedging effectiveness, according to this ratio, is 39%. Furthermore, we examine the role of incentives in reducing the coordination costs of the marketing channel for two cases: with and without futures trade. The empirical results show that as a consequence of increases in producers’ incentives, the coordination cost of the marketing channel decreased considerably for both cases. The coordination costs of the marketing channel with futures trade are lower than without, demonstrating the informational (i.e., price discovery) function of the futures market.

Keywords: agency theory, crop farmers, hedge ratio, risk, coordination costs

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3.1 Introduction

A futures contract (often referred to as ‘futures’, for short) is an agreement to deliver a specific amount of a commodity (or other asset) at a specified future time, and at a specific price, and location. Futures contracts are standardised, which facilitates their trading on organised exchanges. As futures contracts are commitments to trade in the future, actual delivery and payment are not required until the contract matures. A primary use of futures involves shifting risk from a firm that desires less risk (the hedger) to a party who is willing to accept the risk in exchange for an expected profit (the speculator). For example, crop producers can protect themselves from declines in prices of expected outputs by selling futures contracts at the beginning of the growing period and buying back futures at the time their product is ready to be sold in the spot market. As futures and spot prices are positively correlated, losses and gains in the two markets tend to offset each other, leaving the hedger with a return close to what was expected (e.g., Working, 1953; Ederington, 1979).

Yield variability can reduce the revenue risk reduction capacity of hedging for crop farmers, however, generally making it advisable for them to sell futures for only a fraction of the expected harvest (e.g., Moschini and Lapan, 1995). Moreover, although futures and spot prices tend to move in parallel, these movements are not usually identical; this results in basis risk (where the basis is defined as the local spot price minus the futures price). As can be demonstrated by the minimum-variance criterion, this is also why the optimal hedge ratio (i.e., the futures position divided by the spot position) can be less than 1. Consequently, for crop producers and all other traders wishing to reduce risk by hedging with futures contracts, the hedge ratio is of critical importance (e.g., Dawson et al., 2000; Harwood et al., 1999).

Much research has been done on improving the estimation of the optimal hedge ratio: see Lien and Tse (2002) for a review. An important result in this respect has been the replacement of the classical regression method (e.g., Ederington, 1979), which assumes a
Chapter 3. Time-Varying Hedge Ratios

A *time-invariant* hedge ratio, by *time-varying* estimates as permitted in Generalized Autoregressive Conditional Heteroscedasticity (GARCH) and Stochastic Volatility (SV) models. Unfortunately, these GARCH and SV models have two important shortcomings. First, they have little economic content except the notion that ‘rational’ decision-makers might wish to base their choices on the most current information (*i.e.*, changing covariances and variances). In contrast, vertical contractual relationships between crop farmers and agents in other stages of the supply chain determine how much risk the agents in each of the stages bear (*e.g.*, Pennings and Wansink, 2004) and hence, each agent's optimal hedge ratio. Principal-agent theory is a widely used economic approach towards modelling these contractual relationships (*e.g.*, Eisenhardt, 1989; Milgrom and Roberts, 1992; Furubotn and Richter, 1997). Consequently, in this chapter we use the classic model in agency theory as a starting point for deriving the optimal hedge ratio. To the best of our knowledge, this is the first time that price hedging in the futures market has been viewed within the context of vertical contractual relationships in terms of the principal-agent framework.

A second drawback of GARCH and SV models is that they can usually only be estimated for time-series data recorded at frequencies of one day or less. Partly as a consequence of this, these models do not work well, particularly in an out-of-sample context when compared with constant hedge-ratio strategies (*e.g.*, Lien and Tse, 2002). High-frequency data such as daily or hourly observations are rarely considered by crop producers when they have to decide about their production scheme; from the literature it is clear that they base such decisions on an average of prices over a number of years. Supply models with adaptive expectations (see Nerlove, 1958a,b, and Askari and Cummings, 1977) illustrate the point.

Related to this, high-frequency data may contain noise that disappears when they are aggregated to lower frequencies. As they contain less noise, such lower-frequency data could
better reveal economic relationships of interest for crop farmers and the management of the futures exchange (see, for example, Kuiper et al., 2002), such as the relationship between yield variability and the optimal hedge ratio. In this chapter we show that the principal-agent model allows for a time-varying hedge ratio to be estimated from these economic relationships of interest.

The outline of the chapter is as follows. In Section 2, we derive the model and focus on several relationships of interest. In Section 3, we discuss parameter estimation and model validation. In Section 4, we apply the model to an illustrative data set, and find that the model provides useful insights. Finally, in Section 5, we review our findings and discuss their implications.

### 3.2 Model

In this section we outline the classic model in agency theory; see Gibbons (2005) for a recent discussion. The classic agency model has been widely applied to describe the contractual relationships between the various entrepreneurs in the supply chain of a traded commodity; see Sexton and Lavoie (2001) for a recent survey. To derive the optimal hedge ratio, however, we extend the model by having the risk-averse entrepreneurs reduce their risk by hedging with futures contracts.

In what follows, we consider crop farmers who produce a raw farm product which they sell to marketing firms with the help of production contracts offered by the marketing firms. The crop farmers face price risk and output (yield) risk and use futures price contracts to effectively manage their price risk. Given expected-utility-maximisation by the crop farmers and expected-profit-maximisation by the marketing firms we derive the optimal hedge ratio for the crop farmers conditional on the parameters in the production contract that are optimal for the marketing firms and acceptable for the crop farmers.
Let the crop farmers be risk-averse decision makers. A crop farmer may not have full control over the yield, as the yield is vulnerable to the vagaries of nature. Hence, a crop farmer bears the risk of a bad harvest. Nevertheless, s/he may not be the only farmer facing a bad harvest: other farmers could also be hit. If harvest failure is widespread, supply will be limited and prices will be high. Given the inverse relationship between price and quantity supplied, we expect the output value – the product of price and quantity supplied – to vary less than the product of quantity supplied and the price of a fixed-price production contract in which the price is set far before harvest time and hence, does not reflect unexpectedly good or bad harvests (cf. Moschini and Lapan, 1995). Therefore, a fixed-price production contract does not rescue the crop farmer from bearing revenue risk. A contract that bears some relation to the market price, however, is embedded in the following linear function:

\[
    w_t = \alpha_{t,t-1}x_t + \beta_{t,t-1}
\]

(3.1)

where \( w_t \) is the compensation that the marketing firm pays to the crop farmer in exchange for his/her produce, \( x_t \) is the output value at consumer prices realised by the marketing firm when selling the crop farmer’s produce, \( \alpha_{t,t-1} \) is the output-value sharing rate fixed in year \( t-1 \) with respect to the output value in year \( t \), as generated by the harvest whose production schedule was decided upon in year \( t-1 \), and lastly, \( \beta_{t,t-1} \) represents the fixed payment in year \( t \), as established in the contract agreed between the marketing firm and crop farmer in year \( t-1 \), at the time the crop farmer drew up his/her production schedule. A mixed share-rent contract is associated with \( 0 < \alpha_{t,t-1} < 1 \) and \( \beta_{t,t-1} \neq 0 \).

\(^2\) Linearity is the rule, not the exception, when one examines the contracts that are written in real situations, see Holmstrom and Milgrom (1987) and Bhattacharyya and Lafontaine (1995) for possible explanations.
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To simplify the analysis, we consider the marketing firms as the only downstream stage of the supply chain. The model then becomes a two-stage channel, with the crop farmers as the upstream stage and the marketing firms as the downstream stage. The marketing firms are considered to convert the raw farm product into finished consumer goods by performing a set of marketing services, such as collection, cleaning, processing, transportation, and retailing. Given that the marketing firms contract the crop farmers, they are the principals in the classic agency model (e.g., Furubotn and Richter, 1997; Gibbons, 2005), while the crop farmers are the agents. In that model the principal is assumed to be risk-neutral; for example, many marketing firms have become large companies, enabling them to diversify to spread the risk.

In line with the classic agency model, the linear contract in (3.1) is chosen as it corresponds to real-world settings (e.g., Knoeber, 1999; Allen and Lueck, 2002). Moreover, Holmstrom and Milgrom (1987) have shown that the optimal compensation scheme for providing incentives over time to an agent with a constant absolute risk-aversion for the duration of the contract is a linear function of the end-of-period results, such as revenues, costs, or profits. This result is based on the fact that a linear contract provides more uniform incentives than a non-linear contract, as can be seen by viewing the annual output as the outcome of many small daily actions of the agent. Seen from this perspective, a non-linear contract may create unintentional or non-uniform incentives for the agent in the course of the year, depending on the agent’s performance to date (Gibbons, 2005).

In (3.1) the output value at consumer prices, \( x_t \), can be decomposed into two components, of which one is expected and the other is unexpected:

\[
x_t = e_t + \varepsilon_t
\]  

(3.2)

where \( e_t = E(x_t | I_{t-1}) \) is the expectation of \( x_t \) conditional on the information set \( I \) as available in year \( t-1 \), and \( \varepsilon_t \) is the unexpected part of \( x_t \): \( E(\varepsilon_t | I_{t-1}) = 0 \), \( \text{Var}(\varepsilon_t | I_{t-1}) = \sigma_{\varepsilon}^2 \) and \( \text{Cov}(\varepsilon_t, \varepsilon_s | I_{t-1}) \).
= 0 for all \( s \neq t \). All expectations are assumed to be common knowledge among the principal and agent. In turn, the expected output value can be decomposed into price and quantity:

\[
e_t = E(p_tq_t | I_{t-1}) \tag{3.3}
\]

where \( p \) is the consumer price and \( q \) is the quantity consumed, assumed to be equal to the quantity produced.

The cost incurred by the agent when producing the output is assumed to be a convex function of the expected output value:

\[
C_t = \gamma_0 + \gamma_1 t + 0.5c e_t^2 \tag{3.4}
\]

where \( c \) is a positive parameter and the linear time trend represents cost-reducing technical change if \( \gamma_1 < 0. \) This cost function takes into account that planning more production (larger expected \( q \)) and a higher quality (higher expected \( p \)) lead to higher cost.

The agent can manage price risk by using the futures market. In year \( t-1 \), when the production decision is made, s/he sells at price \( F_{t,t-1} \) quantity \( z_{t-1} \) of the futures contract which matures in year \( t \). In year \( t \) the contract is repurchased at the futures price \( F_{t,t} \). Hence, the agent’s net return for year \( t \) is (e.g., Yoo and Maddala, 1991):

\[
\pi_t = w_t - C_t + (F_{t,t-1} - F_{t,t})z_{t-1} \tag{3.5}
\]

where we assume that \( E(F_{t,t-1} - F_{t,t} | I_{t-1}) = \mu_F \), \( \text{Var}(F_{t,t-1} - F_{t,t} | I_{t-1}) = \sigma_F^2 \), \( \text{Cov}(F_{t,t-1} - F_{t,t}, F_{s,s-1} - F_{s,s} | I_{t-1}) = \sigma_{FS} \) for all \( s \neq t \) and \( \text{Cov}(F_{t,t-1} - F_{t,t}, \epsilon_t | I_{t-1}) = \sigma_{\epsilon F} \).

\(^3\) We also performed our analysis with the linear term \( e_t \) included in the cost function, but when estimating the parameters in (3.25), see Section 3, our empirical dataset appeared to be unable to identify the parameters of the linear and quadratic terms as a consequence of collinearity problems.
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Under the assumptions that the agent’s preference exhibits constant absolute risk aversion (CARA) and that the agent’s net return $\pi_t$ is a normally distributed random variable,\(^4\) the agent maximises the following certainty equivalent of his/her uncertain net return (e.g., Chavas, 2004):

$$\max_{e_t, z_{t-1}} \left\{ E(\pi_t|I_{t-1}) - 0.5 \rho_t \text{Var}(\pi_t|I_{t-1}) \right\}$$  \hspace{1cm} (3.6)

where $\rho_t > 0$ is the Arrow-Pratt coefficient of absolute risk aversion. From (3.1) – (3.5) we obtain that

$$E(\pi_t|I_{t-1}) = \alpha_{t-1} e_t + \beta_{t-1} - \gamma_0 - \gamma_1 t - 0.5 c e_t^2 + \mu_t z_{t-1}$$  \hspace{1cm} (3.7)

and

$$\text{Var}(\pi_t|I_{t-1}) = \alpha_{t-1}^2 \sigma_e^2 + z_{t-1}^2 \sigma_F^2 + 2 \alpha_{t-1} z_{t-1} \sigma_{eF}$$  \hspace{1cm} (3.8)

Substituting (3.7) and (3.8) into (3.6) yields the following first-order condition when maximising for $e_t$:

$$\alpha_{t-1} - c e_t = 0$$  \hspace{1cm} (3.9)

and second-order condition $-c < 0$, which complies with the assumption that $c$ is a positive parameter. Equation (3.9) is called the incentive constraint and must be satisfied by any feasible contract. Another constraint that must be satisfied is the participation constraint, according to which the certainty equivalent of $\pi_t$ equals the agent’s reservation wage, a wage that the agent can obtain without risk in an alternative job:

---

\(^4\) For time series data of low frequency, like annual data, this may be a reasonable assumption; the observation by Moschini and Lapan (1995) that the product of the two random variables price and quantity is generally not normally distributed then applies to higher frequencies.
where $\bar{w}_t$ is the agent’s reservation wage.

Solving (3.6) for $z_{t-1}$, which is similar to minimising $\text{Var}(\pi_t|I_{t-1})$ if $\mu_F = 0$, gives the first-order condition

$$\mu_F - \rho_\tau z_{t-1} \sigma_F^2 - \rho_\tau \alpha_{t-1} \sigma_{\delta F} = 0$$  \hspace{1cm} (3.11)$$

and second-order condition $-\rho_\tau \sigma_F^2 < 0$. The hedge ratio is defined as

$$h_t = z_{t-1}/E(q_t|I_{t-1})$$  \hspace{1cm} (3.12)$$

where, in the case of a crop, the expected production $E(q_t|I_{t-1})$ is determined by the product of area planted and expected yield per hectare. Solving (3.11) for $z_{t-1}$ and substituting into (3.12) give the estimate of the optimal hedge ratio as

$$h_t^* = (\mu_F - \rho_\tau \alpha_{t-1} \sigma_{\delta F})/\rho_\tau \sigma_F^2 E(q_t|I_{t-1})$$  \hspace{1cm} (3.13)$$

The expression for $h_t^*$ in (3.13) reduces to 0 if $\mu_F = \sigma_{\delta F} = 0$: that is, the discount rate is zero ($\mu_F = 0$) and the futures price is indifferent to variations in output value ($\sigma_{\delta F} = 0$). Moreover, $h_t^*$ will also go to zero if $\sigma_F^2$ becomes very large. If, however, $\rho_\tau$ becomes very large, then from (3.12) and (3.13) it appears that $z_{t-1}$ goes to $-\alpha_{t-1} \sigma_{\delta F}/\sigma_F^2$, which is $-1$ times the output-value sharing rate times the estimated coefficient of $(F_{t,F-1} - F_{t,t})$ in the linear regression of $\varepsilon_t$ on a constant and $(F_{t,F-1} - F_{t,t})$. Before $h_t^*$ can be estimated by (3.13), we first have to solve the profit maximisation problem of the principal.
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In this two-stage game, the principal maximises her/his expected payoff in the second stage of the game, while anticipating the behaviour of the agent in the first stage of the game as described above:

Max \{E(x_t - w_t|I_{t-1})\} = Max \{(1 - \alpha_{t,t-1})e_t - \beta_{t,t-1}\}  \quad (3.14)

where the expression on the right-hand side results from (3.1) and (3.2). Taking into account the incentive constraint (3.9), the participation constraint (3.10), and agent’s optimal futures position as implied by (3.11), respectively, the principal knows:

\[ e_t = \frac{\alpha_{t,t-1}}{c} \]  \quad (3.15)

\[ \beta_{t,t-1} = \bar{w}_t - \alpha_{t,t-1}e_t + \gamma_0 + \gamma t + 0.5\sigma^2_e - \mu z_{t-1} \]  \quad (3.16)

\[ + 0.5\rho(\alpha_{t,t-1}^2\sigma^2_e + z_{t-1}^2\sigma^2_F + 2\alpha_{t,t-1}z_{t-1}\sigma_{F\varepsilon}) \]

\[ z_{t-1} = (\mu_F - \rho_1\alpha_{t,t-1}\sigma_{F\varepsilon})/\rho_1\sigma_F^2 \]  \quad (3.17)

Substituting (3.16) in (3.14) and then substituting (3.15), gives

\[ Max\{\alpha_{t,t-1}/c - \bar{w}_t - 0.5\alpha_{t,t-1}^2/c - \gamma_0 - \gamma t \]

\[ + (\mu_F^2 - \rho_1\alpha_{t,t-1}\sigma_{F\varepsilon}\mu_F)/\rho_1\sigma_F^2 - 0.5\rho_1\alpha_{t,t-1}^2\sigma_e^2 \]

\[ - 0.5(\mu_F - \rho_1\alpha_{t,t-1}\sigma_{F\varepsilon})^2/\rho_1\sigma_F^2 - (\alpha_{t,t-1}\sigma_{F\varepsilon}\mu_F - \rho_1\alpha_{t,t-1}\sigma_{F\varepsilon}^2)/\sigma_F^2 \} \]

of which the first-order condition is

\[ 1/c - \sigma_{F\varepsilon}\mu_F/\sigma_F^2 - (1/c + \rho_1\sigma_e^2 - \rho_1\sigma_{F\varepsilon}^2/\sigma_F^2)\alpha_{t,t-1} = 0 \]  \quad (3.19)

and the second-order condition imposes \(- (1/c - \rho_1\sigma_e^2 - \rho_1\sigma_{F\varepsilon}^2/\sigma_F^2) < 0.\)
Chapter 3. Time-Varying Hedge Ratios

Solving (3.19) for \( \alpha_{t,t-1} \) we obtain after some rewriting

\[
\alpha_{t,t-1} = \frac{1 - c \sigma_{eF} \mu_F / \sigma_F^2}{1 + c \rho_t (\sigma_e^2 \sigma_F^2 - \sigma_{eF}^2) / \sigma_F^2}
\]  
(3.20)

Equation (3.20), known as the incentive intensity principle, shows that under the condition that \( \alpha_{t,t-1} \) must be between zero (full insurance) and one (full incentive), the more risk-averse the agent is, the smaller \( \alpha_{t,t-1} \) becomes (\( \rho_t \) is higher, implying that \( \sigma_e^2 \sigma_F^2 > \sigma_{eF}^2 \)). Furthermore, if \( \sigma_{eF} = 0 \), then (3.20) reduces to

\[
\alpha_{t,t-1} = \frac{1}{1 + c \rho_t \sigma_e^2}
\]  
(3.21)

in which case \( \alpha_{t,t-1} \) diminishes if the marginal cost of effort increases more quickly (\( c \) is higher), or if there is more uncertainty in output value (\( \sigma_e^2 \) is higher). Substituting (3.20) in (3.13) leads to the following expression for the optimal hedge ratio:

\[
h_t^* = \frac{[\mu_F (1 / \rho_t + c \sigma_e^2) - \sigma_{eF}]}{[\sigma_F^2 + c \rho_t (\sigma_e^2 \sigma_F^2 - \sigma_{eF}^2)]} E(q_t | I_{t-1})
\]  
(3.22)

which includes the time-varying components \( \rho_t \) and \( E(q_t | I_{t-1}) \) so that the optimal hedge ratio can be expected to vary over time.

So, a rational principal determines the optimal values of the contract parameters \( \alpha_{t,t-1} \) according to (3.20) and, subsequently, \( \beta_{t,t-1} \) according (3.16) after substituting (3.15) and (3.17). This implies that not only the agent but also the principal is assumed to know the values of \( c; \sigma_{eF}; \mu_F; \sigma_F^2; \rho_t; \sigma_e^2; \bar{w}_t; \gamma_0; \) and \( \gamma_1 \).

To derive \( \rho_t \) first consider the incentive constraint in (3.9) and the incentive intensity in (3.20). Solving (3.9) for \( \alpha_{t,t-1} \), substituting this solution for \( \alpha_{t,t-1} \) in (3.20) and inserting the values that have already been estimated we arrive at the following solution for \( \rho_t \):
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\[ \rho_t = \{ \hat{\sigma}_F - c \hat{\epsilon}_t \hat{\sigma}_F^2 + \hat{\sigma}_{AF} \hat{\mu}_F \} / \{ c^2 \hat{\epsilon}_t ( \hat{\sigma}_F^2 - \hat{\sigma}_{AF}^2 ) \} \]  
\hspace{1cm} (3.23)

The agent’s risk parameter is considered to be an intrinsic characteristic of the agent and as a consequence of that the estimate of \( \rho_t \) under the actual situation (i.e., with a futures market), which is, in fact, the most realistic estimate of \( \rho_t \) we can obtain, is also used when simulating the market outcomes for the second-best optimal solution when assuming that there is no futures market available.

To assess the importance of the producers’ risk parameter and the availability of a futures market for the performance of the marketing channel, we determine the (agency) coordination costs of the marketing channel involving the farmers and marketing firms. We compare the coordination costs of the marketing channel with and without futures trade. This analysis will provide insights into the role of the futures markets regarding coordination costs of the marketing channel.\(^5\) The agency (coordination) costs (\( AC \)) of the marketing channel are determined as the difference between the expectation of the first-best optimal profits (i.e., first-best optimal solution) and the expectation of the second-best optimal profits (i.e., second-best optimal solution) as follows

\[ AC_t = E(\pi^*_m + \pi^*_t | I_{t-1}) - E(\pi_{ml} + \pi_t | I_{t-1}) \]  
\hspace{1cm} (3.24)

where \( \pi_{ml} = x_t - w_t \) are the profits of the marketing firm, see (3.14), and \( \pi_t = w_t - C_t + (F_{t_{t-1}} - F_{t,t})z_{t-1} \) are the profits of the farmers, see (3.5). The first-best optimal solution of the marketing channel, \( E(\pi^*_m + \pi^*_t | I_{t-1}) \) is obtained by setting the farmers’ risk aversion coefficient in (3.23) to zero (\( \rho_t = 0 \)), where \( \pi^*_m \) and \( \pi^*_t \) are respectively the first-

\(^5\) Agency (coordination) costs may include ex ante information search costs associated with adverse selection (hidden information) problems and/or ex post monitoring and enforcement costs associated with moral hazard problems. These costs are believed to be the main reasons for which the marketing channel cannot achieve the first best optimal solution. We examine the role of incentives in reducing coordination costs of the marketing channel.
best optimal profits of marketing firms and farmers. In this sense both farmers and the marketing firms (in particular the retailers) are considered risk neutral, and information flows between farmers and marketing firms are obtained at zero cost. These restrictions also imply that the futures market is eliminated from the model: \( z_{t-1} = \mu_F = \sigma_{ef} = 0 \). With the above mentioned restrictions for the first-best optimal solution, (3.20) yields \( \alpha_{t,t-1} = 1 \), (3.16) then yields \( \beta_{t,t-1} = \bar{w}_t - 0.5/c + \gamma_0 + \gamma_1 t \), and (3.15) yields \( e_t = 1/c \). These derivations are then substituted into the respective profits of farmers and marketing firms in order to obtain their respective first-best optimal profits. Now that all marketing channel members are risk-neutral, the futures market has become superfluous and the principal can give full incentives to the agent as the principal is no more constrained by the optimal trade-off according to which a higher incentive intensity can only be established at the cost of a higher risk-premium (a higher risk-premium is asked for by the agent as a consequence of the increased risk the agent faces at a higher incentive intensity).

On the contrary, the second-best optimal solution of the marketing channel, \( E(\pi_{mt} + \pi_t | I_{t-1}) \) is obtained when the respective profit functions for marketing firms and farmers take account of risk aversion of the farmers, and that the derived risk-aversion coefficient, \( \rho_t \), in (3.23), is used in estimating the farmers’ profits. Subsequently, we can determine the coordination costs when channel members cannot trade futures contracts but are as risk adverse as they were when they could trade on the futures market. This is done by setting \( \sigma_{ef} = \mu_F = 0 \) and considering the empirical values of \( \rho_t \) obtained before imposing these restrictions as given. Then the difference between the two profits in (3.24) is the coordination cost of the marketing channel when channel members cannot trade on the futures market. In the next section, we discuss how we can estimate these values empirically and assess the validity of the model.
3.3 Econometric Issues and Data Requirements

We now describe the data we used to estimate the parameters for determining the optimal hedge ratio. Note that all prices – whether spot prices or futures prices – are deflated by the consumer price index. The fit of the regression of the consumer price \( p_t \) on a constant and the futures price \( F_{t,t-1} \) gives us the estimate of \( E(p_t|I_{t-1}) \).\(^6\) We will replace \( E(p_t|I_{t-1}) \) by this estimate, denoted as \( \hat{E}(p_t|I_{t-1}) \). Using data on yield per hectare and the number of hectares planted, the estimate of \( E(q_t|I_{t-1}) \), denoted as \( \hat{E}(q_t|I_{t-1}) \), is obtained by the product of area planted and expected yield per hectare, where the expected yield per hectare is assumed to be an autonomous positive linear time trend. For the computation of the expected output value \( e_t \) and the variance of the random component of the output value \( \sigma_e^2 \) denoted as \( \hat{\sigma}_e^2 \), see the appendix at the end of this thesis. Next, using the data on \( F_{t,t-1} \) and \( F_{t,t} \) it is straightforward to obtain the estimates of \( \sigma_{e,F} \), \( \mu_F \) and \( \sigma_F^2 \), denoted as \( \hat{\sigma}_{e,F} \), \( \hat{\mu}_F \) and \( \hat{\sigma}_F^2 \), respectively. Lastly, as we also have data on \( \bar{w}_t \), the only other estimates we need in order to be able to compute the optimal hedge ratio are those of \( \rho_t \) and \( c \).

Next, we substitute (3.23) together with the solution for \( \alpha_{t,t-1} \) into (3.11) to solve for \( z_{t-1} \). Subsequently, the solutions for \( \alpha_{t,t-1} \), \( \rho_t \) and \( z_{t-1} \) are inserted into (3.16) and both the resulting expression for \( \beta_{t,t-1} \) and the solution for \( \alpha_{t,t-1} \) are then substituted in (3.1), yielding

\[
\begin{align*}
    w_t - \bar{w}_t - 0.5\hat{e}_t &= \gamma_0 + \gamma_1 t + c\hat{e}_t(x_t - \hat{e}_t + 0.5\hat{\sigma}_{e,F} \hat{\mu}_F / \hat{\sigma}_F^2) \\
    &- 0.5c^2\hat{e}_t(\hat{\mu}_F^2 / \hat{\sigma}_F^2)(\hat{\sigma}_F^2\hat{\sigma}_e^2 - \hat{\sigma}_{e,F}^2) / (\hat{\sigma}_F^2 - c[\hat{\epsilon}_t\hat{\sigma}_F^2 + \hat{\sigma}_{e,F} \hat{\mu}_F]) \\
\end{align*}
\]

\(^6\) Note that \( p \) is the consumer (i.e. retail) price while \( F \) concerns the futures notation of the producer price. Nevertheless, since we are working with annual data, not with data of a higher frequency such as monthly or weekly observations, we do not expect to observe any asymmetrical price transmission between producers and retailers. For a review of asymmetrical price transmission see Meyer and Von Cramon-Taubadel (2004).
Apart from the $\gamma$ parameters in the deterministic part of (3.25), the only unknown parameter in the equation is $c$. We estimate $\gamma_0$, $\gamma_1$ and $c$ in (3.25) by nonlinear least squares\(^7\) and then substitute the estimate of $c$, denoted as $\hat{c}$, in (3.23) to obtain the estimate of $\rho_t$, denoted as $\hat{\rho}_t$,\(^8\) and in (3.9) to solve for $\alpha_{t,-1}$, denoted as $\hat{\alpha}_{t,-1}$. Finally, we use all these estimates in (3.11) to solve for $z_{t-1}$, denoted as $\hat{z}_{t-1}$. In this way we obtain the optimal hedge ratio in (3.12) (cf. (3.13)). Using (3.16) we can now also obtain an estimate for $\beta_{t,-1}$, denoted as $\hat{\beta}_{t,-1}$, which allows us to compare the estimates $\hat{\alpha}_{t,-1}x_t + \hat{\beta}_{t,-1} = \hat{w}_t$ with the actual values of $w_t$, see (3.1), to evaluate the model’s validity for determining the optimal hedge ratio and the coordination costs of the marketing channel. Furthermore, a required condition for the application of the Certainty Equivalent Approach is that the returns (i.e., profits) of the risk-averse agent should be normally distributed. In this respect, we can test for the normality assumption regarding $\hat{\pi}_t$, as well.

### 3.4 Empirical Illustration

Every year, some eight million tonnes of potatoes are produced in the Netherlands, mainly on family farms. About half are ware potatoes, approximately 20 percent are seed potatoes, while the remaining 30 percent are potatoes grown for starch (NIVAP Holland, 2002). We focus on the ware potatoes.

---

\(^7\) Note that the estimation equation includes regressors that are estimates themselves. Nevertheless, these estimates are not obtained by the fit of extensive regressions and hence, in order to overcome the ‘generated regressors’ problem (see Pagan, 1984), we cannot jointly estimate these regressions in a simultaneous model with (3.25) by FIML. Therefore, our results may be vulnerable to the error-in-variables problem, although footnote 13 shows that our estimate of $c$ seems to be quite consistent.

\(^8\) This section is about estimation and so is equation (3.23). Consequently, (3.23) must be considered as a way to estimate rather than to explain $\rho$ by the data we observe as these data are generally considered to be affected by the intrinsically behavioural parameter $\rho$ (and hence, contain information about its actual value) instead of the other way round. In fact, according to the CARA assumption $\rho$ is a constant for all $e$, i.e., $e$ does not cause $\rho$
There is very little interference in the free market for ware potatoes in the Netherlands and hence 'outside' involvement is minimal (e.g. Young, 1977; Smidts, 1990; Baltussen and Van Asseldonk, 2005). Nevertheless, most ware potatoes are sold to wholesalers, and most of the wholesale trade has become concentrated in relatively few hands, as the major users – particularly the large retailers, processors and export markets – demand large quantities with tight specifications that only the larger wholesalers can meet. In response to this development in the market, the need has arisen to procure potatoes before harvest. Various arrangements to do so have emerged, the most important being fixed price contracts and pooling contracts. These contractual forms are well nested in the linear contract of the classic agency model.9

The fixed-price contract involves selling a net amount of potatoes at a fixed contract price. In the pooling-contract system, potatoes supplied by the farmers are sold by wholesalers throughout the year. The resulting gross returns from these sales, minus the wholesalers’ expenses, are distributed across the producers, in proportion to the amount of potatoes delivered. The reason non-fixed price arrangements have been adopted is because wholesalers wish to retain their core suppliers by offering them contracts that bear some relation to the market price, as these suppliers can use the potato futures contract of the Amsterdam Exchanges10 for hedging purposes and, see Kuiper et al. (2002), price discovery.

The annual data used for our research cover the period 1971 - 2003 and were obtained from Statistics Netherlands and Euronext.11 They include the farm and retail prices (Euro/kg) of ware potatoes, both deflated by the consumer price index (1990 = 1.00); the area planted

---

9 If a farmer sells a relatively larger part of his/her harvest through a fixed price contract at the time that the production decision is made about what and how much to plant, then this can be represented by a lower value of $\alpha_{t-1}$ and a higher value of $\beta_{t-1}$ in (3.1). As a consequence of the lower value for $\alpha_{t-1}$ we can see from (3.17) that $z_{t-1}$ will become smaller (and hence, $h_t^*$) given that $\sigma_{c,}\frac{\partial}{\partial e}$ is smaller than zero (see also the discussion below (3.13)).

10 The Amsterdam Exchange used to be called AEX, but in 2000 it was merged with exchanges in Brussels, London, Lisbon and Paris, creating Euronext.
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(1000 ha) and the yield per hectare (100 kg/ha). As a proxy for \( w \), we multiplied the area planted by the rent price of land (Euro/ha) deflated by the consumer price index. We used the futures price (Euro/kg) for delivery in April of year \( t \) quoted as the closing price of the first trading day of April in year \( t-1 \) to represent \( F_{t,t-1} \); to represent \( F_{t,t} \) we used the futures price (Euro/kg) for delivery in April of year \( t \) quoted as the closing price of the first trading day of November (when most potatoes are sold by the farmers) in year \( t-1 \). Both \( F_{t,t-1} \) and \( F_{t,t} \) are deflated by the consumer price index as well. From these data we derived the variables and parameters of interest as described in the previous section, in order to estimate the optimal hedge ratio for the Dutch case along the lines of the principal-agent model. \(^{12}\) Table 3.1 provides some descriptive statistics of the time series used.

The results of estimating (3.25) by nonlinear least squares are displayed in Table 3.2. The estimate of \( c \) equals 0.27.\(^{13}\) Computing \( \hat{\alpha}_{t,t-1} \) along the lines of (3.10), that is, \( \hat{\alpha}_{t,t-1} = \hat{c} \hat{\alpha} \) while using \( \hat{c} = 0.27 \), yields values that increase within a range of 0.2 and 0.4. These estimated values support the theoretical restriction \( 0 \leq \alpha_{t,t-1} \leq 1 \). Moreover, substituting \( \hat{c} = 0.27 \) in (3.21) yields feasible (i.e., positive) values for \( \hat{\rho}_t \) decreasing from 300 in 1971 to 200 in 2003 according to a decreasing convex curve, indicating diminishing average risk-aversion among farmers. The graph of \( \hat{\rho}_t \) has quite a smooth pattern: note the absence of many short-term fluctuations around the curve that would have detracted from the credibility of the model that allows this coefficient to vary through time for the ‘same producer’. Also observe that the

\(^{11}\) The data are available from the authors upon request.

\(^{12}\) \( F_{t,t-1} \) appears to be an optimal forecast of the farm price \( p_t \) in the sense that \( \delta_0 = 0 \) and \( \delta_1 = 1 \) in the “Mincer-Zarnowitz regression” \( Realisation_t = \delta_0 + \delta_1 Forecast + \epsilon_t \) (see e.g., Diebold, 1998, p. 342) with an \( R^2 \) of 0.60 and, after omitting the outlying observations in 1976, 1984 and 1998, the regression of \( p_tq_t \) on a constant and \( \hat{E}(p_t | I_{t-1})\hat{E}(q_t | I_{t-1}) \) has an \( R^2 \) of 0.61.

\(^{13}\) An estimate of 0.19 is obtained if we rewrite the model in (3.25) as a conditional error-correction model (cf. Boswijk, 1994). Note that the estimate of \( c \) in Table 3.1 does not differ significantly from this super-consistent
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negative coefficient of the linear trend (i.e., the estimate of $\gamma_1$) complies with the cost-reducing technological advances in agriculture.

Table 3.1: Descriptive Statistics of Time Series Variables Used Regarding Dutch Ware Potatoes for the Sample Period 1971-2003 (33 Observations)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Med</th>
<th>Max</th>
<th>Min</th>
<th>SD</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_t$</td>
<td>0.39</td>
<td>0.37</td>
<td>0.89</td>
<td>0.26</td>
<td>0.11</td>
<td>28</td>
</tr>
<tr>
<td>$p_t^f$</td>
<td>0.12</td>
<td>0.10</td>
<td>0.37</td>
<td>0.04</td>
<td>0.08</td>
<td>68</td>
</tr>
<tr>
<td>$F_{t,t}$</td>
<td>0.17</td>
<td>0.14</td>
<td>0.44</td>
<td>0.05</td>
<td>0.10</td>
<td>61</td>
</tr>
<tr>
<td>$F_{t,t-1}$</td>
<td>0.14</td>
<td>0.14</td>
<td>0.21</td>
<td>0.08</td>
<td>0.04</td>
<td>27</td>
</tr>
<tr>
<td>$p_t^f$</td>
<td>250</td>
<td>248</td>
<td>302</td>
<td>213</td>
<td>20.7</td>
<td>8</td>
</tr>
<tr>
<td>$a_t$</td>
<td>70.6</td>
<td>70.6</td>
<td>86.1</td>
<td>52.3</td>
<td>9.22</td>
<td>13</td>
</tr>
<tr>
<td>$y_t$</td>
<td>422</td>
<td>415</td>
<td>531</td>
<td>310</td>
<td>59.1</td>
<td>14</td>
</tr>
<tr>
<td>$q_t$</td>
<td>2.97</td>
<td>2.96</td>
<td>4.46</td>
<td>1.72</td>
<td>0.75</td>
<td>25</td>
</tr>
<tr>
<td>$x_t$</td>
<td>1.12</td>
<td>1.03</td>
<td>1.96</td>
<td>0.72</td>
<td>0.30</td>
<td>26</td>
</tr>
<tr>
<td>$e_t$</td>
<td>1.12</td>
<td>1.14</td>
<td>1.37</td>
<td>0.85</td>
<td>0.15</td>
<td>14</td>
</tr>
<tr>
<td>$w_t$</td>
<td>0.34</td>
<td>0.28</td>
<td>0.80</td>
<td>0.13</td>
<td>0.19</td>
<td>57</td>
</tr>
<tr>
<td>$\overline{w_i}$</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>0.01</td>
<td>0.00</td>
<td>19</td>
</tr>
</tbody>
</table>

Med: Median; Max: Maximum; Min: Minimum; SD: Standard Deviation; CV: Coefficient of Variation (= 100 × SD / Mean); $p_t$: retail price (weighted average per year in €/kg) divided by the consumer price index (1990 = 1.00); $p_t^f$: farm price (weighted average per harvest year running from August in year $t$−1 to May in year $t$ in €/kg) divided by the consumer price index (1990 = 1.00); $F_{t,t}$: futures price for delivery in April of year $t$ quoted as the closing price of the first trading day of November in year $t$−1 (€/kg) divided by the consumer price index (1990 = 1.00); $F_{t,t-1}$: futures price for delivery in April of year $t$ quoted as the closing price of the first trading day of April in year $t$−1 (€/kg) divided by the consumer price index (1990 = 1.00); $p_t^f$: rent price of land (weighted average per year in €/ha) divided by the consumer price index (1990 = 1.00); $a_t$: area planted (× 1000 ha); $y_t$: yield per hectare (× 100 kg); $q_t$: quantity produced (× 10^9 kg) (= $a_t y_t / 10^4$); $x_t$: retail output value (× 10^9 €) (= $p_t q_t$); $e_t$: expected retail output value (× 10^9 €); $w_t$: farm output value (× 10^9 €) (= $p_t^f q_t$); $\overline{w_i}$: rent value of the land used (× 10^9 €) (= $p_t^f a_t / 10^6$).

cointegrating parameter estimate, which shows that the results remain the same, regardless of whether trend stationarity or difference stationarity are chosen.
Table 3.2: Parameter Estimates of the Cost Function as Estimated in Equation (3.25)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_0$</td>
<td>-0.007</td>
<td>-0.057</td>
<td>-0.130</td>
<td>0.897</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>-0.016</td>
<td>0.003</td>
<td>-5.415</td>
<td>0.000</td>
</tr>
<tr>
<td>$c$</td>
<td>0.270</td>
<td>0.094</td>
<td>2.872</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Sample: 1971 - 2003; Number of Observations = 33; $R^2 = 0.53$;
$R^2_{adj} = 0.50$; Std. Error Resid = 0.16; Sum Squared Resid = 0.75;
Durbin-Watson = 2.19

Using the estimates of $c$, $\alpha_{t,t-1}$ and $\rho$, we can solve for $z_{t-1}$ in (3.17) to obtain estimates of the optimal hedge ratio in (3.13). From Figure 3.1, which shows these estimates of $\hat{h}^*_t$, it is clear that the ratio varies over time, decreasing from 0.21 in 1971 to 0.15 in 2003. Measuring risk by $\text{Var}(\pi_t | I_{t-1})$, see (3.8), the average risk reduction over the sample period when $\hat{z}_{t-1} = \hat{h}^*_t \hat{E}(q_t | I_{t-1})$ is used instead of the highest (lowest) hedge ratio, giving $\hat{z}_{t-1} = 0.21 \hat{E}(q_t | I_{t-1})$ ($\hat{z}_{t-1} = 0.15 \hat{E}(q_t | I_{t-1})$), appears to be 5.27% (3.37%). The average risk reduction when using $\hat{z}_{t-1} = \hat{h}^*_t \hat{E}(q_t | I_{t-1})$ instead of no hedging at all is quite stable at 39.14% (minimum = 39.13%; maximum = 39.15%).

To compare our estimates of the optimal hedge ratio with the common price risk minimising hedge ratio (e.g., Ederington, 1979), we utilise (3.1) and (3.17). We can derive the price risk minimising hedge ratio, $h_p$, from (3.17) while using (3.1) if we assume that the discount rate is zero ($\mu_F = 0$), that the output-value sharing rate, $\alpha_{t,t-1}$, is equal to one and that there is no yield risk. It follows that the time-invariant version of $h_p$ can simply be...
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computed as the estimated coefficient of \((F_{t,t} - F_{t,t-1})\) in a regression of \((p_t^f - F_{t,t-1})\) on a constant and \((F_{t,t} - F_{t,t-1})\), where \(p_t^f\) is the farm price in the spot market, see also Table 3.1 and footnote 12.

\[
\text{Figure 3.1: Principal-Agent Model Estimate of the Optimal Hedge Ratio (H) for the Dutch Ware Potato Sector Hedging on the Futures Market in Amsterdam}
\]

The estimate of \(h_p\) is 1 \((i.e.,\) hedging all the output\), (std. error = 0.07; \(t\) value = 14.56), yielding a hedging effectiveness of 87\% (= \(R^2\) of the regression). The price risk minimising hedge ratio \(h_p\) and the corresponding hedging effectiveness are higher than the ones obtained by our model. This can be explained by the fact that our model, in contrast to the price risk minimising hedging framework, does take into account yield risk (reducing \(\sigma_{df}\) in (17)) and the competition of alternative risk management instruments like fixed-price contracts (reducing \(\alpha_{t,t-1}\) in (17)). Consequently, \(h_i^*\) may provide a better understanding of farmers’ hedging behaviour \((e.g.,\) their limited use of futures markets).
Next, regarding the influence of the farmers’ risk parameter for the performance of the marketing channel, the results show that as a consequence of increases in the farmers’
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incentive intensity, the coordination cost of the marketing channel (see (3.24)) decreased considerably. The coordination costs decreased from about 1.29 billion Euros in 1971 to 1.09 billion Euros in 2003, without futures; and from 1.07 billion Euros in 1971 to 0.84 billion Euros in 2003, with futures, see Figures 3.2 and 3.3. In Figure 3.2, we show the expectations of the total profits of the marketing channel for three situations: the optimal (i.e., first-best) situation (i.e., risk neutrality), the second-best situation with futures trade, and the second-best situation without futures trade. The difference between the expected profits for the first-best optimal situation and for the second-best optimal situation with futures trade yields the coordination costs for the situation with futures as shown in Figure 3.3. Similarly, the difference between the expected profits for the first-best optimal situation and the second-best optimal situation without futures trade yields the coordination costs for the situation without futures, also shown in Figure 3.3. The coordination costs with futures are lower than without futures. This result is consistent with the role of futures markets in providing information regarding prices and hence, the hedging function as a risk-management instrument.

Figure 3.4: Farmers’ actual wage (WP = \( w_i \)) and Farmers’ estimated wage (WPE = \( \hat{w}_i \))
Chapter 3. Time-Varying Hedge Ratios

To check the validity of the model that we used to estimate the variables in this chapter, we compare the actual wages of the farmers with their rewards estimated by the model, see Figure 3.4. The estimated value explains 26% of the variance in the actual payment. In spite of this somewhat limited fit, the model does provide an unbiased and significant prediction, as we can see from performing a regression of \( w_t \) on a constant, \( \hat{\alpha}_{t-1} x_t \) and \( \hat{\beta}_{t-1} \), see Table 3.3.

In this regression we cannot reject the joint hypotheses of a zero constant and unit coefficients of both \( \hat{\alpha}_{t-1} x_t \) and \( \hat{\beta}_{t-1} \) (\( p \) value = 0.93). Lastly, testing for the normality of \( \hat{\pi}_t \) by using the proxy \( \hat{\pi}_t = w_t - \hat{C}_t + (F_{t-1} - F_t)\hat{\pi}_{t-1} \) with \( \hat{C}_t = \hat{\gamma}_0 + \hat{\gamma}_1 t + 0.5\hat{\sigma}^2 \), while omitting two outlying observations, also leads to non rejection (\( p \) value Jarque-Bera statistic = 0.60).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.074</td>
<td>0.117</td>
<td>0.633</td>
<td>0.532</td>
</tr>
<tr>
<td>( \hat{\alpha}_{t-1} x_t )</td>
<td>0.774</td>
<td>0.348</td>
<td>2.223</td>
<td>0.034</td>
</tr>
<tr>
<td>( \hat{\beta}_{t-1} )</td>
<td>0.877</td>
<td>0.267</td>
<td>3.280</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Sample: 1971 - 2003; Number of Observations = 33; \( R^2 = 0.27; \)
\( R^2_{\text{adj}} = 0.22; \) Std. Error Resid = 0.16; Sum Squared Resid = 0.74;
Durbin-Watson = 2.16

3.5 Concluding Remarks

For many crops, farmers’ production decisions must be based on the output prices and yield per hectare anticipated in a year’s time. Consequently, crop producers base their production decisions on an average of prices over a number of years, rather than on the price obtained on
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a single trading day. Therefore, a model that considers time series at an annual frequency might be of particular interest for farmers who wish to estimate the optimal hedge ratio. Furthermore, the farmers’ hedging decisions will be influenced by the contractual relationships the farmers have with other channel members (Pennings and Wansink, 2004). The classic agency framework allows us to derive a time-varying optimal hedge ratio taking account of both the crop farmer decision structure (using the average price over a number of years) and her/his contractual relationships in the commodity marketing channel.

In our empirical application of the model to the Dutch ware potato sector’s futures market in Amsterdam for 1971 – 2003, the optimal hedge ratio decreases from 0.21 in 1971 to 0.15 in 2003. Although the hedge ratio clearly varies with time, working with a constant hedge ratio of 0.21 or 0.15 reduces the average risk reduction by only 5.27% and 3.37% respectively vis-à-vis the risk reduction obtained by the time-varying ratio. Nevertheless, compared with not hedging, the average risk reduction by hedging is a stable 39.14% over the whole sample period (1971 - 2003), showing the usefulness of the futures market as a risk-management instrument in the Dutch ware potato sector over the last three decades.

The reported hedge ratios in 1995 (0.16) and 1996 (0.15) are clearly lower than the ones in Pennings and Meulenberg (1997b), who used weekly data on the basis of which they estimated an optimal hedge ratio in a mean-variance framework for Dutch potato growers of 0.44 for 1995 and 1996. This difference is attributable to the fact that their mean-variance model dealt only with price risk. Furthermore, futures markets more often offer the opportunity to hedge against price risk rather than against output value risk, yet – as is captured by the agency model that we propose – it is the latter risk that the farmers must deal with as well. Our estimate of 1 (i.e., hedging all the output) for the price risk minimising hedge ratio obtained on the basis of annual data over the period 1971-2003 confirms the result that higher hedge ratios are obtained if only price risk is considered.
Although the contracts established between farmers and other market participants in the marketing channel may not be identical to those in our model, most contracts do have a fixed (sometimes implicit) and variable (incentive) component. Examples can be found in European agriculture in the dairy sector and horticulture industry, where farmers receive baseline compensation plus a variable compensation based on certain quality and quantity indicators. Furthermore, farmers who are members of a cooperative, as are many Dutch potato growers, have ‘contracts’ of a type very similar to that described in our paper (e.g., Cook, 1995; Fulton and Giannakas, 2001). Our model may be expanded to include some of the idiosyncratic characteristics of contracts in agriculture. Such work could then be used to explain individual differences in farmers’ risk behaviour (e.g., Pennings and Garcia, 2004).

Furthermore, we examine the influence of allowing farmers’ risk aversion to be time-varying instead of being constant and the availability of the futures market as a risk-management instrument for the performance of the marketing channel. The results show that as a consequence of increases in the farmers’ incentive intensity, the coordination efficiency of the marketing channel has been greatly improved as can be observed from the fact that the coordination cost of the marketing channel decreased considerably. The coordination costs decreased from about 1.29 billion Euros in 1971 to 1.09 billion Euros in 2003, without futures trade; and from 1.07 billion Euros in 1971 to 0.84 billion Euros in 2003, with futures trade. The coordination costs with futures are lower than without futures. This result complies with the role of the futures markets in providing information regarding prices.

This chapter has two implications for extension economists. First, it provides a tool (a method) to analyse and determine optimal hedge ratios that account for the fact that the time horizon of farmers, and hence the relevant decision context, is an annual one. Whereas various authors have calculated hedge ratios using weekly or monthly hedge time horizons, this time horizon does not reflect farmers’ actual decision structure. Furthermore, our paper
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takes into account the fact that farmers do not make decisions in isolation, but that they are part of a marketing channel. Their relationship with other channel partners, by means of contracts, influences their optimal hedging behaviour.

Our analysis has been performed on the basis of the implicit assumption of a representative farmer. Furthermore, although the annual frequency of the data we considered in our study is consistent with the fact that agricultural production is a lengthy process, there may be large differences in performance among crop farmers and hence in their individual optimal hedge ratios. There is therefore a clear need for further research on time-series data at the farm level (requiring the availability of panel data).
CHAPTER 4
Incentive Provision and Coordination Costs in Food Marketing Channels: A Multi-Stage Channel Agency-Theory Perspective*

Abstract

Food supply chains have become extensively vertically coordinated through the use of contracts as an organisational response to the needs of consumers in the saturated food markets of the industrialised countries. The contracts involved must establish an optimal trade-off between incentive provision and risk reduction. Agency theory can be used to model this trade-off and we show how to do this in a three-stage (producer, wholesaler, retailer) principal-agent, supply-chain model. Its application to the Dutch supply chain of ware potatoes shows that during the period 1961 - 2002 retailers were able to provide more incentives to wholesalers and producers, and, as a consequence, the costs of coordination in the supply chain decreased considerably.

Keywords: agency theory, supply chains, coordination costs, incentives, risk

4.1 Introduction

Food supply chains are facing a transition from using open-market mechanisms for coordinating the various stages of value adding (e.g., production, wholesale, retail) to negotiated coordination involving governance forms such as alliances, joint ventures, contracts, franchising agreements, and vertical integration (e.g., Boehlje et al., 1999). A driving force behind this integration is the need to coordinate the timing and quality of purchases and deliveries along the supply chain. Perishability of products caused early integration, but other factors — relating to economies of scale in the management of information about consumers and their preferences, for example — reinforced the trend (e.g., Johnson and Berdegué, 2004).

In particular, the rise of mega-processors and -retailers has resulted in small proportions of the produce being traded on the open market. Often, the competitiveness of these enterprises is strengthened through strict grades and standards, imposed on the producer-suppliers through contracts. Contracts provide the contracting parties a certain level of control and risk sharing and are often used to improve quality and/or performance through incentive structures (e.g., Curtis and McCluskey, 2003; Milgrom and Roberts, 1992). As such, vertical coordination through contracting can be seen as an organisational response to an increased demand for quality among increasingly discerning consumers (Wolf et al., 2001). The resulting market orientation implies adjusting production processes and products to respond to specific consumer demands and market signals and trends. In contrast, product orientation as based on the principles that good products sell themselves and should be standardised to keep costs down becomes less suitable, now that consumer food markets in industrialised countries have become saturated, international competition is growing, and food companies must concomitantly meet the rising demand for product differentiation and sustainable production. Wholesalers and processors are important economic actors that link producers with the needs
and wants of the consumers as articulated by the retailers. To become successful, such a link has to solve the problems of information asymmetry and incentive incompatibility between the trading parties. Of these, the producers have more information about their own effort than the wholesalers and the retailers, and if the producers obtain a fixed wage, they want to keep costs down at the expense of quality and/or product differentiation, while the retailers tend to ask for higher quality and differentiated products to satisfy consumers' needs.

Given its focus on developing contracts that align incentives, while at the same time addressing monitoring issues, this paper will employ principal-agent theory to address the issues of coordination and risk-aversion in an integrated food supply-chain model consisting of three stages: producers, wholesalers/processors, and retailers. The key idea within agency theory is that principal-agent relationships should reflect efficient information and risk-bearing costs, incentive alignments, and the contract as the unit of analysis (e.g., Cook and Barry, 2004). An agency problem arises if the risk-averse agent (e.g., producer and/or wholesaler/processor) is assigned decision (or control) rights (e.g., regarding production, distribution, processing) that affect the principal's (e.g., retailer’s and consumer’s) wealth or utility function. The principal cannot fully observe the effort of the agent and, hence, is not sure whether or not the agent acts according to the best interest of the principal when the goals of the principal and agent conflict. Moreover, simply assigning claims to the residual income generated by the asset as an incentive to the agent to act in the interest of the principal does not go without the cost of more risk on the part of the agent, who will then be asking for a higher risk-premium.

Principal-agent theory applies to all cases where one party has an informational advantage over another that can be exploited to the benefit of the advantaged party, at the expense of the advantaged party's trading partner (Salanić, 1997). Given agency problems, we cannot expect a supply chain to function as well economically as it would if all information
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were shared without any cost involved or if the incentives of principal and agent would be cost aligned. This shortfall is called agency costs (Cook and Barry, 2004). Those costs may include \textit{ex ante} search costs (associated with adverse-selection (hidden-information) problems) and/or \textit{ex post} monitoring and enforcement costs (associated with moral-hazard (hidden-action) problems) (\textit{e.g.}, Sykuta and Cook, 2001; Douma and Schreuder, 2002). This chapter will show how to estimate these agency costs in a food supply chain. Its main contribution in this respect is the extension of the widely-elaborated two-stage principal-agent model into a three-stage (\textit{e.g.}, producer, wholesaler, retailer) supply-chain framework. The rest of this chapter is structured as follows. After deriving the model in Section 4.2, an empirical illustration is provided for the Dutch supply chain of ware potatoes in Section 4.3. Finally, concluding remarks are provided in Section 4.4.

4.2 Three-Stage, Supply-Chain, Principal-Agent Model

Consider a product that is produced by producers, processed and distributed by wholesalers, and finally sold to the consumers by retailers. Following Chapters 2 and 3, let $x$ denote the retail value of the product. This value can be decomposed as

$$ x = e + \epsilon $$ (4.1)

where $e$ is the retail value as expected at the time when the producers take their production decision and $\epsilon$ is the unexpected component with mean zero and variance $\sigma^2$. The retailers purchase the product from the wholesalers by offering them the linear contract

$$ W_w = \alpha_w x + \beta_w $$ (4.2)

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where $W_w$ is the retailers' payment to the wholesalers, $0 \leq \alpha_w \leq 1$ is the retail value-sharing rate (i.e., incentive intensity), and $\beta_w$ is a fixed payment. In turn, the wholesalers purchase the product from the producers by offering them the revenue-sharing contract

$$W_p = \alpha_p \alpha_w x + \beta_p \tag{4.3}$$

with $0 \leq \alpha_p \leq 1$ and fixed payment, $\beta_p$. Note that $\alpha_p$ is the incentive intensity in the contractual relationship between the wholesalers and the producers, and $\alpha_p \alpha_w$ is the revenue-sharing parameter of the producers with respect to the total output value of the marketing channel (i.e., when the contractual relationship between the wholesalers and the retailers is taken into account).

In line with the classic agency model, the linear specification of the contracts in (4.2) and (4.3) is chosen, because it corresponds to real-world settings (e.g., Knoeber, 1999; Allen and Lueck, 2002). Moreover, Holmstrom and Milgrom (1987) have shown that the optimal compensation scheme for providing incentives over time to an agent with a constant absolute risk aversion for the duration of the contract is a linear function of the end-of-period results, such as revenues, costs, or profits. This result is based on the fact that a linear contract provides more uniform incentives than a non-linear contract, as can be seen by viewing the annual output as the outcome of many small daily actions of the agent. Seen from this perspective, a non-linear contract may create unintentional or non-uniform incentives for the agent in the course of the year, depending on the agent’s performance to date (Gibbons, 2005).

The effort of wholesalers and producers comes at a cost. Without loss of generality, the costs of effort of wholesalers and producers are respectively specified as follows
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\[ C_w = 0.5c_w e^2 + d_w \]  \hspace{1cm} (4.4)

and

\[ C_p = 0.5c_p e^2 + d_p \]  \hspace{1cm} (4.5)

where \( c_w > 0 \) and \( c_p > 0 \) are respectively the increase in marginal costs of effort of wholesalers and producers, and \( d_w \) and \( d_p \) are trend terms denoting cost changes by new production technology becoming available for wholesalers and producers respectively. Note that the cost functions concern expected costs, not actual costs, because their argument is given by \( e \). This argument also implies that production costs may rise, either by extending the production quantity, or, as reflected by a higher expected output price, by improving product quality.

Finally, while the retailers, who are carrying a broad assortment of products, are assumed to be risk-neutral, the wholesalers and producers are allowed to be risk-averse. The profit of the producers is given by

\[ \pi_p = W_p - C_p = \alpha_p \alpha_w x + \beta_p - 0.5c_p e^2 - d_p \] \hspace{1cm} (4.6)

From (4.1), the expectation of the producers’ profit, conditional on the information set \( I \) being common to all marketing channel members, is

\[ E(\pi_p \mid I) = \alpha_p \alpha_w e + \beta_p - 0.5c_p e^2 - d_p \] \hspace{1cm} (4.7)

The variance of the producers’ profit is
The objective function for profit maximisation can be expressed on the basis of the expected mean-variance (EV) model and, hence, the producers maximise the certainty equivalent of their profit by choosing the optimal level of effort value \(e\), where \(\rho_p \geq 0\) is the risk-aversion coefficient (Chavas, 2004) so that the certainty equivalent of their profit is given by

\[
CE_p = E(\pi_p | I) - 0.5 \rho_p \text{Var}(\pi_p)
\] (4.9)

Inserting (4.7) and (4.8) in (4.9) shows that the producer maximises the following expression

\[
\max \{ \alpha_p \alpha_a e + \beta_p - 0.5 \rho_p e^2 - d_p - 0.5 \rho_p \alpha_p^2 \alpha_a^2 \sigma^2 \}
\] (4.10)

which yields the incentive constraint

\[
e = \frac{\alpha_p \alpha_a}{c_p}
\] (4.11)

This expression clearly shows the incentive mechanism of \(\alpha_p \alpha_a\). Thus, increases in the expectation of the retail value lead to increases in the producers’ revenue-sharing parameter \(\alpha_p \alpha_a\). In the contract between the producer (i.e., agent) and the wholesaler (i.e., principal), one of the constraints that the wholesaler faces is participation. The participation constraint implies that the producer equates the certainty equivalent of profit \(CE_p\) to his/her reservation wage \(\bar{W}_p\) (i.e., the opportunity cost of effort). From this condition, wholesalers can derive that they have to pay a fixed compensation to producers, as given by
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\[ \beta_p = \overline{W}_p + d_p - \alpha_p \alpha_w e + 0.5 c_p e^2 + 0.5 \rho_p \alpha_p^2 \alpha_w^2 \sigma^2 \]  \hspace{1cm} (4.12)

Substituting (4.11) into (4.12) we obtain that

\[ \beta_p = \overline{W}_p + d_p - 0.5 \alpha_p^2 \alpha_w^2 / c_p + 0.5 \rho_p \alpha_p^2 \alpha_w^2 \sigma^2 \]  \hspace{1cm} (4.13)

Having derived the producers’ contract parameters, we now proceed to derive the wholesalers’ contract parameters. The wholesalers’ profit is given by:

\[ \pi_w = W_w - W_p - C_w = (1 - \alpha_p) \alpha_w x + \beta_w - \beta_p - 0.5 c_w e^2 - d_w \]  \hspace{1cm} (4.14)

The expectation of the wholesalers’ profit conditional on the common information set \( I \) in the marketing channel, is

\[ E(\pi_w | I) = (1 - \alpha_p) \alpha_w e + \beta_w - \beta_p - 0.5 c_w e^2 - d_w \]  \hspace{1cm} (4.15)

The variance of the wholesalers’ profit is

\[ Var(\pi_w) = (1 - \alpha_p)^2 \alpha_w^2 \sigma^2 \]  \hspace{1cm} (4.16)

The risk-averse wholesalers maximise the certainty equivalent of their profit for \( \alpha_p \) given the conditions for \( e \) and \( \beta_p \) as derived above. The certainty equivalent is given by:

\[ CE_w = E(\pi_w | I) - 0.5 \rho_w Var(\pi_w) \]  \hspace{1cm} (4.17)

where \( \rho_w \) is the wholesalers’ risk parameter.
Chapter 4. Incentive Provision and Coordination Costs

From equations (4.11), (4.13), (4.15), (4.16) and (4.17) it follows that the wholesaler maximises

\[
\begin{align*}
\max_a (1 - \alpha_p) & \alpha_p \alpha_w^2 / c_p + \beta_w - W_p - d_p + 0.5 \alpha_p^2 \alpha_w^2 / c_p - 0.5 \rho_w \alpha_p^2 \alpha_w^2 \sigma^2 - \\
& 0.5 \sigma \alpha_p^2 \alpha_w^2 / c_p^2 - d_w - 0.5 \rho_w (1 - \alpha_p)^2 \alpha_w^2 \sigma^2 \\
\end{align*}
\]

which yields the incentive-intensity principle:

\[
\alpha_p = \{1 + c_p \rho_w \sigma^2 \} / \{1 + c_p (\rho_w + \rho_p) \sigma^2 + c_w / c_p \} \tag{4.19}
\]

This condition shows that, when neglecting the marginal wholesale cost (i.e., \(c_w = 0\)), simply giving full incentives to the producers by setting \(\alpha_p = 1\) is not optimal if they are risk averse (\(\rho_p > 0\)) and cannot be monitored as to their precise effort (\(\sigma^2 > 0\)).

In the contract between the retailer (i.e., principal) and the wholesaler (i.e., agent), the retailer is constrained by the wholesaler’s participation constraint. The wholesaler’s participation constraint imposes that the wholesaler equates the certainty equivalent of profit \(CE_w\) to his/her reservation wage \(\bar{W}_w\). From this condition, the wholesaler’s fixed compensation is derived as

\[
\begin{align*}
\beta_w &= \bar{W}_w + \bar{W}_p + d_w + d_p - \alpha_p \alpha_w^2 / c_p + 0.5 c_w \alpha_p^2 \alpha_w^2 / c_p^2 + 0.5 \alpha_p^2 \alpha_w^2 / c_p + \\
& 0.5 \rho_p \alpha_p^2 \alpha_w^2 \sigma^2 + 0.5 \rho_w (1 - \alpha_p)^2 \alpha_w^2 \sigma^2 \\
\end{align*}
\]

Having examined the objective functions of the producer and wholesaler, we now turn to the objective function of the retailer. From equations (4.1) and (4.2) the retailers’ profit is given by:
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\[ \pi_r = x - W_w = (1 - \alpha_w)x - \beta_w \quad (4.21) \]

The expectation of the retailers’ profit, conditional on the common information set \( I \), is

\[ E(\pi_r | I) = (1 - \alpha_w)e - \beta_w \quad (4.22) \]

Next, substituting \( \beta_w \) in (4.20) and \( e \) in (4.11) into (4.22), the risk-neutral retailer maximises the expectation of profit as follows:

\[
\begin{align*}
\text{Max}_{\alpha_w} & \left( (1 - \alpha_w)\alpha_p\alpha_w / c_p - \overline{W_w} - \overline{W_p} - d_w - d_p + \alpha_p\alpha_w^2 / c_p - 0.5c_w\alpha_w^2\alpha_w^2 / c_p^2 - \\
& 0.5\alpha_p\alpha_w^2 / c_p - 0.5\rho_p\alpha_p\alpha_w^2\sigma^2 - 0.5\rho_w(1 - \alpha_p)^2\alpha_w^2\sigma^2 \right)
\end{align*}
\]

which yields:

\[ \alpha_w = 1 / \{ \alpha_p c_w / c_p + \alpha_p + \alpha_p c_p \rho_p \sigma^2 + c_p \rho_w (1 - \alpha_p)^2 \sigma^2 / \alpha_p \} \quad (4.24) \]

being the retailer’s incentive-intensity principle towards the wholesaler, which is equal to 1, if the risk aversion coefficients \( \rho_p \) and \( \rho_w \) are zero and no unobservability or risk is involved \( (\sigma^2 = 0) \), see (4.19).

Recall from the linear contract for the wholesaler, as presented in (4.2), that the revenue-sharing parameter is given by \( \alpha_w \). In the contract for the producer, the revenue-sharing parameter is \( \alpha_p \alpha_w \). Consequently, if \( \alpha_p \) were a constant parameter, then both revenue-sharing parameters could still be time varying through \( \alpha_w \). In line with this notion and for the purpose of empirical testing, to be discussed in the next section, we consider \( \alpha_w, \beta_w, \beta_p, \rho_w, \rho_p \) to be unknown variables to be solved by the equations (4.11), (4.12), (4.19), (4.20) and 4.24).
Chapter 4. Incentive Provision and Coordination Costs

Below, we first derive the producers’ revenue-sharing parameter, and then discuss the derivation of the solutions for \( \rho_p \) and \( \rho_w \).

Multiplying (4.24) by \( \alpha_p \), the producers’ revenue-sharing parameter \( \alpha_p \alpha_w \) becomes

\[
\alpha_p \alpha_w = \frac{1}{\{1 + c_w / c_p + c_p \rho_p \sigma^2 + c_p \rho_w \sigma^2 (1 - \alpha_p) / \alpha_p^2\}} \tag{4.25}
\]

Next, rewriting (4.19) yields the following expression for the producers’ risk parameter:

\[
\rho_p = (1 - \alpha_p) \rho_w / \alpha_p + ((1 - \alpha_p) c_p - \alpha_p c_w) / \alpha_p c_p^2 \sigma^2 \tag{4.26}
\]

Substituting (4.11) and (4.26) into (4.25), we obtain

\[
\rho_w = \alpha_p (\alpha_p - c_p e) / c_p^2 \sigma^2 e (1 - \alpha_p) \tag{4.27}
\]

Furthermore, in order to derive the producers’ risk parameter, we substitute (4.27) into (4.26), to obtain

\[
\rho_p = (\alpha_p^2 - 2 \alpha_p c_p e + c_p e - \alpha_p c_e e) / (\alpha_p c_p^2 \sigma^2 e) \tag{4.28}
\]

Inserting (4.11) and (4.28) into (4.12), we obtain

\[
\beta_p = W_p + d_p + 0.5 \alpha_p e + 0.5 (c_p / \alpha_p - 3 c_p - c_w) e^2 \tag{4.29}
\]

Similarly, inserting (4.11), (4.27), and (4.28) into (4.20), we get
Risk, Incentives and Coordination Costs

\[ \beta_w = \overline{W}_w + \overline{W}_p + d_w + d_p + 0.5e - c_p e^2 / \alpha_p \]  \hfill (4.30)

In order to estimate \( \alpha_p, c_w, c_p, d_w, d_p \), the unknown parameters in the model, we need to derive estimation equations. Substituting (4.11) and (4.29) into (4.3), and after some rewriting, we obtain

\[ W_p - \overline{W}_p = d_p + c_p e x + 0.5\alpha_p e + 0.5(c_p / \alpha_p - 3c_p - c_w) e^2 \] \hfill (4.31)

Next, substituting (4.11) and (4.30) into (4.2), and after some rewriting, we arrive at the following equation:

\[ W_w - \overline{W}_w - \overline{W}_p - 0.5e = d_w + d_p + c_p e (x - e) / \alpha_p \] \hfill (4.32)

The incentive parameter \( \alpha_p \) and the parameters in the cost functions \( c_p, d_p, c_w, d_w \) can be estimated in the system of equations (4.31) and (4.32). After having estimated these parameters, we can estimate \( \alpha_w, \rho_p, \rho_w, \beta_w, \) and \( \beta_p \), using their respective expressions as outlined above. Now, the validity of the model can be evaluated by comparing the actual payments \( W_w \) and \( W_p \) over time with their respective estimates \( \alpha_w x + \beta_w \) and \( \alpha_p \alpha_w x + \beta_w \). If the model performs well, it can be used to estimate the agency (coordination) costs by setting

\[ \rho_w = \rho_p = 0 \] \hfill (4.33)

so that we obtain the first-best optimal expressions. Note that the first-best optimal expressions of the parameters are obtained when all channel members (producer, wholesaler,
and retailer) are risk neutral, and information flows among these channel members are obtained at zero cost. Therefore, the risk-aversion coefficients \((i.e., \rho_w \text{ and } \rho_p)\) are set to zero in the expressions originally derived, to obtain the following first-best expressions:

\[
\alpha^*_w = 1 
\]  \hspace{1cm} (4.34)

\[
\alpha^*_p = \frac{c_p}{c_p + c_w} 
\]  \hspace{1cm} (4.35)

\[
\beta^*_p = \frac{W_p + d_p - 2c_p}{(c_p + c_w)^2} 
\]  \hspace{1cm} (4.36)

\[
\beta^*_w = \frac{W_w + W_p + d_w + d_p - 0.5}{(c_p + c_w)} 
\]  \hspace{1cm} (4.37)

Furthermore, \(1/(c_w + c_p)\) is derived from (4.11) as the estimate of the expected first-best, Pareto-optimal retail value \(e^*\). Consequently, the expected first-best, Pareto-optimal profits of retailers, wholesalers, and producers are, respectively

\[
E(\pi_r^* | I) = -\beta^*_w = 0.5 \frac{c_p + c_w}{(c_p + c_w)} - \frac{W_w - W_p - d_w - d_p}{} 
\]  \hspace{1cm} (4.38)

\[
E(\pi_w^* | I) = W_w 
\]  \hspace{1cm} (4.39)

\[
E(\pi_p^* | I) = W_p 
\]  \hspace{1cm} (4.40)
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Then, while considering the empirical values of $c_w, c_p, d_w, d_p, \sigma^2 W_p$ and $\bar{W}_w$ as given, we can compute the first-best expectation of profits (i.e., first-best optimal solution) for the channel members. Adding these first-best optimal profits for producers, wholesalers, and retailers yields the first-best solution for the marketing channel. The second-best optimal solution is the second-best expectation of profit for the marketing channel. This is obtained when the respective profit functions for producers, wholesalers, and retailers take into account the risk aversion of these channel members, whereby the derived risk aversion coefficients, $\rho_p$ in (4.28) and $\rho_w$ in (4.27), are used in estimating the producers’, wholesalers’, and retailers’ expectations of profit. Adding the second-best optimal profits of producers, wholesalers, and retailers yields the second-best solution for the marketing channel. The differentials between the first-best and second-best optimal solutions of the retailers $[E(\pi^*_r | I) - E(\pi_r | I)]$, wholesalers $[E(\pi^*_w | I) - E(\pi_w | I)]$, and producers $[E(\pi^*_p | I) - E(\pi_p | I)]$ are the respective estimated agency (coordination) costs for the retailers, wholesalers, and producers. The sum of these agency costs yields the agency costs for the whole marketing channel. Note that these estimates are maximum levels, because they are based on the assumption that the higher $e^*$ could have been realised in the consumer market.

4.3 Empirical Application

Every year, some eight million tons of potatoes are produced in the Netherlands, mainly on family farms. About half are ware potatoes, approximately 20 percent are seed potatoes, while the remaining 30 percent are potatoes grown for starch (NIVAP Holland, 2002). Most ware potatoes are sold to wholesalers. A negligible amount is sold directly by the producers to the retailers. Most of the wholesale trade has become concentrated in relatively few hands, as the major users, particularly the large retailers, processors, and export markets, demand large quantities with tight specifications, which only the larger wholesalers can meet. Because of
this development in the market, the need has arisen to procure potatoes before harvest, and hence contractual arrangements to do so have emerged. In turn, growers see contracts as a way to reduce price risk (Smidts, 1990; ZLTO and LLTB, 2002). Spot-market prices tend to fluctuate largely from one year to another, due to weather and disease issues, the level of imports, as well as domestic and export demand. Although retailers (wholesalers) may gain knowledge of any wholesaler’s (grower’s) abilities through quality measurement, the wholesaler’s (grower’s) investments, as well as weather and disease conditions, this is not sufficient for the retailer to derive, without uncertainty, from his turnover the wholesaler’s (grower’s) actual level of effort. The interest of wholesalers and growers in hedging on the futures market supports the assertion that they might be risk averse, which will be elaborated on in Chapter 5.

For our empirical analysis, Statistics Netherlands provided us with annual data over the period 1961 – 2002, for the following variables: the farm, export (i.e., wholesale) and retail prices of ware potatoes (Euro/kg), all deflated by the consumer price index (1990 = 1.00), the area planted (1000 ha), the yield per hectare (100 kg/ha), and the rent price of land (Euro/ha), deflated by the consumer price index. From these variables, we obtain several variables of interest. First, the output quantity \( q \) (million tons) is computed as the yield per hectare times the area planted (divided by 10^4). Given the retail price \( p \), the retail value \( x \) is obtained as \( x = pq \) (billion Euro). For the computations of the expectation of the retail value and the variance of the retail value, see the appendix at the end of this thesis. Furthermore, \( W_p \) (\( W_w \)) (billion Euro) is computed as the farm price (export price) times \( q \). The rent price of land times the area planted (divided by 10^6) is used as a proxy for \( W_p \). Finally, we set \( W_w \) equal to zero and use linear models with a constant and linear trend to estimate \( d_w \) and \( d_p \).1

---

1 In the computation of \( x, W_p \) and \( W_w \), we divide by 10^4, and for \( W_p \) we divide by 10^6 each time, to ensure uniformity in the units of measurements of the components that made up each of these variables. We assume that
Now, having obtained time series on \( x, e, W_w, W_p, \bar{W}_w, \bar{W}_p \) and \( \sigma^2 \), we can estimate \( \alpha_p \), the deterministic components \( d_p \) and \( d_w \), and the cost-function parameters \( c_p \) and \( c_w \) in the system of equations in (4.31) and (4.32), as implied by the linear-payment contracts, that is, 
\[
W_w = \alpha_w x + \beta_w \text{ in (4.2), and } W_p = \alpha_p \alpha_w x + \beta_p \text{ in (4.3), and the incentive, participation, and incentive-compatibility constraints.}
\]
The variables in the (4.31) and (4.32) equation system appear to be trend stationary. Hence, the model is estimated in levels by non-linear, seemingly unrelated regression. The estimates are presented in Table 4.1.

In another study (cf. Chapter 5), however, we were able to estimate \( c_w \) with a very high precision: \( c_w = 0.485 \) (\( t \) value = 21.011). In contrast, the estimate of \( c_w = 0.749 \) (\( t \) value = 3.262) in the system of equations (4.31) and (4.32). Henceforth, we refer to this second estimate of \( c_w \) as the result of the unrestricted model. Thus, the results from the equation system (4.31) and (4.32), without any restriction on the parameters, are what we refer to as the unrestricted model. In what follows, we explain another dimension of our estimation of the equation system (4.31) and (4.32). The estimate of \( c_w \) with the higher precision described above, \( c_w = 0.485 \), lies within the 95% confidence interval of \( c_w = 0.749 \) (from the unrestricted model). For this reason, we restricted the equation system in (4.31) and (4.32) by inserting the estimate of 0.485 in place of \( c_w \), before estimating the model by non-linear seemingly unrelated regression. We refer to this model as the restricted model. See Table 4.1 for all the estimates of both the restricted and the unrestricted models. The results of the restricted model are in italics, while the estimate in bold is the “fixed” value for \( c_w \).

---

\( \text{The estimate } c_w = 0.485 \text{ in Chapter 5 was estimated by Full Information Maximum Likelihood (FIML) in a model in which we dealt with a three-stage principal-agent supply chain model that included a futures market.} \)
Table 4.1: Estimates of $\alpha_p$, $c_p$, $c_w$, $d_{p0}$, $d_{p1}$, $d_{w0}$, and $d_{w1}$ Obtained by Non-Linear Seemingly Unrelated Regression Applied to Equations (4.31) and (4.32), Using Unrestricted (U) and Restricted (R) Models (Estimates of the Restricted Model in Italics in Parentheses)

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>t Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_p$</td>
<td>0.556</td>
<td>0.186</td>
<td>2.982</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.571)</td>
<td>(0.192)</td>
<td>(2.971)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>$c_p$</td>
<td>0.254</td>
<td>0.083</td>
<td>3.067</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.258)</td>
<td>(0.084)</td>
<td>(3.085)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>$c_w$</td>
<td>0.749</td>
<td>0.229</td>
<td>3.262</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.485)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$d_{p0}$</td>
<td>0.314</td>
<td>0.079</td>
<td>3.962</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.261)</td>
<td>(0.066)</td>
<td>(3.944)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>$d_{p1}$</td>
<td>0.000</td>
<td>0.004</td>
<td>0.106</td>
<td>0.916</td>
</tr>
<tr>
<td></td>
<td>(-0.004)</td>
<td>(0.002)</td>
<td>(-2.292)</td>
<td>(0.025)</td>
</tr>
<tr>
<td>$d_{w0}$</td>
<td>-0.076</td>
<td>0.082</td>
<td>-0.922</td>
<td>0.359</td>
</tr>
<tr>
<td></td>
<td>(-0.022)</td>
<td>(0.070)</td>
<td>(-0.316)</td>
<td>(0.753)</td>
</tr>
<tr>
<td>$d_{w1}$</td>
<td>-0.007</td>
<td>0.004</td>
<td>-1.564</td>
<td>0.122</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(-1.165)</td>
<td>(0.248)</td>
</tr>
</tbody>
</table>

System Diagnostics:
Sample: 1961-2002
Determinant residual covariance = 0.000104 (0.000107)

Equation-Specific Diagnostics:

<table>
<thead>
<tr>
<th>Equation</th>
<th>Number of Observations</th>
<th>$R^2$</th>
<th>Standard Error of Regression</th>
<th>Sum of Squared Residuals</th>
<th>Durbin-Watson Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eq. (4.31)</td>
<td>42</td>
<td>0.30</td>
<td>(0.30)</td>
<td>0.145</td>
<td>0.78</td>
</tr>
<tr>
<td>Eq. (4.32)</td>
<td>42</td>
<td>0.78</td>
<td>(0.78)</td>
<td>0.081</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Note:
$\alpha_p$ denotes the incentive intensity in the contract between the wholesalers and the producers
$c_p$ denotes the increase in the marginal cost of effort of the producer
$c_w$ denotes the increase in the marginal cost of effort of the wholesaler
$d_{p1}$ denotes the linear part of the producer’s cost function
$d_{w1}$ denotes the linear part of the wholesaler’s cost function
$d_{p0}$ denotes a constant in the producer’s cost function
$d_{w0}$ denotes a constant in the wholesaler’s cost function
$d_p = d_{p0} + d_{p1}T_t$, where $T_t$ is the linear time trend, for which $T_{1961} = 1$, $T_{1962} = 2$, ...
d_w = d_{w0} + d_{w1}T_t$, where $T_t$ is the linear time trend, for which $T_{1961} = 1$, $T_{1962} = 2$, ...
d_p and d_w are the linear trend terms in the producer’s and wholesaler’s cost functions respectively
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Next, using the estimates above, we estimate the key variables in the model: $\alpha_w$, $\beta_p$, $\beta_w$, $\rho_p$ and $\rho_w$. Their solutions can be seen as the estimates of the model. From equation (4.11), the expression for $\alpha_w$ is $c_p e / \alpha_p$. Given that $e$ is a time-varying variable, while $c_p$ and $\alpha_p$ are constant parameters, $\alpha_w$ will be time varying as well. Furthermore, the solutions for $\beta_p$, $\beta_w$, $\rho_p$, and $\rho_w$ in equations (4.29), (4.30), (4.28), and (4.27), respectively, also allow for time-varying values.

The incentive intensity to wholesalers and producers increased over time: $\alpha_w$ ($\alpha_p \alpha_w$) more than doubled from 0.31 (0.16) in the 1960s to 0.65 (0.33) in 2000, see Figure 4.1. These estimates hardly differ between the unrestricted and restricted model. The increase in incentive intensity complies with the decrease of the risk-aversion coefficients ($\rho_p$ and $\rho_w$),

![Figure 4.1: Producers’ Incentive Intensity $\alpha_p \alpha_w$ Unrestricted (APU), Restricted (APR), Wholesalers’ Incentive Intensity $\alpha_w$ Unrestricted (AWU), and Restricted (AWR)](image-url)
see Figure 4.2. The risk-aversion coefficients of the restricted and unrestricted model hardly differ for wholesalers. However, they do differ for producers, as shown in Figure 4.2. In contrast, the fixed payment $\beta_w$ ($\beta_p$) of retailers (wholesalers) to wholesalers (producers) as a percentage of retail turnover ($x$) decreased from 50% (30%) in the 1960s to negative values of $-16\%$ ($-23\%$) in 2002, see Figure 4.3. The estimates hardly differ between the unrestricted and restricted model for both producers and wholesalers. The results imply that from the 1990s onward, producers and wholesalers have to pay a percentage of the retail value as an implicit rent in their respective contractual relationships. These negative percentages came down to a total annual investment of about 0.41 billion Euro on the part of wholesalers and producers in their business relationships with retailers in 2000. With increasingly negative fixed-payment levels, compensated for by higher retail value-sharing rates, wholesalers and producers are getting exposed to more risk, since their rewards are contingent upon an increasing portion of the final retail value. As the retailers in the Dutch potato market have strengthened their bargaining power vis-à-vis producers (cf. Kuiper and Meulenberg, 2002), they are able to dictate the terms of trade in their contractual relationships with producers as well as wholesalers. Therefore, even though producers and wholesalers are considered to be risk-averse channel members, they still have to accept the contract terms offered by retailers in order to successfully market their products. Furthermore, food marketing channels have been transformed from supply-oriented chains into demand-oriented chains, whereby consumer needs have to be met in order for food products to be successfully marketed. This is another reason why the producers and wholesalers have to make these implicit investments to satisfy these needs (e.g., quality and food safety needs) and, therefore, bear the associated risk. But why do retailers let this happen? Transferring risk to upstream stages in the supply chain which have fewer opportunities to spread risk, compared to the large retailers, and who therefore find it more costly to bear, simply reduces the gains from
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trade. In contrast, retailers should prefer to bear the risk themselves (since wholesalers and producers ask for a higher price, as a compensation for the risk they bear) and extract the gains from this by a lower price paid to the wholesalers.

**Figure 4.2: Producers’ Risk-Aversion Coefficient $\rho_p$, Unrestricted (RHOPU), Restricted (RHOPR), Wholesalers’ Risk-Aversion Coefficient $\rho_w$, Unrestricted (RHOWU), Restricted (RHOWR)**

**Figure 4.3: Fixed Payments to Producers as a Percentage of Retail Value \((100 \times \beta_p / x)\), Unrestricted (BPXU), Restricted (BPXR), and Fixed Payments to Wholesalers as a Percentage of Retail Value \((100 \times \beta_w / x)\), Unrestricted (BWXU) and Restricted (BWXR)**
However, retailers do transfer market-level risk to more risk-averse parties such as wholesalers and producers, as is shown by the decreasing variance of the retailers' profit compared to the increasing variance of wholesalers' and producers' profits (see Figure 4.4).

![Figure 4.4: Producers’ profit risk, unrestricted (VARPU), restricted (VARPR), Wholesalers’ profit risk, unrestricted (VARWU), restricted (VARWR), Retailers’ profit risk, unrestricted (VARRU), restricted (VARRR)](image)

Given the retailers’ own risk neutrality, mere risk aversion on the part of the retailer cannot be the reason for transferring market risk, especially considering the high costs traditionally involved in transferring risk to risk-averse (and therefore unwilling) parties. Therefore, there must be another reason to explain this risk shift that seems unprofitable to everyone in the channel on the first sight. Note that the profit risks for the marketing channel members under consideration hardly differ between the restricted and unrestricted models. As explained previously, a possible explanation for why retailers wish to transfer risk to upstream stages in the supply chain, despite the higher risk-bearing costs involved, might be “chain reversal”, whereby traditional supply-oriented chains are transformed into demand-oriented chains. Demand-oriented chains aim to satisfy the needs and demands of the
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consumer, usually by offering high value-added products that better fit consumer needs than mainstream homogeneous products. The retailers, who are closest to the consumer, are the first to discover these consumer needs and wishes. In response to these demands, they start making their own demands on their suppliers, i.e., producers and wholesalers in the form of stricter delivery conditions and/or tighter product specifications. At this point, risk-shifting, as an incentive that makes suppliers co-dependent on the final results, becomes a useful mechanism to ‘force’ these new delivery conditions and/or tighter specifications upon the suppliers. The profits from giving producers and wholesalers more incentives to meet the retailers’ increasingly strict delivery conditions may exceed the retailers’ higher risk-bearing costs.

And indeed, the required coordination efficiency in the supply of ware potatoes has been improved greatly, as a consequence of increases in incentives to producers and wholesalers. This can be observed from the fact that the second-best expectation of the total profits of the marketing channel (under risk aversion) converged to their first-best optimal levels (under risk neutrality) in both the restricted and unrestricted model, see Figure 4.5. However, the convergence of the second-best expectations of the total profits of the marketing channel to their first-best optimal levels is more pronounced with the restricted model than with the unrestricted model. Henceforth, the discussion of the improvements in the coordination efficiency of the marketing channel will be based on the restricted model, even though we have also presented the graphs of the unrestricted model.

The coordination (agency) costs (i.e., $C_a = E(\pi_r^* + \pi_w^* + \pi_p^* \mid I) - E(\pi_r + \pi_w + \pi_p \mid I)$) reduced from 0.16 billion Euro in 1964, which was about 22% of the total retail value (i.e., 100% × $C_a/x$ in 1964), to 0.003 billion Euro in 2002 (2% of the total retail value in 2002), see Figures 4.6 and 4.7. This boils down to a 98% reduction in the coordination costs of the marketing channel over the period 1964-2002.
In order to evaluate the validity of the model, we examine how the estimated payments explain the actual payments for producers and wholesalers. A regression of the producer’s actual payments ($W_{pt}$) on the estimated variable component ($\hat{\alpha}_p \hat{\alpha}_w x_t$) and fixed-payment component ($\hat{\beta}_{pt}$) shows that the estimated payments are efficient predictions and explain about 29% (27%) of the actual payments, see Figure 4.8. In spite of this somewhat limited fit, the model does provide an unbiased and significant prediction, as we can see from performing a regression of $w_t$ on a constant, $\hat{\alpha}_p \hat{\alpha}_w x_t$, and $\hat{\beta}_{pt}$. Testing the joint hypothesis of a zero constant and unit coefficients of both $\hat{\alpha}_p \hat{\alpha}_w x_t$ and $\hat{\beta}_{pt}$ shows that we cannot reject the joint hypothesis ($p$ value = 1.000 (0.983)). Furthermore, testing the joint hypothesis of zero coefficients of both $\hat{\alpha}_p \hat{\alpha}_w x_t$ and $\hat{\beta}_{pt}$ leads to firm rejection ($p$ value = 0.001 (0.002)), see also Table 4.2. The reported values for the restricted model are in italics in parentheses.
Figure 4.6: Coordination (Agency) Costs of the Marketing Channel, Unrestricted (ACU), Restricted (ACR)

Figure 4.7: Coordination (Agency) Costs of the Marketing Channel as a Percentage of Retail Value, Unrestricted (ACXU), Restricted (ACXR)
Table 4.2: Parameter Estimates in the Regression of the Actual Payment to the Producers ($W_{pt}$) on the Variable and Fixed Wage Components that were Estimated by the Unrestricted and Restricted Models (Estimates of the Restricted Model in Italics in Parentheses)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>$t$ Value</th>
<th>$p$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.005</td>
<td>0.107</td>
<td>0.048</td>
<td>0.962</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.106)</td>
<td>(0.237)</td>
<td>(0.184)</td>
</tr>
<tr>
<td>$\hat{\alpha}<em>p\hat{\alpha}</em>{wt}x_t$</td>
<td>0.984</td>
<td>0.338</td>
<td>2.908</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>(0.915)</td>
<td>(0.332)</td>
<td>(2.575)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>$\hat{\beta}_{pt}$</td>
<td>0.986</td>
<td>0.255</td>
<td>3.871</td>
<td>0.0004</td>
</tr>
<tr>
<td></td>
<td>(0.983)</td>
<td>(0.265)</td>
<td>(3.713)</td>
<td>(0.0006)</td>
</tr>
</tbody>
</table>

Sample: 1961 - 2002; Number of Observations = 42; $R^2 = 0.29 (0.27); R^2_{adj} = 0.25(0.24)$; Std. Error Resid = 0.14 (0.14); Sum Squared Resid = 0.78 (0.80); Durbin-Watson = 2.16 (2.10); $F(3,39)$ statistic testing for the joint hypothesis that the intercept is zero and the coefficients of $\hat{\alpha}_p\hat{\alpha}_{wt}x_t$ and $\hat{\beta}_{pt}$ are equal to one = 0.001(0.055) ($p$ value = 1.000 (0.983))

Note: $\hat{\alpha}_p\hat{\alpha}_{wt}x_t$ denotes the variable component of the producer’s wage; $\hat{\beta}_{pt}$ denotes the fixed component of the producer’s wage; $W_{pt}$ is the producer’s actual wage, which is computed as producer price times quantity produced.
Similarly, a regression of the wholesaler’s actual revenue \( W_{wt} \) on the estimated variable component \( \hat{\alpha}_{wt} x_t \) and fixed revenue component \( \hat{\beta}_{wt} \) reveals that the estimated revenues are efficient predictions and explain about 75% of the actual payments, as shown in Figure 4.9 and by the results tabulated in Table 4.3. The model does provide an unbiased and significant prediction, as we can see from performing a regression of \( W_{wt} \) on a constant, \( \hat{\alpha}_{wt} x_t \) and \( \hat{\beta}_{wt} \). Testing the joint hypothesis of a zero constant and unit coefficients of both \( \hat{\alpha}_{wt} x_t \) and \( \hat{\beta}_{wt} \) shows that we cannot reject this joint hypothesis \((p \text{ value} = 0.951(0.927))\). Furthermore, the joint hypothesis of zero coefficients of both \( \hat{\alpha}_{wt} x_t \) and \( \hat{\beta}_{wt} \) leads to firm rejection \((p \text{ value} = 0.000 (0.000))\), see also Table 4.3. The reported values for the restricted model are in italics in parentheses.

### Table 4.3: Parameter Estimates in the Regression of the Actual Payment to the Wholesalers (WW) on the Variable and Fixed Payment Components Estimated by the Unrestricted and Restricted Models (Estimates of the Restricted Model in Italics in Parentheses)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.034 ((-0.041))</td>
<td>0.067 ((0.068))</td>
<td>-0.506 ((-0.601))</td>
<td>0.616 ((0.551))</td>
</tr>
<tr>
<td>(\hat{\alpha}_{wt} x_t)</td>
<td>1.054 ((1.065))</td>
<td>0.099 ((0.101))</td>
<td>10.533 ((10.574))</td>
<td>0.000 ((0.000))</td>
</tr>
<tr>
<td>(\hat{\beta}_{wt})</td>
<td>1.049 ((1.062))</td>
<td>0.136 ((0.138))</td>
<td>7.693 ((7.710))</td>
<td>0.000 ((0.000))</td>
</tr>
</tbody>
</table>

Sample: 1961 - 2002; Number of Observations = 42; \(R^2 = 0.75\) (0.75); \(R^2_{\text{adj}} = 0.74\) (0.74); Std. Error Resid = 0.08 (0.08); Sum Squared Resid = 0.23 (0.23); Durbin-Watson = 1.14 (1.14); \(F(3,39)\) statistic testing for the joint hypothesis that the intercept is zero and the coefficients of \(\hat{\alpha}_{wt} x_t\) and \(\hat{\beta}_{wt}\) are equal to one \(= 0.11(0.15)\) \((p \text{ value} = 0.951(0.927))\).

**Note:** \(\hat{\alpha}_{wt} x_t\) denotes the variable component of the wholesaler’s wage; \(\hat{\beta}_{wt}\) denotes the fixed component of the wholesaler’s wage; \(W_{wt}\) is the wholesaler’s actual wage, which is computed as the wholesale price times quantity produced.
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4.4 Conclusions

Food supply chains have become extensively vertically coordinated through the use of contracts as an organisational response to better satisfy the needs of consumers in the saturated food markets of the industrialised countries. Wholesalers often link producers with consumers' needs as articulated by retailers. The contracts involved must establish an optimal trade-off between incentive provision and risk reduction. Agency theory can be used to model this trade-off and to do so we specified a three-stage (producer, wholesaler, retailer) principal-agent, supply-chain model for estimation and simulation purposes. Its application to the Dutch supply chain of ware potatoes shows that risk has shifted from retailers to producers and wholesalers. Furthermore, as a consequence of increases in incentives to producers and wholesalers, the costs of coordination in the supply chain decreased from 0.16 billion Euro in 1964 to 0.003 billion Euro in 2002, a reduction of 98%. This reduction complies with the ongoing process of chain reversal, whereby the supply chain becomes more demand oriented as producers and wholesalers are given more incentives to enable retailers to increasingly...
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carry high value-added products that better satisfy consumers' needs. This observation reveals that incentives are very important in aligning the goals of channel members. In this chapter we have examined risk, incentives, and coordination costs in the three-stage marketing channel that involves producers, wholesalers, and retailers, when they only trade in the spot markets. The next question is what role the futures market plays in the marketing channel. Consequently, in Chapter 5, we extend the three-stage marketing channel model to include a futures market in order to address the above-mentioned issue.
CHAPTER 5
Contract Relationships and Risk Management in a
Three-Stage Food Marketing Channel*

Abstract
In the last four decades food marketing channels have transformed from traditional supply-oriented chains into demand-oriented chains. With this development, marketing channel members are required to produce and deliver quality products in order to meet consumers’ requirements. In this respect, the transaction mechanism in food marketing channels has changed from an open-market mechanism to a coordinated form of transaction through the use of contracts and other forms of vertical alliances. In this chapter, we examine the interaction of marketing channel members and the influence of these interactions on incentives, coordination costs, risk allocation, and risk-management strategies in a food marketing channel. For this purpose we specify a three-stage, principal-agent, marketing-channel model involving producers, wholesalers, retailers, and a futures market. We compare the situation with and without a futures market. The empirical results regarding the Dutch ware potato marketing channel during 1971-2003 reveal that, as a result of increases in incentives to producers and wholesalers, the coordination costs of the marketing channel decreased considerably, both with and without futures trade. The coordination costs of the marketing channel are lower with a futures market than without, demonstrating the informational (i.e., price-discovery) role of the futures markets so that it can be used for hedging purposes. Nevertheless, as a consequence of decreases in the producers’ and wholesalers’ degree of risk aversion, the optimal dynamic hedge ratio for wholesalers decreased from 14% in 1971 to 10% in 2003, whereas that of producers decreased from 38% in 1982 to 18% in 2002.

Keywords: agency theory, risk, coordination costs, hedge ratio, food marketing channels.

5.1 Introduction

In Chapter 2, we examined incentives, coordination costs and risk shifting in a two-stage marketing channel setting involving producers and retailers, without taking futures markets into account. In Chapter 3, we determined the time-varying hedge ratio for producers in a two-stage marketing channel model involving producers and retailers, taking futures markets explicitly into account. In addition, we examined the performance of the marketing channel by estimating the coordination cost in this marketing channel setting. In Chapters 4 and 5, we expanded our research to a three-stage marketing-channel setting. In Chapter 4 we investigated incentives, coordination cost, and risk shifting in a three-stage marketing-channel setting involving producers, wholesalers, and retailers, without futures markets. Here, in Chapter 5, we examine incentives, coordination costs, and risk shifting in a three-stage marketing channel setting involving producers, wholesalers, and retailers, when a futures market exists. In addition, we modeled and estimated the time-varying hedge ratio for producers and wholesalers in this channel.

In recent years, food marketing channels have changed from production orientation to market orientation. As a result, these marketing channels have been transformed from supply-oriented chains into demand-oriented chains, a process which has been termed chain reversal (e.g., Boehlje, 1996). These structural changes in food marketing channels are characterised by product differentiation, competition, globalisation, and consumers’ desire for quality and safe foods. Another development is the consolidation and concentration of food retailers and the resulting imbalance in bargaining power vis-à-vis their suppliers (e.g., Competition Commission, 2000). These developments in food marketing channels have implications for the strategies of upstream channel members (i.e., producers and wholesalers). For example, the contractual relationships (spot contracts, forward contracts, futures contracts) among
marketing channel members (MCMs) are influenced by the bargaining power of one channel member vis-à-vis the other channel members (Pennings and Leuthold, 2000).

More specifically, the outcomes of the contract negotiations influence the financial risk allocation in food marketing channels. Numerous authors investigated financial risk allocation in food marketing channels (e.g., Knoeber and Thurman, 1995, Martin, 1997, Kuwornu et al., 2004a,b). These studies focused on two stages of the marketing channel. For instance, Knoeber and Thurman (1995) examined financial risk allocation between farmers and integrator companies in the US broiler industry. They found that financial risk shifted from farmers to integrator companies. As a consequence of financial risks, MCMs may wish to hedge against output and input risk in futures markets. In the light of these developments, various authors have estimated optimal hedge ratios for producers (e.g., Pennings and Meulenberg, 1997b; Ederington, 1979; Dawson et al., 2000).

Previous research has raised the question what the role is of futures markets regarding risk allocations in multi-stage marketing channels involving producers, wholesalers, and retailers (cf. Kuwornu et al., 2004a,b). Given the impact of financial risk allocation on MCMs’ performance and given the ability of futures markets to re-allocate risk in the marketing channel, what, then, should be the optimal hedging strategy for the risk-averse MCMs? What are the coordination costs of the marketing channels when MCMs trade in futures markets, compared to when they do not trade in futures markets? Moreover, to the best of our knowledge, research effort that integrates risk allocation in food marketing channels and the estimation of the optimal hedge ratio is either scanty or non-existent. For example, Pennings (2004) specified a model to estimate static forward-contract ratios, in order to investigate the role of forward contracts in reducing the cash-flow volatility of various meat (beef, chicken, and pork) departments of European retailers. However, Pennings’ research focused solely on the retail stage of the marketing channel.
Moreover, as the risk aversion of MCMs may change over time, it is important to consider dynamic hedge ratios. This study seeks to fill this gap in the existing literature, by specifying a model that integrates optimal dynamic hedge ratios and risk allocation in food marketing channels involving producers, wholesalers, and retailers. Such an integrated framework improves our understanding of how MCMs respond to risk in spot markets. Thus, the relationship between the degree of risk aversion and the extent of hedging is a key issue in this study. The chapter’s contribution in this respect is the estimation of optimal hedge ratios for MCMs, while taking the contractual relationships among these MCMs into account. Subsequently, the objective of this study is threefold. First, in this chapter, we seek to extend the above-mentioned empirical investigations to marketing channels involving three stages, while allowing risk-averse channel members to trade in a futures market. Second, we seek to derive and estimate dynamic optimal hedge ratios for the risk-averse MCMs. Third, we seek to address issues of incentives and coordination costs in the context of a food marketing channel where MCMs use the futures market, compared with the situation where they do not use futures.

We specify a three-stage, principal-agent, marketing-channel model for producers, wholesalers, and retailers, extended with a futures market. The principal-agent model (e.g., Gibbons, 2005; Furboth and Richter, 1997; Milgrom and Roberts, 1992) is part of the agency theory framework. Originated in the information economics literature, agency theory studies problems that arise when one party (the principal) delegates work to another party (the agent). The core idea of agency theory is that principal-agent relationships should reflect efficient information and risk-bearing cost, incentive alignments, and the contract as the unit of analysis. The classic model of agency theory is based on the concept of a principal-agent relationship. In the standard theory of the firm, under the separation of ownership from control, shareholders are the principal, while management is the agent. This theory involves
an agent who performs a task for the principal. The principal values the agent’s realised performance and pays him/her compensation, as specified by a contract. However, there are some problems which arise in principal-agent relationships, which can be summarised as follows: The first is information asymmetry between the principal and the agent, i.e., the principal finds it difficult to observe the activities of the agent. The second is a goal conflict between the principal and the agent. The information asymmetry between the principal and the agent is not a problem per se; it becomes a problem when the principal and the agent have different goals. The third is the problem of risk sharing. This issue arises when the principal and the agent have different attitudes towards risk, and when the agent’s risk position changes through alternative incentive arrangements in the contract. Numerous researchers have used agency theory to model contractual relationships (e.g., Eisenhardt, 1989).

In the classic principal-agent model, the principal is said to be risk neutral, whereas the agent is risk averse. This assumption is based on the observation that the principal can easily diversify his/her activities, something which the agent can hardly do. In our modeling framework, we base the choice of principals and agents on the scale of operation of an MCM vis-à-vis the trading partner. We contend that the larger the scale of operation of an MCM, the more easily it can diversify. In this model, we have three MCMs: producers, wholesalers, and retailers. In terms of scale of operation, retailers are normally larger than wholesalers, while wholesalers are larger than producers. Subsequently, we assume a contractual relationship between producers (agent) and wholesalers (principal); and another contractual relationship between wholesalers (agent) and retailers (principal). In our model, retailers who carry a broad assortment of products, and hence are able to diversify, are considered risk-neutral, whereas producers and wholesalers who operate on relatively small scales, and who can therefore hardly diversify against risks, are considered risk averse. This assumption complies with the results of Brorsen et al. (1987), who showed that rice millers whose sole business is
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rice are risk averse. Consequently, our model assumes the risk-neutral retailers only to trade in the spot markets, while the risk-averse producers and wholesalers are assumed to trade in the futures markets as well, to hedge against the risks incurred in the spot markets.

The remainder of this chapter is structured as follows: The theoretical model is specified in Section 2, followed by the empirical application and results in Section 3. Finally, in Section 4, concluding remarks are provided. In what follows, we describe the modeling framework.

5.2 The Theoretical Model

In our model, we consider a product that is produced by farmers, processed and distributed to retailers by wholesalers, and finally sold to consumers by retailers. The retail value of the product is specified as

\[ x = e + \varepsilon \]  

(5.1)

where \( x \) is the actual retail value, \( e \) is the expectation of the retail value, and \( \varepsilon \) is the random component of the retail value, which is assumed to be normally distributed with mean zero and variance \( \sigma^2 \).

We assume a hypothetical linear contract between marketing-channel members. In line with the classic agency model, the linear contractual form is chosen because it corresponds to real-world settings (e.g., Knoeber, 1999; Allen and Lueck, 2002). Moreover, Holmstrom and Milgrom (1987) have shown that the optimal compensation scheme for providing incentives over time to an agent with a constant absolute risk-aversion for the duration of the contract is a linear function of the end-of-period results, such as revenues, costs, or profits. This result is based on the fact that a linear contract provides more uniform incentives than a non-linear contract, as can be seen by viewing the annual output as the outcome of many small daily
actions of the agent. Seen from this perspective, a non-linear contract may create unintentional or non-uniform incentives for the agent in the course of the year, depending on the agent’s performance to date (Gibbons, 2005).

The linear contract between the retailer and the wholesaler is as follows:

$$W_w = \alpha_w x + \beta_w$$  \hspace{1cm} (5.2)

where $W_w$ is the total compensation payment from the retailer to the wholesaler, $\alpha_w$ is the incentive parameter, $\alpha_w x$ is the variable compensation payment, and $\beta_w$ is the fixed compensation. Similarly, the contractual relationship between the wholesaler and the producer is specified as

$$W_p = \alpha_p \alpha_w x + \beta_p$$  \hspace{1cm} (5.3)

where $W_p$ is the total compensation payment from the wholesaler to the producer, $\alpha_p$ is the variable-revenue sharing parameter between the wholesaler and the producer (i.e., the proportion of the wholesaler’s variable revenue that is received by the producer), $\alpha_p \alpha_w$ is the actual incentive parameter from the wholesaler to the producer, and $\alpha_p \alpha_w x$ and $\beta_p$ are the variable and fixed compensation payments to the producer, respectively.

The wholesalers’ cost of effort is specified as

$$C_w = 0.5c_w e^2 + d_w$$  \hspace{1cm} (5.4)

Similarly, the producer’s cost of effort is specified as
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\[ C_p = 0.5c_pe^2 + d_p \]  \hfill (5.5)

where \( d_w \) and \( d_p \) denote trend terms that may reflect technological changes in production; \( c_w \) and \( c_p \) are the increase in marginal costs of wholesalers and producers, respectively. Note that the cost functions concern expected costs, not actual costs, because their argument is given by \( e \). This argument also implies that production cost may increase, either by extending production quantity or by improving the quality of the product, as reflected by a higher expected output price.

Net of fixed retail costs, the retailers’ profit is

\[ \pi_r = x - W_w \]  \hfill (5.6)

which has the following variance:

\[ Var(\pi_r) = (1 - \alpha_w)^2 \sigma^2 \]  \hfill (5.7)

as can be seen by substituting (5.1) and (5.2) in (5.6). Since the product is one of the many stock-keeping units in the retailer’s assortment, we assume that the retailer does not care about this variance. In contrast, in the model, we allow the risk-averse producers and wholesalers to trade futures contracts besides their contractual relationships in the marketing channel, in order to hedge against the risks incurred in the product’s spot market. Accordingly, the producer’s profit \( \pi_p \), resulting from selling futures contracts of his/her produce and the contractual relationship with the wholesaler, is given by
\[
\pi_p = W_p - C_p + Z_p(F_{t, t-1} - F_{t, t})
\]  \hspace{1cm} (5.8)

where \( Z_p(F_{t, t-1} - F_{t, t}) \) represents the producer’s gain or loss from selling futures contracts, in which \( Z_p \) is the quantity of produce sold in the futures market at time \( t-1 \); \( F_{t, t-1} \) is the futures price at time \( t-1 \); and \( F_{t, t} \) is the futures price at time \( t \). Thus, the producer’s result of holding a hedging position can be either positive or negative, depending on whether the futures price at maturity is below or above the price at which the position was initiated\(^1\). The difference in the futures price between time \( t-1 \) and \( t \) is assumed to follow a random walk with drift as follows\(^2\):

\[
F_{t, t-1} - F_{t, t} = \mu_F + \varepsilon_F
\]  \hspace{1cm} (5.9)

where \( \mu_F \), denoting the drift term, reflects storage costs and interest costs in futures trade, and \( \varepsilon_F \) is the error term with zero mean and variance \( \sigma_F^2 \). In the same vein, the wholesaler’s profit from buying futures contracts of the produce required for wholesaling and the contractual relationship with the retailer is given as

\(^1\) If the futures price at maturity, \( F_{t, t} \), exceeds the futures price at the initiation of the contract, \( F_{t, t-1} \), the farmer pays the clearing house the difference between these prices multiplied by the quantity of produce sold, \( Z_p \).

\(^2\) To understand the argument for futures prices following a random walk, we have to begin with the assumption that hedgers at any point in time estimate the value of the commodity based on expectations of the future, and that these expectations are unbiased and rational, given the information that hedgers have at that point in time. Under these conditions, the price of the commodity changes only as new information arrives in the market. If the futures price is an unbiased estimate of the value, then the next piece of information that arrives in the market about the commodity should just be as likely to contain good news as bad. It, therefore, follows that it is just likely to be positive as it is likely to be negative. Thus, a positive price change and a negative price change have 50% chance each. The implication is that each price change will be independent of the previous one, and that knowing a commodity’s price history will not form better predictions of the future price changes. There are prerequisites for the random walk hypothesis to hold. The first is that hedgers are rational and form unbiased expectations of the future, based on all the information available to them at the time. If expectations are too high or too low consistently (i.e., if hedgers are too optimistic or pessimistic), information will not have an equal chance of being good or bad news, and prices will not follow a random walk. The second is that price changes...
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\[ \pi_w = W_w - C_w - W_p + Z_w (F_{t,t} - F_{t,t-1}) \]  

(5.10)

where \( Z_w (F_{t,t} - F_{t,t-1}) \) represents the wholesaler’s gain or loss from buying futures contracts, in which \( Z_w \) is the quantity of produce bought at time \( t-1 \). Thus, the wholesaler’s result of holding a hedging position can also be either positive or negative, depending on whether the futures price at maturity is above or below the futures price at which the position was initiated.\(^3\)

Producers and wholesalers do not only form expectations regarding their respective profits, they are also aware of the uncertainty in these expectations. As in the previous chapters, we measure the uncertainty in producers’ and wholesalers’ profits by their variances as a proxy for their risk. The variance of producer’s profit is

\[ Var(\pi_p) = \alpha_p^2 \sigma_p^2 \sigma_r^2 + Z_w \sigma_w^2 + 2 \alpha_p \alpha_w Z_w \sigma_p \sigma_r \]  

(5.11)

as can be derived from substituting (5.1), (5.3) and (5.9) in (5.8). Similarly, the variance of wholesalers’ profit can be expressed as

\[ Var(\pi_w) = (1 - \alpha_p)^2 \alpha_w^2 \sigma_r^2 + Z_w^2 \sigma_r^2 - 2(1 - \alpha_p) \alpha_w Z_w \sigma_r \]  

(5.12)

after substituting (5.1) – (5.3) and (5.9) in (5.10). Given that the risk aversion of producers and wholesalers complies with the constant absolute risk aversion (CARA) preferences and

---

\(^3\) The wholesalers are expected to try to hedge against purchase value risk. Hence, they go long so that if the futures price at maturity, \( F_{t,t} \), is lower than the futures price at the initiation of the contract, \( F_{t,t-1} \), the wholesaler pays the clearing house the difference between these prices multiplied by the quantity of produce bought, \( Z_w \).
that their profits are normally distributed, their objective functions are equivalent to the
maximisation of their respective certainty equivalents of profits, given as

\[
CE(\pi) = E(\pi) - 0.5\rho Var(\pi)
\]  

(5.13)

where \( CE(\pi) \) is the certainty equivalent of profit, \( E(\pi) \) is the expectation of profit, and
\( 0.5\rho Var(\pi) \) is the risk premium, in which \( \rho \) is the coefficient of constant absolute risk
aversion and \( Var(\pi) \) is the variance of profits. Note that the expectations in the certainty
equivalent of profits are common to all MCMs as these expectations are conditional on a
common information set.

The producer’s objective function can now be expressed as

\[
\begin{align*}
\max_{e, Z_p} & \{\alpha_p e \alpha_w e + \beta_p - d_p - 0.5c_p e^2 + \mu_F Z_p \\
& - 0.5\rho p^2 \alpha_w^2 \sigma_p^2 - 0.5\rho p^2 Z_p^2 \sigma_p^2 - \rho p \alpha_p \alpha_w Z_p \sigma_{\alpha F} \}
\end{align*}
\]  

(5.14)

of which the first-order conditions are

\[
e = \alpha_p \alpha_w / c_p
\]  

(5.15)

and

\[
Z_p = (\mu_F - \rho p \alpha_p \alpha_w \sigma_{\alpha F}) / \rho p \sigma_F^2
\]  

(5.16)
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Having defined the objective function of the producer (i.e., agent), it is important to elaborate on the constraints in the contract between the producer and the wholesaler (i.e., principal). In the contract outlined above, the wholesaler (i.e., principal) is subjected to the participation constraint (reservation utility constraint) and the incentive compatibility constraint. The participation constraint suggests that the producer (i.e., agent) equates his/her reservation wage $\bar{W}_p$ to his/her certainty equivalent of profit $CE(\pi_p)$. From this condition and after inserting $e$ in (5.15) and $Z_p$ in (5.16) into the certainty equivalent of profit in (5.14), the producer’s fixed compensation $\beta_p$ is then derived as

$$
\beta_p = \bar{W}_p + d_p - 0.5\alpha_p^2\alpha_w^2/c_p - 0.5\mu_F^2/p_p\sigma_F^2 + 0.5\rho_p\alpha_p^2\alpha_w^2\sigma^2
+ \alpha_p\alpha_w\mu_F\sigma_{\alpha_F}/\sigma_F^2 - 0.5\rho_p\alpha_p^2\alpha_w^2\sigma_{\alpha_F}/\sigma_F^2
$$

Having derived the conditions for the parameters in the contract offered by the wholesaler to the producer, we now turn to the derivation of the optimality conditions for the parameters in the contract offered by the retailer to the wholesaler. From (5.1) – (5.4), (5.10), (5.12) and (5.13) the wholesaler’s certainty equivalent of profit is obtained as

$$
CE(\pi_w) = (1 - \alpha_p)\alpha_w e + \beta_w - 0.5\alpha_w^2e^2 - d_w - \beta_p - \mu_F Z_w
- 0.5\rho_w(1 - \alpha_p)^2\alpha_w^2\sigma^2 - 0.5\rho_wZ_w^2\sigma_F^2 + \rho_w(1 - \alpha_p)\alpha_wZ_w\sigma_{\alpha_F}
$$

Inserting $e$ in (5.15) and $\beta_p$ in (5.17) into (5.18), the risk-averse wholesaler maximises the certainty equivalent of profit, $CE(\pi_w)$, as follows:

---

4 The participation constraint suggests that the agent (i.e., producer) must at least derive a minimum level of expected utility from his/her contractual relationship with the principal (i.e., wholesaler). The incentive compatibility constraint reflects the restriction that the principal can observe the agent’s output but not the agent’s action or effort. In this sense the effort exerted by the agent is optimal from the agent’s own point of view.
Chapter 5. Contract Relationships and Risk Management

\[
\begin{align*}
\max_{\alpha_p, Z_w} & (1 - \alpha_p) \alpha_w^2 \alpha_p / c_p + \beta_w - d_w - 0.5 c_w \alpha_p^2 / c_p^2 - \bar{W}_p - d_p + \\
& 0.5 \alpha_p^2 \alpha_w^2 / c_p + 0.5 \mu_F^2 / \rho_p \sigma_F^2 - 0.5 \rho_p \alpha_p^2 \alpha_w \sigma^2 - \alpha_p \alpha_w \mu_F \sigma_{\epsilon F} / \sigma_F^2 + \\
& 0.5 \rho_p \alpha_p^2 \alpha_w^2 \sigma_{\epsilon F}^2 / \sigma_F^2 - \mu_F Z_w - 0.5 \rho_w (1 - \alpha_p) \alpha_w^2 \sigma^2 - 0.5 \rho_w Z_w \sigma_F^2 + \\
& \rho_w (1 - \alpha_p) \alpha_w Z_w \sigma_{\epsilon F}^2 \\
\end{align*}
\]

(5.19)

The first-order conditions yield:

\[
\begin{align*}
\alpha_p &= (1 - c_p \mu_F \sigma_{\epsilon F} / \alpha_w \sigma_F^2 + c_p \rho_w \sigma^2 - c_p \rho_w Z_w \sigma_{\epsilon F} / \alpha_w) \\
& / (1 + c_w / c_p + c_p \rho_p S + c_p \rho_w \sigma^2)
\end{align*}
\]

(5.20)

and

\[
Z_w = [\rho_w (1 - \alpha_p) \alpha_w \sigma_{\epsilon F} - \mu_F] / \rho_w \sigma_F^2
\]

(5.21)

where

\[
S \equiv (\sigma^2 \sigma_F^2 - \sigma_{\epsilon F}^2) / \sigma_F^2
\]

(5.22)

Next, like the producer, the wholesaler considers a participation constraint, according to which the certainty equivalent of the wholesaler’s profit, \( CE(\pi_w) \), equals the wholesaler’s reservation wage, \( \bar{W}_w \). From this condition, and after inserting \( Z_w \) in (5.21) into (5.19), the wholesaler’s fixed compensation is derived as

\[
\begin{align*}
\beta_w &= \bar{W}_w + d_w + \bar{W}_p + d_p - \alpha_w^2 \alpha_p / c_p + 0.5 c_w \alpha_p^2 \alpha_w^2 / c_p^2 + 0.5 \alpha_p^2 \alpha_w^2 / c_p \\
& - 0.5 \mu_F^2 / \rho_p \sigma_F^2 + 0.5 \rho_p \alpha_p^2 \alpha_w \sigma^2 + \mu_F \alpha_w \sigma_{\epsilon F} / \sigma_F^2 - 0.5 \mu_F^2 / \rho_w \sigma_F^2 \\
& + 0.5 \rho_w (1 - \alpha_p) \alpha_w^2 S
\end{align*}
\]

(5.23)
Risk, Incentives and Coordination Costs

Subsequently, we substitute (5.21) in (5.20) to obtain the following expression for the producer’s revenue-sharing parameter $\alpha_p$ in his/her contract with the wholesaler:

$$\alpha_p = \left[1 + c_p \rho_w S \right] / \left[1 + c_w / c_p + c_p (\rho_p + \rho_w) S \right]$$

(5.24)

We now turn to the objective function of the risk-neutral retailer. From equations (5.1), (5.2), (5.6), (5.15) and (5.23) the risk-neutral retailer maximises the expectation of profits as follows:

$$\begin{align*}
\text{Max}_{\alpha_w} & \left\{ \alpha_p \alpha_w / c_p - \tilde{W}_w - d_w - \tilde{W}_p - d_p - 0.5c_w \alpha_w^2 \alpha_p^2 / c_p^2 \\
& - 0.5 \alpha_p^2 \alpha_w^2 / c_p + 0.5 \mu_F^2 / \rho_p \sigma_F^2 - 0.5 \rho_p \alpha_p^2 \alpha_w^2 S - \mu_F \alpha_w \sigma_{\delta F} / \sigma_F^2 \\
& + 0.5 \mu_F^2 / \rho_w \sigma_F^2 - 0.5 \rho_w (1 - \alpha_p)^2 \alpha_w^2 S \right\}
\end{align*}$$

(5.25)

for which the first-order condition yields:

$$\alpha_w = \left[1 - c_p \mu_F \sigma_{\delta F} / \alpha_p \sigma_F^2 \right] / \left[ c_w \alpha_p / c_p + \alpha_p + c_p \rho_p \alpha_p S + c_p \rho_w (1 - \alpha_p)^2 S / \alpha_p \right]$$

(5.26)

Recall from the linear contract for the wholesaler, as presented in (5.2) that the revenue-sharing parameter is given by $\alpha_w$. In the contract for the producer the revenue-sharing parameter is $\alpha_p \alpha_w$. Consequently, if $\alpha_p$ is a constant parameter, then both revenue-sharing parameters may still be time varying through $\alpha_w$. In line with this notion and for purpose of empirical testing to be discussed in the next two sections, we consider $\alpha_w, \beta_w, \beta_p, \rho_w, \rho_p, Z_w$.
and $Z_p$ as unknown variables to be solved by the equations (5.15) – (5.17), (5.21), (5.23), (5.24) and (5.26). Below, we first discuss the derivation of the solutions for $\rho_w$ and $\rho_p$.

Rewriting (5.24) yields the following expression for the producer’s risk parameter:

$$\rho_p = \rho_w (1 - \alpha_p) / \alpha_p + (1 - \alpha_p - \alpha_p c_w / c_p) / \alpha_p c_p S$$  \hspace{1cm} (5.27)$$

Next, substituting $\alpha_w$ in (5.15) and $\rho_p$ in (5.27) into (5.26), we obtain the wholesaler’s risk parameter as follows:

$$\rho_w = [(\sigma_F^2 \alpha_p^2 - \sigma_F^2 c_p e - c_p \mu_F \sigma_{\delta F}) \alpha_p] / [(1 - \alpha_p) c_p^2 e \sigma_F^2 S]$$  \hspace{1cm} (5.28)$$

Subsequently, substituting $\rho_w$ in (5.28) into (5.27) we obtain the risk parameter for the producer:

$$\rho_p = [\sigma_F^2 \alpha_p^2 - 2 \sigma_F^2 \alpha_p c_p e - \alpha_p c_p \mu_F \sigma_{\delta F} + c_p e \sigma_F^2 - \alpha_p c_w e \sigma_F^2 S] / [\alpha_p c_p^2 e \sigma_F^2 S]$$  \hspace{1cm} (5.29)$$

These risk parameters are one of the determinants of the producer’s and wholesaler’s hedge ratios. In the model, we assume that the quantity produced $q$ is the same as the quantity consumed. The optimal hedge ratios for the producer and wholesaler, respectively, are given by$^5$

$^5$ The hedge ratio is defined as the proportion of output/input hedged in the futures market. In particular, the hedge ratio of the producer is the proportion of output hedged (i.e., the amount of output sold in the futures market as a proportion of the total output produced). Similarly, the wholesaler’s hedge ratio is the proportion of the quantity purchased by the wholesaler that is hedged in the futures market (i.e., the amount of produce bought in the futures market as a proportion of the total amount of produce purchased by the wholesaler on the spot market).
Risk, Incentives and Coordination Costs

\[ h_p^* = \frac{Z_p}{E(q)} \]  

and

\[ h_w^* = \frac{Z_w}{E(q)} \]  

where \( Z_p \) and \( Z_w \) are as defined above and \( E(q) \) denotes the common expected output.

To assess the importance of the risk parameters for the performance of the marketing channel, we perform some simulations, in order to obtain the agency (coordination) costs \( (AC) \) of the whole marketing channel as the difference between the first-best optimal solution and the second-best optimal solution, as follows:

\[ AC = E(\pi_r^* + \pi_w^* + \pi_p^*) - E(\pi_r + \pi_w + \pi_p) \]  

The terms ‘first-best solution’ and ‘first-best situation’ are used interchangeably in this chapter. They refer to a situation where all MCMs are assumed to be risk neutral. Similarly, the terms ‘second-best situation’ and ‘second-best solution’ are used interchangeably. In this case, risk aversion is assumed for producers and wholesalers. The second-best situation is viewed from two perspectives: with and without futures trade.

In what follows, we describe how we performed the simulations aimed at obtaining the coordination costs of the marketing channel. The first-best optimal solution of the marketing channel, \( E(\pi_r^* + \pi_w^* + \pi_p^*) \), is obtained by setting \( \rho_w = \rho_p = 0 \). These restrictions imply that the futures market is also eliminated in the model: \( Z_p = Z_w = \mu_F = \sigma_{\sigma_F} = 0 \). From these restrictions, and considering \( c_w, c_p, d_w, d_p, \sigma^2, \bar{W}_w \) and \( \bar{W}_p \) as given, it follows from (5.22)

---

6 Agency (coordination) costs may include ex ante information search costs associated with adverse selection (hidden information) problems and/or ex post monitoring and enforcement costs associated with moral hazard problems. These costs are believed to be the main reasons for which the marketing channel cannot achieve the
that $S = \sigma^2$. Furthermore, (5.24) yields $\alpha_p = c_p/(c_p + c_w)$, and (5.26) then shows that $\alpha_w = 1$, so that $e = 1/(c_p + c_w)$, according to (5.15). Next, we can perform simulations in order to obtain $\beta_p$ and $\beta_w$ by using (5.17) and (5.23), respectively. Thus, to obtain the first-best expressions for $\beta_p$ and $\beta_w$, we substitute the first-best expressions for $S$, $\alpha_p$, $\alpha_w$, and $e$, as outlined above, into (5.17) and (5.23). Finally, we can derive the first-best and second-best expectations of profits and variances of the profits of the respective MCMs along the lines of (5.1) – (5.12).7

If all MCMs are risk-neutral, the futures market has become superfluous and the principal can give full incentive to the agent, as the principal is no longer constrained by the optimal trade-off, according to which higher incentive intensity (incentive parameters) can only be established at the cost of a higher risk premium asked for by the agent. The second-best optimal solution for the marketing channel, $E(\pi_r + \pi_w + \pi_p)$, is obtained when producers and wholesalers are risk-averse. Subsequently, we can determine the coordination costs when MCMs cannot trade futures contracts, but are as risk averse as they were when they could trade on the futures market. This is done by setting $\sigma_{\xi F} = \mu_F = 0$, and considering the empirical values of $\rho_p$ and $\rho_w$ obtained from (5.29) and (5.28) respectively, before imposing these restrictions in order to obtain the most realistic estimates of the intrinsically exogenous parameters $\rho_p$ and $\rho_w$, as given. This analysis enables us to compare the coordination costs of the marketing channel with and without futures trade by MCMs.

---

7 To derive the estimates of the expectation of the first-best optimal profits for the MCMs we substitute the first-best optimal expressions of the variables outlined above into the respective expectations of profits of the MCMs. However, to derive the estimates of the expectation of the second-best optimal profits for the MCMs, we substitute where appropriate the variables: $\alpha_p$ in (5.24), $\alpha_w$ in (5.26), $\rho_p$ in (5.28), $\rho_w$ in (5.29), $\beta_p$ in (5.17), $\beta_w$ in (5.23) into the respective expectations of profits of the MCMs.
5.3 Empirical Application: Data, Estimation and Results

We apply the model from the previous section to the Dutch potato industry. Every year, some eight million tons of potatoes are produced in the Netherlands, mainly on family farms. About half are ware potatoes, approximately 20 percent are seed potatoes, and the remaining 30 percent are potatoes grown for starch (NIVAP Holland, 2002). We focus on ware potatoes, as the prices of this type of potato exhibit the highest volatility estimates. It is therefore considered a more risky product than the other types of potatoes (Smidts, 1990). As far as the ware-potato trade in the Netherlands is concerned, there is very little interference in the operation of a free market and hence 'outside' involvement is at a minimum (e.g., Young, 1977; Smidts, 1990; ZLTO & LLTB, 2002; Baltussen and Van Asseldonk, 2005). Most ware potatoes are sold to wholesalers and most of the wholesale trade has become concentrated in relatively few hands, as the major users, particularly the large retailers, processors and export markets, demand large quantities with tight specifications which only the larger wholesalers can meet. Because of this development in the market, the need has arisen to procure potatoes before harvest. In this respect, the potato futures contract of the Euronext Commodity Amsterdam Exchange fulfills a price discovery role (see Kuiper et al., 2002).

For the empirical analysis, Statistics Netherlands provided us with annual data over the period 1971 – 2003, for the following variables: the farm, export (i.e., wholesale) and retail prices (Euro/kg) of ware potatoes, all deflated by the consumer price index (1990 = 1.00), area planted (1000 ha), yield per hectare (100 kg/ha), and rent price of land (Euro/ha), deflated by the consumer price index. Furthermore, we obtained the futures price of potato and the volume of potato futures contracts traded at Euronext Amsterdam Commodity Exchange over the period 1971-2003. We used the futures price (Euro/kg) for delivery in April of year \(t\) quoted as the closing price of the first trading day of April in year \(t - 1\) to represent \(F_{t,t}\); to represent \(F_{t,t-1}\), we used the futures price (Euro/kg) for delivery in April of
year \( t + 1 \) quoted as the closing price of the first trading day of November (when most potatoes are sold by the farmers) in year \( t \). Both \( F_{t,t-1} \) and \( F_{t,t} \) are also deflated by the consumer price index. From these time series, we obtain the following variables of interest.

First, all prices, spot and futures, are deflated by the consumer price index. For the computations of the expectation of the retail value and the variance of the retail value, see the appendix at the end of this thesis. The rent price of land times the area planted (divided by \( 10^6 \)) is used as a proxy for \( \bar{W}_p \) (the producer’s reservation wage). Lastly, we set \( \bar{W}_w \) (the wholesaler’s reservation wage) equal to zero and used linear models with a constant and linear trend to estimate \( d_w \) and \( d_p \).\(^8\)

Note that, in contrast to the modeling framework, where the variables are assumed static, the variables become time varying during the estimation process, as we used time-series data. Hence the subscript \( t \) is imposed on the variables.

The unknown parameters in the model that are left to be estimated, are \( c_p, c_w, d_p, d_w, \) and \( \alpha_p \). In order to estimate these parameters, we need to derive estimation equations. According to (5.15), we can substitute \( e_p \) for \( \alpha_p \) into (5.3) and into (5.17) to obtain, after substituting for \( \beta_p \)

\[
W_{pt} - \bar{W}_{pt} = d_p + c_p e_p x_t - 0.5 c_p e_t^2 + c_p e_t \hat{\mu}_p \hat{\sigma}_{dF} / \hat{\sigma}_F^2 \\
- 0.5 \hat{\mu}_p^2 / \hat{\sigma}_F^2 \rho_{pt} + 0.5 c_p e_t^2 \rho_{pt} \delta
\]

\(^8\) We assume that the reservation wage of producers and wholesalers have direct relationship with their respective expected cost of effort functions in (5.4) and (5.5). These cost functions are linear in nature. Therefore, the linear models that we use to estimate the wholesaler’s reservation wage stem from the specification of these cost functions. We did not use the estimate of wholesaler’s reservation wage in further analysis, which will result into an identification problem, as we are unable to identify which part of the deterministic part of the wholesaler’s cost function is due to changes in costs and which part is due to the reservation wage.
Risk, Incentives and Coordination Costs

Similarly, substituting $c_p e / \alpha_p$ for $\alpha_w$ in (5.23), and then substituting for $\alpha_w$ and $\beta_w$ in (5.2), yields

$$
W_{wt} - \overline{W}_{wt} - \overline{W}_{pt} = \frac{d_p + d_w + c_p e_i x_i}{\alpha_p - c_p e_i^2 / \alpha_p + 0.5(c_p + c_w)e_i^2} - 0.5 \mu_p^2 / \sigma_p \rho_{pt} + 0.5 c_p^2 e_i^2 \rho_{pt} \hat{S} + \mu_p \sigma_d c_p e_i / \sigma_p^2 \alpha_p - 0.5 \mu_p^2 / \sigma_p \rho_{wt} + 0.5[(1 - \alpha_p) / \alpha_p] c_p^2 e_i^2 \rho_{wt} \hat{S} \tag{5.34}
$$

After substituting (5.28) and (5.29) for $\rho_w$ and $\rho_p$, respectively, into (5.33) and (5.34), and modeling the deterministic terms $d_p$ and $d_w$ as linear trends, giving $d_{pt} = d_{p0} + d_{p1} t$ and $d_{wt} = d_{w0} + d_{w1} t$, we can estimate the unknown parameters $\alpha_p$, $c_p$, $c_w$, $d_{p0}$, $d_{p1}$, $d_{w0}$, and $d_{w1}$ in the two-equation system by using Full Information Maximum Likelihood (FIML).

The FIML estimates of the unknown parameters in (5.33) and (5.34) are presented in Table 5.1. The estimate for $\alpha_p$ is significant and fits nicely within the expected constraints $0 < \alpha_p < 1$. The estimates of the marginal cost terms $c_p$ and $c_w$ are positive and significant as well. However, with respect to slopes of the trend terms in the cost functions only the slope of the trend term in the cost function of the producers, $d_{p1}$, tend to be significant. Its negative sign indicates technological advances in agricultural production. Having obtained the estimates of the above-mentioned parameters, we now perform simulations in order to obtain the estimates of the following variables: $\alpha_w$, $\alpha_p$, $\rho_{pt}$, $\rho_{wt}$, $\beta_{pt}$, and $\beta_{wt}$. The simulation procedure has been explained above in the last two paragraphs of Section 5.2 as well as by footnote 8.

The estimates of the incentive parameters for producers ($\alpha_p$,$\alpha_w$) with and without futures market are compared with the first-best situation (i.e., when producers and wholesalers
### Table 5.1: Estimates of $\alpha_p$, $c_p$, $c_w$, $d_{p0}$, $d_{p1}$, $d_{w0}$ and $d_{w1}$ Obtained by FIML Applied to Equations (5.33) and (5.34)

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>t Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_p$</td>
<td>0.581</td>
<td>0.272</td>
<td>2.138</td>
<td>0.033</td>
</tr>
<tr>
<td>$c_p$</td>
<td>0.261</td>
<td>0.116</td>
<td>2.247</td>
<td>0.025</td>
</tr>
<tr>
<td>$c_w$</td>
<td>0.485</td>
<td>0.023</td>
<td>21.01</td>
<td>0.000</td>
</tr>
<tr>
<td>$d_{p0}$</td>
<td>0.276</td>
<td>0.103</td>
<td>2.687</td>
<td>0.007</td>
</tr>
<tr>
<td>$d_{p1}$</td>
<td>-0.007</td>
<td>0.004</td>
<td>-1.758</td>
<td>0.079</td>
</tr>
<tr>
<td>$d_{w0}$</td>
<td>-0.107</td>
<td>0.106</td>
<td>-1.009</td>
<td>0.313</td>
</tr>
<tr>
<td>$d_{w1}$</td>
<td>0.000</td>
<td>0.004</td>
<td>0.013</td>
<td>0.990</td>
</tr>
</tbody>
</table>

**System Diagnostics:**

- **Sample:** 1971 - 2002
- **Log Likelihood:** 53.52002
- **Determinant residual covariance:** 0.000121

**Equation-Specific Diagnostics:**

<table>
<thead>
<tr>
<th>Equation</th>
<th>Number of Observations</th>
<th>$R^2$</th>
<th>Standard Error of Regression</th>
<th>Sum of Squared Residuals</th>
<th>Durbin-Watson Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eq. (5.33)</td>
<td>32</td>
<td>0.32</td>
<td>0.161</td>
<td>0.704</td>
<td>2.23</td>
</tr>
<tr>
<td>Eq. (5.34)</td>
<td>32</td>
<td>0.78</td>
<td>0.084</td>
<td>0.178</td>
<td>1.07</td>
</tr>
</tbody>
</table>

**Note:**
- $\alpha_p$ denotes the incentive intensity in the contract between the wholesalers and the producers
- $c_p$ denotes the increase in the marginal cost of effort of the producer
- $c_w$ denotes the increase in the marginal cost of effort of the wholesaler
- $d_{p1}$ denotes the linear part of the producer’s cost function
- $d_{w1}$ denotes the linear part of the wholesaler’s cost function
- $d_{p0}$ denotes a constant in the producer’s cost function
- $d_{w0}$ denotes a constant in the wholesaler’s cost function
- $d_p = d_{p0} + d_{p1}T_t$, where $T_t$ is the linear time trend, for which $T_{1971} = 1$, $T_{1972} = 2$, …
- $d_w = d_{w0} + d_{w1}T_t$, where $T_t$ is the linear time trend, for which $T_{1971} = 1$, $T_{1972} = 2$, …
- $d_p$ and $d_w$ are the linear trend terms in the producer’s and wholesaler’s cost functions, respectively
Risk, Incentives and Coordination Costs

are risk neutral) and are shown in Figure 5.1. The second-best situation is viewed from two perspectives: with and without futures trade. The estimates of the incentive intensity are higher for the case with futures trade than for the case without. With futures trade, the incentive intensity of producers increased from 0.24 in 1971 to 0.31 in 2003, whereas, without futures trade, it increased from 0.14 in 1971 to 0.25 in 2003. As expected, most incentives can be given in case of risk-neutrality, although, remarkably, around 2000, where the three graphs converge, incentive intensity hardly seems to be affected by the risk aversion of the producers. This result is consistent with the increase in the incentives in the potato contracts in 2000. In 1999, potato production was adversely affected by the flood that occurred in 1998. To motivate the producers to increase production, they were given more incentives by wholesalers and processors in the potato contract in 2000. Hence, the incentive levels converge with the first-best levels. This result may indicate an improvement of coordination among wholesalers and producers.

![Incentive intensity graph](image-url)

**Figure 5.1:** Producers’ Incentive Intensity ($\alpha, \alpha_{\text{u}}$) With Futures (APWF), Without Futures (APNF), and under Risk Neutrality (i.e., First-Best Situation) (APRN)
Similarly, the estimates of the incentive intensity from retailers to wholesalers \( (\alpha_{wt}) \) with and without futures market are compared with the first-best situation and are shown in Figure 5.2. In the same vein, the estimates of the incentive intensity for wholesalers are higher when they trade futures than when they do not. The incentive intensity for wholesalers increased from 0.40 in 1971 to 0.62 in 2000, with futures trade, and increased from 0.22 in 1971 to 0.50 in 2000, without futures trade. Nevertheless, compared to producers, the incentive-intensity estimates regarding wholesalers do not attain optimal levels (\( i.e., \) the incentive intensity obtained when all MCMs are assumed to be risk neutral), showing the reduction in incentive intensity as a consequence of risk aversion.

![Figure 5.2: Wholesalers’ Incentive Intensity \( \alpha_{wt} \) With Futures (AWWF), Without Futures (AWNF), and under Risk Neutrality (\( i.e., \) First-Best Situation) (AWRN)](image)

In contrast to the incentive parameters that show positive trending patterns, the fixed compensations for producers (wholesalers), \( \beta_{pt} \) \( (\beta_{wt}) \), show negative trending patterns over the years. We compare these fixed compensations with their respective first-best situations.
Risk, Incentives and Coordination Costs

As shown in Figure 5.3, producers’ fixed compensations are usually closer to the level of the first-best situation with futures trade than without. This is another indication of the positive impact of the futures market on coordination performance in the marketing channel.

![Figure 5.3: Producers’ Fixed Compensation $\beta^*_p$ With Futures (BPWF), Without Futures (BPNF), and under Risk Neutrality (i.e., First-Best Situation) (BPRN)](image)

Furthermore, it is interesting to note that, before 1990, the actual fixed compensation for the producers was too high compared to its first-best situation (level), while, after 1990, there are some years with an over-investment beyond the first-best situation (level) (see Figure 5.3). These over-investments are indicated by the negative fixed compensations beyond the first-best situations (level). The results suggest that farmers play a crucial role in the transformation process of the agri-food chain, as they seem to be forced to finance some of the activities required by marketing firms (i.e., wholesalers and retailers) in order to meet consumers’ needs and demands in the increasingly saturated consumer food market, amidst growing competition and globalisation. The fact that growers have become more involved in storing potatoes is a
clear example of this development. Yet, another illustration of the above claim is that more and more varieties have been produced and marketed, in order to satisfy consumer needs in recent years, thus limiting the dominance of Bintje in the potato market.

Similarly, the wholesalers’ fixed compensations show negative trending patterns and started to become negative at the beginning of the nineties, see Figure 5.4. It is interesting to note that the wholesalers’ first-best fixed compensations were negative throughout the period of study and much lower than the second-best estimates, which hardly differ between the cases with and without futures. So, as we observed for the incentive intensities, the coordination between retailers and wholesalers is still considerably distant from first-best results.

![Wholesalers' Fixed Compensation](image)

**Figure 5.4: Wholesalers’ Fixed Compensation $\beta_{wt}$ With Futures (BWWF), Without Futures (BWNF), and under Risk Neutrality (i.e., First-Best Situation) (BWRN)**

The increase in incentive intensity, along with decrease and negativity of the fixed compensation payments to producers and wholesalers has implications for financial risk allocation in the marketing channel. The computed variance of profits of producers in (5.11)
and wholesalers in (5.12) shows slightly increasing trending patterns, both in the case with and without a futures market; whereas that of the retailers in (5.7) shows decreasing trending patterns that are quite pronounced, see Figure 5.5. The graphs in Figure 5.5 clearly show that, of all MCMs, the retailers assume most of the risk, as we expect them to do, being the only risk-neutral MCMs. Interestingly, however, of all the MCMs, the risk-neutral retailers profit most from the presence of a futures market, in terms of risk reduction, even though they do not themselves use the futures market as a risk-management instrument. Nevertheless, their risk becomes much lower when the wholesalers and producers use the futures market to manage their risk. Note that, because of the assumption of their risk-neutrality, the retailers are required to take over risk from the risk-averse MCMs (i.e., wholesalers and producers), as much as is optimal for them (i.e., retailers). Hence, one may expect a reduction of risk within the marketing channel, due to an operational futures market, especially to be expressed in the reduction of the retailer’s profit risk.
In the above discussions, our results show that retailers could reduce their risk, because the risk-averse producers and wholesalers use the futures market to reduce their variability in profits. Assuming that producers and wholesalers trade futures contracts, in addition to their spot-market transactions, we estimate their respective optimal dynamic hedge ratios in (5.30) and (5.31). In this instance, producers are assumed to sell futures contracts of their produce, whereas wholesalers are assumed to buy futures contracts of the produce required for wholesaling. This assumption is based on the fact that producers need to sell their produce and wholesalers need inputs (i.e., producer’s products) in order to perform the wholesaling function. Intuitively, as a consequence of decreases in the wholesalers’ degree of risk aversion, the optimal dynamic hedge ratio for wholesalers decreased from 14% in 1971 to 10% in 2003, see Figure 5.6. These results are consistent with the decrease in the volume of futures contracts traded at the Amsterdam Commodity Exchange over the years.

Similarly, the producers’ optimal dynamic hedge ratios decreased from about 38% in 1982 to 18% in 2003, complying with the decrease in the degree of risk aversion, see Figure 5.7. These results are also consistent with decrease in the volume of futures contracts traded over the years.

![Figure 5.6: Wholesalers’ Optimal Dynamic Hedge Ratio (HW)](image-url)
Risks, Incentives and Coordination Costs

The results also show that producers hedge more than wholesalers do, over the period of study. The intuition for this result is that though we considered both producers and wholesalers to be risk-averse agents, producers perceive more market risk than wholesalers. This stems from the fact that there is generally no correlation between producers’ input and output prices, whereas there appears to be high positive correlation between wholesalers’ input (i.e., producer price) and output prices. For instance, the result from the data employed in this research shows that the Pearson correlation coefficient between producer price and wholesale price is 0.46 (p-value = 0.008). This observation is consistent with the notion that there is a clear distinction between risk attitude (i.e., risk content) and risk perception (e.g., Pennings and Wansink, 2004).

Figure 5.7: Producers’ Optimal Dynamic Hedge Ratio (HP)

Figure 5.6 did not show that the hedge ratio is in fact negative instead of positive, because, in a sense, the wholesaler buys a “negative” amount on the futures market. In the model, the wholesalers are positioned as long hedgers (buyers), see (5.10), but based on the empirical data, this results in a negative hedging amount, implying that the wholesalers, like
the producers, go short instead of long. Given the empirical observation that most potato contracts between wholesalers and growers in the Netherlands are closed before or during the planting period, and the fact that most of the wholesale trade is in the hands of farmer cooperatives, wholesalers in fact take over the “short” position of the producers by taking away most of the price risk from the producers.

To assess coordination efficiency, we computed the coordination costs of the marketing channel involving producers, wholesalers, and retailers. Intuitively, as a result of increases in the incentives to producers and wholesalers, the coordination costs of the marketing channel have generally decreased over time, both with and without futures trade. The coordination costs of the marketing channel with (without) futures trade decreased from about 0.09 billion euro (0.24 billion euro) in 1971 to 0.03 billion euro (0.014 billion euro) in 2002, see Figure 5.8. In Figure 5.9, we show the expectations for the total profits of the marketing channel for three situations: the optimal (i.e., first-best) situation (i.e., risk neutrality), the situation with futures trade, and the situation without futures trade. The difference between the expected profits for the optimal situation and for the situation with futures trade yields the coordination costs for the situation with futures, as shown in Figure 5.8. Similarly, the difference between the expected profits for the optimal situation and for the situation without futures trade yields the coordination costs for the situation without futures, also shown in Figure 5.8. A careful look at Figure 5.9 reveals that the coordination efficiency of the marketing channel has been greatly improved, as the expected profits of the marketing channel closely approach the first-best profits from 1995 onward. This result is further confirmed by the fact that the expectations of the retail value for the case with and without futures also reach first-best levels, see Figure 5.10. A point worth noting is that the coordination costs with futures are generally lower than without. This result complies with the role of futures markets in providing information regarding prices.
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Figure 5.8: Coordination Costs of the Marketing Channel With Futures Market (CCWF) and Without Futures Markets (CCNF)

Figure 5.9: The Expectation of Total Profit of the Marketing Channel With Futures (ETPWF), Without Futures (ETPNF), and under Risk Neutrality (ETPRN)
Figure 5.10: The Expectation of Retail (Output) Value With Futures (EWF), Without Futures (ENF), and under Risk Neutrality (i.e., First-Best Situation) (ERN)

Table 5.2: Parameter Estimates in the Regression of the Actual Wage Payment to the Producers ($W_{pt}$) on the Variable and Fixed Payment Components Estimated by the Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.031</td>
<td>0.118</td>
<td>0.261</td>
<td>0.796</td>
</tr>
<tr>
<td>$\hat{\alpha}<em>p\hat{\alpha}</em>{w_t}x_t$</td>
<td>0.873</td>
<td>0.351</td>
<td>2.489</td>
<td>0.019</td>
</tr>
<tr>
<td>$\hat{\beta}_{pt}$</td>
<td>0.950</td>
<td>0.262</td>
<td>3.632</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Sample: 1971 - 2003; Number of Observations = 33; $R^2 = 0.31$; $R^2_{adj} = 0.26$; Std. Error Resid = 0.15; Sum Squared Resid = 0.70; Durbin-Watson = 2.22; $F(3,30)$ statistic testing for the joint hypothesis that the intercept is zero and the coefficients of $\hat{\alpha}_p\hat{\alpha}_{w_t}x_t$ and $\hat{\beta}_{pt}$ are equal to one = 0.10 ($p$ value = 0.96)

Note: $\hat{\alpha}_p\hat{\alpha}_{w_t}x_t$ denotes the variable component of the producer’s wage; $\hat{\beta}_{pt}$ denotes the fixed component of the producer’s wage; ($W_{pt}$) denotes the producer’s actual wage, which is computed as the product of producer price and quantity produced.
In order to evaluate the validity of the model, we examine how the estimated payments explain the actual payments received by producers and wholesalers. A regression of the producers’ actual wages \( W_{pt} \) on the estimated variable component \( \hat{\alpha}_p \hat{\alpha}_{w_r} x_r \) and fixed wage component \( \hat{\beta}_{pt} \) shows that the estimated wages are efficient predictions and explain about 31% of the actual wages, see Figure 5.11 and the results tabulated in Table 5.2.

Similarly, a regression of the wholesaler’s actual compensation \( W_{wt} \) on the estimated variable component \( \alpha_{w_t} \) and fixed compensation component \( \hat{\beta}_{w_t} \) reveals that the estimated compensation is an efficient prediction and explains about 78% of the actual compensation, as shown in Figure 5.12 and in the results tabulated in Table 5.3.

Next, we conducted normality tests (as a diagnostic check of the certainty-equivalent approach) regarding the distributional assumption of profits of producers and wholesalers. The results show that these profits, computed with the costs estimated by the model, are
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normally distributed. The $p$ value of the Jarque-Bera statistic is 0.55 for the producers’ profits, whereas the $p$ value of the Jarque-Bera statistic is 0.16 for the wholesalers’ profits, justifying the application of the certainty-equivalent model in this chapter.

Table 5.3: Parameter Estimates in the Regression of the Actual Payment to the Wholesalers ($W_{wt}$) on the Variable and Fixed Payment Components Estimated by the Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>$t$ Value</th>
<th>$p$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.029</td>
<td>0.069</td>
<td>-0.424</td>
<td>0.675</td>
</tr>
<tr>
<td>$\hat{\alpha}_{wt}x_t$</td>
<td>1.052</td>
<td>0.103</td>
<td>10.163</td>
<td>0.000</td>
</tr>
<tr>
<td>$\hat{\beta}_{wt}$</td>
<td>0.986</td>
<td>0.150</td>
<td>6.567</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Sample: 1971 - 2003; Number of Observations = 33; $R^2 = 0.78$; $R^2_{adj} = 0.77$; Std. Error Resid = 0.08; Sum Squared Resid = 0.17; Durbin-Watson = 1.017; $F(3,30)$ statistic testing for the joint hypothesis that the intercept is zero and the coefficients of $\hat{\alpha}_{wt}x_t$ and $\hat{\beta}_{wt}$ are equal to one = 0.26 ($p$ value = 0.85)

Note: $\hat{\alpha}_{wt}x_t$ denotes the variable component of the wholesaler’s wage; $\hat{\beta}_{wt}$ denotes the fixed component of the wholesaler’s wage; ($W_{wt}$) denotes the wholesaler’s actual wage, which is computed as the product of wholesale price and the quantity produced.

Figure 5.12: Actual Payments to the Wholesalers (WW) and Estimated Payments to the Wholesalers (WWE)
5.4 Concluding Remarks

In this chapter, we extend the widely-known two-stage, principal-agent model into a threestage model involving producers, wholesalers, and retailers, to assess incentives, coordination costs, risk, risk aversion, and risk-management strategies in an agricultural marketing channel. The model allows risk-averse producers and wholesalers to trade in the futures market, in combination with their respective contractual relationships in the spot markets.

We apply the model to assess financial risk allocations in the Dutch potato marketing channel. The results show that the risk-neutral retailers assume less risk, as wholesalers and producers become less risk averse and use the futures market for hedging purposes. In this respect, not only the producers, but also the wholesalers, take a short position (i.e., are selling) on the futures market. This is consistent with the observation that, in the Netherlands, wholesalers and producers already close contracts for the new harvest before or during planting, and most of the wholesale trade is in the hands of farmers’ cooperatives. Consequently, wholesalers take over most of the price risk from the producers (farmers), leaving the producers some room for speculation.

Nevertheless, producers still hedge more than wholesalers, although for both, the optimal hedge ratio decreased: from 14% in 1971 to 10% in 2003 for the wholesalers and from 38% in 1982 to 18% in 2003 for the producers. In order to validate the model’s results, we compared the hedge ratios estimated by the model and the actual volume of futures contracts traded at the Amsterdam Commodity Exchange over time. Indeed, the decrease in the hedge ratios of both producers and wholesalers is consistent with reality, as the volume of futures contracts traded at Amsterdam Commodity Futures Exchange also decreased over the years.

The decrease in risk aversion and optimal hedge ratio goes together with a considerable improvement of coordination between wholesalers and producers. This is shown by the
convergence of the estimated second-best incentive-intensity levels for producers and first-best incentive-intensity values. Note that the producer’s incentive intensity concerns the contractual relationship between the wholesaler and the producer. The coordination between retailers and wholesalers seems to be open to further improvement, although the benefits of these improvements will be minor for the marketing channel as a whole, as total channel profit has already come very close to the first-best profit that the channel would make if all its members were risk neutral. An important point worth mentioning in this respect is that the coordination costs of the marketing channel are generally lower with futures trade taking place than without. This demonstrates the role of futures markets in providing marketing-channel members with information regarding prices. Yet another striking result is that the computed variances of profits of producers and wholesalers show slightly increasing trending patterns, both with and without a futures market, whereas the variance of the profit of the retailers is much larger but shows a decreasing trending pattern that is quite pronounced. These results indicate that the retailers assume most of the risk, as we expect them to do, being the single risk-neutral MCMs. Interestingly, the retailers’ risk is much lower when wholesalers and producers trade in the futures markets in order to manage their risk. Retailers thus profit most from the futures market in terms of risk reduction, while they are not using it themselves. Note that, because they are considered to be risk-neutral, retailers are expected to take over risk from the risk-averse MCMs (i.e., wholesalers and producers) as much as is optimal for them (i.e., the retailers). Hence, it is to be expected that a reduction of risk within the marketing channel, due to the presence of a futures market, will especially be expressed in a reduction of retailer profit risk.

The model has been empirically validated, based on two tests. First, the estimated payments to producers are efficient predictions of the producers’ actual rewards. Similarly, the estimated payments to wholesalers are efficient predictions of the wholesalers’ actual
rewards. The second empirical validation concerns the normality of profits of producers and wholesalers. The assumption regarding the application of the certainty equivalent approach, as used in this chapter and all other chapters, is that the profits of the risk-averse agents should be normally distributed. In this respect, normality tests regarding the producers’ and wholesalers’ profits were conducted, and the results reveal that they are normally distributed.

This chapter provides the following contributions. The first contribution lies in the extension of the principal-agent model. We do not only show how the well-known two-stage principal-agent model can be extended to a three-stage model, but also how it can be extended to include a futures market. More specifically, and contrary to, for example, Knoeber and Thurman (1995), who investigated risk shifting in the US broiler industry in a two-stage market setting involving farmers and integrator companies, we examine risk shifting in a three-stage marketing channel setting involving producers, wholesalers, and retailers, in the presence of a futures market.

The second contribution of this chapter is to the estimation of agency costs in contractual relationships. Agrawal (2002) investigated the issue of incentives, risk and agency costs in the context of land tenancy contracts. We examine incentives, risk, and agency costs in the context of a food marketing channel. Moreover, the chapter examines incentives, risk, and agency costs in a three-stage, marketing-channel setting in the presence of a futures market.

Third, this chapter contributes to the improvement in the estimation of the optimal time-varying hedge ratio. Previous researchers who have focused on modeling and estimating time-varying hedge ratios have used high-frequency data (i.e., daily and weekly data), and have neglected the contractual relationships of channel members (e.g., Ederington, 1979; Pennings and Meulenberg, 1997a,b). This chapter not only uses annual data that conforms to the
decision horizon of producers, but also takes the contractual relationships of channel members into account.

The theoretical and empirical studies in this chapter share several limitations that provide opportunities for future research.

A first limitation of this chapter concerns the assumption of constant absolute risk aversion (CARA) used in our modelling framework, which may not always hold. Our empirical results have shown that the risk attitude of MCMs may change over time, although this does not have to be inconsistent with the CARA assumption.

A second caveat of this chapter concerns the measure of risk. We have used variance of profits as a proxy for the risk of profits of MCMs. However, higher moments of the statistical distribution of profits, such as skewness and kurtosis of profits, might provide more information regarding the risk of profits. Furthermore, the coefficient of variation of profits could also be used to measure the risk (volatility) of profits of MCMs. One advantage, in this respect, is that using coefficient of variation as a measure of volatility controls for differences in means, not only for items that are measured in the same units of measurement, but also for items that are measured in different units of measurement. Further research in this area is called for.

A third limitation of this chapter is that the analyses have been performed on the basis of the implicit assumption of a representative producer, wholesaler, and retailer. There may be large differences in performance among crop producers, wholesalers, and retailers, and hence in their respective risk-management strategies in the marketing channel (e.g., Pennings and Garcia, 2004). Therefore, there is a clear need for further research on time-series data at the individual farm, wholesale and retail level (by using panel data).
CHAPTER 6
General Discussion and Conclusions

This chapter offers a general discussion of our research results and some conclusions will be drawn. Some managerial implications of our results will be given and the chapter is closed by discussing limitations of our study, respectively avenues for further research. But before entering this general discussion, it seems useful to summarise briefly the research findings from the previous chapters.

6.1 Summary of Empirical Results

This thesis focuses on risk shifting, incentives, and coordination costs in the context of commodity marketing channels. In this context the role of futures markets is investigated. Conceptual models addressing these issues are embedded in the framework of Principal-Agent theory. The models are elaborated on two dimensions: (a) length of the marketing channel, either a two stage channel (producer-retailer) or a three stage channel (producer-wholesaler-retailer); and (b) with or without the presence of a futures markets in the channel. The conceptual models are parameterised and tested on the basis of data from the Dutch potato industry. A special feature of our study is that the empirical analysis is executed by means of time series analysis.

In Chapter 1, we provide an introduction to the thesis, including the problem statement, research question, research objectives, research design, and the methodology employed.

In Chapter 2, we apply the classic agency model to investigate risk shifting, coordination costs and incentives in a two stage marketing channel (producer and marketing firm) without the presence of a futures market. The model is tested by econometric time-series
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analysis on the basis of data from the Dutch ware potato industry. The model involves a mixed share-wage/rent contract with a time-varying fixed wage/rent and output-value sharing rate. We show that, if the principal is risk neutral and the agent is risk averse instead of risk neutral, a linear contract can still be optimal, if the fixed payment is negative. The empirical results over the period 1946 - 2003 indicate that, while fixed payments to farmers (agents) have decreased over time and become more and more negative since the 1980s, the incentive intensity has approximately doubled, and the risk premium that farmers demand has remained considerable. Moreover, since the mid 1960s, risk has shifted from retailers to farmers. We argue that this shift could be the consequence of chain reversal, *i.e.*, the transformation of the traditional supply chain into a demand-oriented chain. This is consistent with the fact that retailers have become a powerful stage in the channel (*e.g.*, Kuiper and Meulenberg, 2002). Also, the empirical results show that, as a consequence of increases in the producers’ incentive intensity, the coordination costs of the marketing channel have decreased considerably.

Our research findings contribute to the debate on whether risk attitude is a stable concept (*e.g.*, Pennings and Garcia, 2001). Also, it should be mentioned that our result on risk shifting differs from that of Kroeber and Thurman (1995), who found that risk had shifted from farmers (agents) to integrator companies (principals) in the US Broiler industry. One of the reasons for this different result might be a different market structure: while the US broiler industry is highly integrated, the Dutch ware potato industry is not. This argument is consistent with Pennings and Wansink (2004), who have shown that risk and risk attitude play different roles in different marketing channel structures. Furthermore, the method used in this chapter differs from the procedure in Kroeber and Thurman (1995). Kroeber and Thurman (1995) already knew which contracts had been used in the course of time.
Chapter 6. General Discussion and Conclusions

In Chapter 3, the principal-agent model is extended to include a futures market, in order to assess risk shifting between the principal (retailers) and the agent (producers). We compare the situation with a futures market to the situation without the opportunity of futures trade for the risk-averse producers. The main contribution of this chapter lies in the fact we use classic agency model to derive a time-varying optimal hedge ratio for low frequency, time-series. This type of data is often used by crop farmers when deciding about their production and about their hedging strategy. Rooted in the classic agency framework, the proposed hedge ratio reflects both the producer’s decision horizon and his contractual relationships in the marketing channel. Our study differs from previous studies on this topic, which use high frequency data (daily and weekly data), and neglecting the contractual relationships of MCMs in the channel (e.g., Ederington, 1979; Pennings and Meulenberg, 1997b). The model is empirically tested on the basis of data from the Dutch potato industry and its futures market in Amsterdam over the period 1971 – 2003. The empirical results show that risk shifting from retailers to farmers, possibly as a consequence of chain reversal, can be better managed by farmers if they use futures contracts. This demonstrates the hedging role of futures markets and their function as risk-shifting, mediating market institutions. Furthermore, as a result of increased incentives from retailers to producers, the coordination costs of the marketing channel have decreased considerably.

In Chapter 4 a model is proposed and empirically examined regarding a three-stage, principal-agent, marketing-channel that includes producers, wholesalers, and retailers. We assess incentives, coordination costs, and risk shifting when the MCMs (i.e., producers, wholesalers, and retailers) trade on the spot market only. The model can provide insight into the role of incentives in reducing the coordination costs of the marketing channel and into the role of the wholesaler regarding risk shifting in the marketing channel.
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Its application to the Dutch supply chain of ware potatoes shows that during the period 1961 – 2002, the retailers were able to provide more incentives to the wholesalers and producers, and, as a consequence, the costs of coordination in the supply chain decreased considerably. Probably as a result of concentration of retailers in food marketing channels and the resulting imbalance in bargaining power, it appears that risks are shifted from retailers to producers and wholesalers.

In Chapter 5, we specify a three-stage, principal-agent, supply-chain model that includes producers, wholesalers, and retailers, as well as a futures market. To the best of our knowledge this is the first study which is extending the principal-agent model to risk shifting in a three stage marketing channel including a futures market. Risk shifting is analysed and agency costs are determined. The optimal hedge ratio is determined under the presence of contractual relationships in the marketing channel. The empirical results for the Dutch ware potato marketing channel over 1971 – 2003 reveal that the coordination costs of the marketing channel decreased considerably as a result of increased incentives to producers and wholesalers. The coordination costs of the marketing channel are lower than in the scenario without futures (Chapter 4), demonstrating the informational (i.e., price discovery) role of the futures markets. The futures market enables producers to manage the increasing income variability, thus demonstrating its role as a price-risk management instrument.

6.2. Discussion and Conclusions

In this section we compare the research findings of the previous chapters. Differences and similarities are established, leading to, sometimes tentative, conclusions. The section is organised along five key variables of our model: incentive intensity (output-value sharing rate), fixed compensation, hedge ratio, profit risk and agency (coordination) costs. We discuss each of the variables in turn.
First, we discuss incentive intensity, also known as the output-value sharing rate. Producer incentive intensity is higher in the two-stage model with a futures market than in the same model without a futures market. Possibly, as high incentives are associated with high profit risk, the producer trade futures in order to reduce the increasing profit risk.

Producer incentive intensity is slightly higher in the two-stage model without futures market than in the three-stage model without futures markets. Apparently, without wholesalers, producers need more incentives to satisfy consumer needs than with wholesalers present as an intermediary in the marketing channel. This demonstrates the channel role of the wholesaler regarding incentives to satisfy consumer needs.

Producer incentive intensity in the two-stage model with futures market (consisting of only producers and marketing firms) is the same as in the three-stage model with futures markets. This implies that the intermediary (i.e., wholesaler) plays a marginal role in producer incentive when a futures market is present in the three-stage marketing channel model.

Both producer and wholesaler incentive intensity is higher in the three-stage model with futures markets than in the three-stage model without futures markets. Higher incentives are associated with higher profit risk for producers and wholesalers; producers and wholesalers will trade futures in order to reduce their profit risks.

The second variable of interest is fixed compensation. Producers’ fixed compensation was higher in the two-stage model with futures markets than in the two-stage model without futures markets until the late 1980s. Thereafter, the fixed compensations, both with and without futures, became negative, while the fixed compensations without futures exceeded those with futures. The overall implication of this is that producers make more implicit investments in their contractual relationships when they trade futures. This observation stems from the cost of storage involved in futures trading: when a producer trades futures, it means
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that he is planning to sell his cash position some time in the future, and hence has to store his produce (i.e., potatoes) from harvest time until closure of his futures position.

Producers’ fixed compensation in the two-stage model without futures markets is almost equal to that in the three-stage model without futures markets. Hence, the wholesaler plays a marginal role in the channel regarding the producers’ fixed compensation.

Producers’ fixed compensation in the two-stage model with futures markets is almost the same as in the three-stage model with futures markets. This confirms the earlier assertion that the wholesaler does not play a significant role regarding the producers’ fixed compensation, even in the presence of a futures market.

Producers’ fixed compensation in the three-stage model with futures markets was slightly higher than in the three-stage model without futures markets. From the late 1980s onward, producers’ fixed compensation with futures became lower than without futures. As in the two-stage marketing channel model, the implication is that producers make more implicit investments in their contractual relationships when they trade futures. This is due to the storage costs involved in futures trade, as explained previously.

Wholesalers’ fixed compensation hardly differs for the three-stage model with futures markets and the three-stage model without futures markets. It suggests that the futures market does not play a significant role regarding wholesalers’ fixed compensation.

The third variable that needs comparison is the producer hedge ratio in different situations. Producer hedge ratios are higher in the three-stage model with futures markets, which includes wholesalers, than in the two-stage model with futures markets, where wholesalers are not included. A possible reason for this behaviour is that wholesalers behave in a more opportunistic way than retailers, which stimulates hedging by producers.

Next, we compare the profit risk for MCMs in the different situations considered. Producer profit risk is lower in the two-stage model with futures market than in the two-stage
Chapter 6. General Discussion and Conclusions

The futures market appears to be an effective risk-management instrument: the producers can better manage the increasing variability in their profits (incomes) by using futures contracts.

Producer profit risks obtained from the three-stage model without futures market are slightly lower than in the two-stage model without futures market. It suggests that the wholesaler takes over some of the producers’ profit (income) risks.

Wholesaler profit risk is higher in the three-stage model with futures than in the three-stage model without futures. This stems from the fact that wholesalers have a natural hedge situation if their input and output prices are highly correlated (e.g., Pennings and Leuthold, 2001). In such a situation, a full hedge (i.e., a hedge ratio of 1) introduces profit risk instead of reducing it as demonstrated by Pennings and Leuthold (2001). It suggests that in case of high correlation between input and output prices, wholesalers might better refrain from a full hedge in the futures market.

Retailer profit risk obtained from the three-stage model without futures markets are higher than those obtained from the three-stage model with futures. Thus, as a result of producers’ and wholesalers’ futures trade, retailer profit risk has decreased dramatically.

Finally, we compare the coordination costs of the marketing channel for the different situations distinguished in our research design. The coordination costs of the marketing channel are smaller in the two-stage model with futures markets than in the two-stage model without futures markets. This demonstrates the effect of futures markets regarding coordination costs in a marketing channel, confirming the informational (i.e., price-discovery) and hence, hedging function of futures markets to reduce the risks so that more incentives can be provided.

The coordination costs of the marketing channel are smaller in the three-stage model without futures markets than in the two-stage model without futures markets. This
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demonstrates the role of wholesalers in reducing the coordination costs in a marketing channel. The wholesaler facilitates channel coordination between the producer and the retailer.

The coordination costs of the marketing channel are smaller in the \textit{three-stage model with futures markets} than in the \textit{three-stage model without futures markets}. This further confirms the above assertion that the futures market has a price-discovery and hedging function in the marketing channel.

The methodology developed in this study also allowed for analysing the developments of the key variables of our model through time. Therefore, after the comparison of the general results of the key variables for the different cases of our research design (Figure 1.1), the results of these variables over time will be given. Tables 6.1 and 6.2 report changes in these key variables over time and their comparisons, respectively possible conclusions.

6.3. Methodological Contributions
A basic methodological contribution of this study on risk shifting, incentives and coordination costs in commodity marketing channels is the extension of the principal-agent model from a two-stage (producer-retailer) to \textit{a three-stage} (producer-intermediary-retailer) model, respectively the inclusion of a futures market in the model. In fact, to the best of our knowledge this seems to be the first study which views price hedging in the futures market within the context of vertical contractual relationships in terms of the principal-agent framework. The introduction of a futures exchange in modelling the relationships in a commodity marketing channel enriches the analysis and is consistent with research (\textit{e.g.}, Pennings and Wansink, 2004) revealing that marketing institutions influence marketing channel structures.
Table 6.1: A Comparison of the Developments through Time of the Key Parameters of the Two-Stage Principal-Agent Marketing Channel Model, With and Without a Futures Market for the Dutch Potato Industry

<table>
<thead>
<tr>
<th>Parameters (Variables)</th>
<th>Two-stage model without futures market</th>
<th>Two-stage model with futures market</th>
<th>Comparisons and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Changes over time</td>
<td>Changes over time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased</td>
<td>Decreased</td>
<td>Increased</td>
</tr>
<tr>
<td>Producer incentive intensity (output-value sharing rate)</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Producers’ fixed compensation</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer profit risk</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Retailer profit risk</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination costs of the marketing channel</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer hedge ratio</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Table 6.2: A Comparison of the Developments through Time of the key Parameters of the Three-Stage Principal-Agent Marketing Channel Model, With and Without a Futures market for the Dutch Potato Industry.

<table>
<thead>
<tr>
<th>Parameters (Variables)</th>
<th>Three-stage model without futures market</th>
<th>Three-stage model with futures market</th>
<th>Comparisons and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Changes over time</td>
<td>Changes over time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased</td>
<td>Decreased</td>
<td>Increased</td>
</tr>
<tr>
<td>Producer and wholesaler incentive intensity</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Producers’ and wholesalers’ fixed compensation</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Producer and wholesaler profit risk</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Retailer profit risk</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordination costs of the marketing channel</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producer and Wholesaler hedge ratio</td>
<td></td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>
Another methodological contribution to the existing literature is the application of time-series methodology to the empirical analysis of the principal-agent model in investigating incentives, risk and coordination costs in marketing channels. While previous studies that have focused on modeling and estimating hedge ratios have used high-frequency data \((i.e.,\) daily and weekly data), and have neglected the contractual relationships of channel members \((e.g.,\) Ederington, 1979; Pennings and Meulenberg, 1997a,b), we do not only use annual data that conform to the decision horizon of producers, but also take the contractual relationships of channel members into account. In this respect, we conjecture that the estimates of the time-varying hedging ratios in this thesis will be more consistent with the decision framework of producers than those from previous studies on hedge ratios.

Finally, our approach may provide some indication of the degree of market orientation of channel members: whenever the fixed compensation becomes more negative it indicates the extent of investment made by the channel members \((i.e.,\) producers and wholesalers) to ensure the satisfaction of consumer needs.

### 6.4 Some Managerial Implications

Coordination efficiency in marketing channels can be improved by incentives from retailers to upstream channel members \((i.e.,\) producers and wholesalers). Such incentives are facilitated by the use of risk-reducing instruments, such as futures contracts, by the upstream channel members.

The coordination costs of a commodity marketing channel are lower \textit{with futures trade} than \textit{without futures trade}. Marketing channel members, in particular farmers should be encouraged to use futures effectively.

Empirical results show that the there is a financial risk shift from retailers to producers and wholesalers; due to a bargaining power imbalance in favor of the retailers. The danger of
Retailer dominance in commodity marketing channels should be avoided by effective competition regulation.

6.5 Limitations and Further Research

The theoretical and empirical investigations in this thesis have limitations that provide opportunities for future research.

The assumption of constant absolute risk aversion (CARA) used in our modelling framework, may not always hold. In fact, although not necessarily inconsistent with CARA, our empirical results have shown that the risk attitudes of MCMs may change over time. Moreover, closely related to the changing risk attitudes of MCMs, the assumption of the principal-agent model whereby every principal is risk neutral and every agent is risk averse, might need to be adapted in some cases. In Chapters 4 and 5, for example, we assume the wholesalers (i.e., the principals to producers) to be risk-averse agents in their contractual relationships with the retailers. If this assumption is true, it contrasts the assumption in agency theory that all principals are risk neutral.

Another caveat of our study concerns the measure of risk. We have used profit variance as a proxy for the profit risk (volatility) of MCMs. However, higher moments of the statistical distribution of profits, such as skewness and kurtosis of profits, might provide more information regarding profit risk. Furthermore, the coefficient of variation of profit could also be used to measure the profit risk of MCMs. For instance, an advantage of using the coefficient of variation as a measure of volatility is that this measure controls for differences in means, both for items that have different and the same units of measurement.

In addition, the analyses have been performed based on the implicit assumption of a representative producer, wholesaler and retailer. In reality, however, there may be large differences in performance among crop producers, wholesalers, and retailers, and hence in
their respective risk-management strategies in the marketing channel (e.g., Pennings and Garcia, 2004). There is, therefore, a clear need for further research on time-series data at the individual farm, wholesale, and retail level (requiring panel data).

The models in this study have been applied to only one marketing channel, the Dutch ware potato marketing channel. Therefore, the application of these models to other marketing channels may be an interesting avenue for further research. Finally, testing the models developed in this thesis on international marketing channels could be another suggestion for further research.
APPENDIX

Estimation of the Expected Output Value at Retail Level

The output quantity $q_t$ (million tons) in year $t$ is computed as the yield per hectare times the area planted. We compute the conditional expectation of the consumer (retail) price, $p_t$, and denote it as $\hat{E}(p_t|I_{t-1})$, assuming that the information set $I_{t-1}$ is common to all MCMs. In Chapters 2 and 4, where we do not consider futures markets, we computed $\hat{E}(p_t|I_{t-1})$ by the sample fit of an AR(3) model. In Chapters 3 and 5, however, $\hat{E}(p_t|I_{t-1})$ is obtained as the sample fit of an OLS regression of $p_t$ on a constant and $F_{t,t-1}$. In both models we omitted one or a few observations as a consequence of vertical outlier(s). Using data on yield per hectare and the number of hectares planted, the estimate of the expected output $E(q_t|I_{t-1})$, denoted as $\hat{E}(q_t|I_{t-1})$, is obtained by the product of area planted and expected yield per hectare, where the expected yield per hectare is assumed to follow an autonomous positive linear time trend.

Next, we turn to the estimation of $E(p_tq_t|I_{t-1})$. For this, note that $p_tq_t = E(p_tq_t|I_{t-1})E(q_t|I_{t-1}) + E(p_t|I_{t-1})\epsilon_{qt} + \epsilon_{pt}E(q_t|I_{t-1}) + \epsilon_{pt}\epsilon_{qt}$, where $\epsilon_{pt} = p_t - E(p_t|I_{t-1})$ and $\epsilon_{qt} = q_t - E(q_t|I_{t-1})$ are the unexpected components of $p_t$ and $q_t$, respectively, and $\epsilon_{pt}\epsilon_{qt}$ represents the covariance of $p_t$ and $q_t$, which we may expect to be negative. Consequently, $E(p_tq_t|I_{t-1}) = E(p_t|I_{t-1})E(q_t|I_{t-1}) + E(\epsilon_{pt}\epsilon_{qt}|I_{t-1})$. Now, to estimate $E(p_tq_t|I_{t-1})$ we simply regress $p_tq_t$ on a constant and $\hat{E}(p_t|I_{t-1})\hat{E}(q_t|I_{t-1})$. In this way, $\hat{E}(p_tq_t|I_{t-1})\hat{E}(q_t|I_{t-1})$ extracts all the information of interest out of $\epsilon_{pt}\epsilon_{qt}$ since the regression residuals are orthogonal to $\hat{E}(p_t|I_{t-1})\hat{E}(q_t|I_{t-1})$. Hence, the fit of the regression is denoted as $\hat{E}(p_tq_t|I_{t-1}) = \hat{c}_t$, the expected output value at retail level. In Chapter 3 we used the notation $\hat{c}_t$ for the estimated expected output value. In the other chapters we simply maintained the notation $\epsilon_t$. 

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Next, the estimate of $\varepsilon_i$ denoted as $\hat{\varepsilon}_i$ is obtained by subtracting $\hat{E}(p_tq_t|I_{t-1})$ from $p_tq_t$.

The estimate of $\sigma^{2}_e$ (i.e., the variance of the random output value at retail level) denoted as $\hat{\sigma}^{2}_e$ is simply computed as the fit of a regression of $\hat{\varepsilon}_i^2$ on a constant. In Chapters 2, 4 and 5, we omitted the subscript $\varepsilon$ and the hat on $\hat{\sigma}^{2}_u$, thereby using $\sigma^{2}$. 

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RESEARCH PROBLEM

The liberalisation of agricultural food markets all over the world, among others as a result of WTO agreements and a changing EU agricultural policy (CAP), has increased price volatility in the agricultural industry. This price volatility is the result of uncertainty in agricultural production, caused by uncontrollable elements, such as weather conditions, but also of long production lags (production decisions have to be made far in advance). It is even stronger when a sizable proportion of the output is destined for export markets. As a result both agricultural producers and other members of the marketing channel (i.e., processors, wholesalers, and retailers) are exposed to income uncertainties.

Currently, many agricultural marketing channels are in a transition from using open-market mechanisms for coordinating the various stages of value adding (e.g., production, wholesale, and retail) to negotiated coordination, involving governance forms such as joint ventures, contracts, franchising agreements, and vertical integration (e.g., Boehlje et al., 1999). The present drive for market orientation in agricultural and food markets implies that producers and all other channel members (e.g., processors) should adjust production processes and products in order to respond to specific consumer demands and market signals and trends.

In many agricultural marketing channels intermediaries such as wholesalers link producers with consumers’ demands, as articulated by retailers. They solve problems of information asymmetry and incentive incompatibility among marketing channel members (MCMs). This is often solved by contracts between retailers/wholesalers and producers, in particular if specific qualities are required to satisfy consumers' needs. As a consequence, financial (returns) risks are shifting among members in the marketing channel. This has become an important topic of study, all the more since large processors and supermarket chains seem to be able to dictate the terms of trade and transfer the market-level risk to
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farmers (e.g., Weaver and Kim, 2000). Transferring risk to farmers, who have fewer opportunities to spread risk, than marketing firms which are more able to reduce market risks, will make risk bearing in the marketing channel more costly and reduces the gains from trade.

This study addresses the issues of risk, incentives, and coordination costs in agricultural marketing channels. We approach this problem by employing principal-agent theory. The key idea within agency theory is that principal-agent relationships should reflect efficient information and risk-bearing costs, incentive alignments, and the contract as the unit of analysis (e.g., Cook and Barry, 2004). Given agency problems, we cannot expect a supply chain to function as well economically as it would if all information were shared without any cost involved or if the incentives of principal and agent were cost aligned. This shortfall is called agency costs (Cook and Barry, 2004). These costs may include ex ante search costs (associated with adverse selection (hidden information) problems) and/or ex post monitoring and enforcement costs (associated with moral hazard (hidden action) problems) (e.g., Sykuta and Cook, 2001; Douma and Schreuder, 2002). Incentives are crucial in aligning the goals of the principal and agent (e.g., Laffont and Martimort, 2002; Sappington, 1991).

Agency problems arise if a risk-averse agent (e.g., producer) is assigned decision (or control) rights (e.g., regarding production) that affect the principal's (e.g., retailer) wealth or utility function; the principal, who cannot fully observe the effort of the agent, is not sure whether the agent acts according to the principal’s best interest when the goals of the principal and the agent conflict. They show up also, in the case of risk sharing between the principal and agent when both have different attitudes towards risk.

Principal-agent relationships are evident in food marketing channels where production contracts are dominant and incentives enhance contractual relationships among MCMs. However, the literature on incentives in food marketing channels is scanty (e.g., Heuth et al.,
Summary

1999) and the incentives underlying production contracts are not currently well understood (Goodhue, 1999). To understand the role of incentives in improving coordination efficiency of food marketing channels, this thesis not only examines risk and risk shifting, it also investigates the role of incentives in reducing the coordination costs in a food marketing channel.

In employing the classic principal-agent model to the above-mentioned issues, this thesis does make both theoretical and empirical contributions. The theoretical contribution lies in the application of agency theory to this type of problems in particular in the case of a three-stage channel. Furthermore, we extend the principal-agent model by including a futures market. Futures markets provide risk-management tools to channel members and hedging at the futures markets may shift risk bearing in the channel. In this thesis, we examine among others the influence of futures contracts on risk shifting, incentives and coordination costs.

Yield variability reduces the risk-reduction capacity of hedging for producers, making it advisable, to sell futures up to a quantity less than the expected harvest (e.g., Moschini and Lapan, 1995). Moreover, since futures and spot prices do not completely parallel, hedging at the futures market results in basis risk (i.e., spot price minus futures price).

For channel members wishing to reduce risk by hedging with futures contracts, the hedge ratio is of critical importance (e.g., Dawson et al., 2000; Harwood et al., 1999). This study extends the understanding of hedge ratios by modelling the time-varying optimal hedge ratios for risk-averse producers and wholesalers and estimating this ratio for the Dutch ware potato marketing channel.

An empirical contribution of the study is the estimation and assessment of the developed Principal-Agent models by making use of time series analysis. These models have been applied to the Dutch potato marketing channel. The annual Dutch potato production amounts to about eight million tonnes, which is mainly produced on family farms. About 50%
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of the potatoes produced are ware potatoes, 20% are seed potatoes, and 30% are grown for starch (NIVAP Holland, 2002). The ware potato industry is characterized by high price volatility, as indicated by the relatively high coefficient of variation of 0.69, (based on annual prices over the period 1946-2003). The high price variability in the potato sector can be explained by the fact that there is no government intervention in the potato markets and Dutch potato prices are to a large extent determined by export demand, about two-thirds of annual production. Being one of the most volatile crop markets in Europe, we have chosen the Dutch Ware potato market as our empirical domain. Interesting features of the Dutch ware potato marketing channel for our research are also: many farmers who each produce a small proportion of the total output, and a small number of wholesalers, processors, and retailers; and the presence of a potato futures market in Amsterdam since 1958. Our study focuses on risk, incentives, and coordination costs in the Dutch ware potato marketing channel with and without a potato futures market. The development and empirical testing of the four different principal-agent models, which analyse risk shifting, coordination costs and hedge ratios, is performed in Chapters 2 – 5 and will be summarised now.

RESEARCH RESULTS

In this study four different marketing-channel structures are analysed by combining two lengths of marketing channel (two-stage and three-stage marketing channels) with and without a futures market. In the following, the results from analysing these four alternative models (Ch. 2 – Ch. 5) are concisely reported.

In Chapter 2, we apply the classic agency model to investigate risk shifting, coordination costs and incentives in a two stage marketing channel (producer and marketing firm) without a futures market. The model is tested by econometric time-series analysis on the basis of data from the Dutch ware potato industry. We show that, if the principal is risk
neutral and the agent is risk averse instead of risk-neutral, a linear contract can still be optimal, if the fixed payment is negative. The empirical results over the period 1946 - 2003 indicate that, while fixed payments to farmers (agents) have decreased over time since the 1980s, the incentive intensity has approximately doubled and the risk premium that farmers demand has remained considerable. Since the mid 1960s, risk has shifted from retailers to farmers. This could be the consequence of chain reversal, i.e., the transformation from a traditional supply chain into a demand-oriented chain. Also, it appears that the coordination costs of the marketing channel have decreased considerably, because of increasing producers’ incentive intensity. Our research findings in this chapter contribute to the debate on whether risk attitude is a stable concept (e.g., Pennings and Garcia, 2001).

In Chapter 3, the principal-agent model is extended to include a futures market, in order to assess risk shifting between the principal (retailers) and the agent (producers). The main contribution of this chapter lies in the fact that we use classic agency models to derive a time-varying optimal hedge ratio for low-frequency, time-series data. This type of data is often used by crop farmers when deciding about their production and about their hedging strategy. Rooted in the classic agency theory, the proposed hedge ratio reflects both the producer’s decision and his contractual relationships in the marketing channel. Our study differs from previous studies on this topic, which use high frequency data (daily and weekly data), and neglect the contractual relationships of MCMs in the channel (e.g., Ederington, 1979; Pennings and Meulenberg, 1997a,b). The model is empirically tested on the basis of data from the Dutch potato industry and its futures market in Amsterdam over the period 1971–2003. The results show that risk shifted from retailers to farmers, possibly as a consequence of chain reversal, and that risk can better be managed by farmers if they use futures contracts. This demonstrates the role of futures markets as a risk-shifting, mediating market institution.
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Also in this case coordination costs of the marketing channel have decreased considerably, as a result of increases in incentives from retailers to producers.

In Chapter 4, a three-stage, principal-agent marketing-channel that includes producers, wholesalers, and retailers is modelled and empirically examined. We assess incentives, coordination costs, and risk shifting when MCMs (i.e., producers, wholesalers, and retailers) trade on the spot market only. Food supply chains have become extensively vertically coordinated through the use of contracts as an organisational response to satisfy the needs of consumers in the present saturated food markets. These contracts preferably should establish an optimal trade-off between incentive provision and risk reduction. The proposed principal-agent model can provide insight into the role of incentives in reducing the coordination costs and of the wholesaler regarding risk shifting in the marketing channel. Its application to the Dutch supply chain of ware potatoes shows that during the period 1961-2002, retailers were able to provide more incentives to the wholesalers and producers, and, as a consequence, the costs of coordination in the supply chain decreased considerably. Risks have shifted from retailers to producers and wholesalers, probably as a result of concentration in food retailing and chain reversal.

In Chapter 5, we specify a three-stage, principal-agent, marketing channel model that includes producers, wholesalers, and retailers, as well as a futures market. To our knowledge this is the first study which is extending the principal-agent model to risk shifting in a three stage marketing channel including a futures market. Risk shifting is analysed and agency costs are determined. The optimal hedge ratios are established under the presence of contractual relationships in the marketing channel. The empirical results for the Dutch ware potato marketing channel over 1971-2003 reveal that the coordination costs of the marketing channel decreased considerably, as a result of increased incentives to producers and wholesalers. The coordination costs of the marketing channel are lower than in the scenario
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without futures (Chapter 4), demonstrating the informational (i.e., price discovery) role of the futures markets. The futures market enables producers to manage the increasing income variability, thus demonstrating its role as a price-risk management instrument.

COMPARISON OF RESEARCH RESULTS FROM DIFFERENT MODELS

A comparison of the research findings from the different models in our study offers insight into the impact of different channel structures on risk, incentives and coordination costs in agro-food channels. This comparison is made along the five key variables of our model: incentive intensity (output-value sharing rate), fixed compensation, hedge ratio, profit risk and agency (coordination) costs.

Producer incentive intensity is higher in the two-stage model with a futures market than in the same model without a futures market. Possibly, high incentives are associated with high profit risk and producers trade futures in order to reduce the increasing profit risk.

Producer incentive intensity is slightly higher in the two-stage model without futures market than in the three-stage model without futures markets. Apparently without wholesalers, producers need more incentives to satisfy consumer needs than with wholesalers as an intermediary in the channel.

Producer incentive intensity in the two-stage model with futures market (consisting of only producers and retailers) is the same as in the three-stage model with futures markets. This implies that the intermediary (i.e., wholesaler) plays a marginal role in producer incentives when a futures market is present.

Both producer and wholesaler incentive intensities are higher in the three-stage model with futures markets than in the three-stage model without futures markets. Higher incentives are associated with higher profit risk for producers and wholesalers; producers and wholesalers will trade futures in order to reduce profit risks.
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Producers’ fixed compensation was higher in the two-stage model with futures markets than in the two-stage model without futures markets until the late 1980s. Thereafter, the fixed compensations became negative, while the fixed compensations in the channel without futures became higher than in those with futures. Apparently, producers make more implicit investments in their contractual relationships when they trade futures (e.g., Pennings and Leuthold, 2000).

Producers’ fixed compensation in the two-stage model without futures markets is almost the same as in the three-stage model without futures markets. It suggests that the wholesaler plays a marginal role in the channel regarding the producers’ fixed compensation.

Producers’ fixed compensation in the two-stage model with futures markets is almost the same as in the three-stage model with futures markets. This confirms the earlier assertion that the wholesaler does not play a significant role regarding the producers’ fixed compensation, also in the presence of a futures market.

Producers’ fixed compensation in the three-stage model with futures markets was slightly higher than in the three-stage model without futures markets. From the late 1980s onward, producers’ fixed compensation with futures became lower than without futures. As in the two-stage marketing channel model, the implication is that producers make more implicit investments in their contractual relationships when they trade futures.

Wholesalers’ fixed compensation hardly differs between the three-stage model with futures markets and the three-stage model without futures markets. It suggests that the futures market does not play a significant role regarding wholesalers’ fixed compensation.

Producers’ hedge ratio is higher in the three-stage model with futures markets, which includes wholesalers, than in the two-stage model with futures markets, without wholesalers. Possibly wholesalers behave in a more opportunistic way than retailers, which stimulates hedging by producers.
Summary

Producer **profit risk** is lower in the *two-stage model with futures market* than in the *two-stage model without futures market*. Futures contracts appear to be an effective risk-management instrument.

Producer profit risks obtained from the *three-stage model without futures market* are slightly lower than in the *two-stage model without futures market*. It suggests that the wholesaler assumes some of the producers’ profit (income) risks.

Wholesaler profit risk is higher in the *three-stage model with futures* than in the *three-stage model without futures*. This stems from the fact that wholesalers have a natural hedge situation if their input and output prices are highly correlated (*e.g.*, Pennings and Leuthold, 2001). In such a situation a full hedge by a wholesaler (*i.e.*, a hedge ratio of 1) introduces risk instead of reducing profit risk as demonstrated by Pennings and Leuthold (2001). It suggests that in case of high correlation between input and output prices wholesalers might better refrain from a full hedge in the futures market.

Retailer profit risk in the *three-stage model without futures markets* is higher than in the *three-stage model with futures*. As a result of producers’ and wholesalers’ futures trade, retailer profit risk has decreased dramatically.

The **coordination costs** of the marketing channel are lower in the *two-stage model with futures markets* than in the *two-stage model without futures markets*. This demonstrates the effect of futures markets on coordination costs, confirming the informational (*i.e.*, price discovery) function of futures markets.

The coordination costs of the marketing channel are lower in the *three-stage model without futures markets* than in the *two-stage model without futures markets*. This shows the role of wholesalers in reducing the coordination costs.
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The coordination costs of the marketing channel are lower in the three-stage model with futures markets than in the three-stage model without futures markets. This result confirms the assertion that the futures market has a price discovery function in the marketing channel.

COMPARISON OF DEVELOPMENTS IN MODEL PARAMETERS OVER TIME

The methodology developed in this study also allows for analysing the development of the key variables of our model through time for the Dutch potato industry. Summary results of this comparison are as follows:

(A) For the two-stage principal-agent model, with and without futures trading:

Producer incentive intensity (output-value sharing rate) increased through time both with and without a futures market, possibly since more incentives are required for improving the coordination of the marketing channel.

Producer fixed compensation decreased to negative levels. It means that since 1980 producers pay an implicit rent in their contractual relationship with retailers, possibly because of higher producer involvement in storing potatoes.

Producer profit risk has increased over time whereas retailer profit risk has decreased. Producers can manage the increasing profit risks by trading in the futures market.

Coordination costs of the marketing channel have decreased as a consequence of increases in producers’ incentive intensity and producers’ trade in the futures market.

Producer hedge ratio has decreased possibly because of a decrease in producers’ risk aversion.

(B) For the three-stage principal-agent model, with and without futures trading:

Producer and wholesaler incentive intensities have increased in both cases, with and without a futures market, which might be required to improve marketing coordination.
Summary

Producer and wholesaler fixed compensations have decreased in both cases, with and without a futures market. Producers and wholesalers pay an implicit rent in their contractual relationships, possibly in order to satisfy consumers’ needs.

Producer and wholesaler risk has increased while retailer profit risk has decreased over time in both cases, with and without a futures market. Profit risk has shifted from retailers to producers and wholesalers.

Coordination costs of the marketing channel have decreased in both cases, with and without a futures market, probably as consequence of increases in producer incentive intensity.

Producer and wholesaler hedge ratios have decreased, possibly as a result of a decrease in their risk aversion.

METHODOLOGICAL CONTRIBUTIONS

Our analysis of risk, incentives and coordination costs in agri-food chains makes a number of methodological contributions. A basic contribution is the extension of the principal-agent model from a two-stage (producer-retailer) to a three-stage (producer-intermediary-retailer) model, with and without a futures market. In fact, to the best of our knowledge this study seems to be the first study which views price hedging in the futures market within the context of vertical contractual relationships in terms of the principal-agent framework. The introduction of a futures exchange in modelling the relationships in a commodity marketing channel enriches the analysis and is consistent with research (e.g., Pennings and Wansink, 2004) revealing that marketing institutions influence marketing channel structures.

Another methodological contribution to the existing literature is the application of time-series analysis to the principal agent model in investigating incentives, risk, and coordination costs in marketing channels. While previous studies on modelling and estimating hedge ratios have used high-frequency data (i.e., daily and weekly data), and have not considered the
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contractual relationships of channel members (e.g., Ederington, 1979; Pennings and Meulenberg, 1997a,b), we do not only use annual data that conform to the producers’ decision horizon, but also take the contractual relationships of channel members into account. In this respect, we conjecture that the estimates of the time-varying hedge ratios in this thesis will be more consistent with the decision framework of producers than those of previous studies on hedge ratios.

Finally, our approach may provide indications on the degree of market orientation of channel members: a decrease in fixed compensation to negative levels indicates an increase of investment made by channel members (i.e., producers and wholesalers) to satisfy consumer needs.

MANAGERIAL IMPLICATIONS

Our research results not only offer a better understanding of the risk, incentives, and coordination costs in agri-food chains but have also implications for the management of commodity marketing channels.

First, it appears that coordination efficiency in marketing channels can be improved by incentives from retailers to upstream channel members; producers and wholesalers. Such incentives are facilitated by the use of risk-reducing instruments, such as futures contracts, by these upstream channel members.

Second, since the coordination costs of a commodity marketing channel are lower with futures trade than without futures trade marketing channel members, in particular farmers, should be encouraged to make effective use of futures markets.

Third, there is a financial risk shift from retailers to producers and wholesalers; due to a bargaining power imbalance in favour of the retailers. Therefore, the danger of retailer
Summary

dominance in commodity marketing channels should be avoided by effective competition regulation.

LIMITATIONS AND OPPORTUNITIES FOR FUTURE RESEARCH

Every study, also this one, on such a complex issue like ‘Risk, incentives and coordination costs in commodity marketing channels’ has its limitations. So, it is appropriate to close this summary by considering the basic limitations of this study and combining this with suggestions for further research opportunities.

The assumption of constant absolute risk aversion (CARA) used in our modelling framework, may not always hold. In fact, our empirical results have shown that risk attitudes of MCMs may change over time, although this is not necessarily inconsistent with the CARA assumption. Moreover, closely related to the changing risk attitudes of MCMs, the assumption of the principal-agent model that the principal is risk neutral and the agent is risk averse might have to be adapted in some cases. For instance, in the three stage models (Chapters 4 and 5), we assume wholesalers, being the principal of the producers and as such risk neutral, in the same model to be risk-averse in their contractual relationships with the retailers. The latter assumption contrasts the assumption in agency theory that all principals are risk neutral.

Yet, another caveat of our study concerns the measure of risk. We have used profit variance as a proxy for the profit risk (volatility) of MCMs. However, higher moments of the statistical distribution of profits, such as skewness and kurtosis of profits, might provide more information regarding profit risk. Furthermore, the coefficient of variation of profit could also be used to measure the profit risk of MCMs. An advantage of using the coefficient of variation as a measure of volatility is that this measure controls for differences in means, both for items that have different and the same unit of measurement.
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In addition, the analyses have been performed based on the implicit assumption of a representative producer, wholesaler and retailer. In reality, however, there may be large differences in performance among crop producers, wholesalers, and retailers, and hence in their respective risk-management strategies in the marketing channel (e.g., Pennings and Garcia, 2004). There is, therefore, a clear need for further research on time-series data at the individual farm, wholesale, and retail level (requiring the availability of panel data).

Finally, the models in this study have been applied to only one marketing channel, the Dutch ware potato marketing channel. Therefore, the application of the proposed models to other marketing channels is an interesting avenue for further research.
PROBLEEMSTELING

De liberalisering van agrarische markten over de hele wereld, onder andere als gevolg van W.T.O overeenkomsten en een veranderend gemeenschappelijk landbouwbeleid van de EU (GLB), hebben de prijsvariabiliteit in de landbouw vergroot. Deze prijsvariabiliteit is enerzijds het resultaat van onzekerheid in landbouwproductie, veroorzaakt door onbeheersbare factoren, zoals weersomstandigheden, maar is ook het gevolg van de lange productieduur; besluiten over wat te produceren moeten ver vooraf worden genomen. Dit effect is nog sterker wanneer een aanzienlijk gedeelte van de productie bestemd is voor exportmarkten. Dientengevolge worden zowel landbouwproducenten als andere leden van het marketingkanaal (verwerkende industrie, groothandel, en detailhandel) blootgesteld aan onzekerheid in hun inkomen.

Momenteel zijn vele agrarische marketingkanalen in een overgangsfase van open markt als middel voor de afstemming van de waardetoeweging in de diverse fasen van de het marketingkanaal (producent, groothandel, en kleinhandel) naar een gecoördineerde samenhang met bestuurlijke structuren zoals joint ventures, contracten, franchise overeenkomsten, en verticale integratie (b.v., Boehlje et al., 1999). De huidige noodzaak van marktoriëntatie in de markten van landbouwproducten en voedingsmiddelen impliceert dat producenten en andere actoren in het marketingkanaal (b.v., de verwerkende industrie) hun productieprocessen en producten moeten aanpassen om aan specifieke verbruikersbehoeften te beantwoorden.

In veel agrarische marketingkanalen verbinden intermediaire zoals groothandelaars, het aanbod van producenten met de consumentenvraag, zoals die door detailhandelaars wordt gespecificeerd. Zij lossen de problemen van informatie-asymmetrie en belonings-asymmetrie tussen leden in het marketingkanaal (MCMs) op. Dit gebeurt vaak door contracten tussen
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detailhandelaren/groothandelaar en producenten, in het bijzonder als er specifieke eisen zijn om de consumentenbehoeften te bevredigen. Dientengevolge verschuiven de financiële (winst) risico’s tussen de leden van het marketing kanaal. Dit is een belangrijk onderwerp van studie geworden, te meer omdat grote verwerkende industrieën en supermarktketten de voorwaarden schijnen te dicteren en het marktrisico overdragen op landbouwers (b.v., Weaver en Kim, 2000). Het overdragen van financiële risico’s op landbouwers, die minder mogelijkheden hebben om risico te spreiden, dan handelsondernemingen, maakt risico dragen in het marketing kanaal duurder en vermindert de winsten in het marketingkanaal.


Agency problemen ontstaan als een risico mijdende agent (b.v., de producent) beslissings- of controlerechten toegewezen krijgt (b.v., betreffende productie), die de rijkdom
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of nutsfunctie van de principaal (b.v., detailhandelaar) beïnvloeden. De prinicpaal, die de inspanning van de agent niet ten volle kan waarnemen, weet niet zeker of de agent handelt in het beste belang van de principaal, met name als de doelen van agent en principaal conflicteren. Zij treden ook op wanneer principaal en agent risico delen en zij beiden een verschillende attitude tegenover risico hebben.

Principaal-agent relaties doen zich voor in agrarische marketingkanalen waar productiecontracten domineren en prestatieprakkels contractuele relaties tussen MCMs kunnen verbeteren. Echter, tot nog toe is de literatuur over prestatieprakkels in agrarische marketingkanalen schaars (b.v., Heuth et al., 1999) en de productieprakkels die aan productiecontracten ten grondslag liggen worden thans nog niet goed begrepen (Goodhue, 1999). Daarom onderzoekt dit proefschrift niet alleen risico en risico verschuivingen, maar ook de rol van prestatieprakkels in het verminderen van de coördinatiekosten in een agrarisch marketing kanaal.

Door gebruik te maken van het klassieke principaal-agent model voor bovengenoemde vraagstukken levert dit proefschrift zowel theoretische als empirische bijdragen. Theoretisch ligt de bijdrage in de toepassing van agency theorie op dit type problemen, in het bijzonder in het geval van een drie-fasen marketingkanaal. Voorts breiden wij het principaal-agent model uit door de termijnmarkt hierin op te nemen. Termijnmarkten verstrekken aan actoren in het marketingkanaal mogelijkheden tot risico dekking, waardoor ook verschuiving van risico in het kanaal kan optreden. In dit proefschrift, onderzoeken wij onder andere de invloed van termijnmarkten op risico-verschuiving, prestatieprakkels en coördinatiekosten in een marketingkanaal.

Variatie in de opbrengst per ha vermindert de mogelijkheid tot risico reductie voor producenten, hetgeen het raadzaam maakt, om de maximale verkopen in de termijnmarkt te beperken tot een hoeveelheid kleiner dan de verwachte oogst (b.v., Moschini en Lapan, 1995).
Ook dient men zich te realiseren dat de prijzen in de termijnmarkt en de spot markt niet volledig parallel lopen, hetgeen leidt tot een basisrisico (d.w.z., spot-prijs minus toekomstprijs) van transacties in de termijnmarkt (b.v., Pennings en Meulenberg, 1997).

Voor kanaalleden die risico wensen af te dekken door termijncontracten is de hedge ratio van groot belang (b.v., Dawson et al., 2000; Harwood et al., 1999). In deze studie wordt de analyse van de hedge ratio uitgebouwd door tijdsafhankelijke, optimale hedge ratios voor risico-mijdende producenten en groothandelaren te modelleren en deze hedge ratio te schatten voor het marketingkanaal van Nederlandse consumptie-aardappelen.

Een empirische bijdrage van de studie is de schatting en de beoordeling van de ontwikkelde principaal-agent modellen door middel van tijdreeksanalyse. Deze modellen zijn toegepast op het marketingkanaal van Nederlandse consumptieaardappelen. De jaarlijkse Nederlandse aardappelproductie bedraagt ongeveer acht miljoen ton, hoofdzakelijk geproduceerd op gezinsbedrijven. Ongeveer 50% van deze productie zijn consumptie aardappelen, 20% zijn pootaardappelen, en 30% worden benut voor zetmeelproductie (NIVAP Holland, 2002). De markt van consumptieaardappelen wordt gekenmerkt door hoge prijsvolatiliteit, hetgeen blijkt uit de vrij hoge variatiecoëfficiënt van 0,69 (gebaseerd op jaarlijkse prijzen over de periode 1946-2003). De hoge prijsvolatiliteit in de aardappelsector kan worden verklaard door het feit dat er geen overheidsinterventie in aardappelmarkten plaatsvindt en de Nederlandse aardappelprijzen in hoge mate bepaald worden door de exportvraag, zijnde ongeveer twee derde van de jaarlijkse productie. Als één van de meest volatiele agrarische markten in Europa, is de Nederlandse consumptie-aardappelmarkt gekozen voor ons empirisch onderzoek. Interessante eigenschappen van het marketing kanaal voor Nederlandse consumptieaardappelen zijn ook dat de productie wordt gerealiseerd door een groot aantal relatief kleine landbouwers, die ieder een klein aandeel in de totale productie hebben, tegenover een beperkt aantal groothandelaars, industrieën en detailhandelaren,
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alsmede de aanwezigheid van een aardappeltermijnmarkt (in Amsterdam sinds 1958). Onze studie concentreert zich op risico, prestatieprikkels en coördinatiekosten, terwijl we rekening houden met het al of niet deelnemen van kanaalleden aan de aardappeltermijnmarkt. De ontwikkeling en de empirische toetsing van vier verschillende principaal-agent modellen, gericht op de analyse van verschuiving in risico, van coördinatie-kosten en van de hedge ratio in marketingkanalen is uitgevoerd in Hoofdstukken 2 – 5. De resultaten hiervan zullen nu worden samengevat.

DE RESULTATEN VAN HET ONDERZOEK

In deze studie worden vier verschillende structuren van een marketingkanaal geanalyseerd door twee verschillende lengtes van marketingkanalen te vergelijken (twee- fasen en drie-fasen marketingkanalen), met wel of geen termijnmarkt. De onderzoeksresultaten voor deze vier alternatieven (Hfdst. 2 – Hfdst. 5) worden bondig gerapporteerd.

In Hoofdstuk 2 benutten wij het klassieke agency model voor de analyse van risicoverschuivingen, coördinatiekosten en van prestatieprikkels om coördinatiekosten te verminderen in een marketingkanaal met twee fasen (producent en marketing onderneming) zonder aanwezigheid van een termijnmarkt. Het model wordt getoetst met behulp van econometrische tijdreeksenanalyse op basis van gegevens betreffende de Nederlandse markt voor consumptieaardappelen. Wij tonen aan dat bij een risico-neutrale principaal en een risico-mijdende agent, een lineair contract nog optimaal kan zijn, indien de vaste vergoeding negatief is. De empirische resultaten over de periode 1946 - 2003 laten zien dat, terwijl vaste vergoedingen aan landbouwers (agenten) in de periode sinds de jaren '80 zijn gedaald, de prestatieprikkels ongeveer verdubbeld zijn terwijl de risicopremie die de landbouwers eisen aanzienlijk is gestegen. Sinds het midden van de jaren '60, is het risico van detailhandelaren
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naar landbouwers verschoven. Dit zou het gevolg van ketenomkering kunnen zijn, namelijk, van een traditionele supply chain naar een vraag-gestuurde keten.

Ook blijken door meer prestatieprikkels aan producenten de coördinatiekosten van het marketingkanaal beduidend te zijn verminderd. De resultaten van dit hoofdstuk kunnen bijdragen tot het debat over de vraag of risico een stabiel concept is (b.v., Pennings en Garcia, 2001).

In Hoofdstuk 3 wordt het principaal-agent model uitgebreid met de aanwezigheid van een termijnmarkt. Verschuivingen in risico tussen de principaal (detailhandelaar) en de agent (producenten) worden onderzocht. De voornaamste bijdrage van dit hoofdstuk ligt in het benutten van traditionele agency modellen om een tijdsafhankelijke optimale hedge ratio af te leiden met gebruik van tijdreeksgegevens van lage frequentie. Dit type gegevens wordt door landbouwers gebruikt bij beslissingen over productie en hedge-strategie. De ontwikkelde hedge ratio is gebaseerd op de traditionele agency theorie en weerspiegelt de beslissing van de producent met in achtname van contractuele relaties in het marketingkanaal. Onze studie verschilt van vorige studies over dit onderwerp, omdat de laatstgenoemden hoog-frequente gegevens (dagelijks en wekelijkse gegevens) gebruiken en de contractuele relaties van de leden in het kanaal veronachtzamen (b.v., Ederington, 1979; Pennings en Meulenberg, 1997a,b). Het model is empirisch getest op basis van gegevens over de Nederlandse aardappelmarkt en van de termijnmarkt in Amsterdam gedurende de periode 1971 - 2003. De resultaten laten zien dat de verschuiving van risico’s van detailhandel naar landbouwer, beter door landbouwers kan worden verwerkt als zij van termijncontracten gebruik maken. Dit demonstreert de mediërende rol van termijnmarkten in de verschuiving van winstrisico’s in een marketingkanaal. Ook in dit model worden de coördinatie kosten van het marketingkanaal beduidend minder door hogere prestatieprikkels van detailhandelaren (principaal) aan producenten (agent).
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In Hoofdstuk 4 wordt een principaal-agent model van een marketingkanaal met drie fasen (producent, groothandelaar, en detailhandelaar) ontwikkeld en empirisch onderzocht. Wij bepalen prestatieprikkels, coördinatiekosten en winandrisico’s voor de kanaalleden (d.w.z., producent, groothandelaar en detailhandelaar) die enkel op de spot (effectieve) markt handelen. Agrarische marketingkanalen worden verticaal gecoördineerd door het gebruik van contracten om aan de consumentenbehoeften te kunnen voldoen in de huidige verzadigde voedselmarkten. Deze contracten zouden bij voorkeur een optimale trade-off moeten opleveren tussen het verschaffen van prestatieprikkels en risicovermindering. Het voorgestelde principaal agent-model kan inzicht verschaffen in de rol van prestatieprikkels in het verminderen van de coördinatiekosten en in de rol van de groothandelaar in het verschuiven van risico’s in het marketingkanaal. Toepassing ervan op het Nederlandse marketingkanaal van consumptie-aardappelen toont aan dat detailhandelaren over de periode 1961-2002 meer prestatieprikkels aan de groothandelaren en producenten verstrekten en dat dientengevolge de coördinatiekosten in het marketingkanaal beduidend verminderden. De risico's zijn verschoven van detailhandelaar naar producent en groothandelaar, mogelijk als gevolg van concentratie in de levensmiddelendetailhandel.

In Hoofdstuk 5 wordt een principaal-agent model voor een marketingkanaal uitgewerkt dat producenten, groothandelaren en detailhandelaren omvat, met aanwezigheid van een termijnmarkt. Voor zover bekend is dit de eerste studie die het principaal-agent model uitbreidt naar risicoverschuivingen in een marketingkanaal van drie fasen, met de aanwezigheid van een termijnmarkt. Risico-verschuiving wordt geanalyseerd en de agencykosten worden bepaald. De optimale hedge ratio wordt vastgesteld, onder de aanwezigheid van contractuele relaties in het marketingkanaal. De empirische resultaten voor het marketingkanaal van Nederlandse consumptieaardappelen over de periode 1971-2003 laten zien dat de coördinatiekosten van het marketingkanaal beduidend verminderden tengevolge
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van grotere prestatieprikkels aan producenten en groothandelaren. De coördinatiekosten van het marketingkanaal zijn lager dan in het scenario zonder termijnmarkt (Hoofdstuk 4), wat de informatie-rol (namelijk, informatie over prijzen) van de termijnmarkten bevestigt. De termijnmarkt biedt producenten de mogelijkheid om de stijgende inkomensvariatie te beperken.

VERGELIJKING VAN DE ONDERZOEKSR ESULTATEN VOOR DE VERSCHILLENDE MODELLEN

Een vergelijking van de onderzoeksresultaten van de verschillende modellen in onze studie toont het effect van verschil in kanaalstructuur op risico, prestatieprikkels en coördinatiekosten in agrarische marketingkanalen. Deze vergelijking wordt gemaakt voor de vijf hoofdvariabelen van ons model: intensiteit van de prestatieprikkel (de mate waarin output-waarde wordt gedeeld), vaste vergoeding, hedge ratio, winstrisico en agency kosten.

De intensiteit van de prestatieprikkel voor de producent is hoger in het twee-fasen model met termijnmarkt dan in het model zonder termijnmarkt. Mogelijk gaan hoge prestatieprikkels samen met een hoog winstrisico en handelen producenten in termijncontracten om dit stijgend winstrisico te verminderen.

De intensiteit van de prestatieprikkel voor de producent is enigszins hoger in het marketingkanaal van twee fasen zonder termijnmarkt dan in het drie fasen model zonder termijnmarkt. Blijkbaar hebben producenten bij afwezigheid van een groothandelaar meer aansporingen nodig om op consumentenbehoeften in te spelen dan wanneer een groothandel in het kanaal aanwezig is.

De intensiteit van de prestatieprikkel voor de producent in het twee fasen model met termijnmarkt (producent en detailhandelaar) is hetzelfde als die in het drie fasen model met termijnmarkt. Dit impliceert dat de tussenpersoon (groothandelaar) een marginale rol vervult in het geven van prestatieprikkels aan de producent wanneer een termijnmarkt aanwezig is.
Zowel voor producent als groothandelaar is de intensiteit van prestatieprikkels hoger in het drie fasen model met termijnmarkt dan in het drie fasen model zonder termijnmarkt. De grotere prestatieprikkels gaan samen met een hoger winstrisico voor producenten en groothandelaar, die daarom de termijnmarkt benutten om winstrisico's te verminderen.

De vaste vergoeding voor producenten was tot het einde van de tachtiger jaren hoger in het twee fasen model met termijnmarkt dan in dat zonder termijnmarkt. Daarna, werden de vaste vergoedingen negatief, terwijl die in het kanaal zonder termijnmarkt hoger waren dan in het kanaal met termijnmarkt. Blijkbaar maken de producenten meer impliciete investeringen in hun contractuele relaties wanneer zij handelen op de termijnmarkt (b.v., Pennings en Leuthold, 2000).

De vaste vergoeding van producenten in het twee fasen model zonder termijnmarkt is bijna hetzelfde als in het drie fasen model zonder termijnmarkt. Dit suggereert dat de groothandelaar een marginale rol speelt in de vaste vergoeding van de producent.

De vaste vergoeding van producenten in het twee fasen model met termijnmarkt is bijna hetzelfde als in het drie fasen model met termijnmarkt. Dit bevestigt de eerdere constatering dat de groothandelaar geen significante rol speelt in de vaste vergoeding van de producenten, ook bij aanwezigheid van een termijnmarkt.

De vaste vergoeding van producenten in het drie fasen model met termijnmarkt was enigszins hoger dan die in het drie fasen model zonder termijnmarkt. Sinds het einde van de jaren '80 was de vaste vergoeding voor producenten met termijncontracten lager dan voor die zonder termijncontracten. Zoals ook voor het twee fasen model werd vastgesteld, houdt dit in dat producenten meer impliciete investeringen in hun contractuele relaties maken wanneer zij gebruik kunnen maken van een termijnmarkt.
De vaste vergoeding van groothandelaren verschilt nauwelijks tussen het drie fasen model met termijnmarkt en dat model zonder termijnmarkt. Dit betekent dat de termijnmarkt geen significante rol speelt in de vaste vergoeding van groothandelaren.

De hedge ratio van producenten is hoger in het drie fasen (producent, groothandel, detailhandel) model met termijnmarkt, dan in het twee fasen (producent, detailhandel) model met termijnmarkt. Mogelijk gedragen groothandelaren zich meer opportunistisch dan detailhandelaren, hetgeen bevordert dat producenten hun prijsrisico’s afdekken in de termijnmarkt.

Winst risico voor producenten is lager in het twee fasen model met termijnmarkt dan in dat model zonder termijnmarkt. Blijkbaar zijn termijncontracten een efficiënt instrument voor het dekken van prijsrisico’s.

De winstrisico's van de producent in het drie fasen model zonder termijnmarkt zijn iets lager dan die in het twee fasen model zonder termijnmarkt. Dit betekent dat de groothandelaar een deel van de winst (inkomens) risico's van de producent overneemt.

Het winstrisico van de groothandelaar is groter in het drie fasen model met termijnmarkt dan in het drie fasen model zonder termijnmarkt. Dit vloeit voort uit het feit dat groothandelaren een natuurlijke risicobescherming hebben doordat hun inkoopp- en verkoopprijzen sterk gecorreleerd zijn (b.v., Pennings en Leuthold, 2001). In een dergelijke situatie introduceert volledige dekking in de termijnmarkt voor een groothandelaar (d.w.z., een hedge ratio van 1) extra prijsrisico. Dit suggereert dat groothandelaren zich bij een hoge correlatie tussen hun inkoop- en verkoopprijzen, zich beter zouden kunnen onthouden van volledige prijsdekking in de termijnmarkt.

Het winstrisico van de detailhandelaar in het drie fasen model zonder termijnmarkt is hoger dan in het drie fasen model met termijnmarkt. Als gevolg van de termijntransacties van
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producenten en groothandelaren wordt het winstrisico van de detailhandelaar zeer sterk verminderd.

De coördinatiekosten in het marketingkanaal zijn kleiner in het *twee fasen model met termijnmarkt* dan in het *twee fasen model zonder termijnmarkt*. Dit demonstreert het effect van termijnhandel op de coördinatiekosten, hetgeen de informatiefunctie (*d.w.z.*, prijs ontdekking) van termijnmarkten onderstreept.

De coördinatiekosten in het marketingkanaal zijn kleiner in het *drie fasen model zonder termijnmarkt* dan in het *twee fasen model zonder termijnmarkt*. Dit toont the rol van groothandelaar in het verminderen van de coördinatiekosten.

De coördinatiekosten van het marketingkanaal zijn kleiner in het *drie fasen model met termijnmarkt* dan in het *drie fasen model zonder termijnmarkt*. Dit bevestigt de stelling dat de termijnmarkt de functie van prijs ontdekking in het marketingkanaal heeft.

**DE ONTWIKKELING VAN DE MODELPARAMETERS OVER DE TIJD**

De methodologie van onze studie staat toe om de ontwikkeling van de belangrijkste modelvariabelen over de tijd te bestuderen en te vergelijken voor de verschillende modellen. In het volgende geven wij hiervan een samenvatting.

**(A)** Voor de *principaal-agent modellen van een marketingkanaal met twee fasen, met en zonder termijnmarkt*:

De intensiteit van de prestatieprikkel voor de producent (het aandeel in output waarde) nam toe in de modellen met en zonder een termijnmarkt, misschien omdat meer prestatieprikkels vereist zijn voor de verbetering van de coördinatie in het marketing kanaal. **De vaste vergoeding voor producenten** verminderde tot een negatieve waarde. Dit betekent dat sinds 1980 de producenten in hun contractuele relatie met detailhandelaren een impliciete
vergoeding betalen, misschien wel omdat producenten meer betrokken raken bij de aardappelopslag.

Het winstrisico van de producent is toegenomen terwijl het winstrisico van de detailhandelaar is verminderd. De producenten kunnen de stijgende winstrisico’s afdekken door gebruik te maken van de termijnmarkt.

De kosten van de coördinatie van het marketingkanaal zijn gedaald als gevolg van verhogingen van de intensiteit van de prestatieprikkels aan producenten en het handelen van producenten op de termijnmarkt.

De hedge ratio van de producent is verminderd mogelijk wegens een daling van het risico-mijdend gedrag van producenten.

(B) Voor de principaal-agent modellen van een marketingkanaal met drie fasen, met en zonder termijnmarkt:

De intensiteit van de prestatieprikkel voor producent en groothandelaar is toegenomen, zowel in het geval van met als zonder termijnmarkt, hetgeen wellicht nodig is om marketing coördinatie te bevorderen.

Vaste vergoeding voor producenten en groothandelaren is verminderd, zowel in het geval van met als zonder termijnmarkt. Producenten en groothandelaren betalen een impliciete vergoeding in hun contractuele relaties, wellicht om consumenten tevreden te stellen.

Het risico van de producent en van groothandelaar is toegenomen terwijl het winstrisico van de detailhandelaar is afgenomen, zowel in het geval van met als zonder termijnmarkt. Het winstrisico is verschoven van detailhandelaar naar producent en groothandelaar.

De coördinatiekosten van het marketing kanaal zijn verminderd, zowel in het geval van met als zonder termijnmarkt, waarschijnlijk als gevolg van grotere prestatieprikkels voor de producent.
**Samenvatting**

**De hedge ratio van de producent en van de groothandelaar** is verminderd, misschien als gevolg van afgenomen risico aversie.

**METHODOLOGISCHE BIJDRAGEN**

Onze studie van risico, prestatieprikkels en coördinatiekosten in agrarische marketingkanalen levert ook een aantal methodologische bijdragen. Een fundamentele bijdrage is de uitbreiding van het principal-agent model van een twee fase (producent-detailhandelaar) naar een drie fasen (producent-intermediair-detailhandelaar) marketing-kanaal, met en zonder termijnmarkt. Zover wij kunnen nagaan is dit de eerste studie die prijsrisico-dekking via de termijnmarkt bekijkt binnen de context van verticale contractuele relaties en in het kader van een principaal-agent model. De introductie van een termijnmarkt in de modellering van de relaties in het marketingkanaal van commodities verrijkt de analyse en sluit aan bij ander onderzoek *(b.v., Pennings en Wansink, 2004)* waarin wordt aangetoond dat marketing instituten invloed hebben op kanaalstructuren.

Een andere methodologische bijdrage is de toepassing van tijdreeksenanalyse op het principaal-agent model in het onderzoek naar prestatieprikkels, risico, en coördinatiekosten in marketingkanalen. Terwijl voorgaande studies voor de modellering en het schatten van hedge ratios gegevens gebruiken met hoge frequentie *(namelijk, dagelijkse en de wekelijkse gegevens)*, en de contractuele relaties tussen kanaalleden niet overwegen *(b.v., Ederington, 1979; Pennings en Meulenberg, 1997a,b)*, gebruiken wij jaar-gegevens die met de beslissingstermijn van producenten overeenkomen en houden wij tevens rekening met contractuele relaties tussen kanaalleden. Derhalve denken wij dat onze schattingsprocedure van tijdsafhankelijke hedge ratios beter aansluit bij het beslissingskader van producenten dan de procedures uit vorige studies.
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Tot slot kan onze onderzoeksbenadering aanwijzingen geven over de mate van marktgerichtheid van kanaalleden; een daling van de vaste vergoeding tot een negatief niveau wijst op investeringen door de deelnemers in het marketing kanaal (producenten en groothandelaars) om consumentenbehoeften te bevredigen.

IMPLICATIES VOOR HET MANAGEMENT

Onze onderzoekresultaten bieden niet alleen een beter inzicht in de risicos, de prestatieprikkels en de coördinatiekosten in agrarische marketingkanalen maar hebben ook implicaties voor het management van ondernemingen in deze kanalen.

Ten eerste. Het blijkt dat coördinatie efficiëntie in marketingkanalen kan worden verbeterd door prestatieprikkels van detailhandelaren aan kanaalleden stroomopwaarts, te weten producenten en groothandelaren. Dergelijke prikkels zijn onder meer effectief doordat deze kanaalleden gebruik maken van risico mijdende instrumenten, zoals termijnmarkten.

Ten tweede. Aangezien de coördinatiekosten van het marketingkanaal lager zijn in de situatie waarin een termijnmarkt aanwezig is ten opzichte van de situatie zonder termijnmarkt, zouden kanaalleden, in het bijzonder landbouwers, moeten worden aangemoedigd om efficiënt gebruik te maken van termijnmarkten.

Ten derde. Er doet zich in het marketingkanaal een verschuiving van het financieel risico voor van detailhandelaar naar producent en groothandelaar wegens een gunstiger onderhandelingspositie van de detailhandel. Om het gevaar van een dominante detailhandel in marketingkanalen te vermijden, is effectieve concurrentieregelgeving wenselijk.

BEPERKINGEN VAN HET ONDERZOEK EN MOGELIJKHEDEN VOOR TOEKOMSTIG ONDERZOEK

Elke studie van een dergelijk complex vraagstuk als “Risico, prestatieprikkels en coördinatiekosten in marketingkanalen” heeft zijn beperkingen. Daarom is het zinvol om tot
Samenvatting

slot aandacht te besteden aan een aantal beperkingen van dit onderzoek en dit te combineren met suggesties voor verder onderzoek.

De veronderstelling van constante absolute risico aversie (CARA) die in onze modellering wordt gebruikt hoeft niet altijd van toepassing te zijn. In feite, hebben onze empirische resultaten aangetoond dat risico attitudes van kanaalmeden in de tijd kunnen veranderen, ook al hoeft dit niet strijdig te zijn met de veronderstelling van CARA. In samenhang met veranderende risico attitudes van kanaalmeden moet de veronderstelling van het principaal-agent model, dat de principaal risico neutraal en de agent risico mijndend is, wellicht in sommige gevallen worden aangepast. Bijvoorbeeld, in de modellen van een marketingkanaal met drie fasen (Hoofdstukken 4 en 5), veronderstellen wij een groothandelaar, die principaal is in zijn relatie tot de producent en als zodanig risico neutraal is, terwijl hij in hetzelfde model geacht wordt risico mijndend te zijn in de contractuele relatie met de detailhandelaar.

Een ander voorbehoud ten aanzien van onze studie betreft de ‘risico’ maat. Wij hebben de variantie van de winst gebruikt als een proxy variabele voor het winstrisico van kanaalmeden. Echter hogere momenten van de statistische kansverdeling van winsten, zoals scheefheid en kurtosis, zouden meer informatie over het winstrisico kunnen verstrekken. Voorts zou ook de variatiecoëfficiënt kunnen worden gebruikt om het winstrisico van kanaalmeden te meten. Een voordeel van het gebruik van de variatiecoëfficiënt als maat voor volatiliteit is dat deze controleert is voor verschillen in het gemiddelde, zowel voor items die in verschillende als voor items die in dezelfde eenheid zijn gemeten.

Verder zijn de analyses uitgevoerd onder de impliciete veronderstelling van een representatieve producent, groothandelaar en detailhandelaar. In werkelijkheid kunnen zich echter grote verschillen voordoen in de prestaties van producenten, groothandelaren en detailhandelaren, met als gevolg verschillen in de strategieën van risico-beheer (b.v., Pennings
Risk, Incentives and Coordination Costs

en Garcia, 2004). Er bestaat daarom behoefte aan verder onderzoek op basis van
tijdreeksgegevens op het niveau van het/de individuele landbouwbedrijf, groothandel en
detailhandel (hetgeen de beschikbaarheid van panelgegevens vereist).

Tot slot, de modellen in deze studie werden slechts toegepast op één marketing-
kenaal, het marketingkanaal van Nederlandse consumptie-aardappelen. Toepassing van de
voorgestelde modellen op andere marketingkanalen is dan ook een interessante weg voor
verder onderzoek.
Publications


Conference Proceedings


Risk, Incentives and Coordination Costs


CURRICULUM VITAE

John Kofi Mensah Kuwornu was born on the 29th of March, 1968 at Kpong in Ghana. He attended the Kpong Methodist Schools for his primary education during the period 1975-1984. From 1984-1988, he studied and obtained the General Certificate of Education, Ordinary Level (G.C.E, O Level). In 1988, he proceeded to the Foso Teachers’ Training College where he obtained a Teachers’ Certificate “A”, 3-Year Post Secondary, awarded by the Institute of Education, University of Cape Coast, Ghana in 1991. He then taught Mathematics and General Science at the Junior Secondary School Level during 1991-1993. Between 1990 and 1992 he studied and obtained the General Certificate of Education, Advanced Level (G.C.E, A Level). In 1993, he proceeded to the University of Ghana, Legon, where he obtained a Bachelor of Arts degree (Honours) in Economics with Political Science in 1997. During the period 1997-1999 he taught Mathematics at the the Akrokerri Teachers’ Training College and Bekwai SDA Senior Secondary School in Ghana, and also served as an Assistant Examiner in Mathematics and Economics for the West African Examinations Council (WAEC). In 2000, he was awarded the Wageningen University Fellowship to study for the Master of Science degree in Agricultural Economics and Management, where he specialised in Marketing and Consumer Behaviour. In December 2001, he enrolled as a PhD student in Agricultural Economics and Marketing at the Wageningen University. His PhD research is entitled “Risk, Incentives, and Coordination Costs in Agro-food Chains in the Presence of Futures Markets”. John is an occasional reviewer for Agricultural and Food Science.