Finance and Organization

The Implications for Whole Farm Risk Management

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"The Doctoral School of Economics and Management is an active national and international research environment at CBS for research degree students who deal with economics and management at business, industry and country level in a theoretical and empirical manner".

Contents

Preface

This thesis was written in the period February 2010 to September 2013 as part of an industrial Ph.D. project that has been a partnership between the Knowledge Centre for Agriculture and the Department of Strategic Management and Globalization at Copenhagen Business School. The Ph.D. education was organized by the Doctoral School of Economics and Management at Copenhagen Business School.

Several people have contributed to the making of this thesis, and I would like to thank them all. First, I would like to thank the Knowledge Centre for Agriculture for providing an excellent working environment for most of my research and for significant financial support. Second, I am grateful to my two academic supervisors, Professor Torben Juul Andersen for his moral and academic support and guidance throughout the entire pre-project and project phase, and co-advisor Professor Nicolai Juul Foss for his support, guidance and for opening doors to interesting research environments, especially the European School of New Institutional Economics. Third, I am grateful for the support and advice of my business advisor Stine Hjarnø Jørgensen.

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English summary

This thesis analyzes the institutional framework around risk management in Danish agriculture, with the two main sectors, the hog and the dairy sector in mind, and it suggests a new more active role for the cooperatives in these sectors, with regard to the reallocation of price risk among members.

The thesis consists of a general introduction, three linked but independent and self-contained papers and a conclusion. The first paper introduces a measure of credit capacity using Data Envelopment Analysis. This is a novel application of a well-known methodology from production economics on financial issues. The paper was motivated by the fact that most literature on risk management explains the rationale for risk management activities such as hedging, with increased ability to obtain finance via debt. However, no hedging had been performed on the output side for Danish pig or dairy farms, while access to debt capital seemed abundant. It seemed that farmers may have been thinking "Why hedge, if you can borrow?" The perception of the abundant availability of liquidity in the form of credit reserves may have been an explanation for the absence of other risk management activities in the sectors and why a measure and empirical analysis of the development in credit capacity was needed. However, existing measures of access to credit had focused on the dichotomous question of whether firms are financially constrained or not, while the relative unconstrainedness of firms (farms) would have explained the absence of risk management. An analysis of some 92,000 farm accounts from 1996 to 2009 found that access to credit roughly doubled during the period. This may have been an important explaining factor for the (absent) development of risk management institutions.

The second paper provides a cross-country comparison of the development in hog marketing in the U.S. and Denmark over time. While the technological and structural development in the hog sector in Denmark and the U.S. has been somewhat similar, the marketing arrangements in the U.S. have changed dramatically while the status quo has been maintained in Denmark. Over the past 20 years, the marketing of hogs in the U.S. has shifted from being predominantly based on spot-marketing to a situation where backward vertical integration, production and marketing contracts are the dominant marketing arrangements. This development is usually explained using transaction costs and/or risk management arguments, which may omit important complementary effects of the financial en-

vironment. In contrast to the U.S. development, the Danish *modus operandi* when it comes to the process of selling finished hog to further processing stages in the value chain (the marketing arrangement) have been very stable, being dominated by cooperatives the entire period, cooperatives being a hybrid form of forward vertical integration. The second paper suggest that the status quo in Danish hog marketing is due to complementary effects between the cooperative processing and marketing of pork and a financial system providing ample access to credit.

The cooperative organization of marketing reduces transaction costs, but it does not allow the members to individually manage price risk, while it also reduces the relevance of market-based price risk management such as hedging with futures. Provided a financial environment with ample access to credit is present, the absence of price risk management institutions is irrelevant, as it is a redundant risk management tool when credit reserves are abundant. However, in the aftermath of the global financial crisis, the financial environment is changing which may result in the disappearance of one of the complementary factors that made price risk hedging irrelevant. Cooperative marketing will, however, still reduce the relevance of futures-based hedging, as basis risk will be substantial.

Danish farmers may be left in a situation in which the access to credit that crowded out market-based risk management has disappeared and cooperative marketing inhibits effective use of potentially emerging market-based risk management instruments. The third paper suggests and analyzes the possibility of cooperatives organizing the reallocation of price risk among cooperative members in the situation described above. Given sufficient heterogeneity in member risk preference and sufficiently low direct transaction costs, the potential gains from reallocation will be substantial.

Dansk Resume (Danish Summary)

Denne afhandling analyserer de institutionelle rammer for risikostyring i dansk landbrug med de to hoveddriftsgrene, svineproduktion og mælkeproduktion i tankerne. Afhandlingen foreslår en mere aktiv rolle for andelsselskaberne i disse to sektorer med hensyn til omfordeling af prisrisiko iblandt andelshaverne.

Afhandlingen består af en generel introduktion, tre indbyrdes tilknyttede, men selvstændige og uafhængige artikler samt en konklusion. Den første artikel introducerer et mål for kreditkapacitet baseret på Data Envelopment Analysis. Dette er en nyskabende anvendelse af velkendt metode fra produktionsøkonomien på finansielle forhold. Artiklen er motiveret af det forhold, at meget eksisterende risikostyringslitteratur forklarer anvendelsen af instrumenter til afdækningen af prisrisiko med øget adgang til fremmedfinansiering. Det forholder sig dog samtidig sådan, at der stor set ingen afdækning af prisrisiko foregår på salgssiden blandt danske svine- og mælkeproducenter, mens adgangen til gældsfinansiering har været rigelig. Det ser ud til at have været en tilstand, hvor danske landmænd kan have tænkt "Hvorfor afdække priserne, når jeg i forvejen kan låne?" – Opfattelsen af rigelig adgang til likviditet i form af kreditreserver kunne potentielt forklare fraværet af andre risikostyringsaktiviteter, hvorfor der var behov for et mål for og en empirisk analyse af udviklingen i kreditkapaciteten. Eksisterende mål for adgangen til finansiering var imidlertid fokuseret på det dikotomiske spørgsmål om virksomheder var finansielt begrænsede eller ej, mens den relative grad af finansielle (u)begrænsninger kunne forklare fraværet af andre risikostyringsaktiviteter. En analyse af 92.000 landbrugsregnskaber over perioden fra 1996 til 2009 fandt, at adgangen til kredit rundt regnet blev fordoblet over perioden. Dette kan være en vigtig forklarende faktor for fraværet af udvikling af de institutionelle rammer for risikostyring.

Den anden artikel leverer en sammenligning af udviklingen i markedsføringsstrukturen mellem svineproduktionssektoren i USA og i Danmark. Mens den teknologiske og strukturelle udvikling i svineproduktionssektoren i USA og i Danmark har været sammenlignelig, så har udviklingen i markedsføringsstrukturen i USA medført dramatiske forandringer, mens en status quo tilstand er blevet opretholdt i Danmark. Over de seneste 20 år er markedsføringsstrukturen i den amerikanske svinesektor gået fra at være domineret af et spotmarked til en situation, hvor baglæns vertikal integration, produktions- og markedsføringskontrakter er de dominerende markedsføringsstrukturer. Denne ud-

vikling er normalt forklaret ved hjælp af transaktionsomkostnings- og/eller risikostyringsargumenter. Disse forklaringer kan udelade vigtige komplementære effekter af det finansielle institutionelle miljø. Den danske markedsføringsstruktur i svinesektoren har i modsætning til den amerikanske været meget stabil med andelsselskaber som den dominerende faktor i hele perioden. Andelsselskaber er en hybrid form for forlæns vertikal integration. Artiklen finder, at den stabile markedsføringsstruktur i Danmark kan forklares ved hjælp af komplementære effekter mellem afsætningen via andelsselskaberne og et dansk finansielt system, der har stillet stor adgang til kredit til rådighed.

Afsætningen via andelsselskaber i Danmark reducerer transaktionsomkostningerne, men på den ene side, så giver det ikke andelshaverne mulighed for individuel styring af prisrisiko og på den anden side reducerer afsætningen via andelsselskaber værdien af markedsbaserede instrumenter til reduktion af prisrisiko såsom futures. Under tilstande, hvor det finansielle institutionelle miljø leverer rigelig adgang til kredit, er fraværet af andre risikostyringsinstrumenter ikke så væsentlig, idet de ville være overflødige værktøjer i sammenhæng med rigelige kreditreserver. Efter den globale finansielle krise er det finansielle miljø imidlertid under forandring og en af de komplementære faktorer, der gjorde afdækning af priser unødvendig, kan være ved at forsvinde. Afsætning via andelsselskaber vil dog stadig vanskeliggøre individuel styring af prisrisiko via futures o.l., idet basisrisikoen mellem variationen i futures priser og de priser, der modtages i det fysiske marked via andelsselskaberne, vil være betydelig.

Danske landmænd kan være havnet i en situation hvor den store adgang til kredit, der fortrængte markedsbaserede risikostyringsinstrumenter, er forsvundet, mens afsætning via andelsselskaberne er en hindring for effektiv brug af potentielt kommende markedsbaserede risikostyringsinstrumenter. Den tredje artikel foreslår og analyserer muligheden for, at andelsselskaberne organiserer reallokering af eksponeringen over for prisrisiko blandt andelshaverne i en situation som ovenfor beskrevet. Såfremt andelshaverne er tilstrækkeligt heterogene i deres evne til at bære risiko og såfremt transaktionsomkostningerne ved omfordelingen kan holdes tilstrækkeligt lave, vil værdien af omfordeling af risikoen være betydelig.

Chapter 1

Introduction

1.1 Introduction

"New markets do not emerge, nor do they appear. They are *made* by the activities of firms. New markets are created when firms correctly sense (by accident or by design) a latent need and communicate their solution to that need: markets spring into being when economic actors shift resources to that firm's solution. The most visible way to create a new market is to offer a product/service that is novel, thereby addressing needs that were not met (and perhaps not even sensed)"

(Anderson and Gatignon, 2005, p. 1)

The major industry-related contribution of this thesis is the suggestion to the pork and dairy cooperatives in Denmark to create markets for the reallocation of price risk among their members. Recent developments in the institutional framework of Danish agriculture suggest that some needs are not met, and perhaps not even sensed yet. These developments relate to the institutional framework for risk management and they consist of, in broad terms, changes in agricultural policy, changes in the world market price (volatility) of agricultural commodities (the food crisis), changes in the financial environment (the global financial crisis (GFC) and Basel accords) and changes in domestic environmental and land-ownership regulation.

The main overarching research question of the thesis is how the different elements of the institutional framework around agricultural risk management interact, how they are affected by exogenous shocks to the institutional matrix and how the process of adaptation to such shocks can be facilitated. In this sense the thesis deals with the adaptive efficiency (North, 2005) with respect to agricultural institution related to risk management. The thesis is focused on the implications of interaction between whole farm risk management, finance and the organization of the agricultural value chain.

The term whole farm risk management is used to stress the point that it is the management of the whole farms risk exposure that is of concern in the thesis. Farms are thought of as sole proprietorships or alternatively partnerships or closely held corporate entities. The point is that it is the farmer's management of his or her overall personal economic risk exposure that is of concern, and not the management of specific risks. That said the thesis will revolve around the need and possibility for Danish livestock farmers, to manage output price risk exposure and how this need interacts with the financial and organizational environment.

This is not to say that this specific risk exposure is important in and of itself, but as a major contributor to the overall whole farm risk exposure, price risk management may be important in some circumstances.

A casual look at risk management practice in Danish livestock farming will show that there is next to no individual management of output price risk exposure. The thesis will explore the idea that the interaction between risk management and finance is one important reason for the absence of output price risk management in Danish livestock farming. The thesis will show that access to credit, historically, has been quiet easy for Danish farmers. This may have influenced the farmers toward a perception of large credit reserves, which in turn may reduce their demand for output price risk management. Farmers may have been asking themselves the rhetorical question; Why hedge, if I can borrow?

Shocks to the institutional matrix or the institutional framework around agricultural risk management may upset the existing equilibrium. Changes in agricultural policy may increase the price volatility exposure that farmer perceive, The GFC and the following changes to the financial systems (formal and informal) may reduce the farmers perceived credit reserves. The general change in world markets for agricultural commodities (the food crisis) may increase the price volatility that farmers perceive, and so on.

The terms institutional matrix and institutional framework are synonymously used to describe "the complex interdependent, institutional structure that characterizes the modern human environment" (North, 2005, p. 156). Following North (1991) institutions consist of formal and informal rules and the enforcement of both. This means that the terms above cover a very broad framework of rules among other things covering personal belief systems (culture), formal rules in the form of government legislation and private rules in the form of contracts etc. as well as the interaction between these rules and their enforcement systems.

The changes mentioned above are, in effect, shocks to the institutional framework around risk management, and may initially result in an institutional vacuum, where the existing risk coping mechanisms no longer are sufficient. Eventually the institutional framework will adapt to the shocks, but

the adaption process may be fare from efficient, and the new equilibrium may be one out of a number of possible equilibriums, and not necessarily the socially optimal equilibrium.

The changes will likely affect the latent need for price risk management institutions in Danish agriculture; institutions that cannot be expected to emerge or appear, but can be *made* by the activities of firms central in the sector, such as the pork and dairy cooperatives.

Creating market solutions that enable farmers to manage price risk exposure individually may be a way of adapting to changes in the institutional environment that increase existing price risk exposure (e.g. agricultural policy) and / or changes that decrease the effect of existing risk coping mechanisms (e.g. credit reserves). These market solutions may eventually become institutionalized themselves.

The aim of this thesis is to improve the understanding of the consequences of changing financial and organizational frames for risk management. With this aim in mind, the thesis provides three papers prepared for academic journals, related to the developments mentioned above.

The complexity of the overarching research question leads to a need for the formulation of a number of more concrete research questions for the thesis: (How) does the financial system affect risk management in Danish agriculture? (How) does the financial system interact with organization of the agricultural value chain? And how can organizations in the agricultural value chain respond to changes in the financial system affecting the farmers' whole farm risk management? In sum, what implications for whole farm risk management follow from the interaction of finance and organization and how does this affect the adaption to changes in these institutional domains?

The thesis is based on the research hypotheses that credit reserves are affected by institutional environment around finance and that credit reserves potentially have major effect on the overall risk management practice of farmers. As such the thesis builds on the hypothesis of the risk balancing principal first formulated by Gabriel and Baker in (1980). The risk balancing principal has widely been use to criticize agricultural policies that target farmers risk exposure, with the argument that farmers will respond to a policy driven change in a specific risk exposure with a risk balancing behavior to adjust the farmer's total risk to the individual target level. For example farmers may re-

spond to income stabilizing agricultural policies (e.g. policies that reduce the farmers business risk) with an increase in financial risk to adjust the overall total risk exposure for the farmer.

The risk balancing concept can be seen as the theoretical background for the crowding out effect that some agricultural policies may have on market based risk management possibilities (Meuwissen et al., 2008; OECD, 2009, 2011). The point being that market based solutions may not emerge or survive if agricultural policies cover most of the latent need that the market based solution potentially could satisfy. The thesis works with the research hypothesis that financial environment can have an crowding out effect on market based risk management (e.g. hedging) similar to the crowding out effect of agricultural policies. A further introduction to and discussion of the risk balancing concept and the crowding out effect is given in section 1.2.6 below.

The thesis also explores the hypothesis that interdependencies between the financial environment and organization of economic activity exists and that this interdependent relationship is a codetermining factor for risk management practice.

The first paper develops a measure of the development in the financial environment of Danish agriculture up to the GFC. A change in the credit capacity and the level of utilization of this capacity is identified with the measure. Increasing credit reserves for Danish farmers up to the GFC may have affected the institutional framework for risk management by crowding out market-based price risk management instruments. The paper is mainly focused on the methodological development of the credit capacity measure, this also constitutes the main contribution to the literature, however, the paper also reemphasizes the effect of credit reserves which to some extent does not get the attention it deserves and the paper provides empirical evidence that supports the hypothesis that the financial environment can have a crowding out effect on other risk coping mechanisms. The paper has been accepted for publication in the Agricultural Finance Review (Pedersen and Olsen, forthcoming).

The first paper relates to the overall theme of the thesis by documenting the abundant credit capacity prior to the GFC, which suggests a crowding-out effect of credit reserves on other risk management instruments and suggests serious changes to this effect in the wake of the financial crisis. As such the paper gives a partial answer to the research question: (How) does the financial system affect risk management in Danish agriculture? The empirical findings of the paper support the crowd-

ing out effect of finance on other risk coping alternatives, which is based on the theoretical foundation of the risk balancing, there is however no specific test of the risk balancing hypothesis in the paper as it focusses on the development of the measure for development in the financial environment.

The second paper compares the development in the marketing arrangements in the U.S. and Danish hog industry and suggests complementarities between some financial environments and some organizational arrangements, specifically the Danish financial system and the dominant cooperative form of organizing agricultural marketing in Denmark. Changes in the financial environment after the GFC can affect this complementarity and possibly affect the way risk is managed in the value chain. The manuscript presented in this thesis is an extended version, linking papers I and paper III and providing a more thorough presentation and discussion of theory as well as data than would be possible in a normal research paper format.

The second paper focuses on the possible interaction effect between the institutional environment with regard to finance and the organization of the value chain. The paper presents an exploratory qualitative cross country comparisons, comparing only two cases, thus the results are rather weak and should not be over emphasized. However, the paper contributes to the literature by raising the issue of the possible effect of finance and risk management on organization of agricultural value chains which to some degree may be omitted in the existing literature (James et al., 2011).

The paper provides a partial answer to the research question: (How) does the financial system interact with organization of the agricultural value chain? The theoretical discussion of the paper supports the hypothesis that the financial system constitutes an important part of the institutional matrix and that this affects the organization of the agricultural value chain, furthermore the organization of the value chain may affect the way risks are managed. The empirical finding from the case study suggests that a financial environment where access to credit is relatively easy complements cooperative organization of marketing in agricultural value chains. However the empirical evidence for this finding is very weak, and should not be over emphasized.

The motivation for the thesis is rooted in my work with agricultural risk management and reoccurring situations, where I found myself considering questions like, ‘How will the organization of risk

management in Danish agriculture adapt to changes in the surrounding institutional environment? Especially, how will the sector adapt to the changes in the financial environment, in the wake of the financial crisis?' The question most likely came to my mind due to my belief that the agricultural financial environment has affected organization and risk management thinking in Danish agriculture. Whether or not this belief reflects the truth is investigated in papers I and II of the thesis.

The third paper investigates a possible element in an adaptation process, where marketing cooperatives assume a more active role in facilitating risk management options for their members. The paper is a mechanism design paper which suggests and analyzes the potential for the reallocation of price risk among cooperative members. This is found to be a possible element in the adaptation to the changes in the institutional frames for agricultural risk management in Denmark, implied by the two first papers.

The paper provides a partial answer to the research question: How can organizations in the agricultural value chain respond to changes in the financial system affecting the farmers' whole farm risk management? The paper suggests one possible response to the changes in the institutional environment. Obviously many other options exist.

The rest of this chapter consists of two main sections. The first provides a broad introduction to risk, risk management and financial theory related to Danish agriculture and the research hypothesis. The aim of the section is to define what is meant by risk, uncertainty and risk management in the thesis; to establish the theoretical foundation of risk management and financial theory upon which the thesis is built, especially the risk balancing concept, and to introduce the financial situation in the Danish agricultural sector. The second section introduces New Institutional Economics (NIE), which represents the main methodological approach of the thesis, and discusses the structure, methodological approach and issues of the three individual papers.

1.2 Risk Management

1.2.1 RISK, UNCERTAINTY AND AMBIGUITY

This subsection will introduce and discuss the concepts of risk, uncertainty and ambiguity and define what is meant with the term risk in this thesis.

The terms “risk” and “uncertainty” are often used synonymously. However, the terms Knightian risk and Knightian uncertainty are sometimes used to stress the distinction between risk and uncertainty used by Knight (1921), where risk refers to a situation where outcomes are drawn from a known distribution, such as the throw of a dice, while uncertainty refers to outcomes without full knowledge of the underlying distribution. This leads to a distinction between risk aversion and ambiguity aversion, where risk aversion refers to the preference for lower variance of outcomes, while ambiguity aversion refers to the preference for known risk over uncertainty, as illustrated by the Ellsberg Paradox (Ellsberg, 1961; Fox and Tversky, 1995).

The distinction between the terms may also relate to value assignment, where uncertainty is a value-free statement about an outcome distribution, while risk is a value-charged statement, which usually indicates aversion (Hardaker et al., 2004).

Knightian risk and ambiguity or Knightian uncertainty can be seen as two extremes on a continuum. In business, very few situations can be characterized by risk in the Knightian sense. However, many situations are quantified probabilistically with actuarial methods to approximate an underlying distribution. In this sense, risk assessment can be seen as a subjective process, which may be aided by quasi-objective methods and procedures, but ultimately relies on the judgment of the decision maker. In this case, the distinction between risk and uncertainty reduces to statements about the process of risk assessment. Risk management is not only the management of risk in the Knigthtian sense, but also the process of assessing or estimating the distribution of uncertain events, and the management of these (Moschini and Hennessy, 2001). In this thesis, risk management is just as much a question of uncertainty management as it is a question of management of risk in the Knigthtian sense.

The risk perceived and subjectively assigned by the decision maker is important. Whether this entails objectively applying a methodology or whether it be a subconscious process is of less relevance in this thesis, where risk is defined as the decision makers’ subjective perception of the outcome distribution, as risk in the Knightian sense has very little relevance in business related to agriculture.

Uncertain events are often treated as if they were risky events because assigning a probability distribution eases communication. As long as awareness about the uncertainty of the underlying distribution is kept in mind, this can help communication about uncertain events. However, the risk[1] that probability distributions are taken too literally is introduced.

1.2.2 BERNOULLI'S PRINCIPLE – THE SUBJECTIVE EXPECTED UTILITY HYPOTHESIS

This subsection will introduce and discuss the subjective expected utility hypothesis and alternative behavioral assumptions in decision theory.

The subjective expected utility (SEU) hypothesis is the state of the art in analysis of decisions under uncertainty with regard to agricultural risk management (Huirne et al., 1997). In general decision theory the SEU was first proposed by Bernoulli (1738) but gained important impact on economics and management thinking after von Neumann and Morgenstern (1947) structured decision making under (Knightian) risk and Savage (1954) extended the framework to decision making under uncertainty.

The SEU hypothesis integrates the risk preferences and the subjective probability of the decision maker. That is, the utility function and the subjective beliefs about the probability of specific outcomes are integrated. Following Anderson, Dillon and Hardaker (1977) the SEU hypothesis can be deduced from four axioms listed below:

1. Ordering
2. Transitivity
3. Continuity
4. Independence

With ordering it is meant that decision makers faced with two risky prospects are able two order them (state preference of one over the other) or is able to state indifference.

[1]The term risk is here used without reference to a known distribution

With transitivity it is meant that a decision maker that prefers the risky prospect a_1 over the risky prospect a_2 and also prefers a_2 over a_3 is assumed to prefer a_1 over a_3.

With continuity it is meant that for a decision maker preferring a_1 over a_2 and a_2 over a_3, this decision maker will be indifferent between the choice of a lottery that yields a_1 with subjective probability $P(a_1)$ and a_3 with probability $1 - P(a_1)$ and the risky prospect a_2.

With independence it is meant that if a decision maker prefers a_1 to a_2 any lottery that yields a_1 and any other outcome a_3, will be preferred to a lottery that yields a_2 and a_3 as outcomes (when $P(a_1) = P(a_2)$). This is known as the sure-thing principle (Nau, 2007).

The SEU hypothesis states that for a decision maker who accepts these axioms there exists a utility function U which associates a single utility value $U(a_j)$ with any risky prospect a_j. The utility of a risky prospect is the expected utility of the prospect derived from the subjective probability weighted outcomes, as follows (Hardaker *et al.*, 2004):

$$U(a_j) = \int U(a_j|S)g(S)dS \tag{1}$$

Where S is the state of nature and $g(S)$ is the continuous probability distribution.

Early critique of the SEU was raised by Allais (1953) and Ellsberg (1961). The Allais paradox is a compelling decision problem that violates the independence axiom of the SEU and the Ellsberg paradox questions whether uncertainties can be translated into subjective risk. The Ellsberg phenomenon can be viewed as ambiguity aversion or as a source-dependent attitude toward risk (Nau, 2007).

In the 1980s the critique of the SEU picked up in intensity and a number of alternative decision theories were developed by behavioral economics as extensions to the SEU models. Most famously the work on prospect theory by Nobel laureate Daniel Kahnemann and coauthor Amos Tversky (Kahnemann and Tversky, 1979; Tversky and Kahneman, 1992).

Prospect theory is a variation of the more general rank-dependent utility (RDU) models that where developed independently by Quiggin (1982), Schmeidler (1989), Luce and Narens (1985) and Yaari (1987) and address the violations of the independence axiom. The key difference between RDU models and SEU models is the replacement of the independence axiom (in SEU) with the weaker comonotonic independence axiom (in RDU) (Nau, 2007; Wakker et al., 1994).

In response to the critique raised by the Ellsberg paradox a number of extensions to the SEU has been made. Two examples are the maxmin expected utility model (Gilboa and Schmeidler, 1987) and the more nuanced second order utility functions (Chew and Sagi, 2007; Ergin and Gul, 2009; Klibanoff et al., 2005; Nau, 2006).

1.2.3 UTILITY ASSUMPTIONS – OBJECTIVE FUNCTIONS APPLIED IN THE THESIS

This subsection will discuss the behavioral assumptions applied in this thesis.

The thesis applies two models with behavioral assumptions for the decision makers (farmers) in question; the models are Gabriel and Baker (1980) and Collins (1997). The models are based on liquidity concerns and wealth maximizing objectives (further introduction and discussion below) and are interpreted as focusing on the risk (and uncertainty) of cash insolvency (Donaldson, 1961).

The research assumption regarding decision making can be formulated as follows: Farmers are assumed to maximize wealth (future consumption possibilities) under uncertain economic conditions subject to immediate consumption needs and subject to the risk of cash insolvency leading to bankruptcy.

This means that farmer try to maximize their consumption possibilities “tomorrow” under consideration of the level of consumption “today” and under consideration of a reasonable risk (uncertainty) of going out of business.

This assumption deviates from usual behavioral assumption that focus on income level and variation (return and variation), in the way that it is not income variation per say that is assumed to be of concern to the farmer, but rather the risk of bankruptcy (terminal equity under some disaster level), which may be influenced by (down side) income variation, and the risk that income variation will

restrict consumption. The assumption is however normal in the agricultural finance literature (Barry and Robison, 2001; Hardaker and Lien, 2005; Just, 2003).

With regard to the thesis' research assumptions on decision making under risk and uncertainty the models applied satisfy the SEU hypothesis. The main results of the thesis are however robust with regard to relaxations of the axioms of the SEU.

The Collins model is used as a convenient framework of analysis in the third paper. This model builds on the behavioral assumption that "the manager wants to maximize expected wealth subject to the constraint that the chance that terminal equity is less than some disaster level" (Collins, 1997, p. 495) is below some acceptable level. This can be thought of as the farmers' subjectively acceptable level of bankruptcy risk but can also represent any other minimum acceptable level of equity.

A RDU model relying on decision weights rather than subjective probabilities in the SEU models can be interpreted in the Collins framework as applied in the thesis. The key assumption in the thesis is that farmers are able to rank different risk management options that trade off the level of risk (and ambiguity) against the expected monetary value, as they are perceive by the individual decision maker.

As elicitation of specific utility functions is not a key objective of this thesis the specific behavioral assumption is not a major concern. Despite the limitations of the SEU it is still considered the best normative model for decision analysis (Hardaker and Lien, 2005).

Following (Hardaker *et al.*, 2004) asset integration is assumed in the thesis, this means that financial losses or gains form a risky business decision is viewed as an equivalent to changes in net assets or wealth.

It is also a central assumption that most farmers are risk averse. This is no to say that they do not take risks. But they only do so provided there is a sufficient incentive. That is, a risk premium (RP) that yields a certainty equivalent (CE) of the risky prospect above the certainty equivalent of the 'sure thing'. It is not assumed that no one has risk preferences or that no one is risk neutral or that everyone has the same level of risk aversion. In fact it is a key assumption in the third paper, that

there is heterogeneity in the CE of farmers stemming from the assumptions that farmers are heterogeneous in the perception of and attitude towards uncertainty as well as in their capacity to carry risk in the eyes of external financial partners. The third paper exploits the profit opportunity of inter-agent differences in risk aversion and subjective perceptions of uncertain outcomes.

The expected monetary value of a risky prospect minus the CE equals the RP (when all pecuniary and non-pecuniary aspects are valued in money terms). This is also referred to as the cost of risk in paper III following terminology of Chavas (2011).

The main focus of this thesis is the coping strategies of agricultural decision makers with regard to their perceived exposure to risky and uncertain farm-related events. Resent research suggests that farmers' subjective beliefs and their degree of risk aversion are related, which affects their risk management strategies (Menapace et al., 2012). The farmers' perception of risky prospects is taken as given in this thesis and it assumed that the farmer is able to rank them.

1.2.4 RISK MANAGEMENT

This subsection will introduce and discuss the basic purpose of risk management and define the term as it is used in this thesis.

Risk and uncertainty are omnipresent. This is especially true in agriculture, where the major productive factors are relatively exposed to the natural environment, while major political interest in the sector may change agricultural and trade policy, foreign or domestic, thereby having a significant impact on farmers who are exposed to general economic conditions just like any other business (Moschini and Hennessy, 2001). Farm businesses, which are typically small in terms of the number of employees, are susceptible to human risks such as sickness, injury or cognitive lapses.

The range of different types of risk includes operational risk, economic risk and strategic risk (Andersen and Schrøder, 2010). Finance and organization potentially have implications for the management of all risk categories. This thesis primarily focuses on the implications for risk management of changes in finance and organization, while acknowledging that other aspects of risk management can be affected as well.

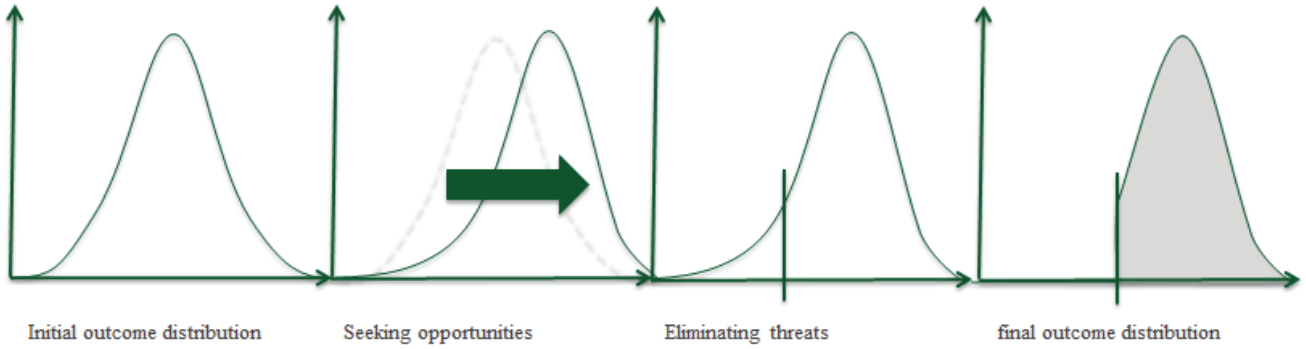

Figure 1.1: The dual aim of strategic risk management.[2]
Source: Adapted from Andersen and Schrøder (2010)

The dual aim of risk management is represented by the tradeoff between minimizing the probability of financial failure, and maximizing the probability that the strategic goals for the farm will be achieved. Figure 1.1 illustrates the dual aim of strategic risk management which is to, on the one hand, seek opportunities and, on the other, manage the risk of crippling losses (The Institute of Risk Management, 2002).

By identifying, assessing and coping with risk and uncertainty, risk management balances this tradeoff. Risk management must therefore be an integrated part of strategic management. This thesis deals primarily with the question of which risk coping strategies are open to farmers and how this is affected by institutional factors. Questions concerning the identification and assessment of risk and the optimal choice among the open risk coping strategies are beyond the scope of this thesis.

The strategic goals of the farmer are taken as given in this thesis and acceptable levels of perceived exposure to risk and uncertainty is assumed to be an integrated part of strategic goal formulation (although this may be a subconscious process). Risk management is defined as the part of management that deals with the perceived risks and uncertainties that are associated with reaching the strategic goals. As such risk management is associated with most choices in farm management, as almost no choices are independent of some level of risk or uncertainty.

[2] Note the axes are not equidistant.

1.2.5 RISK COPING ALTERNATIVES

This subsection will introduce and discuss the four basic risk coping alternatives. The theme of the thesis is closely related to these alternatives as it explores interaction between different coping alternatives.

There are four major categories of risk coping strategy; Accept, Reduce, Transfer and Avoid. These strategies are depicted in Figure 1.2. Avoiding risk means not engaging in the risky activity, e.g. not flying due to a fear of crashing, or not marrying due to a fear of divorce, etc. At first glance this strategy seems attractive as the possibility of losses connected with the activity is eliminated. However, the possibility of returns from the activity is also eliminated. The saying: "Noting ventured, noting gained", moderates the avoidance strategy. This is, however, an integrated part of most people's everyday lives, we are just not consciously aware of all the things we do not do because they involve risk.

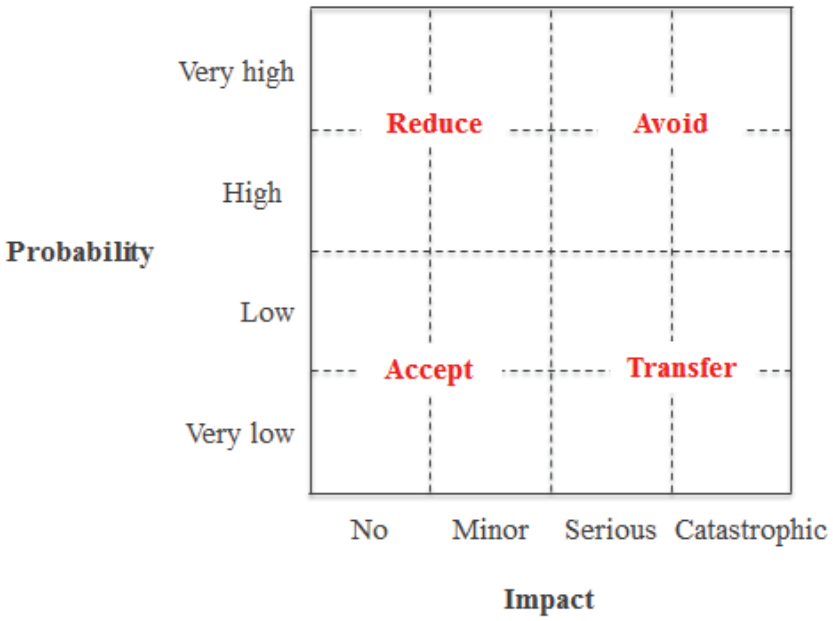

Figure 1.2: The four major categories of risk coping strategies.

Transferring or sharing risk can be illustrated by the archetypical risk management instrument, insurance. Buying fire insurance for the home for example transfers part of the risk of a serious loss on a primary asset for many families. Hedging of price risk in agriculture is also a risk transfer or

risk sharing strategy, as the farmer transfers the price risk exposure to the counterpart in the hedging arrangement, for example by use of a futures or a forward contract.

The reduction of risk is another example of risk coping that is so integrated in everyday lives that we often do not think about it. Looking both ways before crossing the street is an example of a risk coping strategy that greatly reduces the risk of getting run over. Many risk reduction strategies in agriculture are so integrated with general farm management that it is hard and pointless to distinguish them. One risk reduction strategy does however deserve special attention. Diversification is a risk reduction strategy that mitigates the impact of exposure but not the probability of incurring losses. It is illustrated by the phrase "don't put all your eggs in one basket" which has a clear agricultural reference. Diversifying the portfolio of activities and/or investments in a farming business reduces the risk of devastating losses as the probability of everything going wrong at the same time reduces with an increasing number of activities. The chances are that with a well-chosen portfolio, bad outcomes in one line of activity will be mitigated by good outcomes in other lines of activity. Markowitz (1952) formalized the diversification strategy by proposing a solution to the portfolio selection problem.

In agriculture, like many other sectors, there is a distinct trade-off between diversification gains and specialization gains (Benni et al., 2012). Many, in principal diversifiable, risks are not diversified away, because this would mean foregoing the gains of specialization and exploiting economies of scale. The risk of adverse weather conditions, for example, could in principal be diversified away by having many small farms all around the world. Yet, this is not a common strategy for the very good reason that the gains from specialization and economies of scale would be lost.

The last major category of risk coping strategies is acceptance of risk or risk retention. In a business such as agriculture, some risks must be accepted, preferably those that have a low economic impact and low probability of occurrence. Risk that cannot be effectively mitigated by any other means must be retained, effectively being the key word, as there are always tradeoffs between the different coping strategies. The risk management challenge is to optimize the use and combination of the different strategies. The upside of the term "nothing ventured, nothing gained" is that gains or profits are associated with risk retention. There may not be such a thing as riskless return, but there is

such a thing as return-less risk. Retaining risk with adequate reward, reducing or transferring risk at minimum possible cost or avoiding the return-less risk is at the core of risk management.

1.2.6 BASIC FINANCIAL THEORY

This subsection will introduce and discuss basic financial theory. This is the roots of the literature on the interaction between the firms risk exposure, finance and the separation of risk pertaining to the firm in a fully equity financed situation and the risk associated with the use of debt in the finance of the firms activities.

The Separation Theorem, attributed to Tobin (1958), says that the optimal choice of an investment portfolio can be separated into two steps. The first step is the construction of the efficient portfolio, as shown by Markowitz (1952), while the second is combining this efficient portfolio with a risk-free asset through borrowing or lending to construct a "ray of dominant sets" (Tobin, 1958, p. 84), i.e. separating the choice of where to be on the efficient portfolio frontier from the decision maker's risk preference. The ray of dominant sets later became known as the Capital Market Line in the framework of the Capital Asset Pricing Model (CAPM) (Sharpe, 1964) illustrated in Figure 1.3.

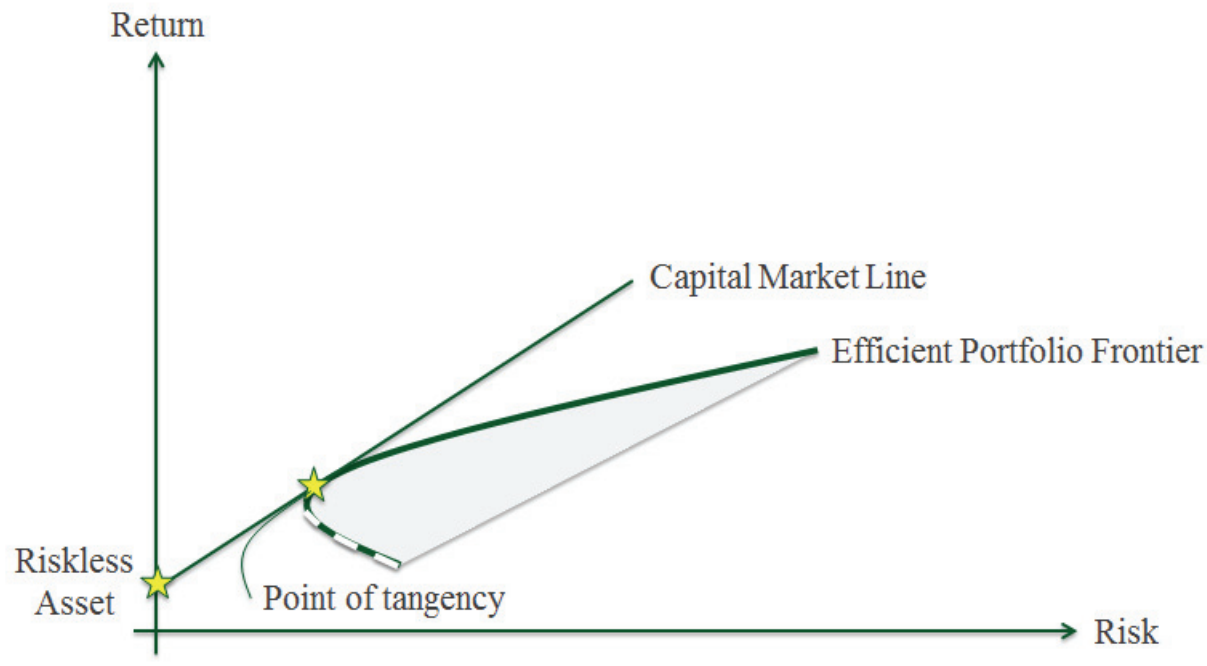

Figure 1.3: Capital Asset Pricing Model

While the separation theorem and the CAPM are keystones of financial economics and are very strong in illustrative power, the notion of a riskless asset does however seem to have next to no practical relevance for agricultural risk management from a farmer's point of view. The positive holding of cash seen as a riskless asset with no or low return may have some practical merit, but negative holding (shorting) of the riskless asset, e.g. borrowing, at the riskless interest rate is not usually a relevant option for farmers, and when it is, only to a limited extent. This is well recognized by Sharpe (1964), but may be less well recognized by some of the economist applying the theory. The key insight; that all practical alternatives possibly included in a portfolio should be taken into account when analyzing risk exposure, is however valid. For agriculture, this includes positive and/or negative holdings of financial instruments such as cash, corporate stock and bonds, as well as borrowing and related instruments such as interest rate swaps and foreign exchange rate exposure, and obviously the core agricultural activities (Hardaker *et al*., 2004) which usually constitutes a somewhat diversified portfolio.

The Separation Theorem can also be seen a source of inspiration for the distinction between business risk and financial risk in the Gabriel and Baker (1980) concept, although this is not referenced specifically. Extensions of Gabriel and Baker, however, do make the explicit connection (Barry and Robison, 1987; Barry et al., 1981; Collins, 1985).

When the transfer of risks is institutionalized, the notion of borrowing at the riskless interest rate becomes more relevant. There is an important difference between an institutional investor's perspective and that of an individual farmer. Insurance is a classic example of risk transfer from the farmer's (insurers) point of view. However, institutionalizing the risk transforms the issue to a matter of diversification (risk reduction) via reinsurance from the insurance company's point of view.

The extent, to which risks are institutionalized, as well as the form in which they are institutionalized, is related to the risk uncertainty continuum discussed above. Generally, the higher the degree of confidence in quantitative assessments of the risk, the more likely the case that some form of market institution will be in place to transfer the risk. For example the availability of the market institution 'insurance' rest upon the applicability of actuarial calculations and the law of large numbers (Andersen and Schrøder, 2010) among other conditions for insurability.

Policy initiatives may be in place where markets have failed, in the case of the EU Common Agricultural Policy (CAP), price risk have been reduced, but the risk of discontinuation of the policy has also been introduced, effectively transforming market risk into policy risk. The interaction of the different institutional frames for farming and business in general are complex. For example, the CAP has probably crowded out market-based risk management instruments (OECD, 2011). The first paper of this thesis proposes that the financial environment has had a similar crowding out effect on market-based risk management. Changes in the institutional frames for finance can have important implications for a number of different risk management aspects. The implications with regard to organization and price risk management will be in focus the thesis.

1.2.7 FINANCIAL CONSTRAINTS

This subsection will briefly introduce and discuss the corporate finance tradition for measuring access to credit. The first paper of the thesis develops an alternative to this approach.

A firm's internally generated cash flow is a key concern for risk management. A major rationale for hedging has been the increased ability to raise external capital in the form of debt due to more stable internal cash flows and lower default risk (Froot et al., 1993). Thus, the rationale for hedging as a risk management tool is to increase access to finance, to facilitate the execution of investment plans and to improve the ability to achieve strategic goals. The results of Reynolds *et al*. (2009) suggest that smaller firms, which presumably face steep costs of accessing external funds, are hedging with derivatives to smooth their cash flows to reduce default risk and improve the availability of external funds for investment. This rational connects risk management with issues related to access to finance.

Access to finance is commonly regarded as a key requirement for economic growth. In numerous studies in corporate finance as well as in the development and agricultural economics literature, the existence and importance of financial or credit constraints have been examined (Petrick, 2005). With regard to credit constraints in agriculture, the concept has been investigated thoroughly for a long period of time, but the majority of investigations have focused on the omnipresent credit constraints in the immature credit markets in the developing countries or former Eastern Bloc countries (Briggeman et al., 2009). Research on the impact of mature credit markets in developed countries is more limited, although some research exists (Hubbard and Kashyap, 1992).

One of the major research questions in corporate finance has revolved around the extent, effect and measurement of financial frictions, reflecting how the institutional environment, with regard to finance, has a number of policy implications.

The literature on the measurement of financial constraints has been shaped by the question of whether investment-cash flow sensitivities are appropriate measures for financial constraints, or not. In their seminal paper, Fazzari, Hubbard and Petersen (FHP) (1988) establish that underinvestment will occur when external capital is more costly than internal finance. However, Kaplan and Zingales (1997) criticize the above authors for their dependency on the assumption of monotonicity, whereby investment sensitivity increases monotonically in the degree of financial constraint, as the authors did not provide a well-grounded theoretical foundation for their assumption. Kaplan and Zingales (2000) stated that "Investment-cash flow sensitivities are not valid measures of financing constraints," which was countered by Fazzari *et al*. (2000) who maintained that "Investment-cash flow sensitivities are useful".

There are still unresolved issues when it comes to quantifying financial constraints (Bond and Van Reenen, 2007). However, the impact of financial constraints on firm behavior is important. The bulk of research on these issues in the general corporate finance literature is concerned with what Barry and Baker (1971, p. 222) call "External credit rationing" and is narrowly focused on the dichotomous categorization of firms being either financially constrained or unconstrained and thereby ignores the important dynamics of self-imposed limitations on credit use which Barry and Baker (1971) emphasize in the agricultural finance literature. Focusing narrowly on whether firms are financially constrained or not will greatly limit the understanding of the interaction between investment, finance and risk management behavior.

Dealing with unlisted and non-incorporated agricultural firms (farms) poses some additional methodical challenges to the usual setting of incorporated and listed firms that are traditionally the subject of corporate finance. The investment cash flow sensitivity measure's reliance on Tobin's q to control for investment opportunities is one important example, as most agricultural firms (farms) are not traded on stock exchanges and thus there is no observable market valuation from which to calculate Tobin's q.

Models which attempt to navigate around this problem (Petrick, 2005) tend to build up a large number of poorly supported behavioral assumptions (Bond and Van Reenen, 2007). The difficulties identified with existing measures related to access to credit led my co-author and I to propose an alternative approach to the problem which culminated in paper I, which is presented in chapter 2.

The paper develops a measure for access to credit and the utilization of this access and thus represents a measure of credit reserves which are an important part of liquidity reserves which in turn is an important part of the whole farm risk management considerations.

The general focus on the relationship between risk management and finance is that represented by Froot et al. (1993) which basically say 'manage risk and you shall borrow' however the line of inquiry pursued in this thesis stress the reverse relationship, that emphasizes the effect of the managers perceived credit reserve on risk management, this follow the focus of Donaldson (1961) among others.

Investment cash flow sensitivity measures that have been the focus of corporate finance say nothing about the credit reserves of firms, and thus ignore the link between finance and risk management. Paper I address this problem by proposing a novel measure of credit access.

1.2.8 LEVERAGE AND LIQUIDITY

This subsection will introduce and discuss the role of credit reserves as a risk coping alternative. The key models applied in the thesis are introduces as well as the key concepts of risk balancing and the crowding out effect.

Baker (1968) emphasized the link between liquidity, risk management and finance in the agricultural finance literature. Gabriel and Baker (1980) formulated a model in which the probability that some critical cash demand cannot be met is a function of the net cash flow, fixed debt servicing obligations, liquidity reserves and minimum liquidity requirements.

Keynes (1936) also realized the importance of liquidity in the description of three types of motives for holding cash; the income-motive, the business-motive and the precautionary-motive, and stated that: "The strength of all these three types of motives will partly depend on the cheapness and the

reliability of methods of obtaining cash, when it is required, by some form of temporary borrowing, in particular by overdraft or its equivalent. For there is no necessity to hold idle cash to bridge over intervals if it can be obtained without difficulty at the moment when it is actually required" (Keynes, 1936, p. 196). Note that Keynes says that price as well as non-price mechanisms affect the use of borrowing, "cheapness" and "reliability". Non-price mechanisms generally do not receive the attention they deserve. The current post financial crisis situation is characterized by low interest rates (cheapness), but difficult (unreliable) access to credit for many economic agents.

Because a debt contract involves a fixed commitment to repay the principal and interest, it is normally considered to increase both the potential profit and the possibility of loss (Donaldson, 1961). This is what is reflected in the Separation Theorem. The real option value of "debt capacity as a reserve against the unexpected rather than as a continuous source" of liquidity is however an important safeguard against cash insolvency (Donaldson, 1961, p. 78).

Related to the value of credit reserves, there are two main arguments against the current use of debt. One is framed in a positive sense and one in a negative. Credit reserves may be held to ensure the financial ability to exercise major investment opportunities promising unusual returns on investment in the unknown future, and credit reserves may be held in anticipation of possible negative future cash flow from operations (Donaldson, 1961).

As a risk-coping mechanism, the maintenance of credit reserves is a universal tool that covers most risk exposures. Other risk-coping tools tend to be much more specific. For example, credit reserves can be used to cope with uncertainty with regard to future revenue from crop production. Alternative risk management instruments, e.g. operational risk management such as weather insurance or price risk management instruments such as hedging with forwards or futures, are often much more specific and a holistic approach to risk management becomes a much more complicated task with these specific instruments, as their use has to be coordinated (Coble et al., 2000).

Gabriel and Baker (1980) formulate a model where the liquidity considerations mentioned above are explicit. The paper introduces the risk balancing concept defining it as "the adjustment in the components of total risk (i.e., business risk and financial risk) that results from an exogenous shock to the existing balance" (Gabriel and Baker, 1980, p. 561).

In Gabriel and Baker (1980) the shock is represented by a change in business risk (e.g. insurance, government programs, weather modification, technological or market innovations). In this thesis the major shock is represented by a change in financial risk in the wake of the GFC.

Gabriel and Baker (1980) look at risk in a probabilistic sense which is a convenient way of communicating about risk and uncertainty even though it may be a simplification. They define total risk as "the probability, α, that one will be unable to generate a minimum level of funds needed for home consumption as well as business requirements after having serviced debt (Gabriel and Baker, 1980, p. 562). Mathematically expressed as follows:

$$P(cx + \mu - I \leq z) \leq \frac{\sigma_s^2}{[(\bar{c}x + \mu - I) - z]^2} \leq \alpha \qquad (2)$$

where:

α = probability that some critical cash demand cannot be met (default risk)

cx = net cash flow

$\bar{c}x$ = expected net cash flow

μ = liquidity reserves

I = fixed debt servicing obligations

z = minimum liquidity requierment

σ_s^2 = the subjective variance of net cash flow

The measure developed in paper I is a useful proxy for μ in the Gabriel and Baker (1980) model above. Preliminary empirical evidence of Gabriel and Baker build on the change in land price to proxy for change in μ. We provide a more refined and micro-oriented measure of change in credit availability. Escalante and Barry (2001) provide empirical evidence for the risk balancing hypothesis of Gabriel and Baker (1980), Barry (1983) and Barry and Robison (1987).

Barry, Baker and Sanint (1981), Collins (1985) and Barry and Robison (1987) provide variations of the risk balancing hypothesis based on the expected utility mean variance approach.

It is well established that agricultural policy affects the risk management of many farmers. This can be seen in terms of policy impact on the level and way of hedging (Berg and Kramer, 2008; Coble

et al., 2004; Gray et al., 2004) or in terms of the policy impact on diversification in the farming activity (Lien and Hardaker, 2001; O'Donoghue et al., 2009).

Implications for policy effect under risk balancing is specifically addressed by Featherstone et al. (1988), that point out that income stabilizing policy may induce a risk balancing farmer to increase financial risk in response to a policy that reduces business risk as well as in response to income augmenting policies. Turvey and Baker (1989, 1990) stress the role of farm capital structure in relation to policy and market based risk management (hedging).

Crowding out effect is used by OECD (2009) as a label for the effect of agricultural policy on risk coping alternatives (e.g. hedging or insurance with market based instruments), Meuwissen, van Asseldonk and Huirne (2008) and Garrido and Bielza (2008) also use the term. A general definition of the term can be "when the presence of one institution undermines the functioning of another" (Bowles, 2004, p. 495) and as such it can be seen as the opposite of institutional complementarity. This is a term that will be used in this thesis as well. OECD describes the effect as follows:

"Interaction among policy measures has been shown to be very significant […]. In particular there is scope for crowding out market measures that cover the same type of risk as government programs: deficiency payments or price stabilization schemes tend to crowd out price hedging through futures and options. There is also evidence that insurance subsidies may increase specialization of the farm […]. This effect of crowding out other strategies diminishes the capacity of such mechanisms to reduce variability and improve welfare" (OECD, 2009, p. 40).

In addition to the effect of policy on market measures, the term crowding out, will also be used in relation to the possible effect of the financial system on market measures in this thesis. Specifically, the hypothesis that the perception of large credit reserves may crowed out market measures in a way that is similar to the crowding out effect of some policies.

The interaction among policy, risk management and finance is well established. The main focus has been the impact of policy on risk management. In this thesis however the impact of the financial environment on risk management is emphasized.

In the Gabriel and Baker model in equation (2) risk management can be interpreted as activities that adjust $\bar{c}x$ and σ_s^2 for example via hedging or diversification. Policies that stabilize income (reduce σ_s^2) may induce the farmer to increase leverage which will increase I as well as $\bar{c}x$ and σ_s^2 (as a function of increased scale) via risk balancing.

A central tenant in this thesis is that it is the perceived as well as the actual available credit reserves that are important with regard to decision behavior. Furthermore, the credit capacity is not constant, as the lenders' "eagerness for new loan opportunities varie[s] from time to time as the flow of funds into the capital market varie[s] and as their particular portfolio requirements [are] shifted. Thus it might be that an unusually large flow of funds available for investment could lead to a temporary though perhaps modest relaxation in the risk standard of the lender. The timing of the particular loan request therefore had some bearing on the risk decision" (Donaldson, 1961, pp. 129–130). The GFC may be characterized as the culmination of a period with an extraordinarily significant relaxation in the risk standard, the effect of which is reflected in a recently published model by Eggertsson and Krugman (2012) where a sudden and unexpected change in access to credit spurs economic instability similar to the current crisis. "An extended period of steady economic growth or rising asset prices will encourage relaxed attitudes towards leverage. But at some point this attitude is likely to change, perhaps abruptly – an event known variously as the Wile E. Coyote moment or the [Minsky][3] moment" (Eggertsson and Krugman, 2012, p. 1475).

The financial environment is represented by μ, in the Gabriel and Baker model, as liquidity reserves are the sum of liquid asset in reserve and credit reserves as emphasized by Donaldson (1961). The impact of a shock to the financial system (e.g. the GFC) will affect the balance between risk management, policy and finance and may initiate an adaption process. This is the theme of this thesis. Paper I develops a novel measure that can proxy for μ, paper II explores the interaction between organization and risk management in the light of the policy and financial environment and paper III explores a possible part of the adaption process involving cooperative organization of marketing that dominates the Danish livestock sector.

[3] Typo, original text reads "Minksy" but should read "Minsky"

Paper III is based on an extension of the Collins (1997) model supporting a positive economic theory of hedging. Like Gabriel and Baker (1980), Collins (1997) takes the approach to risk that it can be formulated as a probability of cash insolvency or in the words of Gabriel and Baker (1980, p. 562) being "unable to generate a minimum level of funds needed for home consumption as well as business requirements after having serviced debt". Following Collins (1997), the model is:

$$\tilde{E}_1 = E_0 + [p_h H + \tilde{p}_c(1 - H)]Y - kY - iD - F \tag{3}$$

Where $\tilde{E}_1$ is the terminal equity, E_0 is the initial equity, p_h is the forward price of hedged output, H is the hedge ratio, $\tilde{p}_c$ is the stochastic cash price of the unhedged output, Y is output, k is variable costs, i is the interest rate paid on debt, D is debt and F is fixed costs. Given stochastic cash price of output, terminal equity is a stochastic function of not only realized cash price and the quantity hedged, but also the financial leverage of the firm.

Let $g(E_1)$ be the probability density function for terminal equity. The objective function in the Collins (1997) model is:

$$\begin{aligned} \max \bar{E}_1 &= \int_{-\infty}^{\infty} E_1 g(E_1) dE_1 \\ \text{s.t.} &\int_{-\infty}^{d} g(E_1) dE_1 \leq \alpha \end{aligned} \tag{4}$$

This means that farmers are assumed to try to maximize their wealth subject to the constraint that the risk of wealth under some subjective disaster level is under some acceptable level. The disaster level can be thought of as the risk of insolvency, but may represent any other minimum level of wealth acceptable for the farmer.

This thesis revolves around the question of what happens to the interaction between risk management, finance and organization before and after a Minsky moment. Liquidity reserves, being the sum of liquid assets and the credit reserves defined as the maximum amount of unused credit (Baker, 1968), are a major risk management tool, not least in Danish agriculture. In a Minsky mo-

ment, credit reserves and thus liquidity reserves can by reduced dramatically introducing the need for alternative means for the management of risk.

The first paper of this thesis provides empirical evidence suggesting that attitudes towards the use of debt were relaxed up to the GFC. The concept of business risk and financial risk suggests that this relaxation of access to credit will have affected the risk management practices used by Danish farmers. The GFC, which can be seen as the culmination of Minsky moment and the chaotic period after, suggest changes to the crowding out effect of finance on other risk coping mechanisms.

Paper II explores the possibility of interactions between finance, risk management and organization. If there are important interactions and if there are important changes to the financial environment in the wake of the financial crisis, this will possibly have an effect on risk management and organization.

Paper III explores a possible organizational reaction to the changes in the agricultural business environment after the GFC. Specifically the Danish marketing cooperatives ability to empower their members with the possibility of individual (output) price risk management.

Unlike the universal nature of risk-coping via credit reserves, the alternative risk management instruments are likely to be more specific. The misuse of specific risk management instruments may increase the exposure to related risk aspect. For example in the case of forward pricing under operational risks the cost of operational failure may be amplified by the cost of failure to meet contracted quantities. This leads to the question of the optimal hedge ratio (Hull, 2002).

1.2.9 RISK MANAGEMENT IN DANISH AGRICULTURE

This subsection gives a brief historical account of the development in risk management and related institutional domains in Danish agriculture to place the thesis in context. It describes the input/output asymmetry in the hedging opportunities for Danish farmers which the third paper seeks to address. The section continues by discussing the possible impact of the GFC on the institutional matrix.

Structural changes in Danish agriculture have affected the way risk has been managed during the past forty years. Danish agriculture was still diversified on the farm level up to the 1970s, but then specialization in pigs, dairy and cash crops began to dominate the sector to such an extent that hardly any diversified farms are left today (Hansen, 2010). However, diversification took another form in the 2000s, when some farmers increased their off-farm investments, often by leveraging their existing farm asset portfolio. While there has been a lot of productivity gain from specialization in the recent decades, there has also been an increase in risk exposure, which has been further amplified by an increase in financial leverage.

One reason for this development is likely due to the development of the EU (EC) Common Agricultural Policy (CAP), which stabilized prices and to some extent converted business risk to policy risk during the 1980s and 1990s. Agricultural policy probably crowded out market-based risk management instruments and institutions (OECD, 2009), which is consistent with Gabriel and Baker's (1980) and Turvey and Baker's (1990) theory of risk balancing between business risk and financial risk, where a exogenous reduction in business risk, due to agricultural policy, leads the farmer to increase financial risk (leverage) to a level where total risk reaches the status quo. As will be shown in the first paper, access to credit increased during the 2000s, which may be an additional explanatory factor for the absence of risk management in Denmark, as agricultural policy may crowd out risk management institutions as may abundant access to credit in a credit cycle boom. This effect is generally not well recognized.

Contracting is somewhat asymmetric in livestock production in Denmark. Farmer's hedge inputs such as feedstuffs, etc. but they do not hedge outputs, such as milk and meat. The expected behavior of a risk adverse farmer with weak positive correlation between input and output would be to hedge symmetrically or not to hedge at all (Pennings and Wansink, 2004). Given a high debt level in the sector, it could be presumed that hedging is a prerequisite for access to finance (Froot *et al*., 1993). However, this has not been the case. The relatively easy access to credit may in fact have diminished the need for risk management and prevented risk management institutions from developing. If access to credit becomes harder in the post GFC world, it is important to understand the reasons for the absence of the institutional framework for risk management and to stimulate the development of risk management institutions which empower farmers to cope with risk at the farm level.

The financial markets have changed tremendously in the aftermath of the GFC. Obtaining access to credit for investments is (and for some time is expected to be) much harder than it was before the crisis. This means that Danish famers, and their stakeholders in the agribusiness and financial industries, will move toward a financial environment in which risk management is an important factor in determining access to external finance for investments. An implication of this development is that more constrained firms, if possible, will use derivatives more than the less constrained firms. Risk management has not been a key management topic in Danish agriculture until recently. This leads to the flipside of the Froot *et al*. (1993) argument which suggests that, in the presence of abundant access to external finance, there is little reason for the hedging of cash flows, which means that a situation in which no financial institutions (products and markets) have the ability to transfer risk between hedgers and other market participants, will develop, simply because of the lack of demand. Farmers may have been asking the rhetorical question: Why hedge, if you can borrow? This implies that a long period of relatively easy access to credit may devalue more market-based risk management (hedging) and explain why risk management institutions are not well developed in Danish agriculture. The recent development in agricultural finance and the overall credit supply calls for institutional entrepreneurship with regard to risk management institutions.

1.2.10 AGRICULTURAL FINANCE IN DENMARK

This subsection continues the historical account of the development in the institutional domain with special focus on finance. The section compares capital structure in Danish agriculture with EU agriculture to illustrate that there is something special about the financial environment of Danish agriculture.

Blancard *et al*. (2006, p. 351) state that "farmers' operations and investments heavily depend on internal financing," which is consistent with the EU average self-financing rate in Figure 1.4. In 2009, the Farm Accountancy Data Network (2012) (FADN) data show a EU level average debt-to-asset ratio of 15.6 %, which is consistent with Barry and Robison (2001). The average Danish debt-to-asset ratio was, however, significantly higher at 52.0 %. For farms in the economic size units >= 100 in the FADN (2012) database, the 2009 EU average debt-to-asset ratio was 28.4 % while the Danish average was 60.3 %.

Investments in Danish agriculture have been relativity high compared to other EU countries. This may be due to relatively easy access to credit for investment in Denmark compared to other EU countries. Defining the self-financing rate as the cash flow over gross investments for European Size Units >= 100 in the FADN (2012) database, shows that the self-financing rate in Danish agriculture is lower than all other regions and is falling faster than most other regions with a comparable data stream. The EU average self-finance rate over the period from 1989 to 2009 was 2.062 with almost no development over the years. In comparison, the Danish average self-finance rate was 0.708 and falling by approximately 5 percentage points a year. The Netherlands is the only comparable region in EU and even here the level of the self-financing rate is 0.57 above the Danish level on average.

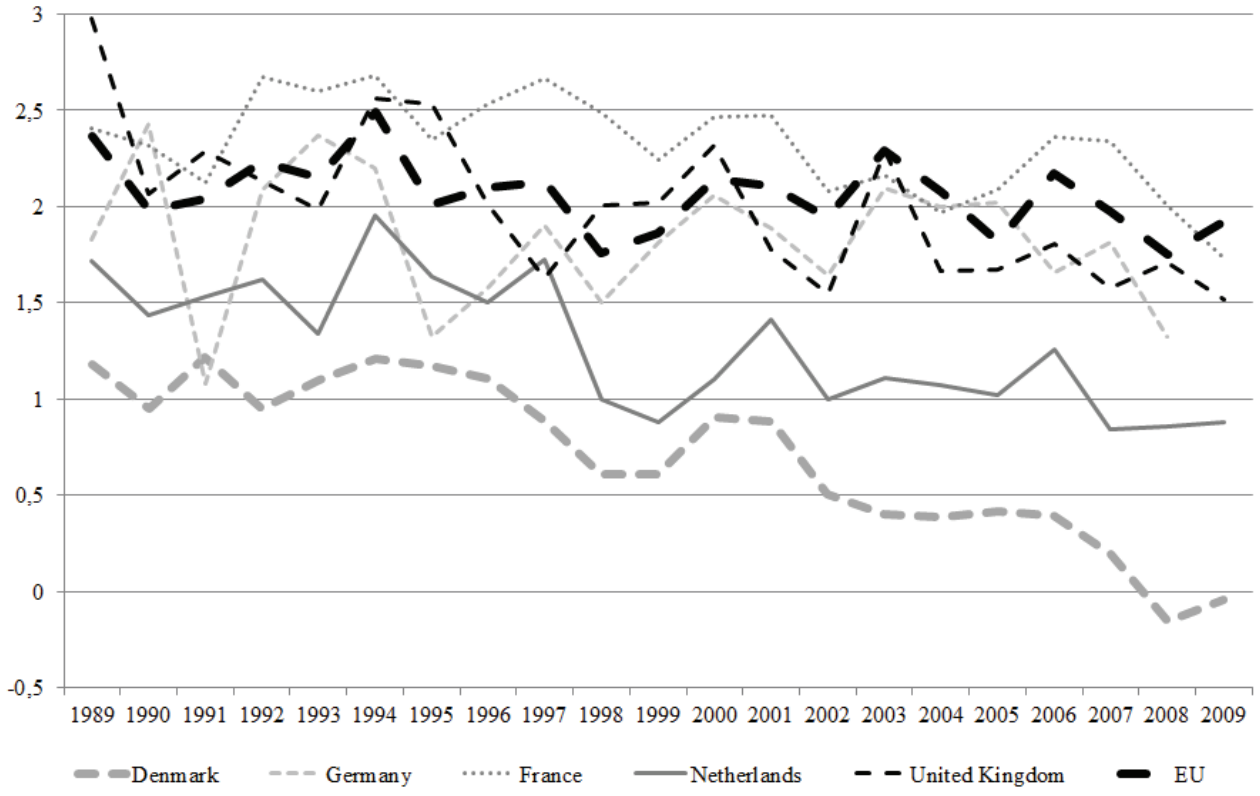

Figure 1.4: Self-finance rate in selected EU regions from 1989 to 2009
Source: FADN (2012) (European Size Units >= 100)

Many characteristics of Danish agricultural finance are similar to those of agricultural finance in other developed economies. Agriculture is heavily reliant on non-depreciable assets, such as farmland, in which much of the economic return occurs as capital gains or losses. It has been shown by

Barry and Robison (1986) that the debt-carrying capacity of non-depreciable assets is considerably lower than that of depreciable assets under traditional loan repayment arrangements. It is, therefore, logical to expect lower aggregate debt-to-asset ratios for the farm sector (Barry and Robison, 2001). Danish agriculture does not, however, exhibit significantly lower debt-carrying capacity than other sectors.

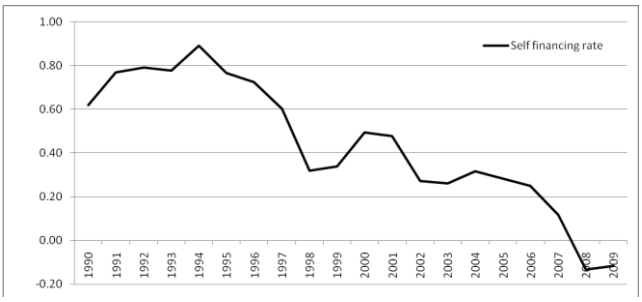

Figure 1.5: Self-financing rate

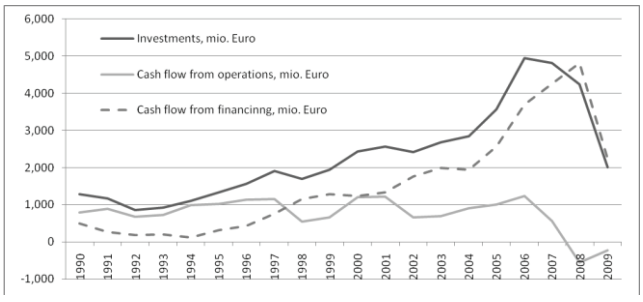

Figure 1.6: Cash Flows

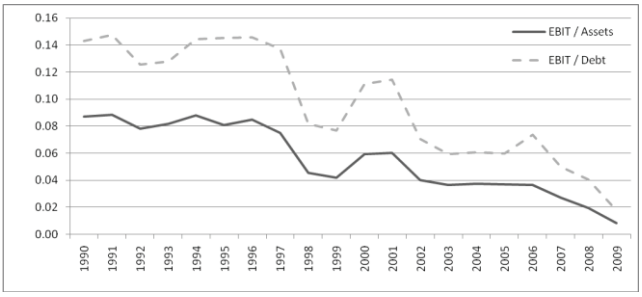

Figure 1.7: EBIT/Assets and EBIT/Debt

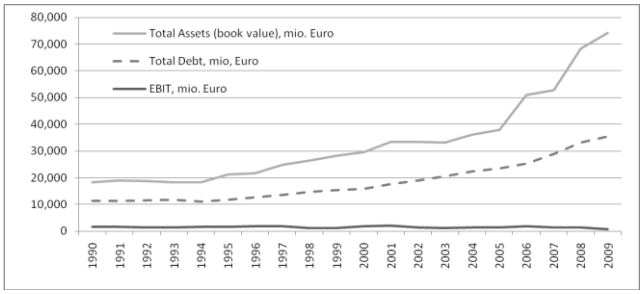

Figure 1.8: Total Assets, Debt and EBIT

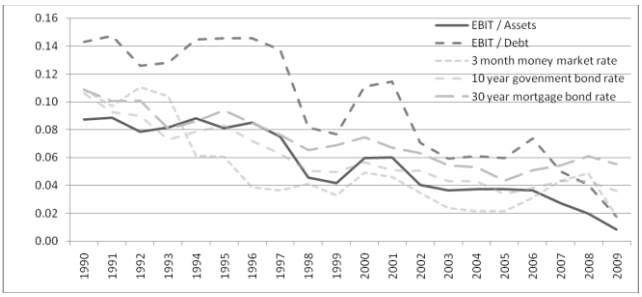

Figure 1.9: EBIT/Assets, EBIT/Debt and interest rates

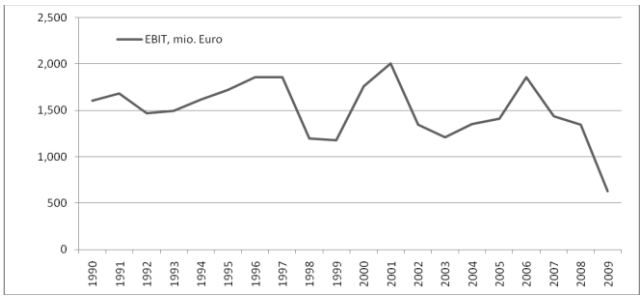

Figure 1.10: EBIT

Source: Figures 1.5-1.10 Statistics Denmark (2010)

Since 1994, the self-financing rate of Danish agriculture has declined (Figure 1.5). Investments per year increased reaching a peak level in 2006 after which they declined rapidly in the following years during the financial crisis of 2008 and 2009 (Figure 1.6). Since 1994, the total assets of Danish agriculture measured at book value have increased at an accelerating rate. Debt in Danish agri-

culture has also increased over the period and debt-to-asset ratios have been almost constant. Sector level earnings before interest and tax (EBIT) have been relatively constant over the period of increasing asset valuation and debt. The sector level EBIT has fluctuated roughly between one and two billion Euro per year, except in 2009 when the level fell by nearly 600 million Euros (Figures 1.8 and 1.10). EBIT over assets and EBIT over debt have declined over the period. For EBIT over assets, the level has been close to the level of the Danish ten year government bond (Figures 1.7 and 1.9).

During the period there have been large (partly unrealized) capital gains in the sector, which is not reflected in the EBIT. It appears that factors other than increasing EBIT may have driven the large and increasing investments in the sector up to the financial crisis. Expectations of continuing large capital gains may be an explanation. A decreasing interest level combined with a constant sector level EBIT may rationally explain (some of) the increase in the asset value. Capital gains are expected on farmland in the long run, as Barry and Robison (1986, p. 388) argue: "… accounting measures may not provide a valid basis for comparing the true profitability of farmland investments with that of other assets". Accounting rates of return have been relatively low in Danish agriculture along with agricultural returns in other countries. Economic returns, though, have been relatively high due to higher leverage and high capital gains. This relatively high economic return is thus as much a return on financial positions as it is a return on agricultural activity.

If investors lower their (weighted average) cost of capital, the present value of future cash flows increases. This may (partly) account for the increasing asset values and higher willingness to pay for agricultural assets, especially land. Whether or not investors have fully accounted for discrepancies in the duration of underlying agricultural assets and the duration of financing is questionable. It may even be that the discrepancy has increased, as Danish farmers, to an increasing extent, have made use of variable interest loans. Variable interest rate loans have carried a low interest rate, but they may also have affected the cost of capital that farmers (unconsciously) have used in their investment decisions, making the profitability more sensitive to interest rate changes. Lower interest rates and a larger discrepancy between the duration of finance and the duration of fundamental assets may have driven over-investment, as access to credit does not seem to have been a constraining factor.

The Danish Mortgage Bond System is characterized by the balancing principal which ensures that each loan from the mortgage bank is matched or balanced by bonds of the same amount. Based on collateral in real estate, borrowers can loan up to a legally determined loan to value limit. The mortgage bank issues bonds to the borrower and usually sells them on the behalf of the borrower in the financial market. The borrower receives the revenue from the bond sale which may be different than par. The borrower now pays the mortgage bank quarterly installments which are composed of interest, principal repayments and administrative fees. The borrower has the option to prepay the loan at par or to buy bonds of the series behind the loan. The Danish mortgage banking system plays an important role as a source of debt finance for fixed enterprise investments, such as agricultural land and buildings, especially for small and medium enterprises. The mortgage bond system's "position in the market is supported by the fact that the structure of private enterprise in Denmark is dominated by small and medium-sized enterprises. Unlike bigger companies, they cannot issue corporate bonds, and instead rely on funding of their fixed assets through mortgage credits." (United Nations, 2005, p. 30).

The Gabriel and Baker (1980) concepts of business and financial risk stress the importance of credit reserves. The first paper in the thesis introduces a measure for access to credit which can be used to identify credit reserves. The measure supports the hypothesis of increasing access to credit up to the financial crisis. Inflated credit reserves would have reduced the need for business risk management (hedging) according to Gabriel and Baker's (1980) risk-balancing concept. This lack of demand will have crowded out the need for risk management, adding this to the crowding out effect of agricultural policy. Thus the lack of an institutional framework for market-based risk management in agriculture is not surprising. However, the role and interaction effect of the financial system does not play a major role in the policy debate, exemplified by the lack of focus in OECD (2009, 2011) reports on risk management in agriculture. This is a serious caveat.

1.3 Research Approach

1.3.1 NEW INSTITUTIONAL ECONOMICS

This subsection gives a brief introduction to New Institutional Economics which is the main research approach of the thesis addressing the overarching research question of the implications of interaction of finance and organization on whole farm risk management. In the individual papers of the thesis, the NIE approach is most clear in the second paper as this paper applies an explorative

comparative institutional analysis. In the first paper the link to NIE should be seen through the empirical support for an institutional crowding out effect (Bowles, 2004) by a financial system that provides easy access to credit. The third paper is a mechanism design paper proposing new designs in response to institutional change, integrating NIE and mechanism design as suggested by Hurwicz (1987).

The trade-off between diversification and specialization mentioned above illustrates an important fact realized by Ronald H. Coase (1937). The fact is that the coordination of activities internally in firms and externally between firms involve costs and whichever costs are lowest determines the efficient boundary between the firm and the market. Coordinating activities on the aforementioned hypothetical farm with activities diversified all over the globe would be very costly, which explains why this is not the usual way of organizing farming. One way of mitigating these coordination costs is to establish joint stock farm operations along with other farmers all over the world, taking the job as a hired farm manager on one of them and holding a portfolio of stocks in all the farms. However this is not the usual way of organizing farming either. The diversification of activities locally, e.g. producing grain, meat, milk, eggs, etc. on the same farm was, however, the usual way of coping with risk not so very long ago. New Institutional Economics (NIE) has some very good explanations for agricultural organization. Allen and Lueck (1998) is one example of a NIE explanation for the organization of farms as owner-operated enterprises. The interplay between seasonality and randomness creates moral hazard, a situation where the optimal level of effort is higher for the owner operator than for a hired farm manager. This, along with limits to the gains from specialization and timing problems, results in sole proprietorships becoming the optimal organizational form. The successful mitigation of seasonality and randomness does, however, lead farm organization to converge towards corporate ownership. Such a trend is illustrated by the development in modern livestock farming where confinement systems shield production from the effects of seasonality and randomness.

Table 1.1: New or Neo-institutional Economics?

	Zero Transaction Costs	Perfect Information	Rationality
Neoclassical Economics	+	+	+
Neo-institutional Economics	-	-	+
New Institutional Economics	-	-	-

Source: (Sykuta and Chaddad, 1999)

New Institutional Economics and Neo-Institutional Economics relax some of the major assumptions in Neoclassical Economics. Transaction costs and imperfect information are introduced in both New and Neo-Institutional Economics, while New Institutional Economics takes a step further and adds bounded rationality to the complexity and realism of economic models (Sykuta and Chaddad, 1999). The realization that institutions matter and the focus of research on the way different institutions work and interact with each other is central to NIE.

There are three different ways of using the term 'institutions'. First, the term may mean organizational establishments in casual conversation (e.g. financial institutions such as banks or mortgage institutions). Second, the term may refer to 'the rules of the game' (North, 1990) and third the term may refer to the 'equilibrium strategy' of the game (Aoki, 2001, 2007).

The term 'the institutional framework around finance' will be used to distinguish the financial institutions as part of the institutional matrix and financial institutions as organizations (e.g. banks) in this thesis.

The second and third use of the term needs further explanation. The institutions as 'rules of the game' (North) refers to the formal and informal rules in society such as constitutions, laws, property rights and taboos, customs, traditions, etc. According to this view "rules are exogenously predetermined outside the domain of economic transactions" (Aoki, 2007, p. 1). The use of the term as an 'equilibrium strategy' of a game can be seen as an elaboration of the rules of the game view. In this view the institutions are endogenously determining each other.

The major open questions in the 'rules of the game' view of institutions is how the rules are determined and who enforces them, "who enforces the enforcer" (Aoki, 2007, p. 5). The major open question in the 'equilibrium strategy' view is a variation of the knowledge problem (Hayek, 1945). How can bounded-rational and asymmetrically informed agents find mutually consistent choices?

Aoki tries to reconcile the rules of the game view and the equilibrium strategy view with the following definition:

"An institution is self-sustaining, salient patterns of social interactions, as represented by meaningful rules that every agent knows and are incorporated as agents' shared beliefs about how the game is played and to be played" (Aoki, 2007, p. 6).

This thesis approaches risk management from a NIE perspective. Against the background of a realization that institutions matter and that great changes to financial systems may result from the financial crisis, the NIE approach is an effort to try to understand the process of institutional change, the interaction effects between finance, organization and risk management and how adaptive change can be stimulated in an appropriate manner.

Williamson (2000) refers to four levels of social analysis where NIE is principally concerned with the second and third levels. Institutional governance (Williamson, 2000) or institutional arrangements (Klein, 1999) at the third level are defined within the institutional environment of the second level. Figure 1.11 depicts an adaptation of Williamson's framework in which finance and risk management examples which link changes at the four levels have been added. Although changes at the top level, the social embeddedness level, are usually very slow, Williamson recognizes occasional abrupt changes spurred by events like wars or financial crises. Whether or not the current financial crisis is appropriately placed at the top level (L1) is a matter for discussion. On the one hand, the frequency of financial crises does not seem to correspond with the frequency in the Williamson framework, whereas on the other hand, it seems clear that the level of trust and the perception of risk changed radically at the outbreak of the financial crisis. This can best be characterized by changes in informal institutions, placing them at the social embeddedness level. These changes have stimulated a host of changes in the formal institutions of level two (L2) such as the regulation of the financial sector, the ongoing work with the implementation of Basel III being a prominent example. The changes in level one and two affect the governance level, level three (L3), affecting access to credit, the governance of existing (debt) contracts and the choice between debt and equity. The changes at level three go on to affect level four (L4) where, among a number of other decisions, risk management decisions are made in an effort to align actual risk exposure with target risk exposure, under the recognition of the costs of reducing risk.

NIE is a highly diverse field affecting "economics, political science, law, strategy, sociology, growth and development, history and other disciplines" (Klein, 2000, p. 479) and employing differ-

ent theoretical and empirical approaches from Moral Hazard and Agency Theory to Transaction Cost Economics at the third level (L3) of analysis as well as a broad range of analytical approaches the second level (L2) ((Klein, 2000)).

The 'rules of the game' view on institutions tends to focus on the downward pointing arrows on the left hand side in Figure 1.11, as oppose to the upward pointing arrows on the right hand side (punctuated). This illustrates the exogenous view, whereas the endogenous view puts more equal focus on the factors determining the institutional framework. The Williamson (2000) figure does however also illustrate that 'exogenous' is too radical a label for the 'rules of the game' view, as the upward pointing arrows can be seen as an recognition of some level of endogeneity.

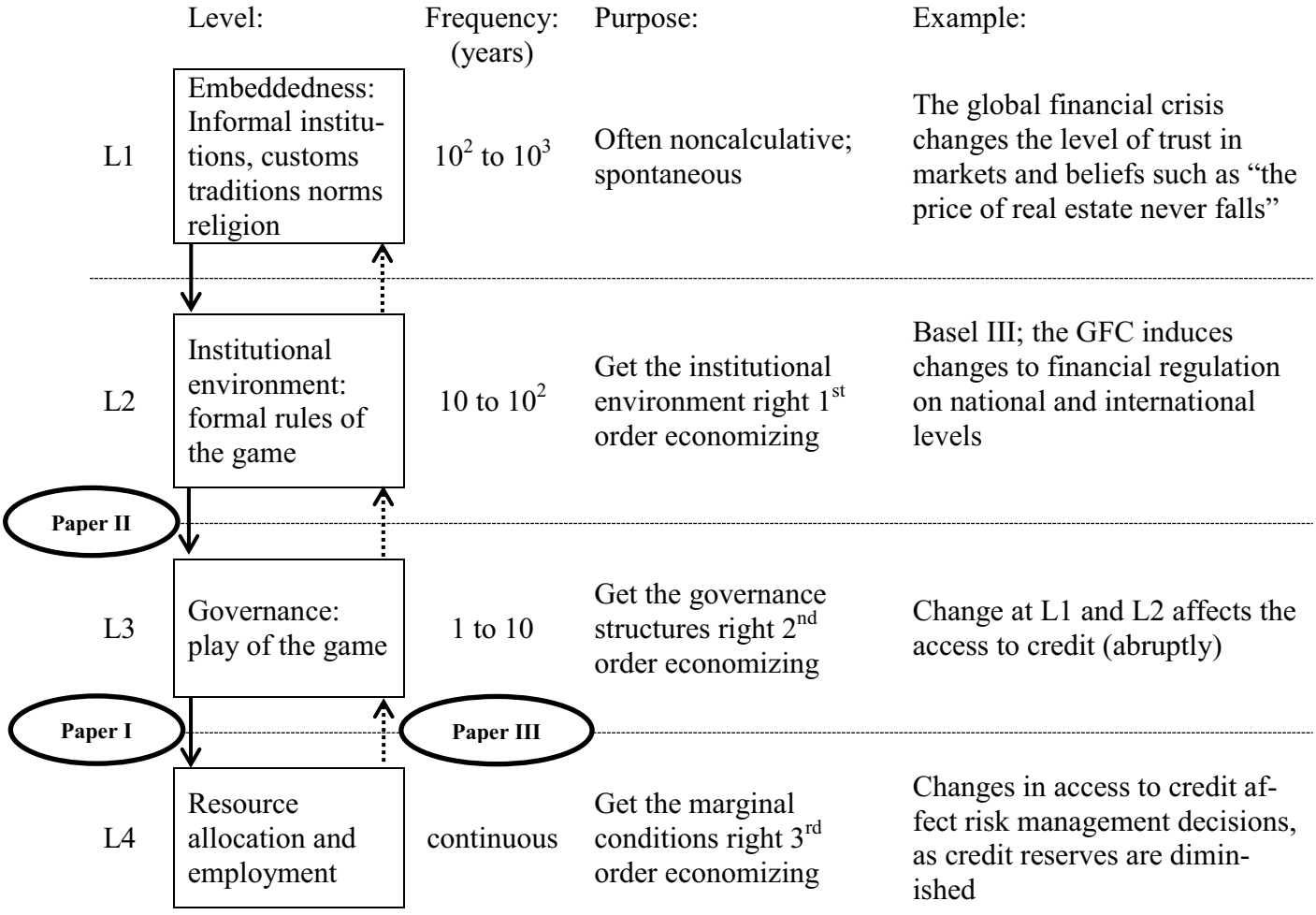

Figure 1.11: Economics of Institutions with consequences of the financial crisis.
Source: Adaptation from Williamson (2000).

The interdependence of the institutional framework is not only a matter of interdependence across institutional levels as depicted above, but also a matter of interdependence across institutional domains. Aoki (2007) use the four prototype domains: economic exchange, organizational exchange, political exchange and social exchange.

The first paper in this thesis is concerned with a measure for the gradual increase in access to credit in Danish agriculture up to the financial crisis and suggests abrupt changes in this access to credit occurred with the financial crisis, situating the paper at level three and level four in the Williamson (2000) framework.

The second paper introduces NIE more thoroughly and contributes to the field by stressing the importance of including financial institutions and related interaction effects in NIE analysis. The paper applies an inter-temporal cross-country comparison of hog marketing arrangements in Denmark and the U.S., based on this exploratory case study it suggests that differences in the institutional environment, with regard to agricultural finance, affect the evolution of the marketing arrangements. This paper is situated at level two and level three in the Williamson (2000) economics of institutions framework.

The third paper is an exercise in institutional entrepreneurship and mechanism design, where a model for reallocation of risk among members in agricultural cooperatives is introduced and analyzed. This model is a suggested adaptive change, in the face of a changing financial environment. As such this paper can be seen as a feedback, from level four to levels two and three in the Williamson (2000) economics of institutions framework. The model for reallocation will satisfy the latent need for risk management which emerged when the "Minsky" moment reduced farmers' liquidity reserves.

There may exist institutional complementarities or the opposite, institutional crowding out, among institutions in different domains. Institutional complementarity exits if institutional alternatives in one domain are positively affected by institutional alternatives in another domain. One example of institutional complementarity that will be proposed in this thesis is the possible institutional complementarity between the institution 'easy access to credit' in the domain of finance, and the institu-

tion of ‘cooperative processing and marketing’ of agricultural products in the domain of organization.

Cooperative processing and marketing is proposed to complement easy access to credit by reducing the marketing risk of the individual farmer. Farmers that are members of cooperative do not have to worry about finding a buyer for their products in the short term. This is an attractive property not the least for lenders to the farmer. The existence of some level of marketing security is proposed to increase the farmers’ access to credit.

In turn, relatively easy access to credit is proposed to complement cooperative processing and marketing. Cooperatives depend on debt from the financial markets and equity from there members to finance their activity. Easy access to finance may complement the institution of cooperative processing and marketing in two ways, directly via easy access to debt financing of the cooperatives activity and indirectly via easy access to debt financing of the members private activity, making it easier for members to accept that the cooperative retains earnings to build equity.

The thesis builds on the research assumption that institutional crowding out exist in institutional linkages between the domain of finance and the domain of risk management (hedging possibilities). Institutional crowding out is when the presence of one institution undermines the functioning of another (Bowles, 2004). In this thesis the institutions of easy access credit in the domain of finance leads farmers to the perception of having large credit reserves. This makes the farmer reluctant to use risk management tools such as price risk hedging via futures or forwards, as the risk of being unable to meet liquidity requirements is mitigated by large credit reserves. This reduces demand for this type of risk management tool to a level where the tool will not be offered at competitive market prices or not offered at all.

Another example of institutional linkages is that of bundling, which is a type of linked game (Aoki, 2007). Bundling occurs when multiple similar domains are grouped and change the equilibrium strategy. The third paper of this thesis can be seen as a suggestion of a third party bundling institution (Aoki, 2007). The paper suggests a reallocation mechanism for price risk exposure for members in cooperatives in the livestock sector (milk and meat). In principal, members in these cooperative could reallocate price risk bilaterally by betting with each other on the cooperative price. How-

ever, this behavior is not observed, likely because transaction costs, stemming from search cost and counterparty risk, are prohibitively high, this means that the equilibrium strategy is no exchange. The paper suggests a mechanism that reduces or eliminates these costs where the cooperative act as a form of auction and clearing house for this exchange. Bundling (non-existing) bilateral risk reallocation with a double auction mechanism may institutionalize risk reallocation and enhance the number of possible risk coping alternatives available to the farmer / cooperative member, the equilibrium strategy changes with the introduction of institutional innovation. The establishment of this institution is not only dependent on the two parties of the exchange, but also the motivation of the third party (Aoki, 2007), in this case the cooperative. Improving the risk management possibilities for their members may improve the investment possibilities of their members which is in the interest of the cooperative, as this improves their long term supply chain.

1.3.2 METHOD

This subsection discusses methodological issues with regard to the individual papers as well as the overall thesis. The thesis consists of three papers with different but complementary methodological approaches. The central ideas in the thesis are based on an institutional approach to risk management based on New Institutional Economics (NIE), but the focus of the papers shifts and may be outside or at the perimeter of most definitions of NIE.

The research question for the thesis is 'what implications for whole farm risk management follow from the interaction of finance and organization and how does this affect the adaption to changes in these institutional domains?'

The individual papers deliver partial answers to this question as part of a comparative institutional analysis (Aoki, 2001, 2007; Greif, 1998) to answer the overall question. However, given the complexity of the question the thesis should be seen as an improvement of the understanding of the institutional dynamics related to agricultural risk management rather than definitive answers. Realizing that interaction between the institutional domains in question exists may however be an important first step in the understanding of institutional change.

The overall research question

Being part of an industrial PhD project the thesis provides a normative recommendation to the co-operatives in the Danish livestock sector, suggesting that they facilitate reallocation of price risk among their members. The recommendation builds on positive analysis of the context in paper I and paper II and a positive analysis of the suggested mechanism in paper III. The third paper is however normative in the sense that it analysis the mechanism in question compared to the status quo. As such it is not a global optimum but rather a discrete improvement that is suggested, other possible improvement is likely to exist.

The dependent variable of the overall research question of the thesis should be seen as the risk coping alternatives open to farmers. The main explanatory variables of the thesis is the institutional framework around finance, specifically the crowding out of finance on market based price risk hedging and the likely change in this effect after the GFC, and the institutional framework in the domain of organization, specifically complementary effects between Danish organization of processing and marketing of meat and milk and the Danish financial environment.

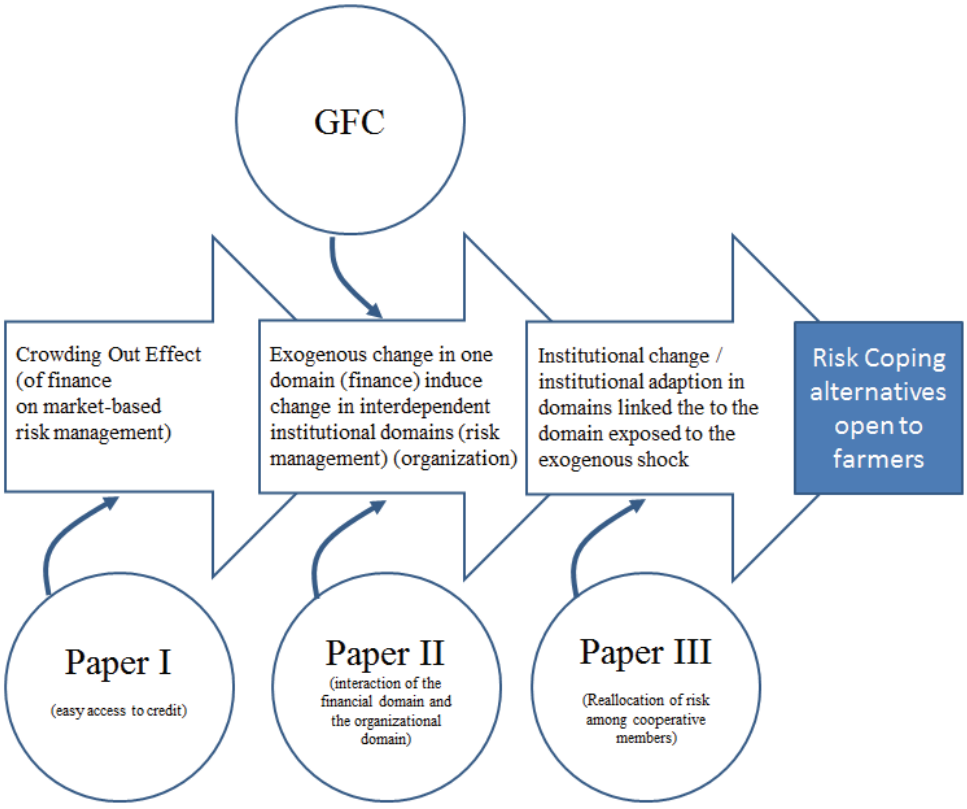

Figure 1.12 The relation between the three papers and the overall research question.

Figure 1.12 illustrates the how the three papers support the overall research question. Papers I and II address the institutional frames, specifically a crowding out and a complementary effect. Paper III addresses the process of institutional change by analyzing one possible institutional adaption in response to the exogenous shock to finance caused by the GFC.

While the dependent and explanatory variables are defined, is should not be taken as an indication of independence. Figure 1.13 illustrates the main interaction effects of interest in this thesis. Following Aoki (2007) endogenous institutions and institutional change is assumed.

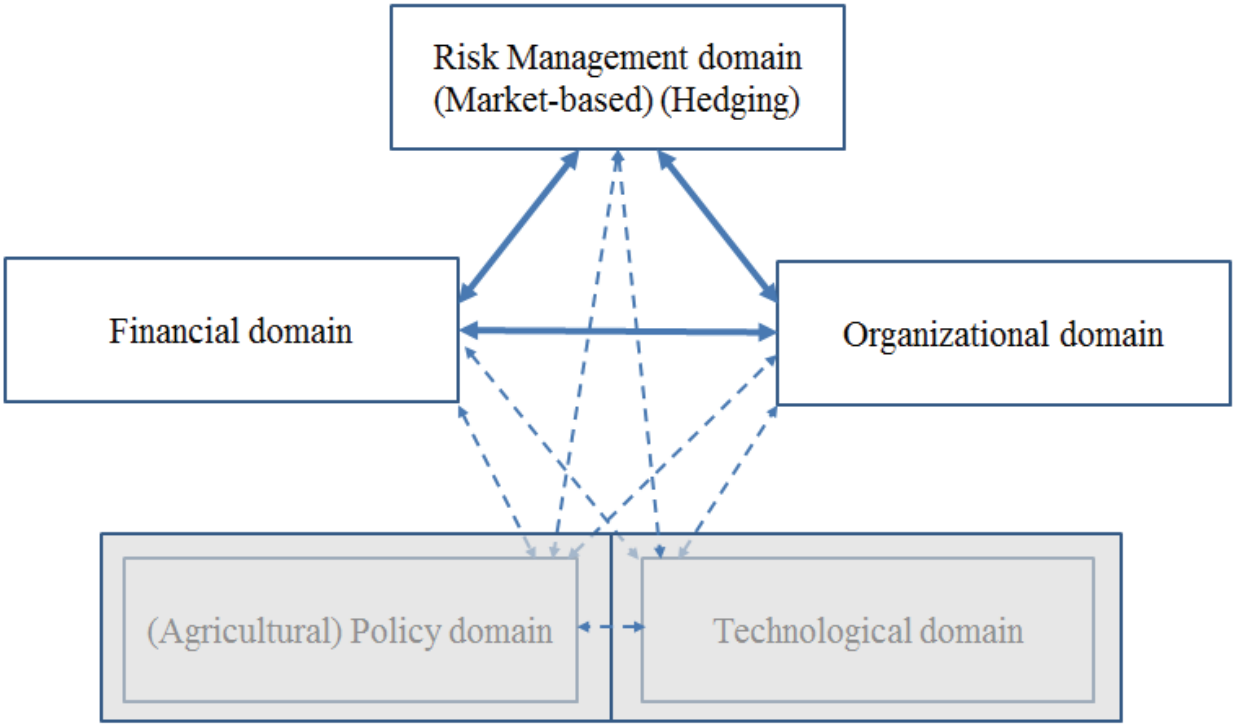

Figure 1.13 Interaction between the main institutional domains of interest in the thesis.

The role of technology in institutional economics is somewhat disputed, but key scholars emphasize the importance of integrating technological, institutional and organizational aspects in economic analysis (Aoki, 2001; North, 1991; Williamson, 2000).

The first paper

The first paper is mainly a methodological contribution to the finance literature. It suggests a novel measure for credit capacity based on the estimation of a debt possibility frontier. This frontier is estimated with Data Envelopment Analysis (DEA) which is well known in production economic

applications. The results of the paper show an increase in access to credit up to the financial crisis, suggesting increased credit reserves and a possible crowding out effect on alternative risk management instruments. In this way, the possible consequences of changing financial institutions on risk management practices are illustrated.

The paper does not provide a test of the financial crowding out hypothesis; it lays the groundwork for such a test in future research by introducing the novel measure for credit capacity. The significant difference between this measure and more conventional measures, such as debt-to-assets or debt-to-equity ratios is the avoidance of statistical noise from accounting practice especially valuation of assets is tricky in agricultural accounting as the main asset, land, is unique and market price observations are unreliable. Introducing this new application of DEA a number of methodological and communicational choices have been made.

As mentioned in the paper the use of varying returns to scale (VRS) following Wheelock and Wilson (1999) introduce the problem of ill-defined change scores, for this reason the use of the VRS decomposition is contested in the modern literature. However, it is a choice between two sub-optimal methodological alternatives, as the alternative is a reliance on an assumption of constant returns to scale. My co-author and I made the choice of VRS acknowledging the discussion in the literature.

As the central point of the paper is to introduce the measure and the idea of a debt possibility frontier the model is kept as simple as possible. A lot of further development and alternative model specifications are possible, these are only discussed to a limited degree in the paper to hold focus on the central point. Application and variations of the measure could be the subject further research. One weakness of the measure and applicability in future research and applications is the reliance on quite large data requirements, which may be a challenge in many situations.

The paper holds a discussion on the lenders' strategic behavior during the credit cycle bust, as this behavior may imply serious problems for the reliability of the measure during these periods. During a credit cycle boom the method is proposed to give a valid measure of change in credit capacity. A discussion of the strategic behavior of the lenders during the credit cycle boom might have been appropriate, however, this is a very large discussion and not seen as central to the point of the paper.

Giving an adequate discussion of the strategic behavior of the lenders during the credit cycle boom is beyond the scope for the paper and for this thesis, as this strategic behavior is likely to be a central part of the reason for the GFC.

However, one brief comment on the strategic behavior of lenders may be reflected in the now (in)famous quote by former Citigroup CEO Charles Prince to Financial Times in June 2007: "As long as the music is playing, you've got to get up and dance." This has been taken to reflect that the incentive structure of bank employees tended to promote a relaxed attitude towards leverage. If you, as an individual banker, were worried about leverage another bank was there to take the deal from you. You would not perform to the benchmark and risk losing bonus, promotion or even your job. As long as most banks fueled the leverage driven economy 'the music was playing' and your individual incentive was to follow the crowd 'and dance along'.

Even if there was some level of awareness of the problem in the (top level of) banking sector, bounded rational borrowers responding to the signals in the market cannot have been expected to predict the GFC. Perception of large credit reserves when assets were increasing in value seem a fair assumption.

The second paper

The second paper is a more mainstream NIE paper. The paper applies a cross-country comparative analysis, based on the method of difference, to induce a theoretical explanation for different organizational developments in agricultural value chains based on risk management and finance in combination with more traditional transaction cost arguments. It compares two environments otherwise similar, where the phenomenon, organizational change, differs. The paper finds that cooperative marketing and relatively unconstrained access to credit may have important complementary effects on the process of organizational change which is often seen as a consequence of technological change driving investment in specific assets. Due emphasis on the implications of the financial environment is often omitted in transaction cost explanations of organizational change.

Following Grief (1998) and Aoki (2001) the paper presents a comparative institutional analysis (CIA), balancing the synchronic problem of understanding the institutional matrix in equilibrium with the diachronic problem of understanding the mechanism of institutional change.

"Institutional arrangements can be diverse across economies even if they are exposed to the same technological knowledge and are linked through the same markets. Thus we need to rely on comparative and historical information to understand why particular institutional arrangements has evolved in one economy but not in others. By this we imply that an institutional analysis must be also comparative and historical" (Aoki, 2001, p. 3)

The paper compares the development in hog marketing arrangements in the U.S. and Denmark. The significant change seen in the U.S. hog marketing arrangements is usually explained by coordination and risk management needs (MacDonald and Banker, 2004; MacDonald and McBride, 2009; MacDonald et al., 2004; Martinez and Zering, 2004; Martinez, 1999, 2002). It is argued that this explanation neglects controlling for the state of financial institutions. Specifically, this omission leads to a failure of the theory to explain why the developments in the U.S. hog marketing arrangements have not been mirrored in Denmark. Complementary effects of the financial environment and cooperative marketing may refine the theoretical explanation and improve the predictive power to cover the Danish as well as the U.S. case.

The historical and comparative case study is explorative in the sense that it relies on secondary research describing the development in hog sector, especially the development in marketing arrangements in the U.S. and in Denmark. As such the analysis may be biased by the availability of secondary research.

The level of research and the comparability of research within the domains of interest are unbalanced across the two countries. This leaves the analysis with areas that are relatively unsupported. Specifically the domain of agricultural finance does not have an in depth comparative analysis, and the paper relies on the assumption that the financial systems differ significantly, which may be supported by casual observations, furthermore the paper relies on the assumption that access to credit was easier in Denmark than in the U.S. during the period of analysis. While I believe this assumption to hold it is admittedly only weakly supported in the paper. Further research efforts could be directed at comparative analysis of financial systems (credit markets). This could possibly complement the fairly large literature following La Porta et al. (1997) on legal origin which is used to explain differences in equity markets in the corporate finance literature.

Many important factors are omitted in the paper, as the focus is on the claim that financial institutions matter, in the process of organizational adaption to technological change. The point of the paper is that financial institutions *also* matter, it is not that only financial institutions matter. By omitting many of these factors in the analysis the ability to control for these factors and asses the relative importance of the institutional financial environment is foregone. The same thing may however be said about the analysis that omit financial factors, if it is accepted that these play some role of unknown relative importance. In this light the contribution to the wider institutional literature is that of raising the question of whether or not the omission of controlling for financial institutions is a serious bias. The paper suggests that this might be the case.

The first two papers are concerned with the "why" of risk management practice in Danish agriculture, especially the absence of market-based risk management. The papers focus on the financial and organizational coping mechanisms which, along with other factors, may explain risk management practice. The third paper and the concluding chapter of this thesis are more concerned with the "how", that is, how to adapt existing institutional frames for risk management and organization in response to changing institutional frames with regard to finance and policy.

The third paper

The third paper is a mechanisms design paper. It explores the possibility of the reallocation of risk among cooperative members on an internal market, in cases where external markets for the reallocation of price risk are inefficient due to basis risk. The paper finds that there is potential for the reallocation of risk among cooperative members if transaction costs are low enough and member heterogeneity in their cost of carrying risk is large enough.

The paper can be seen as a reaction to the seemingly asymmetric hedging possibility of Danish farmers in the livestock sector where farmers can and do hedge on the input side of the firm but have no possibility of hedging on the output side of the firm. For simplicity reasons the hedging activity on the input side of the firm is ignored in the paper along with any other stochastic noise except the output price risk, as it is not the aim of the paper to specify optimal hedging strategies for farmers. The aim of the paper is to show the possibility of reallocative gain via reallocation of price risk on the output side of the firm. Naturally the effort of hedging output price risk should be coor-

dinated with hedging activity on the input side, along with all other risk management activities in a whole farm risk management perspective.

The paper builds on the argument that output price risk cannot be hedged effectively on futures markets due to prohibitive basis risk, the claim is supported by existing research (Meuwissen et al., 2008). The magnitude of this basis risk is an interesting subject for further research, but is beyond the scope of this thesis.

The global financial crisis may seriously affect the complementary relationship between the financial environment and the cooperative organization of marketing by reducing access to credit (Paper II). The financial crisis removes or reduces the crowding out effect of access to credit on risk management (Paper I), leaving an institutional vacuum with regard to risk management. The third paper suggests a way of filling this institutional vacuum by introducing a model for the reallocation of price risk among cooperative members.

The concluding chapter

Chapter five in this thesis offers some concluding remarks, as well as a brief discussion of alternative coping strategies.

The Irish cooperative dairy, Connacht Gold's Chief Executive Officer, Aaron Forde, when talking to an audience of Irish farmers in 2010 put the situation like this: "Without the protection of the traditional European Union tools of intervention and refunds, we are exposed to the volatility of world markets, changes in supply/demand balance, currency fluctuations and climate or food scare events. Therefore, the only way we can protect ourselves as businesses and farmers is by having a relentless focus on doing things better, […] in the United States and other regions forward contracts and hedging instruments act as buffers for farmers against price volatility. Irish and European farmers have no such mechanisms" (cf. Ryan, 2010).

While the absence of effective risk management mechanisms is true, this does not mean that they cannot be made. As Anderson and Gatignon (2005, p. 1) teach us: "New markets do not emerge, nor do they appear. They are *made* by the activities of firms."

Chapter 2

Paper I

Measuring Credit Capacity on Danish Farms using DEA[4]

Abstract
Purpose – The purpose of this paper is to introduce a novel measure of access to credit suited to estimate the relative change in credit reserves.
Design/methodology/approach – A debt possibility frontier is estimated using Data Envelopment Analysis (DEA) and the Malmquist index is calculated. The Malmquist index is redubbed the Debt Development index and decomposed into "Change in debt capacity" and "Change in debt capacity utilization." Bootstrapping is applied for statistical inference. The method is applied to an unbalanced panel of 92,000 Danish farm accounts from 1996 to 2009.
Findings – We find that credit capacity roughly doubled for Danish farmers over the period, and that the utilization of credit capacity generally was proportional to capacity change, utilization being higher for dairy and pig farms than for crop farms.
Research limitations/implications – Changes in credit reserves may have important implications for risk management practice, investment and technology adoption and related policy issues. The method is limited by the possibility of lenders' strategic behavior during credit cycle busts. In credit cycle booms, the method gives a good basis for estimates of change in credit reserves.
Practical implications – In a period of increasing credit reserves, risk management institutions are unlikely to develop. Like agricultural policy, access to credit may crowd out market-based risk management.
Originality/value – The study represents a novel application and interpretation of a well-known method.

Keywords: DEA, Malmquist index, Debt Development index, Access to Credit, Agricultural Finance, Credit Reserves, Risk Management

Article Classification: Research paper

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2.1 Introduction

This paper contributes to the agricultural finance and risk management literature that recognizes the important role of credit reserves by introducing a measure of access to credit, which is suited to estimate the relative change in credit reserves. The measure is based on Data Envelopment Analysis (DEA) and estimates a debt possibility frontier. The Malmquist index is calculated to capture change over time and the index is decomposed to identify change in debt capacity and change in debt capacity utilization.

C. B. Baker, along with a number of co-authors, has emphasized the important link between liquidity, risk management and finance (Baker, 1968; Baker and Hopkin, 1969; Barry and Baker, 1971; Barry *et al.*, 1981). Major themes in this literature include the relationship between hedging and finance (Turvey, 1989) and risk balancing between business and financial risk (Gabriel and Baker, 1980) and related policy issues.

Most research on related issues in the general finance literature is concerned with what Barry and Baker (1971, p. 222) call "External credit rationing"[5]. We find the holistic approach of Baker with co-authors and followers, which focuses on both internal and external credit rationing, more interesting than the narrow focus on external credit constraints that preoccupies the literature. The narrow focus on credit constraints fails to explain or predict the behavior of firms or farms in situations where constraints are not binding. The dichotomous categorization of firms as being either financially constrained or unconstrained does not capture the important dynamics of self-imposed limitations on credit use which Barry and Baker (1971) emphasize. Focusing on whether firms are financially constrained or not will greatly limit the understanding of the interaction between investment, finance and risk management behavior.

One reason for the predominant research focus on credit constraints may be the lack of empirical measures for credit reserves. Gabriel and Baker (1980) use changes in land prices as a proxy for changes in credit reserves in a preliminary attempt to verify their risk balancing hypothesis. We provide a refined measure of this proxy based on actual debt obtained on comparable farms. Our

[5] This can be illustrated by a comparison of a Google Scholar search on "credit reserves" and "liquidity reserves" as opposed to a search on "credit constraints" and "financial constraints." Credit reserves get 597 hits, liquidity reserves get approximately 1,350 hits, while credit constraints get approximately 23,000 hits and financial constraints get approximately 91,500 hits. The more specific "investment cash flow sensitivity," which is focused on empirical measures of credit constraints, gets approximately 1,370 hits.

approach is to estimate a debt possibility frontier using DEA and to calculate and reinterpret the Malmquist index and its components, two of which are change in debt capacity and change in debt capacity utilization. We demonstrate the approach on an unbalanced panel of 92,000 Danish farm accounts during the period 1996 to 2009. An additional feature of our approach is that it reduces the reliance on the book valuation of assets which may be biased by changes in accounting practices.

The paper is structured as follows: Section 2.2 provides a brief introduction to the literature on measures of credit constraints, to which we provide an alternative. Section 2.3 introduces the DEA method in the new application. Section 2.4 describes the data set. Section 2.5 discusses the results and section 2.6 provides some implications and concluding remarks.

2.2 Background

The literature on credit constraints has had a strong empirical focus on access to credit. The existence and importance of credit constraints has been examined extensively since the late 1980s in the corporate finance literature, where it has been typical to test whether investment opportunities are exercised according to the assumption of the frictionless market or not. Several assumptions are employed when estimating the shadow value of capital or the marginal revenue product of capital. These assumptions include perfect competition, constant returns to scale and that the market valuation of the firm is not affected by bubbles or fads (Bond and Van Reenen, 2007). One of the biggest discussions in the field is on functional forms, i.e. the assumptions of monotonicity (Fazzari et al., 1988, 2000; Kaplan and Zingales, 1997, 2000). With regard to credit constraints in agriculture, the concept has been investigated thoroughly for a long period of time, but the majority of the investigations have focused on the omnipresent credit constraints in the immature credit markets in the developing countries or former Eastern Bloc countries (Briggeman *et al.*, 2009). In the research on households' access to credit in developing countries, the frictionless market assumption is substituted by the life-cycle/permanent income hypothesis (Diagne et al., 2000). Research on mature credit markets in more developed countries is limited, although some research exists (Hubbard and Kashyap, 1992).

The quantitative literature on credit constraints mainly focuses on parametric methods, although nonparametric methods are also applied to a lesser extent. Nonparametric measures of credit con-

straints in agriculture were introduced by Färe *et al.* (1990) and applied and extended with secondary analysis by Blancard *et al*. (2006) on French panel data from 1994 to 2001. Nonparametric methods are relevant to use as they have no distributional assumptions and a minimum of assumptions regarding functional forms, as opposed to the parametric measures mentioned above. However, it is important to note that the approaches following Färe *et al*. (1990) cannot grasp the fact that agents may be constraining themselves for behavioral reasons related to risk and uncertainty. This is recognized as a caveat in the concluding remarks of Färe *et al*. (1990). The problem is generally not well recognized in the parametric line of research on credit constraints. The method introduced in this paper differs fundamentally from Färe *et al*. (1990) and Blancard *et al*. (2006). These authors estimate profit functions using nonparametric frontier analysis, and analyze the effect of expenditure constraints. The approach introduced in this paper estimates a debt possibility frontier directly. This paper's focus on maximum credit obtainable and the relative use of credit capacity, rather than the dichotomous evaluation of credit constraints, is a central part of the methodological discussion on the survey-based analysis of access to credit in Diagne *et al*. (2000). Both parametric and nonparametric credit constraint models are very deterministic, in the sense that farms (firms) are either financially constrained or not, and they do not provide answers regarding the extent to which farms are credit constrained or the extent of possible self-imposed restrictions on the use of credit (Barry and Baker, 1971; Diagne *et al.*, 2000). The method introduced in this paper provides a relative answer to this question both on a sector level and on an individual farm level. These answers may be important explanatory factors for behavioral and institutional phenomena related to risk management and investments.

2.3 Method

2.3.1 DATA ENVELOPMENT ANALYSIS

The method introduced here estimates the maximum credit available for individual farms, using linear combinations of actual observed debt, obtained by the most indebted comparable farms. The maximum credit available less the current debt is the credit reserve, which plays an important role in the farmers' credit risk and liquidity management and thus in whole farm risk management considerations (Barry *et al.*, 1981; Turvey and Baker, 1990). Debt is reliably observable from accounting data, but maximum credit available is not directly observable and must be estimated. However, once this has been achieved, calculating credit reserves is straight forward.

A DEA model is applied to estimate the maximum credit available called the debt possibility frontier and to measure the development of the frontier debt capacity over time. Furthermore, the utilization rate of this capacity is calculated and traced over time. Debt capacity utilization is a measure of the amount of debt on a specific farm as a ratio of the maximum debt of comparable farms, taken as a proxy for the maximum debt capacity. It is important to note that this is a proxy of maximum available credit for the individual farm. The frontier does not estimate the maximum credit available for the entire agricultural credit market, but rather the perceived availability of credit to the individual farmer *ceteris paribus*.

The non-parametric frontier method DEA was originally proposed by Charnes, Cooper, and Rhodes (1978). The frontier estimates the maximum output that can be transformed for any given set of inputs. Usually this frontier represents a production technology. However, in this application it represents a debt possibility frontier. An important distinction between this application and the production economic application is that being on the frontier is generally something to aspire to in production economics, as it means that the farm is technically efficient. However, in this application, it is generally not something to aspire to, but is rather an indication of the maximum debt that could be obtained in the event of adverse circumstances. The amount of unused debt capacity is the credit reserve. In the traditional production economic setting, this translates into inefficiency, but in the setting suggested here it may represent an efficient way of coping with risk.

The output, $\mathbf{y}^t$, in this model is debt, where the most indebted farmers, relative to the input of the model, generate the debt possibility frontier. The major assumption of this approach is that farms in the interior of the feasible debt possibility set can use the frontier as an estimator of the maximum credit available. The assumption is that the maximum debt of peers indicates the maximum available debt for the farmer. The debt possibility frontier is conditioned on a number of input factors, labeled collateral value factors. These are physical assets, farmer characteristics and performance measures. A formal description of the model, which closely follows the production economic tradition, is as follows:

Consider the debt possibility frontier, $\boldsymbol{S}^t$, which models the transformation of collateral value factors $\mathbf{x}^t \in \mathbb{R}_+^N$ into debt possibility $\mathbf{y}^t \in \mathbb{R}_+^M$ (Färe et al., 1994), where N and M are the dimensions of the collateral value factor and debt vectors and t is time.

$$\boldsymbol{S}^t = \{(\mathbf{x}^t, \mathbf{y}^t) : \mathbf{y}^t \text{ is feasible given } \mathbf{x}^t\} \tag{5}$$

The debt possibility frontier, $\boldsymbol{S}^t$, is convex, bounded, and closed for all $\mathbf{x}^t \in \mathbb{R}_+^N$. Obtaining debt requires some collateral value factors and all collateral factors and debt are strongly disposable, which means that debt is not a must in order to hold collateral value items, but is a way of financing assets. The debt possibility frontier is unobservable and hence the distance to the frontier is unobservable and must be estimated (Wheelock and Wilson, 1999). The debt distance function is estimated as:

$$\widehat{\boldsymbol{D}^t}(\mathbf{x}^t, \mathbf{y}^t) = (sup\{\theta : (\mathbf{x}^t, \theta\mathbf{y}^t) \in \mathbf{S}^t\})^{-1} \tag{6}$$

There are few fundamental properties for feasible production sets in the production economic application of DEA. These must also be satisfied for the debt frontier application. Following Coelli *et al.* (2005), the debt possibility set can be defined as:

$$\mathbf{P}(\mathrm{x}^t) = \{\mathrm{y}^t : \mathbf{y}^t \text{ is feasible given } \mathbf{x}^t\} = \{\mathrm{y}^t : (\mathrm{x}^t, \mathrm{y}^t) \in \boldsymbol{S}^t\} \tag{7}$$

For each x^t, the output set $\mathbf{P}(\mathrm{x}^t)$ must satisfy:

i. $0 \in \mathbf{P}(\mathrm{x}^t)$;
ii. non-zero output levels cannot be generated from zero levels of inputs;
iii. $\mathbf{P}(\mathrm{x}^t)$ satisfies strong disposability of outputs;
iv. $\mathbf{P}(\mathrm{x}^t)$ satisfies strong disposability of inputs;
v. $\mathbf{P}(\mathrm{x}^t)$ is closed;
vi. $\mathbf{P}(\mathrm{x}^t)$ is bounded;
vii. $\mathbf{P}(\mathrm{x}^t)$ is convex;

In the debt frontier context, i) implies that no debt is a possibility for any given set of inputs, that is, it is possible for a farm to be totally equity financed; ii) implies that no debt can be obtained if all inputs are zero; iii) implies that if a given debt level is feasible, any non-negative debt level equal or

below is also feasible, any debt level below the frontier may reflect internal credit rationing, whereas the frontier itself reflects external credit rationing; iv) implies that if a given debt level is feasible at a given input level, it is also feasible at any input level at or above; v) closedness is a mathematical requirement with no important financial implications; vi) implies that unlimited debt levels are not possible with a given set of inputs; vii) implies that any weighted average of two levels of debt capacity is feasible. This requirement implicitly means that all outputs and inputs are continuously divisible.

2.3.2 DEBT DEVELOPMENT INDEX

The DEA debt possibility frontier can be used to estimate the Debt Development index (DDi) which is a reinterpretation of the Malmquist productivity index[6] (Caves et al., 1982; Färe et al., 1992). This index is employed to measure change over time. Rather than computing the DDi for adjacent years, we use 1996 as the single base year. This is done to obtain the cumulative debt development, rather than the marginal change from year to year. A parallel example from production economic applications of the Malmquist index is Klein *et al*. (1992). Using a single base year also avoids problems with interpretation, as one should be cautious when interpreting the adjacent year changes over multiple periods, unless technical change is Hicks-neutral (Bogetoft and Otto, 2010). By debt development we mean the change in use of debt relative to the frontier which reflects the debt capacity.

The Debt Development index is defined as:

$$\widehat{DDi_i^{t2}}(y^{t2}, x^{t2}, y^{t1}, x^{t1}) = \left[\frac{\widehat{D}_c^{t1}(x_i^{t2}, y_i^{t2})}{\widehat{D}_c^{t1}(x_i^{t1}, y_i^{t1})} \times \frac{\widehat{D}_c^{t2}(x_i^{t2}, y_i^{t2})}{\widehat{D}_c^{t2}(x_i^{t1}, y_i^{t1})}\right]^{\frac{1}{2}} \tag{8}$$

and it expresses the development in debt for a farm i in period $t1$ to period $t2$ with reference to a debt frontier with constant returns to scale (CRS) given by collateral value factors. In the two dimensional illustration of Figure 2.1 it is given by:

$$\begin{aligned}\widehat{DDi_i^{t2}}(y^{t2}, x^{t2}, y^{t1}, x^{t1}) \\ = \{[(B'B/B'B^{c1})/(A'A/A'A^{c1})] \times [\,(B'B/B'B^{c2})/(A'A/A'A^{c2})]\}^{½}\end{aligned} \tag{9}$$

[6] The Malmquist index (or the Malmquist Productivity Index) is a productivity index introduced by Caves *et al*. (1982), which can be used to compare two production functions representing the production technology of two economies, or to compare the production technology of a single economy at two different points in time.

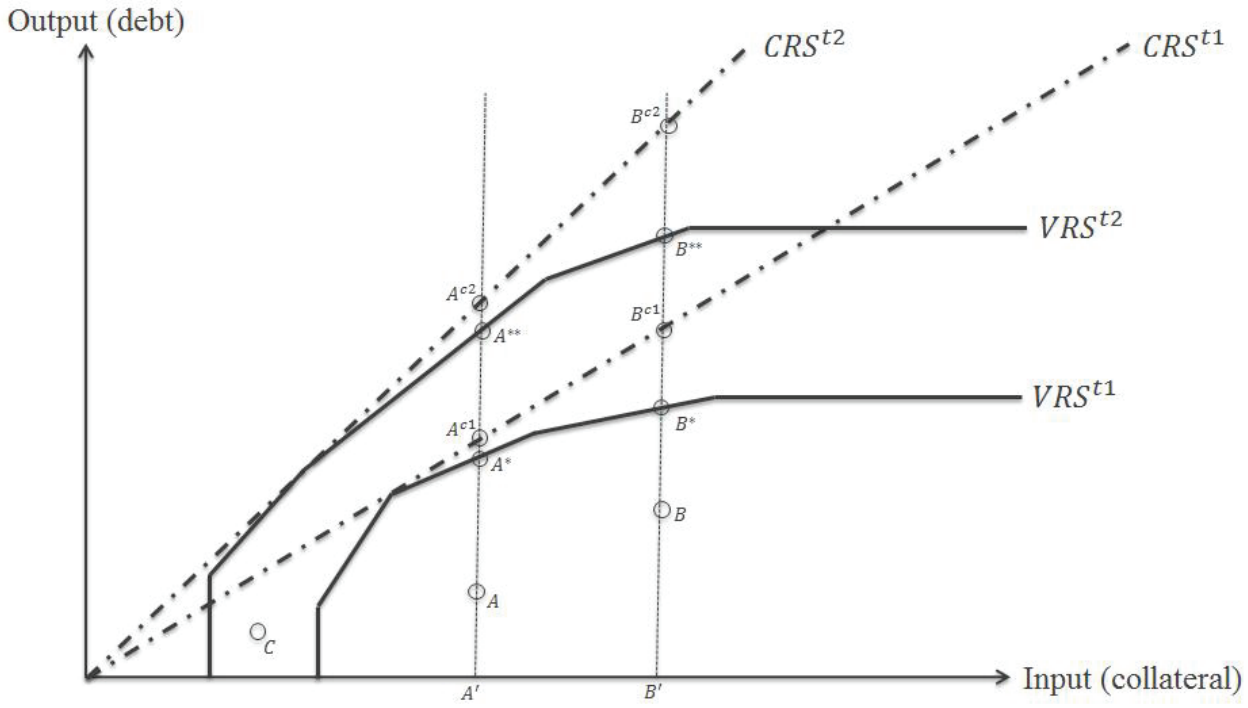

Figure 2.1: Decomposition of the Debt Development index.

The interpretation of equation (5) can be illustrated by the following example: Suppose you are a farmer at time $t1$, your total liabilities are given by $\mathrm{A'A}$, and amount to € 1,000,000. Your $CRSt1$ frontier debt capacity is given by $\mathrm{A'A^{c1}}$ and is € 2,700,000. The $CRSt2$ frontier debt capacity is given by $\mathrm{A'A^{c2}}$ and is € 4,300,000 which is the frontier debt capacity at time $t2$, if you have exactly the same collateral as you had at $t1$. At time $t2$ your total liabilities are given by $\mathrm{B'B}$. Now let's suppose they have risen to € 2,000,000 and your collateral has also risen which is reflected in the horizontal movement from $\mathrm{A'}$ to $\mathrm{B'}$. The $CRSt1$ frontier debt capacity is given by $\mathrm{B'B^{c1}}$ and is €4,000,000, the $CRSt2$ frontier debt capacity is given by $\mathrm{B'B^{c2}}$ and is € 6,300,000.

Numerically, the Debt Development index can now be calculated as follows:

$$\widehat{DDi_i^{t2}}(y^{t2}, x^{t2}, y^{t1}, x^{t1}) = \{[(2/4)\ /(1/2.7)] \times [\ (2/6.3)/(1/4.3)]\}^{½} = 1.36 \qquad (10)$$

Debt Development indices which are above one indicate relatively increased indebtedness, while indices which are below one indicate relatively decreased indebtedness. By relatively we here mean the change in the debt of the farm relative to the frontier known as the debt capacity. Hence, the

DDi is the development in the relative indebtedness from $t1$ to $t2$. In the example above, the farm at point B in Figure 2.1 is 36% more indebted than the farm at point A.

Following Färe *et al*. (1994) and Wheelock and Wilson (1999), the estimate of the DDi can be decomposed. This decomposition enables us to express the debt development with respect to a debt frontier with varying returns to scale (VRS). By VRS it is meant that the relation between debt and collateral on the frontier does not have to be constant. This is a weaker and more appropriate assumption for the shape of the debt possibility frontier. The data is more tightly enveloped assuming VRS which yields a smaller and more conservative estimate of the debt possibility set $\mathbf{P}(\mathrm{x}^t)$ than an estimate based on the assumption of CRS. The Wheelock and Wilson (1999) decomposition goes further and is followed in the DDi reinterpretation of the Malmquist index:

$$\begin{aligned}\widehat{DDi_i^{t2}} = {} & \Delta\, Debt\ capacity\ utililization \\ & \times \Delta Debt\ capacity\ utililization\ related\ to\ scale \\ & \times \Delta Debt\ capacity \times \Delta\ Debt\ capacity\ related\ to\ scale\end{aligned} \tag{11}$$

Where:

$$\Delta\, Debt\ capacity\ utilization = \left[\frac{\widehat{D}_v^{t2}(x_i^{t2}, y_i^{t2})}{\widehat{D}_v^{t1}(x_i^{t1}, y_i^{t1})}\right] \tag{12}$$

$$\Delta\, Debt\ cap.\ utilization\ \ related\ to\ scale = \left[\frac{\widehat{D}_c^{t2}(x_i^{t2}, y_i^{t2})/\widehat{D}_v^{t2}(x_i^{t2}, y_i^{t2})}{\widehat{D}_c^{t1}(x_i^{t1}, y_i^{t1})/\widehat{D}_v^{t1}(x_i^{t1}, y_i^{t1})}\right] \tag{13}$$

$$\Delta\, Debt\ capacity = \left[\frac{\widehat{D}_v^{t1}(x_i^{t1}, y_i^{t1})}{\widehat{D}_v^{t2}(x_i^{t1}, y_i^{t1})} \times \frac{\widehat{D}_v^{t1}(x_i^{t2}, y_i^{t2})}{\widehat{D}_v^{t2}(x_i^{t2}, y_i^{t2})}\right]^{\frac{1}{2}} \tag{14}$$

$$\begin{aligned}&\Delta\, Debt\ capacity\ related\ to\ scale \\ &= \left[\frac{\widehat{D}_c^{t1}(x_i^{t2}, y_i^{t2})/\widehat{D}_v^{t1}(x_i^{t2}, y_i^{t2})}{\widehat{D}_c^{t2}(x_i^{t2}, y_i^{t2})/\widehat{D}_v^{t2}(x_i^{t2}, y_i^{t2})} \times \frac{\widehat{D}_c^{t1}(x_i^{t1}, y_i^{t1})/\widehat{D}_v^{t1}(x_i^{t1}, y_i^{t1})}{\widehat{D}_c^{t2}(x_i^{t1}, y_i^{t1})/\widehat{D}_v^{t2}(x_i^{t1}, y_i^{t1})}\right]^{\frac{1}{2}}\end{aligned} \tag{15}$$

The decomposition is illustrated in Figure 2.1. The components related to scale capture the fraction of the change which is related to scale change. These parts are not recognized as pure change in

debt capacity or pure change in the debt capacity utilization and do not have an important economic interpretation, but they are important controls in the shift from CRS to VRS. The $\Delta\, Debt\ capacity$ is the shift in the VRS debt frontier measured as the geometric mean of the shift between the frontiers measured at the position of the farm at the two different points in time. In the two dimensional illustration of Figure 2.1 it is the geometric mean given by:

$$\Delta\, Debt\ capacity = \{[(A'A/A'A^{*}\ /(A'A/A'A^{**})] \times [\ (B'B/B'B^{*})/(B'B/B'B^{**})]\}^{½} \qquad (16)$$

The change in debt capacity is the change in the frontier, that is the relative movement of the frontier or the change in how much the most indebted farmers can borrow.

The $\Delta\, Debt\ capacity\ utilization$ is the change in the debt capacity utilization relative to the VRS debt frontier measured as the debt capacity utilization at the second period over the debt capacity utilization in the first period. In Figure 2.1, this is illustrated by:

$$\Delta\, Debt\ capacity\ utilization = (B'B/B'B^{**})/(A'A/A'A^{*}) \qquad (17)$$

The change in debt capacity utilization is the relative change in the actual to maximum debt ratio. This is somewhat similar to a change in a debt-to-asset ratio. However, here assets are substituted by the estimate of maximum debt.

One important weakness in the Wheelock and Wilson (1999) decomposition is that points like C in Figure 2.1 will have no frontier projection for the VRS^{t1} frontier, and $\Delta\, Debt\ capacity$ will be ill-defined in this case. It is a methodological trade-off between a reliance on the CRS frontier or the VRS frontier, with the possibility of ill-defined change in debt capacity scores. We consider the latter alternative to be the best and we acknowledge the discussion in the Malmquist index literature. We omit farms with ill-defined change in debt capacity scores.

The output-oriented efficiency score in the production economic application can be reinterpreted as the debt to debt capacity ratio, or more loosely defined as the management adjusted debt to collateral value ratio. We assume that collateral and earnings (EBIT) are the fundamental factors, which determine the debt capacity or loan approval on the individual level. The non-utilized amount of

debt capacity can be interpreted as credit reserves and in Figure 2.1 the credit reserves at time $t1$ for the farmer represented by the point A are illustrated by the distance between A and A*. This is a useful proxy for μ in the Gabriel and Baker (1980) model shown in (14).

$$P(cx + \mu - I \leq z) \leq \frac{\sigma_s^2}{[(\bar{c}x + \mu - I) - z]^2} \leq \alpha \tag{18}$$

where:

α = probability that some critical cash demand cannot be met (default risk)

cx = net cash flow

$\bar{c}$x = expected net cash flow

μ = liquidity reserves

I = fixed debt servicing obligations

z = minimum liquidity requierment

σ_s^2 = the subjective variance of net cash flow

Gabriel and Baker (1980) used land price change as a proxy for change in μ in a preliminary empirical test of their risk balancing hypothesis. We provide a more refined and micro-oriented measure of change in credit availability.

2.3.3 MODEL SPECIFICATION

The requirements listed in section 2.3.1 correspond to the Danish credit market. The Danish agricultural credit market is strongly influenced by collateral-based lending as illustrated by the role of loan to value (LTV) limits in the mortgage banking regulation of the Mortgage-Credit Loans and Mortgage-Credit Bonds Act and the Financial Business Act (Association of Danish Mortgage Banks, 2012). The system is layered with its base in the, in some ways unique, Danish mortgage banking system. The mortgage banks offer loans based on collateral in real estate, while additional loans are offered by commercial banks, trade credits, etc. Some farmers use leasing arrangements, primarily to finance machinery.

The hard lessons learned about collateral based lending during the 1980s in U.S. agriculture (Harris et al., 2009), were not learned in Denmark. The U.S. shift from collateral-based lending to cash flow based lending has not occurred in Denmark. Figure 2.2 illustrates the U.S. debt to cash flow

ratio decline from its level in the 1980s, and the absence of such a decline in Denmark. Note the different scales. The Danish reliance on collateral-based lending is substantiated by a qualitative study by Jakobsen (2011).

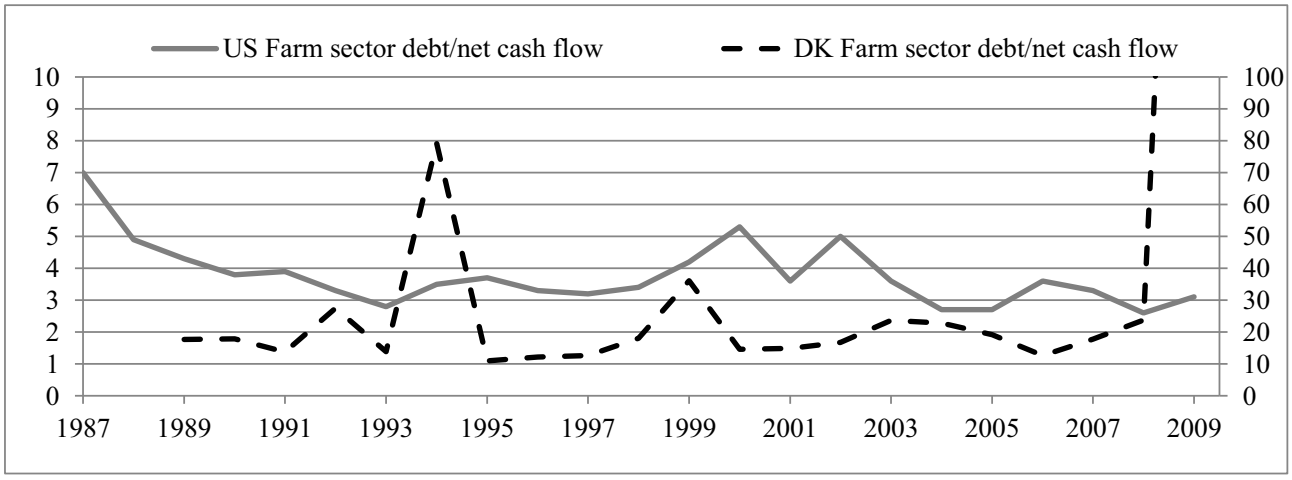

Figure 2.2: Ratio of farm sector debt/net cash flow, U.S. on left scale, DK on right scale.
Source: Harris *et al.* (2009) for U.S. data and FADN (2012) for DK data.

We present three variations of a single output model with nine (crop), twelve (dairy) and eleven (pigs) inputs in section 2.2.4. The single output is debt in all models and the inputs are collateral value proxies, such as assets, earnings and an inverse transformation of age.

The main inputs in the model are assets. These are true collateral items in the sense that the lender can repossess them if the farmer is unable to honor the terms of the lending agreement. Some of these assets are measured in book value and some in physical terms, as the book valuation of some of the assets is inconsistent across time and accounts. Accounting practice behind the data generating process has changed, notably with regard to the valuation principles of assets. In Danish agricultural accounting, there has been a gradual shift away from the use of public valuation[7] towards the market valuation of real-estate assets. Since there is no counterpart involved in the valuation of assets that are not traded, one should be cautious when using such data; this is generally a problem that is not considered, e.g. Zhao *et al.* (2008) and Grosen *et al.* (2012). The method introduced in this paper is robust regarding this problem, as the physical measure of assets is unaffected by

[7] The public valuation of a real-estate asset is an estimate made every two years, based on the average prices from the preceding two years, and is therefore lagged.

changes in accounting principles. For the collateral value of financial assets and for the collateral value of machinery, the book valuation is used directly for two reasons. First there is no detailed information on machinery and financial assets, and second, the book value of these assets is more reliably marked to market than real estate assets.

Earnings before interest and tax (EBIT) are used as a proxy for management level and debt servicing ability. Age and EBIT serve as inputs to control for management quality; EBIT as the level of management quality and an inverse transformation of age as a measure of the persistence of management quality.

The inverse transformation of age is to satisfy requirement iv), whereas all other requirements in section 2.3.1 are satisfied for all practical purposes. Zhao *et al.* (2008) propose that old farmers have better access to credit than younger farmers which is in apparent contradiction to our inverse transformation of age. Barry *et al.* (2000, p. 928) state that: 'Older farmers should be less financially-constrained than younger farmers because they may have longer relationships with their lenders, greater equity accumulations, and generally stronger financial measure.' We agree with this statement. However, we believe that the relation between age and access to credit is due to the indirect effects of age on debt capacity. Age itself may have a negative direct effect on access to credit, while 'longer relationships with lenders, greater equity accumulation and generally stronger financial measures' are positively related to both age and access to credit. The correlation between age and access to credit is spurious and does not necessarily suggest a direct positive causal relationship between age and access to credit.

The main assumptions of the model are that lower collateral, lower earnings and higher age (*ceteris paribus*) may cause lower debt capacity. If someone has a given level of debt with a given level of input, then anyone with the same level of input can generate at least as much debt. If someone has a given level of debt with a given level of input, then anyone with a higher level of input can generate at least as much debt. The inputs are determined by the institutional framework with regards to the Danish mortgage banking system. This is a fairly robust system for collateral-based lending as it has been functioning for more than 200 years, and in this time, no bond holder has suffered a financial loss (Association of Danish Mortgage Banks, 2012). During the study period, the corporate ownership of farms was restricted by law in Denmark, making the individual or family ownership of

farms the dominant and stable ownership structure. Possible future changes in the ownership trend could affect credit availability, and should be controlled for in this case. Under other institutional frameworks, for example cash flow based credit systems, the model specification should be amended to the specific conditions. The fundamental idea of estimating the debt possibility frontier is the core contribution of this paper, whereas the specification of the model is state dependent, and the applied specification is related to the Danish institutional framework.

One may argue that interest rate considerations are missing from the model. However, Asset Pricing Theory suggests that expected future cash flow and interest rates determine the value of the asset. Since asset prices, and hence the collateral value of assets, are affected by interest, this has been consciously omitted due to endogeneity concerns. In a cash flow based model, interest would certainly be an important input, but this is not the case in a collateral based model.

An important assumption in the model is that farmers can obtain as much debt as the most indebted comparable farmers. This is a reasonable assumption in times of increasing credit supply (in a credit cycle boom). However, this also represents the major weakness of the presented approach as the potential strategic behavior of lenders in the case of a credit cycle bust may mean that this assumption no longer holds. Some path dependency in lending behavior could be expected in a credit cycle bust, where farmers with a large loan arrangement would be able to borrow money for going concern, while farmers in stronger financial positions would be unable to debt finance investments. Issuing more credit to weak or insolvent farmers can reduce the expected loss for the bank if there is a fair chance that the farmer will make it through the crisis. Furthermore, the bank may expect lower losses given default, at a later point in time. Foreclosing on multiple farms at the same time may have systemic effects and reduce the value of collateral in the entire agricultural loan portfolio if the real estate market is flooded with a supply of farms. Such action would increase the bank's own funding costs and may not minimize the losses given default. A likely strategy for the lenders is therefore to foreclose on insolvent and defaulting farmers at a slow pace. In our context, this type of lender behavior may pose a methodological problem, in the sense that it may not be possible for farmers to borrow in line with the maximum debt of their fellow farmers if they so desire. During a credit cycle boom, the model presented is considered a reliable measure of access to credit, while during a credit cycle bust, the measure may be weakened by the strategic considerations of lenders.

The model may suffer from minor omitted variable bias as off balance sheet assets may represent collateral. Some farms may be able to raise collateral from assets which do not appear on the balance sheet. Notably, family members are known to use their assets to raise collateral for loans to other family members. No data is available on the extent of this problem and while it is not a major methodological problem in the authors' view, it is nevertheless a recognized caveat. The inputs in the model were chosen as they convey the important factors of collateral value when issuing loans in the agricultural sector in Denmark.

2.4 Data

The data set consists of an unbalanced panel of account data from 1996 to 2009. The data were retrieved from the Knowledge Centre for Agriculture's accounting database, which stores a large sample of the accounts made in the partnership Danish Agricultural Advisory Service.

Table 2.1. Number of farms in each subsector in the unbalanced dataset

Number of farms in each subsector				Number of farms relative to years in dataset			
Year	Crop	Dairy	Pigs	Years in dataset	Crop	Dairy	Pigs
1996	897	6,154	3,180	1	1,218	2,346	1,689
1997	842	5,592	3,072	2	643	2,130	1,522
1998	795	5,428	2,746	3	443	1,850	1,262
1999	728	4,760	2,538	4	364	1,573	1,017
2000	649	4,296	2,517	5	209	1,191	779
2001	602	4,093	2,552	6	183	1,536	725
2002	522	3,489	2,212	7	94	857	406
2003	418	2,338	1,448	8	62	469	237
2004	627	3,011	1,710	9	35	201	140
2005	719	3,048	1,858	10	34	166	97
2006	730	2,855	2,165	11	20	130	88
2007	793	2,697	1,632	12	16	135	53
2008	767	2,491	1,428	13	7	88	33
2009	683	1,411	1,251	14	2	45	34

Source: Knowledge Centre for Agriculture's accounting database

The measure of access to credit is based on a benchmarking approach for farmers with homogenous production. To secure the homogeneity of the farms, they are split into the three main subsectors of Danish agriculture: crop, dairy, and pig production. All farms in the sample had to have a workload of at least 1,665 hours per year (full time) and focus on farm production. Therefore, the non-farm

assets are less than the farm assets and the farmland makes up at least half of the total amount of land (excluding farms which are mainly involved in forestry). These requirements are general to the crop, dairy, and pig models, but individual model constraints are applied to secure homogenous production for each subsector. Few outliers were detected and deleted which resulted in the dataset presented in Table 2.1. The left-hand side of the table depicts the number of farms in each of the three models in the analyzed period, while the right-hand side depicts the number of years that farms are in the dataset. The main asset and the main source of collateral for farmers is land of which there are four types in the model: soil type 1 (clay); soil type 2 (sandy); non-farmland (forest, meadows, roads, etc.) and farmland which has been leased out. There are five other inputs in the crop model: assets outside agriculture (book value); equipment (book value); EBIT; operator age, and the number of slaughter pigs as a proxy for the value of the buildings (it is not uncommon to see crop farms with some slaughter pig production).

The model for specialized dairy farms includes the number of cows, the amount of milking quota and the number of heifers to adjust for the additional collateral value of the milk production related facilities and value of quota. The model for specialized pig farms includes the number of sows and the number of piglets produced to adjust for the additional collateral value of the pig production facilities. In Table 2.2, the means of all model variables are presented. The 'Model' column identifies which models the variables enter.

We find that the book valuation of assets in Danish farm accounts is biased, among other things, because of a change in accounting principles as argued earlier. The book valuation and market value of agricultural assets have been in an alignment process during the past decade, but the market value of highly illiquid and highly specific assets, such as those in agriculture, is uncertain. We develop a measure which can capture the development of access to credit using non-parametric methods with minimum reliance on the book valuation.

Three inputs are, however, measured monetarily. These are the assets outside agriculture, equipment, and EBIT. Debt and assets outside agriculture are deflated with the consumer price index (Statistics Denmark, 2010), while equipment is deflated with the equipment value index (Statens Jordbrugs- og Fiskeriøkonomiske Institut, 1994 to 2000; Fødevareøkonomisk Institut, 2001 to 2009). The crop mix changed in Denmark during the study period. Winter wheat substituted spring

barley thereby changing the cash flow and potentially affecting the debt level. This effect is, however, very minor and therefore is not controlled for in this paper. We have chosen not to correct for the development in productivity over time, or price changes in farm products (crops, meat and milk). Any development in productivity or prices, which explains a change in profitability, is captured by our management proxy, EBIT.

Table 2.2. Model input and output means for the crop, dairy and pig models

Mean of all years	Model*)	Crop	Dairy	Pigs
Clay soil, hectares	[C, D, P]	63.8	13.7	37.9
Sandy soil, hectares	[C, D, P]	34.8	49.4	38.7
Non-farmland, hectares	[C, D, P]	7.5	4.9	6.6
Farmland leased out, hectares	[C, D, P]	1.4	0.8	1.5
Dairy cows	[D]	-	80.5	-
Heifers	[D]	-	79.4	-
Milking quota; 1,000 kg	[D]	-	607	-
Sows	[P]	-	-	192
Piglets	[P]	-	-	4,242
Slaughter pigs	[C, D, P]	541	70	2,845
Operator age	[C, D, P]	48	46	46
Assets outside agriculture; 1,000 €	[C, D, P]	345	164	261
Equipment value; 1,000 €	[C, D, P]	148	111	175
EBIT, 1,000 €	[C, D, P]	89	77	94
Debt; 1,000 € (Output)	[C, D, P]	965	821	1,155

*) C = Crop model, D = Dairy model, and P = Pig model.

Source: Knowledge Centre for Agriculture's accounting database

The non-parametric DEA-method is sensitive to measurement errors as no stochastic elements are inherent in the model. One way to quantify the sensitivity is by use of the bootstrapping method. Hence the DDi estimates and the decomposed estimates are bootstrapped with Hall Percentile intervals based on differences (Simar & Wilson, 2000). The basic idea of bootstrapping is to mimic the original production set, in this case the debt possibility set, by drawing a random sample and replacing the original data to create pseudo-samples conditional on outputs (Bogetoft & Otto, 2010). The random sample is biased, as it is a subsample of the original data. Hence, the data is bias-corrected prior to drawing the random sample and afterwards the DDi is calculated based on the random sample of bias corrected inputs and outputs. Furthermore, the bootstrap estimates are smoothed and the temporal correlation between periods is handled as in Simar and Wilson (1999). The bootstrap procedure is repeated 2,000 times for each observation. Results from bootstrapping of the DDi esti-

mates are used to analyze sensitivity and to generate confidence intervals for each of the decomposed measures.

2.5 Empirical Results

2.5.1 ESTIMATION OF DEA AND DEBT DEVELOPMENT INDEX SCORES

The estimations are performed by the FEAR package (Wilson, 2008) for the statistical environment 'R' (R Development Core Team 2010). The results show an increasing average debt capacity during the period 1996 to 2009. This is consistent with the hypothesis of increasing access to credit. A farmer with a debt capacity change of 2.0 in 2009 could borrow twice as much in 2009 compared to 1996 when controlled for earnings and when debt and other monetarily measures are deflated.

The debt capacity change and the debt capacity utilization change are the important results of the model, while the scale-related changes are minor. The mean of the change scores from the reference year 1996 to the year in question is calculated for all farmers with scores defined. The last years of the 1990s did not add substantially to debt capacity. In 2004, however, the increase in debt capacity in Danish agriculture accelerated. The development in debt capacity change is illustrated in Figure 2.3 for the three subsectors.

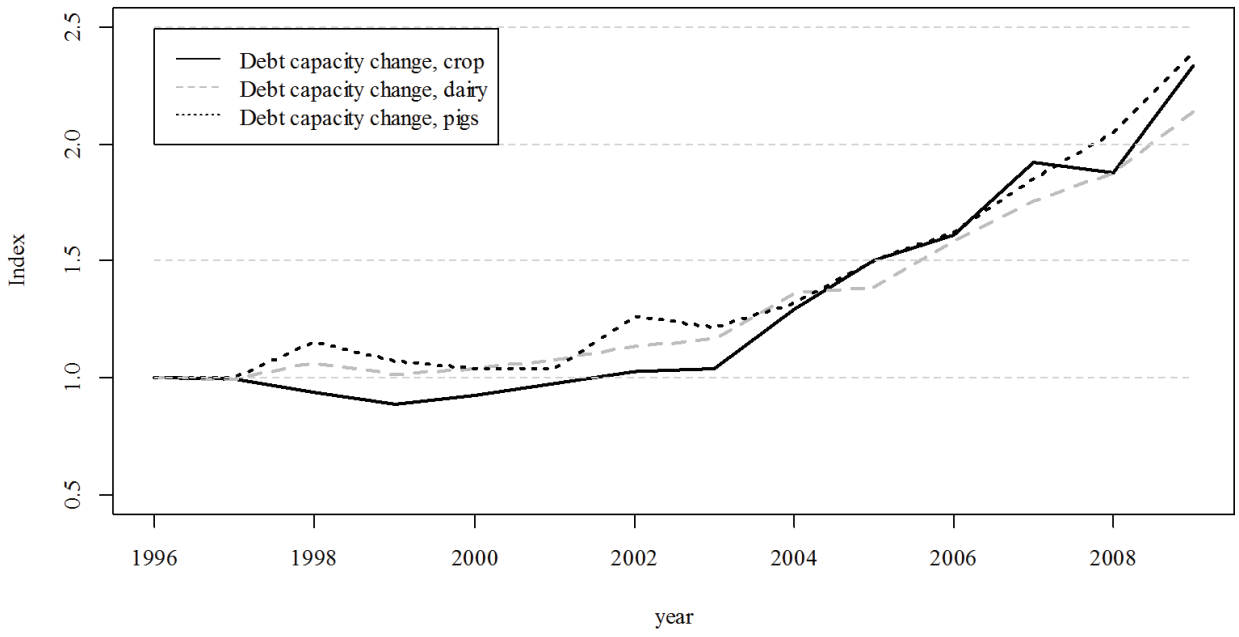

Figure 2.3: Debt capacity change for three production types

The mean debt capacity utilization was roughly the same level across the sectors in 1996, with a mean utilization of 0.62 for crop, 0.58 for dairy and 0.66 for pigs. The mean debt utilization and the results from the decomposition of the DDi are presented in Table 2.3 for the years 2004 to 2009. The DDi and the components are listed on the right-hand side.

Table 2.3.

Mean debt capacity utilization and Debt Development index decomposition from 2004 to 2009

Year	Mean debt capacity utilization	No. of farms both years*	Debt Devel-opment index	Change in debt capacity utilization	Scale related change in debt capacity utilization	Change in debt capacity	Scale related change in debt capacity
				Crop			
2004	0.61	64	1.346	1.081	0.938	1.296	1.048
2005	0.62	64	1.617	1.113	0.931	1.500	1.065
2006	0.52	57	1.436	0.911	0.939	1.608	1.046
2007	0.46	55	1.515	0.817	0.920	1.923	1.093
2008	0.50	46	1.654	0.918	0.919	1.875	1.070
2009	0.50	35	1.958	0.855	0.965	2.334	1.008
				Dairy			
2004	0.61	617	1.496	1.114	0.919	1.365	1.134
2005	0.60	538	1.532	1.098	0.919	1.385	1.154
2006	0.57	437	1.663	1.061	0.899	1.586	1.163
2007	0.54	364	1.772	1.021	0.918	1.756	1.181
2008	0.56	295	1.929	1.011	0.905	1.880	1.198
2009	0.63	152	2.385	1.176	0.905	2.137	1.139
				Pigs			
2004	0.78	265	1.562	1.252	0.937	1.316	1.070
2005	0.76	231	1.675	1.142	0.915	1.503	1.122
2006	0.74	252	1.757	1.133	0.911	1.624	1.112
2007	0.76	143	2.157	1.168	0.909	1.854	1.149
2008	0.80	99	2.501	1.221	0.941	2.051	1.090
2009	0.79	87	2.645	1.204	0.941	2.391	1.151

* with 1996 as the base year for farmers in the dataset in 1996 and the year in question.

The change in debt capacity utilization is below 1 for crop, close to 1 for dairy and around 1.2 for pigs. This reflects the development in the mean debt capacity utilization which fell to 0.50 for crop, increased to 0.63 for dairy and increased to 0.79 for pigs in 2009. The debt capacity utilization can be interpreted as the change in debt to debt capacity ratio, which is a good measure of credit reserves and is closely related to the debt to asset ratio when controlling for management, age, and the

lender's valuation of assets. The scale related changes for both debt capacity and debt capacity utilization range from 0.899 to 1.198 for all three subsectors, which suggests that the change in scale does not cause changes in debt structure. The main measure in Table 2.3 is the debt capacity change, which roughly doubled in the period, also shown in Figure 2.3. This reflects an outward move of the VRS debt possibility frontier.

The interpretation of the numbers in Table 2.3 can be illustrated by the following example: Suppose you were a pig farmer in 1996 with total liabilities of €1,000,000 and an estimated maximum debt capacity of €2,000,000 based on the most indebted comparable farms. Your debt capacity utilization was 50% and your credit reserves were estimated at €1,000,000. In 2009, the change in debt capacity compared to 1996 was 2.391, which means that the maximum debt capacity increased to 2.391 x €2,000,000 = €4,782,000, holding assets and management level constant, adjusted for inflation. If the debt of your farm remained constant at €1,000,000 (adjusted for inflation), your debt capacity utilization would be 1,000,000 / 4,782,000 = 20.9 % and your credit reserves would be €3,782,000. Now suppose that your debt capacity utilization followed the sector level change in debt capacity utilization, i.e. 1.204. Then your debt capacity utilization in 2009 would be 50% x 1.204 = 60.2%. This means that the total liabilities would be €4,782,000 x 60.2 % = €2,878,764 and your credit reserves would be €1.903.236.

The results in Table 2.3 are the means of the scores for farmers in the sample in 1996 and the year in question. The measure is biased because it is only calculated for the farmers who were farmers in 1996. Operator age is used as an input and the farmers in the measure for 2009 are older than the average farmer. Also, some farmers start with a small farm and build up a larger farm. Hence it is expected that the debt capacity change is measured at the part of the frontier where the farmers are older and where the farms are larger. Finally, the number of accounts included in the mean calculation decreases with time.

The debt possibility set in 2009 consists of 683 farms (see Table 2.1) for the crop producers, and the efficiency estimates are calculated on the basis of this debt possibility set. The average DDi change for crop producers is estimated based on the 35 farms in the data set in both 1996 and 2009. These farms are not representative, as the farmers had been in farming for at least 14 years in 2009, which precludes young farmers. This may constitute a survivorship bias. It is important to note, however,

that this is not a bias in the estimation of the frontier. As all data are included in this process, the possible bias is because development is not measured homogeneously on the frontier. A solution to this issue is to measure the mean farm. Each input and output in the mean farm is the mean of all farmers for the relevant year within the production type. This average farmer does not age. The results for the mean farm show no significant difference, which suggests that the bias is minor. Measuring the development at 'interesting' places on the frontier may be seen as tantamount to the practice used in Logit and Probit analysis where we want to measure response to marginal changes in x_j at 'interesting' values of x, which is often, but not always the mean (Wooldridge, 2002).

The change in debt capacity generally drives the change in the DDi over the years. Scale effects tend to be minor, while the debt capacity utilization has some positive effects on DDi for dairy and pig farms and a negative effect on DDi for crop farms. The ability to raise debt increased from 1996 to more recent years, which is displayed in Table 2.3. This ability was primarily utilized by the Danish dairy and pig farmers, while crop farmers seem to have been self-imposing more restraints on the use of credit as change in debt capacity utilization was above one for dairy and pig farmers, but below one for crop farmers in 2006 to 2009.

2.5.2 BOOTSTRAP RESULTS

Bootstrapping makes statistical inference possible based on the empirical distribution of the bootstrap estimates of the decomposed index. The bootstrap is used to identify the number of farms for which there is a statistically significant debt capacity change at the 5 per cent level. Figure 2.4 shows the share of farms for which there is an expansion in the debt capacity at the 95 per cent confidence level.

In summary, the results show that ease of access to credit increased significantly from 1996 up to the global financial crisis with the magnitude of the increase being roughly double. Our debt capacity measure shows increases in the magnitude of 76 - 92 per cent from 1996 to 2007. From 2004, all three subsectors have a large proportion of farms with a significant increase in the debt capacity (change in debt capacity > 1, at the 95% confidence level). There is no doubt that access to credit was easier in Danish agriculture in 2007 than it was in 1996. What is puzzling about our results is that access to credit seemed to increase during the financial crisis in 2008 and 2009. Our measure does not distinguish between debt generated for investment finance and debt generated to cover

operating losses. The development in debt is especially difficult to track in transition periods early in a crisis when investment finance becomes constrained, but current operations are financed (as lenders consider this to be the loss minimizing strategy). With some differences across the subsectors, many farmers incurred losses on financial arrangements as well as losses on current operations during the crisis. These farmers experienced increasing debt capacity (utilization), drawing on their credit reserves, even though they were experiencing decreasing access to investment finance and were possibly credit constrained in executing profitable investments. The measure does not distinguish between the behavioral or strategic reasoning behind loan approvals or credit expansion. However, we believe that Danish farmers experience greater credit constraints now, than they did prior to the financial crisis.

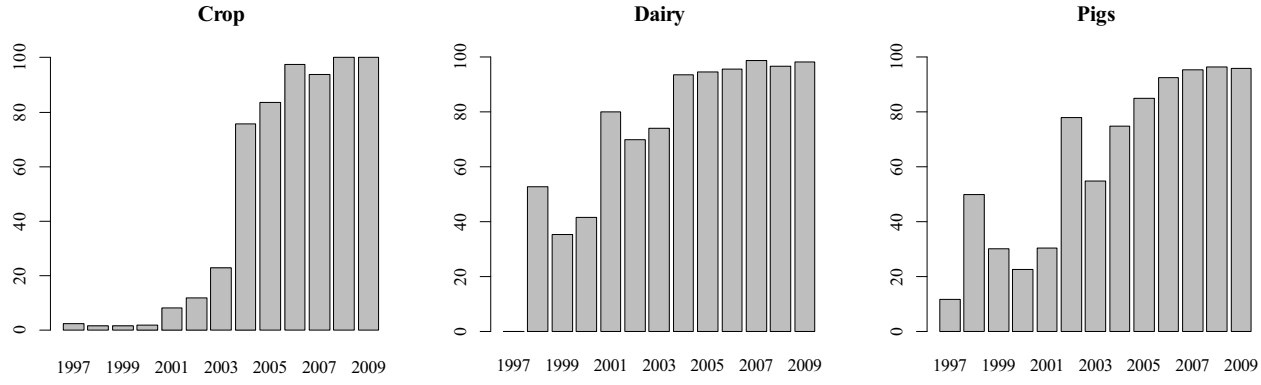

Figure 2.4. Share of farms with a significant increase in debt capacity since 1996

* Due to computational burden, results for dairy are not reported for 1997.

2.6 Conclusion

We suggest a non-parametric measure for access to credit based on DEA. Our measure is based on the decomposition of the Malmquist index which is well-known in productivity analysis. Our measure captures many aspects of access to credit and credit reserves based on a minimum of assumptions. Our alternative measure is a valuable complement to the qualitative surveys produced by central banks, for sectors or datasets where parametric models are not applicable. We apply our measure to Danish farm accounting data, as agriculture is one of the sectors for which we consider our measure to be applicable.

The central contribution of the paper is the use of non-parametric DEA methods in the credit access literature and the notion of a debt possibility frontier. There is great research potential in refining the model specifications and exploring applications. One avenue for further research could be to look at possible differences in the movement of the frontier at different farm sizes, e.g. different input levels. Sectors with relatively homogeneous agents and a lack of a reliable valuation of assets seem to be cases where the non-parametric approach could be a relevant alternative to the parametric approaches used today. Measures of credit constraints are often used in investment-cash flow sensitivity analyses which are based on assumptions of farmers as fully rational decision makers. Our direct measure is a more appropriate measure to use in such analyses, especially if the financial institutions are well developed.

Second stage analysis is a relatively common complement to DEA. There may be interesting avenues of future research in second stage analysis of the debt possibility frontier application. However, Simar and Wilson (2011) point to a number of assumptions in these analyses that are not well justified. One of the strengths of the methodology suggested in this paper is its simplicity and the relatively small number of assumptions, compared to the parametric models in the credit constraint literature. Applying second stage analysis may be useful, but one will have to increase the number of assumptions and to some extent compromise the above mentioned strengths. This must be balanced. Any further discussion or the application of second stage analysis is beyond the scope of this paper.

We find that debt capacity in Danish agriculture increased significantly during the period 1996 to 2009 and that the level roughly doubled. When banks and mortgage institutions are reviewing their lending policies, this finding could influence a shift from collateral-based lending to cash flow based lending, hopefully causing a healthier debt structure in Danish Agriculture in the future. Further, this finding has important implications for risk management and investment behavior. It is widely recognized that agricultural policy may crowd out market-based risk management (OECD, 2009), although the financial environment may also have a crowding out effect and be an important explanatory factor in the development of market-based risk management institutions. The usual risk balancing discussion is about whether or not an agricultural policy initiative that reduces farmer's business risk will lead farmers to increase their financial risk to hold total risk constant. Variation in the liquidity reserves (μ) in the Gabriel and Baker (1980) model, specifically credit reserves, will

have a major impact on agricultural risk management policy and should therefore be an integrated part of the analysis. However, this is largely ignored, OECD (2011) being a recent example.

In the case of Denmark, where the results of this paper show that access to credit has been increasing over a long period of time, the financial environment may help explain the absence of market-based risk management in agriculture. Danish farmers may have been thinking "Why hedge, if you can borrow?" The post financial crisis financial environment is changing in Denmark. These changes may be increasing the need for the development of market-based risk management institutions. Further research on the dynamics of the interaction between risk management, credit access and investment in changing financial environments is needed. The measure of access to credit presented here may be a valuable tool in this effort.

Chapter 3

Paper II

Financial Institutions Matter[8]

The Moderating Effect of the Financial Environment on Organizational Adaptation to Change

Abstract
Purpose – The paper explains the role of the financial environment in determining the organization of agricultural value chains.
Design/methodology/approach – The theoretical suggestions are built on induction based on exploratory observations from a cross-country comparison of the evolution of hog marketing arrangements in the U.S. and Denmark.
Findings – It is suggested that financial environments where access to credit is relatively unconstrained will complement forward integration through cooperatives.
Research limitations/implications – This challenges existing approaches to explaining organizational change in agriculture based on transaction cost economics (TCE) which focuses more narrowly on technological drivers of asset specificity. It is suggested that TCE approaches may omit important interaction effects between the asset specificity of technological developments and the financial environment.
Practical implications – The financial environment in Denmark is changing in the post GFC world which may be putting the existing organizational form under pressure and may lead to adaptive changes.

Keywords: Finance, Organization, Complementarity, Institutional change, Technological change.

Article Classification: Research paper

[8] Presented for a group of industry stakeholders at a seminar at the Knowledge Centre for Agriculture, September 24th 2012.

3.1 Introduction

This paper argues that the financial system plays a potentially important role in determining organizational forms. The asset specificity attributes of production technology are traditionally seen as a major determinant for organizational form in transaction cost economic (TCE) explanations of organization of agricultural marketing Significant changes in the structure and organization of the U.S. agricultural sector have been explained with transaction cost arguments where changes in asset specificity, uncertainty and/or frequency of exchange, driven by technological change, lead to changing organizational forms. The U.S. hog sector has shifted from being dominated by the spot market, to a situation in which production and marketing contracts and full backward vertical integration are the dominant governance structures. (MacDonald and Banker, 2004; MacDonald and McBride, 2009; MacDonald et al., 2004; Martinez and Zering, 2004; Martinez, 1999, 2002). In the meantime, the dominant governance structure in the Danish hog sector has been marketing cooperatives.

The role of the institutional environment with regard to finance has largely been ignored in the existing agricultural literature. This may be a serious caveat, as the financial environment may interact with technological developments in determining the distinct organizational form. Williamson (1991a, 1991b), being a major proponent of the TCE approach, also recognizes a systems approach where the different levels of social analysis interact or moderate each other, Aoki (2001, 2007) is another major proponent of this approach when high levels of endogeneity is accepted.

A large body of work has explained the organizational transformation of U.S. livestock agriculture based on TCE arguments (MacDonald et al., 2004; Martinez and Zering, 2004; Martinez, 1999, 2002) James *et al*. (2011) critiques these approaches in that they may omit the cumulative or interactive effects of different exogenous determinants of the organizational form and emphasize finance as one such determinant. This paper supports the critique raised by James *et al*. (2011) specifically the possibility of interaction effects in the form of complementarities between finance and organization in the process of adaption to technological change. However they do not necessarily have to be exogenous factors.

The paper poses the question: If the TCE arguments sufficiently explain organizational transformations as seen in the U.S., why has no organizational transformation taken place in Denmark,

which, from a technological view point, have seen a similar increase in the TCE drivers asset specificity, uncertainty and frequency of exchange?

Williamson (1991a, 1991b) explains, Japanese corporate organization with the complementary relation and the distinctive institutional supports of employment, subcontracting and banking. In a similar way, this paper will, argue that the distinctive institutional environment with regard to finance can help explain the differences in the evolution of organization in the agricultural value chains in the U.S. and Denmark. The analysis balances what Aoki (2001) calls the synchronic and the diachronic problem, on the one hand trying to understand the complexity and diversity of governance structure as an instance of multiple equilibriums, on the other hand trying to understand the process of institutional evolution and change in a framework consistent with an equilibrium view of institutions (Aoki, 2001).

This is a focus that puts the paper within New Institutional Economics where the primary research focus deals with level two and three of social analysis; the institutional environment level and the governance level respectively (Williamson, 2000). With a focus on the effects of differences in the institutional environment with regard to finance on the governance structure, the paper examines the interaction between the institutional environment level and the governance level, specifically the interaction between finance and organization, and the possible complementary effects between finance and some organizational forms. This is done with comparative institutional analysis based on induction from an inter-temporal cross-country comparison, the papers finds that interaction in the form of complementary effect between the financial environment and the organizational structure in agricultural value chains may exist in the process of adapting to technological change.

The historical comparison compares two cases. The U.S. case, in which organizational change occurs, is compared with the Danish case where no organizational change occurs, but which is in all other respects the same as the U.S. case. In doing so, the paper takes up the challenge posed by Ménard and Klein (2004) to apply a comparative approach to the study of organizational arrangements their innovation and their institutional environment. Based on stylized facts and with a special emphasis on the finance and risk management implications of different organizational arrangements, the study compares hog marketing arrangements in the U.S. and Denmark in the light of different institutional frameworks with regard to finance.

Figure 3.1 illustrates the basic claim of the paper; that while technological change may induce investments in co-specific assets, the degree to which this will lead to organizational adaptation is moderated by the institutional environment. Here, the institutional environment with regard to finance and risk management is emphasized. However, this does not necessarily mean that other dimensions of the institutional environment are less important, nor does it mean that the factors necessarily are exogenous, endogeneity and feedback loops will be discussed later.

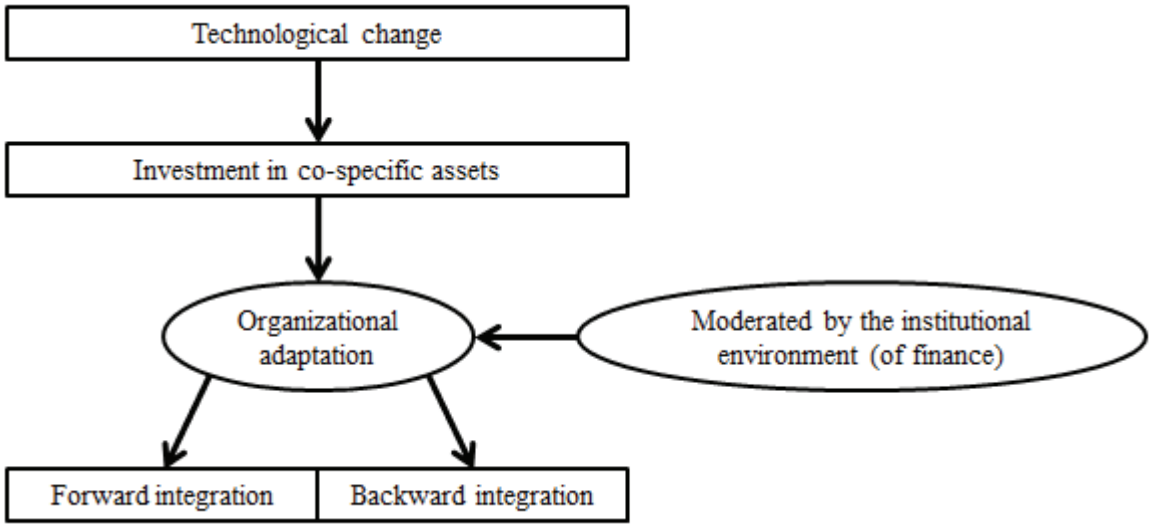

Figure 3.1: Asset specificity and institutional environment codetermine organizational form

While this paper can be seen as a building block which supports the systems approach, integrating the institutional environment level and the governance level of analysis as advocated by Williamson (1991a, 1991b) and Aoki (2001, 2007), the paper challenges the TCE view on debt and equity considerations, where debt and equity are seen as two different governance structures, one based on rules and another on discretion, and where the redeployability of the underlying asset is the determining factor (Williamson, 1988).

While the redeployability of the underlying assets is an important factor with regard to the use of debt, this paper argues that there is more to it than that. The use of debt plays a number of roles, including an important role with regard to risk management. The diverse roles of debt are important reasons why the institutional environment with regard to finance is argued to be an important moderating factor in the process of organizational adaptation.

The theoretical background for this claim is grounded in a holistic approach to a number of different theories of debt, TCE theories of technological drivers of asset specificity inducing organizational change and theories of cooperative organization.

3.2 Theoretical background

3.2.1 THE DIFFERENT CHARACTERISTICS OF DEBT

Different economic schools of thought emphasize different aspects of the phenomenon, debt. Williamson recognizes that the different perspectives of agency theory and TCE theory are "mainly complementary" (Williamson, 1988, p. 568). This section tries to bridge these perspectives with insights from corporate and agricultural finance literature, as the approach to debt in the literature is far from holistic. A more unified approach to debt, which acknowledges multiple aspects, is applied to the question of organizational form in agricultural value chains and the financial structure of sole proprietorships, the family farm being the archetypal sole proprietorship. A short introduction to these different aspects is warranted.

Classic financial theory is based on the separation theorem, where a combination of the efficient portfolio and the risk-free asset constructs dominant sets and separates the choice of where to be on the efficient portfolio frontier from the decision maker's risk preferences. In this line of theory, the role of debt is to extend the capital market line beyond the tangency point on the efficient portfolio. That is borrowing at the risk-free rate and leveraging the efficient portfolio instead of holding combinations of the risk-free asset and the efficient portfolio tangency point (Markowitz, 1952; Sharpe, 1964; Tobin, 1958)

Agency theory, pioneered by Jensen and Meckling (1976), sees debt as a financial instrument that adjusts risk and return through the leverage effect, much like the classic financial theory. Authors in this field do, however, implement the interrelated risk distorting effects of debt. The first is the incentive effect associated with a highly leveraged firm. If leverage is high, the lender will carry the downside of risky decisions (if the risky activity results in a financial loss, this will by a loss to the lender) while the owner (borrower) will get the upside of risky endeavors (the lender will only receive interest, if the activity turns out to be very profitable the gain will go to the borrower), this will induce the lender to risk adjust the cost of borrowing. Second, the incentive effect will induce the lender to incur monitoring costs, and adjust the cost of borrowing accordingly. Third is the cost

of bankruptcy and reorganization in cases where monitoring and pricing do not prevent default situations. Anticipating all these costs, the lender incorporates the costs into the price offered to the borrower, meaning that the borrower will carry the full wealth effect of agency costs associated with the use of debt.

"The existence and size of the agency costs [of debt and outside equity] depend on the nature of the monitoring [and bonding] costs, the tastes of managers for non-pecuniary benefits [the ability to signal this to lenders] and the supply of potential managers who are capable of financing the entire venture out of their personal wealth [as these agent will have competitive advantages, eliminating competition carrying agency costs, within the limits of their wealth]" (Jensen and Meckling, 1976, p. 330).

Jensen and Meckling (1976) base their model on an, initially, equity-financed entrepreneur who given an investment opportunity has to choose the right combination of debt and outside equity to finance the investment. Williamson calls the agency theory approach based on entrepreneurs "rather special" (Williamson, 1988, p. 578). Given the share of economic activity governed by SMEs compared to large corporations, one could however reverse this argument[9]. In relation to corporate finance, Williamson's critique is understandable, but in relation to agriculture, the focus of this paper, where farms are usually sole proprietorships or family partnerships, Jensen and Meckling's approach is the natural reference point.

Most literature relies on the price mechanism to convey the transaction cost and / or the agency cost of using debt. However, Stiglitz and Weiss (1981) show that credit rationing, which is a non-price mechanism, represents agency and transaction costs of imperfect information. Instead of debt becoming "available on progressively worse terms" (Williamson, 1988, p. 578), debt may simply not be available.

On the plus side of using debt, Modigliani and Miller (1958, 1963) formalized the tax incentives of debt instead of equity. Important as it is, it cannot explain all aspects of debt. Debt also enables agents to exercise profitable investment opportunities, which are beyond the limits of their personal

[9] "The [U.S.] small business share of private nonfarm GDP held relatively steady from 1998 through 2004 at 50 percent of the total" (Kobe, 2007, p. 26).

wealth, which is rational as long as the marginal returns from investment are above the marginal cost of debt including the agency costs of debt and as long as these costs are below the marginal costs of outside equity including the associated agency costs (Jensen and Meckling, 1976).

Jensen´s (1986) free cash flow concept showed how debt could reduce the agency cost of free cash flows by aligning the incentives of principals and agents. The theory is developed in the environment of two principals, the lender and the outside equity provider, and one agent, the manager and inside equity provider. In an agricultural context, there typically is no outside equity provider, but debt may still shift the farmer's focus from non-pecuniary goals to pecuniary goals as there are pecuniary obligations to meet. This can induce a higher level of effort by the owner-operator (Barry and Robison, 2001).

Agricultural finance literature following Baker (1968), and corporate finance literature following Donaldson (1961) have recognized the risk mitigating effect of unused credit reserves, which reduce the need to hold cash or other liquidity reserves. If debt is available, it can serve as a liquidity reserve. Keynes (1936) also realized the importance of liquidity and the role of debt and he described the precautionary motive for holding cash as dependent "on the cheapness and the reliability of methods of obtaining cash, when it is required, by some form of temporary borrowing, in particular by overdraft or its equivalent. For there is no necessity to hold idle cash to bridge over intervals if it can be obtained without difficulty at the moment when it is actually required" (Keynes, 1936, p. 196). Note that Keynes states that price as well as non-price mechanisms affect the use of borrowing, "cheapness" and "reliability", this is congruent with Stiglitz and Weiss's (1981) emphasis on non-price mechanisms, which generally do not receive the attention they deserve. Even Modigliani and Miller (1963) recognize the importance of credit reserves in addition to their focus on bankruptcy costs and tax advantages of using debt, stating that: "These additional considerations, which are typically grouped under the rubric of "the need for preserving flexibility," will normally imply the maintenance by the corporation of a substantial reserve of untapped borrowing power. The tax advantage of debt may well tend to lower the optimal size of that reserve, but it is hard to believe that advantages of the size contemplated under our model could justify any substantial reduction, let alone their complete elimination" (Modigliani and Miller, 1963, p. 442).

TCE sees debt as a governance structure based on rules rather than discretion (Williamson, 1988). Having the modern corporation in mind, the focus is turned to project finance which yields important insights, as the importance of the redeployability characteristics of the investment assets are highlighted. In the case of default, assets will be liquidated and lenders will recover their claims to the extent that the assets in question are redeployable. The more specific the assets, the less the value of a pre-emptive claim and the less attractive the terms of debt that will be offered eventually leaving the investment opportunity to be equity financed or not exercised at all.

The link between project finance and corporate capital structure is, however, unclear, as the composition of the portfolio of assets in the firm is not explained. Thus the possibility of interaction effects on the financing and risk management side of different investment projects is ignored. Donaldson (1961, p. 143) puts it like this: "within a single corporate entity the risk of cash insolvency must be considered on a company-wide basis."

While the redeployability of an asset, which Williamson (1988) emphasizes, affects the potential loss a lender will expect given default, Williamson (1988) ignores the probability of default which may be affected by the interaction in the portfolio of assets which the legal borrowing entity holds. Furthermore, the TCE approach to debt ignores that fact that a loan which is based on a single investment project will be part of a portfolio of loans, from the lenders point of view, and as such, portfolio considerations will apply on both sides of the transaction; "one person's liability, is another person's asset" (Eggertsson and Krugman, 2012, p. 1471).

In this paper all of the above mentioned aspects of using debts are integrated. Summing up they are:

1) The redeployability characteristics of the investment assets matter (collateral)
2) Unused credit capacity serves as a flexible liquidity reserve
3) Use of debt is restricted by both price and quantity constraints
4) Debt affects the risk / return structure of investments through the leverage effect
5) There are tax advantages to the use of debt
6) Debt shifts the management focus from non-pecuniary to pecuniary gains

3.2.2 OUTSIDE EQUITY

The TCE account of the cost of using outside equity in agriculture, following Allen and Lueck (1998), is based on uncertainty and (in)frequency and not the predominant TCE factor, asset specificity. The cost of outside equity stems from the opportunity for opportunistic behavior based on asymmetric information about the effects of random shocks of nature (uncertainty) as well as labor effort levels and the relatively high cost related to monitoring the labor effort in short and seasonal (infrequent) production stages involving few distinct tasks. This corroborates agency theory's explanation of the cost of using outside equity, as it stems from incentive dilution due to increased incentive for on-the-job consumption by the management and the monitoring costs involved in curtailing this incentive. Jensen and Meckling (1976) stress that reduced effort can be seen as a form of on-the-job consumption[10].

3.2.3 THE PECKING ORDER THEORY OF FINANCE AND TCE

The pecking-order theory of finance is attributed to Donaldson (1961). Briefly summarized it states that firms prefer retained earnings over debt and debt over the issuing of outside equity. Williamson (1988) identifies the following caveats in the pecking-order theory; 1) a lack of reference to the characteristics of the assets in pecking-order theory, and; 2) a lack of TCE justification for preferring retained earnings over debt.

Williamson compares equity to intra firm coordination and debt to markets in a parallelization of Coase's (1937) central question, firm or market, with the question of equity or debt; "parallels between corporate finance and vertical integration are especially striking" (Williamson, 1988, p. 576). If, however, one not only looks at the characteristics of the assets which Williamson stresses, but also looks at the characteristics of the financial side, one will find different types of debt and the central tenet of agency theory, different types of equity. The simplification of the asset side, of which agency theory may be guilty, is mirrored by the simplification of the liabilities and equity

[10] "We shall continue to characterize the agency conflict between the owner-manager and outside shareholders as deriving from the manager's tendency to appropriate perquisites out of the firm's resources for his own consumption. However, we do not mean to leave the impression that this is the only or even the most important source of conflict. Indeed, it is likely that the most important conflict arises from the fact that as the manager's ownership claim falls, his incentive to devote significant effort to creative activities such as searching out new profitable ventures falls. He may in fact avoid such ventures simply because it requires too much trouble or effort on his part to manage or to learn about new technologies. Avoidance of these personal costs and the anxieties that go with them also represent a source of on-the-job utility to him and can result in the value of the firm being substantially lower than it otherwise could be" (Jensen and Meckling, 1976, p. 313).

side of the balance sheet, of which TCE is guilty. Describing both sides in more detail is relatively straight forward and bridges the two approaches to finance.

A TCE justification for preferring retained earnings over debt and outside equity emerges when the distinction between market acquisition and the internal production of capital as merely debt and equity is refined. More appropriately, retained earnings could parallel internal production and both debt and outside equity could parallel the market acquisition of products. Simply put, there is such a thing as an (outside) equity market and a debt market. Transactions in both these markets are associated with transaction costs. A TCE justification for preferring retained earnings over debt in corporate-type firms could be that the joint action of the payment of dividends and obtaining debt could be associated with more costs than simply retaining the earnings for the simple reason that it generates a lot of transactions. Tax issues are ignored by Williamson, but they most likely play a major role in reality. Agency arguments for the pecking order theory, such as asymmetric information, adverse selection, moral hazard and signaling still apply.

In the case of the sole proprietorship, preferring retained earnings over debt when financing investment opportunities is essentially a question of the choice between consumption and savings. For the sole proprietor, residual earnings that are not consumed are saved, and savings in any form are an investment. Under the assumption of a stabile consumption behavior such as predicted by the permanent income hypothesis, windfall earnings will by definition be preferred to debt in financing investments, including bank deposits. As long as outside equity is not introduced, private savings and equity financed investments will be identical.

3.2.4 TCE AND TECHNOLOGICAL CHANGE

Transaction cost economics generally explains organizational form on the basis of three factors; asset specificity, uncertainty and frequency (Milgrom and Roberts, 1990). Asset specificity is the main explanatory factor, as the specificity of assets has a major effect on the risk of post contractual opportunistic behavior.

If the value of an asset is related to the relationship between contracting parties, the risk of opportunistic behavior may exist as one party may try to appropriate quasi-rents (Klein *et al*., 1978) from relationship specific investments made by the other party. Realizing this risk, decision makers will

be reluctant to make such investments based on inter-firm relationships. However, relation specific assets will stimulate integration to the extent that internalizing the relationship will mitigate the cost of opportunistic behavior.

Asset specificity takes six different forms: 1) Site specificity; 2) Physical asset specificity; 3) Human-asset specificity; 4) Brand-name capital; 5) Dedicated asset, and; 6) Temporal specificity (Williamson, 1991).

The increasing specialization of agricultural production, especially livestock, is driven by developments in production technology, which can only be reaped through increasing scale (Key and McBride, 2003, 2007; MacDonald and McBride, 2009). This is also the case in the processing stage of the agricultural value chain. Reacting to special consumer demands may also lead to the need for investment at both the production (farm) level and the processing level. These investments are relationship-specific, and therefore difficult to motivate without organizational forms that reduce the risk of opportunistic behavior because bilateral dependency poses added contracting hazards.

In agriculture, the existence of cooperatives has long been explained by their role in the mitigation of the hold-up problem[11] (Ménard, 2004; Sexton, 1990). Processing and marketing cooperatives are a form of forward integration, where farmers (cooperatively) own processing facilities and market their products. This organizational form has been instrumental in the swift adoption of technological developments. An alternative to the cooperative forward integration is backward integration, where firms originating in the processing stage of the agricultural value chain, integrate primary production stages with their processing activities. This can be through inter-firm contracts (quasi-integration) or by vertical integration.

A central premise in TCE and agency theory is, however, that contracts "can never specify exactly what actions are to be taken and what payments are to be made in all possible future contingencies" (Milgrom and Roberts, 1990, p. 61) and must therefore be incomplete. This leads to the second factor which explains organizational form, uncertainty, which is the primary reason for the impossibility of complete contracts. Greater uncertainty leads to greater costs of doing business, because rigid contracts, on the one hand, are less likely to determine efficient outcomes, while flexible contracts,

[11] The hold-up problem being the agency theory label for post contractual opportunistic behaviour (Klein *et al*., 1978; Staatz, 1987)

on the other hand, are open to interpretation and thus to costly renegotiation (Milgrom and Roberts, 1990).

The complexity of the contractual arrangements, which determine the organizational form, is related to the frequency of transactions. As the cost of complex arrangements is sunk, they are more likely to be made where frequent transactions are expected.

Co-specialized assets, that is cases where both sides of the transaction have made specific investments, are more likely to be co-owned (Klein *et al*., 1978). In cases where assets are non-transferable, such as human capital, the degree of co-specialization determines the organizational structure (Grossman and Hart, 1986).

Allen and Lueck's (1998) explanation for agricultural organization is along these lines. Based on the observation that agriculture is both seasonal and random, they conclude that these two factors lead to potential moral hazard problems and limitations regarding the gains from specialization. This makes the family farm an efficient organizational form as the moral hazard problem is eliminated or reduced without sacrificing significant gains from specialization. If seasonality and randomness can be mitigated, the family farm becomes a less obvious organizational form as alternatives become more competitive.

The limitations to the gains from specialization are related to the relatively low level of asset specificity of agricultural assets, as many farmers usually use somewhat similar production technologies. Land is by definition spatially specific, but it can be used for the production of a variety of alternatives, often with relatively little difference in the return to land. Most agricultural machinery (tractors, etc.) is also fairly general purpose and mobile. The seasonal nature of production means that the specialization of human and physical capital is limited. For example, a combine harvester is only productive for a couple of months a year, which is why specializing regarding the use of this machine has it limits.

Given the exposure to the natural environment, production results are prone to uncertainty. This entails a moral hazard problem as monitoring the effort of hired management is costly and the effort level of management cannot be determined by observing results (a good result may be due to signif-

icant effort or good luck, while a bad result may be due to minimal effort or bad luck). This results in the family farm organization being the dominant organizational form as management and significant parts of other labor inputs are supplied by the owner along with equity capital with no associated monitoring costs. There is no separation of ownership and control in the Berle and Means (1932) sense.

The degree to which the ability to control the natural environment is harnessed by technological change, for example through modern livestock confinement systems, decreases the degree to which the family farm is the obvious organizational form. Reducing the effects of seasonality and uncertainty is usually contingent on large location-specific investments involving high degrees of specialization. The production environment becomes controlled or controllable, which is why production failures are linked to failures of management, which in turn reduces the moral hazard problem associated with asymmetric information.

Technological changes which open the possibility of exploiting economics of scale in livestock agriculture almost always involve specific investment (Key and McBride, 2003, 2007; MacDonald and McBride, 2009). These investments have to be finances, following the pecking order theory, by inside equity, debt or outside equity in preferred order. Limits to the access to credit, due to prohibitive prices or rationing, may lead to specialization. Focusing available capital on fewer more specialized activities enables production at a larger scale, but focused on more narrow stages of production. If the perceived benefits of investment are high enough, increased use of outside capital may be justified as long as the marginal cost of capital (including agency costs) is below the marginal return of the investment. Likewise, if the perceived marginal cost of capital (including agency costs) is declining, more investment opportunities may become attractive, and the use of outside capital may increase.

The value of many agricultural commodities is dependent on timing, as they are perishable, non-storable and/or will decline in value with sub-optimal market timing. This leads to a special kind of asset specificity called temporal specificity (Masten, 2000). Milk will spoil quickly if it is not stored, transported and processed in a proper and timely fashion. In a similar manner, hogs may only be within their target weight class for a short period of time. Because of temporal specificity,

the marketing of livestock commodities has to be coordinated to avoid a loss of production and rent-seeking behavior.

When spot markets have failed in the coordination of production, processing and the marketing of perishable livestock commodities such as milk or meat, cooperatives have historically been organized to deal with the coordination problem, and more recently coordination has been accomplished through contracting. These organizational forms maintain the incentive structure of the family farm, avoiding moral hazard and eliminating (or reducing) monitoring costs, while mitigating the transaction costs associated with asset specificity due to specialization and product characteristics. While full-scale backward integration also mitigates the transaction costs, it introduces the moral hazard problem with hired management and thus monitoring costs, to the extent that seasonality and/or the uncertainty (randomness) of nature are not fully controlled.

3.2.5 COOPERATIVE ORGANIZATION IN THE AGRICULTURAL VALUE CHAIN

Cooperatives are hybrid organizational forms between market and hierarchies (Ménard, 2004) that reduce some of the transaction cost associated with asset specificity. The fact that many agricultural commodities have temporal and spatially specific characteristics means that transportation is an important but costly factor (Masten, 2000). Combined with relatively few processing facilities, due to economics of scale at the processing stage, markets for agricultural raw commodities tend to have oligopsonistic characteristics. Sexton (1990) shows how the existence of cooperatives, in markets like this, have a procompetitive effect on non-cooperative rivals, as cooperatives reduce the possibility of (tacit) collusion among the non-cooperative processors. In this way, cooperatives reduce transaction costs by working as a completive yardstick (Sexton, 1990) that reduces the risk of post-contractual opportunistic behavior.

Technological changes are the underlying driver of development in agriculture, where other organizational forms may lead to hold-up problems and thereby reduce investment and hamper technological adoption; cooperatives establish farmers as residual claimants and reduce the hold-up problem (Fulton, 1995). The major weakness of cooperatives is the vaguely defined property rights (Cook, 1995). This weakness leads to a number of problems including the horizon, portfolio, control, free-rider and influence cost problem that may reduce incentives to invest in the cooperative (Royer, 1999), although some problems may lead to overinvestment (Olesen, 2007). Another problem is the

quantity control problem in which the individual member does not carry all the costs of quantity changes, as the marginal effect associated with the cooperative revenue and processing cost functions are shared between all members proportionately (Bogetoft and Olesen, 2000; Fulton, 1995; Hansen, 2011). These problems may, however, be overcome or mitigated by organizational innovations such as the New Generation Cooperative (Burress et al., 2008).

3.2.6 THE RISK MANAGEMENT ROLE OF ORGANIZATIONS - EFFECT OF POLICY, TECHNOLOGY AND FINANCE

Increased specialization and the increased use of outside capital in the form of debt will increase the risk exposure of the firm (farm) in two ways. The market risk exposure to competitive prices will increase as production is specialized and increased. Specialization will also increase the risk of hold-up dependent on TCE characteristics, asset specificity, uncertainty and frequency.

The ability to manage both these types of risk cost efficiently differs across organizational arrangements. Typically, the organizational literature focuses on the risk of hold-up and other TCE related risks. The ability to manage the more simple market risks is, however, also affected by the organizational form. The extent to which organizational form copes with these issues depends on alternative arrangements which cope with risks. The OECD (2011) explains how agricultural policy may crowd out other risk management arrangements. The financial environment may have a similar effect in cases where the perceived access to credit leads decision makers to believe that they have large credit reserves.

Under institutional environmental conditions where market risks are low due to market stabilizing agricultural policy, and the existing market risk is managed by perceived credit reserves, it is only natural to expect that organizational development will have reduced focus on these types of risks, while maintaining the ability to cope with hold-up related risks.

Under institutional environmental conditions where production technology does not lead to a high risk of hold-up, i.e. under conditions of low asset specificity, low uncertainty and low frequency of transactions, but where the production is exposed to pure market related price risk, it is only natural to expect the organizational development will have less focus on hold-up related risks, and an in-

creased relative focus on market risks, for example through combined use of institutions such as spot and futures markets.

In institutional environments where the need to cope with both hold-up related risks and with market related risk it is natural to expect the organizational development to focus on both these issues through organizational or quasi-organizational arrangements such as integration or contract production. The dual aim of contract production to cope with both market and hold-up risk is recognized by MacDonald and Korb (2011) who analyze the development in agricultural contracting in the U.S.

Policy, technology and finance are important frames for the organizational form, because they affect the role the organization will have to play with regard to risk management. Some organizational forms may need to adapt in the event of changes in the institutional environment. Processing and marketing cooperatives, as seen in the Danish livestock sector, have evolved to cope with hold-up risks in environments where the need for a focus on market risks was reduced, initially due to diversified production on the farms, and later due to agricultural policy and a financial environment which provided the farmer with a perception of relatively large credit reserves (Paper I). Farms specialized due to technological developments, which may have been adopted quicker due to price stabilizing agricultural policies. Later, market risk increased due to changing agricultural policy, while more recently, the risk coping mechanism of credit reserves has been reduced due to the global financial crisis. An institutional vacuum may be appearing, in which Danish farmers are exposed to risk for which there are no longer any available coping mechanisms.

Market-based hedging mechanisms, such as futures markets, may not fill the gap, because farmers may be exposed to different price fluctuations in the physical market than in the futures market. This basis risk may be especially strong for cooperative members as their exposure on the physical market, while strongly related to market risk, is also related to the cooperative specific business risk associated with the cooperative's operations, market and strategic risks. Furthermore, there may be a lack of natural counterparts in these types of commodity futures markets, which is why they are difficult to establish.

Price risk management in the form of hedging is widely seen as a way to improve, or a prerequisite for, access to credit. A major rationale for commodity price hedging is improved access to credit, both in the general financial literature (Froot *et al*., 1993) and in the specific agricultural finance literature (Heifner, 1972) where "lenders in some instances are willing to provide more credit to farmers who hedge" (Turvey, 1989, p. 634). "Several of these studies have focused on hedging […] and its relationship to a producer's use of leverage. These studies generally conclude that hedging tends to increase as the farm's debt level rises" (Harwood *et al*., 1999, p. 39). These conclusions are in apparent contrast to the observation that price risk management activity (hedging) is higher and leverage is lower in the U.S. compared to Denmark where risk management activity is low and leverage is high. The line of research mentioned above tends to ignore the reverse argument, that ample access to credit or liquidity may crowd out the rationale for business risk management. Baker (1968), Barry and Baker (1971), Gabriel and Baker (1980), Keynes (1936) and Modigliani and Miller (1963), are examples of a recognition of this credit reserves argument.

The financial institutional environment may affect the perceived access to credit and thus the perceived credit reserves. This may have a major effect on investment behavior as well as risk management behavior. A major theme in the finance literature is credit constraints and investment cash flow sensitivities. This literature, however, focuses narrowly on external credit rationing which draws attention away from the more interesting "self-imposed limitations on credit use" (Barry and Baker, 1971, p. 222). Liquidity reserves have a small explicit effect on income or cash flow risk, "most of its influence is implicit in that it affects the production organization as well as the financial organization of the farm" (Gabriel and Baker, 1980, p. 562). Extending this line of reasoning, the perceived level of credit reserves will also affect the organization of marketing, e.g. spot market, cooperative marketing, contracting or vertical integration by the processor.

The question is what determines whether the coordination, technology adaptation or market risk management problems will be mitigated through market, quasi-forward or backward integration, other hybrid forms or a hierarchy? We suggest that the financial system plays a pivotal role in answering this question.

In the following, a cross country comparison of the development in the U.S. and Danish hog marketing arrangements is made in an effort to illustrate and exemplify the moderating role of the financial system in organizational adaptation to technological change.

3.3 Cross Country Comparison of Development in Hog Marketing

3.3.1 METHOD

John Stuart Mill is widely considered to be the father of the modern comparative method. This section follows the "Method of Difference" which is a comparative method that can be described as follows: "By comparing instances in which the phenomenon does occur, with instances in other respects similar in which it does not" (Mill, 1882, pp. 478-479).

In the empirical TCE literature, one of three general methods are applied: qualitative case studies, quantitative case studies, and cross-sectional econometric analysis (Shelanski and Klein, 1995). With regard to the role of the financial system and risk management, Williamson's (1991b) work on the Japanese corporation can be seen as a related qualitative case study. Woolverton and Sykuta (2009) apply a comparative institutional analysis to the question of farmers' hedging decisions and this paper can be considered as a related quantitative case study. Finally, Acemoglu *et al*. (2009) is an example of a related cross-sectional econometric analysis. Acemoglu *et al*. (2009) find interaction effects of financial development and contracting costs in a large multi-country, multi-industry analysis of vertical integration, linking TCE literature (Williamson, 1975, 1985) and property rights theories (PRT) (Grossman and Hart, 1986; Hart and Moore, 1990) with the body of work which emphasizes the importance of the institutional environment which governs the relationship between firms and financial intermediaries, i.e. the institutional environment with regard to finance (Banerjee and Newman, 1993; Kumar et al., 1999; Rajan and Zingales, 1998).

The aforementioned existing research on agricultural organization does not include the interaction effect of the institutional environment level and the governance level emphasized by Williamson (1991a, 1991b), Acemoglu *et al*. (2009) and James *et al*. (2011). Financial development and vertical integration are not unambiguous concepts, however. Instead of more or less developed financial systems (Acemoglu *et al*. 2009), more subtle differences in the financial institutions may affect organization. Likewise, the degree of vertical integration may also be refined with respect to direction, e.g. what determines whether vertical integration developments will be of forward or backward

integrating nature, in line with PRT? What determines other quasi-integrated hybrid organizational forms? These questions are not addressed by Acemoglu *et al*. (2009).

The cross-country comparison presented in the following is best described as an explorative comparative case study. Empirically, the cross-country comparison finds that complementary effects of the Danish financial system and the dominating cooperative form of processing and marketing livestock commodities may explain why technological change has been adopted in Denmark without organizational changes such as those seen in the U.S. This supports the proposition that financial institutions matter with regard to organizational adaptation to technological change.

3.3.2 THE DANISH AND U.S. HOG SECTORS

The Danish and U.S. pork industries are major export-oriented industries. Both have undergone substantial and somewhat similar structural changes over the past decades, driven largely by technological development. However, the development in the U.S. has been characterized by significant increase in vertical integration and the use of production and marketing contracts, whereas the Danish hog marketing procedures have been relatively stable, relying on traditional processing and marketing cooperatives.

Denmark is a major pork producing country with approximately 2 % of world production and a large share of world trade. The U.S. is an even larger producer with approximately 10 % of world production[12] (Foreign Agricultural Service / USDA, 2011). However, relative to its population, Danish production is much higher than in the U.S. with approximately nine times the per capita production of the USA. The U.S. production is, however, concentrated in two major clusters, one in southern Minnesota and Iowa which accounts for approximately 40 % of national production, and one in North Carolina which accounts for approximately 15 % of national production. Furthermore, approximately 30 % is located in the other "Heartland" states which neighbor the Minnesota / Iowa cluster and the Great Lakes. The per capita production of pork in the state of Iowa is approximately three times that of Denmark while the absolute production is roughly 170 % that of Denmark. Density measured per hectare is higher in Denmark as the total arable farmland in Iowa is more than four times that of Denmark (Danmarks Statistik, 2011; Economic Research Service / USDA, 2012).

[12] China is the largest pork producing and consuming country in the world with approximately 50% of world production and consumption (Foreign Agricultural Service / USDA, 2011).

Large scale structural changes have been followed by increasing size and specialization in both the U.S. and Danish hog operations during recent decades. From 1992 to 2004, the number of hog farms decreased by 70 % in the US and by roughly 63 % in Denmark, while the average size of operations increased by 492 % in the U.S. and by 347 % in Denmark.

Concentration of production in the U.S. hog sector has changed rapidly. In 1990, 58 % of the U.S. hog inventory belonged to farms with less than 1,000 head. In 2000, 51 % of production belonged to 156 operations with more than 50,000 head, while in 2010, only 130 operations (0.215 % of all operations) with more than 50,000 head controlled 57 % of the total inventory.

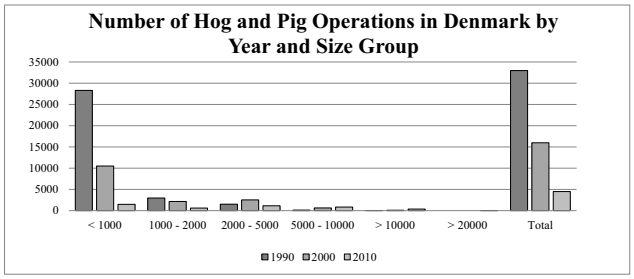

Figure 3.2a

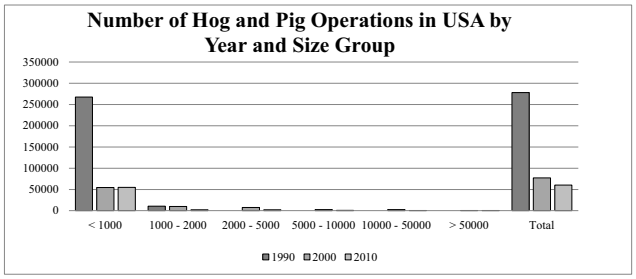

Figure 3.2c

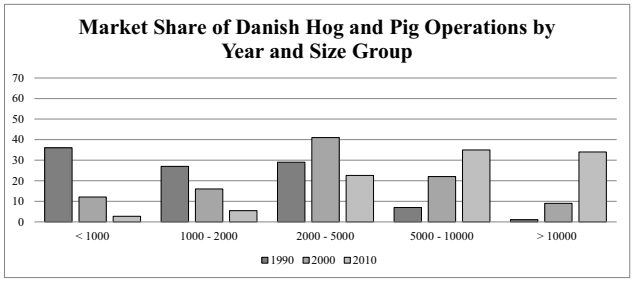

Figure 3.2b

Source: Danish Agriculture & Food Council (2011)

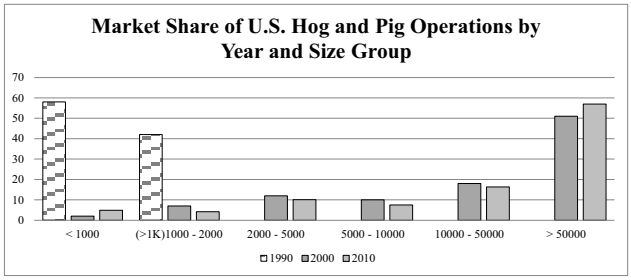

Figure 3.2d

Source: Hog and Pigs NASS USDA (1991), Lawrence and Grimes (2001), Land in Farms NASS USDA (2012)

Figures 3.2a and 3.2d illustrate the structural development in Denmark and the U.S. As can be seen, there is a similar trend in development towards fewer, larger and more specialized farms, although the super large farms that have emerged in the U.S. have not emerged in Denmark. There are legal reasons for this as the acreage size of farms has been restricted in Denmark and farmers have been legally required to own a progressively larger share of land needed for the disposal of manure. The combination of these two pieces of legislation has effectively capped the size of Danish hog operations. Whether other factors, such as financial constraints, would have restricted the development in

the absence of legal restrictions based on structural and environmental policy is a hypothetical question which is very hard to answer, although the possibility cannot be ruled out.

Key and McBride state that large scale U.S. "operations that specialize in a single phase of production [...] have replaced farrow-to-finish operations that traditionally performed all phases of production" (2007, p. 1). This trend toward specialization in single stages of production is a form of vertical disintegration, which is in contrast to another trend; the increasing backward vertical integration, which is shown below. Key and McBride (2007) further report that the share of total output, from specialized finishing operations, increased from 22 % to 77 % in the period from 1992 to 2004, while integrated "Farrow-to-finish" production fell from 65 % to 18 %. A somewhat similar picture can be discerned regarding the structural change in Denmark, although the degree of specialization may be lower while the development has also been slower. Definitions of farm types may play a role. Some Farrow-to-feeder operations are hybrid farm types that are partly specialized and partly integrated. These farms may show up as Farrow-to-finish farms in statistics even though they would characterize themselves as Farrow-to-feeder operations.

Table 3.1 shows the development in the share of hog operations within the different production organizations. The table shows the share of farms within the different categories, and does not present the development in output mentioned above due to size distribution.

Table 3.1: Share of Hog farms within different groups related to specialization

Country	Denmark			USA		
Year	1990	2000	2010	1992	1998	2004
Farrow-to-finish (Integrated)	49 %	49 %	43 %	54 %	49 %	31 %
Feeder-to-finish (Specialized)	28 %	39 %	46 %	19 %	31 %	40 %
Other* specialized producers	23 %	13 %	10 %	27 %	20 %	29 %

Source: (Danish Agriculture & Food Council, 2011; Key and McBride, 2007)

3.3.3 ORGANIZATION OF HOG PRODUCTION

The shift from the intra-firm (farm) coordination of production to the market coordination of production is affected by the transaction cost of market coordination relative to the costs of intra-firm coordination in a Coasian perspective. A reduction in transaction costs relative to the cost of the

intra-firm coordination of hogs is not the only possible explanation. Technological process innovation in production, which yields potential economies of scale within specialized production phases, combined with budget constraints (due to transaction costs in the financial system or reservation value of credit use), or combined with environmental restrictions on size, may have led to the increased specialization as the potential gains from economies of scale would have been traded off against the transaction costs of market coordination within size constraints due to financial or legal restrictions, or a combination of these.

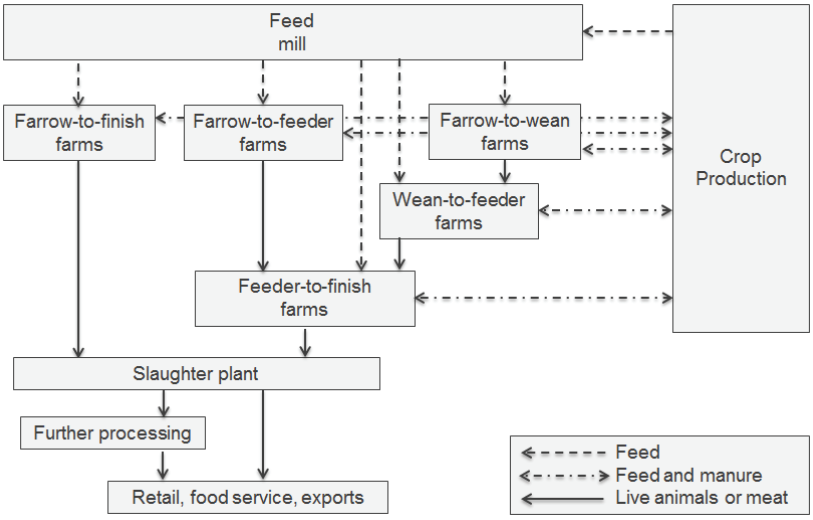

Figure 3.3: Organization of hog production, Source: Adapted from MacDonald and McBride (2009)

From a transaction costs point of view, the hybrid farms mentioned above are interesting as the reason for partly integrating may be due to information asymmetries and / or problems with keeping or observing quality standards. A farrow-to-feeder producer with a partly integrated feeder-to-finish operation may select the best quality feeder pigs for his own feeder operation, and sell lower quality pigs to separate feeder operations in a Lemon type market (Akerlof, 1970). Sellers may adversely select low quality feeder pigs for sale and keep high quality feeder pigs for finishing. However, since planning and relationships play an important role for continual supply and demand relationships between farrow-to-feeder and feeder-to-finish operations, farrow-to-feeder operations may

actually keep low quality pigs and only deliver high quality animals to customers. This may occur if it is hard or costly to observe the value of low quality feeder pigs, and so, the buyer may demand significant price cuts. To avoid this potential asymmetry of expected value, favorable selection may occur, and the farrow-to-feeder farmer may select the low quality feeder pigs for his integrated feeder-to-finish operations. Breeding stock will also play a role.

The decision to partly integrate may be influenced by other circumstances. Initial endowment of production facilities or bundling of assets in the purchase of neighboring farms may leave the farmer with some production-specific assets on hand dedicated to one phase of production while trying to specialize in another phase of production. Utilizing these assets in a manner such as the one described above may be the best alternative, as the assets are not costlessly redeployable.

As shown in Table 3.1, the organization of hog production is somewhat similar across countries but is heterogeneous within countries. Figure 3.3 above illustrates the different organizational structures of production and the picture is similar in Denmark and the USA. The degree of integration between crop production and animal production differs widely both within and across countries. In the U.S., the per cent share of home-grown grain fed has been declining, especially for specialized Feeder-to-finish operations (Key and McBride, 2007). This trend has not been so clear in Denmark which is partly due to the legal linkage of land ownership and animal production.

3.3.4 DANISH DEVELOPMENT

Figure 3.4 illustrates the development in specialization in hog production in Denmark relative to the general structural development in Danish agriculture. The increase in the total number of farms in 2005 was due to the redefinition of farms. Figure 3.5 shows the development in the number of pigs slaughtered in Denmark and the number of pigs exported live. Since 1993, the number of slaughtered pigs in Denmark has been relatively stable at around 20 million head a year. The export of live pigs has however increased gradually. This is mainly the export of feeder pigs for finishing in Germany, but also finished pigs for processing. In 1997, substantial live exports of, primarily, feeder pigs began from Denmark. This export accelerated in 2005 and in 2011, 0.40 live pigs were exported for every pig slaughtered in Denmark.

The trend towards increased live export may be explained by a number of coevolving factors;

a) Slaughterhouse labor cost differentials between Denmark and Germany.
b) The Danish lead in know-how regarding the Farrow-to-feeder part of the value chain.
c) Investment in the Farrow-to-feeder part operations driven by animal welfare legislation.
d) A financial system with greater access to credit in Denmark.
e) A legal requirement that the ownership of land in Denmark is in conjunction with livestock operations.[13]
f) Higher land ownership requirement in e) for Feeder-to-finish than for Farrow-to-feeder relative to value added.
g) High land price inflation which is probably influenced by d) and e), and increasing the relative effect of f).
h) A lower level of competition in the producer-processor interface (Hobbs, 2001) than the feeder-finish interface.

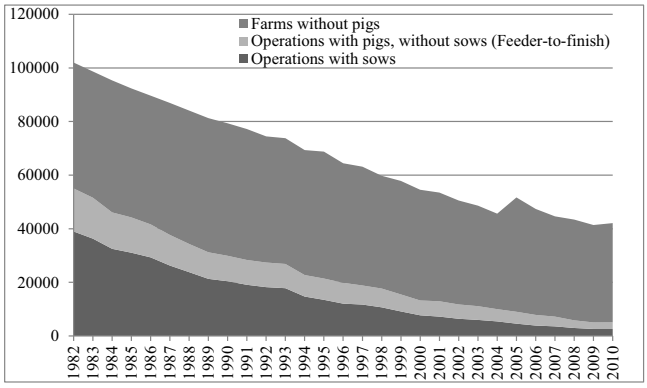

Figure 3.4: Structural development in Danish agriculture

Source: (Danmarks Statistik, 2012a)

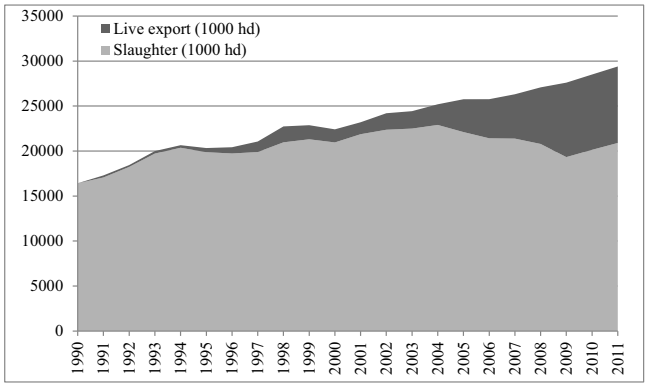

Figure 3.5: Slaughter and live export from Denmark

Source: (Danmarks Statistik, 2012b)

3.3.5 DEVELOPMENT IN THE USA

As shown, the production of pork has undergone great change during recent decades. Size structure has developed rapidly like in most other agricultural subsectors. The structural shifts have been accompanied by regional shifts in production. Natural and technology-related economic conditions have been affected by policy. An example of this is the development in livestock production in Io-

[13] It was legally required that farms with large livestock operations had to be "harmonious" in the sense that they had to own a large part (60%) of the land, needed to recycle nutrients from animal manure.

wa, where early dominance in animal feeding evolved because of the naturally abundant supply of grain, which made it more profitable to raise livestock and transport meat, than to transport grain and raise the livestock near the consumer. These natural favorable conditions for livestock production, reflected in the price differentials to other states, were reduced by technological development in transport and were further skewed by the loan rates (Hayes et al., 1996) given by the Commodity Credit Corporation as part of U.S. agricultural policy. “Because this loan rate was the same in all regions, it effectively removed the grain price differential that had given Iowa's livestock feeders their initial advantage” (Hayes *et al*., 1996, p. 2). The Iowa hog industry stagnated contrary to North Carolina where the hog industry thrived up to 1997 when the state enacted a moratorium on the construction of medium and large scale hog operations due to environmental concerns (Key and McBride, 2007).

The trade policy of foreign governments effectively encouraged U.S. grain exports at the expense of U.S. livestock exports up to the GATT and NAFTA agreements. The European Community subsidized value-added exports so that pork and food-importing countries placed import restrictions on livestock products in an attempt to capture the value-added in livestock industries. These international policies led the U.S. to export more feed grains and consequentially reduce Iowa's livestock production (Hayes *et al*., 1996).

The liberalization of world trade opened world meat markets, and because it became more efficient to export meat than to export feed grains, U.S. meat export surged. Domestic agricultural policy changes reduced the skewing effect of the loan rates, and along with technological and regulatory changes in the logistics of pork, the comparative advantage of Iowa’s hog industry was restored (Hayes *et al*., 1996).

Hayes *et al*. (1996) argue that the geographical development in the structure of U.S. pork production was due to the removal of institutional barriers with the GATT and NAFTA agreements and a call for the leaders in Iowa to solve the differences “regarding discussions on perceived negative environmental, economic and social aspects” (Hayes *et al*., 1996, p. 15). Key and McBride (2007), however, regard the North Carolina moratorium on the construction of new and expanded hog operations with 250 or more hogs to be the reason for the rapid growth in Iowa and other regions; “Restricted growth in North Carolina may explain the particularly rapid growth of the industry in West-

ern States. Open space and a relatively low population density in these states provide greater flexibility in managing animal waste" (Key and McBride, 2007, p. 10).

3.3.6 MARKETING ARRANGEMENT FOR HOGS

The transition from family firm to large corporations is a salient characteristic of industrial development, although agriculture has largely resisted this development (Allen and Lueck, 1998). In the case of U.S. hog production, the development toward large scale industrialized corporations has been significant compared to many other subsectors and regions of the world. The U.S. hog production sector still has distinct features from agrarian tradition but combined with modern industrial organization it forms a number of diverse organizational structures.

Production technology has driven development toward investments in dedicated production assets which are specific for hog production as well as specific investments in human capital dedicated to hog production. Production technological development has, however, been dependent on the availability of finance for the realization of technological innovations. Technological development and the financing required for its implementation go hand in hand in the explanation of structural development.

Technological progress in hog production has been an important driver for structural change and specialization both in the U.S. and in Denmark. Technological change in the processing and marketing of pork has driven market concentration in the processing link of the supply chain both in the U.S. and Denmark. There are, however, significant differences in the structure and development of marketing arrangements in the two countries. In Denmark, cooperative meat processing dominates the marketing channel for hogs, while in the U.S. there has been a shift from the spot market pricing of hogs to contract production and backward integration.

3.3.7 DEVELOPMENT IN U.S. HOG MARKETING

Contracting is usually explained in part by risk shifting motives and coordination motives, where spot market prices have failed to signal consumer demands for specialized products and shifts in consumer tastes (MacDonald *et al*., 2004). Contract production can reduce farmers' business risk, typically price risk and in some cases also yield risk, but in reducing business risk the farmer may increase exposure to strategic risks related to specific investments (MacDonald and Banker, 2004).

The risk that increased possibility to exert market power on the buyer side of the market, by processors in monopsony positions, has been of concern. The increasing concentration of processing in the U.S., dominated by IOFs, has led to concerns about hold-up risk. Contracts can be used to mitigate the risk of hold-up as well as to exert market power (MacDonald *et al*., 2004).

A number of surveys have examined producer behavior related to the choice of marketing arrangement in the U.S. hog sector (Davis and Gillespie, 2007; Key and McBride, 2003; Zheng et al., 2008) from a risk reduction or transaction costs perspective. Franken *et al*. (2009) analyses Illinois hog farmers and finds empirical support for both transaction costs and risk preference explanations individually and in a unified framework.

U.S. hog marketing has changed radically in the recent decades, with a significant shift from the spot marketing of hogs to contract production and backward vertical integration. Figure 3.6 shows the development in relative importance of the spot market. In 1994 it was the dominant coordinating vehicle with 62 % of hogs marketed through the spot market, but by 2010, only one tenth of the relative market size remained, with 6.2 % of hogs marketed through the spot market (Plain, 2011).

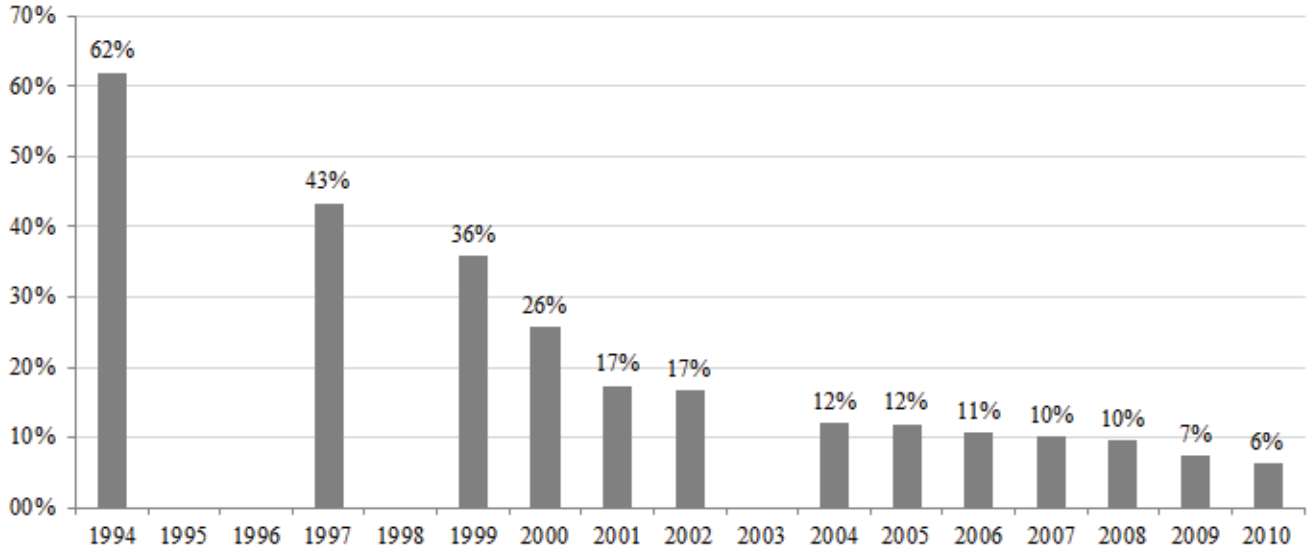

Figure 3.6: Per cent of barrows and gilts sold on the spot market live or carcass weight basis. Source: (Plain, 2011)

The development has been followed by Glenn Grimes and Ronald L. Plain (Grimes and Plain, 2009; Plain, 2011) based initially on surveys and later on data from mandatory price reporting (MPR). The MPR data is separated into six categories:

- Negotiated: Non-packer raised hogs sold on spot market on a carcass weight basis
- Market Formula: Non-packer raised hogs sold on contracts based on publicly reported prices
- Other Market Formula: Non-packer raised hogs sold on futures price based contract
- Other Purchase Agreement: Non-packer raised hogs priced in a different way than the above
- Packer Sold: Hogs raised by one packer and slaughtered by another packer (processor)
- Packer Owned: Hogs raised and slaughtered by the same packer (processor)

Table 3.2 shows the development in pricing method for hogs in the U.S. from 1994 to 2010. From 1994 to 2002, the data are survey-based from the U.S. Hog Marketing Contract Study (Grimes and Plain, 2009), while from 2002 to 2010, the data are based on MPR data. Surveys report pricing of hogs in January whereas MPR data are year averages. There is some discrepancy in the data, but the general trend is clear. Packers (processors) have integrated vertically into production of hogs and raise more than 31% of production via ownership, another 59 % of production is contracted in some way.

Table 3.2: Hog marketing structure in the U.S., Percent Hogs Slaughter by Pricing Method

	Glenn Grimes Packer Surveys Pricing Method Used for Market Hog Purchases in January									USDA / AMS Market News Reports Market Hog Sales by Pricing Method								
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2002	2003	2004	2005	2006	2007	2008	2009	2010
Mandatory Price Reporting carcass weight priced																		
Negotiated	62			43.4		35.8	25.7	17.3	16.7	13.8	12.6	10.4	10.4	9.0	8.2	8.1	6.5	4.9
Market Formula						44.2	47.2	54.0	44.5	40.8	37.1	38.2	38.6	35.4	35.7	35.6	41.4	36.5
Other Market Pormula						3.4	8.5	5.7	11.8	8.7	7.2	8.6	8.4	8.1	8.1	9.4	6.5	10.1
Other Purchase Agreement						14.4	16.9	22.8	8.6	12.2	18.0	17.0	15.5	14.8	13.8	12.6	11.2	12.4
Packer Sold									2.1	2.1	2.0	2.0	2.3	5.9	6.1	5.9	5.5	5.3
Packer Owned									16.4	16.4	17.8	18.1	19.4	20.7	22.3	23.1	24.0	25.2
Total	62			43		98	98	100	100	94	95	94	95	94	94	95	95	94
Mandatory Price Reporting live weight priced												1.6	1.5	1.7	1.9	1.5	0.9	1.3
Non-Mandatory Price Reporting												4.2	3.9	4.4	3.9	3.9	3.9	4.3
Total										100	100	100	100	100	100	100	100	100

Source: (Grimes and Plain, 2009; Plain, 2011)

3.3.8 PRODUCTION CONTRACTS AND MARKETING CONTRACTS

There are two general types of contracts in use in the U.S. hog industry, production contracts and marketing contracts. Both are intermediate forms of governance between the extremes; spot market and (backward) vertical integration (MacDonald *et al*., 2004).

In the spot market, the farmer controls assets and production decisions on the farm and receives prices for farm output, negotiated at the time of sale. In this governing structure the market mechanism governs the allocation of resources, subject to any market imperfections and transaction costs. With marketing contracts the farmer still controls assets and production decisions on the farm, but the contract may specify the quantity and timing of the output. The farmer receives prices negotiated prior to, or during, production. Marketing contracts shift some price risk from the producer to the processor and increase the processor's ability to schedule production and control input costs. Production contracts shift control over some production decisions to the contractor (the processor) and/or ownership over some of the traditional farm assets. Contractors will often provide feed, veterinary and logistical services as well as providing the feeder pigs, of which they retain ownership. Farmers provide labor, equipment and housing and are paid a fee for a service. Vertical integration shifts all control to a single firm and the farmer / manager of the hog production stage is compensated according to skill and time (MacDonald *et al*., 2004).

3.3.9 DEVELOPMENT IN HOG PROCESSING IN DENMARK

The cooperative structure in Denmark has reduced the risk of hold-up situations, as the risk that cooperatives will exploit their members is considered to be less likely than the risk that IOFs in the processing link of the supply chain will exploit asset specificity on the producer side of the market.

There is a 125-year history of cooperative slaughterhouses in Denmark, with the first cooperative slaughterhouse being established in 1887 (Svendsen and Svendsen, 2004). In the 1870s, Danish agriculture was transformed from being a mainly grain exporting sector to a mainly livestock product exporting sector. Open market trade policy and technological developments were key elements of the institutional environment which shaped this development. The growing livestock product export spurred investment in processing facilities which were often organized as cooperatives.

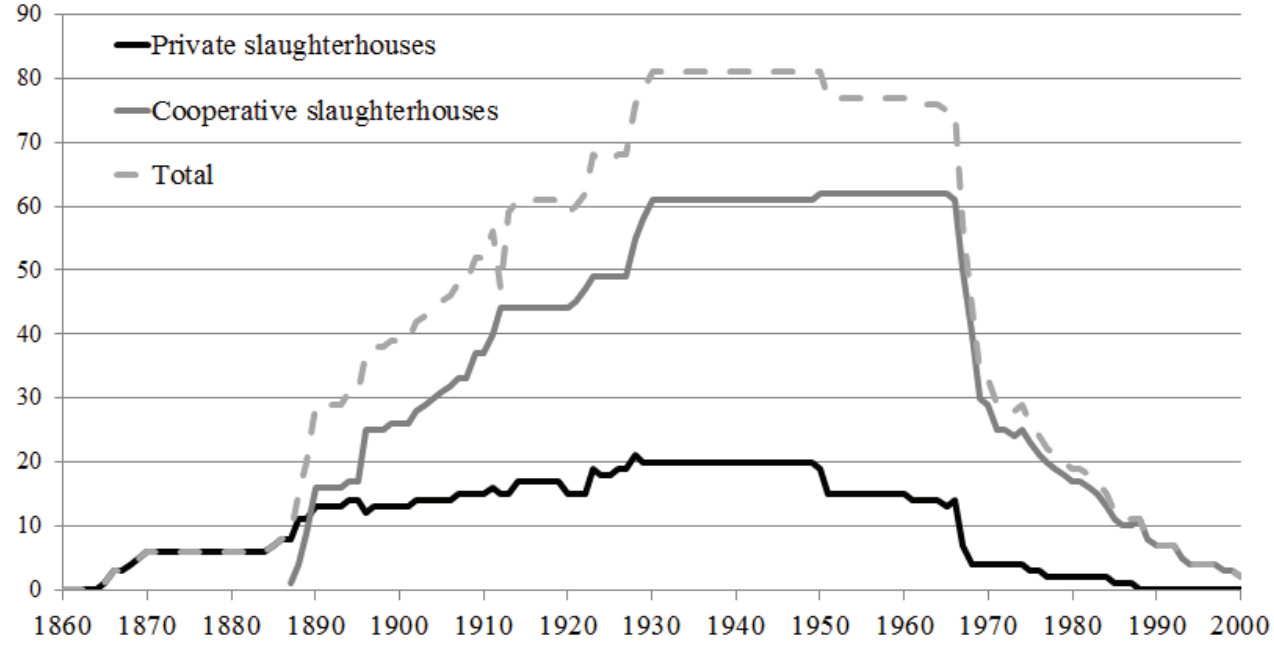

Figure 3.7: Slaughterhouses in Denmark from 1860 to 2000.

Source: Pedersen and Strandskov (2011)

The number of cooperative slaughterhouses (Figure 3.7) peaked in the period from the 1930s to the 1960s and declined rapidly in the 1970s with a wave of mergers (Pedersen and Strandskov, 2011). The consolidation of the sector continued during the 1980s and 1990s and reached a significant landmark in 1998 with the merger of the two cooperatives Danish Crown and Vestjyske Slagterier creating the (at the time) third largest slaughtering company in the world and the largest in Europe (Hobbs, 2001). In 1970 there were 50 cooperative and four IOF meat processing companies in the association Danish Slaughterhouses (DS), known as the Danish Meat and Bacon Council, but by 2010 only two cooperatives were left (Table 3.3).

Table 3.3: Hog processing firms in Denmark

Members of DS	Year	1970	1980	1990	2000	2010
Cooperatives		50	18	5	-	2
IOF		4	2	1	-	0
Nonmembers with > 10.000 hd. processed / year		-	-	7	-	8

Source: (Danish Agriculture & Food Council, 2011)

While the structure of production and the structure of processing have developed tremendously in the Danish hog sector during the past forty years, the marketing of hogs has not changed much. Up to the merger of Danish Crown and Vestjyske Slagterier in 1998, the industry good organization Danish Slaughterhouses quoted an industry-wide weekly base price for hogs determined by a committee of representatives of all of the members. The EU Commission approved the merger subject to a number of conditions, including the abandonment of the base price committee. Prior to the merger, the competition between cooperatives in the Danish Pork sector was on the size of the end of year patronage payment, as the base price was the same. This changed very little in the post-merger setting, as Danish Crown effectively became the price leader and the competition continued to be based on the patronage payment. The quality payment and logistical cost differentials have been adjusted on an on-going basis without major changes.

The role of marketing cooperatives in hog marketing is very important in Denmark, as they are by far the dominant organizational form (Pedersen and Strandskov, 2011). The long history of this organizational form has very likely affected the belief system of hog farmers and the sector's techno-structure[14]. Discussions of a transition of cooperatives toward corporate ownership or a new type of cooperative structure have however been held from the early days in the 1890s (Heyman, 1890 cf. De samvirkende danske Andelsslagterier, 1972) and up to the present-day (Andreasen, 2011; Hansen, 2011; Krogshede, 2011a, 2011b). A conflict of interest between cooperative management and members is another important issue that may hamper organizational adaptation. Classic agency problems between owners and hired management have been studied intensively for IOFs and while similar problems exist for cooperatives, the research has been limited to date (Hueth and Marcoul, 2009).

3.3.10 DIFFERENCES IN THE FINANCIAL INSTITUTIONAL ENVIRONMENT

According to the World Economic Forum's Financial Development index (WFE) (2011), Denmark is ranked 15 out of 60 countries with a score of 4.3 on a 1-7 scale, while the U.S. is ranked 2 with a score of 5.1. Acemoglu *et al*. (2009) use a financial development index comparable with the WEF index. While indices like these capture many aspects of very complex systems, they cannot capture the subtle differences in financial systems.

[14] Techno-structure refers to cooperative management and leaders in sector organizations.

For the questions posed in this paper, the relevant issue is not so much greater or less financial development, but is rather related to the subtle differences in the financial systems. The aim of the section is to demonstrate that there are important differences in the financial environment in the U.S. and Danish agricultural value chains. A detailed analysis and explanation of these differences is beyond the scope of this paper, but it is a relevant subject for further research.

Danish agriculture in general and specifically the Danish hog sector has a very high debt to asset ratio compared to the U.S. which indicates that access to credit has been relatively easy in Denmark compared to the U.S[15]. Figure 3.8 illustrates the development in debt to asset ratios over the past two decades. The farm sector debt to net cash flow is another way of illustrating the differences in the financial systems of the U.S. and Denmark. Figure 3.9 shows the development of Danish and U.S. debt to net cash flow on the sector level.

Anecdotally, lending in the U.S. is said to be cash flow based, while lending in Denmark is said to be collateral-based. Figures 3.8 and 3.9 support this idea. Danish agriculture is much more indebted than the agricultural sector in the U.S., both with respect to the value of assets and with respect to net cash flow. This difference in indebtedness is an indication of subtle underlying differences in the financial systems, which can affect the organization of the value chain.

Here the difference in indebtedness will be taken as an indication of easier access to credit for farmers in Denmark than in the U.S. following the reasoning that farmers in a sector with a high level of debt in general must be willing and able to obtain credit, thus preserving relative easy access to credit for investment finance and as a financial buffer in the form of credit reserves.

An alternative interpretation of the difference is that the Danish farmers have exhausted their credit reserves and their ability to debt finance investments, compared to U.S. farmers. Pedersen and Olsen (forthcoming) (Paper I) shows that this is not the case that Danish farmers exhausted their credit reserves, at least not prior to the GFC. Nevertheless, some difference in the institutional environment of agricultural finance in Denmark and the U.S. is indicated.

[15] The Danish data are biased as they are based on public valuation of assets, which is lagged. The public valuation system is based on average market prices for real estate every second year. This means that the book value of assets will be lower than the market value in an increasing market and vice versa.

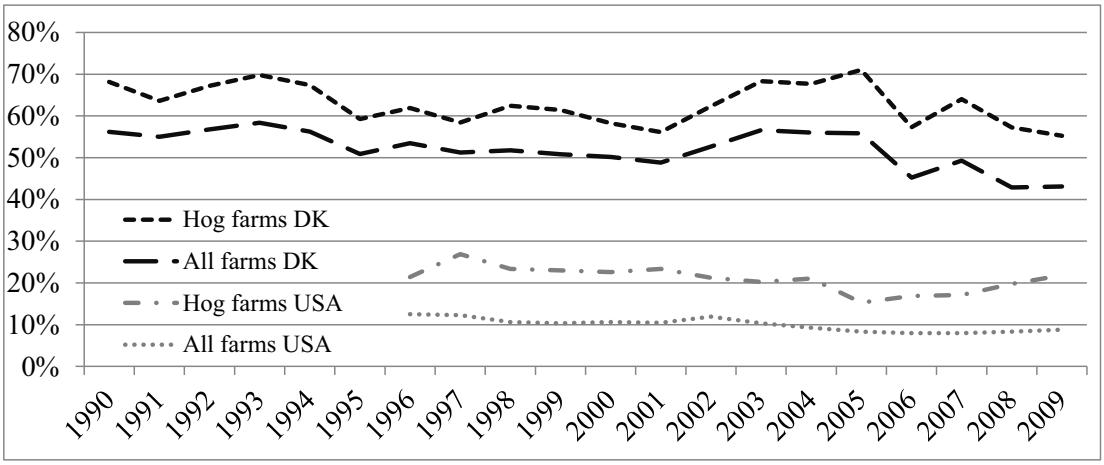

Figure 3.8: Debt to Asset ratios in U.S. and Danish agriculture

Source: ARMS ERS/USDA for U.S. data and Danmarks Statistik / Statistikbanken for Danish data.

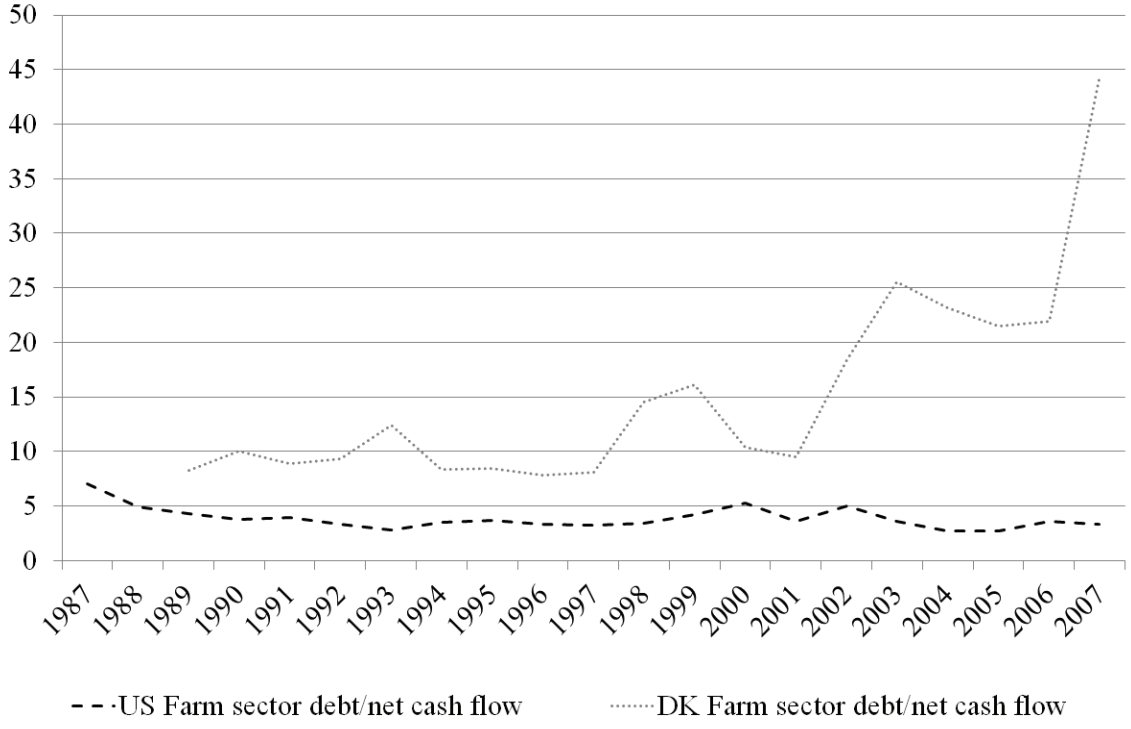

Figure 3.9: U.S. and Danish farm sector debt to net cash flow.

Source: Harris *et al*. (2009) for U.S. data and FADN for Danish data

3.4 Discussion

3.4.1 PLACING FINDINGS IN A LITERATURE CONTEXT

The tendency, in parts of the agricultural economic literature, to omit the complementary effects of finance and organization as criticized by James *et al*. (2011) may be a serious caveat as the characteristics of the financial environments may be very different and may have an important impact on the organizational development.

The diffusion of technological innovations will most often necessitate investments in specific assets; in the case of the U.S. hog industry this was no different. As producers (farmers) were initially largely unable and/or unwilling to finance these specific investments, processors took on more financing and more risk which enabled farmers to finance the residual investments needs. This is manifested via vertical integration or production contracts whereby the processor owns the animals and the farmers are paid a fee for a service so that some of the financing and risk is shifted away from the farmer. Alternatively, the shift is manifested via marketing contracts where only the risk is shifted (MacDonald *et al*., 2004).

"Growth in hog contracting was driven in part by production differentiation. Processors wanted more control over the characteristics of the hogs they acquired, which helped them provide a consistent quality of meat to consumers" (Hoppe and Banker, 2010, p. 38). This kind of control over product characteristics and adaptation to consumer preferences has to a large extent been done by the cooperatives in Denmark. Greater willingness to make on-farm product specific investments by members may be related to greater trust in cooperatives than IOFs as found in the sugar beet industry (Balbach, 1998), more relevant elements of contract design are linked to organizational structure by Sykyta and Cook (2001).

Specific investments driven by technological development have changed the organization of U.S. hog marketing, but what would have happened if farmers had been able to finance the specific investments themselves? In Denmark investment has, largely, been debt financed both in the vertically integrated cooperative processing facilities and at the individual farm level. The fact that this has been achieved means that access to credit has been available. The availability of ample access to credit indicates that the credit reserves have appeared large, leading to a reduced demand for risk

management via hedging, which may have crowding out futures market-based risk management as well as contract production and (backward) vertical integration.

Cooperative marketing reduces transaction costs related to price discovery by producers and reduces the business risks related to post contractual opportunistic behavior, the hold-up problem. Danish farmers have "marketing security" in the sense that the cooperative guarantees to market their hogs. Important as this is, it should not be confused with price guarantees. The cooperative will pay the farmer the same price as other members, for the same quality delivered at the same time. This is risk reduction via pooling, which is different to forward contracting (Hardaker *et al*., 2004). The "marketing security" has however been appreciated by lenders to Danish agriculture and the organization of marketing has affected access to credit and risk management.

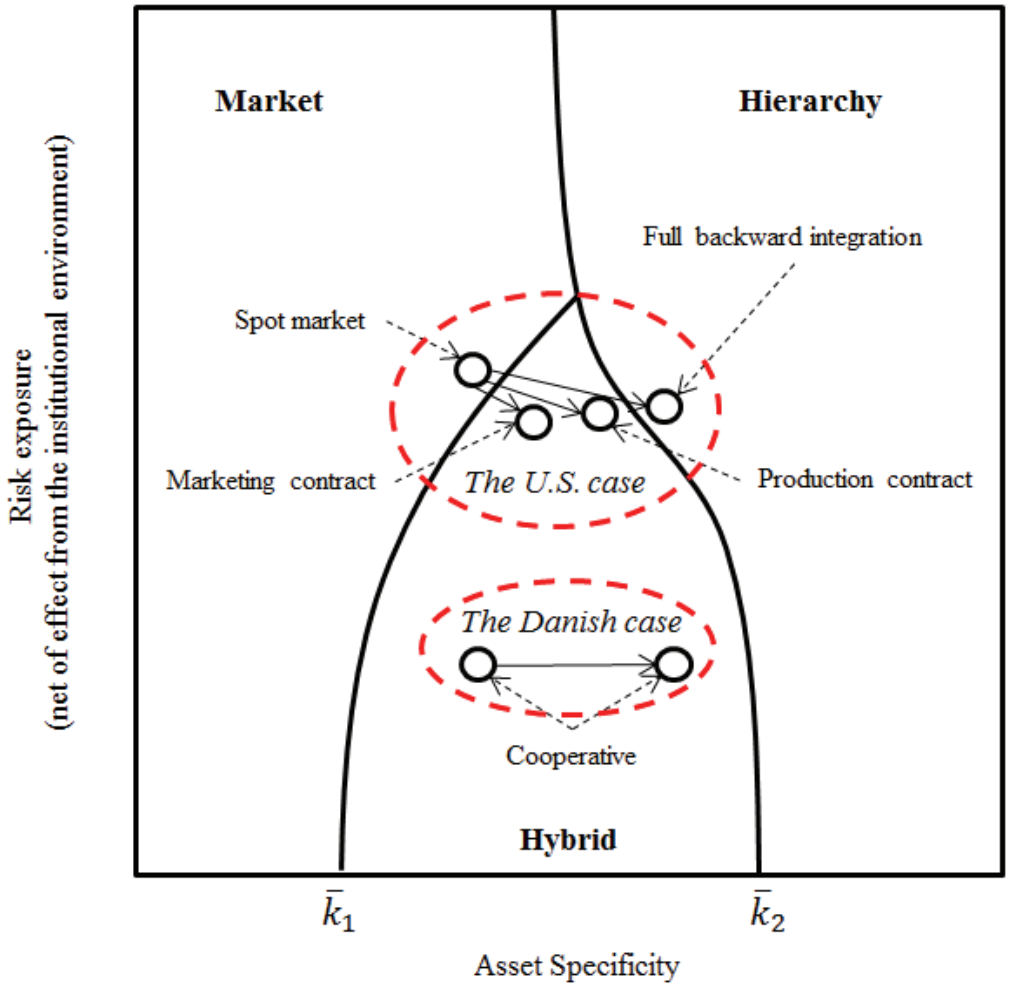

Figure 3.10: Adapted from Williamson (1991b) illustrating organizational adaptation

The positive effect of marketing security via cooperative marketing on access to credit for Danish farmers is widely accepted, although it is anecdotal in nature[16]. The relative security of supply is recognized as a positive effect on the cooperatives' access to credit by Hansen (2011). The argument, stressed in this paper, that an institutional environment providing relatively unconstrained access to credit has a positive effect on cooperative marketing is not generally recognized, but may be an important factor.

Figure 3.10 illustrates the U.S. and Danish development in an adaptation of a Figure 3 in Williamson (1991b). In the U.S. case, increased asset specificity driven largely by the technological development, leads to organizational adaptations toward marketing contracts, production contracts and full backward vertical integration. Because the Danish hog sector operated in a financial institutional environment where access to credit yielded a perception of large credit reserves, Danish farmers operated at a lower (perceived) level of risk exposure, net of the effect of the institutional environment. Although the Danish hog sector has witnessed increased levels of asset specificity, similar to the U.S. sector, this has not led to organizational adaptation, because of the moderating effect of the financial institutional environment.

We belief that the financial framework is an important and relatively neglected institutional frame, in explanations of organizational adaptions to change. However, this is not to say that a host of other factors are not playing important roles. The paper is intended to highlight what we belief to be the fact that financial institutions also matter. Therefore an alternative variation of the title of the paper could have been: Financial Institutions *also* Matter.

The question that follows, if one accepts the claim that financial institutions also matter, is how much do they matter? To answer this question, a much better control for other intuitional factors must implemented, than is the case in the present paper. This paper cannot say how big an impact the financial environment has due to omitted factor bias, but the claim that there is some effect is maintained.

[16] To my knowledge, no research has documented this effect. Hansen (2011) addresses the farmers' interest in marketing security, but does not link this interest to the access to credit.

Consequently, if the claim is accepted, other research omitting to control for the financial environment also suffers from omitted factor bias. The scope for further research is substantial.

3.4.2 GENERALIZATION OF FINDINGS

Imagine a sector consisting of producers and processors, where investment in technological developments will give the firms a competitive edge. These investments are, however, co-specific, meaning that their payoff is subject to specific investments of the contractual constituency and that they expose the firms to ex post opportunistic behavior from the contractual constituency. Vertical integration may mitigate this risk and increase the incentive to invest. Vertical integration does, however, mean that the firm will not only invest in its primary technological development, but also in the up/down stream producers/processors' assets including the co-specific investments. This increases the pressure on finance as all of these investments have to be financed by combinations of retained earnings, debt and outside equity.

Following the pecking order theory, retained earnings are initially preferred to debt, and debt is initially preferred to outside equity. Assume that the retained earnings are depleted. The state of the financial environment is now a key determining factor. If the access to credit is relatively unrestricted, investment will be debt financed, whereas if access to credit is relatively restricted, the decision maker will turn to outside equity to supplement debt.

Suppose that access to credit is relatively unrestricted. The relative agency cost of debt (monitoring, bonding, etc.) for the producer compared to the processor, will determine whether integration will be forward or backward. If the (agency) cost of debt is relatively low for producers compared to processors, producers will integrate forward into processing, whereas if cost of debt is relatively high for producers, processors will integrate backward into production. If access to credit is relatively restricted, outside equity is more likely to be the cheapest finance alternative on the margin. The relative (agency) cost of outside equity (monitoring) for the producer compared to the processor, will determine whether integration will be forward or backward. If monitoring is relatively low for producers compared to processors, producers will integrate forward into processing and vice versa. Figure 3.11 illustrates the effect of the financial institutional environment on organizational form.

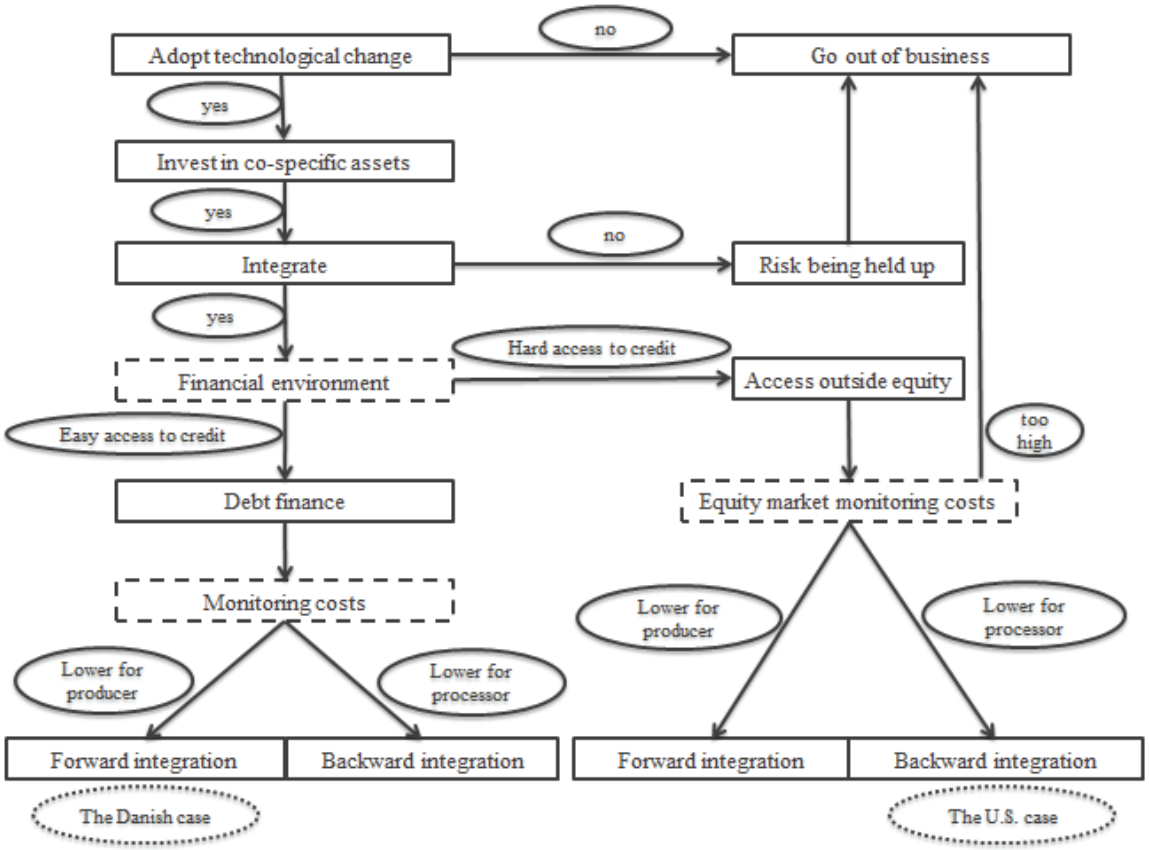

Figure 3.11: The effect of the financial institutional environment on organizational form

At first glance it may seem odd that monitoring costs differ with the direction of integration, and in the case of full-scale integration most likely there would be no difference. But considering agriculture where the cooperative is a common organizational form, the case of processing and marketing cooperatives enables farmers in the production stage to forward integrate into the processing of agricultural commodities to avoid potential hold-up problems and ensuring sufficient coordination. The cost of monitoring cooperative management for cooperative members is likely to be much lower than if the management of the processing firm had to monitor the management of backward integrated production units.

The cooperative organizational form is, however, based on relatively easy access to credit for the producers. This factor is determined by the financial institutions, which is why financial institutions matter in the understanding of why specific organizational forms emerge, evolve and/or persist.

The other integration extreme seen in agriculture is the backward vertical integration of processors, which enables the coordination and increasing willingness to make specific investments as the risk of hold-ups is reduced. Backward integration in livestock value chains is seen in the U.S., among other places, where intermediate levels of vertical integration or quasi-integration are seen in the form of contract production. Backward vertical integration is a likely consequence of relatively restricted access to credit, and lower relative costs of monitoring the processor than the producer, from the equity investor's point of view.

The central tenet in this theory is that financial institutions matter, paraphrasing Vernon Smith' statement that "institutions matter because incentives and information matter" (Smith, 1994, p. 116), the proposition of this theory could be formulated as follows:

Financial institutions matter with respect to organization and risk management because financial institutions determine the access to credit, which crowd outs outside equity in the organizational structure of the firm and hedging in the risk management of the firm.

This proposition does not imply that other institutional factors are unimportant, the intention is rather to stress that financial institutions may not get the attention they deserve in research related to New Institutional Economics and to explain, in more detailed, why and how financial institutions matter with respect to organizational form.

With the term financial institutions, the whole financial system is addressed, at all levels, ranging from the informal institutional level based on traditions, customs, norms and religion, to formal institutions such as policy, legislature, bureaucracy and to governance structures of financial organizations and marginal price/quantity considerations (Williamson, 2000). All these levels of the financial system may affect the cost of using debt. The cost of debt being different than the price, e.g. the interest, charged by the lender. As discussed in section 3.2.1, debt has multiple characteristics all of which affect the cost of using debt, but which are not necessarily built into the price mechanism.

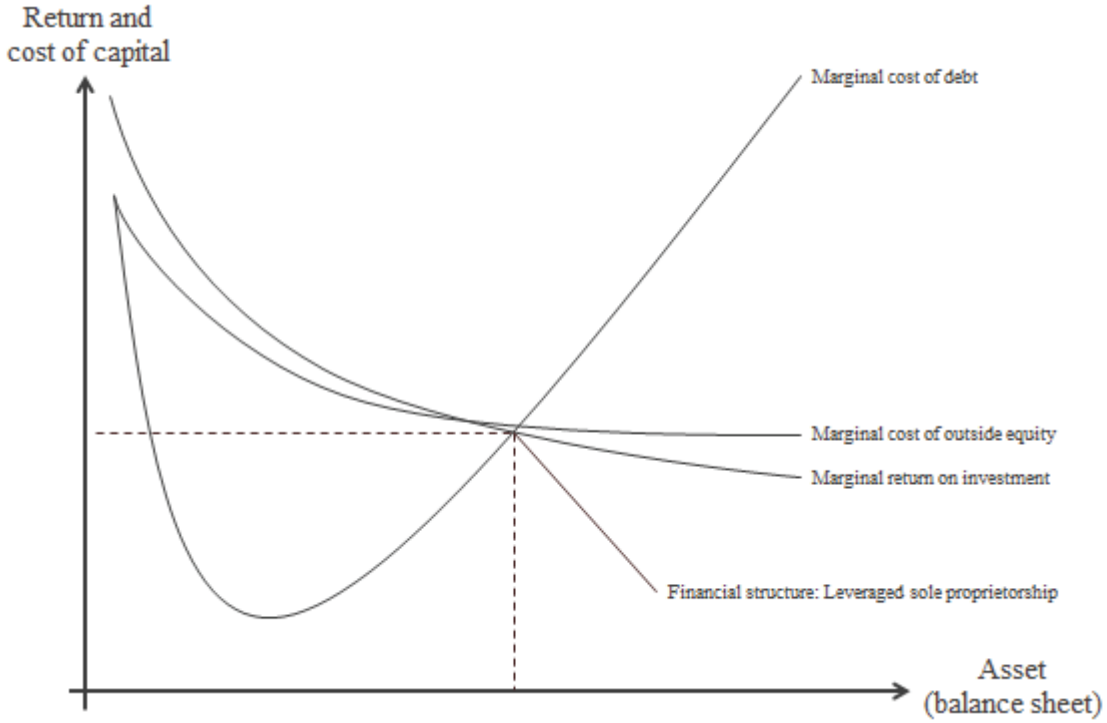

Figure 3.12a): Governance structure: Leveraged sole proprietorship

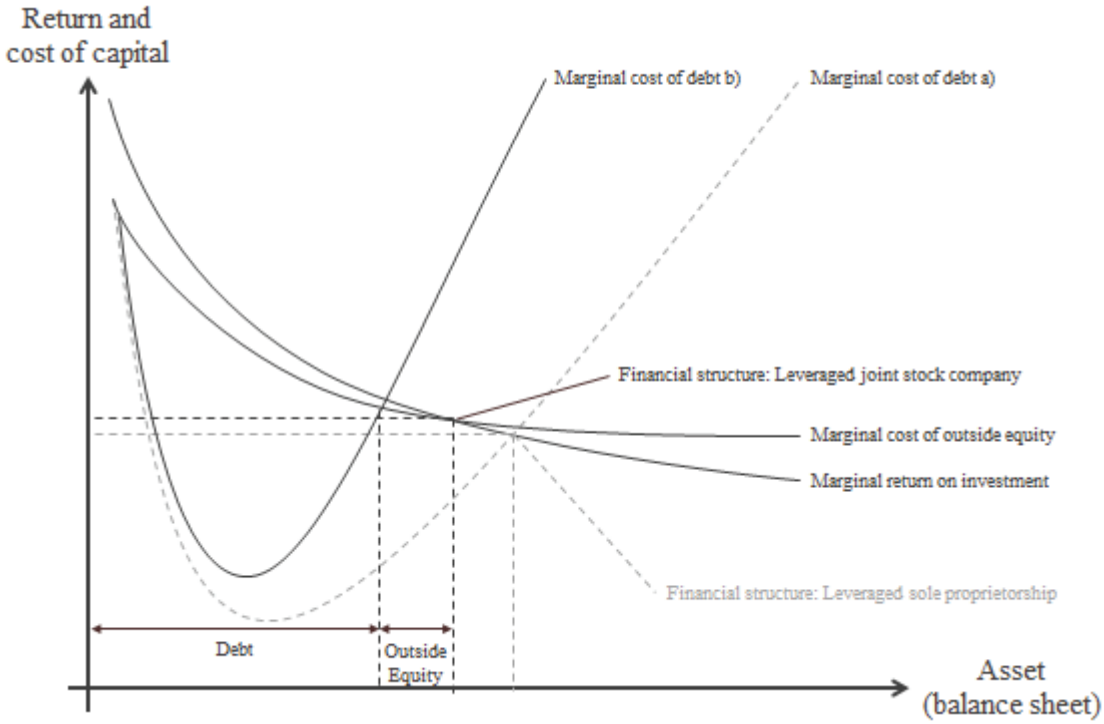

Figure 3.12b): Governance structure: Leveraged joint stock company

Synthesizing all these factors in the concept of the marginal cost of debt, and comparing these with the marginal cost of outside equity and the marginal return on investment can illustrate the effect of financial institutions on organizational form. Figure 3.12a) illustrates an organization, the size of which is determined by the marginal return on investment (MRI) and the marginal cost of capital (MCC) represented by the substitutes marginal cost of debt (MCD) and marginal cost of outside equity (MCE)[17]. The optimal scale of the organization is where the MRI = MCC which is Min(MCD, MCE). The case represented in Figure 3.12 a) is a case where the MRI = MCD < MCE, meaning that the optimal scale is reached where the marginal cost of debt is below the marginal cost of outside equity. Notice that the MCD dominates MCE within the scale of the organization. This determines that the organizational form be a leveraged sole proprietorship. Figure 3.12b) illustrates a case, otherwise similar to a), but where the financial institutions make access to credit harder and therefore the marginal cost of debt higher. In this case the MRI = MCC where MCE < MCD and the organizational form is a leveraged joint stock company.

The inner loop of figure 3.13 illustrates the narrow TCE explanation of organizational change criticized by James *et al*. (2011) for omitting the financial environment. In contrast, the proposition of this paper is illustrated in the outer loop of Figure 3.13. The brief TCE story is that new technological developments lead to investments in specific assets, and that this affects the organizational form.

The longer story proposed here begins the same way, but realizes that investments need to be financed. The choice of financial structure depends on the financial institutions determining the access to credit and will affect the balancing of business risk and financial risk. This may affect the use of other risk management alternatives such as hedging, and will affect the organizational form. The organizational form may affect the diffusion of new technologies and the circle is complete. This illustration suggests important interaction between organization, finance and risk management, as well as production technology. Exogenous changes in one factor are likely to increase the probability of adaptive change in the other factors.

[17] MCD and MCE being functions of the optimal use of the other substitute.

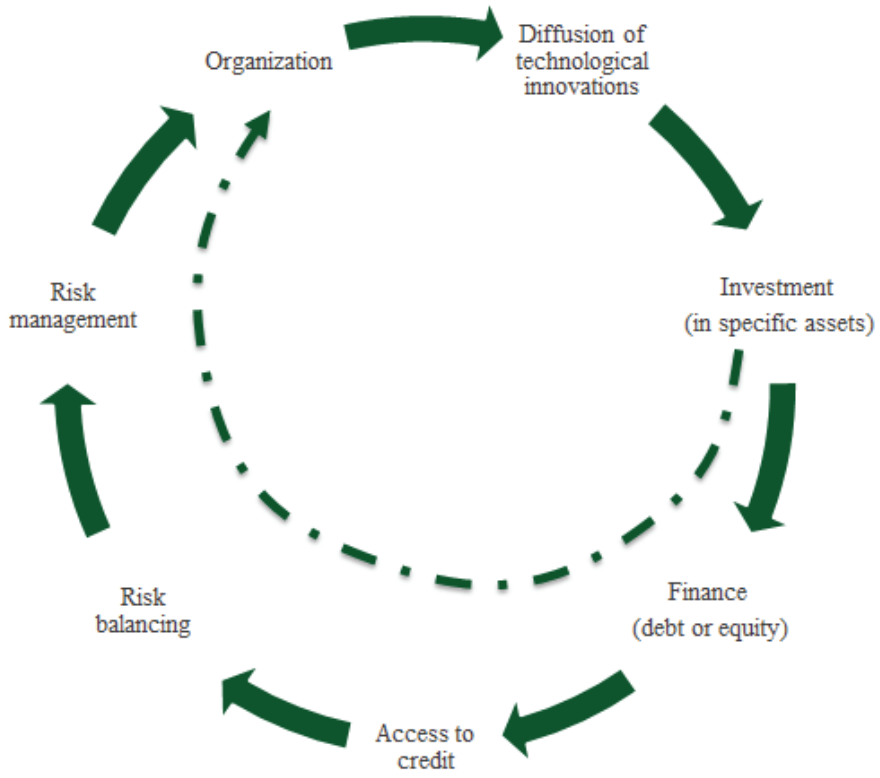

Figure 3.13: The financial environment moderates organizational adaptation to technological change

In this paper we stress the effect of the financial system on hog marketing arrangements in the U.S. and Denmark and link the cooperative marketing in Denmark to the Danish financial system. It must, however, be recognized that cooperatives play an important role in some agricultural sectors in the U.S., which are presumably faced with the same financial environment as the U.S. hog sector. The estimated share of farm marketing through cooperatives in the U.S. in 2001 was 28%, ranging from 12% for the category "all other" to 13% for livestock/wool/mohair and 83% for dairy (Kreanzle and Eversull, 2003).

The hog sector is part of the livestock category where cooperative marketing plays a minor role. In the U.S. dairy sector, however, cooperatives play a major role. This illustrates that the financial environment is not the whole story. One major difference between the hog sector and the dairy sector in the U.S. is the agricultural policy, which may affect the risk exposure of farmers and the ability of cooperatives to affect the farmer's ability to cope with risk exposure. Comparisons of the reasons

behind the cooperative organization of dairy marketing in the U.S. and the IOF organization of processing in the hog sector is beyond the scope of this paper, but it would be an interesting avenue for further research.

Legal systems affect organization in agriculture in a number of ways. They affect the way property rights are allocated and transferred, the degree to which specialization can be developed and the contracts that connect the links in the food supply chain, which means that a study of the agri-food industry has to be a combined law, economics and organizations undertaking (Ménard and Valceschini, 2005; Williamson, 1991). A "fundamental lesson of the new institutional approach to the organization of agriculture activities is that costs of alternative arrangements of transactions at the micro level as well as costs imposed on transactions by alternative policies at the macro level must be assessed in order to understand how specific solutions are selected and why some work better than others" (Ménard and Valceschini, 2005, p. 426).

Total costs cannot be seen as the sum of production costs and transaction costs. Instead they must be considered together and "efficient organization is not simply a matter of minimizing transaction costs" (Milgrom and Roberts, 1990, p. 57). Market conditions on factor markets, including financial markets, and transaction and agency costs should be analyzed simultaneously. The interaction effect between the financial environment and the contacting costs, determined by best available production technology, is a key determining factor of organizational form.

Changes in institutions exogenous to Danish agriculture are unfolding, notably changes in the financial institutions following the GFC, the Basel III being a prominent example. A central question posed by this paper is how to adapt to these changes. This should not be seen as an attempt to improve economic performance by changing one institution, but a recognition of the possible need to adapt institutions and governance structures in a response to exogenous changes in other parts of the institutional matrix. North (2005, p. 157) puts it like this: "The artifactual structure that defines the performance of an economy comprises interdependent institutions; changing just one institution in an attempt to get the desired performance is always an incomplete and sometimes a counterproductive activity." Learning by observing practices in other institutional environments can be valuable, although exact replication of practices will be suboptimal if institutional linkages are important (Williamson, 1991). This is the light in which the comparative analysis should be seen.

Organizational conventions can be hard to change as structural inertia build up against competitive pressure from a changing institutional environment. Organizational entrepreneurship, either through experimentation or imitation of successful organizational practices elsewhere, “are likely to result in "modification”, or a "ramification" of conventional organizational architecture that may significantly alter some characteristics of the existing conventions, yet retain other basic features” (Aoki, 2001, p. 129). This seems to suggest that the cooperative marketing of hogs in Denmark could and should be retained with some modifications to adapt to new institutional settings unfolding after the GFC, the cooperatives’ role in relation to the individual farmer’s ability to manage risk exposure being one such possible area for modification.

Technology, organization, finance and risk management are intertwined and all areas may be affected by exogenous shocks to the other. This is likely to be a general result, deviations from which are exceptions to the rule.

3.5 Conclusion

The tendency in parts of the literature to express causal explanations directly from technology induced specific investments to organizational change may omit many insights and complementary factors from the corporate finance, agricultural finance and risk management literature. It is well recognized that institutions matter. The specific finding and emphasis of this paper is that financial institutions matter regarding organizational development.

Three of the world’s significant hog production clusters are located in USA and Denmark. In the U.S., the number one hog production cluster is located in Iowa while another significant cluster is located in North Carolina. Trends in U.S. and Danish pork industries have been somewhat similar, the direction has almost been the same, but the origin and the speed travelled have been different. However, there is one important non-event in the Danish pork industry compared to the U.S. industry; the absence of change in the marketing arrangements. This may be “the dog that didn’t bark” with reference to Sir Arthur Conan Doyle’s detective Sherlock Holmes[18].

[18] In the short story Silver Blaze, by Sir Arthur Conan Doyle, the famous detective Sherlock Holmes solves the crime of a kidnapping of a race horse, by the fact that the guard dog didn’t bark, leading Sherlock Holmes to conclude that perpetrator was someone the dog knew. This is an iconic example of the importance of looking for clues outside the scope of the obvious and tangible.

While the general development in the U.S. hog industry has been driven by technological development which has induced investments in specific assets, the development in the organizational design and the marketing arrangements may be conditioned on the financial environment. In the U.S., the adoption of new technologies and gains from increasing scale has been financed by capital inflow from the investor-owned processing level and risk shifting from the producer to the processor level (Martinez, 1999). In contrast, the Danish hog industry has adopted technological developments and gains from economies scale, within the limits of the environmental regulation, largely by debt financing both at the cooperatively owned processing level and at the individual farm level. This reflects the fact that Danish hog farmers are highly leveraged compared to U.S. hog farmers, as is the case with Danish agriculture compared to U.S. agriculture in general, indicating that access to credit and the willingness to utilize debt capacity is generally higher in Denmark than in the U.S.

Reduced price risk is stated as one reason for contract production by U.S. producers. Whereas there seem to be other important factors in the explanation, it may well be that U.S. hog farmers have been more aware of price risk management than Danish hog farmers. Conversely, Danish hog farmers seem to have been relying more on the risk mitigating effect of credit reserves (Baker, 1968; Barry and Baker, 1971; Gabriel and Baker, 1980) than their U.S. counterparts who have been relying on price risk management through the use of contracting and other risk management possibilities.

The fact that debt financing of the development has been possible is likely to have influenced the organizational development. The ability to debt finance the development is probably linked to the characteristic Danish mortgage bond system. This system is under pressure from the international alignment of financial institutions. Changes in the Danish financial system may elicit change in the marketing arrangements in the Danish hog industry. Enhancing marketing options to include price risk transfer through cooperatives will allow greater control over financial returns for the cooperative members with highest willingness to pay for price risk reduction (presumably the most risk averse) and thus insulate some producers from market risk.

The financial crisis has left Danish agriculture in a situation where the heavy reliance on borrowing facilities may no longer be viable. Other risk management strategies are needed, but the institutional framework is not present. Price risk management is not practiced as the cooperatives are shifting

market risk uniformly to all members delivering identical products. There may be some risk sharing between different products within the same cooperative (Bogetoft and Olesen, 2004), but this is not a clear mechanism and there is no shift of market risk within the same product. This does not have to be the case, as it is possible to reallocate risk among members according to their cost of carrying risk (Paper III). This governance structure is however not yet in use.

The question is whether the financial crisis is "the beginning of the end of the cooperative structure itself?" (Ménard and Klein, 2004, p. 754) or to paraphrase Winston Churchill, whether it is "perhaps, the end of the beginning" of the cooperatively organized marketing of agricultural products, indicating that we are on the verge of a new era in which new roles for processing cooperatives are about to emerge. 2012 was the UN International Year of Cooperatives.

Chapter 4

Paper III

Reallocation of Price Risk among Cooperative Members[19]

Abstract

Purpose – The purpose of this paper is to explore the theoretical possibility of reallocation of price risk among members of processing cooperatives in the Danish hog and dairy sectors.
Design/methodology/approach – Based on the observation that no effective price risk management institutions exist for Danish hog and dairy farmers, possible explanations for this are discussed and the possibility of cooperatives to reallocate risk among members is analyzed.
Findings – Use of futures to hedge individual farmer price risk is absent, which may be due to prohibitively high basis risk. The reason for this basis risk is that cooperative prices, while they are influenced by market fluctuations reflected in futures markets, are also influenced by cooperative positions via contracting on the output-side, as well as general business specific risk. Farmers are exposed to the cooperative price as residual claimants of the cooperative. Endowing members with proportional forward contracts and organizing the exchange of these contracts via a double auction mechanism will reallocate risk, realizing gains depending on member heterogeneity and transaction costs.
Research limitations/implications – The paper opens a number of research questions related to the model, such as the optimal level of endowment of forward contracts.
Practice implications – Credit reserves are probably diminishing in Danish agriculture post the financial crisis. Introducing institutions that increase the ability to manage price risk may be of great value in a situation where the ability to cope with risk via credit reserves has been reduced.
Originality/value – Most research on risk transfer focuses on vertical reallocations of risk in the value chain, whereas this paper is original in the sense that it explores the possibility of horizontal risk transfer.

Keywords: futures, hedging, reallocation gains, risk management, cooperatives, mechanism design, auctions

JEL classification: G13, G32, Q13, D61, D8

[19] Presented at the 123rd EAAE Seminar, Price Volatility & Farm Income Stabilisation in Dublin, Ireland, Feb. 23rd and 24th, 2012 and the 19th International Farm Management Congress in Warsaw, Poland, July 21st to 26th, 2013.

4.1 Introduction

The main livestock sectors in Denmark, the hog and the dairy sectors, are characterized by asymmetry in the contracting behavior. On the input side, forward contracting and substantial self-sufficiency rates of grain or feed from the arable side of the farm are traditionally dominant. On the output side, there is tradition for the spot-price marketing of milk and meat delivered to cooperative dairies and slaughterhouses. This behavior is counter intuitive as the expected behavior of risk adverse farmers with weak positive correlation between input and output would be to hedge symmetrically or not to hedge at all (Pennings and Wansink, 2004). The asymmetric behavior may however be explained by interactions with related institutional domains such as agricultural policy, finance and organization. Recent changes in these domains suggest the need for adaptive changes in risk management institutions. However, this response may be very challenging and not automatic (Aoki, 2001).

According to Bogetoft and Olsen (2004), risk sharing between producers and processors in producer cooperatives is limited to risk sharing between producer product groups and risks the absorption of the equity buffer. This paper challenges this statement by suggesting the grouping of members according to their cost of carrying risk[20] rather that their product attributes. By introducing mechanisms that reallocate risk from the individuals faced with a high cost of risk to individuals with a low cost of risk, the aggregate cost of risk can be reduced (Chavas, 2011).

Most research on hedging explores the vertical reallocation of risk in the value chain, the use of forward contracting, commodity futures and options being the main vehicles for the reallocation (Garcia and Leuthold, 2004). This paper explores the possibility of horizontal risk transfer among cooperative members. Endowing members with a forward contracted share of delivery, and organizing the transfer of this share via an auction mechanism at a market price will potentially lead to the reallocation gains.

The paper is structured as follows: Section 4.2 gives some background on hedging and why it may not have been widespread in Denmark. Section 4.3 provides an introduction to the characteristics of the marketing of Danish livestock products via the dominant marketing cooperatives. Section 4.4

[20] Following Chavas (2011) the term cost of risk is used to represent Arrow-Pratt risk premium, This is done to distinguish the cost of risk from the price z paid for reduction of risk, labelled the risk premium in this paper. The cost of risk refers to both capacity to bear risk and the attitude towards risk, which is the willingness and ability to carry risk.

argues for the potential heterogeneity of cooperative members in their attitude towards risk management, and discusses the potential gain from the reallocation of risk. Section 4.5 discusses why this reallocation may not be handled via futures markets. Section 4.6 represents the main body of the work and extends a model by Collins (1997) to illustrate the potential for reallocating risk via the transfer of forward contracted delivery among cooperative members. The section also discusses the assumptions of the model. Section 4.7 provides some concluding remarks.

4.2 Background on risk management in Danish agriculture

In the 1970s, Danish agriculture was still characterized by fairly diversified farms and low leverage. During the 1980s, increasing specialization and leverage in the sector could be related to the price support regime in the EU's common agricultural policy. This can be interpreted as a meso-level effect of the balancing of business and financial risk (Gabriel and Baker, 1980). In the 1990s and 2000s, price support was substituted by income support, thereby reintroducing the potential for increased price risk. The reintroduction of price risk coincided with the build-up of the credit bubble which imploded in 2008 leading to the global financial crisis (GFC).

It is widely recognized that agricultural policy may have a crowding out effect on market-based risk management institutions (OECD, 2009; Turvey and Baker, 1989, 1990). However, it is less well recognized that ease of access to credit, which may occur in the case of a credit bubble, may also crowd out market-based risk management.

The connection between hedging and financial structure is, however, recognized by part of the literature (Collins, 1997; Garcia and Leuthold, 2004; Pennings and Garcia, 2004; Pennings and Leuthold, 2000; Turvey and Baker, 1989, 1990), who see the motivation for hedging and risk management as a desire to avoid financial failure which is related to, but different from, a desire to reduce income variability. The literature suggests heterogeneity in willingness to pay for hedging. While this literature focuses on the financial aspects of hedging behavior, only Turvey and Baker (1990) stress and distinguish between liquidity aspects and capital structure aspects. A focus on the possible impact of macro-economic fluctuations of the business cycles on finance and its implications for hedging and risk management is generally absent. The importance of credit reserves, explicitly described in Gabriel and Baker (1980), is not emphasized. In a leverage cycle framework (Geanakoplos, 2010), the credit reserves may, however, not be constant even though debt and assets

are and thus the debt-to-asset ratio may not fully reflect the credit reserves. An increase in the access to credit for Danish agriculture in the late 1990s and 2000s is demonstrated by Pedersen and Olsen (Paper I). The crowding out effect of easy access to credit on risk management institutions may have been substantial in this period. Post GFC changes in the financial environment and agricultural policy reform may lead to a situation of institutional vacuum, where the institutions that crowded out the need for market-based risk management institutions disappear, although market-based risk management institutions may not appear instantly. The potential lack of risk management institutions may have significant social costs.

4.3 The marketing of milk and meat in Denmark

Danish agriculture is dominated by two major processing and marketing cooperatives; Arla Foods in the dairy sector and Danish Crown in the pork (and beef) sector. These firms are in the top ten of Danish firms with regard to turnover and the top fifteen with regard to the number of employees.

These two cooperatives have near monopsony power in the Danish markets for milk and meat. As pointed out by Hobbs (2001, p. 27), this leads to "the unusual situation where, despite the fact that the processing and downstream supply-chain activities are performed by farmer-owned organizations, there remain concerns over the effects of concentration in the industry." The mergers which led to the formation of the current cooperatives were subject to a number of conditions, including that they partially relinquished their exclusive supply requirement for members and that the notice for leaving the cooperative was shortened.

Within both cooperatives there are base price schemes with quoted prices for current spot deliveries to the cooperatives and end-of-year patronage payments based on a split of the residual claims among patronage payments, retained earnings on personal member accounts and retained earnings for collective equity build up in the cooperative. In addition to the base price schemes, there are general quality schemes and market-specific contracts.

The farm-gate price of milk is based on fat and protein content, quality, logistics and especially contracted credence attributes such as organic or grass-milk. Similarly, the farm-gate price of hogs is based on weight and quality parameters and especially contracted credence attributes such as UK special pigs, free-range pigs, etc.

The Arla Foods payment scheme is based on a basic commodity value which is a linear function of the fat and protein content of the milk delivered and a constant term. This is the stated price that Arla Food changes on a regular basis according to current market and business conditions. Quality bonuses or penalties are added / subtracted as a percentage of the basic commodity value for somatic cell count, bacterial count and spore count. On top of this a fixed payment for willingness to accept independent determination of when Arla Foods collects the milk from the farm and a quantity payment based on the yearly delivery from the farm is paid as an adjustment of the difference in the costs of colleting the milk due to quantity and logistical flexibility. For organic producers a fixed premium is paid per kg. A minor fixed membership fee is paid by the farmer. On top of this the farmer receives a supplementary payment based on resolution of the board of representatives in proportion to the amount of business conducted with the cooperative (Arla Foods, 2013).

The Danish Crown payment scheme is based on a basic price per kg slaughtered weight in the weight class from 70.0 to 89.9 kg with a meat percent of 61%. More lean hog get premiums while more fat hogs get penalties. For hogs in other weight class's alternate prices apply. Danish Crown has a number of different logistical models adapted to the different production modes of the members. For different credence attributes a number of special payments apply, the different models are; 'Antonius', 'UK-pigs', 'EU-heavy pigs', 'Male pigs', 'Bornholm pigs', 'Free range pigs' and 'Organic pigs'. Like Arla Foods the farmer receives a supplementary payment based on resolution of the board of representatives in proportion to the amount of business conducted with the cooperative (Danish Crown, 2013).

There are clear price differentiation schemes on the physical attributes of the products and supplement payments for special contracted products, such as organic production, that often involve changes in on-farm production processes and specific investments. Although criticized for reducing competition (Bogetoft and Olesen, 2007), Danish cooperatives have shown that they can manage price differentiation among members on a number of product attributes. One thing they are not differentiated on, however, is the acceptable volatility of the base price. Danish hog and dairy farmers have no effective way of adjusting their hog or milk price risk exposure.

The substantial price risk that Danish farmers are exposed to is illustrated in Figure 4.1, note the change in milk price characteristic in 2007. Before 2007 milk price was declining but fairly stable, after 2007 more price variation is seen.

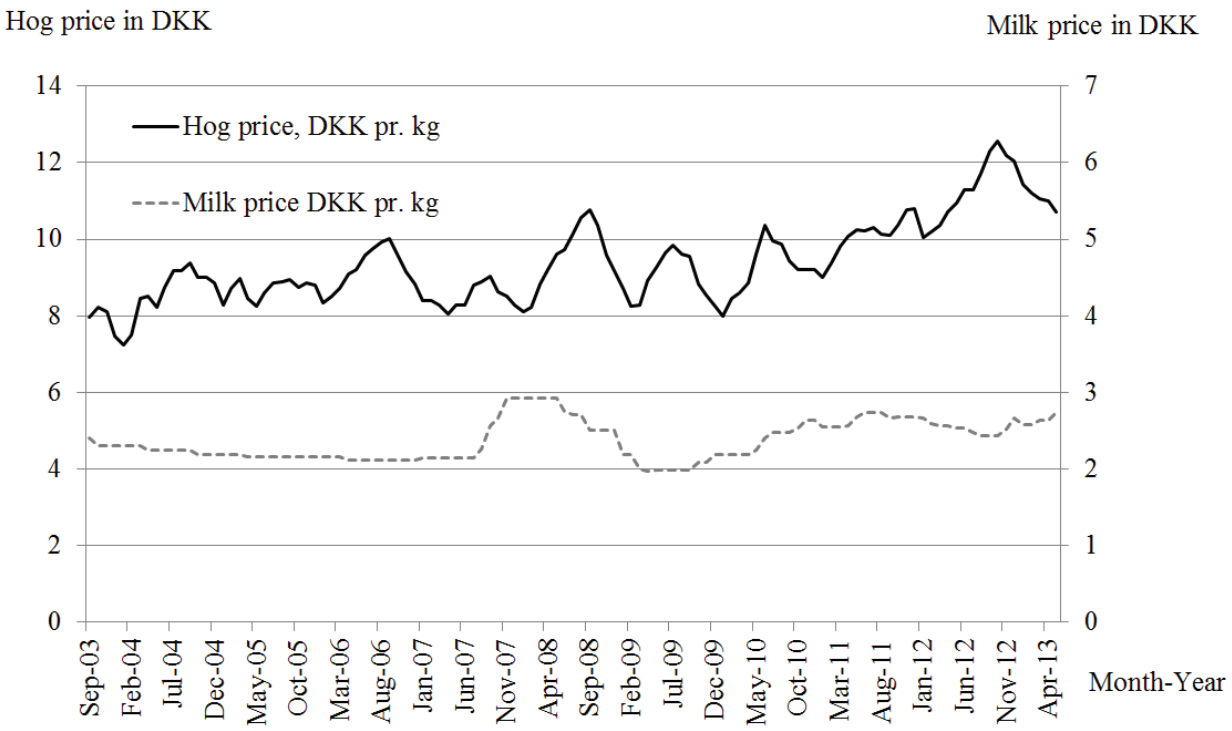

Figure 4.1: Monthly milk and hog price from Sep-2003 to May-2013. Source: FarmtalOnline (2013)

4.4 Member heterogeneity in risk exposure, appetite and management needs

Recent work by Chavas (2011) stresses the interaction between uncertainty and externalities in efficiency analysis of the agricultural sector. Using a certainty equivalent approach, the Coasian efficiency evaluation is extended to include risk allocation. It is stated that "an efficient allocation should try to reduce the aggregate cost of risk" (Chavas, 2011, pp. 398) and three ways of doing this are mentioned. First, risk exposure can be reduced. Second, when exposure involves externalities, it can be managed by coordination schemes using contracts or policy. Third, "the aggregate cost of risk […] can be reduced through risk-transfer mechanisms. By redistributing the risk away from the individuals who face a high cost of risk […], such mechanisms can reduce the aggregate cost of

risk" (Chavas, 2011, pp. 398-399). Chavas (2011) implicitly stresses the importance of heterogeneity and explicitly stresses the potential for reallocating risk.

Pennings and Leuthold (2000) and Pennings and Garcia (2004) explicitly stress the heterogeneity in hedging behavior using structural equation modeling to analyze the behavioral characteristics of Dutch hog farmers. The Dutch hog sector is very similar to the Danish hog sector, although the marketing traditions and the use of hog futures are important differences. Pennings and Leuthold (2000) analyze the following characteristics; perceived performance of futures as effective hedging tools, entrepreneurial freedom, perceived risk exposure, risk attitude, market orientation and the level of understanding of futures as a financial instrument. To test for heterogeneity, the sample was segmented in two. Across the two segments all characteristics except the level of understanding were significant drivers for hedging activity. There were, however, differences between characteristics leading the use of futures across the two segments. The study shows heterogeneity in the drivers for the use of futures in a sector very similar to the Danish hog sector. In the USA, the use of price risk management is widespread in both the dairy and hog sectors and in Ireland the cooperative dairy Glanbia has forward contracted part of its production with members, linking member supply-side forward contracts to specific business partner contracts on the demand side (Keane, 2012). This illustrates demand for price risk management instruments in the dairy sector. Assuming heterogeneity in the attitude towards risk management instruments among Danish hog and dairy farmers seems fair.

Collins (1997) presents a model where heterogeneity in cost structure, profitability and financial structure affect the likelihood of financial failure and motivate different levels of hedging via futures contracts.

4.5 The problem with futures markets – Basis risk

Futures markets could potentially solve the problem of commodity price risk adjustment for the individual cooperative member. There may, however, be liquidity problems in existing futures markets (Berg and Kramer, 2008) for milk and pork, and hedging in these markets are subject to considerable basis risk (Meuwissen, van Asseldonk and Huirne, 2008). A fundamental problem is the substantial basis risk that emerges from the fact that even if futures markets could transfer market price risk effectively, farmers, as cooperative members, are exposed to business risk in the dairy or

meat processing and marketing business. This is a broad definition of the basis risk concept, but a useful one. A narrow definition of basis risk is the difference between the spot cash price and the futures price (Hull, 2002).

In the case of the hedging of farm-gate milk or hog prices, derived prices of semi-processed products, trade on futures exchanges, for example skim milk powder (SMP) and butter, can be used. Combining futures in these two products could hedge milk price, but errors in relative weights could add to a broadly defined basis risk.

"Theory predicts that as maturity approaches, cash and futures prices must converge and the basis approaches zero, except for delivery costs" (Garcia and Leuthold, 2004, p. 242). The semi-processing of livestock commodities, transforming non-storable commodities to storable commodities, is an extension of the delivery cost line of reasoning. Even for non-storables "[p]rices are still expected to converge at maturity, and the futures price for non-storables is considered a market-expected cash price for a future time" (Garcia and Leuthold, 2004, pp. 242-243). The "delivery" costs may, however, include considerable transformation costs from non-storable to storable.

The Danish marketing cooperatives are going much further in adding value to commodities, which adds to the basis risk from the farmer/cooperative member's point of view if commodity prices are hedged via semi-processed commodities futures, and physical delivery is to cooperatives that add substantially more value to the average product via processing and marketing. The cooperatives down-stream contracting and risk management behavior may also have an impact on the broad definition of basis risk. If cooperatives have significant contract production down-stream, their earnings will not necessarily be fully reflected in the commodity market price, unless their down-stream contracting was hedged via an effective futures market.

The distinction between the market price risk and business risk is important, but not necessarily obvious. The "market price" for milk or pork in Denmark is greatly affected by the success or failure of the processing and marketing activities of the respective marketing cooperative. A potential global or European futures market price for milk or pork would be, if not independent, then very weakly dependent on the success or failure of the processing and marketing activities of the dominant marketing cooperative on the Danish market.

Global or European market price risk is what could potentially be transferred via a futures exchange. However, the relevant risk of concern to the Danish dairy or hog farmer is the aggregate of business and market risk of the respective market and marketing cooperative. A futures market for the transfer of commodity price risk on milk or pork would realistically be based on the physical delivery to local processing facilities. As Arla Foods and Danish Crown have near monopsony in Denmark, it is very hard to avoid exposure to processing and marketing business risk for Danish dairy and hog farmers. As explained above, the close connection between cooperative business risk and market risk means that market risk is very hard to avoid or adjust for Danish livestock farmers.

The difference between futures market risk and the aggregate of cooperative business and market risk is a key element of the basis risk involved in synthetic futures based hedging. Information asymmetries about processing costs and marketing contract and risk management status between cooperatives and members makes an effective hedge of, e.g. milk via synthetic combination of SMP and butter futures very difficult, if not impossible. The marketing cooperative may, however, not be very willing to disclose this information for strategic competition related reasons.

Example of risk, unrelated to market risk: The case of Arla Foods in the cartoon controversy

One example of specific business risk, which would not have been hedged in the case of use of futures market contracts and the physical delivery of milk to Arla Foods, is the case of the controversy following the Danish newspaper Jyllands-Posten's publishing of cartoons of the Islamic prophet Muhammad in 2005. The controversy affected Danish exports to the Middle East, notably the significant export of dairy products. The estimated loss for Arla Foods was 460 million DKK (Pedersen, 2010) equivalent to a price fall for the residual claimants of 0,075 DKK / kg member delivered milk in 2006 (Arla Foods, 2007) or more than a 3 % price cut in the farm-gate price in 2006. Business risk like this are not transferable on a futures market, but may possibly be transferred among cooperative members.

The pricing behavior of cooperatives may be affected by investment and finance considerations. The members are the residual claimants, but residual earnings may be retained in the cooperative for investment purposes or for reduction of debt. Thus strategic considerations concerning finance and possible credit constraints, as well as variation in investment opportunities for the cooperative, will affect the aggregate of the cooperative spot cash price and the end of year patronage payment.

This may affect the difference between the cooperative price and the futures price, as well as the predictability of this difference, which will increase the difficulty of use of commodity futures for the hedging of cooperative members' price risk. Possible agency problems may exist, arising from a conflict of interest between owners and the management of the cooperative. These problems are beyond the scope of this paper.

A number of potential problems with the use of futures hedging to reduce the cost of risk are identified. It should be noted, however, that even early literature on the topic by Working (1953) realized that, much the same as in insurance, the chief risk management function of hedging is to protect "against serious, crippling, loss. Carrying insurance against small losses that occur frequently is ordinarily poor business" (Working, 1953, p. 339). The cost of hedging must be weighed against the benefit of hedging. A lower quality hedge, with high basis risk, may be attractive if it comes at a discount compared to a high quality hedge, although a high quality hedge at an attractive price will be preferred if it is possible.

4.6 Potential for reallocation of price risk among cooperative members

4.6.1 THE MODEL

Marketing cooperatives may have some unutilized potential for differentiation of price risk exposure between cooperative members. By forward contracting different percentages of commodity turnover with cooperative members, the aggregate price risk of the cooperative can be redistributed among cooperative members.

Elaborating on the Collins (1997) model framework shows that cooperative member heterogeneity, in the usual factors which motivate hedging, yields potential gains from trade, thereby redistributing risk from members with a high cost of risk to members with a low cost of risk, as suggested more generally by Chavas (2011). One usual explanation for hedging is the reallocation of risk vertically in the supply chain. The idea suggested here is to utilize the potential gain from reallocation of risk horizontally in the supply chain, that is, reallocation among cooperative members with heterogeneous cost of risk.

As stated in Collins (1997, pp. 494-495), the "realistic objective of a single-period model is to maximize the expected effect of this period's operations on the firm's terminal equity […] subject to the

constraint that the chance that terminal equity is less than some disaster level (d) is less than α" which is the individual's acceptable probability of financial failure. Following Collins (1997), the model of terminal equity of the individual farmer is:

$$\tilde{E}_1 = E_0 + [p_h H + \tilde{p}_c(1-H)]Y - kY - iD - F \tag{19}$$

Where $\tilde{E}_1$ is the terminal equity, E_0 is the initial equity, p_h is the forward price of hedged output, H is the hedge ratio, $\tilde{p}_c$ is the stochastic cash price of the unhedged output, Y is output, k is variable costs, i is the interest rate paid on debt, D is debt and F is fixed costs. Given stochastic cash price of output, terminal equity is a stochastic function of not only realized cash price and the quantity hedged, but also the financial leverage of the firm. For simplicity the possibility of capital gains and losses are ignored.

Let $g(E_1)$ be the probability density function for terminal equity. The objective function is:

$$\begin{aligned} \max \bar{E}_1 &= \int_{-\infty}^{\infty} E_1 g(E_1) dE_1 \\ \text{s.t.} &\int_{-\infty}^{d} g(E_1) dE_1 \leq \alpha \end{aligned} \tag{20}$$

Where α is the acceptable risk of terminal equity below the individual disaster level, reflecting the individual cost of risk. Expected terminal equity is:

$$\bar{E}_1 = E_0 + [p_h H + \bar{p}_c(1-H)]Y - kY - iD - F \tag{21}$$

and

$$\frac{\partial \bar{E}_1}{\partial H} = (p_h - \bar{p}_c)Y \tag{22}$$

The relevant situations are where, $\bar{p}_c$, the expected spot cash price is above the forward price of hedged output $(\bar{p}_c > p_h)$ or an equivalent situation where there is a trade-off between expected terminal equity and a reduction in the risk of financial failure.

Following Collins (1997), suppose for simplicity that the price $\tilde{p}_c$ is uniformly distributed between the worst possible price (a) and the best possible price (b). The uniform density function is defined as:

$$f(p_c) = \frac{1}{b-a}, a \leq p_c \leq b; 0 \; otherwise \tag{23}$$

Further, following Collins (1997), given $f(p_c)$, the probability density function for terminal equity $g(E_1)$ is uniformly distributed with E_b representing the terminal equity under realization of (b) and E_a representing the terminal equity under realization of (a). The probability that a terminal equity level will be less than the disaster level is:

$$\int_{-\infty}^{d} g(E_1)dE_1 = \frac{d - E_a}{E_b - E_a}, \; E_a < d < E_b \tag{24}$$

Now suppose this model reflects the Danish situation for the marketing of milk and hogs. Because of near monopsony and prohibitive basis risk for futures markets, there are no effective hedging tools and $H = 0$. All cooperative members receive the same stochastic price $\tilde{p}_c$ for a given output, which reflects the residual claims in the cooperative.

If the goal of the marketing cooperative is to maximize the individual member's terminal equity subject to the constraint that the probability of terminal equity is less than some disaster level, which is less than the acceptable risk of financial failure, the ability to redistribute price risk among heterogeneous members will increase utility assuming zero transaction cost. The commonly stated goal of cooperatives is to maximize the commodity price received by their members. An example of this is in Jeppesen and Jørgensen (2012), this may differ from the assumed goal above. Whether the stated goal of maximum price is due to communicational convenience (as maximizing integrated profit may be a difficult concept to communicate) or otherwise, goals that maximize integrated profit and thus take the on-farm costs into account seem more relevant (Bogetoft and Olesen, 2000). Following Chavas (2011), the on-farm costs ought to include the cost of risk.

Suppose the marketing cooperative has three member segments, one with a low cost of risk, one with a medium cost of risk and one with a high cost of risk. Total quantity marketed through the

cooperative is $Y_{coop} = Y_{low} + Y_{medium} + Y_{high}$ where the subscripts low, medium and high represent the three member segments.

The residual claims in the cooperative are:

$$[p_h H + \tilde{p}_c(1 - H)]Y_{coop} \tag{25}$$

where $H = 0$, by tradition. That is, the cooperative payment to the member is proportional to the amount of business the member has with the cooperative. As a member the farmer is an owner of the cooperative and entitled to the residual claims, that is a proportion of what is left after all prior claims are satisfied (costs of running the cooperative).

But suppose members were endowed with an equal and positive forward price and an equally positive and proportional forward priced quantity, $\bar{H}$. Equation (21) could be extended to:

$$\begin{aligned} &\left[p_h \bar{H} \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1 - \bar{H}) \frac{Y_{low}}{Y_{coop}}\right] + \left[p_h \bar{H} \frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1 - \bar{H}) \frac{Y_{medium}}{Y_{coop}}\right] \\ &+ \left[p_h \bar{H} \frac{Y_{high}}{Y_{coop}} + \tilde{p}_c(1 - \bar{H}) \frac{Y_{high}}{Y_{coop}}\right] = [p_h \bar{H} + \tilde{p}_c(1 - \bar{H})]Y_{coop} \end{aligned} \tag{26}$$

This endowment is equivalent of a pre-commitment to increase the aggregate prior claims and reduce the residual claims, as well as reducing the quantity of which the residual claims will be proportionally divided. Notice that the average price and the variation in average price are unchanged for all segments. However, marginal price ($\tilde{p}_c$) volatility (σ_c) is increased.

Assume for convenience that the forward price is equal to the expected spot cash price, $p_h = \bar{p}_c$. As stated above the relevant situation is where ($\bar{p}_c > p_h$) or an equivalent situation where there is a trade-off between expected terminal equity and a reduction in the risk of financial failure.

Now suppose cooperative members were allowed to exchange $\bar{H}Y_{coop}$ among each other at a market price z. Cooperative members with a high cost of risk would presumably be willing to pay

$zh\overline{H}\frac{Y_{low}}{Y_{coop}}$ for an increase in the forward contracted quantity by $h\overline{H}\frac{Y_{low}}{Y_{coop}}$. Similarly, cooperative members with a low cost of risk would presumably be willing to reduce the forward contracted quantity by $h\overline{H}\frac{Y_{low}}{Y_{coop}}$ in return for pecuniary compensation $zh\overline{H}\frac{Y_{low}}{Y_{coop}}$, where h is the share of the endowed fixed price quantity that the low cost of risk members will be willing to sell at the price z.

This is such an equivalent situation and a trade-off between expected terminal equity and a reduction in the risk of financial failure is created. High cost of risk members can be in a financial position where they don't have the capacity to bear risk or they can have high cost of risk because of a high level of risk aversion. Likewise, the low cost of risk members can be in a strong financial position with moderate risk aversion, or they may be in a weaker financial position but have a low level of risk aversion, in both cases they have to be both willing and able to take on increased risk exposure in return for adequate compensation.

The cooperative members with a medium cost of risk would be unwilling to pay z for a marginal increase in the forward contracted quantity, and unwilling to receive z for a marginal reduction in the forward contracted quantity. They would be unaffected at the average price volatility level, but would be affected by an increase in variation at the marginal price ($\tilde{p}_c$) level.

Equation (22) could be extended to:

$$\begin{aligned}
&\left[p_h\overline{H}\frac{Y_{low}}{Y_{coop}} - p_h h\overline{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\overline{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h\overline{H}\frac{Y_{low}}{Y_{coop}} + zh\overline{H}\frac{Y_{low}}{Y_{coop}}\right] \\
&+\left[p_h\overline{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\overline{H})\frac{Y_{medium}}{Y_{coop}}\right] \\
&+\left[p_h\overline{H}\frac{Y_{high}}{Y_{coop}} + p_h h\overline{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\overline{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h\overline{H}\frac{Y_{low}}{Y_{coop}} - zh\overline{H}\frac{Y_{low}}{Y_{coop}}\right] \\
&= [p_h\overline{H} + \tilde{p}_c(1-\overline{H})]Y_{coop}
\end{aligned} \tag{27}$$

The expected terminal equity for cooperative members with a low, medium and high cost of risk, respectively, is

$$\bar{E}_{low_1} = E_{low_0} + \left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h h\bar{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h\bar{H}\frac{Y_{low}}{Y_{coop}} + zh\bar{H}\frac{Y_{low}}{Y_{coop}}\right] \quad (28\text{ a})$$
$$-kY_{low} - iD_{low} - F_{low}$$

$$\bar{E}_{medium_1} = E_{medium_0} + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] \quad (28\text{ b})$$
$$-kY_{medium} - iD_{medium} - F_{medium}$$

$$\bar{E}_{high_1} = E_{high_0} + \left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h h\bar{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h\bar{H}\frac{Y_{low}}{Y_{coop}} - zh\bar{H}\frac{Y_{low}}{Y_{coop}}\right] \quad (28\text{ c})$$
$$-kY_{high} - iD_{high} - F_{high}$$

As pointed out above, the heterogeneity in factors which affect hedging behavior can take many forms (Pennings and Garcia, 2004; Pennings and Leuthold, 2000). Assume these factors are condensed in the cost of risk (Chavas, 2011) and assume, without loss of generality, that the cost of risk is inversely reflected in the level of acceptable probability of financial failure $\alpha_{low} > \alpha_{medium} > \alpha_{high}$ holding the disaster level equal for all members at the point of financial failure where $\tilde{E}_1$ is zero, $d_{low} = d_{medium} = d_{high} = 0$.

The objective function of the three segments could be stated as:

$$\max \bar{E}_{i\_1} = \int_{-\infty}^{\infty} E_{i\_1} g\left(E_{i\_1}\right) dE_{i\_1}$$
$$\text{s.t.} \int_{-\infty}^{d} g\left(E_{i\_1}\right) dE_{i\_1} \leq \alpha_i \,, where\ i \in \{low, mediun, high\} \quad (29)$$

This means that members with a low cost of risk *ceteris paribus* will accept a higher probability of financial failure than members with a high cost of risk, against compensation of $zh\bar{H}\frac{Y_{low}}{Y_{coop}}$. Members with a high cost of risk will accept a lower expected terminal equity, $\bar{E}_{high\_1}$, in return for a lower probability of financial failure.

Assume that $g\left(E_{low\_1}\right) = g\left(E_{medium\_1}\right) = g\left(E_{high\_1}\right)$ ex ante, before endowment of $\bar{H}$ and transfer of risk. The only thing separating the three segments is $\alpha_{low} > \alpha_{medium} > \alpha_{high}$.

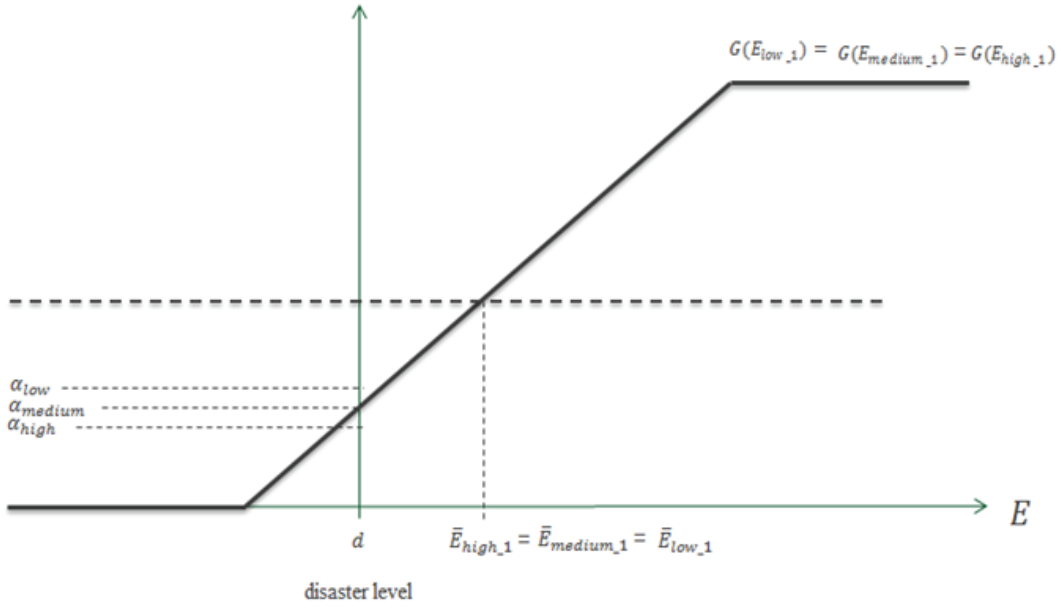

Figure 4.2 a): Cumulative distribution function of terminal equity, ex ante

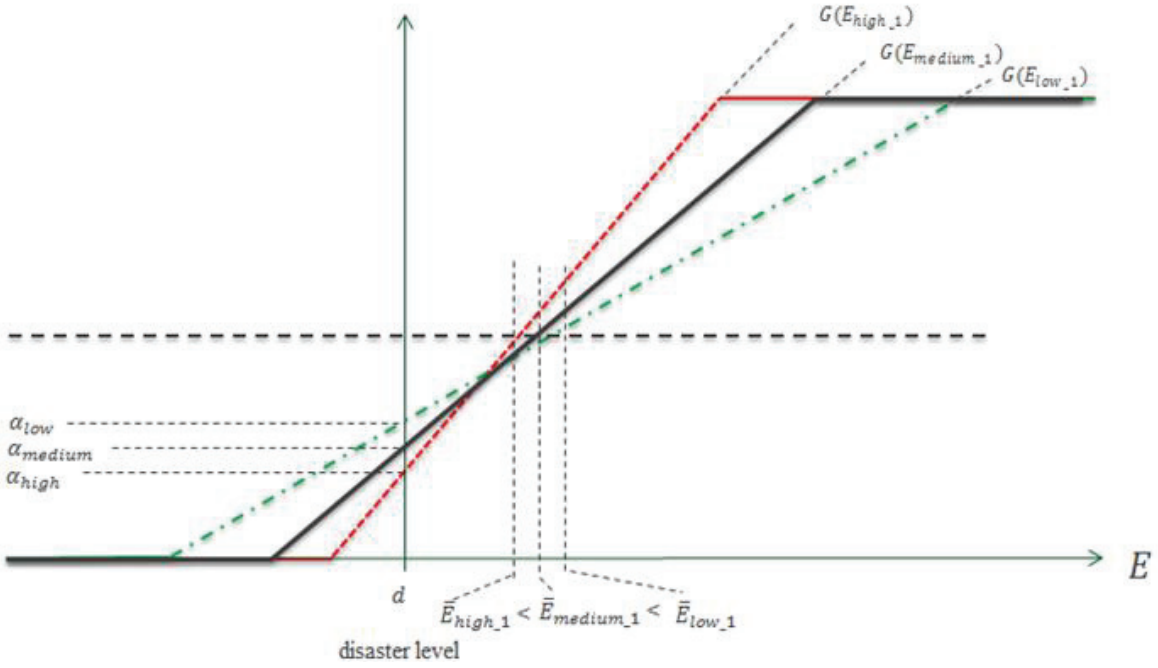

Figure 4.2 b): Cumulative distribution function of terminal equity, ex post

As illustrated in Figure 4.2 a, the condition for equation (25) is not satisfied for the high cost of risk segment, since the probability of financial failure is above α_{high}, the acceptable level of financial failure. Given the endowment of $\overline{H}$ it is possible to transfer risk among members in exchange for pecuniary compensation and obtain an ex post situation (Figure 4.2 b) in which risk is adjusted to the level where the probability of financial failure is equal to the acceptable level, for each segment. Expected terminal equity will shift from $\bar{E}_{low\_1} = \bar{E}_{medium\_1} = \bar{E}_{high\_1}$ in the ex ante situation to $\bar{E}_{low\_1} > \bar{E}_{medium\_1} > \bar{E}_{high\_1}$ in the ex post situation. $G(E_{i\_1})$ denotes the cumulative distribution function of terminal equity of segment i.

Assuming that $\frac{\partial Y}{\partial \sigma_c} = 0$, that $h > 0$ and zero transaction costs, a change in the traditional endowment of $\overline{H} = 0$ to $\overline{H} > 0$ will increase the aggregate utility without anyone being worse off. This constitutes a Pareto improvement. This claim builds on the following reasoning; endowing members with a non-zero but low positive $\overline{H}$ changes nothing, neither the expected terminal equity nor the variation in terminal equity. Nobody is worse off. Now if $h > 0$ this means that someone made a voluntary market transaction, and this means that someone is better off, making it a Pareto improvement. These assumptions, however, need further discussion.

4.6.2 TRANSACTION COSTS

An actual endowment of $\overline{H} > 0$ and the subsequent exchange of forward contracting rights will incur some direct transaction costs. The cost structure of direct transaction costs will presumably have some fixed element related to setup costs, etc. If these are assumed to be negligible or covered more than fully by direct transaction fees paid by participating segments, there could still be room for Pareto improvement. In this case, non-participating members will no longer be unaffected but will receive part of the redistribution gains, that is the transaction fees paid by participating members less the part of direct transaction costs covered by the cooperative multiplied by $\frac{Y_{medium}}{Y_{coop}}$. Modern electronic market platforms have relatively low direct transaction costs, which is why assuming variable transaction costs, although a simplification of reality seems fair.

The model could be extended to cover variable transaction costs τ in the following way:

$$\begin{aligned}
&\left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h h\bar{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h\bar{H}\frac{Y_{low}}{Y_{coop}} + zh\bar{H}\frac{Y_{low}}{Y_{coop}} - \frac{\tau}{2}h\bar{H}\frac{Y_{low}}{Y_{coop}}\right] \\
&+\left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] \\
&+\left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h h\bar{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h\bar{H}\frac{Y_{low}}{Y_{coop}} - zh\bar{H}\frac{Y_{low}}{Y_{coop}} - \frac{\tau}{2}h\bar{H}\frac{Y_{low}}{Y_{coop}}\right] \\
&= [p_h\bar{H} + \tilde{p}_c(1-\bar{H}) - th]Y_{coop}
\end{aligned} \tag{30}$$

Expected terminal equity for cooperative members with a low, medium and high cost of risk, respectively, would be:

$$\begin{aligned}
&\bar{E}_{low_1} = \\
&E_{low_0} + \left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h h\bar{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h\bar{H}\frac{Y_{low}}{Y_{coop}} + zh\bar{H}\frac{Y_{low}}{Y_{coop}} - \frac{\tau}{2}h\bar{H}\frac{Y_{low}}{Y_{coop}}\right] \\
&\qquad -kY_{low} - iD_{low} - F_{low}
\end{aligned} \tag{31 a}$$

$$\begin{aligned}
&\bar{E}_{medium_1} = \\
&E_{medium_0} + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] \\
&\qquad -kY_{medium} - iD_{medium} - F_{medium}
\end{aligned} \tag{31 b}$$

$$\begin{aligned}
&\bar{E}_{high_1} = \\
&E_{high_0} + \left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h h\bar{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h\bar{H}\frac{Y_{low}}{Y_{coop}} - zh\bar{H}\frac{Y_{low}}{Y_{coop}} - \frac{\tau}{2}h\bar{H}\frac{Y_{low}}{Y_{coop}}\right] \\
&\qquad -kY_{high} - iD_{high} - F_{high}
\end{aligned} \tag{31 c}$$

If transaction costs are sufficiently low, there will still be potential for Pareto improvements by enabling the reallocation of price risk.

Assuming zero setup costs means zero costs if $h = 0$, this is of course a simplifying assumption. But given the turnover of the cooperatives in question, assuming the fixed setup costs of a price risk reallocation scheme to be negligible seems a fair simplifying assumption.

In reality, the cost structure of a risk reallocation mechanism is likely to involve relatively high fixed cost (setup costs) compared to negligible variable costs. The setup costs will, however, most likely be relatively low compared to the reallocation gain. Experiences from the introduction of a sugar beet contract exchange in Denmark in 2008 among farmers are good and the cost of running an exchange like this is negligible compared to the economic size of the cooperatives in question. The sugar beet contract exchange not only facilitated the efficient reallocation of contracts, it did so whilst keeping bid and ask information confidential through use of secure multiparty computation (SMC) technology (Bogetoft and Nielsen, 2012).

In principal the reallocation of risk suggested above could be done by cooperative members betting on the cooperative pay-out bilaterally. However, as Danisco and the Danish Sugar Beet Growers Association realized when they implemented their contract exchange, bilateral bargaining involves considerable searching and matching costs and is associated with strategic behavior. Mechanism design and implementation are pivotal in order to obtain the reallocation gains (Bogetoft and Nielsen, 2012). Organization of a forward contract exchange by cooperatives may significantly increase the gains derived from the reallocation of price risk. Not only will searching and matching costs be reduced, counterparty risk, involved in a bilateral betting scenario, will also be reduced by having the cooperative act as a clearing house, thereby shifting counterparty risk from a member to member issue, to a member to cooperative issue. Reduced counterparty risk is a feature of exchange-traded derivatives such as futures and options as opposed to negotiated contracts. In this way the concept of futures (standardized contracts) and forwards (negotiated contracts) converge, as the forward contracts exchanged are standardized, but cooperative specific, with exchange being restricted to cooperative members.

4.6.3 QUANTITY EFFECT OF INCREASED VOLATILITY OF MARGINAL PRICE

In the analysis above it was assumed that change in the volatility of price has no effect on output, $\frac{\partial Y}{\partial \sigma_c} = 0$. This assumption may be strong which is why the effect of relaxation is discussed as it may influence the model outcome. As Turvey (1989) points out, production and marketing issues are often treated independently, although they are inherently integrated parts of one decision problem.

As classical theory dictates, the short run production will be maintained as long as marginal revenue is greater than or equal to marginal cost, $\tilde{p}_c \geq k$. In the long run all costs will have to be covered. The question is how long is the long run? How flexible is the cost structure at the individual farm level and on the cooperative wide level.

The time horizon of the suggested endowment of forward contracts to cooperative members is a key variable. The contract horizon length is assumed to be positively related to the value of hedging. Very short contracts will approach a no contract situation, while longer contracts will improve cash flow predictability for members with an above average hedge ratio within the contract period. Members, having sold part of their forward contract endowment to other members, will have a below average hedge ratio. The price of accepting increased price volatility, for members with below average hedge ratio, will increase with the length of the time horizon of forward contracts. The optimal length of such contracts is beyond the scope of this paper, although a pragmatic suggestion for the time horizon of the forward contract could be that the hedged price p_h and quantity endowment $\overline{H}$ are specified in advance for the cooperative's fiscal year, stating p_h as the expected average price and the individual member endowment $\overline{H}_i$ to be based on the individual member's preceding year's delivery to the cooperative.

Suppose forward contract is specified as above, then the short run will become the cooperative's fiscal year. The volatility of the unhedged price $\tilde{p}_c$ will increase and will affect the production quantity in cases where $\tilde{p}_c < k$ with k representing the within year flexible costs. In general, the cost structure of modern Danish livestock production is relatively fixed and cases where $\tilde{p}_c < k$ will presumably be seldom. However, across the members of the cooperative, there will likely be a distribution of production technologies at work. Older production facilities that are near the end of their productive lifespan, may be shut down early in cases where $\tilde{p}_c$ is low. Similarly, these facilities may be kept in production for a while longer in cases where $\tilde{p}_c$ is high. This sort of dynamic will most likely have some effect on the total production Y_{coop} and $\frac{\partial Y}{\partial \sigma_c} \neq 0$ and thus have an impact $[p_h H + \tilde{p}_c(1-H)]Y_{coop}$ and an accelerating impact on σ_c. The cooperative average price will be affected at some level and the above-mentioned impact on non-participating members will be understated. Pareto improvements will be less likely, as the possibility that non-participating members will not be automatically compensated will increase. There will, however, still be significant poten-

tial for improvement of the weaker Kaldor-Hicks efficiency measure as a function of the risk reallocation possibility (Gowdy, 2004).

If delivery of Y_{coop} declines as a consequence of low $\tilde{p}_c$, the cooperative may be able to mitigate this effect by sourcing input from outside the group of members. This may be a realistic strategy in cases where general market price downturn drives $\tilde{p}_c$ to a low level. In cases where the lower $\tilde{p}_c$ is related to business specific factors, this may not be possible. As mentioned earlier, mergers leading to the formation of the current cooperatives were subject to a number of conditions, including that they partially relinquished their exclusive supply requirement for members. Members are, however, still required to deliver a substantial part of their production to the cooperative within the year, and are only able to leave the cooperative, without penalty, with due notice effective at the end of the year. Side-trading is therefore limited if the length of forward contracting endowments is aligned with the possibility of leaving the cooperative. However, members who cease production, as mentioned above, will not be restricted.

Because of the proportional payment schemes, cooperatives traditionally have inherent incentive problems in the sense that they signal average benefit to the member, and the member is incentivized to react to average benefit. This may not be equal to marginal benefit, and maximizing integrated profit may be difficult because of difficulty in equating marginal cost and marginal benefit, which is called the quantity control problem. In New Generation Cooperatives (NGC), this problem is mitigated through contract production. NGCs are usually characterized by closed membership and transferrable delivery rights (Bogetoft and Olesen, 2000). In some sense the suggested endowment and reallocation of forward contracted prices is similar to the operation of NGCs, although the model differs from NGCs in the sense that membership is not closed and the endowment of forward contracting is only short therm.

As mentioned, the level of endowment of forward contracts, $\overline{H}$, to cooperative members is zero by tradition. Increasing this level and reallocating the contracts among members via a double auction will most likely yield reallocation gains. Increasing the level of $\overline{H}$ too much will, however, reintroduce risk in the form of counterparty risk. In case of a high level of $\overline{H}$ the risk that the cooperative will be unable to pay p_h for the contracted quantity may be introduced. A balance between the po-

tential reallocation gains on the one hand, and the increase in counterparty risk on the other, will determine the optimal level of $\overline{H}$. This analysis is beyond the scope of this study. A suggested level of $\overline{H}$ around 20 % of Y_{coop} seems to be low enough to avoid the risk of being unable to pay p_h, driving the cooperative into bankruptcy, while yielding a significant potential for reallocation gains.

Tying the individual endowment of $\overline{H}$ to the preceding year's delivery will introduce a second order effect on commodity price. Revenue from commodities delivered to the cooperative will not only be in the form of p_h or $\tilde{p}_c$ but also in the form of, $z_{year\ two}\overline{H}_{year\ two}Y_{year\ one}$, the value of endowment of forward contracting the following year. Assume for illustration that the risk premium z is 5 % of the expected spot cash price and that the endowment of $\overline{H}$ is 20% of the previous year's delivery, the second order price effect will be a 1 % increase in the expected price.

Bak-Pedersen and Neergaard-Petersen (2003) suggest a model with many similar aspects targeting new (young) entrants to the hog sector. They suggest a five year contract based on the average price of the previous five years. The main difference between the model presented in this paper and the Bak-Neergaard-model is that the suggested contracts here would be one year contracts based on expected price. Other important differences are: a) all members have the same access to the contract; b) the risk premium paid for reducing price risk via contract is determined by an auction mechanism and not by fiat; c) all members are endowed with a contract quantity in equal proportion to the previous delivery, which means that members who do not participate in the auction will experience minimal change in their risk exposure if they have stable production, and; d) the Bak-Neergaard-model suggests that the cooperative should carry the liquidity burden associated with risk, while the liquidity burden is transferred to the residual claimants in the model presented here.

The importance of the financial framework conditions are recognized by Bak-Pedersen and Neergaard-Petersen (2003) and they conclude that the value of their contract model is reduced by favorable access to credit at the time, but that future adverse developments in the financial markets may increase the relevance of the model. This is important insight and the actual development in the post financial crisis world may very well increase the potential value of risk reallocation among cooperative members.

Bogetoft and Olesen (2000, 2002, 2004, 2007) have performed rigorous analyses of contracting in Danish agriculture. Their main frame of analysis is producer / processor contracting and one of the main issues is the conflict between motivation of optimal effort and optimal risk sharing. Examples of risk related to effort can be quality aspects or animal health issues. Processors may be better able to carry the cost of risk associated with stochastic processes related to these issues, although the cost of risk may be significantly reduced by the producer's optimal effort. In these cases, motivational problems may exist.

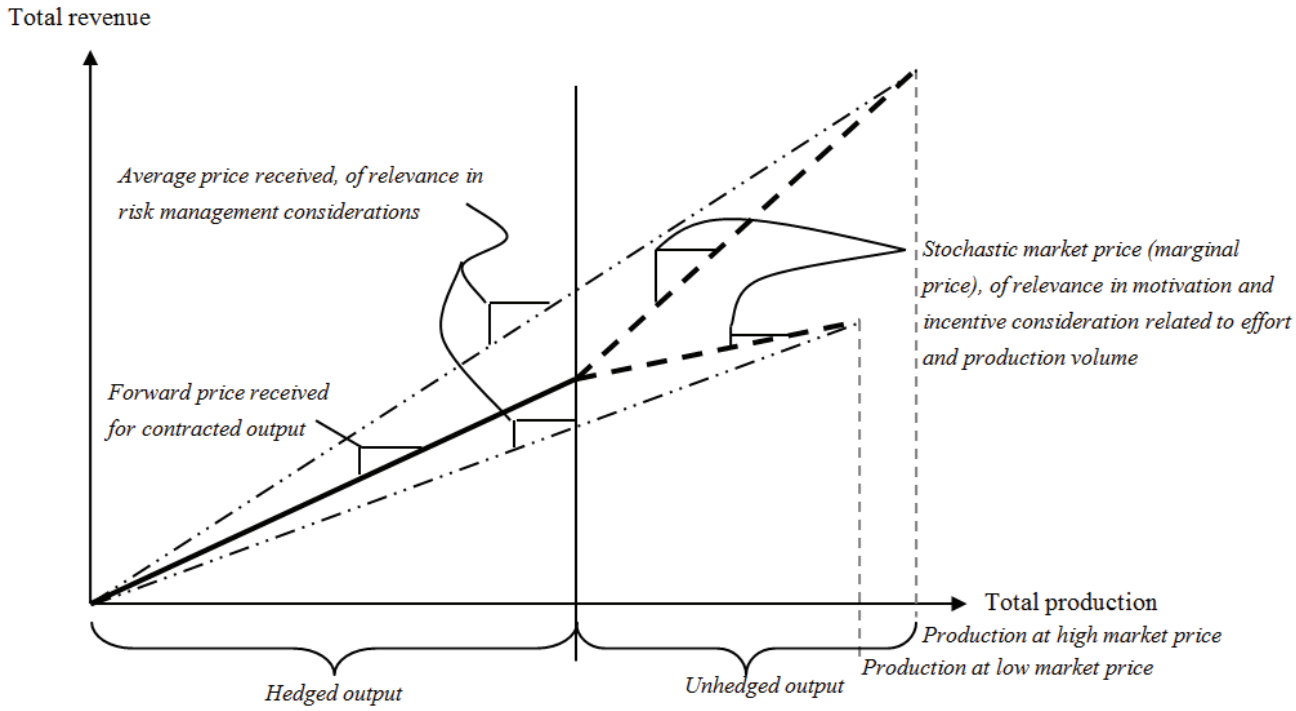

Figure 4.3: Price risk exposure for farmers using forward contracts

With regard to price risk and price risk transfer, the motivational problems that preoccupied Bogetoft and Olesen (2004) are not major problems if hedge ratios are moderate. Price risk transfer via hedging reduces the variation of average price received around the hedged price subject to the increased variation of the price of unhedged production and the hedge ratio. Classical production theory predicts that production quantity is motivated, not by the average price, but by the marginal price, which is the price of the unhedged production. Increasing production to the level where marginal costs are equal to marginal revenue is unaffected by hedging at moderate levels from the indi-

vidual farmer's point of view. Figure 4.3 illustrates differences in forward contracted price, average price and marginal (unhedged) price with the differences in the slope of the total revenue curve.

Forward contracting part of production will to some extent mitigate the quantity control problem, in the sense that the cooperative via $\tilde{p}_c$ sends a stronger signal of marginal benefit as opposed to average benefit. The above-mentioned effect on non-participating members may be positive as better price signals may increase integrated profit. Pareto improvement may, however, still be too strong an efficiency criterion, because the distribution of effects may potentially put some groups in a situation where they are worse off, ex post.

Today cooperative management do not receive any signals on the acceptable risk taking in the processing and marketing business except for the signals sent via the members' democratic organization. An internal market price for forward contracts may improve the ability to signal the farm-level cost of risk to cooperative management in a more efficient way. This may help coordinate collective risk management. Basis risk on futures markets may be lower from the cooperative's point of view than from the farm's point of view as asymmetry in information on cooperative exposure may be substantial. Garcia and Leuthold (2004, p. 261) pose the question "Will individual managers have to turn to locally based forward contracts offered by large processing firms who then have access to futures markets to manage their risk?" The question seems to suggest a fruitful line of reasoning.

4.7 Conclusion

The potential gain from the reallocation of risk among cooperative members will depend upon the distribution of cooperative member attitudes towards, and perceptions of, risk, their alternative risk mitigation possibilities and differences in financial structure and possibly the macroeconomic environment, all reflected in the members individual cost of risk. Given sufficiently low transaction costs and sufficiently high heterogeneity of members, the potential gains would be positive. It is the author's belief that the potential is great in the current post GFC environment, although it is not static, as alternative ways of mitigating risk evolve dynamically and the potential will be conditioned on the present alternatives at any given time.

"Necessity is the mother of invention" (Ester Boserup cf. Rogers, Jalal, & Boyd, 2008, p. 20) the question is whether necessity is also the mother of institutional innovation with regard to risk management in agriculture?

Until recently, institutions may have been in place that crowded out the need for transferring price risk away from some of the livestock producers in Denmark. These institutions may be changing drastically and the ability to transfer price risk may be becoming valuable. Traditionally, commodity futures are thought of as vehicles for the transfer of price risk vertically in the value chain. Here endowment and the transfer of forward contracts among cooperative members is suggested to extract the potential gains from the horizontal reallocation of risk.

Research questions like; what is the optimal endowment of $\bar{H}$? what is the optimal forward price p_h? and what is the potential gain from the reallocation of risk? are still open questions. However, it seems likely that advances in electronic market platforms and market design could reduce transaction costs to a sufficiently low level, where this type of reallocation could be a source of social gain. Price risk management tools could potentially alleviate some of the financial constraints that Danish agriculture is experiencing in the aftermath of the GFC.

As noted, the potential (net) gain will depend on the heterogeneity of the cooperative members (gross gain potential) and the transaction costs involved in reaping the gross gain potential. The estimation of the gross gain potential, e.g. the cost of carrying risk, is an open research area. Zheng *et al*. (2008) analyze the potential welfare loss from reducing the choice of marketing arrangements for agents with a heterogeneous risk preference in the U.S. hog industry. This approach may provide a useful way of estimating the potential gain from increasing the choice of marketing arrangements among agents with a heterogeneous risk preference.

Chapter 5

Conclusion

5.1 Conclusion

5.1.1 CHANGE IN THE FINANCIAL ENVIRONMENT: THE IMPLICATIONS FOR RISK MANAGEMENT

This chapter will summaries the central findings of the three papers and will relate these findings to the bigger picture. Some aspects of this bigger picture which are not, or are only very briefly dealt with in the papers will be discussed here.

The first paper quantifies and substantiates the general notion that access to credit was quite easy for Danish farmers up to the GFC. While the papers' core contribution is methodological, suggesting a novel measure for credit capacity by estimating debt possibility frontiers using Data Envelopment Analysis, the implications of the empirical results are important for the understanding of risk management practice in Danish agriculture up to the GFC.

During the past 40 years, the risk exposure of Danish farmers has increased as a function of increasing specialization and leverage. Looking at these two factors alone, this development is counterintuitive as you would expect to see some risk balancing, e.g. counterbalancing the increasing business risk, from increased specialization, with decreasing financial risk via a reduction in leverage. However, this has not been the case, most likely because the risk mitigating effect of diversification that was lost with specialization was replaced by price stabilizing agricultural policy. When the gradual policy focus shifted toward more market-oriented policy, price risk was reintroduced leaving farmers highly specialized, highly leveraged and exposed to price risk. The general business cycle and the more subtle details of the institutional environment with regard to finance, did however offer the Danish farmers increasing access to credit.

In an environment with increasing access to credit, perceived credit reserves will most likely increase as well, which will in turn crowd out other risk coping strategies. OECD (2009, 2011) stresses the crowding out effect of agricultural policy on market-based risk management instruments, such as futures and insurance markets. Basically the argument is that if agricultural policy reduces farmers' risk exposure, it will also reduce demand for market-based risk management instruments. Because of this, demand may not reach a critical mass, where market-based instruments will appear or flourish. While this effect is important, the interaction with the institutional environment with regard to finance is an important, but largely omitted, effect.

While OECD (2009, 2011) realizes that risk management will affect farmers' access to credit and investment behavior, the realization of the reverse effect is much more unclear, i.e. the crowding out effect of access the credit on market-based risk management instruments. In order to achieve a thorough understanding of agricultural risk management practice necessitates a thorough understanding of the financial environment and not solely an understanding of the natural and policy environment within which farmers operate.

The increasing access to credit, documented in the first paper, will most likely have had a major effect on the way risk was managed in Danish agriculture up to the GFC. The institutional subtleties of the financial system in Denmark, however, reach much further back in history. In an historical perspective, access to credit was probably relatively easy for Danish farmers compared to most of their international counterparts. The effect of the international business cycle boom up to the GFC, or maybe more appropriately the international credit cycle boom, was more significant in the Danish institutional environment than it was in other more restrictive financial environments, and similarly, the effect of the bust and the following process of deleveraging has had more severe consequences for the Danish institutional environment for agriculture, *ceteris paribus*.

5.1.2 ORGANIZATIONAL CHANGE: THE IMPLICATIONS FOR RISK MANAGEMENT

The subtleties of the financial system that affect the access to credit may also affect the way production is organized. The second paper explores this notion. The paper develops a theory of organization which emphasizes the interaction between technological development and the financial system, built on observations from agricultural value chains. The development in hog marketing arrangements in the U.S. and Denmark is compared using the method of difference.

There is substantial research on the driver for the significant change in livestock marketing arrangements in the U.S. This research is based on TCE arguments and basically concludes that technological change drives organizational change because it induces investments in more specific assets. While this is probably a correct assessment of the key drivers of the evolution of organizational arrangement in the U.S. livestock sector toward contract production and backward integration, there seems to be some elements missing in a more comprehensive understanding of organizational change.

The comparison of the development in hog marketing arrangements in the U.S. and Denmark shows that the technological change, which was supposed to drive the organizational change in the U.S., also occurred in Denmark, but without any resulting organizational change. This suggests that omitted factors may bias the TCE explanation of organizational change. Interaction between a financial system, with relatively easy access to credit, and technological change may result in different organizational outcomes than interaction between financial systems with relatively hard access to credit and technological change.

The theoretical prediction developed in the paper is that in situations where technological development drives investment in specific assets, the financial institutional environment, which determines the access to credit, will determine whether investments will be financed via debt markets and/or equity markets affecting organizational form.

If access to credit is relatively easy, forward integration via the cooperative organization of processing and marketing is a likely outcome as long as the monitoring costs are lower for farmers (cooperative members) who are monitoring hired cooperative management, than the monitoring costs for farmers who are monitoring hired farm managers in a backward integrated privately held processing firm.

If access to credit is difficult, firms will turn to the stock market for access to credit. If investors on the stock market have lower costs of monitoring backward integrated or quasi-integrated processing firms than forward integrated farms, it is likely that investor owned backward integrated firms will become the organizational outcome of technological change.

An understanding of the connection between the institutional environment of finance and the cooperative organization of processing and marketing is important. Recognizing the connection is a first step toward anticipating the impact of change in the one factor on the other.

Organization may mitigate at least two important risk factors. The main focus in organizational research is on the mitigation of hold-up risk or post contractual opportunistic behavior. The other important risk factor that organization may mitigate is market price risk; that is the volatility in prices that would be present in perfect markets without agency or transaction costs.

Backward integration and contract production seen in the U.S. mitigate both these risk factors, whereas the Danish cooperatives only mitigate the risk of hold-up. As the market risk has been relatively low and access to credit has been relatively easy in Denmark, there has been no, or relatively little, reason for the Danish system to cope with market risk, as credit reserves have been a favored risk coping mechanism. In the post-GFC world, the ability to mitigate risk via credit reserves is no longer as viable. This constitutes a challenge for the Danish system. Change in market price volatility and access to credit constitute change in parts of the institutional matrix, which will induce the need for adaptive changes in other parts of the institutional matrix, e.g. other risk management institutions.

5.1.3 ADAPTING TO CHANGE – THE REALLOCATION OF RISK AMONG COOPERATIVE MEMBERS

The third paper explores one possible role of the Danish processing and marketing cooperatives in relation to the emerging risk management challenges. Specifically it explores the possibility of reallocating price risk among cooperative members as an alternative to the futures-based hedging of price risk.

There is no, or only very limited use, of futures based price hedging on the output side by farmers in the two main livestock sectors in Denmark, the dairy and the hog sector. One reason for the low use of the futures-based hedging is that farmers market their produce through cooperatives. Marketing via cooperatives means that the price risk farmers are exposed to in the physical market is different to the price risk that they may potentially hedge via futures markets.

If the futures market was a place where farmers could hedge the pure market risk associated with their produce, it may still not help the farmers enough, as they are exposed to the cooperative price in the physical market, which is a combination of the pure market risk and the cooperatives' business risk.

If, however, the cooperative members are sufficiently heterogeneous regarding their cost of coping with risk and the transaction costs associated with the reallocation of the cooperative price risk among the members are low enough, there will be potential gains from a mechanism that enables cooperative members to reallocate risk among themselves.

The basic idea of the mechanism is that all members are endowed with a proportional forward contract each year, say 20 % of last year's delivery, to a fixed price close to the cooperatives expected price the coming year. Endowing members with a fixed price on a part of the quantity increases the volatility in price of the residual part of the quantity (80 %), as it is this (now reduced) part of the quantity that holds the residual claims to the cooperatives earnings. As long as all members receive a fixed price on 20 % and a stochastic price on 80 % of their delivery to the cooperative, the member's end of year expected average price and the variation in this average price will be the same as if the mechanism was not in place. However, endowing members with a forward contracted quantity, and enabling trade with these fixed price quantities, enables the reduction of cooperative price risk exposure for some members, by paying a risk premium to the members who are increase their risk exposure, by selling part of their fixed price contracted quantity.

In a perfect world, this mechanism would not be efficient, as ultra-liquid futures markets could transfer risks much better. If, however, futures markets do not work, for some reason or another, the potential for reallocation of cooperative price risk among the member could yield substantial gains from trade.

Of the three papers summarized above, the first two deal with the "why´s" and the third deals with a "how" in the sense that the two first papers deal with why risk have been managed the way it has, up to the GFC. In understanding the "why", the understanding of possible consequences of changes in the historically determining factors is improved. Realizing that the changes in the institutional frames for agricultural risk management, including finance and organization, will induce change in the risk management practice, the third paper turns to a "how" in the sense that it explores one suggestion of how agricultural risk management can adapted to change. This is not a stand-alone or even the most probable risk management adaptation, but it is a novel contribution to the (coming) debate of how to adapt to the new institutional framework, broadly labeled "the new normal." The key message is that cooperative can and should play an active role in dealing with the new challenges that face their members. In the following, examples of other alternatives of how to adapt are discussed briefly; most adaptations could be seen in combination with the suggestion above or with each other.

5.1.4 ADAPTING TO CHANGE – ACCESSING CAPITAL THROUGH REITS

The introduction of outside equity capital to the primary farm level from investors such as pension funds could be a way of transferring risk away from the fewer and fewer active farmers. Outside equity is a universal risk management tool, much like debt. Outside equity may have the advantage regarding risk carrying capacity compared to the inside equity of sole proprietorships, that investors can diversify (diversifiable) risk away in the portfolio. Sole proprietors often do not have a very diversified portfolio, as most of their capital is tied up in their firms.

One way of reducing debt, while keeping the agency costs of outside equity at a minimum, is to establish real estate investment trusts (REITs) invested in farms or possibly only land, which could be labeled FREITs and LREITs (Painter, 2000, 2011). Establishing FREITs or LREITs that rent agricultural assets to producers (tenant famers) could be a way of shifting the capital structure of the agricultural sector so that it is better aligned with the new financial environment where access to credit is limited and where farmers need greater solvency to buffer against risks. Renting land would enable tenant farmers to reap almost the same economies of scale as in the case ownership, while reducing the strain on solvency.

5.1.5 ADAPTING TO CHANGE – RETAINING CAPITAL THROUGH POSTPONED SUCCESSION

A variation of LREITs that is already in place in Denmark is combinations of ownership and tenant farming. It is quite common for farmers to rent the land of retired farmers who continue to live on their farms. In a sense these are examples of very small LREITs where the retired farmer has his own pension fund invested in the farm. There may be tax and non-pecuniary advantages of this model. There is a current debate in Danish agriculture which focuses on sector-level succession problems, as young farmers have great difficulty in accessing finance for succession of older generations. The debate seems to lack the insight that if succession is postponed, and assets are leased instead of sold; the young generation can assume control without assuming ownership of the most capital-intensive assets (land). This will retain equity in the sector and preserve sector level solvency.

5.1.6 ADAPTING TO CHANGE – BACKWARD INTEGRATION AND CONTRACT PRODUCTION

Converting processing and marketing cooperatives to joint stock companies and listing them on the stock exchange may be a way of accessing capital on the sector level. Combining this with production or marketing contracts will yield a structure that is somewhat similar to the structure in the U.S. It is possible to mitigate both the market and the hold-up risks in this way. But the risk of hold-up will most likely increase from the present situation dominated by cooperatives. The sector may end up in a trade-off between the need to cope with market risk and the need to cope with hold-up risk (unless market risk is handled in the way suggested in the third paper). The irony of this situation is that the timing of a stock market listing of the cooperatives is likely to be suboptimal, in the sense that the time where cooperative members agree to sell the firm on the stock market is likely to be when they cannot access the credit they need. This would most likely be at a time when investors have a low risk appetite and are buying bonds instead of stocks, which will be reflected in the price of the issued stock.

5.1.7 ADAPTING TO CHANGE – COLLECTIVE REDUCTION OF RISK

Cooperatives may try to hedge their revenue, thereby reducing price volatility collectively. Global Dairy Trade is an auction platform for internationally traded commodity dairy products that was established in 2008. The dominant Danish dairy cooperative Arla Foods is a participating seller on the platform. The sale of commodities for future delivery is a way for Arla Foods to hedge future revenues, although participation is very low and the hedging activity is unlikely to have a significant impact on the volatility of the price Arla Foods is able to pay its members.

5.2 Final conclusion

This thesis explores the implications of finance and organization on agricultural risk management from an institutional perceptive. It concludes that financial institutions matter and that they interact with organizational forms, thereby affecting the way risks are managed. Financial institutions are changing and will most likely affect risk management practice in Danish agriculture along with the increased volatility in commodity prices. This change will most likely be direct, via the effect of reduced credit reserves, and potentially indirect via the effect of changing financial institutions on organization.

Describing the risk transferring function of debt, Donaldson (1961, p. 86) captures an essential point with regard to risk management in the following quote: "Every private enterprise operating in a competitive dynamic economy has a degree of uncertainty associated with expected future income. This risk is inescapable and it must be borne by someone. Of the several distinct groups representing various interests in this future income, however, not all are equally willing to assume the risk. As a consequence and by means of negotiated legal contracts some groups are able to shift "their share" of the risk to another group, giving up something in the process – usually the chance of a larger share of the uncertain future income. Of course, in reality no group ever escapes risk entirely in an absolute sense but the risk is greatly reduced". The mechanism described in Paper III is a possible supplementary risk transfer vehicle. In the event of the fundamentally reduced risk transfer capacity of credit reserves due to changes in the institutional environment, supplementary risk transfer vehicles may come in demand. It is, however, important to recognize that the risk management potential of the reallocation of risk among cooperative members as well as other hedging alternatives is short term. As such, the risk management potential for hedging is the modest aim of budget security rather than the elimination of risk exposure for the investment in question. In contrast to hedging, large liquidity reserves may be a long term safeguard against cash insolvency and/or bankruptcy. This tendency in agricultural risk management research to focus on the short term while the serious problems are long term problems is addressed by Just (2003).

The need for institutional adaptation seems clear. Institutional adaptation is however not an automatic process, the efficiency both with regard to new mechanisms and the appropriate timing of their introduction is a challenge to governance in the industry. This thesis finds that processing and marketing cooperatives in Denmark can play a major role in enabling the management of Danish farmers' core risk factors. This is a new role for the cooperatives, which is emerging from the institutional vacuum created by the changing institutional framework regarding finance and increasing commodity price volatility. It is the hope that this thesis will help cooperatives realize the role they can play and motivate them to assume this new role.

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