Economic Consequences of Collaborative Arrangements in the Agricultural Firm

Karin Larsén
Faculty of Natural Resources and Agricultural Sciences
Department of Economics
Uppsala

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Abstract

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This thesis consists of five papers that analyse various aspects of contracts in agriculture. Four papers concern collaborative arrangements between farmers. Different types of gains from partnerships are analysed, such as gains from risk-sharing and diversification, biological effects, cost savings on machinery and labour and improved farm efficiency. Also a potential cost of partnerships – the risk of opportunistic behaviour among partners – is analysed. The objective of the first paper is to analyse if there are incentives for a partnership between a specialised piglet and fattening pig producer (vertical co-ordinated integration). Using data for average Swedish pig producers, it is shown that improved production results in vertically coordinated production as well as risk reduction create incentives for specialised piglet and fattening pig producers to collaborate. The second paper analyses the incentives for collaboration between a crop and a dairy farm by applying a model of a share contract. This study uses data from two pair of case farms representing crop and dairy farms of various sizes. The results suggest that gains from risk sharing, diversification, improved crop rotation and machinery- and labour-sharing can be substantial in a partnership. Paper IV analyses farmers' decision to engage in partnership arrangements, involving machinery- and labour-sharing with other farmers. A theoretical framework is used to illustrate that any incentive to act opportunistically is deterred by presence of social norms. The empirical analysis, based on a questionnaire to Swedish farmers in combination with FADN-variables, suggests that moral hazard problems are perceived to be relatively limited in existing partnerships, which are characterized by a considerable a degree of trust and good social relations. In the last paper, the impact of machinery- and labour-sharing arrangements on farm efficiency is analysed using the same data sources as in Paper IV. The results suggest that average efficiency is greater among the partnership farms, compared with the non-partnership farms. Moreover, partnership farms with the most extensive collaboration, i.e. that share all machinery, display the highest average efficiency scores. One paper deals with farmers' participation in agri-environmental payment programs. In that study, farmers' decision to participate in agri-environmental payment programs is analysed, as well as the impact of program participation on economic performance. It is found that larger farms are more likely to be program participants and that program participation has a positive impact on farm performance (profitability). Methodological approaches used in the thesis include mathematical programming considering risk, Data Envelopment Analysis and econometrics.

Keywords: horizontal integration, agricultural firms, partnerships, machinery- and labour-sharing, farm performance, moral hazard, social norms, trust, mathematical programming, data envelopment analysis, regression analysis

Author's address: Karin Larsén, Department of Economics, SLU Box 7013, S-750 07 Uppsala, Sweden.

Contents

Appendix

Papers I-V

The thesis is based on the following papers, which are referred to by their Roman numerals:

I. Larsén, K., Skargren P., Lagerkvist, C.-J. & Andersson, H. (2007). Optimal share contracts between pig producers. *Agricultural and Food Science* 16(3): 199-211.

II. Samuelsson, J., Larsén, K., Lagerkvist, C-J. & Andersson, H. Risk, return and incentive aspects on partnerships in agriculture. Forthcoming in *Food Economics*.

III. Larsén, K. Participation in agri-environmental programs and impact on farm performance: an empirical analysis applied to Swedish agriculture. Forthcoming in *Agrobiodiversity and Economic Development* edited by Kontoleon, A., Pascual, U., and Smale, M., Routledge (Taylor and Francis).

IV. Larsén, K. Participation, incentives and social norms in partnership arrangements among farms in Sweden. *(Manuscript).*

V. Larsén, K. The effect of machinery- and labour-sharing arrangements on farm efficiency – some results from Sweden. *(Manuscript).*

Paper II is accepted for publication in *Food Economics* and paper III is forthcoming as a book chapter in *Agrobiodiversity and Economic Development* edited by Kontoleon, A., Pascual, U., and Smale, M. Paper I is reproduced with the kind permission of the journal concerned.

1. Introduction

Agricultural firms engage in contractual arrangements with various parties. The purpose of collaborative arrangements varies, as does the nature of the contracts. Contract forms may be 'horizontal' (e.g. contracts between farmers) or 'vertical' (e.g. contracts between farmers and processors). Examples of contract partners are other farmers, employees, processors, landlords and government agencies.

There is a considerable amount of literature analysing contracts and organizational structure in agriculture. In the seminal paper by Stiglitz (1974), the principal-agent problem is discussed in the context of sharecropping. Organisational structure in agriculture has also been analysed using transaction cost approaches (e.g. Allen and Lueck, 1998; 2002; Schmitt, 1991). A brief review of contract theory and its applications to agriculture is provided in the following sections. There are a number of empirical studies that analyse the impact of farm organization on farm performance. For example, several authors compare farm productivity of family farms and corporate structures in the Central and East European Countries (i.e. Mathijs & Swinnen, 2001; Latruffe et. al, 2005)[1].

However, little attention has been paid to aspects related to partnership arrangements between farmers in the form of, for example, machinery- and labour-sharing arrangements. These partnerships are often characterized by partial arrangements such joint ownership or mutual exchange of some machinery. With a few exceptions (e.g. Nielsen, 1999) and to the best of the author's knowledge, gains attributable to such partnerships have not been analysed in the literature.[2] Four of the five papers in this thesis focus on issues related to partnerships between farmers and aims to fill some gaps in the current state of knowledge.

Some 60-80% of Swedish farms are nowadays engaged in partnerships covering machinery- and labour-sharing with other farms (Lantbruksbarometern[3], 2005; own survey, 2006). The partnership arrangements between farmers analysed in this thesis include machinery- and labour-sharing arrangements, contracts between specialized pig producers (vertically co-integrated production) and the case where a dairy farmer and a crop farmer 'merge' their farms. Some questions this thesis attempts to answer are: what is to be gained from partnership arrangements among farmers? How much can capital costs be reduced and/or what is the impact of partnerships on farm performance? Are there biological effects of collaborative arrangements that can improve the economic performance of an agricultural firm? For risk averse farmers, partnership arrangements may promote risk reduction in net income by risk sharing and diversification effects. Moreover, the risks associated with introducing new technologies can be shared among farmers.

Another aspect of contracting is the potential problem of opportunistic behavior among the partners. This is a central topic in contract literature (especially in the

[1] A review of some of these studies is provided in Gorton & Davidova (2004).

[2] There is, of course, an extensive literature on cooperatives in agriculture. However, the cooperatives covered in that literature usually takes the form of supply and marketing cooperatives, and is thus distinguished from the type of partnerships covered in this thesis.

[3] Lantbruksbarometern is an annual survey conducted by the bank Swedbank (previously called Föreningssparbanken) and the Federation of Swedish Farmers (LRF).

principal-agent literature) and arises when at least one input or action is unobservable to the other part, which, in turn, creates incentives to 'shirk'. When applying existing theories to collaborative arrangements between farmers it must however be considered that these partnerships differ in many ways from other types of business contracts. Partnerships are often initiated between farmers who know each other: they may be neighbours, friends or relatives. This is likely to act as a deterrent to acting opportunistically, as shirking one's commitments is more costly in social terms. The role of social norms and trust is analysed in Paper IV.

While the present thesis is mainly concerned with aspects related horizontal contracts between farmers, one of the papers (Paper III) is concerned with a special case of a vertical contract - farmers' participation in agri-environmental programs. This type of contract is generally characterized by information asymmetry concerning farmer 'types' (adverse selection): when farmers receive payments for the provision of agri-environmental services, the principal (the regulator) cannot see the farmers' true costs for providing these services. The study aims to analyse determinants of farmers participation in agri-environmental programs as well as to analyse the impact on farm performance from program participation.

The outline of this 'kappa' is as follows. First, a brief review of contract theory is provided. Thereafter, some literature related to contracts in agriculture is summarized followed by a review of aspects of contracts considered in the papers. The methodological approaches used are then reviewed. Finally, the results and findings are summarized, followed by a discussion of the contribution of the research and possible fields for future research.

2. A brief review of contract theory

Various theoretical approaches have been suggested in the literature to explain different aspects of contracting, e.g. the choice of a particular type of contract or ownership structure. In this chapter, a brief review of two established theories – the principal-agent theory and the transaction cost theory – is given, followed by a summary of the property rights approach suggested by Hart (1995). The review focuses on parts of the theories that are relevant for the types of contracts this thesis analyses: e.g. team-production in the principal-agent theory, incomplete contracts in the transaction cost theory and asset ownership in the property rights approach. The purpose is to describe briefly the general background of the theories. It should be noted that some of them are not applied to a large extent in this thesis (e.g. transaction cost theory and the property rights approach).

In the different theories, various aspects of contracting are in focus: asymmetric information concerning 'actions' and 'types' in the principal-agent theory, the costs of contracting in the transaction costs theory and residual control rights in the property rights approach. Thus, the different theoretical approaches are useful for analysing different aspects of contracting. As noted by for example Bogetoft & Olesen (2004), there is some overlapping between the theories, as principal-agent theory is concerned with a subset of aspects discussed in transaction cost theory.

2.1 Principal-agent theory

Asymmetric information is commonly present when a contract is to be established between two or more parties. The principal-agent theory distinguishes between two types of problem caused by information asymmetry between contracting parties - *moral hazard* and *adverse selection*.

Moral hazard can be exemplified by a landlord who is unable to observe the input choice of a tenant farmer (where the unobservable input is often referred to as 'effort'). The 'unobservability' of effort implies that the agent (tenant) does not provide the optimal level of effort, from the principal's (landowner's) point of view. The problem of asymmetric information arises when at least one input is unobservable (as the amount of observable input can be specified in the contract). Many authors have discussed how optimal incentive schemes can be instituted under varied circumstances. Special cases of the principal-agent model have been analysed in the literature, including multiple-tasks (Holmstrom & Milgrom, 1991), double moral-hazard (Agrawal, 2002) and team production (Alchian & Demsetz, 1972; Holmstrom, 1982). This thesis examines the latter case - so-called team-work models - i.e. production with several agents[4]. When output is shared among several agents in a team and the effort of each is unobservable to the others, there exist incentives for an agent to shirk in effort. The reason is that each agent only receives a share of the total output but has to pay the full cost for his/her effort, implying that the effort level provided by each partner is less than the 'first-best'

[4] Partnership arrangements among farmers, which four of the five papers in this thesis analyses, are characterized by a contract between two or more agents (farmers) rather than a principal-agent relationship.

effort level (i.e. the effort that maximizes the sum of the agents' objective functions). Various mechanisms that deter opportunistic behaviour have been suggested in the literature, e.g. peer pressure and social norms (e.g. Barron & Gjerde, 1997) and dynamics (Radner, 1986). The role of social norms in partnerships among farms is discussed in Paper IV.

The second type of problem caused by information asymmetry is the unobservability of 'types'. For example, a manager who hires a new worker may not be able to separate highly productive workers from less productive workers. This problem was originally discussed by Akerlof (1970) in the case of the market for used cars. He showed that unobservability of types (high or low quality cars) leads to an inefficient outcome where only the latter are traded. Various factors that mitigate the problem of adverse selection have been suggested in the literature, including signalling (Spence, 1973), reputation concerning product quality (Shapiro, 1983; Allen, 1984) and warranties (Gal-Or, 2001). Farmers' participation in agri-environmental payment programs (analysed in Paper III) is an example of the adverse selection problem, as the principal (the government) does not have full information about the agents (farmers) costs of providing environmental services.

2.2 Transaction cost theory

In principal-agent theory, the only contract cost assumed is that related to observation of variables (such as monitoring a worker's effort). Transaction cost theory regards implementing and maintaining a contract as costly. The transaction cost literature began with the classical work by Coase from 1937, 'The nature of the firm'. Other important works include Coase (1960), Cheung (1969) and Williamson (1979).

It is often impossible to frame a contract that specifies all actions that should be carried out by the partners in all conceivable situations. Even if it was practicable, it would be very costly. Therefore, contracts are often incomplete. Hart & Moore (1988) show that there may be inefficient outcomes when partners renegotiate a contract. The reason is that the outcome of the renegotiation will be determined by initial bargaining powers of the partners rather than factors such as economic efficiency. As a result, when the partners expect the contract to be renegotiated in the future, they may not make the 'first-best' investments in the initial contract (Hart and Moore show that, under certain circumstances, this leads to under-investment). This problem will appear when the first-best investment is 'relation-specific' (that is, when the investment has a higher value within the partnership than if the partners were to separate). Because the partners fear potential hold-up problems in the sense of an incomplete contract and a relation-specific investment, they may prefer to make investments that are relatively non-specific.

2.3 A property rights approach

Hart (1995) noted that transaction costs theory can not explain why a merger of two firms reduces hold-up problems. Nor does the principal-agent theory explain what happens when firms merge. In order to address this question, Hart discusses the so-called property rights approach to firm ownership.

As discussed above, contracts are often incomplete as they do not specify all actions (such as all usages of an asset) that should be carried out in all conceivable situations. The main idea of the property rights approach is that ownership structure plays an important role, as the owner of an asset decides on use in a situation that is not specified in the contract. This is sometimes referred to as 'residual control rights'. These will affect the partners' incentives to make relation-specific investments. For example, a firm that acquires another firm may have relatively strong incentives to make relationship-specific investments as it receives a larger share of the residual control rights. Conversely, the acquired firm has relatively little incentive as it receives a smaller share of the residual control rights.

Hart (1995) furthermore notes that there may be an inefficient outcome if residual control rights do not concur with residual income rights. To illustrate this, it is useful to divide the asset's value into two parts: short-term income from using the asset and long-term income (change in the asset's value). The individual who has the control rights considers the asset's long-term value. However, the user of an asset (who lacks control rights) has no incentive to consider the long-term value. As a result, the user may overuse or misuse the asset. This problem can be alleviated by providing the worker with residual income rights. The idea is that an agent who owns an asset is likely to maintain it more effectively as he/she appreciate the asset's long-term value (Holmstrom & Milgrom, 1994). Lamoreaux (1998) extends Hart's ideas by considering that there are differences in firm ownership (as a result of employing different organizational forms).

3. Some literature on contracts in agriculture

A brief summary of some of the literature on contracts and organizational structure of agriculture is provided in this section followed by a general overview of some theoretical and empirical literature related to contracts in agriculture.

3.1 Contracts and organizational structure

Contracting and organizational structure in agriculture have been devoted considerable attention in the literature. This section attempts to summarize some of this literature, but more extensive reviews can be found elsewhere (for example in Knoeber, 2000).

The literature on contacting in agriculture has often aimed to explain the choice of a particular contract form, such as rental, wage or share contracts. Many authors have focused on risk sharing among the contract partners, and the trade-off between risk sharing and incentives (e.g. the seminal work by Stiglitz, 1974). In a rental contract, the farmer bears all the risk whereas the landlord bears all the risk in a wage contract. In a share contract, the risk is shared between the landlord and the tenant. Traditionally, in the landlord – tenant example, the landlord is assumed to be risk-neutral whereas the tenant (farmer) is assumed to be risk averse (although there are studies assuming that both parties are risk averse). However, sharing risk also implies a cost if the farmers 'effort' (e.g. managerial ability) is unobservable, as the farmer only receives a share of total output but has to pay the full cost for his/her own effort.

The risk-sharing explanation has however not always been confirmed by empirical data. An often mentioned example is Rao (1971) who found that the relatively risky tobacco production in India was characterized by rental contracts whereas the relatively less risky rice often was sharecropped.

There are exceptions from the tradition of emphasizing risk sharing and the trade-off between risk sharing and incentives as the primary explanation of contract choice, including the work by Allen & Lueck (e.g. 1998; 2002). In fact, they develop a framework were they assume risk neutrality of all involved parties and thereby avoid having to make assumptions about agents risk preferences. Instead, they apply a transaction cost approach and focus on the trade-off between benefits and costs when, for example, analysing optimal farm organization. They test their predictions using data from North America.

Yet another explanation for the choice of a particular contract type provided in the literature is that of self-selection (e.g. Hallagan, 1978). Hallagan (1978) considers the choice of a particular contract as endogenous and depending on the farmer's managerial ability. If farmers differ in managerial ability, this implies that those with relatively high managerial ability will choose rental contracts whereas those with relatively low managerial ability will choose wage contracts. Thus, farmers with an intermediate ability will chose a share-contract. However, Eswaran & Kotwal (1985) argue that the self-selection explanation may be to simplistic. They propose a model where both the farmer and the landlord have incentives act opportunistically.

3.1 Summary of some of theoretical and empirical literature

There is an extensive amount of literature dealing with different types of contracts in agriculture, focusing on different aspects and using different theoretical and empirical approaches. An attempt is made to summarize some of the empirical and theoretical literature related to contracts in agriculture in Table 1.

Table 1. Summary of some literature related to contracts in agriculture.

Author(s)	*Core concept*	*Type of study*	*Factor(s) considered*
Allen & Lueck, 1998	Optimal farm organisation / Organizational structure in agriculture	Derive and test predictions about optimal farm organization and extent of farm integration	Transaction costs
Smith, 1991		Explain the dominance of family farms in the western economies using a transaction cost approach.	Transaction costs
Deninger, 1995		Suggest theoretical reasons and provide examples for productivity differences between agricultural service cooperatives and collectives.	Various theoretical predictions of farm organization
Bezemer, 2004		Develop a framework to analyse behaviour of family farms and corporate farms in the presence of risk.	Risk
Carter, 1987		Model the tradeoffs between risk sharing and incentives in institutional choice in agriculture.	Trade-off between risk sharing and incentives
Mathijs & Swinnen, 1998		Analyse determinants of agricultural decollectivization.	Factors that influence decollectivization
Bogetoft & Olesen, 2003	Multiple producers	Analyse the impact of different competitive regimes on the ability to provide incentives based on noisy information systems.	Multiple producers and processors Moral hazard Adverse selection
Gorton & Davidova, 2004	Productivity and efficiency	Reviews studies of productivity and efficiency in the CEE countries where one of the main questions assigned is the impact of organizational form (more precisely, family farms versus cooperative structures).	Productivity and efficiency measurement
Dorward, 1999	Mathematical risk programming	Develope a conceptual approach that relates transaction costs, transformation costs and risks to the choice of utility-maximising contract	Transaction costs Risk
Kaylen et. al., 1989		Analyse agricultural insurance contracts using a mathematical programming approach.	Risk

4. Aspects of contracts considered

In section 2 it was discussed that various theoretical approaches are useful for analysing different aspects of contracts. The question is then: what aspects of contracts are considered in this thesis? As noted by Bogetoft & Olesen (2004), papers on contract theory typically focus on only a few (often only one) aspects of contracting. Such approach is often necessary in scientific work were effects are traced analytically using stylized models (Bogetoft & Olesen, 2004). This is also the case in this thesis, i.e. only one or a few aspects of contracts are considered in each paper.[5] To answer the question about what aspects of contracts that are considered in this thesis, it is meaningful to use the holistic approach to contracting discussed by Bogetoft & Olesen (2002; 2004).

Although the overall goal of a contractual arrangement depends on the involved partners and their preferences, it is not unrealistic to assume the overall goal (at least from an economic point of view) is to maximize total profits (Bogetoft & Olesen, 2004). In order to do this, different concerns must be taken into account. Bogetoft & Olesen (2002; 2004) separate between three main concerns in contracting, namely:

- *Coordination*;
- *Motivation* and
- *Transaction costs*

Coordination of production activities and risk is necessary in order to maximize total profit and to minimize the cost of risk. Thus, two main aspects of coordination can be distinguished: *coordination of production* and *coordination of risk*. (Bogetoft & Olesen, 2004).

Motivation is divided into three main aspects: *participation*, *effort* and *investment* (Bogetoft & Olesen, 2004).

As for transactions costs, four main aspects are distinguished by the authors: *entering a contract*, *conflict resolution*, *monitoring*, and *influence costs*. These are not discussed in greater detail here, but the interested reader is referred to Bogetoft & Olesen (2004).

The papers in this thesis consider mainly aspects of the first two concerns, i.e. coordination and motivation. A review of the aspects considered in the papers is provided in Table 2.[6]

[5] To avoid any misunderstanding: the contribution of this thesis is largely empirical, not theoretical.

[6] The overview considers the three main aspects of contracts discussed by Bogetoft and Olesen (2002; 2004), but not all of the aspects within each main group (it only considers those that have been discussed/analysed in at least one paper).

Table 2. Aspects of contracts considered in this thesis. (IR-const. = Individual Rationality constraint).

Aspect of contracts		*Paper I*	*Paper II*	*Paper III*	*Paper IV*	*Paper V*
Coordination	*Coordination of production*	-	The applied methodology allows for calculation of 'optimal levels' of production activities to be undertaken by the collaborating partners. †	-	-	-
	Coordination of risk	Risk sharing among the partners	Risk sharing among the partners	-	-	-
Motivation	*Participation*	Each party is assumed to participate in the partnership when his/her IR const. is satisfied.	Each party is assumed to participate in the partnership when his/her IR const. is satisfied.	It is argued a farmer participate in a payment program when he/she is equally or better off than otherwise (i.e. when the IR const. is satisfied). ††	In the theoretical framework (based on Allen & Lueck 1998; 2002), it is assumed that each party participates in a partnership when his/her IR const. is satisfied.	It is indirectly assumed that farmers collaborate when they are better off than otherwise, i.e. when their IR-const. is satisfied. †††
	Effort	-	-	-	Each partner's 'effort' is assumed to be unobservable but presence of social norms is assumed to reduce opportunistic behaviour.	-
Transaction costs		-	-	-	The cost of deviating from a group norm, discussed and formalized in Paper IV, can be viewed as a(n) (additional) transaction cost. ††††	-

† This is, however, not the main focus of the study.
†† Farmers are assumed to be heterogeneous and potential endogeneity in the participation decision is accounted for in the empirical analyzis.
††† Potential endogeneity in the participation decision is however not accounted for the empirical application.
†††† It should be noted that largest the contribution of Paper IV (according to the author) is its empirical part and not the modeling of transaction costs.

5. Methodological approaches

In order to consider and analyse the different aspects of contracts discussed in section 4, various methodological approaches have been applied. This section provides a brief review of some of the methodological approaches used in the papers.

In Table 3, an overview of the methodological approach(es) used in each paper is given. Mathematical programming that considers risk is used in Papers I and II and is reviewed in section 3.1. Data Envelopment Analysis (DEA), also a mathematical programming method, is applied in Paper V to obtain measures of farm efficiency and is discussed in the following section (3.2).

Econometric methods are applied in the last three papers and include linear and non-linear regression models. The linear models applied include OLS (Ordinary Least Squares) and 2SLS (Two-Stage Least Squares) and the non-linear include limited dependent variable models (e.g. Probit and censored and truncated regression models) and count data models.[7]

Table 3. Overview of methodological approaches used in the papers.

Methodological approach	*Paper*				
	I	II	III	IV	V
Mathematical programming	X	X†			
Data Envelopment Analysis (mathematical programming)					X
Econometrics			X	X	X

†The application in Paper I is not a typical mathematical programming model in the sense that the optimal level of different activities are determined. In this case, the production activities are given (piglet and fattening pig production) but a contract curve is derived by varying welfare weights.

5.1 Mathematical programming, risk and utility functions

Mathematical programming methods are useful for the type of problem where an objective function (e.g. profit or utility) is optimized (e.g. maximized) subject to one or several constraints (e.g. limitations on resources). Risk was first introduced into mathematical programming models by Freund (1956) and can be considered by using for example Quadratic or MOTAD programming. A review of these methods can be found in for example Hardaker et al. (2004). Utility maximization in mathematical programming is discussed by e.g. Lambert & McCarl (1985). Patten et al. (1988) discuss so-called Utility-efficient programming (EU). An EU problem takes the following general form:

$$\underset{X}{Max}\, E[U] = \sum_k p_k U(z_k, r), \text{ r varied} \qquad (1)$$

[7] There is a considerable amount of articles and text books discussing these methods (to mention a few text books: Greene, 2003; Wooldridge, 2008; Maddala, 1993; Cameron & Trivedi, 1998) and they will not be reviewed here.

s.t.

$$\begin{aligned} & Ax \le b \\ & z_k = c_k{}'x \\ & x \ge 0 \end{aligned} \qquad (2)$$

where $E[U]$ is the expected utility, p_k is the probability of state *k (k=1, ..., K)*, *z* is a vector of net income by state, *r* is a measure of risk aversion, $U(z,r)$ is the utility of net income by state at risk aversion *r,* and *x* is a vector of activity level. Various software programs can be used for the type of problem described above, including GAMS (Brooke et al., 1992) and Excel.

The mathematical programming models used in Papers I and II are special cases of the above general maximization problem where the objective function is a weighted sum of the two collaborating partners' utility functions (Petersson & Andersson, 1996). The weights can be interpreted as the farmers' relative bargaining power and the core of Pareto efficient contracts is derived by varying the welfare weights for different levels of the risk aversion coefficient (see Papers I and II for a more detailed description). It may furthermore be noted that the application in Paper I is not a typical mathematical programming model, in the sense that the objective is not to determine the optimal level of production activities. In this application, the production activities are predetermined (piglet and fattening pig production) and the contract shares the only decision variables.

In both studies, the producers are assumed to have CARA (Constant Absolute Risk Aversion) utility functions. An appealing feature of its CARA function is the applicability in decision analysis (Hardaker et al., 2004). Moreover, Lien & Hardaker (2001) found that the choice of utility function had minor impact in an application to Norwegian farms.

5.2 Efficiency measurement using DEA

In Paper V, efficiency (as defined by Farrell, 1957) is used as measure of farm performance. An appealing feature of this measure, compared to other performance measures, is that it considers all inputs and outputs at the same time (Coelli, 1995). Technical efficiency thus reflects a firm's ability to convert inputs into outputs (i.e. it measures the distance to the production frontier). Both parametric and non-parametric methods to obtain estimates of technical efficiency have been suggested. An advantage of the non-parametric methods is that they do not require a functional form of the production function to be specified, whereas a disadvantage is that they assume no noise in the data. Parametric methods allow for noise, but they require a functional form of the production function to be specified. In Paper V, a non-parametric method, Data Envelopment Analysis (DEA), originally suggested by Farrell (1957), is applied to obtain technical efficiency scores. When using DEA, a piece-wise linear production frontier (surface) is determined by the most efficient firms in the sample. The DEA efficiency score is thus a relative measure where the firms in the sample form the reference group.

DEA efficiency scores can be either output- or input-oriented. An output-oriented efficiency score provides a measure of how much output can be increased for given levels of inputs. Correspondingly, an input-oriented efficiency score provides a measure of how much inputs can be reduced for given levels of outputs. Input and output oriented measures give identical scores under the assumption of CRS. The decision as to which orientation to use should be based on information concerning which factors (inputs or outputs) the firm managers have most control over (Coelli et al., 2005). In many applications, input and output oriented measures give similar results (Coelli et al., 2005).

The idea of the output-oriented efficiency score, used in Paper V, is illustrated in Figure 1. Assume that a firm has two outputs, y_1 and y_2, and one input, x. A production possibility curve for a fixed level of the input x is illustrated in Figure 1. A firm that is operating at point A is inefficient as it is below the production possibility curve. Inefficiency is represented by the distance AB and the efficiency score is obtained as

$$TE = 0A / 0B \tag{3}$$

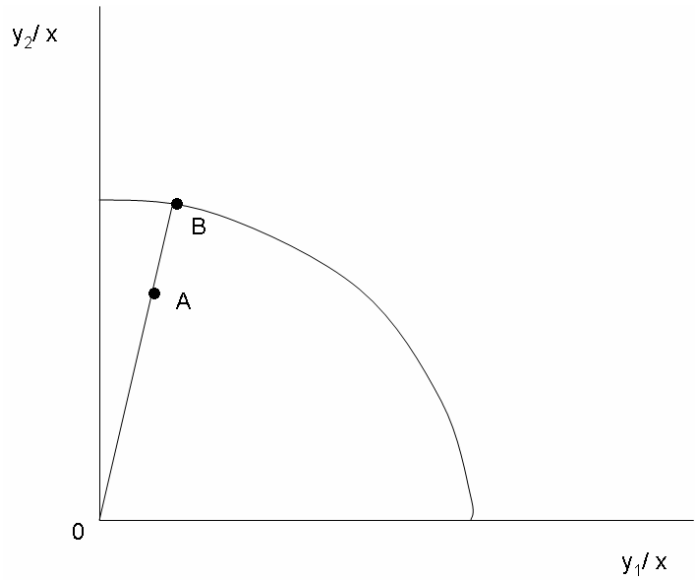

Figure 1. Output-oriented efficiency score.

The output-oriented DEA efficiency score for firm i is obtained by maximizing (4) subject to the constraints in (5). Constraint (6) must hold when VRS (variable returns to scale) is imposed.

$$\max_{\phi,\lambda} \phi_i \tag{4}$$

s.t.

$$
\begin{aligned}
&-\phi y_i + Y\lambda \geq 0 \\
&x_i - X\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}
\tag{5}
$$

$$
N1'\lambda = 1 \tag{6}
$$

where x_i and y_i are $m \times 1$ and $s \times 1$ column vectors with inputs and outputs for firm i, X and Y are $m \times n$ input and $s \times n$ output matrixes representing data for all firms and λ is an $n \times 1$ vector of constants. The technical efficiency score of firm i is defined as $1/\phi_i$ and lie between zero and one. This optimization problem can be solved in various software programs such as Excel, GAMS (Brooke et al., 1992), DEAP (Coelli, 1996) and FEAR (Wilson, 2007).

When constant returns to scale (CRS) is imposed, each firm is assumed to operate at an optimal scale. If a firm does not operate at an optimal scale, the CRS efficiency score will be a mix of 'pure' technical efficiency and scale efficiency (SE). The relation between the CRS efficiency score (TE_{CRS}), VRS efficiency score (TE_{VRS}) and the scale efficiency is

$$
TE_{CRS} = TE_{VRS} \times SE \tag{8}
$$

Thus, estimates of scale efficiency can easily be calculated when using DEA (these are calculated in Paper V).

Once the technical efficiency scores have been obtained, it is often of interest to 'explain' the firms' inefficiency by analysing the impact from various factors (often referred to as 'environmental variables') on efficiency. When DEA is applied, this is often done by regressing the efficiency score on explanatory variables using a Tobit model (because the dependent variable can be considered as censored). It was recently suggested by Simar & Wilson (2007) that there is an unknown form of serial-correlation among DEA efficiency scores that leads to invalid inference when using standard methods for inference in the second-stage regression. In order to consider this, the authors suggest two bootstrap procedures that can be used to perform valid inference. These bootstrap procedures are therefore applied in Paper V in addition to the conventionally used Tobit regression.

6. Data

6.1 Papers I and II

Paper I utilizes data for average Swedish pig producers obtained from the database 'Agriwise' available from the Swedish University of Agricultural Sciences. In Paper II, data for gross returns and operating costs from two pairs of case farms representing crop and dairy farms of various sizes are combined with data from the crop management advisory services. Detailed descriptions of the variables can be found in Papers I and II.

6.2 Papers III, IV and V

An overview of the data used in Papers III, IV and V is provided in Figure 1. In all three papers, FADN-variables (Farm Accountancy Data Network) are utilized. The FADN consists of accountancy data and some variables representing characteristics of the farms/farmers (such as farmer's age, geographic location and type of farming). The FADN variables are collected in all member states of the European Union and are intended to be representative with respect to various types of farming systems, localization and farm size. In Sweden, the variables are collected for approximately 1000 farms each year of which about 100 are replaced every year.

In Paper III, the FADN-variables are complemented with information about farmers' participation in agri-environmental programs (e.g. acreage and payments) provided by the Swedish Board of Agriculture.

Questionnaires concerning farmers' participation in contractual arrangements that involve labour- and machinery-sharing are used in Papers IV and V as a complement to the FADN-variables. The questionnaire can be found in the Appendix. It was sent to 1042 farms in Sweden in the spring of 2006 and the response rate amounted to 76.4%. Not all respondents answered all the questions, implying that not all observations could be used in the papers. The questionnaire was sent to all farms participating in the FADN during at least one of the years 2001-04.

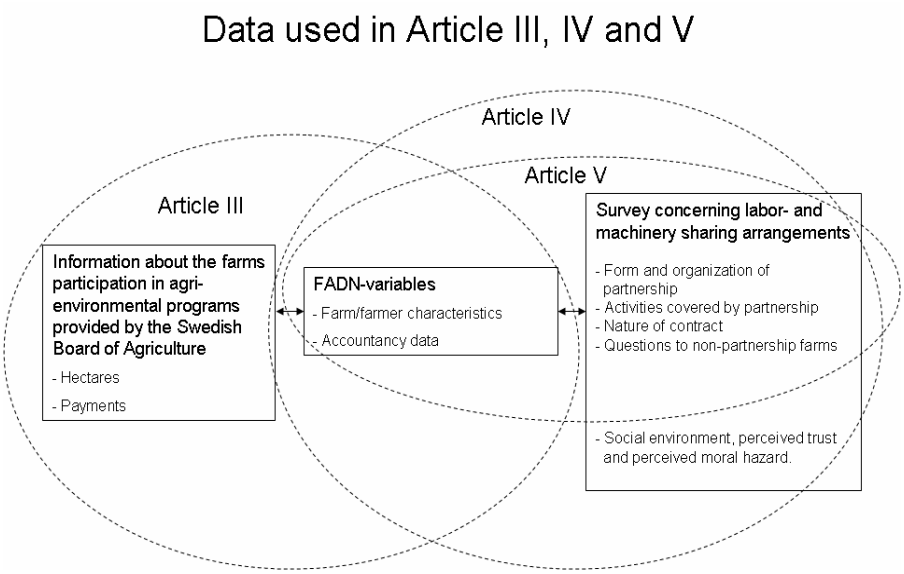

Figure 2. Overview of data used in papers, III, IV and V.

7. Results and findings

7.1 Paper I

The objective of Paper I, *Optimal share contracts between pig producers*, was to analyse if there exist incentives for forming a partnership between a specialized piglet and fattening pig producer (vertical co-ordinated integration) using a model of a share contract arrangement (Petersson & Andersson, 1996).

Swedish pig producers are subject to uncertainty in prices and an important consideration in the analysis is that a partnership arrangement between a piglet and a fattening pig producer may serve as a measure to reduce the price risk for both categories of producers. Another important factor motivating the development of contractual arrangements is that pigs in vertically coordinated production systems, where the piglets are age-segregated, display positive health effects (Holmgren & Lundeheim 2002). Thus, the theoretical model considers improved production results in vertically co-integrated pig production (higher growth rates, improved feed conversion efficiency and lower mortality as well as the variances in growth rates and prices.

In the empirical section of the analysis, data for average piglet and fattening pig producers in Sweden that are accessible in the data base Agriwise (SLU) is used. The results suggest that the incentives to participate in a partnership increases as the levels of risk aversion of the producers' increases and the potential expected utility gains (money metric) amount to about 25% for both categories of producers.

7.2 Paper II

The second paper, *Risk, return and incentive aspects on partnerships in agriculture*, analyses the incentives for a collaborative arrangement between a crop and a dairy farm by applying a model of a share contract (Petersson & Andersson, 1996). Factors that are considered in the analysis are: 1) crop rotation effects, 2) diversification effects, and 3) reduced machinery and labour costs. Furthermore, the model considers the fact that forage is assumed to be produced at the farm, and implies a greater degree of risk exposure. The data used in the study consist of four case farms (two dairy farms and two crop farms). The results suggest that potential expected utility gains (money metric) attributable to crop rotation and diversification effects amount to 32-50 % for the dairy farms and are even higher for the crop farms. When the partnership also includes machinery and labour, the prospective gains reveal an even greater potential. In general, potential gains increase when the partners are more risk averse irrespectively of the extent of collaboration.

7.3 Paper III

The objective of the third paper, *Participation in agri-environmental programs and impact on farm performance: an empirical analysis applied to Swedish*

agriculture, is to analyse the farmers' decision to participate in agri-environmental payment programs as well as the impact on the economic performance of the firm. Given an (economically) efficient payment program, farmers are compensated for their costs of participating in a program (such as forgone revenues from conventional production and maintenance costs). There is, however, a problem of asymmetric information, as the principal (the regulator) does not know the agents (farmers) costs of providing the environmental services (e.g. Carlsen, 2001). The farmer makes a decision as to how many hectares he/she want to devote to the production of environmental services and how much land to retain in conventional production. If the farmer is, at least partly profit maximizing, the participation decision is influenced by forgone revenue from conventional production and costs engendered by program participation as well as the magnitude of the program payments.

The data set consist of FADN-variables for the period 1998-99 that are complemented with information concerning farmers' participation in agri-environmental programs (provided by the Swedish Board of Agriculture).

In the first part of the study, factors that determine farmers' decision to participate in the programs are analysed. Not unexpectedly, larger farms (in terms of land) participate to a greater extent. The localisation of the farm also has a statistically significant impact on the participation choice. The impact of program participation on economic performance is analysed in the second part of the analysis (were economic performance is measured as the rate of return on total assets). As expected, the results suggest that program participation has a positive impact on farm performance (2.5-8.5% depending on model specification).

7.4 Paper IV

The objective of Paper IV, *Participation, incentives and social norms in partnership arrangements among farms in Sweden*, is to analyse a farmer's decision to engage in partnership arrangements, involving machinery- and labour-sharing, with other farmers. The study focuses on the incentive aspects, potential moral hazard problems and the role of social norms.

Common forms of collaboration are mutual exchange of machinery and joint ownership of machinery. A potential gain from collaboration is the possibility to reduce the costs of capital. Other potential benefits include access to more advanced technology and task specialization among the partners. But there are also potential costs associated with partnership arrangements among farms. In so-called team production, where output is shared and at least one input (such as 'effort') is unobservable to the other partners, there may be incentives to shirk in effort (Holmstrom, 1982). A farmer's 'managerial ability' may be considered as an unobservable input that potentially may cause incentives to shirk in a partnership arrangement (Eswaran & Kotwal, 1985). In the case when inputs are shared, there may be incentives to overuse or misuse assets that are owned jointly (so-called asset moral hazard, see for example Hart, 1995). Factors that mitigate the moral hazard problem have been discussed in the literature; they include peer pressure and social norms (Barron & Gjerde, 1997; Kandel & Lazear, 1992) and dynamics (Radner, 1986). Partnerships between farmers are often characterized by personal

relations (friends, neighbours, relatives) and it is conceivable to believe that opportunistic behaviour therefore is costly in social terms.

A theoretical framework developed by Allen & Lueck (1998; 2002) to analyse farm organization illustrates the decision to become a partnership as a trade-off between the advantages of task specialization and reduced capital costs versus the cost of moral hazard. Their framework is extended to also account for the effects of social norms among collaborating partners. Moreover, a model of an input-sharing arrangement is used to analyse the impact of social norms on asset moral hazard. In both cases, the presence of social norms implies that incentives to act opportunistically are reduced.

In the empirical part of the analysis, the impact on the perceived effort levels on the extent of collaboration (measured as the number of tasks that the partnership encompasses) is analysed. The empirical data consists of FADN-variables over the period 2001-04 complemented with a survey of the same farmers concerning their participation in labour- and machinery-sharing arrangements (see Figure 2). The surveyed partnership farmers indicated that they, in general, are satisfied with the social environment in the partnerships, which are characterized by a considerable degree of trust. Perceived moral hazard problems are found to be relatively limited. Regression results suggests that the degree of perceived effort has a positive and statistically significant impact on the number of tasks that the partnership encompasses, and that younger farmers are more likely to collaborate with other farmers.

7.5 Paper V

As discussed in Paper IV, potential benefits from machinery- and labour-sharing arrangements between farmers include reduced capital costs and the possibility of investing in more advanced technology. Thus, even if capital costs are not reduced as a result of the collaboration, better and more advanced technology can lead to increased yields, improved quality of the products and/or reductions in labour input. Yet another advantage of partnerships is the possibility of obtaining higher product prices and paying lower factor prices thanks to coordinated marketing of products and purchasing of production factors.

The objective of Paper V, *The effect of machinery- and labour-sharing arrangements on farm efficiency – some results from Sweden*, is to analyse the effect on farm efficiency of machinery- and labour-sharing arrangements among farmers. The data consists of FADN-variables for the period 2001-04 complemented with a questionnaire to the farmers concerning their participation in such arrangements (see Figure 2). The descriptive statistics show that partnership farms are, on average, larger than non-partnership farms (both in terms of land and in terms of value of total output). It may also be noted that the average capital costs are not lower for partnership farms compared to non-partnership farms. The organizational form of a machinery- and labour-sharing arrangement vary substantially – from informal lending of machinery to sharing all machinery equipment. In this study, it is separated between two main organizational forms (*Org 1* and *Org 2*). *Org 2* denotes farms that share all machinery with one or several other farms.

A non-parametric method, Data Envelopment Analysis (DEA) was used to obtain estimates of the farms efficiency scores (Farrell, 1957). For both groups of producers, the average efficiency score was found to be higher on average for the partnership farms compared to the non-partnership farms (in their own reference groups). It was also found that the average efficiency score among the collaborating farms is, on average, higher when the organizational form of the partnership is more developed. Farms that share all machinery with other farms display the highest average efficiency score. Thus, although the partnership farms do not face lower capital costs per hectare on average, they display a higher efficiency. In addition, when other factors were controlled for, partnership arrangements are found to have a positive and statistically significant effect on farm efficiency.

8. Conclusions

8.1 Contribution of thesis

The main contributions of the thesis are largely empirical. The specific contribution of each paper is summarized below.

In Paper I, it is shown that both biological effects, as a result of improved production results in vertically coordinated production, and risk reduction create incentives for specialized piglet and fattening pig producers to collaborate.

Paper II gives important insights into which factors that create incentives for crop and dairy farms to collaborate. When the farmers 'merge' their firms, they have access to a larger set of production activities than is the case when they operate independently. Consequently, diversification gains are greater when farms collaborate, compared to independent farming. Apart from diversification gains, crop rotation effects can be more effectively utilized in a partnership than in independent production. This is especially evident in the case where a partnership between a dairy and a crop farm is established since the yields of most crops are substantially improved when forage is introduced in the rotation. Potential expected utility gains and the span of possible (Pareto efficient) contracts from improved crop rotation and diversification effects due to risk sharing depend, of course, on the farmers' attitude towards risk. The analysis also considers gains from including labour- and machinery-sharing as a part of the collaboration. An important contribution of Paper II is the insight that the gains attributable to risk sharing, diversification and crop rotation effects can be substantial in a partnership between a crop farm and a dairy farm. These gains are even greater when machinery- and labour-sharing is included. Thus, Papers I and II provide important empirical insights to factors that offer incentives for farms to collaborate.

Paper III provides insights in to the motives of Swedish farmers' choice to participate in agri-environmental programs. Moreover, the impact of program participation on farm performance (profitability) is analysed and the difficulties related with the determination of farmers 'true' cost of program participation is discussed.

In the literature on contracts, especially in the principal-agent literature, moral hazard is suggested to incur a cost in a collaborative arrangement when at least one input (such as a farmers managerial ability) is unobservable. In Paper IV, it is emphasized that contractual arrangements between farmers differ in many ways from other types of business contracts. One important difference is that farmers who initiate a partnership often know each and this personal relationship is likely to preclude opportunistic behaviour through the presence of social norms. The theoretical framework developed by Allen & Lueck (1998; 2002) to analyse farm organization was extended to also consider presence social norms. A questionnaire sent out to approximately 1000 Swedish farmers suggests that moral hazard problems are perceived to be relatively limited in existing partnerships, which are characterized by good social relations and high levels of trust.

The contribution of the last paper in the thesis (Paper V) is to obtain estimates of average efficiency gains from machinery- and labour-sharing arrangements, using

a sample of Swedish crop and livestock farms. Existing studies that evaluate the effects of partnerships have focused mainly on case farms (including Paper II). One advantage of using case farms is that the analysis can be performed in much greater detail (for example when calculating machinery and labour costs). Despite this advantage, an analysis of a larger set of farms enables us to draw more general conclusions concerning the economic effects of partnerships (for the analysed sample).

8.2 Discussion and fields for future research

The work process in the present thesis has resulted in several ideas for future research in the context of contracts in agriculture, especially concerning contracts between farmers. Some of these ideas and are discussed below.

Much of the literature in contract theory has been devoted to explaining the choice of a particular contract or why different contract types co-exist. As discussed in section 3, various theoretical approaches have been used to explain why a fixed rent, wage or share-cropping contract is chosen in the landlord-tenant case. The survey concerning labour- and machinery-sharing arrangements revealed that there is a wide variation in the form and organization of existing partnerships between farmers – from informal lending to owning all machinery jointly and coordinated purchase of production factors (see Table 2 in Paper IV). A topic for future research could be to explain the choice of contract type in machinery- and labour-sharing-arrangements between farmers (e.g. owning some assets jointly, renting or lending assets or 'merging')[8]. This may be done by, for example, using the concepts of 'residual control rights' and 'residual income rights' discussed by Hart (1995). As most partnerships between Swedish farmers are characterized by partial arrangements (such as sharing of some machinery) and not 'complete mergers' between the farms (see Paper IV), it may be meaningful to consider the discussion by Lamoreux (1998) of differences in the nature of ownership (resulting from different organizational forms) in such an analysis.

As discussed above, the survey used in Paper IV and V revealed that most partnerships between farmers are partial arrangements. This may seem a bit surprising as the results in Article V suggest that partnerships farms with the most developed organizational form of the partnership (i.e. that share all machinery with one or several other farms) are the ones that perform best (this effect is especially pronounced for the crop farms). Also the results of Paper II indicate that gains in partnerships were the farms 'merge completely' can be substantial. At the same time, problems with opportunistic behaviour are perceived as relatively limited in existing partnerships (Paper IV). So, why are most partnerships between farmers characterized by partial arrangements and not by 'complete mergers'? A part of the explanation could be that also partnership farmers want to sustain a certain degree of independency.[9] Another reason could be a lack of information of the gains attributable to labour- and machinery-sharing arrangements. It could also

[8] Allen & Lueck (2002) have partly done this already. They discuss ownership versus contracting for the control of assets.

[9] The survey suggested that independency is one of the most important reasons why non-partnership farms do not collaborate (see Table 6 in Paper IV).

be the case that older farmers do not want to make decisions that will affect their children who will take over the farm once they retire. This hypothesis is consistent with the finding in Paper IV that younger farmers are more likely to collaborate. Moreover, partial arrangements are probably often a first step towards a more integrated collaboration. These points are, however, only speculations and the 'answer' to this question is left for future research.

Another topic for future research is the role of incomplete contracts in partnerships between farmers. In the literature on incomplete contracts (e.g. Hart & Moore, 1988), it is suggested that incompleteness of contracts, under certain circumstances, implies inefficient outcomes such as under-investment. As noted by Allen & Lueck (2002), contracts in modern agriculture are often quite simple[10]. The survey concerning machinery- and labour-sharing arrangements used in the present thesis reveal the same pattern; contracts between farmers are not very detailed in general (see Table 1A in Paper IV). One explanation for this may be that the appreciable degree of trust and good social relations between collaborating farmers not only deters opportunistic behaviour (see Paper IV), it may also reduce the need to write very detailed contracts as a farmer need not fear that his/her partner(s) will 'hold it up'. Another part of the explanation may be that many machinery- and labour-sharing arrangements among farmers cover relatively non-specific investments. As discussed in section 2.3, hold-up problems only occur if investments are relation-specific.

An advantage of partnerships where the farms coordinate their purchase of production factors and/or marketing of products is that they are able to receive more beneficial prices. This aspect was discussed in Paper V, but a more detailed analysis of the gains attributable to this factor may be warranted.

In the same paper, it was argued that a farmer's choice of entering into a partnership arrangement may not be exogenous. A field for future research is thus to test and account for potential endogeneity in the participation choice when analysing the impact of collaborative arrangements on farm performance.

Yet another aspect of contracting not covered in this thesis is the impact on financial structure. A partnership arrangement between two or more farms may affect their capital structure, as one potential benefit being the reduction of capital costs due to its more intensive use. Reduced capital costs will improve the cost and profit structures of the farms, but may also have an impact on their financial structure.

[10] It should be noted that they refer to crop-sharing and cash rent contracts between tenants and landlords.

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