W.J.J. (Jos) Bijman and George W. J. Hendrikse

Power, asset ownership and investments in agrifood chains

Abstract
The allocation of ownership of assets in an agrifood chain has an impact on the efficiency of the chain as a whole because it affects the incentives for investment by the participating firms. Incomplete contract theory assumes that no complete contract about the distribution of the surplus of an investment is possible. Therefore, post-contractual negotiation over the surplus may takes place. The ex post distribution of surplus of any investment will be determined by the bargaining power of the firms, which is based on ownership of the assets indispensable for surplus generation. This paper analyses the relationship between investment incentives and ownership of assets in a three-party supply chain. In order to obtain an efficient response to changes in market conditions and technology, it may be necessary to shift asset ownership from one chain participant to another.

Introduction
Agrifood systems all over the world are experiencing the simultaneous and seemingly opposing developments of vertical disintegration and strengthening vertical coordination. Reorganising vertical supply structures from integrated firms into independent units is taking place in many industries, due to changes in technology, demand and competition (McMillan, 1995). Increasing vertical coordination is particularly visible in the agrifood sector (Martinez and Reed, 1996). Changes in the market for agrifood products, in farm support policies, in consumer demand and in technological development require more collaboration in the agrifood supply chain (Downey, 1996).

One of the main reasons for strengthening vertical coordination in the agrifood sector is the search for synergy benefits, or complementarities, in activities carried out at different stages of the production and distribution chain. By (better) coordinating the activities of firms at different stages of the chain, the efficiency of the chain can be enhanced. Examples of such activities are logistics, information exchange, quality control, product innovation and marketing. Vertical coordination can take many forms, ranging from pure price coordination, through contract coordination, to administrative coordination of successive stages of a supply chain in vertically integrated structures. The main managerial question for firms engaged in agrifood production and distribution is how to choose the most efficient form of vertical coordination.

The ownership structure in a supply chain has an impact on efficiency, because it affects the incentives for investment. As ownership is a powerful incentive for enhancing the value and

1. Jos Bijman is at the Agricultural Economics Research Institute (LEI) in The Hague, the Netherlands (e-mail: w.j.j.bijman@lei.wag-ur.nl). George Hendrikse is at the Rotterdam School of Management, Erasmus University Rotterdam, the Netherlands (e-mail: g.hendrikse@fbk.eur.nl). This paper is part of a research project on innovation in the organisation of agrifood chains. We would like to thank Paul Diederan for his valuable comments. The financial support of the Dutch Agri Chain Competence Foundation is gratefully acknowledged.
productivity of an asset, loosing control over the asset may negatively affect the willingness to invest in it. In this paper we study the relationship between investment incentives and ownership of assets in a three-party supply chain. We particularly look at investments that have complementarities in the chain. We will show how a change in ownership structure (e.g. vertical integration) may affect the investment decisions of all three firms in the supply chain.

In studying the effect of asset ownership on investment incentives, we use the incomplete contract theory of the firm (see e.g. Hart, 1989). This approach assumes that no complete contract about the division of surplus is possible, and no (sufficient) trust is present among the firms carrying out a transaction. Therefore, *ex post* division of surplus of any investment is determined by the bargaining power of the firms, which is based on asset ownership.

This paper is organised as follows. In section 2 we will briefly describe the basic assumptions and results of the incomplete contract theory of the firm. Section 3 presents various investment decisions and ownership structures in a three-party supply chain. Section 4 analyses which ownership structures are first-best efficient. Section 5 presents the conclusions.

**Incomplete Contract Theory**

Incomplete contract theory builds on and combines the results of several strains of economic organisation theory. It is based on maximising behaviour (like the neo-classical approach); it emphasises incentive issues (like the principal-agent approach); it emphasises contracting costs (like the transaction cost approach); it treats the firm as ‘standard form’ of contract (like the nexus of contracts approach); and, it relies on the idea that a firm’s owner has the right to decide who uses the firm’s assets and who doesn’t. Its advantage over these other approaches, however, is its ability to explain both the costs and benefits of integration; in particular, is shows how incentives change when one firm acquires another one (Hart, 1989: 1771).

The starting point, as in transaction cost economics (Williamson, 1985), is the impossibility to write enforceable comprehensive contracts, due to bounded rationality of economic actors. Real world contracts are almost always incomplete in the sense that there are inevitably some circumstances or contingencies that are left out of the contract, because they were either unforeseen or simply too expensive to enumerate in sufficient detail. As contracts are incomplete, actions and payments must often be determined *ex post*, either unilaterally or through negotiation. Consequently, contracting parties should be concerned *ex ante* with the threat of opportunistic behaviour and the results of possible renegotiation. This is particularly problematic if *ex ante* relationship-specific investments have to be made.

A relationship-specific investment implies that the investment only generates surplus in a relationship with a specific transaction partner. The revenues generated by a relationship-specific investment (or the relationship-specific part of an investment) is named the quasi-surplus (*q*). The quasi-surplus is made up of the surplus (revenues minus costs) plus that part of the investment that is sunk in the relationship (see figure 1). The sunk part of the investment will not be recovered if the relationship is terminated prematurely.
Figure 1. The quasi-surplus

\[
\begin{align*}
\text{Revenues} & \quad \quad \quad \text{surplus} \\
\text{Costs} & \quad \quad \quad \text{sunk costs (k)} \\
& \quad \quad \quad \text{non-sunk costs} \\
\end{align*}
\]

Relationship-specific investments create the opportunity for hold up, i.e. for ex post appropriation of revenues by the non-investing contract party. If a firm cannot sufficiently protect his investment against hold up, it will not invest. Therefore, incomplete contracts may lead to under-investment in the economic relationship. Klein et al. (1978) and Williamson (1979, 1985) have suggested that vertical integration (i.e. bringing both trading partners under common ownership) may solve this inefficiency problem. However, as Grossman and Hart (1986) have argued, vertical integration brings costs as well as benefits, because a shift in ownership affects the incentives to invest of the firms concerned.

To understand what is changing when two firms merge, Grossman and Hart (1986) and Hart and Moore (1990) have developed a so-called property rights theory of the firm. A firm is identified with a collection of non-human assets under common ownership, where ownership means holding residual rights of control. Residual rights are those rights to an asset that are not explicitly assigned to another party (including the state). The allocation of residual rights of control has effect on the bargaining position of parties to a contract after they have made relationship-specific investments. In the absence of comprehensive contracts, property rights largely determine which ex post bargaining position will prevail. A firm owning assets that are essential for revenue generation in the relationship is in a position to reap at least some of the benefits from the relationship that were not explicitly allocated in the contract, by threatening to withhold the assets otherwise. Thus, a shift of ownership affects the ex ante investment incentives of contract parties: the acquiring firm's incentives to make relationship-specific investments increase, while the acquired firm's incentives decrease.

The main Grossman/Hart/Moore conclusions on efficient asset ownership in a two party vertical relationship (i.e. buyer-seller relationship) are the following. (1) A party with an important investment (in human capital) should have ownership rights over the asset for which the investment is required. (2) If an investment by party 1 becomes relatively more important than an investment by party 2, 1 should own more assets than 2.

A three-party agrifood supply chain

Increasing vertical coordination in a specific agrifood supply chain may have an impact on the investment decisions of each of the participating firms individually. Investment by firm 1 in one stage of the chain must be coordinated with activities by firms 2 and 3 in other stages in order to obtain optimal chain performance. As there are complementarities among the activities of 1, 2 and 3, each investment is (at least partly) specific to the relationship between 1, 2 and 3. The
maximum surplus an investment can generate is only obtained if all firms in the chain collaborate. In sum, enhancing vertical coordination in an agrifood chain may increase the deployment of relationship-specific assets.

An example of such complementarities is the production and marketing of organic food. Consider a chain of three firms - farmer, processor and retailer — and three assets — land, processing equipment and retail shop. The three firms sign a contract for an exclusive trade relationship. The farmer invests in obtaining special knowledge to be able to shift from conventional agriculture to organic farming. His newly acquired knowledge is related to the land he owns and is worthless if he has no access to the land. The organic products yield higher chain revenues if the processor and the retailer keep the organic products separate from conventional products. Thus, there are complementarities in this chain.

The maximum chain surplus will only be obtained if the farmer invests and all three assets are deployed. If the processor withdraws from the chain after the farmer has made his investment, the farmer may incur a loss (namely that part of the investment that was specific for the relationship with the processor). The processor may pose a hold up, i.e. he can use his ex post bargaining power to demand a more profitable division of total surplus. The retailer has a similar bargaining power vis-à-vis the farmer. This threat of hold up may induce the farmer to abstain from doing the efficient investment.

One solution for the inefficiency problem is vertical integration, i.e. the farmer takes over the processor and becomes the owner of the processing equipment. Once the farmer has full authority over the processor, he no longer faces the risk of hold up. He will make the investment that is specific for the relationship with the processor. This argument of protecting farmer investment from opportunistic behaviour by processors has always been a major reason for establishing farmer-owned cooperatives (Søgaard, 1994).

The situation, however, becomes more complicated when also the processor and the retailer are making relationship-specific investments. The processor can invest in R&D that yields a special processing technology for organic produce (e.g. low energy use in processing). This technology is specific for the equipment that the processor already owns, and the investment only yields surplus if this equipment is used. Here, complementarities are present because the maximum revenues from this investment are only obtained if the raw material supplied by the farmer (who may be the only organic farmer in the area) is used and the products are sold through the shops of the retailer who has a special image for selling organic produce. Finally, the retailer may invest in organising a marketing campaign that attracts customers willing to pay a higher price for organic produce. The marketing campaign is based on the company name. This investment, too, is relationship-specific (or chain-specific), because it generates a higher total surplus if the farmer and the processor guarantee a sufficient supply of organic food.

Thus, each investment by a firm in one stage of the chain will only generate the maximum surplus if assets in other stages of the chain are also deployed. These other assets are called essential assets. The maximum chain surplus will be obtained if each firm in the chain makes a chain-specific investment and all essential assets are deployed. The important point here is that the owner of an essential asset can decide whether that asset will be deployed or not. This bargaining power can be used to appropriate a larger part of the quasi-surplus in cases of ex post renegotiation about the contract. This risk of hold up may induce firms not to make ex ante chain-specific investments. The key issue here is that the distribution of ownership of essential assets over the various firms in a chain influences the decision of each firm to make ex ante chain-specific investments.
The three essential assets (land, equipment and shop) can be divided among the three parties (farmer, processor and retailer) in at least 10 different ways\(^2\). Figure 2 shows for each ownership structure the assets each party owns. Ownership structure I is a supply chain with assets independently owned, i.e. the farmer owns the land, the processor owns the equipment and the retailer owns the shop. Ownership structure II is an expression of the farmer-owned cooperative, where farmers own the processing company at the second stage of the chain. Under ownership structure III the land is owned by the processor, like in a plantation system. Under IV the processor owns the retail facilities, like in a factory outlet system. Ownership structure V is found where a retailer owns production facilities, e.g. for its private label products. Structure VI pictures a situation where the farmer is contracting out the processing activities, but sells the products in his own shop. Similarly for ownership structure VII, where the farm is in the hands of the retailer, while an independent firm processes the farm product. Ownership structures VIII, IX and X are all fully integrated supply chains owned by respectively the farmer, the processor and the retailer.

<table>
<thead>
<tr>
<th>Figure 2. Ten ownership structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
</tr>
<tr>
<td>farmer</td>
</tr>
<tr>
<td>processor</td>
</tr>
<tr>
<td>retailer</td>
</tr>
</tbody>
</table>

a : asset, non-owner  
A : asset, owner  
\(\circ\) : combined ownership

Efficient ownership structures

The bargaining power of each party in case of ex post renegotiation over the quasi-surplus depends on the ownership structure. A measure for this bargaining power is the Shapley value (SV).\(^3\) Given the ownership structure, the Shapley value can be computed by (1) determining the marginal contribution to the quasi-surplus for each possible order of parties in the coalition of all parties, then (2) adding up these contributions and (3) dividing the sum by the marginal contribution of all parties. Thus, if party 1's marginal contribution to the quasi-surplus of a certain coalition of the chain participants is higher then party 2's marginal contribution, party 1 has a larger Shapley value and has more bargaining power.

\(^2\) Other ownership structures are possible, e.g. party 1 owning A3 and party 3 owning A1, but it can easily be proven that such ownership structure is dominated by one of the listed ten. Therefore they will not be incorporate in our analysis.

\(^3\) The Shapley value is a solution concept in cooperative game theory (see Shapley, 1953). The Shapley value can be used as a formalisation of the notion of power (Hart and Moore, 1990).
Given the Shapley value of party 1 and the quasi-surplus that its investment generates, we can obtain the part of the quasi-surplus that party 1 will receive in the bargaining process. This part is equal to the maximum chain-specific investment party 1 is willing to do *ex ante*. If the actual chain-specific investment needed to generate the expected surplus is larger than the part of the quasi-surplus received in the bargaining process, party 1 will not invest. This means a loss of efficiency for the chain as whole.

By multiplying the Shapley value with the quasi-surplus we obtain the relationship-specific (or sunk cost) part of the investment. Thus, the chain-specific investment \( k \) of party 1 under ownership structure I is

\[ k_1 \leq SV_1(I) \cdot q_1. \]

With this formula the maximum investment of each party in the chain under various ownership structures can be computed. Once we have the maximum investment levels for all parties under the various ownership structures, we can rank these ownership structures according to the level of the incentive for chain-specific investments they hold for each party. If we assume, for all investments, that \( q = x \) if one asset is deployed, \( q = 2x \) if two assets are deployed and \( q = 3x \) if three assets are deployed, we obtain the following ranking of ownership structures (as shown in figure 2) for party 1:

\[ III/VII < IX/X < I/IV/V < II/VI < VIII. \]

Under ownership structure VIII party 1 will do the highest investment, while under III and VII it will do the lowest investment. Ownership structure VIII is always first-best efficient regarding the investment of party 1. Every surplus generating investment by party 1 will be implemented, because all benefits of the investment accrue to party 1 (as \( SV_1(I) = 1 \)). If one of the other ownership structures applies, under-investment may occur because the positive externalities of investment are not taken into account by the investing party. Going from structure VIII to structures III and VII in the ranking means lowering the maximum investment by party 1. Because the farmer owns fewer assets, his bargaining power is smaller, which leads to a smaller part of the quasi-surplus in case of hold up by the other parties. If an investment by party 1 generates low surplus (i.e. it has a high level of \( k_1/q_1 \)), then few ownership structures are efficient. In other words, the lower the level of \( k_1/q_1 \), the more ownership structures lead to investment decisions that are first-best efficient for the chain as a whole.

Similarly, the ranking of maximum possible outlays regarding the investment \( k_2 \) by party 2, for the various ownership structures, is:

\[ II/V < VIII/X < I/VI/VII < III/IV < IX. \]

The ranking of maximum possible outlays regarding the investment \( k_3 \) by party 3, for the various ownership structures is:

\[ IV/VI < VIII/IX < I/II/III < V/VII < X. \]

The ordering of efficient ownership structures for each investing party shows that a change in ownership structure at the same time makes investing more attractive for one party and less
attractive for another party. For instance, going from II to III weakens the farmer's incentive to invest, while it increases the processor's incentive to invest.

When under a specific ownership structure actual investments by the three parties are less than the maximum (k < SV * q, for all three parties), all will invest and the maximum chain surplus will be obtained. This ownership structure is first-best efficient. To find out if a particular combination of investments will yield the first-best, we use the participation constraints of the three parties, i.e. k₁ ≤ SV₁ * q₁, k₂ ≤ SV₂ * q₂ and k₃ ≤ SV₃ * q₃.

Conclusions

From this analysis of how ownership structure affects incentives for investment by different parties in a specific agrifood supply chain, we can draw several conclusions. Firstly, for the relationship-specific (or chain-specific) investment of each party the set of efficient ownership structures shrinks when k/q₁ increases, i.e. when the required level of investment increases for a given surplus. When k/q₂ increases, the ownership structure is more critical in preventing hold-up problems. The mirror-image of this is that a higher surplus of a given investment makes more ownership structures efficient.

Secondly, first-best efficient allocation of asset ownership is determined by the value of k/q for party 1 compared to the value of k/q for party 2 and for party 3. If k/q is larger for the farmer than for the processor or the retailer, then the farmer should own more assets. In other words, when the chain-specific investment by the farmer generates only a small surplus (relative to the investment) while the chain-specific investment by the processor (or retailer) generates a large surplus, then the farmer should own more assets in order to obtain the efficient investment decisions. This conclusion is in line with the Grossman/Hart/Moore results as presented in section 2.

Thirdly, when the investments of all parties have the same k/q ratio, then the party with the largest investment should have the most assets, because not investing by this party entails a larger efficiency loss than not investing by the other parties. This implies that a change in the relative size of the investments of the different parties may demand a shift in ownership structure to obtain the first-best efficient chain. This is an interesting conclusion for farmer-owned processing cooperatives (i.e. ownership structure II), when the processor has to make substantial relationship-specific investments (for instance in brand name promotion). If the investment by the processor becomes more important for total chain surplus than the investment by the farmer, a farmer-owned processing cooperative may not be the most efficient ownership structure.

Of course, there is a trade off between the second and the third conclusion. The highest chain surplus can only be found if the comparison of k/q₁ for all parties and the comparison of (q₁ - k₁) for all parties are combined in one model. In this paper we have only focussed on the first-best outcome, i.e. on the finding ownership structures and level of chain-specific investment that yield sufficient incentives for all parties to invest.

With the model we have developed, of which this paper only presents a simplified version, we can show which maximum chain-specific investments each chain participant will do given the surplus an investment generates and ownership structure of essential assets. Turning the argument around, we can show which ownership structure are efficient given certain chain-specific investments by the chain participants. In this paper we are only concerned with efficiency, i.e. we focus on how the maximum chain surplus can be obtained. We have not considered the equity issue, i.e. how the surplus is divided among the firms participating in an agrifood chain.
If changes in technology or changes in agrifood markets shift the relative importance of the individual investments of different chain participants, e.g. if retailer investment becomes more important than farmer investment, it may be necessary to change the allocation of ownership of essential assets. A change in ownership structure may induce parties to make those investments that generate the chain optimum. In sum, it may be necessary to change the ownership structure of an agrifood chain to obtain a combination of investment decisions that yields the first-best.

References

Downey, W.D. (1996),


Hart, O. (1989),

Hart, O., and J. Moore (1990),

Klein, B., R.G. Crawford and A.A. Alchian (1978),

Mahoney, J.T. and D.A. Crank (1995),

Martinez, S.W., and A. Reed (1996),
*From Farmers to Consumers: Vertical Coordination in the Food Industry*, Washington, DC: USDA/ERS.

McMillan, J. (1995),

Shapley, L.S. (1953),

Segaard, Willy (1994),
*Farmers, cooperatives, new food products*, Aarhus: Aarhus School of Business (MAPP Monograph).

Williamson, O.E. (1979),

Williamson, O.E. (1985),