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Co-specific investment and integration in the agrifood chain

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1. Introduction

The global agrifood chain has experienced a number of major changes in recent years. Rapid introduction of new technologies and innovations as a result of significant public and private investments in agricultural research and development (R&D) have affected agriculture profoundly. Evolution of production techniques due to mechanization, new chemical inputs, genetic selection of crops and animals, new crop varieties, and countless other technical and organizational improvements have boosted the fast growth of agricultural productivity (Moschini and Lapan, 1997). Many new agricultural and food products have been the direct result of technological advances, particularly in the area of food processing and genetic engineering. Consumers have also influenced these developments by demanding and responding to an increased variety of foods and food products.

A view that commands considerable consensus is that agricultural productivity growth is due to innovations as a result of R&D investments of all the upstream and downstream participants in the agricultural and food sector (Moschini and Lapan, 1997). Innovations require the coordination of multiple industry participants and can not be achieved through the efforts of one single player. To put it another way, various independent industry participants have to make co-specific investments when they engage in interconnected innovational activities that provide positive benefits not achievable by individual initiative alone.

Most of the past research in agriculture were funded by benevolent public authorities and provided directly by the government agents, like universities. Whereas publicly sponsored research institutions are still actively involved in agricultural research, a sizable and increasing portion of R&D in agrifood sector is now also initiated by private firms that typically supply inputs to farmers, for example in the seed industry where private R&D is overturning the once dominant position of public R&D. A distinctive feature of many innovations in the last few decades is that they are produced mostly from R&D efforts undertaken by the private sector, and they are typically protected by intellectual property rights (IPRs), such as patents (Rausser, Scotchmer, & Simon, 1999). The patent holder is endowed with monopoly rights on the innovative product or process for a limited time period, which gives the innovator the ability to exclude others from making, using, or selling the new product or process (Moschini and Lapan, 1997).

There exist many real world examples where, regardless of the potential net gains, individuals and firms are not able to coordinate their activities to innovate and take advantages of market opportunities. We use the framework of New institutional economics (NIE) to address how economic agents coordinate their actions to overpass the barriers that limit their abilities to engage in innovation and seize potential gains. Specifically, the concept of asset specificity is employed to address the transaction specific investments to be made by multiple parties in the transaction.

Asset specificity refers to the degree to which a particular asset can be redeployed for an alternative use without a loss in productive value, i.e. the degree to which the cost of the asset is a sunk cost (Williamson, 1989). Hold-ups occur when unanticipated events place the contractual relationship outside the self-enforcing range (Klein, 1996). Parties to an agreement worry about being forced to accept disadvantageous terms once they have committed to transaction specific investments. Agents with a high degree of asset specificity have lower bargaining power and are more vulnerable to the hold-up problem. As a consequence, under incomplete contracts, parties maintain strong incentives to underinvest in specific asset, if they anticipate that their bargaining strength does not allow recovery of the initial investment. Potential gains from trade may be unexploited. NIE literature suggests that integration promote efficient transaction when the above situation presents itself. Where contracts are incomplete, integrated ownership would eliminate any risk of ex post renegotiation, thus aligning efficiently ex ante investors' incentives to specific investments (Nicita & Sepe, 2012).

The current model of co-specific investment is based on Koss & Eaton (1997). It is however more general one in that more than two parties along the production and marketing chain are investing in assets specific to the same use. In addition, Shapley value instead of Nash bargaining is used to determine the division of surplus arising from exchange. The paper takes account of two market responses to the potential hold up problem. One is vertical or lateral integration of operations. The other response is partial redistribution of specific investment costs to the potentially opportunistic party serving as a credible commitment to mutually advantageous exchange. These two solutions rely only on the pursuit of individual self interest to proscribe the enforcement necessary to prevent contractual breach.

2. Model

Suppose a more healthy potato with high amylase content and low glycemic index (GI) is demanded by the consumers who are willing to pay a price R for this new product. For this market potential to be realized, the contributions of farm input supplier, the farmer and the retailer in terms of relation specific ex ante investments are needed. We assume there are two identical firms at each stage to represent the plurality of players involved in various stage of the supply chain in a simple fashion. There are two seed suppliers (s_1 and s_2) that have the research capacity and are able to develop and market the seed for this new type of potato. Two identical farmers (f_1 and f_2) qualify for the potato production. Two retailers (r_1 and r_2) in the distributional channel can promote and market the new product.

The cost of the ex ante investment in stage 1 incurred by each player at stage i involved is denoted as I_i , where $i=s, f$ or r . It is assumed that $R > I$, where $I = \sum I_i$, implying that ex ante efficiency consideration dictates that it's profitable to take the joint investments. In stage 2, each party must decide whether to complete the

exchange of this new product, or to employ the investment in the next best alternative exchange. Denote the ex post opportunity costs arising from the specific investments by C_i . If the investment I_i is purely specific to the production of this new potato, no alternative use exists and $C_i=0$. It is assumed that $I_i \geq C_i$, indicating that the relation specific investments earn a non-positive return when undertaken independently. It follows that $R > C$, where $C = \sum C_i$. The trade should be entered into since it generates a larger quasi rent than any alternative exchange. Assume that all the parties involved know with certainty the value of R , I_i and C_i .

Given that ex ante investments have been made, the incentive for each party to complete the ex post exchange depends upon not only the size of R and C_i , but also the distribution of the ex post quasi rent θ ($\theta = R - C$). We use Shapley value $S(i)$ to determine the division of the ex post gains from trade in the multilateral bargaining game (Shapley 1953). Shapley value presents the average value a player can add to all the possible coalitions of all players. It assigns the unique equilibrium payoff accruing to every player that represents his/her marginal contribution and bargain power ex post.

There are six independent players from three consecutive levels of the supply chain. At least one player from each level has to participate to complete the transaction and serve the final demands for the product in question. If we normalize the total gain to 1, the Shapley values of all parties are: $S_{s_1} = S_{s_2} = S_s = \frac{1}{6}$, $S_{f_1} = S_{f_2} = S_f = \frac{1}{6}$,

$S_{r_1} = S_{r_2} = S_r = \frac{1}{6}$. That is, each player contributes equally to the transaction and should have an equal share of the surplus. The ex post return to each party R_i is determined as follows: $R_i = C_i + \frac{1}{6}\theta = C_i + \frac{1}{6}(R - C)$.

In stage 1 a firm would undertake the initial specific investment I_i only if it can receive non-negative real rents N_i , as efficiency dictates. Namely, it has to earn a return sufficient to recover the initial investment to enter into the transaction. That is,

$$N_i = R_i - I_i = C_i + \frac{1}{6}\theta - I_i = C_i + \frac{1}{6}(R - C) - I_i = \frac{5}{6}C_i + \frac{1}{6}R - \frac{1}{6}\sum_{j \neq i} C_j - I_i \geq 0.$$

The player's bargaining strength increases with value of their ex post alternatives and decreases with other players' ex post opportunity costs. Specifically, the smaller the ex post opportunity cost relative to the initial investment, the less likely that the party's share of the quasi rent will cover the initial investment (Koss & Eaton, 1997). The real rent to each party N_i increases with the relation specific gross revenue R and the value of his/her own next best alternative option C_i , and decreases with other parties' opportunity costs and his/her own investment cost. If the transaction generates a net loss for party i , the loss $I_i - R_i$ is strictly smaller than the loss he/she

would incur in the next best alternative $I_i - C_i$. Given the ex ante undertaking of the initial specific investment, party i would choose to complete the transaction in order to minimize the loss. Therefore, party i is subject to a hold-up, knowing this, he or she would be unwilling to incur the investment cost in stage 1. Player i anticipates being held up ex post by other parties in the transaction when his/her initial investment cost is high, his/her opportunity cost is low relative to other parties' outside option, or the gross revenue is low. In other words, the higher the real rent to a given co-specific investment, the smaller the likelihood of ex post hold up and therefore market failure.

3. Common ownership: One way to prevent market failure

Market failure is a situation where the best attainable outcome is not achieved. It occurs if any party sees himself/herself as a potential victim of hold-up and thus refuses to proceed. Consequently, potential gains from trade arising from ex ante relation specific investment are unexploited.

Integration can be one way of avoiding market failure. It implies that the decisions to be made by various parties are now made by only one party, and the combined real rents accrue to the same party too. Horizontal or vertical integration may take place between firms at the same or different levels of the supply chain after stage 1.

Common ownership may provide a vehicle for safeguarding against ex post contractual performance problems. No hold-up would exist among the parties consolidated. Now the transaction consists of three stages. In stage 1, each party makes co-specific investment independently. In stage 2, integration between parties takes place. Decisions on completion of the transaction are made in stage 3. The merged firm decides over the assets under common ownership and also receives all the ex post return from the assets. We examine various cases of integration and their impact on the potential hold-up problem and the allocation of surplus.

Case 1: lateral integration

The widespread trend in the last few decades in the sector of agricultural inputs supply, especially the commercial seed industry, is that tremendous consolidations take place among competing companies. Recent technological advances and legal protection (e.g. patent) encourage the accumulation among farm input suppliers (Howard, 2009). When the two seed providers in our model merge and become the sole player in the first level of the food chain, the Shapley values of all the parties are

$$S_s = \frac{8}{15}, S_{f1} = S_{f2} = S_{r1} = S_{r2} = \frac{7}{60}.$$

Before the horizontal integration, two seed providers together receive one third of the total surplus. After integration, the consolidated seed supplier could receive more than half of the total gains because it is the only source that provides the crucial input, seeds, for the production and thus more important than other players in the chain

that are substitutable. This explains why acquiring firms in the seed industry have paid significant premiums for competing companies in recent years. These premiums suggest an expectation of even higher rates of profit in the future (Howard, 2009). Meanwhile, the integration hurts the other parties in the chain in terms of their bargaining power and share of surplus.

In response to this, the farmers may form a bargaining association which acts as one single bargaining unit. The Shapley values of all parties are $S_s = S_f = \frac{5}{12}$, $S_{r1} = S_{r2} = \frac{1}{12}$.

The two farmers receive collectively 5/12 of the ex post return. Each farmer gets 5/24 of the quasi rent if they share the revenue equally. Compared with the share of 7/60 as independent farmers, they are better off by establishing the bargaining association because their bargaining power has strengthened. Similarly, the real rents of the farmers increase in this case as compared to the previous case, while bargaining strength and consequently the quasi and real rents of both the input supplier and retailer decrease, if other conditions remain unchanged.

Circumstances may also, of course, permit that the two retailers are merged and become a pivotal player in the chain that can market the final product. The analysis is symmetrical. Their bargaining power and share of total gains will increase and risk of being held up will decrease.

Case 2: partial vertical integration

In addition to horizontal integration, acquisition strategies are increasingly extending vertically through multiple levels of the food chain. Suppose there are one seed company that has acquired the patent of new seed, two farmers and two retailers that produce and market the new potato. The seed company may seek to integrate with one of the farmers (say farmer 1 who is on the leading edge of the adoption of new technologies) to gain a larger share of the total quasi rent and avoid hold-up between them. Then farmer 2 is left out in the transaction and the Shapley values of all parties are $S(s+f_1)=2/3$, $S(r_1)=S(r_2)=1/6$. The new conglomerate's share, 2/3, is larger than the summed share of the two merging parties when they are independent, 39/60, which implies extra return forthcoming. Meanwhile, the Shapley values of the two retailers are increased too (from 7/60 to 1/6) after the partial integration between the seed provider and a farmer.

Therefore the integration is beneficial for all the parties that remain in the transaction, including the parties that are not integrated. The reason is some agent will be moved out of transaction. Similarly, if a takeover takes place between the seed provider and one of the retailers, the other retailer would be excluded from the exchange and all other parties benefit.

Another possibility for vertical integration is that one of the retailers (say r_1) and one of the farmers (say f_1) are consolidated. Then the Shapley values of the parties are $S(s)=7/12$, $S(f_1+s_1)=1/4$, $S(r_2)=S(f_2)=1/12$. This integration improves the bargaining power of the seed supplier (from $8/15$ to $7/12$), farmer 1 and retailer 1 (from a sum of $7/30$ to $1/4$), while the situation of the unintegrated retailer and farmer are worse off (from $7/60$ to $1/12$).

4. Ex ante credible commitment as a solution to post contractual opportunism

Williamson (1983) observes that transactions that are potentially subject to hold-up are often supported by the potentially offending party making an ex ante credible commitment to the exchange. The potentially opportunistic party can prevent the market failure by ensuring a positive expected return to the potential wronged party. That is, the latter should receive some form of ex ante side payment in stage 1 that constitute an investment specific to the transaction or incur a lower ex ante investment cost.

Suppose the input supplier s_1 is the promoter of the new product as he/she has already invested heavily on R&D and acquired a patent for the seed breeding technology. Concerned with market failure, s_1 has incentives to complete the transaction of the new product to recover this initial investment. In the notation of our model, $N_{s_1} \geq 0$. This seed provider needs the participation of a farmer and a retailer (say f_1 and r_1) to finish the transaction and is willing to take on some of their initial investment. The result is that the other players (s_2 , f_2 and r_2) are left out of the game. There is only one player at each stage. Their Shapley values are $S_s = S_f = S_r = \frac{1}{3}$.

Assume that the farmer and retailer that remain in the trade are the potential victims of hold-up. To ensure the completion of the transaction, the seed provider agrees to take on G_f (G_r) of the farmer (retailer)'s ex ante specific investment. G_i can take the form of training on the production or marketing of the new product provided by the innovator, which is valuable contingent on the other parties' involvement in the transaction. G_i has to satisfy the following:

$$R_s^0 - I_s^0 - G_f - G_r = C_s^0 + \frac{1}{3}\theta - I_s^0 - G_f - G_r \geq 0,$$

$$R_f^0 - I_f^0 + G_f = C_f^0 + \frac{1}{3}\theta - I_f^0 + G_f \geq 0,$$

$$R_r^0 - I_r^0 + G_r = C_r^0 + \frac{1}{3}\theta - I_r^0 + G_r \geq 0,$$

where I_i^0 is the initial requisite specific investment for party i , C_i^0 and R_i^0 are the ex post opportunity cost and the return for party i respectively, in absence of an ex ante credible commitment.

There exists a range of ex ante credible commitments that could serve to ensure that efficient trades are undertaken in face of anticipated ex post hold-up. The actual size of the commitments depends upon the relative bargain strengths and investment costs of the parties ex ante. In order to induce the potential victims of hold up to partake in the transaction, it suffices that the potentially opportunistic party incurs a minimum credible commitment cost of $G_f^{\min} = I_f - R_f, G_r^{\min} = I_r - R_r$. If the ex ante contractual agreement is accompanied by such payments from the input supplier to the farmer and retailer, the returns to the farmer and retailer are just sufficient to entice them to participate. While they exact none of the relation specific rent, the input supplier would earn a positive return to his/her initial investment. This would obtain if the seed provider has all the ex ante bargaining power.

Suppose the bargaining power of each party ex ante is the same as that ex post. That is, the division of real rent is also determined by the Shapley values of all parties under contract β as follows:

$$R_s^\beta = (I_s^0 + G_f^\beta + G_r^\beta) + \frac{1}{3}\rho, R_f^\beta = (I_f^0 - G_f^\beta) + \frac{1}{3}\rho, R_r^\beta = (I_r^0 - G_r^\beta) + \frac{1}{3}\rho, \text{ where } \rho = R - I.$$

The contractually agreed upon division of the rent will obtain only if the following conditions are satisfied simultaneously:

$$R_s^\beta = R_s^0 = C_s^0 + \frac{1}{3}\theta, R_f^\beta = R_f^0 = C_f^0 + \frac{1}{3}\theta, R_r^\beta = R_r^0 = C_r^0 + \frac{1}{3}\theta.$$

Denote the return of party i 's relation specific investment when undertaken independently as $D_i^0 = I_i^0 - C_i^0$. The ex ante credible commitments necessary to uphold the transaction that requires investment in specific assets are given by:

$$G_f^\beta = \frac{2D_f^0 - D_r^0 - D_s^0}{3}, G_r^\beta = \frac{2D_r^0 - D_f^0 - D_s^0}{3}. \text{ In total the seed provider has to invest in}$$

$$\text{self enforcement capital } G^\beta = G_f^\beta + G_r^\beta = \frac{D_f^0 + D_r^0 - 2D_s^0}{3}.$$

Let $G^\beta=0$, then we get $D_s^0 = D_r^0 = D_f^0$. That is, when the non-salvageable value of the advance investment undertaken by all the players are equal, no self enforcement capital is required to uphold the efficient exchange. All parties will abide by the promise ex post.

More generally, when both ex ante and ex post bargaining power are determined by the Shapley values, the credible commitments that would induce efficient transactions are given by:

$$G_f = (1 - S_f)D_f^0 - S_f D_r^0 - S_f D_s^0,$$

$$G_r = (1 - S_r)D_r^0 - S_r D_f^0 - S_r D_s^0,$$

$$G = G_f + G_r = S_s D_f^0 + S_s D_r^0 - (1 - S_s)D_s^0.$$

The results above imply that the level of credible commitment the party receives increases with the return of his/her relation specific investment when undertaken independently, decreases with the same return of other players and his/her Shapley value. The magnitude of the ex ante commitment the party incurs decreases with the return of his/her relation specific investment when undertaken independently, and increases with the return of the other parties who receive the commitments and his/her own Shapley value.

5. Conclusions

Change brought about by science and technology has shaped agriculture since the industrial revolution, and the speed of the induced economic change has picked up its pace in the last decades. Production processes are improved tremendously. New products are constantly brought to market. Innovations bring about sizeable economic benefits, which are typically shared across various participants. In the process of innovation, multiple participants in the value chains for differentiated product markets have to work together to realize opportunities which could not be achieved independently.

At the core of market failure arising from hold-up is the existence of transaction-specific investments, that is, investments which have a lower value in an alternative transaction (Koss & Eaton, 1997). In an example of agrifood chain innovation that requires all parties along the chain to make co-specific investments, we identify the potential hold-up between participants ex post and market failure as the result of hold-up.

Two market responses to the problem are proposed. First, integration between various participants might mitigate the hold-up problem. Given that ex ante investments have been made, the incentives to complete the ex post exchange depends upon the division of the ex post quasi-rent (Koss & Eaton, 1997). Integration alters the division of ex post quasi-rent. We demonstrate in various cases that integration improves the bargaining power of the agents merged. At its essence, integration for the purpose of acquiring the property rights and residual rights of control bypasses the need to coordinate the actions of multiple decision makers and render the merging parties stronger bargaining power. It reduces the risk of ex post hold up.

Another solution to the hold-up problem is that the potential opportunistic party agrees to pay the potential victim of hold-up ex ante an amount that is sufficient to recover the latter's initial investment cost. To convince the potential wronged party

to join the contract, an upfront commitment is made to serve as a self enforcing agreement among parties. The size of the commitment depends on the non-salvageable value of the advance investment undertaken by all the players and their marginal contribution to the total surplus.

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