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One Player Games versus Two Player Games: Comparing Agribusiness Cooperatives with Investor-Owned Business Models

Frederick Parker, PhD
Department of Agricultural & Resource Economics
3338 Nelson Hall, Campus Box 8109
North Carolina State University, Raleigh, NC 27695, USA
001-919-515-0338, fred_parker@ncsu.edu

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Abstract (250 words)

Cooperative business firms are prevalent in agribusiness, yet no concise generalized model exists to demonstrate how and why cooperative firms differ from, and may be selected over, the more common investor owned business firm. It is shown within a generic transaction game that cooperatives fill both producer and consumer roles as an aggregated player that is expected to maximize aggregate producer and consumer payoffs rather than maximizing either payoff separately, which contrasts with investor owned firms as essentially two player games between separate and competing producers and consumers where each player seeks to maximize their separate payoff individually. A cardinally valued game theoretic matrix is used to demonstrate the expected differences between these one-player versus two-player games, which clearly demonstrates that cooperatives are expected to achieve greater total payoffs and social welfare relative to investor owned firms, because investor owned firms generate dead weight loss when maximizing producer surpluses as expected under prevailing microeconomic theory. The use of cardinal payoff values rather than ordinal is important because it permits aggregation of payoffs within the model, and because it directly reflects the cardinal payoffs actually used in agribusiness decisions, such as revenue, expense and profit measures. The results may indicate the reason that cooperative firms are selected and have been successful in agribusiness. However, weaknesses of the cooperative model are also discussed, conjecturing that cooperatives may be preferable to investor owned businesses under limited circumstances but because these circumstances occur frequently in agribusiness the cooperative model is observed more frequently there.

Introduction

One of the most unique aspects of agribusiness and rural enterprises in general, relative to other industries and urban enterprises in general, is the prevalent use of cooperative business forms in agribusinesses relative to the prevalence of investor owned firms elsewhere. This is not to say that stock companies, sole proprietorships and other forms of investor owned business are not present in agribusiness, or that producer or consumer owned cooperatives are not present in urban settings, just that they are more prevalent in rural and agribusiness settings.

Because of this prevalence, it is understandable that rural communities familiar with the cooperative business model might continue to use them as new needs and projects developed, thereby augmenting the prevalence of the model in rural agribusinesses. For example, while the cooperative model originated as purchasing cooperatives in the United Kingdom (Thompson 1995), it quickly spread to marketing cooperatives, consumer-owned cooperatives, and even in to rural utilities such as electricity and telephony (LeVay 1983, Cobia 1989). The choice for predominantly agriculture-oriented rural communities was clear. They went with the organization form they knew best for collective activity. A form of organization that had proven successful in continuous operation over the course of decades, despite rarely being mentioned, much less taught, in mainstream business schools to this day. Yet despite its proven success with cooperatives growing into multi-million dollar international firms in billion-dollar industries, even the strongest practical advocates and most studied scholarly experts regarding cooperatives have a difficult time explaining exactly why cooperatives are successful, much less how or why they may be different from and potentially preferable to the vastly more studied and better understood investor owned business model. A cardinally valued game theoretic matrix is used to address this gap in the literature toward a better understanding of the cooperative model, especially as it compares with investor-owned companies.

Literature Review

Cooperatives are a type of business firm distinguished from other types of firms primarily as being owned by their users (Cobia 1989). There are many different types of firms that are classified as cooperatives, but this aspect of user ownership is consistent in the definition of cooperatives (LeVay 1983). Users are any economic actors that could otherwise conduct business with a different business entity through market transactions, but select to transact with the cooperative firm instead (Nourse 1922, Albaek and Schultz 1998). For example, a cooperative may be owned by the producers of its inputs, by suppliers of its labor, or by the consumers (customers) of its products and services (Bartlett et al 1992, Craig 1992, Anderson et al 1979). When such actors are both the cooperative's users (as customers, producers, labor, etc.) and the cooperative's owners, this places the same economic actors in two roles relative to the same firm. Importantly, the two roles normally have opposing objectives in non-cooperative business forms, such as the conflicting roles of owners seeking higher prices (to increase profits) versus customers seeking lower prices. This is the case for agribusiness cooperative customers also owning their cooperatives and thereby having two roles filled by the same individuals as user/owenrs, versus investor-owned utilities filling both roles with separate, non-integrated actors in competition for available surpluses from the transactions that result.

This is important because the dynamics change when both roles are filled by the same economic actors, but explaining how, why, and the resulting benefits in a rigorous yet understandable manner has seemed elusive. In fact, there are many theories regarding the benefits of the cooperative form of enterprise, largely based upon potential benefits from collective action represented by the firm generally (Coase 1937, 1960, North 1990). Hansmann (1988, 1996) indicates that cooperatives may be capable of reducing transaction costs for their owners relative to market transactions, consistent with Transaction Cost Economics but ignoring potential benefits from vertical integration aside from transaction cost differentials. Hart and Moore (1996) argue that member

cooperatives provide governance advantages, and Ostram (2000, 2003) shows through game theory and experiment that cooperatives and collective action may be capable of solving difficult problems such as the Prisoner's Dilemma.

Operationally, cooperatives are also theorized to provide a means of accomplishing various objective functions that are difficult to achieve in markets (Nourse 1922, Sexton 1990, Ghoshal and Moran 1996, Dierker and Grodal 1999). In fact, a consistent concept behind the various theories regarding cooperatives is that their benefits are generally not consistent with profit maximization by the firm. For example, worker owned firms may strive to maximize salaries or to ensure job security at the expense of firm profitability (Jones and Svejnar 1985, Craig 1992). Producer owned firms may seek to guarantee delivery rights or maximize input prices paid to the producer-owners (Bonin et al 1993, Choi and Feinerman 1993), and consumer-owned firms may maximize owner value derived through consumption of the firms' products (Enke 1945). Yet none of the existing literature seems to be widely accepted, much less utilized, within cooperatives themselves or within academia beyond a relative few specialists in the field.

This is not despite efforts to use cooperatives in academic research, although to date cooperatives have primarily been assumed to be profit maximizing investor owned firms where the investors just happen to be users as well, in virtually all empirical studies on them (Bonin et al 1993). Specifically, empirical research on cooperatives predominantly assumes that profit maximization is the primary objective function (Choi and Feinerman 1993, Albaek and Shultz 1998), generally concluding that cooperatives are inefficient as profit maximizers relative to investor-owned firms in the same industries (Porter and Scully 1987, Lerman and Parliament 1994). However, it is important to note that the existing empirical research generally does not study profit maximization directly, but rather compares cost minimization questions as a question of economic duality with profit maximization. In that regard, Akridge and Hertel (1992) found empirical evidence of excess capacity in cooperatives causing higher costs relative to investor owned firms, and separate studies found evidence of significant overinvestment in capital by cooperatives relative to investor owned firms that led to

higher costs and lower profitability (Sexton et al 1989, Caputo and Lynch 1993). Featherstone and Al-Kheraiji (1995) found evidence that cooperatives misallocate debt capital and other inputs in comparison with investor owned firms, and Schroeder (1992) found inefficiencies in supply chain management leading to higher costs and lower profits in cooperatives relative to investor owned firms. Hardesty and Salgia (2004) go further, stating that empirical evidence indicates that cooperatives "destroy owner value".

However, and importantly, the majority of cooperatives state that their objective is not profit maximization (Cobia 1989), as assumed in the studies discussed above. In fact, other studies tacitly assume that cooperatives do not maximize profit like investor owned firms, indicating that cooperatives and investor owned firms are demonstrably different but can coexist in the same market, and that the presence of cooperatives may improve the economic value received by consumers from all firms (Sexton and Sexton 1979, Neary and Ulph 1997). It is further recognized that a firm does not have to maximize profitability to be successful (Jensen 2002), especially when the firm is not publicly traded (Dutta and Radner 1999). In turn, empirical frameworks to test whether primary cooperative objective functions are something other than profit maximization have been proposed (Sexton 1990, Dierker and Grodal 1999, Giannakas and Fulton 2005), and there has been limited success testing for empirical evidence of non-profit maximizing objective functions in cooperatives, especially within labor-owned firms (Craig and Pencavel 1992, Bartlett et al 1992). However, the majority of proposed structures have not generated significant empirical results (Lawson 1992), generally attributed to a lack of suitable data to conduct the proposed research (Gupta and Kohl 1990, Bonin et al 1993), as well as difficulties separating the effects of agency problems from differences in objective functions (Sexton and Iskow 1993, Cook 1995).

But as mentioned, none of this work has provided a concise means of satisfactorily explaining the differences of cooperatives relative to investor owned firms, that is both rigorous enough for academic research and understandable enough for use by cooperative professionals and other practitioners such as analysts and public officials.

Analysis

To help fill this gap and contribute to a better understanding of cooperatives in relation to investor-owned firms, a simple but cardinally valued game theoretic model is used to compare the expected strategies of a single player within a "one player game" where both roles of producer and consumer are assumed by an integrated player, as contrasted with the expected strategies of separate players in two player games such as prevalent in the investor owned model where the roles of producer and consumer are filled by non-integrated players. A cardinally valued game theoretic matrix is used to demonstrate these expected differences between one-player and two-player games, to clearly demonstrate that cooperatives are expected to achieve greater total payoffs and social welfare relative to investor owned firms, because investor owned firms generate dead weight loss when maximizing producer surpluses as expected under prevailing microeconomic theory that can be avoided in a one player agribusiness. The use of cardinal payoff values rather than ordinal is important because it permits aggregation of payoffs within the model, and because it directly reflects the cardinal payoffs actually used in agribusiness decisions, such as revenue, expense and profit measures.

This cardinally valued matrix is achieved by simply placing the expected payoffs within a standard supply and demand analysis in to a game theoretic matrix. Under this common model and using basic neoclassical microeconomic assumptions, we know that at any given price and quantity combination the resulting Consumer Surplus and Producer Surplus may be calculated, and these surpluses may be used as payoffs from the transaction at any price and quantity combination. In fact, these facts are so well documented in most basic economics textbooks that they are neither surprising nor unique, and therefore are not replicated here. However, it is less widely discussed that there are four likely equilibriums within supply and demand analysis (Cobia 1989):

(1) Supply = Demand; where Marginal Cost = Average Revenue, Social Welfare is maximized, and neither players have prevailing market power (such as under perfect or pure competition)
(2) Profit Maximization; where Marginal Cost = Marginal Revenue, and Producer Surpluses are maximized because the producer has prevailing market power
(3) Consumer Surplus Maximization subject to a no-loss provision (no negative Producer surplus), because the consumer has prevailing market power
(4) No Transaction, where negotiations between producers and consumers fail and therefore both surpluses are zero (the supply and demand graph origin)

In turn, each of these four equilibriums provides distinct price and quantity combinations permitting the calculation of producer and consumer surpluses under each equilibrium, providing distinct cardinally valued payoffs under the most common and expected conditions and neoclassical assumptions of positively sloped Supply and negatively sloped Demand that may be used in a concise and universal four cell game theoretic matrix. Further, under neoclassical assumptions we know that these cardinal values will follow a predictable pattern of inequalities (that again may be verified in most basic economics textbooks and therefore are not replicated fully here) as follows:

$$PS_2 > PS_1 > PS_3 > PS_4$$

$$CS_3 > CS_1 > CS_2 > CS_4$$

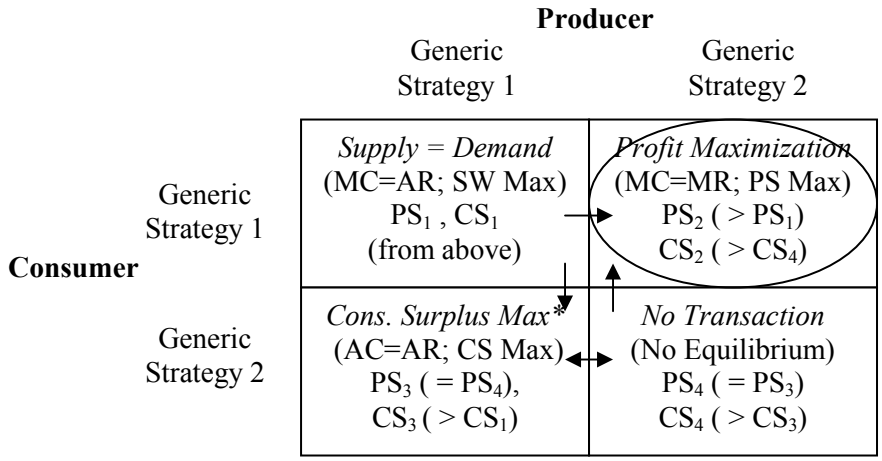
PS_x = Producer Surplus at equilibrium x as indicated above

CS_x = Consumer Surplus at equilibrium x

As such, the resulting cardinally valued matrix demonstrates that transactions within a standard supply and demand analysis have two non-maximal Nash equilibriums and a single weakly dominant Nash equilibrium corresponding to neoclassical profit maximization as shown in Figure 1 on the next page. This includes the expected preferences between generic strategies within a two player game including the payoff inequality relationship as listed for the four equilibriums above. Of course, in itself this

is not surprising as it merely confirms traditional neoclassical supply and demand analysis, especially in relation to Social Welfare and Dead Weight Loss analysis, although the facts that it confirms well known and proven tenets of microeconomic theory help support the use of the model for comparisons of agribusiness cooperatives and investor owned firms. This comparative analysis is the contribution of this paper.

Figure 1: Cardinally Valued Matrix (preferences shown for two player game)



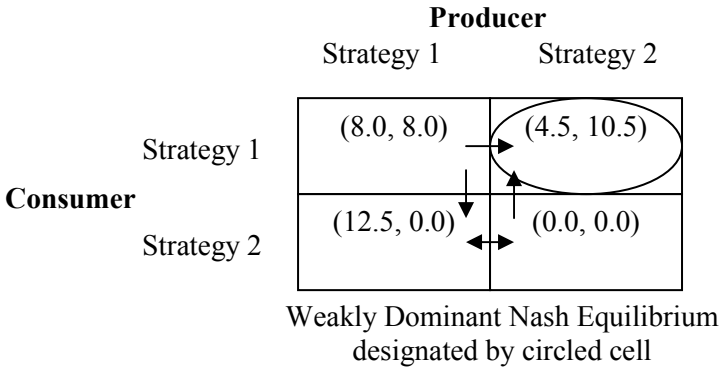
*CS Max = Consumer Surplus Maximum subject to Producer No-Loss Provision
Weakly Dominant Nash Equilibrium designated by circled cell

Although Figure 1 above describes what is expected from neoclassical economic theory as explained previously, it is not particularly easy to work with analytically. Therefore, arbitrarily selected numerical values may be used in the matrix to better demonstrate the preferences and choices being made by separate non-integrated producers and consumers in a two player game, and by an integrated player in a one player game such as within an agribusiness cooperative. This is shown in Figure 2 on the next page, which corresponds to the producer and consumer surpluses shown at the top of the next page as calculated from an actual supply and demand graph, although reconstructing the detailed calculations here is unnecessary because the relationship of inequalities is the important characteristics for analysis and are maintained. Again, the subscript identification correlates to the four equilibriums discussed above.

$(PS_2=10.5) > (PS_1=8.0) > (PS_3=0.0) = (PS_4=0.0)$

$(CS_3=12.5) > (CS_1=8.0) > (CS_2=4.5) > (CS_4=0.0)$

Figure 2: Cardinally Valued Matrix with numerical payoffs (two player game)



Weakly Dominant Nash Equilibrium
designated by circled cell

Figure 2 clearly demonstrates what is expected under neoclassical economic theory for a two party transaction between non-integrated producers and consumers, which is the same that is expected under game theory for a two player game between non-integrated players. The fact that the profit maximizing equilibrium is the weakly dominant strategy is expected, as well as the fact that total Social Welfare is not maximized at profit maximization (but where producer surpluses are maximized), indicating the existence of Dead Weight Loss in the game. In fact, within the context of this game matrix, Social Welfare is equal to the aggregate of producer and consumer surpluses, which may be easily added to the matrix as shown in bold in Figure 3 below.

Please note that the aggregate surpluses - which may equivalently be called aggregate social welfare - are the total payoffs available in the game; and in turn, *are the potential total payoffs available to perfectly coordinated players*. This is important because perfect coordination between the players is not only possible if one player performs both producer and consumer roles in the game – in fact perfect coordination is *expected* if one player fills both roles as in an agribusiness cooperative.

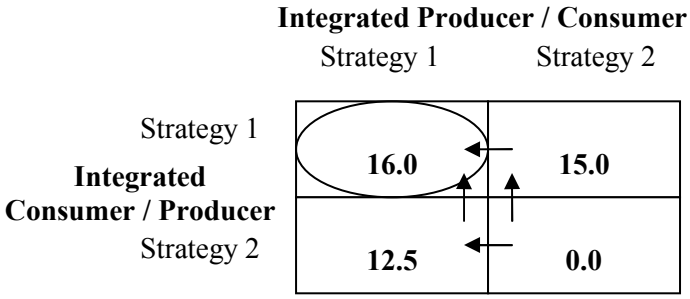
Figure 3: Cardinally Valued Matrix with Aggregate Surpluses (in bold)

		Producer Strategy 1	Strategy 2
Consumer	Strategy 1	(8.0, 8.0) **16.0**	(4.5, 10.5) **15.0**
	Strategy 2	(12.5, 0.0) **12.5**	(0.0, 0.0) **0.0**

In other words, we expect dead weight loss within the weakly dominant Nash equilibrium if two separate producer and consumer players are competing to maximize their own individual surpluses. However, should we expect the same Nash Equilibrium to hold if both producer and consumer roles are filled by the same, integrated player? For example, what if the Consumers own the company and thereby have control over operational and pricing practices and policies through control of the Board of Directors and thereby management of the company? In this case, the Consumers are essentially also the Producers in the transaction; or stated differently, the same integrated player has control over both roles and is thereby capable of perfect coordination between the players. In this case we expect that the integrated actor will prefer the highest payoffs available and thereby will focus upon the aggregate surpluses because they represent the maximum payoffs possible. The preferences for such an integrated player capable of perfect coordination between the two roles are shown in Figure 4 on the next page.

This result from a one player game that perfectly coordinates between the two roles should not be surprising, but is both novel and important because it clearly demonstrates what should be expected within the agribusiness cooperative model, because this single player dynamic is exactly what is available within the cooperative model that differentiates it from the investor owned model. In fact, this matrix demonstrates that for a one player game where both roles are perfectly coordinated by the "integrated producer / consumer", we expect a completely different equilibrium that is a

Figure 4: Matrix Maximizing Aggregate Surpluses (one-player game)



Strictly Dominant Nash Equilibrium designated by circled cell

strictly dominant Nash equilibrium consistent with social welfare maximization. This directly contrasts with the weakly dominant Nash equilibrium of profit maximization in the two player game above, and thereby clearly demonstrates what may be the key difference between agribusiness cooperatives as one player games versus the investor owned business model as two player games. Simply, they have different objective functions that correlate with different Nash equilibriums within the same transaction.

Discussion

The foregoing analysis has shown a new and potentially important way of evaluating the cooperative business model, which demonstrates that agribusiness cooperatives may be most accurately represented as one player games. In turn, because transactions within a one player game are capable of perfect coordination, we expect that agribusiness cooperatives will pursue strategies that maximize social welfare within the transaction, because the entire social welfare within the transaction accrues to the same integrated producer / consumer player, which may be the customer/owner, worker/owner, or user/owner of a cooperative through the aggregate surpluses that may be achieved. In other words, it is expected that within agribusiness cooperatives the integrated player will not select to maximize either producer or consumer surpluses individually, because either strategy will necessarily result in dead weight loss (as documented in economics

textbooks as well as shown above) *that reduces the payoffs to the integrated player*; and because a single integrated player is capable of perfect coordination to maximize the total payoff any strategy other than the strictly dominant Nash equilibrium correlating to aggregate surplus maximization is irrational and therefore not expected. This stands in contrast to the two player investor owned model which expects the weakly dominant Nash equilibrium of profit maximization (producer surplus maximization) along with its necessary dead weight loss, because in a two player game each player is expected to maximize their individual surplus, which is merely rational for non-integrated players.

Or perhaps to state it more succinctly, this analysis demonstrates that with identical transactions and available payoffs while assuming rational players, we expect distinctly different strategies from a one player game (where both roles are perfectly coordinated) and a two player game (where both roles are competitive rather than perfectly coordinated). In turn, because agribusiness cooperatives are more similar to one player games, and the investor owned model is more similar to two player games, we should expect them to be distinctly different in the payoffs they pursue - and the strategies they choose to pursue them - through company policies and practices.

For example, in day to day decisions an investor owned firm is expected to select the strategy that maximizes profit almost regardless of its effect on social welfare, but in the same day to day decisions an agribusiness cooperative should be expected to select the strategy that maximizes social welfare rather than profit or any other individual surplus. Far different than the prevailing assumption in cooperative literature that agribusiness cooperatives have the same objectives as investor firms but are apparently merely inefficient profit maximizing firms, this analysis demonstrates that an accurate analysis of agribusiness cooperatives must at least consider them as one player games with distinctly different strategies and payoffs relative to investor owned firms, and therefore the two types of firms should be considered exclusive and distinct.

In truth, though, it must be acknowledged that a one player game is trivial from the perspective of game theory, just as one player playing Chess or Poker against themselves may be, and is perhaps even boring. However, this should not indicate that

one player games are trivial and uninteresting from a more general economic perspective specifically because these one player games appear capable of achieving significant economic goals, most notably social welfare maximization (which requires reduction of dead weight loss), better coordination of transactions, and the like. In fact, perhaps the entire point of the cooperative business model – and the reason that it has succeeded and thrived within agribusinesses for so many decades - is that it removes the "excitement" of competition in two player games along with its hazards, by instead focusing solely on the "boring" task of achieving the maximum payoffs available from the game due to the absence of competition.

This raises an important question, though: if the cooperative model is apparently capable of such significant economic benefits, why is it not the prevailing model of the firm across all industries? The literature on both cooperatives and investor owned firms indicate that the latter far outweigh the former in virtually every category, from number of firms to total profits. This is an interesting question that requires significant future work, but perhaps it is as simple as the nature of one player games.

Of course, the potential for vertical integration to create a cooperative one player game is necessary, but assuming this and for purposes of discussion, perhaps the reason that cooperatives are not more prevalent outside of agribusiness is simply that regardless of their potential benefits one player games are not as interesting or "exciting" as two player games, either for academic researchers or professional businesspeople. However, rural communities and agribusinesses are known for favoring the most efficient methods of production that involve the lowest risk, or stated differently, they tend to accept boring low risk options so long as they get the job done. Perhaps the prevalence of agribusiness cooperatives is nothing more than tolerance for boring but productive tools within rural communities in any form they take, and thereby may be the reason that cooperatives are so prevalent in agribusinesses and rural communities generally. However, this is based primarily on anecdotal evidence and a categorical determination to this effect requires more work, but this appears to offer a promising area for future research on a business model that appears potentially capable of significant economic benefits.

Conclusion

One of the most unique aspects of Agribusiness and rural enterprises in general, relative to other industries and urban enterprises in general, is the prevalent use of cooperative business forms relative to the prevalence of investor owned firms elsewhere. Yet despite the proven success of cooperatives over decades and growth into multi-million dollar international firms in billion-dollar industries, even the strongest practical advocates and most studied scholarly experts regarding cooperatives have a difficult time explaining exactly why cooperatives are successful, much less how or why they may be different from and selected over the vastly more studied and better understood investor owned business model. This article helps fill this gap by showing that agribusiness cooperatives may essentially be one player games, whereas investor owned firms involve essentially two player games, which results in different expected strategies, payoffs and Nash equilibriums based solely on whether the game is being played by two non-integrated producer and consumer players than by a single integrated single player capable of prefect coordination within transactions. In fact, perfect coordination within one player games makes social welfare maximization not only possible, but *expected*, which contrasts sharply with the expectation of dead weight loss under the Nash equilibrium corresponding to profit maximization in a two player game. An analysis is presented to support these conclusions, but also acknowledges that one player games are boring despite their advantages, which may help explain their prevalence in agribusiness and rural communities, but not in urban communities or academic literature. Potential exists for future work based on this model.

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