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Institutional Structures and the Horizon Problem in Agricultural Co-operatives: An Experimental Economics Approach

by

Richard James Vyn ©

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ABSTRACT

The purpose of this research study is to compare the structures of traditional co-operatives and New Generation Co-operatives (NGCs). The major problem under review is the horizon problem, which creates disincentives for members to invest in the co-operative, making it difficult for co-operatives to accumulate the equity necessary for maintaining their business activities.

The structure of New Generation Co-operatives is believed to alleviate the horizon problem. In this research study, this hypothesis is tested using an experimental economics approach. The results from the experiment show that the NGC structure increased investments.

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CHAPTER ONE

INTRODUCTION

1.1 Background

Agricultural co-operatives have been an important form of organization in agriculture over the past century. Their ability to reduce costs for farmers and offer increased market access are two of the main reasons for the emergence of co-operatives as a leading agricultural organization. Agricultural co-operatives are also believed to offer improved product and service quality and improved bargaining power when dealing with other businesses (Harris, 1998). These factors have enabled the co-operatives to enhance their competitiveness in the agriculture industry since their establishment began in the early 1900s. However, in the late 1980s, co-operatives began to experience a decrease in market share. This decrease in market share is occurring for two main reasons. The first reason is that changes in the overall structure of the agricultural industry have created external pressures on agricultural co-operatives, and these external forces are making it more difficult for co-operatives to succeed in the agricultural industry. The second reason is that the internal organizational structure of traditional co-operatives creates incentive problems within co-operatives that cause difficulties in generating investment capital, thus creating further difficulties for co-operatives in their quest to adapt to the external pressures from the changing structure of the agriculture industry.

The current transformation of agriculture toward industrialization at a global level is the main driving force behind the external factors affecting traditional agricultural co-operatives. Some key components of this transformation are that markets are less commodity driven and more product driven, production is more capital intensive and value-added, decision making is becoming more interdependent amongst all levels of the market, and information is becoming an increasing source of power. The end of rivalries between the Western capitalist system and the Eastern collective one has led to increasing international trade in agriculture (Cracknell, 1996). This has affected the agriculture industry, with private organizations expanding their enterprises internationally in an attempt to grab a share of the newly developing market. Trade liberalization has resulted from the improved international relations, and with the influx of private organizations in the international market, North American governments have lessened their influence in the agriculture industry, employing a more hands-off role in this sector. For example, in Canada, some price support programs and production-based subsidies have been removed, there has been deregulation of industries such as grain transportation, and there is decreased support for agricultural research. Marketing boards and government marketing agencies are experiencing a loss of support (Stefanson & Fulton, 1997). Without the government support, the increasing competition from private organizations becomes a major threat to the survival of agricultural co-operatives. In order to survive, they must be able to adapt to both the global transformation of agriculture and to the reduced political power.

In addition to global changes, there are also changes occurring at local levels. For example, Western Canadian agriculture has been experiencing some unsettling changes. The removal of the Western Grain Transportation Act (WGTA) not only reduced the price of grain in western Canada, but resulted in the replacement of a highly regulated system with what may turn out to be a market-based system that could cause increased transportation costs. Other changes at the local level have been the specialization of farm production and the increase in the size of farm operations. This has caused agricultural communities to spread out, making it more difficult for local agriculture organizations to service the more geographically separated farms. Agricultural co-operatives must be able to adapt to this changing structure of rural economies.

These external factors have increased the pressures on the internal management of co-operatives, forcing them to deal with inherent problems in traditional organizational structures of co-operatives. The traditional co-operative has long been the main form of agricultural co-operative. However, the internal organization of these co-operatives has fallen under some criticism (Cook, 1995). As co-operatives have expanded to include more than one enterprise or focus, their membership has become more diversified. Each member of a co-operative has different incentives for patronizing the co-operative. Consequently, many different ideas may emerge for the direction that the business should be taking. This can make it more difficult for co-operatives to pursue new enterprises, such as engaging in value-added ventures.

There are two main problems that impede the adaptation of co-operatives to the globalization and industrialization of agriculture. The first, and most important, is the horizon problem (Cook, 1995). When co-operative membership is diversified, there will inevitably be different investment horizons among the membership. Older members will tend to have shorter investment horizons, and will therefore be less willing to invest in the long-term future of the co-operative. They do not have incentives to invest long-term because they will not benefit from a return on this investment. This is due to the fact that they may no longer be a member of the co-operative by the time that the investment generates a return. Conversely, newer members will tend to have longer investment horizons and will therefore be more willing to invest in the long-term future of the co-operative, as they will still be members when the long-term investments accumulate returns. Older members will likely want more of the co-operative's profits returned to the members, while newer members will prefer that profits be re-invested back into the business for potential future returns.

A second problem in traditional co-operatives is inefficiency in their operations, which often stems from a form of free riding. In traditional co-operatives, new members have the same patronage rights as existing members and are entitled to the same payment per unit of patronage. This can create an incentive to overuse the services available. This overuse creates difficulties in maintaining an efficient operation, as co-operatives cannot control the amount of use of their services. This lack of control means that the co-operative's services will generally not be used at optimal profit maximizing levels for the co-operative. In addition, because the use of the co-op's services is not tied to a member's investment level, there is no incentive to patronize the co-operative at a lower rate if the member has less equity invested in the co-operative. Since all members receive the same patronage rights regardless of their investment, a disincentive is also created for investment in the co-operative (Cook, 1995). These problems, further defined in Chapter 2, are potentially avoided through the structure of the New Generation Co-operatives.

The comparison of traditional co-operatives with New Generation Co-operatives (NGCs) centers around their different property rights structures. Traditional co-operatives are often said to have vaguely defined property rights (Cook 1995). The problems created by these property rights create an inability to generate sufficient equity capital from members. This constrains the ability of co-operatives to move into capital-intensive and value-added ventures (Gurung, 2000). These ventures are necessary to remain competitive in today's agriculture industry. This issue has led to the conception of NGCs as an alternative style of co-operative, which focuses on the development of more defined property rights for co-operative members. These property rights are designed in an attempt to avoid several problems in traditional co-ops that have been a hindrance to their organizational efficiency. These problems, which include the horizon problem, have long affected equity levels in co-operatives (Cook, 1995). However, it is thought that these problems may be avoided through the structure of New Generation Co-operatives, which ties patronage to the level of invested equity, and sets the amount of equity at an efficient level (Harris et al., 1996).

The success of agricultural co-operatives depends on how well they can adapt to the changes in their environment. Co-operation among members is essential for the success of the adaptations. In order to maintain this co-operation, there needs to be an agricultural co-operative structure that can minimize the effects of the investment horizon problem and other problems, such as sub-optimal service use. This study will first examine the effectiveness of the present structures in traditional co-operatives; then it will compare this to the effectiveness of the alternative structures found in New

Generation Co-operatives. The purpose of this study is to test empirically whether the difference in property rights structures between NGCs and traditional co-operatives affects investment equity and service use levels in a co-operative. The results can be applied to the agricultural community in their decisions for rule structures pertaining to their co-operative institutions.

1.2 Research Objectives

The specific aims of this study are five-fold.

1. Examine inherent incentive problems in traditional co-operatives.
2. Examine the structure of New Generation Co-operatives. Compare the structure of NGCs to that of traditional co-operatives in a property rights framework.
3. Discuss the advantages and disadvantages of traditional co-operatives and New Generation Co-operatives in terms of internal incentive structures relating to investment and to the use of co-operative services.
4. Develop working hypotheses about the performance of New Generation Co-operatives as compared to traditional co-operatives in the areas of investment and use of co-operative services.
5. Develop an experiment that simulates New Generation and traditional co-operative property rights structures and the investment horizon problem. Use this experiment to test the working hypotheses concerning the performance of the two types of co-operatives.

The research tool used to test the hypotheses is experimental economics. Experiments are a relatively new research tool in economics. Experimental economics has been used mainly in the study of common pool resource problems and public goods issues. There have not been any experiments developed to study the internal workings and rule structures of co-operatives. Economics experiments use human subjects to participate in a game that simulates the economic environment and incentives of interest. For example, in public goods experiments, human subjects are divided into groups. Each member of the group must decide whether to allocate given resources, often called tokens, to a private market or a public market. The game simulates an actual public goods scenario because individuals will receive the public good even if they do not contribute to it. For this reason, they have an incentive to let other individuals supply the public good while they cash in on the private good. These incentives for free riding can ultimately lead to under-provision of the public good.

Public goods or collective goods experiments have an application in the study of agricultural co-operatives, as the services provided by co-operatives to their members, such as marketing services, retention of past earnings, and investment in capital projects, are collective goods. The fact that these services are not excludable to members creates the collective good, and the fact that the members are not required to invest in the co-op to receive these services creates incentives to free ride, thus impeding efficiency. The group ownership structure and the collective goods problem are the first aspects of the experiment developed in this study. Experimental methods allow for manipulation of the rules of the game in order to simulate rule structures in actual economic situations. This allows for observation of how specific rules affect the group's ability to provide itself with efficient levels of a collective good. In this study, the different rule structures of traditional co-operatives and NGCs will be simulated so that the inherent incentives in each may be examined empirically. The fact that the rules are controlled in the experiment allows the researcher to test empirically the effect of the rule structures on the behaviour of the subjects and make inferences about how the rule structures affect behaviour in actual co-operative settings. The other aspect of the experiment deals with the investment horizon problem and the impact of NGC and traditional co-operative rule structures on long-term investment.

The details of the experimental design and methods are discussed in Chapter 4. In Chapter 2, the literature relating to this study is reviewed. Agricultural co-operatives are described at length in this chapter. This supplies the background for formulating the hypotheses concerning the investment horizon problem and the sub-optimal use of co-operative resources. Chapter 3 contains a review of relevant public goods and experimental economics literature. Chapter 5 analyzes and discusses the results from the experiments. Finally, Chapter 6 presents conclusions and suggestions for further research in this area.

CHAPTER TWO

AGRICULTURAL CO-OPERATIVES

This chapter gives a background description of co-operatives in Sections 2.1 and 2.2, points out some advantages of the co-operative structure in Section 2.3, then discusses how the structure of traditional co-operatives has led to some inherent incentive problems in Section 2.4. The inefficiencies that stem from the investment horizon and sub-optimal service use problems, as mentioned in the previous chapter, are discussed in more detail in this section as well. The discussion of these problems leads into the underlying basis of New Generation Co-operatives, and their potential solutions for these problems, as described in Section 2.5.

2.1 Organization and Historical Development of Agricultural Co-operatives

According to the International Co-operative Alliance (1996), a co-operative is "an autonomous association of individuals voluntarily united to meet their common economic, social, and cultural needs through a jointly-owned and democratically-controlled enterprise." Co-operatives operate in almost every sector of the economy, including financial, retail, housing, forestry, and agriculture. Agricultural co-operatives are owned and controlled by the producers who deliver commodities to the co-operative, or who purchase goods and services from them. These co-operatives give the producers the opportunity to own and control businesses related to their farming operations.

Co-operatives differ from other types of businesses in their primary objective, which is to provide benefits to their members in the form of goods and services. A secondary objective is to provide benefits in the form of patronage refunds based on the profits of the co-operative. The main objective of other types of businesses - such as sole proprietorships, partnerships, and corporations – is to generate profits for the owners of the business.

Control in traditional co-operatives follows the principle of 'one member, one vote'. This means that each member only has one vote regardless of the amount of equity they have invested in the co-operative. Control of co-operative operations is carried out through a board of directors, comprised of members who are elected by the other members. The board represents the members as it attempts to provide direction for the business through the establishment of goals and policies. The main issue of control in co-operatives is often the decision-making regarding the types of goods and services that the business will provide (Harris, 1998).

While control of co-operatives is based on the principle of 'one member, one vote', the distribution of benefits is proportional to the amount of investment by the members. Those who deliver more commodities or purchase more goods and services from the business will garner more benefits. These benefits are distributed to the members in the form of patronage refunds. A surplus from the co-operative can be re-invested in the business for the improvement of services or can be distributed to the members. The patronage refunds are determined as a proportion of the member's use of co-operative services during the previous year (Harris, 1998).

Agricultural co-operatives usually have flexibility in deciding on the proportion of patronage refunds they return to members in cash, and their decisions can have important impacts on patron cash flows. A high cash proportion of patronage refunds can enhance the patron's cash flows and can help the co-operative attract new business. On the other hand, by paying low cash patronage refunds the co-operative can make investments that enhance the value of co-operative equity and make it easier to return equity to retiring members. The decision regarding the levels of cash patronage refunds can be complicated by different preferences among members. Royer and Shihipar (1997) found that member preferences regarding the proportion of patronage refunds that a co-operative pays in cash will change during the course of the member's farming career. For example, younger members typically prefer high cash patronage refunds at the expense of equity revolvement. As these members accumulate equity investments in the co-operative and begin approaching retirement, they may prefer lower cash refunds and more rapid equity revolvement. Preferences are also affected by other personal and co-operative factors, such as the member's discount rate as well as the co-op's rate of return to equity and its growth rate, two factors that affect the length of the revolving period. The differences in member preferences regarding distribution of patronage refunds lead directly to the investment horizon problem, the main problem that is studied in this thesis.

Most agricultural co-operatives began as relatively small, local, single product organizations. These organizations were a reflection of the structure of farming communities over a large part of the past century, small communities that focused on one main type of product. As such, they were highly accessible to and easily understood by their members. These centrally located organizations provided the farmers with services that helped to decrease the costs of inputs and increase the ease of marketing their products. These organizations were an alternative to the impersonal incentives of private firms, firms that focused on maximizing their own profits. The producer-friendly environment and services of co-operatives appealed to many farmers. This appeal, combined with the ability of these co-operatives to compete with private firms, propelled co-operatives into their place as a competitive form of organization in the agriculture industry. Many of these small agricultural co-operatives have grown into large multi-product businesses using sophisticated technologies and servicing large geographical territories. They divide their work among various departments and levels of the organization. This makes co-operative operations more efficient through economies of scale, but it presents a potential cost in efficiency, as the ideal of democratic member control becomes more difficult to maintain (Gray and Butler, 1994).

2.2 Types of Traditional Agricultural Co-operatives

Agricultural co-operatives have traditionally been of three main types: supply, marketing, and processing co-operatives. The organization of these co-operatives has been described in the previous section. A more recently developed form of organization has been the New Generation Co-operative, which is described in section 2.5.

Supply co-operatives provide producers with inputs and services at competitive rates. Inputs available from co-operatives include petroleum, feed, and fertilizers. They also provide services such as breeding, artificial insemination, and seed cleaning. There is a wide range of supply co-operatives, from simple buying clubs organized by producers to take advantage of volume discounts, to large wholesale and retail operations which offer a wide variety of goods and services. These co-operatives can charge market prices for the goods and services, or they can charge at cost plus an operating margin. In both cases, the profits are returned to the members at the end of the year. The members of supply co-ops also have the option of selling to non-members, which can increase the profits of the co-operative (Harris, 1998).

Marketing and processing co-operatives are created for producers to jointly market, distribute, and process their products. By pooling their resources, producers are able to hire professional marketing specialists who can help them employ more efficient marketing strategies. These co-operatives use different methods to keep track of the commodities delivered by their members. Some pay producers a market price when the commodity is delivered. Others will pay a pooled price based on the average returns earned by the co-operative over a specified period of time. Others simply find buyers for the producers and never take ownership of the product. They charge a per-unit price for this service. In each case, members can receive additional payments at the end of the year based on the co-op's profits. Marketing agreements are often used to stipulate the way that products will be processed or marketed by the co-op. This enables the co-operative to operate more efficiently. Processing co-ops can save costs by coordinating the volume of the members' production with the capacity of their facilities (Harris, 1998).

Marketing and processing co-operatives can use different methods to account for their members' products that are delivered to their facilities. Two types of these marketing arrangements are marketing pools and call marketing. In marketing pools, producers of a certain commodity pool their production to be marketed by the co-op. The co-op takes ownership of the commodity and makes all the marketing decisions regarding that commodity, such as when and where to sell. The producers receive an average price earned by the pool during that marketing period. They generally receive an advance payment at the time of delivery. Progress payments are made to the producers as the commodity is marketed, and a final settlement payment is made at the end of the marketing season when all the costs and revenues have been determined. This final payment is adjusted according to the quality of the producer's commodity (Harris, 1998).

The advantage to this type of pooling is that the commodity is given to marketing specialists to be sold at the highest price possible on any given day. They are in the market every day, which reduces the risk for producers of missing the highest price or of selling all their production at a low point in the market. Risk is also lessened by spreading it over a group of people instead of having it fall on only one producer. No producer in a pool will ever receive the highest price for their commodity, but they are protected from selling at the bottom of the market. However, some producers do not feel at ease with giving up the control of marketing decisions. They would rather take the risk of selling their production based on their own knowledge of the market. Another insecurity some producers have with the idea of pooling is the delays in the final payments from the co-op. Some producers would rather not wait until the end of the marketing season to receive all their returns from their crops (Harris, 1998).

A call marketing arrangement leaves ownership of the commodity with the member who produced it, even after it has been delivered to the co-op. The members then decide when to sell and how much to sell at any time during the marketing season. The co-operative does the actual selling of the commodity and transfers the returns to the member. Members will often set a minimum price at which the co-op may proceed with the sale. A small part of the returns is kept by the co-op to cover operating costs and to contribute to equity capital (Harris, 1998).

2.3 Advantages of the Traditional Co-operative Organization

Traditional co-operatives have been a prevalent form of organization for marketing and processing of agricultural products and supply of agricultural inputs for some time. Their importance stems from several benefits that producers obtain from membership in agricultural co-operatives. These benefits include improved bargaining power, reduced processing and input costs through economies of scale, increased returns, improved product and service quality, and reduced risk (Harris, 1998).

Co-operatives can improve the bargaining power of individual farmers through several methods. Individual producers may have a restricted bargaining position when their products are ready for market. Because of the perishability of many crops and the major investments many farmers have in production facilities that cannot be used for other purposes, producers may have little choice in marketing their crops. Lacking an alternative marketing outlet, they may be forced to accept low prices. The situation, which appears particularly oppressive to smaller farmers, requires the collective action of the co-operative. Farmers acting as a group through the co-operative have a larger market share. The mechanism for assistance in this case is for the co-operative to offer farmers a guaranteed market at a fair price for their products (Brown et al., 1988).

Co-operatives can also reduce costs, including the cost of many farm inputs and the processing costs of producing agricultural wholesale products. Costs are reduced by pooling producer capital and resources through a co-op that can reduce the per-unit costs of processing for producers by taking advantage of scale economies derived from processing large volumes of product. Costs of inputs and services can also be reduced by ordering large volumes. Co-operatives can also assure the availability of essential products and services, which smaller companies may be unable to provide. This allows producers to focus on the production of goods, rather than on finding buyers and suppliers (Harris, 1998).

Producers can increase their returns through a co-operative, as the surpluses are often returned to them as patronage refunds. Investor-owned firms do not return any surpluses to producers. These refunds add to their income from the production of commodities. Co-operatives can improve product and service quality, as they set certain standards for the commodities that producers deliver. The producers can also implement grading systems and standards. This can improve the quality of product available to consumers (Harris, 1998).

Co-operatives may also reduce risk for producers. By pooling their production, farmers can minimize price and market risk, as agricultural commodity prices can have major fluctuations. Since marketing co-operatives are involved in the markets every day, they will not miss the high prices, and any effects of low prices are minimized, as the risk is spread over a large number of producers. Also, the producers have limited liability as members of a co-operative. They cannot lose more than the amount that they have invested in the business (Harris, 1998).

Advantages of co-operatives also include their ability to respond to market failures that confront limited resource farmers. Centner (1988) has identified several significant types of market failure: oligopsony, asymmetric information, and restricted bargaining position. Oligopsony, a market condition in which there are few buyers and many sellers, poses special problems for agricultural producers. In this situation, farmers may have few choices for marketing their products and little control over the prices they receive for their crops. The co-operative, owned and managed as a business by its members, can help to alleviate these problems. The co-operative can act as a collective bargaining agent to secure better prices for agricultural goods in situations where oligopsony exists. Members of the co-operative can also establish prices for products sold to the co-operative.

A second type of market failure, asymmetric information, may occur when producers cannot differentiate between quality and non-quality goods. In these situations, co-operatives can supply additional marketing services by gathering and distributing market information for the members, information that may be difficult to obtain for individual producers. If producers do not have sufficient information on inputs being purchased, they may not get the best value for their money. Through dealing with a co-operative that is owned and managed by producer members, producers can learn more about the quality of their inputs (Brown et al., 1988).

2.4 Disadvantages of Traditional Co-operatives

As mentioned in Chapter 1, the internal organization of traditional co-operatives has fallen under some criticism. The structure of these co-operatives makes it more difficult for the co-operative to expand or invest in value-added ventures. Royer (1999) discusses several problems intrinsic to the co-operative organizational form. These problems include the horizon problem, the portfolio problem, the control problem, the free riding problem, and the influence costs problem. All five of these problems are discussed below, but the main focus of this study is on the horizon problem.

The portfolio problem occurs because members invest in the co-operative in proportion to their use and because equity shares in the co-operative generally cannot be freely bought or sold. Members are unable to diversify their investment portfolios according to their personal wealth and preferences for risk. As a result, members require higher returns on co-operative investments and are less likely to invest in new assets than corporate shareholders. This problem is intensified to the extent that the risks associated with the co-operative enterprise are positively correlated with the risks involved with the member's own farming operation (Royer, 1999).

Control problems exist to some degree in any organization in which there is separation of ownership and control. These problems may be more serious in co-operatives because of the lack of a market for exchanging equity shares and the lack of equity-based management incentive mechanisms available to other firms. The inability of co-operative members to trade equity shares among themselves prevents the concentration of equity in the hands of a few shareholders, which decreases the incentive for individual members or boards of directors to make difficult decisions regarding innovation or initiating management change. The absence of an equity market also prevents the ability to monitor the co-operative's value and evaluate the performance of the management. Because of a lack of means to compensate or motivate managers, co-operatives may have a harder time attracting and keeping good managers. The restriction of co-operative membership to producers also contributes to this problem, as it becomes difficult to find specialists in various areas to include on the management team (Royer, 1999).

The influence costs problem occurs where costs associated with activities in which members of groups within an organization engage in an attempt to influence the decisions that affect the distribution of wealth or other benefits within the organization. These include both the direct costs of influence activities and the costs of poor decisions caused by influence activities (Royer, 1999).

The co-operative form of organization has been hypothesized to be inefficient relative to investor-owned firms (IOFs). Studies by Porter and Scully (1987) and Ferrier and Porter (1991) argue that co-operatives will exhibit allocative inefficiency because of the horizon problem. Because members benefit from co-operative investments only over their horizon as patrons, it is hypothesized that co-operatives will under-invest in long-term assets such as capital and instead pursue opportunities designed to generate short run payoffs. This prevents them from choosing the optimal mix of inputs and results in allocative inefficiency. Co-operatives are also hypothesized to be technically inefficient because of the transferability problem. Due to the fact that co-operative stock is not transferable, co-operatives are unable to rely on stock prices as a measure of performance, and because ownership is generally dispersed over many members, individual members have limited incentives to monitor performance. As a result, managers are more likely to pursue objectives contrary to cost minimization, which is necessary for the maximization of member benefits. There can also be a lack of incentive in co-operatives to contribute to the base of equity capital that may be used to finance capital input purchases. Porter and Scully and Ferrier and Porter also argue that co-operatives will exhibit scale inefficiency because they often lack sufficient patronage to achieve the cost minimizing scale of operation. This could be due to increasing costs of control as the number of patrons increases and to legal restrictions on the volume of non-member business conducted (the control problem). According to Porter and Scully, co-operatives survive because of favourable tax treatment, favourable credit terms, and free services provided by the government.

There are also arguments to suggest that co-operatives will perform more efficiently than IOFs. There are possible cost savings due to internalizing transactions through vertical integration. Another potential gain in technical efficiency comes from improved information flows in co-operatives, as the members are also the directors. Sexton and Iskow (1993) reported that there are deficiencies in the Porter and Scully and Ferrier and Porter studies that could make their findings somewhat unreliable. They went on to do a study that found little evidence to support the perception that IOFs are more efficient than co-operatives, which is common among many farmers and co-operative experts.

2.4.1 Collective Goods and Free Riding

The free riding problem often arises in situations involving public goods or common pool resources. Public goods are neither excludable nor rival. Non-excludable refers to situations where it is difficult or impossible to exclude individuals who do not pay for consuming the benefits arising from a resource. Non-rival refers to the concept that the amount that one person consumes has no effect on the amount for other people to consume, and the consumption of the good by one person does not exclude others from consuming the same good. An example of a public good is a lighthouse. The light consumed by one ship does not prevent other ships from consuming the light, and the amount consumed by that ship does not affect the amount of light available for consumption by the other ships (Stretton and Orchard, 1994).

Goods such as national defense, law and order, lighthouses, streets, and streetlights are called 'public' because they cannot be supplied to anyone without being made available to everybody, and each user cannot be made to pay for them. There are goods such as highways, bridges, weather forecasts, and national parks that are possible but unusual for which to charge users. There are also goods which could easily be supplied through a market, but which some governments choose to provide to some or all of their citizens free or at reduced cost, such as education, health services, and public transportation (Stretton and Orchard, 1994).

The nature of public goods dictates that no individual can get exactly their money's worth of exactly the public goods they want. This inefficiency motivates people, as self-interested maximizers, to try to pay as little as they can while taking as many public goods as they can. That behaviour causes the following three inefficiencies. First, most people will not get exactly the public goods they want, and which they would be willing to pay for if they had to, if the goods were only available as market goods. Second, inequity arises as some people get more than their tax-paid shares of public goods while others get less. Finally, people are motivated to understate their wants when asked how much they are willing to pay for a public good, as each hopes to get the goods they want at a lower cost, or at the expense of other taxpayers. But with everyone acting in this way, there will always be an under-supply of public goods, as the amount of public goods provided is based on the total amount of tax the population votes to pay (Stretton and Orchard, 1994). Another way of saying this is that when too much free riding occurs, the optimal amount of the good may not be produced, and under-production of the good will occur (Cornes and Sandler, 1986).

Underproduction refers to a comparison between the equilibrium amount of the public good and the Pareto optimal amount. The Pareto optimum occurs at a point or points where nobody can be better off without somebody else being worse off. When the equilibrium amount falls below the Pareto optimal amount, then underproduction occurs.

This is believed to result for the provision of most public goods, for several reasons. If exclusion is not possible, then there is no incentive for firms to supply the good, and there will be insufficient production. If exclusion is possible, then some potential consumers who are willing to pay for the good may be excluded from consuming the good, and also from paying for it. As a result, their demand will not be recognized by the producer of the good, and a sub-optimal amount of the good will be produced. Optimal provision often requires different prices for different individuals, based on the amount each individual would be willing to pay. However, these prices are not readily available, as consumers are generally not willing to truthfully state how much they would pay for the good. Due to this information problem, the seller has no choice but to charge everybody the same price, and this will lead to underproduction (Cornes and Sandler, 1986).

For agricultural co-operatives, the free riding problem may occur both inside and outside the organization. Inside the co-operative, these problems come from the fact that the rights to the residual claims are generally tied to patronage instead of investment. New members are not required to make initial investments proportional to their use, yet they receive the same rights to residual claims as existing members and are paid the same patronage dividend per unit. This encourages decisions that increase patronage refunds per member, and a disincentive for investment results (Royer, 1999). Members will often not receive a return on an equity investment, which creates incentives for putting their money towards their own ventures, rather than those that would benefit the co-operative. The free riding problem occurs because ownership in most traditional co-operatives conveys no benefit; rather, benefit is obtained through the patronizing of the co-operative.

Royer and Bhuyan (1995) found that both producers and consumers benefit from the forward integration of co-operatives into processing activities, however, these benefits do not ensure that a co-operative has an incentive to integrate. Co-operatives that are successful in restricting producer output to optimal levels may have an incentive to integrate forward because integration allows them to capture monopoly profits in the processed product market and maximize the aggregate profits of the vertical market structure. Co-operative theorists argue that co-operatives will be unsuccessful in restricting producer output because the receipt of patronage refunds gives producers an incentive to expand output. This is a good example of the effects of the free riding problem, and illustrates how the lack of control over the use of co-operative services can prevent the co-operative from achieving a profit maximizing level of service use.

Member opportunism, another form of free riding, is a problem in co-operatives that have a policy to accept all member deliveries. Members have an incentive to shirk on quality, as the individual producer does not carry the full liability of such behaviour. Members may view their co-operative as a clearinghouse for product during periods of low prices and quality, but may resort to other marketing channels when prices and quality are high. This free riding behaviour can create widely fluctuating delivery levels in co-operatives, making it difficult for them to maintain consistently optimal levels of product deliveries.

Another type of collective good that is relevant to the study of agricultural co-operatives is the common pool resource. Common pool resources are goods that are similar to public goods in that they are non-excludable, and similar to private goods in that they are rival. Since these goods are generally free for anybody to use, there is a danger that each user's consumption of the good will deplete the remaining available supply. Although most common pool resources are potentially renewable, the high political and economic costs of acting together to sustain a resource mean that depletion will often occur faster than renewal. Facilities and services provided by traditional co-operatives more closely resemble common pool resources than do those provided by NGCs, as there is much less exclusion involved in traditional co-operatives. The marketing resource offered by grain processing co-operatives has similar traits to a common pool resource. When one producer delivers more grain, there is less capacity for the deliveries of grain from other producers. Also, the more people that join as members of the co-operative, the further the profits will be spread out. Though with more members there could be increased profits, the negative effect of the increase in the number of members could over-ride the positive effect of the increase in profits. Because users tend to ignore the negative effects that their actions have on others, over-appropriation results and the resource is depleted, as patronage refunds decrease due to overuse of services. This, again, is the problem of free riding. A generally accepted premise is that users of common pool resources will over-invest in appropriation from the resource (Walker et al., 1990). This overuse also creates problems in co-operatives with achieving the profit maximizing level of use.

When a common-pool resource is subject to over-exploitation, it may be possible to create combinations of public and private institutions that can save that resource. New Generation Co-operatives attempted to avoid over-exploitation and fluctuating delivery levels by limiting the membership and implementing a fixed level of accepted product deliveries through selling membership shares which act as delivery rights to the co-operative. The well-defined property rights of these institutions lend themselves to decreasing overuse, and as such, less difficulty with inefficient operations.

2.4.2 Capital Acquisition and the Horizon Problem

Co-operatives receive a large part of their capital from direct member investment, which is a basic responsibility of membership. This investment shows that the members expect to benefit from being a part of the co-operative, and display their commitment by making use of the co-op. There are three types of direct member investment – the purchase of membership shares, the purchase of investment shares, and the payment of fees. Co-operatives can charge a yearly membership fee, or simply charge a fee when a new member joins the co-operative. Individuals are sometimes required to invest an initial amount of capital to become a member of a co-operative. For this requirement, co-operatives generally offer membership shares, where each member must purchase at least one. The value of these shares can vary, depending on the nature of the co-operative, and there is usually no interest paid on them by the co-op. Co-operatives can also issue investment shares to members for the purpose of raising capital. Some co-operatives require members to buy investment shares in proportion to the amount of business they do with the co-op. In doing this, the member's investment is a reflection of their use of the services provided by the co-operative (Harris, 1998).

Capital acquisition has been a long-standing problem for co-operatives. The difficulties co-operatives face in raising funds is receiving more attention as co-operatives diversify their operations to include more processing activities. The horizon problem, according to Sexton (1991), is the largest obstacle to the successful entrance of co-operatives in value-added processing activities, as these activities require large capital investments that generally only pay off in the long run. The horizon problem arises when an investor's claim on the net cash flow generated by an asset is expected to terminate before the end of the asset's useful life. As a result, the investor is likely to under-invest in the asset because the return to the investor is less than the return generated by the asset (Royer, 1999). The horizon problem is essentially a disincentive for members to invest in long-term projects, and arises in co-operatives from three factors: (1) co-operative returns are distributed to members on the basis of patronage; (2) individual co-operative members will prefer investments that will provide payoffs during their expected patronage period (or investment horizon); (3) the ages of co-operative members vary, leading to different investment horizons. The combination of these three factors leads to differences among members concerning incentives for investing in the long-term future of traditional co-operatives. These differences result in under-investment in the co-operative by the membership, even though investment is necessary for the co-operative's long-term success (Knoeber and Baumer, 1983). The horizon problem also encourages co-operative directors to increase current payments to members instead of investing in more assets and to increase equity revolvement rather than building up the level of equity in the co-operative (Royer, 1999).

Co-operatives have tried to combat these problems by retaining earnings as member equity, however, these retained earnings must eventually be returned to the members. As a result, these retained earnings are more like a form of debt than a form of equity, and the redemption of retained earnings can decrease a co-operative's asset base and lead to slower growth. Also, members do not receive a return on this investment, regardless of the growth in the value of the co-operative (Harris, Stefanson, and Fulton, 1996).

One of the unique characteristics and principles of co-operatives is that members provide the equity capital that the co-operative uses to finance its assets. Marketing co-operatives obtain equity capital by deducting and retaining a small percentage of the net proceeds from the marketing of a member's commodity. This equity is refunded to the member over a period of time after the member leaves the co-op, and is in essence a non-interest bearing loan from the member. There is a strong desire for co-operative members to increase the liquidity of their co-operative stock, especially as they approach retirement. This creates an incentive for some members to attempt to restructure the co-operative in order to increase the stock liquidity – the root of the horizon problem. One method could be to sell the co-operative to private investors at the co-operative's market value if this value is in excess of book value. An alternative to selling the co-operative is to create a member property right based on the contractual right to deliver commodity to the co-operative and to allow members a limited right to sell and transfer this asset to other members or non-members under the condition that they obtain membership in the co-operative (Moore and Noel, 1995). This is the basis underlying the New Generation Co-operative.

2.5 New Generation Co-operatives

New Generation Co-operative (NGC) is the term that has been given to the dozens of value-added processing, selected membership co-operatives that have formed in the north-central United States in recent years. Examples of these NGCs are the North American Bison Co-operative, Southern Minnesota Beet Sugar Co-operative, and Dakota Dairy Specialties Co-operative. They have sprung up in many sectors of agricultural production, from emerging niche markets to more traditional markets. A common reason for the formation of NGCs is the desire to develop new value-added products and to gain access to an increased share of the consumers' food dollar. Another reason for the development of NGCs was an attempt to address the horizon problem and other problems associated with traditional co-operatives. An important aspect of NGCs that differentiates them from traditional style co-operatives is the linking of producer capital contributions and product delivery rights. A member's patronage and a member's equity are always equal (Harris, Stefanson, and Fulton). This discourages any attempts at free riding, as a member cannot receive patronage without investing in the co-operative. This also enables the co-operative to operate closer to its profit maximizing level.

The sale of membership equity shares is used to raise capital to finance the NGCs. These equity shares also act as a contract between the members and the co-operative, where the member is obligated to deliver the contracted quantity (either with their own produce or with produce purchased elsewhere) while the co-operative is obligated to purchase the product, as long as it meets certain quality requirements. Equity shares are usually tradable, often subject to approval from the board of directors. The quantity and price of the delivery right shares are determined according to the amount of product needed for efficient operation of the co-operative's processing facilities and the amount of capital required to purchase these facilities. The NGCs generally raise between 30 and 50 percent of their capital requirements through the sale of delivery right shares (Harris, Stefanson, and Fulton, 1996).

Membership is restricted to producers who wish to deliver a portion of their product to the processing facility. The prices of tradable shares reflect the return members expect to receive from the co-operative over time. In valuing the returns, members can look at the difference between the cost of producing the farm product and the revenue generated from processing this product and selling the processed product. The principle of 'one-member, one-vote' still applies when electing a board of directors and when deciding on major co-operative policy issues. The earnings of the co-operative belong to the members and are distributed to them on the basis of their patronage, just as in a traditional co-operative. The NGC membership entitles farmers to a guaranteed market for a portion of their production, a share of the earnings generated by the co-operative's processing operations, and any change in the value of the tradable shares. Because members have financed a large part of the capital up front with the equity shares, a significant portion of the co-operative's profits are returned to the members at the end of the year (Harris, Stefanson, and Fulton, 1996).

The NGCs appear to have overcome the horizon problem by altering the incentive structure associated with co-operative ownership. They require members to invest in the co-operative in order to benefit from its use. The up front investment requirement gets rid of incentives for members to reduce or eliminate their capital investment. However, this investment requirement also represents the greatest disadvantage of NGCs. It may be extremely difficult for farmers, especially young farmers, to come up with the capital necessary for the purchasing of equity shares. Farmers may often prefer to invest capital into their own operation rather than have it tied up in a co-operative. On the other hand, the farmers must also realize that the equity shares can eventually be sold to other farmers for a higher price. This transferability of shares provides the co-operative with a permanent source of equity and provides producers with the opportunity to earn returns on their investment. Share price will continue to increase if members and potential members have a positive perception of investment decisions made by the co-operative and of the future value of their shares (Harris, Stefanson, and Fulton, 1996).

Co-operatives can combat member opportunism through the contracting of delivery rights. Quantity and quality controls can allow for efficient levels of production to be achieved for processing operations and can enable the processing co-operative to develop brand reputations based on quality. The narrow, value-added focus of NGCs increases their ability to exploit the members' knowledge of farm product characteristics by facilitating the grading or segregation of product at the farm level. Compared to traditional co-ops, NGC membership is likely to be more homogeneous, as NGC value-added processing activities are generally limited to one commodity group, which minimizes the potential for conflict (Harris, Stefanson, and Fulton, 1996).

2.5.1 Tradable Delivery Rights

Secondary markets are created for the sale of the delivery rights among members of a New Generation Co-operative. There is no direct co-operative intervention in these secondary markets, although the co-operatives often provide information concerning the availability of these assets. The following set of conditions are necessary to form and sustain a secondary market in tradable delivery rights (TDRs): the TDRs are perceived to have value by the potential buyers, there are willing sellers, transaction costs are small relative to the perceived value of the TDR, co-operative membership and crop pools are closed, and there are co-operative by-laws that allow the transfer of the delivery rights. The buyer of a TDR gains two potential benefits: a patronage right to deliver a specified amount of product to the co-operative marketing pool and a right to share in the marketing pool net proceeds based on the proportion of the total marketing pool that the TDR represents (Moore and Noel, 1995). These two benefits give a potential patronage value to the TDR, and this value can potentially eliminate the horizon problem. This is due to the fact that a long-term investment in the co-operative can increase the value of the TDR, as the potential returns from owning the TDR will increase due to the investment. With expected increases in the value of TDRs, there is more incentive for the co-operative member to invest in the co-op, thus negating the investment horizon problem.

The TDR value can be affected by the co-operative marketing pool and the membership policy. Open pool and open membership allow the addition of new members and their production to the co-operative pool, and allow existing members to increase their product deliveries to the co-operative pool. Closed policies do not allow this increase in deliveries. With closed pool and membership policies, as found in NGCs, TDRs will have value. The TDR value in this case is the capitalized value of the premium return value and can be calculated:

$$TDR_0 = \sum_t \frac{EPR_t(1+g)^t}{(1+Ks)^t}$$

where TDR_0 is the current value of a transferable delivery right, EPR_t is the expected premium return value at the end of period t, Ks is the opportunity cost of capital and g is the expected growth rate of the TDR (Moore and Noel, 1995).

For perishable annual crops, TDR valuation comes from market access and favourable terms of trade. Market access provides farmers with a market for a specific crop, so there is no need to find a buyer, even for specialty crops. Market access can also cause a decrease in the variance of the farm income stream. For the terms of trade, there is no risk of contract cancellation, and many growers feel more confident being part of a co-operative. Co-operatives can gain the following benefits by developing a TDR program: they can generate equity from the initial offering of the TDRs, they can gain continued equity contributions from co-operative members who are holders of TDRs, and they can provide their members with a marketable asset that reflects the current patronage value of the co-operative, which can exceed its stock value. TDRs become valuable when the pool is fixed in size (closed), members are protected from exploitation of quasi-economic rents, and they have an assured buyer for their produce. The greater the buyers' aversion to risk, the higher the value of the delivery right. The right has additional value if the co-operative generates a premium per unit return due to product differentiation and market power (Moore and Noel, 1995).

2.6 Conclusions

The discussions in this chapter suggest that internal governance and incentive problems inherent in traditional co-operatives can lead to sub-optimal performance and decline in the profitability of a traditional co-operative. In addition, the different structure of NGCs may potentially alleviate the problems found in traditional co-operatives. While there may be many advantages of NGCs as compared to traditional co-operatives, this thesis focuses on two, which may be summarized by the following hypotheses. First, NGCs will have greater long-term investment than traditional co-operatives and second, NGCs will operate consistently closer to the optimal level than will traditional co-operatives. These hypotheses are tested in this thesis through the use of experimental economics methods, which are discussed in the next section.

CHAPTER THREE

EXPERIMENTAL ECONOMICS

In the previous chapter, two hypotheses were developed that will be tested in this study. These hypotheses state that the structure of NGCs will allow them to avoid the horizon problem and operate closer to a profit maximizing level. Section 3.1 of this chapter describes the rationale behind the use of experimental economics for testing these hypotheses. Section 3.2 delves into the history and development of experimental economics. Some advantages and disadvantages of experimental economics are discussed in sections 3.3 and 3.4. Section 3.5 reviews a variety of related experimental economics studies. The design of the particular experiment used to test the hypotheses is discussed in Chapter 4.

3.1 The Testability of Hypotheses through Economic Methods

The aim of this thesis is to test two hypotheses relating to the investment and profitability performance of New Generation Co-operatives as compared to traditional co-operatives. The first hypothesis relates to the investment horizon problem, and the second to the fluctuating service use problem. The question then arises as to how these hypotheses can be tested, as such hypotheses have not been previously tested. These two hypotheses were drawn from the literature discussed in Chapter 2. Much of the literature in the previous chapter, such as the discussion of the advantages and disadvantages of traditional co-operatives and NGCs, is based on economic theory in the area of collective goods, which include public goods, club goods, and common pool resources. The conclusions drawn about the performance of traditional co-operatives and NGCs are applications of these theories to the area of co-operatives. The conclusions are also supported by interpretation of observed trends in the agriculture industry. However, this literature does not provide an empirical test. Traditionally, economists attempt to test theories using econometric methods applied to observational data derived from statistical agencies such as Statistics Canada, Canadian Industry Statistics, American Statistical Association, and the US Census Bureau. However, since this data is not generally collected for the purpose of testing such hypotheses, it may be difficult to construct a valid test. Also, in testing hypotheses regarding an area of interest that is relatively new, such as with NGCs, even if some form of data existed, there would not be enough observations to estimate the econometric model or to generate statistically significant results. These restrictions create difficulties for testing the two hypotheses in this thesis using traditional economic methods. However, experimental economics provides a method for testing these hypotheses.

3.2 The Development of Experimental Economics

Although economics is often viewed as a non-experimental science, experimental methods have become more widespread in economics over the past 25 years. The main advantage of experiments is that they provide a way to evaluate theories under controlled laboratory conditions.

Economics experiments have been motivated and conducted for many different reasons. Some experiments have been designed to test the predictions of formal theories in a controlled environment, which allows for clear interpretation of the observations and their relationship to the theory in question. Experiments are also used to study issues that have not been explained by existing theory. These are often motivated by earlier experiments, and are designed to isolate the variable about which there is little knowledge. Other experiments are designed to test for possible effects of a change in policy. Experimental environments can be created to resemble actual market situations, which can be tested for reactions to a proposed policy change. This can provide policymakers with useful information regarding market strategies without requiring them to test them out in the actual market environment (Roth, 1995). The motivation behind the experimental design developed in this study is similar. This study attempts to test the performance of two different incentive structures inherent in the two types of co-operatives with respect to short-run service use and long-term investment. This experiment may provide information useful to policy makers and decision-makers within the agricultural co-operative business.

Interest in the idea of using laboratory methods in economics did not arise until the late 1940s and early 1950s. Simplified versions of natural markets were created within the confines of an experimental laboratory. These market experiments studied the predictions of neoclassical price theory. Interest also grew in testing behaviours exhibited in non-co-operative game theory. Public goods games and common pool resource games, which are the basis for the design of experiments in this thesis, are examples of the types of games that have been widely studied in the experimental economics literature (i.e. Andreoni, Isaac and Walker). A third form of experiments, individual decision-making experiments, used even simpler environments, where exogenous random events were the only uncertainty. These experiments were created to study the behaviours of individuals relating to expected utility. However, over time the distinctions between these three types of experimentation have become less apparent (Davis & Holt, 1993).

3.3 Advantages of Experiments

The two main advantages of experimental methods are replicability and control. Replicability refers to the ability of other researchers to reproduce the experiment, and validate the results on their own. This allows researchers to confirm the findings of other experiments rather easily. Non-experimental observations are much more difficult to validate due to their lack of replicability (Davis and Holt, 1993). This problem is further complicated in economics, due to the methods of data collection. Economic data is not usually collected by economists; rather, data used in economics is often collected by government employees or businessmen for other purposes. This can often make it difficult to find appropriate and accurate data that would be useful for testing economic models. Laboratory experiments allow for replication, which provides a way to collect more accurate data and data that is more directly useful for testing economic models.

Control, the second main advantage of experimental methods, is the ability to manipulate laboratory conditions so that observed behaviours can be used to evaluate different theories. Natural markets suffer from a lack of control, which makes the collection of relevant data much more difficult. In some situations, relevant data cannot be collected because no economic context can be found to match the assumptions of the theory. The predictions of game theory are also difficult to evaluate with data collected from actual situations. For example, in testing the sub-optimal service use hypothesis directly in a traditional co-operative, economic theory would predict that product deliveries to the co-operative or use of the co-operative's services would not approach an optimal level of deliveries or use. It can be extremely difficult to observe the actual levels of the use of services in such a setting, and almost impossible to determine the optimal level. The theory cannot be tested without the knowledge of such actual and optimal levels. Similarly, testing the investment hypothesis would be difficult because of the lack of ability to determine the optimal levels of investments for individual co-operatives. However, these problems can be alleviated in a laboratory setting because the experimental environment can be controlled. This means that underlying production structures, incentive structures, and optimal levels can be explicitly defined, and actual levels of contribution and investment can be easily observed and quantified (Davis and Holt, 1993)

3.4 Possible Disadvantages of Experiments

There are also criticisms of using laboratory methods in economics. One reservation is that the subject pools are generally made up of graduate and undergraduate students, people who are regarded as 'less sophisticated' than the decision makers in the economy. Students may think much differently than the economic agents involved in actual markets. However, studies such as Smith, Suchanek, and Williams (1988) have compared the behaviours of these two groups, and have not found significant differences between the two.

Another reservation with the use of experimental methods is that real markets are complicated, while laboratory environments tend to be fairly simple. This can be viewed in two ways. There are cases where a theory can work in a simple laboratory setting but not in a natural setting. In these situations, the theory may not have accounted for an important factor in the economy. But when a theory does not work even in a simple environment, there is a good chance that it will not work in a more complicated natural setting. In this case, it is helpful to first test out a theory in a simple environment. Difficulties in establishing and controlling the laboratory environment can also cause this experimentation to be less effective. But overall, the advantages far outweigh the disadvantages, and as a result, the use of experimental methods in economics has become much more widespread (Davis & Holt, 1993).

3.5 Experimental Results from Collective Goods Experiments

The experiments in this study involve decisions that are similar to both public goods and collective goods dilemmas. The co-operative's services can be viewed as a collective good, as members can make use of these as much as they want. However, beyond a certain point the value of these services to the members will decline due to overuse. Investment in the co-operative can be viewed as a public good. This investment is necessary to maintain the co-operative; however, members have no individual incentive to contribute to this investment. This section reviews some previous research that is related to these experiments.

There has been a vast amount of research performed using public goods and collective goods experiments. These experiments have been performed to make observations about typical human behaviours regarding voluntary contributions to public good provisions. Weimann (1994) discusses some of these behaviours based on observations of experimenters such as James Andreoni, Mark Isaac, and James Walker. In a typical public goods experiment, subjects form groups of size n and are given a fixed number of tokens w_i, which can be invested in a private or a public good. A token invested in the private good will have a return of r, and a token invested in the public good results in a payment of v to every subject, with $r>v$ and $nv>r$. The payoff to each individual is:

$$\pi_i = (w_i - g_i)\, r + v \sum g_i, \quad i = 1,\ldots,n,$$

where g_i is i's contribution to the public good. For a one-shot version of this game, $g_i = 0$ is the dominant strategy, which means that there will be no contribution to the public good as all subjects try to maximize their own payoffs. This is also the dominant strategy, and equilibrium, for a repeated game with a known number of repetitions. However, public goods experiments have shown that subjects do not choose this strategy. They generally start out by contributing an average of about 50% of their tokens to the public good. These contributions will usually decay as the game progresses. In a game with a known number of repetitions, there is a 'final round effect', where contributions reach their lowest point for the game in the final repetition. In the final round, more subjects will choose their dominant strategy, as they know that there are no more rounds for the other subjects to 'punish' them – by choosing their own dominant strategy and not contributing to the public good. But even in the last round of many experiments, the number of subjects that actually choose their dominant strategy is not as high as expected. In these experiments, a high percentage of people voluntarily contribute to public goods, despite strong incentives to free ride. This has puzzled experimenters, as these observations cannot be explained by the standard model of rational behaviour. The results suggest that people are co-operative and not only selfish. Similar results may be expected in the experiments of this study, with voluntary contributions that defy the standard model of rational behaviour.

Andreoni (1995) suggested that the fact that subjects choose to be co-operative rather than follow the dominant strategy may be due to the positive externalities associated with the public goods. Similar experiments on oligopolies and the commons almost always follow the Nash equilibrium predictions; however, there are negative externalities associated with these games. Andreoni tested the effects of these differences by using positive and negative framing on co-operation. He used the regular public goods game on two groups of subjects. A positive frame was given to the first group, where their choice of contributing to a public good was described as having a positive benefit for the other subjects. For the second group, a negative frame was used. In this case, the subjects' choice was framed as purchasing a private good which, since the opportunity cost was the purchase of a public good, made the other subjects worse off. This negative framed game, though its incentives were the same as the positive framed game, became more like the games involving oligopolies or the commons, as the externalities became negative. Andreoni found that the subjects with the positive frame condition were much more co-operative than were the subjects with the negative frame condition. From this observation, he concluded that the co-operation in public goods experiments could be a result of the 'warm glow' people get from creating a positive externality, and this 'warm glow' was stronger than the 'cold prickle' from creating a negative externality. This effect could potentially be evident in the experiments in this study, as the subjects may strive to attain the 'warm glow' from creating a positive externality through investing in the co-operative as opposed to keeping their money for themselves, thus creating a negative externality.

The issue of free riding is prevalent in the public goods experiments, and many questions have been raised as to the role it plays in these experiments. With the usual method of payoffs, as described earlier, it is Pareto efficient for all subjects to invest all their tokens in the public good, as this would maximize their return. However, since the individual return from the private good exceeds the individual return from the public good, the rational Nash equilibrium behaviour in the single-shot game is to invest nothing in the public good – to free ride. This equilibrium also holds for the finitely repeated game, as shown by Friedman (1986). For this reason, zero investment in the public good is the dominant strategy for each player. But as Andreoni (1988) noted, free riding was seldom observed. He believed this may have been due to a lack of understanding of the incentives of the game, and understanding would increase as the game was repeated. Once the subjects recognized their dominant strategy, they would adopt the free riding behaviour. With enough repetition, Andreoni hypothesized, all subjects would eventually choose the Nash equilibrium of zero contribution. However, his findings proved contrary to this. He used a public goods experiment where upon completing ten rounds of the game, the group of subjects was told that the game was to be extended for ten more rounds. The level of contribution had dropped to its lowest point after the tenth round, but in the eleventh round, contributions had increased back to the level from the first rounds. The decay from the last few rounds had not continued into the extended rounds.

Most free riding occurs at the end of the game, especially in the last round, when the subjects know that they are at the end of the game. At this point, there seems to be much less of an incentive for them to co-operate. This situation does not truly represent a real-life situation, especially not that of an agricultural co-operative, where the 'game' would have an infinite number of rounds. For this reason, the subjects in the experiments for this study will not know exactly when the game will end. They will not be informed as to the precise number of rounds in the game.

Andreoni (1988) performed an experiment to compare the contribution levels between strangers and partners. To assimilate strangers, he changed the groups after every round, while the groups stayed the same throughout the game for the partners. Andreoni found that the groups of partners contributed less than the groups of strangers, and there was a higher proportion of free riders in the groups of partners. However, the research of Weimann (1994) contradicted these findings. Weimann also found that the groups of partners exhibited a more uniform behaviour than the groups of strangers, as the strangers tended to vary their contributions more than the partners did. For the experiments in this study, the groups will remain the same, as this will provide a better representation of agricultural co-operatives. Co-ops do not have constant membership changes. Some members are added and some will drop out over time, but overall, co-operatives are more like the group of partners, where the members become better acquainted with each other as time goes on.

A major problem with public goods provision is that, for a single period, low levels of contribution are a dominant strategy equilibrium, while a higher level of provision is Pareto-superior. But this is not the only source of problems for the voluntary contributions mechanism. Under certain environments, a potential provider can have an incentive to contribute only if there is a guarantee that others will also contribute. Without such a guarantee, the provider may withhold contributions. This is known as the assurance problem. Isaac, Schmidtz, and Walker (1989) created an experiment to study the effects of a provision point on this assurance problem. Instituting a provision point caused a discontinuity in the return to the public good. If contributions did not meet a certain specified level, the provision point, the return from the contributions is zero. At or above the provision point, the returns become positive. In this environment, non-contribution is no longer a dominant strategy. Instead, there are multiple Nash equilibria, some of which can be Pareto ranked. With a provision point in place, contributions were often found to remain at a higher level through the first number of rounds, so long as the provision point was not too high. However, sometimes there was a sharp decline in contributions toward the end of the game, as subjects went from cheap riding to free riding, giving up all chances of attaining the provision point. But in many groups, contribution levels remained high throughout the game, as subjects realized it was not in their best interest to free ride. Co-operatives have occasionally used the idea of a provision point. For example, the Saskatchewan Wheat Pool requires that members do at least 75% of their grain and farm supply business with the Pool in the first three years of their membership, in order for them to be eligible for the New Member Stock Option Plan (http://www.swp.com). The experiments in this study uses a concept similar to the provision point, as the groups of subjects must invest a certain amount before any benefits from investing are received.

Social dilemmas appear in two basic forms – the public goods problem, where the individual must decide whether to contribute to a common resource, and the commons dilemma, where the individual must decide whether to take from a common resource. These two forms are equivalent in terms of outcomes, but because they involve different decision frames, they are not psychologically equivalent. In the case of providing for a public good, individuals must decide how much to contribute of something of value already in their possession. In relation to what one starts with, such a decision requires giving up something, enduring an immediate and certain loss in order to gain an uncertain future benefit. Assuming that individuals have disincentives to co-operate, under this frame of reference individuals will be risk seeking, they will prefer to risk long-term loss in order to keep as much as possible of what they have in the short run. In the case of the commons dilemma, individuals begin with nothing and must decide how much to take for themselves, so anything taken results in a definite gain. This frame of reference should make individuals comparatively more risk averse, in the sense that they will settle for a smaller immediate gain rather than take a larger gain that carries the risk of long-term loss. Overall, subjects kept more for themselves under the public goods frame than under the commons dilemma frame (Brewer and Kramer, 1986). The experiments in this study include elements that are similar to both public goods problems and commons dilemmas.

Under the commons dilemma frame, group size had no effect on behaviour, but in the public goods frame, individuals in large groups kept more than did individuals in small groups. Importance of a collective or common social identity may result in greater weight being given to collective gains over individual gains alone. Whether individuals co-operate in a social dilemma may depend on whether they think of themselves as single and autonomous individuals or whether they regard themselves as sharing membership in and identification with a larger aggregate or social unit. Kramer and Brewer (1984) found evidence to support this theory. Individuals were more likely to co-operate when a collective-level identity was made important than when differentiating subgroup identities were made important. The subjects in the experiments for this study were placed into groups and presented with a situation where each member of the group could potentially benefit through co-operation. According to the findings of Kramer and Brewer, the subjects would be more likely to co-operate in this situation where they find some of their identity in the group.

Under the commons dilemma frame, the negative effects of increasing group size were overriding the group identity effects. Co-operation increased under collective identity conditions in comparison with individual identity conditions, and this effect was strongest when group size was large. The opposite was the case for the public goods frame, especially with large groups, as group identification did not seem to help in overcoming the negative effects of group size (Brewer and Kramer, 1986).

3.6 Conclusions

This chapter has provided some background information on experimental economics and outlined the rationale behind the use of experimental economics for this study. Some previous research was discussed in an attempt to provide examples of how experimental economics has been put to use in the past, and how it relates to the problem at hand in this study. The next chapter will discuss the design of the experiments that were carried out in this study.

CHAPTER FOUR

EXPERIMENTAL DESIGN

This chapter describes the experimental design for this study. The experiment is designed for the purpose of testing the two hypotheses generated in Chapter 2, the first being that the tradable shares in New Generation Co-operatives help to avoid the investment horizon problem, and the second being that service use is closer to profit maximizing levels in NGCs. The experiments involved the participation of human subjects in two different treatments, a traditional co-operative (TC) treatment and a New Generation Co-operative (NGC) treatment. These treatments simulated the structures and incentives found in traditional co-operatives and NGCs. The payoff structure was the same for both treatments; however, the incentives differed between the two treatments, and modeled the incentives that exist in the two types of co-operatives. Actual cash payoffs were given to the subjects to ensure that the subjects had real financial incentives. What follows is a detailed description of the experimental design.

4.1 General Experimental Design

This section describes the underlying structure of the experimental design that was common to both treatments. All forms used in both treatments are shown in Appendix F. A flow chart for the procedures of each round is given in Appendix O for the TC treatment and in Appendix P for the NGC treatment.

4.1.1 Simulation of Grain Processing Co-operative

Each treatment simulated a grain processing co-operative over twelve time periods. Five subjects participated in each round, and each subject, or player, participated in the experiment for up to five rounds. The experiment was set up as a game that subjects were to play. The subjects were not told how many rounds were in the game, in an effort

Table 4.1: The overlapping generations structure.

	Round 1	Round 2	Round 3	Round 4	Round 5
Player 1	X				
Player 2	X	X			
Player 3	X	X	X		
Player 4	X	X	X	X	
Player 5	X	X	X	X	X
Player 6		X	X	X	X
Player 7			X	X	X

to avoid final round effects that often occur in public goods experiments. However, each subject was informed as to how many periods they would participate in when they joined the experiment.

The experiment had an overlapping generations structure, which allowed for the modeling of the horizon problem. This structure was set up so that one player 'retired' after each round, and a new player joined for the next round (see Appendix G). An excerpt from this appendix is provided in Table 4.1. The players retired in the order that they joined the game, so most players were in the game for five rounds. With twelve rounds, sixteen players were needed for the game.

4.1.2 Endowments of Tokens

In each round, each player was allocated 20 tokens. A token was the equivalent of a thousand bushels of grain. This amount did not vary from round to round, as this experiment assumed uniform yields.

4.1.3 Marketing Decisions

The subjects made decisions in each round regarding the marketing of their allocated grain, for which they had two options. The first option was a private market, called Business X. In this market, the players received a certain price per bushel for their grain. That was all that they received from this market, as they did not get a share of the business's profits. The second option was the co-operative, called Business Y. The players received a set price per bushel for their grain, a price that was always lower than the market's price. This price did not change. The market's price varied according to how much grain was delivered to the co-op. As more grain was delivered to the co-op, the private market was willing to pay more per bushel, so that it could achieve its capacity requirements. The main difference between the private market and the co-operative was that the players would get a share of the co-op's profits, based on how much each individual sold to the co-op, as compared to how much the rest of the group sold to the co-op. The more tokens they sold to the co-op, the higher their share of the co-op's profits. Each individual always received a payment from the sale of their tokens; however, co-operative profits were only distributed if there were enough tokens sold to Business Y to generate profits. The players indicated where they wanted to sell their tokens by filling out a Marketing Decision card (see Figure 4.1). The marketing decisions resulted in short-term payoffs, as described in section 4.2.

4.1.4 Investment Potential Forms

After the marketing decisions had made, the subjects were given an Investment Potential (IP) form (see Figure 4.2 for examples), which informed them what the profits from the co-operative were for the round, as well as the amount of their share of those profits. There was a table on the IP form that showed the potential returns for each player over the remainder of the rounds that they had left in the game, depending on what the group decided to do with the profits of Business Y. The first part of the table indicated what the player's returns would be over the rest of his or her lifetime in the game if the profits were refunded each time. The figures for each round represented 7% of the player's share of the profits from Business Y. The second part of the table showed what the player's returns would be if the profits were re-invested each round. This table was

Figure 4.1: Marketing Decision Card

Marketing Decision Card

Group # ________ Player # ______

Round # ________

Token Sales (must sum to 20):

Business X ________________ Business Y ________________

Figure 4.2: Investment Potential Card (examples)

NGC Treatment

Player 5 **Round** 1

Business Y Profits:				10,000	
Your Share of Profits:				3,000	
Periods Left Before You Retire: (including this period)				5	
Current Amount Re-Invested:				0	
Amount Required for Expansion:				26,000	
Return Potential					
Profits Refunded every round:					
3	4	5	6	7	**Total**
210	210	210	210	210	1,050
Profits Re-invested every round:					
3	4	5	6	7	**Total**
500	500	500	500	1,500	3,500
- if there is Expansion by Round				6	

TC Treatment

Player 5 **Round** 1

Business Y Profits:				10,000	
Your Share of Profits:				3,000	
Periods Left Before You Retire: (including this period)				5	
Current Amount Re-Invested:				0	
Amount Required for Expansion:				26,000	
Return Potential					
Profits Refunded every round:					
3	4	5	6	7	**Total**
210	210	210	210	210	1,050
Profits Re-invested every round:					
3	4	5	6	7	**Total**
0	0	0	0	1,500	1,500

Figure 4.3: Payout Card (example)

Round 1	
Player # 3	Tokens
Business X	6
Business Y	14
Bus.Y Total	50
Payout	2,642
Profit Share	1,982
T-bill Returns	-
Your Re-inv	1,982
Total Re-inv	7,078

intended to show each player which investment option would be best for them, determining their investment incentives.

4.1.5 Profit Share Decisions: Refund vs. Re-Invest

Those that sold some tokens to Business Y (delivered some grain to the co-operative) had the opportunity to decide on what to do with those profits. They were presented with two options. Their first option was to have the profits refunded to them, while the second option was to re-invest the profits in Business Y for a future expansion. If the profits were refunded, their share of the profits was invested individually in a T-bill, earning a 7% rate of return. This was a one-time return, they only collected 7% of those profits once. In Figure 4.2, the return from refunding is $210, which is 7% of $3000, the individual's share of the profits. When the decision had been made to keep the profits for themselves, that money could only be used for the short-term investment, it could not be put in the short-term investment for a year and then used to re-invest in Business Y. The profits were either put into the short-term investment, or they were re-invested. Re-investing in Business Y could increase the profit potential of the co-op through an expansion of co-operative production capacity, which would result in the co-op operating at a higher production level (see section 4.3 for a description of production levels). Increasing the profit potential of the co-op increased each player's profit share, thus increasing their total earnings. In Figure 4.2, the return from re-investing is based on the individual's potential increase in profit share, a result of the co-op's expansion. This expansion did not happen immediately, it took at least four rounds to build up enough re-investment to fund the expansion. Once an expansion did occur, Business Y moved up to the next production level, which generated greater profits for the co-operative and for the players. The players would then use the next level payoff table in the following round for making their marketing decisions (for explanation of payoff tables, see section 4.2).

Once the players received their IP forms and reviewed potential returns on investment, they had to decide what to do with the co-operative's profits. For the TC treatment, this entailed a group vote, while players in the NGC treatment decided individually what to do with their share of the profits. This will be discussed in more detail later in this chapter.

4.1.6 Individual Payout Forms

After the investment decisions had been made, the players each received an individualized Payout form (see Figure 4.3). These forms indicated to each player where they had sold their tokens, the total amount sold to Business Y, how much they had earned in that round, their T-bill returns if the profits were refunded, and how much they had re-invested in the co-operative. If there was enough re-invested equity for an expansion, then the co-operative would expand after the current round, and the new profit function would come into effect for the next round. The re-investment levels needed to move up to the next production levels were:

Level 1 to Level 2: \$26,000
Level 2 to Level 3: \$68,000 – \$26,000, or \$42,000
Level 3 to Level 4: \$130,000 – \$68,000, or \$62,000

After each round, one player retired, and a new player filled the vacant place. Any equity that the retiring player in the TC treatment had invested in the co-op was returned to him or her; however, he or she would not gain any rate of return on this equity. Retiring players in the NGC treatment could still earn a return on their invested equity if the co-operative expanded soon after their retirement. This is explained in more detail in section 4.6.

4.2 Modeling the Short-term Payoff Structure of a Co-operative

In this experiment, short-term payoffs are determined by marketing decisions (see section 4.1.3). The short-term payoff structure was developed and used for both the TC and

NGC treatments so that differences in payouts between the two treatments could be attributed to incentive effects and not to the underlying payoff structures. This section describes the short-term payoff structure in more detail.

Subjects participating in these experiments received part of their payoffs in each round from the profits of the co-operative. The short-term profit function for the co-operatives in each treatment is given by the following equation:

$$\pi_t = P^o * G - P^i * G - C(G),$$

where P^o is the output price of the processed grain, the price which the co-op receives for the grain which it processes, P^i is the input price of the grain, the price which the co-op pays the farmers for delivering the grain, *C(G)* is the cost function, and *G* is the amount of grain delivered to the co-op (in 000s of bushels)

The output price in lab dollars ($\$^l$) for the co-op is set at $\$^l3.50$ per bushel. The input price for the co-op, or the price that farmers receive for selling grain to the co-op, is set at $\$^l2.95$ per bushel. The price for the private market starts at $\$^l3.00$ per bushel and increases by 0.3 cents for each token that is delivered to the co-operative, up to the point of optimal token sales. For example, this price will level out at $\$^l3.18$ if the optimal amount of token sales to the co-op is 60 tokens per round. Each player has a cost of $\$^l2.50$ per bushel for producing the grain.

The cost function for the co-operative is given by the following equation:

$$C(G) = [b(G - m)^2 + a] * G + F,$$

where *b* is the slope of the function, *G* is the amount of grain delivered to the co-op (in 000s of bushels), *m* is the point where the cost function is minimized, *a* is the cost at the minimum point, and *F* is the fixed cost, set at $\$^l2000$.

4.2.1 Individual Payoffs

The payoff tables (see Appendix E) summarize how individual payoffs change depending on their own marketing decisions and the individual marketing decisions made by other players. The figures in the payoff tables include earnings from token sales to the private market and to the co-operative, as well as the share of profits from the co-operative. A fixed cost of production for the grain is taken off these figures. The formula for the figures in the payoff tables is given by the following equation:

$$E = P^c * T^c + P^p(\Sigma T^c) * T^p - C(T) + \pi_t(G, T^c),$$

where E is the individual earnings, P^c is the price of grain for the co-operative, T^c is the number of tokens that the individual sold to the co-operative, P^p is the price of grain for the private market, in part determined by the number of tokens that the group sold to the co-op, T^p is the number of tokens that the individual sold to the private market, $C(T)$ is the cost of production for the grain, and $\pi_t(G, T^c)$ is the individual's share of the co-operative's profits.

At the first production level, the optimal would be close to 50 tokens sold collectively to the co-operative (Business Y) by the players in the group. This optimal would change based on the production level at which the co-operative was operating. The optimal increased by 10 tokens for each level up to the fourth level, where the optimal was close to 80 tokens.

The payoff tables allowed the players to attempt to determine how to optimize their payoffs, based on the potential decisions of the rest of the group. To determine their payoff, each player looked down the first column to find the number of tokens that they decided to sell to Business Y, then went across the table to find where this matched the number of tokens that the rest of the group sold to Business Y. The number at this intersection was the payoff for that player. For example, at the first payoff level, if one player sold 7 tokens to Business Y and the rest of the group sold 44 tokens to Business Y, then that player's payoff would be $2400. If one player sold 14 tokens to Business Y and the rest of the group sold 36 tokens, then that player's payoff would be $2642. The payoff tables only include columns for the tokens sold by the rest of the group that are multiples of four. This arrangement was used to condense the otherwise oversized payoff tables. The players could determine the numbers between the columns on their own in order to get a good idea of what those payoffs would be. The payoff tables that were given to each player were shaded. The lighter shading represented an increase in payoffs as the player sold more tokens to Business Y, while the darker shading represented a decrease in payoffs.

4.3 Long-term Investment and Impacts on Short-term Payoffs

After each round, the players were given the option to sacrifice short-term payoffs for potentially greater long-term payoffs by deciding what to do with the co-operative's profits. They were presented with two options. The first option was to have the profits returned to them immediately. The second option was to re-invest the profits back into the co-operative in an attempt to generate greater profits in the future. Once the amount of total re-investment reached a certain level, the co-operative would be able to expand, thus creating the opportunity to operate at higher profit levels. With increased profits, the players could potentially earn a higher level of patronage. However, players who retired before the co-operative expanded would not earn a return on their re-investment.

When the co-operative expanded, higher profits were generated through changes in the cost function, which decreased the unit costs. As stated earlier, the cost function was given by the equation:

$$C(G) = [b(G - m)^2 + a]* G + F$$

Table 4.2: Cost minimizing and profit maximizing information for each level.

	Level 1	Level 2	Level 3	Level 4
b	0.05	0.06	0.07	0.09
m	13	29	44	59
a	300	270	240	210
G	50	60	70	80
^{1}	7077.50	11,340.40	16,387.60	23,024.80

The values for *b*, *m*, and *a* depended on the production level at which the co-operative was operating. As the co-operative moved from the first production level through to the fourth one, the slope (b) and the point where the cost function was minimized (m) increased, and the cost at the minimum point (a) decreased. The combination of these factors caused the cost function to decrease as the co-operative moved from the first through to the last production level. This was meant to model economies of scale. As the co-operative expanded it could spread out its costs more efficiently through its increase in grain handling capacity. The cost of processing per bushel of grain decreased as the volume of grain being processed increased. The values for *b*, *m*, and *a* across the four levels are given in Table 4.2. In this table, the profit maximizing number of token sales to Business Y (G) at each level is given, as well as the maximum profits for Business Y at each level (^{1}).

4.4 Traditional Co-operative Treatment

In each treatment, there were certain aspects of the experimental design that were specific only to that treatment. This was due to the differences that exist between the structures of the two types of co-operatives. The experimental design attempted to closely model the structure of each co-operative, thus creating the differences with regards to design and incentives between the two treatments. This section and the following one discuss the differing aspects of the two treatments.

Figure 4.4: Voting Decision Card

Voting Decision Card

Group # ________ Player # ______

Round # ________

Vote on one of the following two choices:

Refund / T-bill Re-Investment

________________ ________________

Figure 4.5: Profit Share Decision Card

Profit Share Decision Card

Group # ________ Player # ______

Round # ________

Check one of the following two choices:

Refund / T-bill Re-Investment

________________ ________________

Figure 4.6: Additional Share Offering Card

Additional Share Offering

Player # ________

# of Shares you want to buy

____

In the traditional co-operative (TC) treatment, the decision regarding the distribution of the co-operative's profits was arrived at through a vote. This vote consisted of the players filling out a Voting Decision card (see Figure 4.4), indicating what they wanted to do with the profits. Each member of the group was entitled to vote if they had sold tokens to Business Y. If a player sold all their tokens to Business X, they could not take part in the voting process. The Investment Potential forms indicated to each player what their returns could be for both investment options. They were required to vote either for a refund of the profits or for a re-investment in Business Y. A majority vote was necessary for re-investment, otherwise the profits were all refunded. This meant that if there was an even number of voters (eg: 4), a tied vote would result in the profits being returned to the members. The result of the vote determined the investment decision for every player in the group, regardless of how each individual voted.

If there was no chance of the co-operative expanding within the player's lifetime, then the potential returns were zero. If the co-op could expand before the player retired, their potential returns from re-investing would most likely be greater than their returns from refunding the profits. Whether or not the co-operative would be able to expand before the player retired depended partly on the current re-investment equity, which was given on the IP form. If this figure was coming close to the amount required for an expansion, then there was a greater probability that Business Y would expand before the player retired. The other factor that played a role was the number of rounds the player had left before retirement.

It took at least four rounds of re-investment before an expansion could take place. This meant that those who had four or less rounds left before they retired would not benefit from the expansion, and they would not get a return on their re-investment. This is how traditional co-operatives are set up, with no direct return on members' investment. If the members remain in the co-operative long enough, and the co-operative has been successful in their business operations, then the members could eventually benefit from their continued investment in the co-operative.

4.5 New Generation Co-operative Treatment

The procedures for the NGC treatment were similar for the most part to those of the TC treatment. However, there were some important differences in the design. The first five players in the game started out with ten shares each. These shares represented the most important difference between traditional co-ops and NGCs. There were no shares offered in traditional co-operatives. New Generation Co-operatives offered tradable shares as delivery rights. These shares gave the owner the right to deliver a certain amount of product to the co-operative. In this case, players could sell one token to the co-op (Business Y) for each share that they owned. The money needed by all the players in the game to buy their shares was lent to them, and they were able to pay this money back at the end of the game with their earnings from the co-operative and from the sale of shares. This was an interest free loan, for the purpose of keeping things simple.

4.5.1 Token Sales Requirements

In the NGC treatment, the players were required to sell as many tokens as shares that they had from the co-operative. They were not allowed to sell more, as the co-operative had set its capacity to maximize efficiency. They could sell less, however, there was a penalty of $[1]500 per token assessed against them, as the co-operative had to find grain elsewhere to replace the undelivered amount. This penalty would decrease the player's earnings.

4.5.2 NGC Investment Potential Form

The Investment Potential form in this treatment differed slightly from that of the previous treatment. The main difference occurred in the second part of the table on the IP form (see Figure 4.2), with the potential returns from re-investment. The figures in this part of the table were based on the return that each player would receive when the co-op expanded. In this treatment, the players could still earn a return on their re-investment if they were retired when the co-op expanded. The return for each round was based on what they would earn if the co-op expanded within six rounds. This is explained in more detail in Section 4.6 on investment incentives.

The players did not vote on what to do with the profits, as NGCs do not have a 'one member, one vote' policy regarding distribution of profits. Each member in these co-operatives can do whatever they want with their share of the profits. For this reason, this decision was made individually by each player. The players indicated their decisions by filling out a Profit Share Decision card (see Figure 4.5). Each player had the opportunity to keep their share of the profits or re-invest them, regardless of what other players decided to do. Their share of the profits was based on the number of shares that they had in Business Y as compared to the number of shares that the rest of the group had in Business Y.

4.5.3 Share Offering for Co-operative Expansion

After there had been enough re-investment to fund an expansion, there was a share offering from the co-op, where ten more shares were put on the market at a certain price. This was a fixed price, but the price was different for each of the expansions. The players each had the opportunity to buy two shares at first, which they could do by filling out an Additional Share Offering card (see Figure 4.6). If not all ten shares were sold right away, then the players would have a chance to buy one more share, starting with the 'oldest' member, the one closest to retiring. If all ten shares were still not sold, then these ten extra shares would not be distributed, and the co-op would not expand. In this case, the shares would be offered again after the next round. This pattern continued until all the shares were sold.

It would always work to the players' benefit to buy the additional shares when they were offered. For the players that were still in the game, they would benefit from the increased profit level. Even if the players were retiring, they would be able to benefit from selling these shares, as they would be worth more to the new player. The revenue from the sale of these shares was distributed to all the players that had re-invested in the co-op, including the players who had already retired. The amount that each of these players received was based on their percentage of the total amount re-invested. Once the players had bought all ten additional shares, then the co-op expanded and the potential profits increased, as the co-op moved up to the next production level. After this happened, it would take at least four more rounds before the next set of ten shares could be offered.

4.5.4 Share Auction

At the end of each round, one player retired, and had to auction off his or her shares. This was done through a double auction. The new player joined the game for the double auction. All six players were given a Share Auction Status card (see Figure 4.7). For the retiring player, this card told them how many shares they had to sell, the minimum price they were willing to accept per share, and the maximum price the market would allow. The minimum willingness to accept per share for retiring players was equal to the most that they could have made if they had kept all the profits for themselves and invested this money at 7%. They did not want to accept less than it cost them to buy the share. Therefore, by re-investing their profits, there was almost no chance of them being worse off. There was greater potential for them to be much better off. For the other players, this card told them how many shares they had, how many shares they would be allowed to buy based on the maximum allowable number of shares at that point, their maximum willingness to pay per share, and the minimum price the market would allow. This maximum price per share was based on the player's potential profits from owning that share.

To start the double auction, the seller filled out an Offer to Sell card (see Figure 4.8), stating the number of shares that he or she wished to sell and the price at which to sell them. This offer was posted on the Offer Board. The potential buyers could then fill out their Offer to Buy cards (see Figure 4.9), stating the number of shares they wished to buy

Figure 4.7: Share Auction Status Card (examples)

Player 1	
Shares	10
Shares for sale	10
Minimum willingness to accept	2000
Market maximum	2265

Player 5	
Shares	10
Max. # of shares	14
Shares you can buy	4
Maximum willingness to pay	2177
Market minimum	2000

Figure 4.8: Offer to Sell Card

Offer to Sell

Player # ________

# of Shares ________ Price / Share ________

Figure 4.9: Offer to Buy Card

Offer to Buy

Player # ________

# of Shares ________ Price / Share ________

and the price at which to buy them. These offers were also written on the Offer Board for all to see. If there were no matching offers, then these procedures were repeated. Once there was at least one matching offer and all the shares were off the market, then the auction was over. The seller did not have to sell all their shares to one buyer, they could sell some of their shares at one price to one player and sell other shares at a different price to another player. There was some pressure for the buyers to get their counteroffers in as soon as possible before another buyer took the shares. If two matching offers to buy came in at the same time, then the shares were split between the two players who made the offers. There was a maximum number of shares that a player could have at one time. This number depended on the production level at which the co-operative was operating. The maximum number started at 14 shares for the first level, and increased by two for each level, up to a maximum of 20 shares at the fourth level.

4.6 Investment Incentives

When faced with the re-investment decision, there were differing incentives involved in the two treatments. It should have taken at least four rounds before the expansion could happen. In the traditional co-op, the benefits from re-investing did not kick in until after the expansion had taken place. For this reason, four of the five players would not have an incentive to re-invest, as they would have retired before the co-operative could reach the new production level. They would not see any of these benefits. By keeping the profits for themselves, they would be able to earn a small return on this money, instead of not seeing any returns. However, if a player had just one round with the higher profit levels, he or she could make much more of a return in that one year than from continuously investing in a short-term investment (see Appendix H for potential earnings from investments). Therefore, there would be one player who had an incentive to vote for re-investment. This gives rise to the horizon problem, as many members are at different points in their lifetime and have different incentives. They have various reasons for using the co-operative, and they are not all committed to improving the co-op's facilities.

Even with the incentives against re-investment in the TC treatment, the subjects in the experiment may still re-invest. This would be due to feelings of obligation towards helping the group, doing the 'right thing', instead of focusing on their personal monetary rewards. If re-investment took place in the TC treatment, the incentives would change for some players. For example, if during the first round a re-investment was made, then in the second round there would no longer be an incentive for four out of five players to vote against re-investment. Each time a re-investment occurs, one more player will have an incentive to re-invest, as this re-investment brings the opportunity for expansion and its related benefits one round closer. For example, if expansion could occur after two more rounds of re-investment, then three out of the five players would have an incentive to re-invest, as the benefits from an expansion would come about in their lifetime. If three of five players have an incentive to re-invest, and vote accordingly, then a re-investment would have a majority vote, thus changing the group incentives. Once the expansion does occur, the incentives revert to their original state, with four of the five players having incentives against re-investment. Consequently, in this experiment the 'no re-investment' equilibrium in the TC treatment was inherently unstable.

In the NGC, even if the players were not around for the increased profit levels, they could still benefit from re-investing. As long as the co-operative expanded within six rounds, the players would get a return on their re-investment. When there was enough re-investment to fund an expansion, the co-op offered ten additional shares. The profits from the sale of these shares were distributed to all the players that re-invested in the co-op, based on their percentage of the total re-investment. This would generally give the players at least a 15% return on their re-investment. If the co-operative did not expand after six rounds, then the re-investment from the first of those six rounds was returned at face value to the players who re-invested that round. In this case, there would be no return on re-investment. When this re-investment from the first round was returned, the total re-investment for the seventh round would have decreased by that amount. This was the risk that was involved with the re-investment. For example, if $2000 was re-invested after the first round, and only $8000 had been re-invested by the sixth round, then there would not have been enough for an expansion. In this case, the $2000 of re-investment from the first round would be returned at face value to the players who re-invested this amount. This would put the total re-investment back to $6000 at the start of the seventh round. There could be another potential benefit to re-investment, as the shares would be worth more if more profits have been re-invested. The closer the co-operative was to expanding, the more the shares were worth to incoming players, as they would have more rounds at the higher profit levels. For this reason, the retiring players could sell their shares at a higher price. This system potentially avoided the horizon problem by enabling all members to benefit from improvements to the co-op, even if they had already retired. The members were still all at different points in their lifetimes, but this system allowed them to become united in their commitment to the improvement of the co-op's facilities. The underlying payoff structures of the treatments were the same, but there were different incentives involved in the two types of co-operatives.

4.7 Lab Dollar to Real Dollar Conversions

All payoff figures were given in lab dollars ($\$^{1}$). A conversion rate from lab dollars to Canadian dollars was put in place for each treatment. These conversion rates were set up in such a way to ensure that the subjects would receive adequate compensation for their time. The conversion rate for the traditional co-operative treatment was 600 to 1, while the conversion rate for the New Generation Co-operative treatment was 800 to 1. This discrepancy between the two treatments was due to the fact that players in the NGC treatment could earn up to twice as much more than those in the TC treatment due to their earnings from the sale of shares. A conversion rate of 800 to 1 for the TC treatment would have resulted in payoffs that would be somewhat low with respect to the amount of time required of the subjects. Conversely, a conversion rate of 600 to 1 for the NGC treatment would have resulted in payoffs that would be fairly high with respect to the amount of time invested by the subjects.

4.8 Experimental Controls on Communication and Information

Communication between players was not a factor in this experiment, as none was allowed in either treatment. Communication was not used in this experiment, as it would not have been a true representation of how the co-operatives work. Especially in traditional co-operatives, members do not discuss amongst each other how much grain they will be delivering, and how much each member should deliver in order to maximize the co-op's profits. Instead, each member delivers the amount that works best for them, based on their own personal situation.

Some information was withheld from the players in order to make the decisions made by subjects in the experiment as simple as possible. Test runs of the experiment revealed that it was fairly demanding and complex for subjects. With too much information, the players could feel overwhelmed, so anything that they did not need to know was not made known to them. An example of this is the prices that they received for selling their tokens to either business. These prices would have been extraneous information, as they were incorporated into the payoff tables, and the players could make their marketing decisions based on these tables, without being given the exact prices. The players were also not told about their costs of production for the tokens (the grain). These costs did not matter to them, as they were also incorporated into the payoff tables.

Information was also withheld from the players so that it would not affect their decisions. The players were not told that one of the businesses was a co-operative, as this knowledge could have affected their behaviour. If the players had known that the experiment was a study of co-operatives, they may have felt compelled to 'co-operate', and do what they thought would be best for the whole group instead of making their decisions based on their own incentives. This would have created a less accurate portrayal of the real world. The players were also not told that the tokens represented grain, in an effort to make this experiment as generic as possible for them.

4.9 Formal Hypotheses

This section describes more formally how the two general hypotheses, as developed in the previous chapters, will be tested. For the hypothesis of closer to optimal service use in New Generation Co-operatives, the pattern of token sales in each treatment will be compared. To test if NGCs resolved the investment horizon problem, the amount of re-investments in each treatment will be compared.

In comparing the token sales to Business Y, or the contributions to the collective good, it is not the actual amount of token sales that is compared; rather, it is the difference from the optimal amount that is used as the dependent variable for the regressions. There are two ways to define the optimal. The first way in which the optimal is defined for this study is referred to as the conditional optimal for the co-operative. The conditional optimal is the number of tokens that must be sold to Business Y to generate the largest single period profit for the co-operative, based on the production level at which the co-operative is operating. For example, when the co-operative is operating at Production Level 2, the optimal number of tokens for the group to sell to Business Y to generate the greatest profits is 60 tokens. This number will be different at each production level. For this reason, this is a conditional optimal, meaning that the optimal amount of token sales is conditional on the production level at which that specific group is operating.

The second way in which the optimal is defined is referred to as the optimal path. This is based on what the token sales to Business Y should be in order to maximize profits throughout the entire game. The optimal path assumes that the co-operative expands every four rounds, as this would maximize profits over the entire experiment. The optimal path would be tokens sales of 50 to Business Y in rounds 1 through 4, sales of 60 in rounds 5 through 8, and sales of 70 in rounds 9 through 12. The optimal path is the same for all groups, and does not depend on the production level that a group may be on at a specific point in time. For this reason, the optimal path may be different from the conditional optimal. The data will be analyzed with both definitions of the optimal, as the conditional optimal analysis will show how close each group comes to selling the optimal number of tokens for maximizing their personal profits at that point in time, and the optimal path analysis will show how close the group comes to maximizing their profits over the course of the experiment.

There are two ways of comparing the differences in token sales from the optimal. The first is to calculate the difference between optimal sales and actual sales (optimal minus actual), and compare the means of these differences. The second way is to take the absolute differences and compare them. Comparing the absolute values will determine if the token sales were more variable in one of the treatments, which would indicate greater fluctuations from the optimal level of token sales.

In comparing re-investment levels between the two treatments, the difference from the optimal amount is used as the dependent variable, just as with the comparison of token sales. The two types of optimals are also used in comparing the amount of re-investments. The conditional optimal refers to the amount that should be re-invested in a specific round based on the production level at which the group is operating. The optimal path is based on the amount that should be re-invested in order for expansions to take place every four rounds, thus maximizing profits over the course of the game. If re-investment levels are much higher in the NGC treatment than in the TC treatment, this would indicate that New Generation Co-operatives can avoid the investment horizon problem through the incentives associated with their property rights structure.

4.9.1 Tests for Differences from Optimal

To test whether token sales and re-investments in each treatment are different from the optimal through all twelve rounds of the experiment, the following regression equation is used:

$$Y_{ij} = \beta_0 * D1_{ij} + \beta_1 * D2_{ij} + \varepsilon_{ij}, \qquad (4.1)$$

where Y_{ij} is the difference from the optimal for the i^{th} observation in treatment j (j=1 for NGC, j=0 for TC), $D1$ is a dummy variable for the NGC treatment ($D1_{ij}$=1 when j=1, otherwise $D1_{ij}$=0), and $D2$ is a dummy variable for the TC treatment ($D2_{ij}$=1 when j=0 otherwise $D2_{ij}$=0). This equation was used for analysis of both the token sales and re-investment. The formal hypothesis that arises from this equation is the following:

$$H_0: \ \beta_0 = 0, \ \beta_1 = 0$$
$$H_1: \ \beta_0 \neq 0, \ \beta_1 \neq 0, \qquad (4.1a)$$

with the null hypothesis stating that there is no difference between each treatment and the optimal, and the alternative hypothesis stating that there is a significant difference.

The difference in token sales and re-investment levels from the optimal can also be tested at the different stages of the experiment. The experimental design specifies that re-investment leads to expansions in the co-operative, which result in an increase in the optimal for both token sales and re-investment. These increases in the optimal are not smooth transitions; rather, they are a series of steps. For this reason, the rounds in the experiment are split up into three stages in order to test for significant differences at each stage. The number of rounds at each stage can be different for each replication, as some groups take longer than others to build up enough re-investment for expansions. This testing at each stage was executed using the following regression equation:

$$Y_{ij} = \beta_0{*}D11_{ij} + \beta_1{*}D12_{ij} + \beta_2{*}D13_{ij} + \beta_3{*}21_{ij} + \beta_4{*}D22_{ij} + \beta_5{*}D23_{ij}+\varepsilon_{ij}, \qquad (4.2)$$

where Y is the difference from the optimal for the i^{th} observation in treatment j, $D1x_{ij}$ is the dummy variable for the NGC treatment at level x ($D11_{ij}$=1 when j=1 and the group is operating at the first production level, otherwise $D11_{ij}$=0; $D12_{ij}$=1 when j=1 and the group is on level 2, otherwise $D12_{ij}$=0; $D13_{ij}$=1 when j=1 and the group is on level 3, otherwise $D13_{ij}$=0), and $D2x_{ij}$ is the dummy variable for the TC treatment at level x

($D21_{ij}$=1 when j=0 and the group is operating at the first production level, otherwise $D21_{ij}$=0; $D22_{ij}$=1 when j=0 and the group is on level 2, otherwise $D22_{ij}$=0; $D23_{ij}$=1 when j=0 and the group is on level 3, otherwise $D13_{ij}$=0). This equation is used for both token sales and re-investments analyses. The formal hypothesis that can be tested with this equation is:

$$H_0: \beta_0 = 0, \beta_1 = 0, \beta_2 = 0, \beta_3 = 0, \beta_4 = 0, \beta_5 = 0$$
$$H_1: \beta_0 \neq 0, \beta_1 \neq 0, \beta_2 \neq 0, \beta_3 \neq 0, \beta_4 \neq 0, \beta_5 \neq 0, \qquad (4.2a)$$

with the null hypothesis stating that there is no difference between each treatment and the optimal at any level, and the alternative hypothesis stating that there is a significant difference.

The previous two hypotheses have compared each treatment to the optimal. To test for significant differences between token sales and re-investments in the two treatments, the difference in token sales and re-investments from the optimal in each treatment must be compared with each other. The hypothesis for the comparison of the two treatments is derived from equation 4.1:

$$H_0: \beta_0 = \beta_1$$
$$H_1: \beta_0 < \beta_1, \qquad (4.3a)$$

with the null hypothesis stating that there is no difference between the coefficients of difference for each treatment, and the alternative hypothesis stating that the NGC coefficient is significantly smaller than the TC coefficient, thus, the NGC treatment is significantly closer to the optimal. The alternative hypothesis is a one tailed hypothesis because the general hypotheses stated in Chapter 2 suggested that NGCs avoid the horizon problem and operate closer to optimal levels, and the fulfillment of these hypotheses requires the NGC treatment to be significantly closer to the optimal. Thus, the coefficient for the difference from the optimal in the NGC treatment must be smaller

Table 4.3: Comparisons performed through the data analysis.

Dependent Variable			Regressions*		
Token Sales	**Difference**	1	NGC vs CO	TC vs CO	NGC vs TC
		2	NGC vs OP	TC vs OP	NGC vs TC
	Absolute Diff.	3	NGC vs CO	TC vs CO	NGC vs TC
Re-Investment	**Difference**	4	NGC vs CO	TC vs CO	NGC vs TC
		5	NGC vs OP	TC vs OP	NGC vs TC

* NGC = New Generation Co-operative treatment, TC = traditional co-operative treatment, CO = conditional optimal, and OP = optimal path

than the coefficient for the TC treatment.

The comparisons made in the analysis are listed in table 4.3. Comparisons are made for token sales and for re-investments. For token sales, the comparisons are made in terms of differences from conditional optimal levels and optimal paths. In addition, token sales in each treatment are compared to test for differences between the two treatments. Also, absolute differences of token sales from conditional optimal levels in the two treatments are tested. For re-investments, comparisons are made once again in terms of differences from conditional optimal levels and optimal paths. Finally, re-investments levels in the NGC and TC treatments are compared.

4.10 Conclusions

This chapter has presented a detailed description of the experimental design, with a breakdown of the differences between the two treatments. The differences between the treatments led to the development of the formal hypotheses in the last section of this chapter. The results from the testing of these hypotheses are discussed in the next chapter.

CHAPTER FIVE

ANALYSIS AND DISCUSSION OF RESULTS

The experiment described in the previous chapter was run between November 20, 2000 and November 23, 2000. Four replications of each treatment were run during this time. This chapter discusses the results of the experiment. Section 5.1 analyzes the results of the token sales for each treatment. Section 5.2 analyzes the results of the re-investments for each treatment. In Section 5.3, there is a discussion of the comparison of the two treatments. All ANOVA results are provided in Appendix K. The charts created from the results can be found in Appendix L. Groups 1 to 4 make up the New Generation Co-operative treatment, while groups 5 to 8 comprise the Traditional Co-operative treatment.

Differences in the two treatments were measured in terms of both token sales to and re-investment in Business Y. Measured differences between the two treatments allow for formal testing of the hypotheses developed in Chapter 2, that the structure of the New Generation Co-operative reduces the investment horizon and service use problems found in traditional co-operatives.

5.1 Token Sales

As stated in Chapter 4, token sales represent sales of grain to private processors (represented by Business X) and to co-operatives (represented by Business Y). Average token sales to Business Y for the NGC treatment are charted in Figure 5.1 and for the TC treatment in Figure 5.2. A complete set of charts is provided in Appendix L.

5.1.1 Difference From Conditional Optimal

In the first set of analyses, the dependent variable is the difference in token sales from the

Figure 5.1: Average Token Sales to Business Y (co-operative) for the NGC Treatment

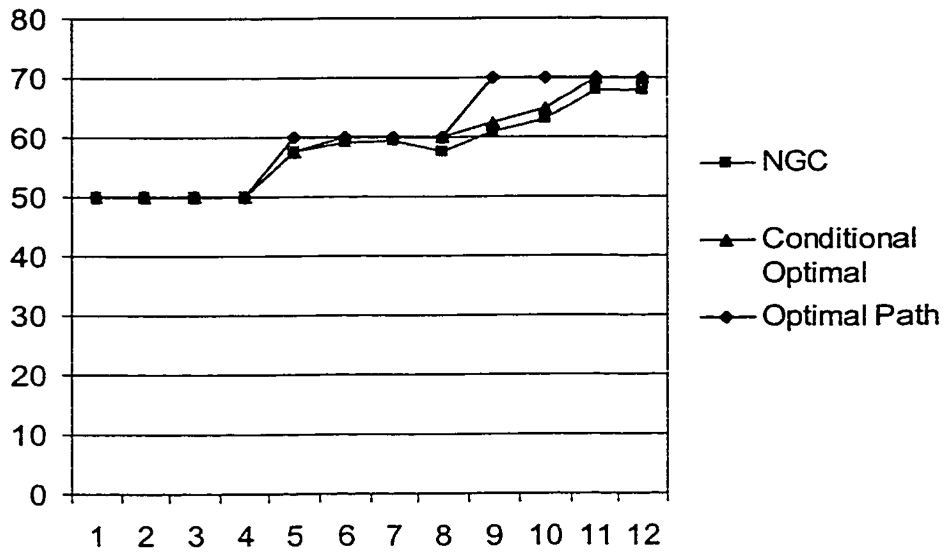


Figure 5.2: Average Token Sales to Business Y for the TC Treatment

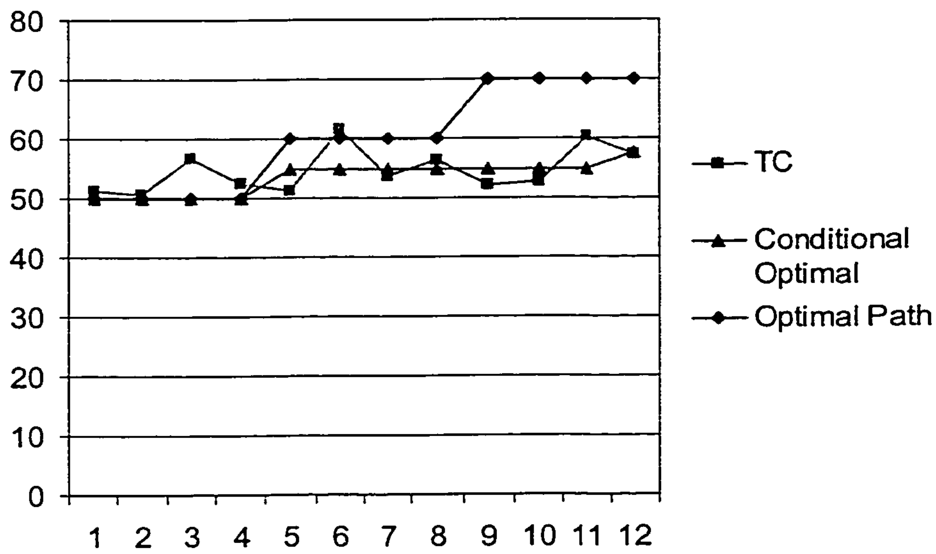


Table 5.1: Summary of ANOVA results on the difference from conditional optimal in overall token sales.

Independent Variable	Coefficient	Standard Error	p-value
D1 (NGC)	0.958	0.8266	0.2493
D2 (TC)	-1.1875	0.8266	0.1542

F-stat = 1.6846

conditional optimal (the optimal sales to the co-operative given the current investment level). The first part of this analysis uses the model given in equation 4.1:

$$Y_{ij} = \beta_0 * D1_{ij} + \beta_1 * D2_{ij},$$

where Y_{ij} is the difference in token sales from the conditional optimal for the co-operative (conditional optimal – actual sales) for the i^{th} observation of treatment j, $D1$ is the dummy variable for the NGC treatment, and $D2$ is the dummy variable for the TC treatment. A regression was run to test for significant differences between the token sales for each treatment and the conditional optimal. The null hypothesis is that token sales do not differ from the conditional optimal. The formal hypothesis statement of the null and alternative hypotheses are as stated in equation 4.1a. The results from the analysis of variance for this model are provided in Appendix K and are summarized in table 5.1. The ANOVA results give t-stats for each of the dummy variables that are not statistically significant. This means that token sales in both treatments were not significantly different from the conditional optimal. Thus, the null hypothesis is not rejected. Of note is the F-stat that corresponds to a p-value of 0.19, which indicates that the overall model is not significant. However, a single factor ANOVA generates an F-stat that is significant at the 90% confidence level, attributing some significance to the model. These results suggest that neither token sales to the NGC nor to the traditional co-operative were different from the conditional optimal, when compared over the entire twelve periods in the experiment. Figures 5.1 and 5.2 indicate how close the token sales for each treatment were to the conditional optimal.

The second analysis is more specific and tests for differences between token sales to the co-operative and the conditional optimal across the two treatments at different production levels. The second regression equation has six explanatory variables, all dummy variables, as modeled in equation 4.2:

$$Y_{ij} = \beta_0*D11_{ij} + \beta_1*D12_{ij} + \beta_2*D13_{ij} + \beta_3*21_{ij} + \beta_4*D22_{ij} + \beta_5*D23_{ij}+\varepsilon_{ij}$$

Here again the variable Y_{ij} equals conditional optimal sales minus actual sales. There are three dummy variables for each treatment. The coefficients for each dummy variable represent the differences in token sales from the optimal token sales, conditional on each of the three production levels. The formal statement of the null and alternative hypotheses is as stated in equation 4.2a. The statistical test is for differences between token sales and the conditional optimal at each stage of the experiment for both treatments. The results, shown in table 5.2, indicate that there are no significant differences at any of the three production levels for the NGC treatment, while the TC treatment only has a significant difference from the conditional optimal at the first production level. A positive coefficient in this case indicates that token sales are less than the conditional optimal while negative coefficients indicate token sales are greater than the conditional optimal. Thus, the significant negative coefficient for level 1 of the TC treatment indicates that players sold too many tokens to the co-operative at the first production level. This may be due to the fact that each individual is trying to maximize their individual benefits but end up cycling around, and mostly above, the equilibrium. This cycling may occur because it takes some time for the participants to find the equilibrium. Once they find it, they seem to stick fairly close to it, as suggested by the results and indicated in Figure 5.2. An odd result from this analysis was the p-value of 1 for D11. This may be due to the fact that token sales at the first level in the NGC treatment were never different from the optimal, and with no difference in any of the observations, the analysis generates a p-value of 1. For the most part, the null hypothesis for this analysis is not rejected.

Table 5.2: Summary of ANOVA results on the difference from conditional optimal in token sales at each level.

Independent Variable	Coefficient	Standard Error	p-value
D11 (NGC)	0	1.3794	1
D12 (NGC)	1.5	1.2717	0.2413
D13 (NGC)	1.4545	1.7148	0.3986
D21 (TC)	-2.40625	1.0054	0.0188
D22 (TC)	1.4	1.4684	0.3429
D23 (TC)	-1	5.6873	0.8608

F-stat = 1.4567

Table 5.3: Token Sales vs Conditional Optimal - Summary of results for difference in means and variance between the two treatments.

t-test for difference in means	
t-stat	-1.8355
p-value	0.0348
F-test for difference in variance	
F-stat	12.2946
p-value	5.9428E-15

In comparing the two treatments, and to test hypothesis 4.3a, a t-test is run to check for differences in means while an F-test is run to check for differences in variance. The results from these tests are provided in table 5.3. The p-value from the t-test shows that there is a significant difference in the mean difference from the optimal for the two treatments, so the null hypothesis is rejected. Even though neither of the treatments has a difference from the optimal that is statistically significant, the significant difference between the two treatments is due to the fact that the difference in the NGC treatment is a positive number while the difference in the TC treatment is a negative number. The results from the F-test for difference in variance give a p-value that is close to zero, indicating that the variance is much greater in the TC treatment. This confirms what can be seen in figures 5.1 and 5.2. This variance in token sales around the optimal level can prevent the co-operative from operating at a profit maximizing level.

5.1.2 Difference From Optimal Path

In the second set of analyses, the dependent variable (Y_{ij}) is the difference in token sales from the optimal path. This analysis uses the same explanatory variables as the previous one, as given in equation 4.1, to test hypothesis 4.1a. The results are given in table 5.4. D2 was again statistically significantly different from zero, indicating a significant difference between the TC treatment and the optimal path. D1 was only significant at the 90% confidence level, showing that there is less of a significant difference in the NGC treatment. Both of these coefficients are positive, which means that the actual token sales are lower than the optimal path. In this case, the null hypothesis is rejected. Once again, the F-stat points to the relative insignificance of the model, however, a single factor ANOVA gives an F-stat indicating that the model is significant at the 90% confidence level.

The second regression in this analysis uses the six dummy variables, as modeled in equation 4.2, to test hypothesis 4.2a. For the NGC treatment, the results, as summarized in table 5.5, show that the only significant difference between token sales and the optimal path occurs at the third level. In the TC treatment, there was a significant difference at all three levels, with the difference at level one being significant only at the 90% confidence

Table 5.4: Summary of ANOVA results on the difference from optimal path in overall token sales.

Independent Variable	Coefficient	Standard Error	p-value
D1 (NGC)	2.2083	1.2083	0.0708
D2 (TC)	5.2708	1.2083	3.297E-05

F-stat = 1.6060

Table 5.5: Summary of ANOVA results on the difference from optimal path in token sales at each level.

Independent Variable	Coefficient	Standard Error	p-value
D11 (NGC)	0	1.6648	1
D12 (NGC)	1.625	1.6648	0.3316
D13 (NGC)	5.0	1.6648	0.0035
D21 (TC)	-2.8125	1.6648	0.0946
D22 (TC)	4.25	1.6648	0.0124
D23 (TC)	14.375	1.6648	1.979E-13

F-stat = 10.6048

Table 5.6: Token Sales vs Optimal Path - Summary of results for difference in means and variance between the two treatments.

t-test for difference in means	
t-stat	1.7922
p-value	0.0382
F-test for difference in variance	
F-stat	6.1453
p-value	2.7381E-09

level. Also, this coefficient is negative, which shows that the actual token sales were higher than the optimal path. The other two coefficients were positive, therefore, the actual token sales for this treatment dropped below the optimal path. This analysis shows that the difference between the actual and the optimal token sales increases significantly at each level.

There is no significant difference between group token sales for the NGC treatment and the optimal path until the third level. Once again, there is a p-value of 1 for D11, indicating no difference from the optimal path for token sales at the first level of the NGC treatment. The null hypothesis is again rejected in this test.

A t-test and an F-test are run to compare the mean and variance between the two treatments, testing hypothesis 4.3a. The results are shown in table 5.6. The p-value for the t-test indicates a significant difference in means between the treatments. This means that the null hypothesis in 4.3a is rejected. In the F-test, a value of 6.14 was given for the F-stat, well above the critical one-tail value of 1.62. This suggests that there is significantly more variance in token sales in the TC treatment, which indicates a less efficient business operation. Overall, there is a significant difference between the two treatments with respect to the difference between actual token sales and the optimal path.

5.1.3 Absolute Difference From Conditional Optimal

Absolute differences are tested for reasons that become apparent when examining the token sales charts for the NGC and TC treatments (see Appendix L, Charts 5 to 8). These graphs show that token sales of groups in the traditional co-operative treatment cycled above and below the conditional optimal, while the token sales of groups in the New Generation Co-operative treatment remained very close to the conditional optimal, occasionally dropping lower than the optimal but never going above. The pattern observed in the NGC treatment is due to the restrictions imposed on the players in this treatment, as they were required to sell as many tokens to Business Y as the number of shares that they owned. The number of shares sold to these players was equal to the conditional optimal. The players were not allowed to sell more tokens, as the co-operative would not want more grain delivered to them than what they had contracted for. They could sell fewer tokens than the number of shares that they owned, but they were penalized for this. Nevertheless, some players chose to sell fewer tokens from time to time. This is indicated by the dips below the optimal on the graphs.

In the TC treatment, there are no shares involved, and players can sell as many tokens to Business Y as they want. They make these sales decisions based on the payoff tables, which help them determine the optimal amount of tokens that the groups should sell to the co-operative in order to maximize their profits. However, each player in the group has no idea how many tokens the other players are selling to the co-operative, the only clues they have are the numbers of token sales from previous rounds. Making predictions based on the previous sales is not always reliable, as one player retires and another player joins after each round, preventing a pattern from setting in. In addition, if each player in the group notices that too many tokens were sold in the previous round, they may each try to compensate for that in the next round, resulting in a less than optimal number of tokens sold in that round. When this occurs, the opposite reaction could take place for the next round. This cycling effect could actually draw the average difference from the optimal closer to zero. By analyzing just the difference, it can be determined whether the groups in the TC treatment managed to bring their average token sales close to the optimal. The NGC treatment has a much higher probability of consistently selling close to the optimal number of tokens to the co-operative. Analysis of the absolute difference from the optimal determines how far from the optimal the groups were, and allows a comparison of variability between the two treatments. This comparison will give a good indication of the fluctuations in service use that occur in each type of co-operative, and could suggest which type of co-op would come closer to a profit maximizing level of service use.

The third set of analyses uses the absolute difference between actual token sales and the conditional optimal as the dependent variable (Y_{ij}). The first regression, modeled from equation 4.1 to test hypothesis 4.1a, looks at the overall difference from the optimal for each treatment. D1 and D2 are the independent variables, representing the NGC and TC treatments. The results are summarized in table 5.7. D2 is statistically significantly different from zero, indicating a significant difference between the token sales and the conditional optimal for the TC treatment. D1 is only significant at the 90% confidence level, so there is less of a difference in the NGC treatment; however, the null hypothesis is still rejected.

Table 5.7: Summary of ANOVA results on the absolute difference from conditional optimal in overall token sales.

Independent Variable	Coefficient	Standard Error	p-value
D1 (NGC)	0.9583	0.5239	0.0705
D2 (TC)	6.3125	0.5239	9.013E-21

F-stat = 26.1151

Table 5.8: Summary of ANOVA results on the absolute difference from conditional optimal in token sales at each level.

Independent Variable	Coefficient	Standard Error	p-value
D11 (NGC)	0	0.8760	1
D12 (NGC)	1.5	0.8077	0.0666
D13 (NGC)	1.4545	1.0891	0.1850
D21 (TC)	6.09375	0.6385	2.541E-15
D22 (TC)	7.13	0.9326	2.146E-11
D23 (TC)	1.0	3.6120	0.7825

F-stat = 9.6075

The second regression has the six dummy variables as set out in equation 4.2 for the purpose of testing hypothesis 4.2a. The results are given in table 5.8. The only significant difference in the NGC treatment occurred when the co-op was at the second production level, and this difference is only significant at the 90% confidence level. In the TC treatment, significant differences from the optimal occurred at the first and second production levels, thus, the null hypothesis is rejected. At the third level, there is a much smaller difference. Though there is no significant difference from the optimal at this level, it should be noted that there are very few observations for this variable, as groups in the TC treatment did not often make it to the third level. In the few times that these groups operated at the third level, they may have sold close to the optimal number of tokens. Also, the variance at the third level is much higher than at the other two levels. Because there are so few observations at this level, their effect on the overall difference from the optimal for the TC treatment would be minimal.

Table 5.9: Token Sales vs Conditional Optimal - Summary of results for difference in means and variance between the two treatments.

t-test for difference in means	
t-stat	7.227
p-value	6.4449E-11
F-test for difference in variance	
F-stat	4.3391
p-value	7.7588E-07

Comparison of the two treatments again involves a t-test and an F-test, with the results given in table 5.9. The t-stat of 7.22 is well above the critical one-tail value of 1.66, which shows that there is a significant difference in the means of the two treatments. This means that the null hypothesis is rejected. The p-value for the F-test is close to zero, which indicates that there is significantly more variance in token sales for the TC treatment. This analysis demonstrates a significant difference between the two treatments in terms of the absolute difference between actual token sales and the conditional optimal.

5.2 Re-investments

The fourth and fifth sets of analyses compare the re-investments in Business Y from each group to the optimal re-investment. Once again, there are two definitions of the optimal that are used, the conditional optimal and the optimal path. Since the actual re-investment can never be greater than the optimal re-investment, the absolute difference is not necessary for this analysis. These regressions use the same explanatory variables as do the regressions for token sales. The difference from the previous analyses is that these regressions use the negative of the difference, the actual minus the optimal instead of the optimal minus the actual. This is done for ease of explanation. The total re-investment by group and the average re-investment by treatment are charted in Figures 5.3 and 5.4.

Figure 5.3: Total Re-Investment by Group

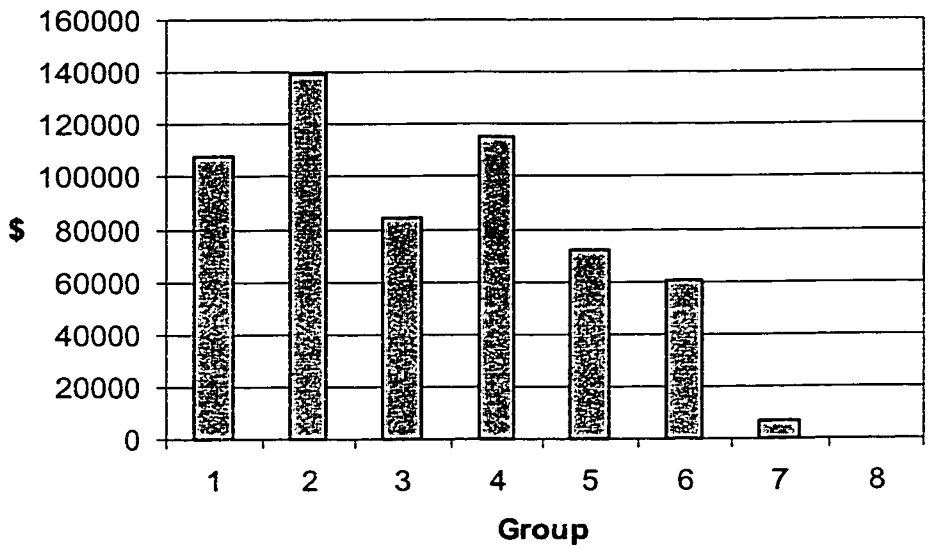
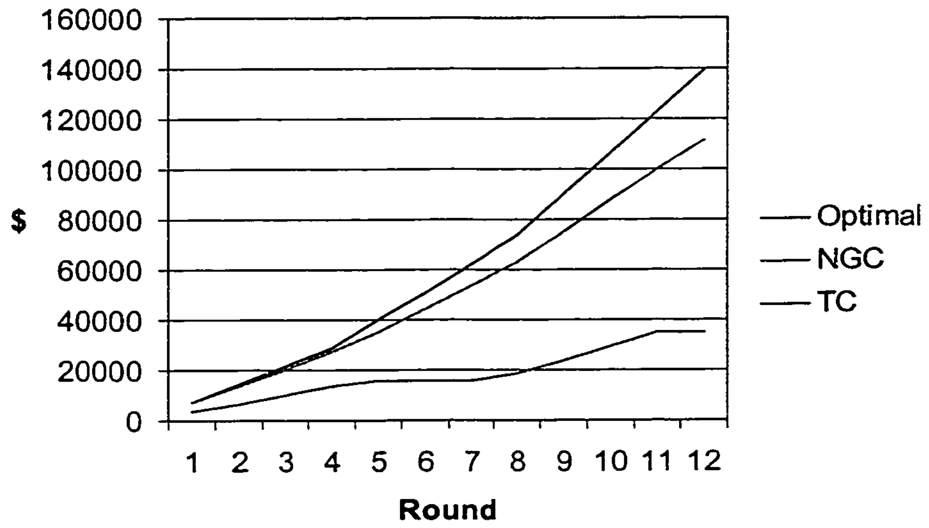


Figure 5.4: Average Re-Investment by Treatment



5.2.1 Difference From Conditional Optimal

The fourth set of analyses uses the difference between the re-investment and the conditional optimal as the dependent variable. The first part of this analysis has D1 and D2 as the explanatory variables, as modeled by equation 4.1. The results in table 5.10 show that both dummy variables are significantly different from zero, indicating that there is a difference between the actual and conditional optimal re-investments for both treatments, thus, the null hypothesis for 4.1a is rejected. However, when looking at the p-values, it is obvious that there is a much greater probability for D2, or re-investments from the TC treatment, to be different from the optimal.

The second regression uses the six explanatory variables from equation 4.2. The results, summarized in table 5.11, show that in the NGC treatment, there are significant differences from the optimal at the second and third levels, but not at the first level. In the TC treatment, the re-investments are significantly different from the conditional optimal at all three levels, which means that the null hypothesis for 4.2a is rejected. The coefficients are all negative, because the actual amounts re-invested are less than the optimal amount. The coefficient for the difference is much lower for the third level of the TC treatment than for the other two. This could again be a result of having only a few observations at the third level, as the groups did not often make it to the third level. The variance is also much higher for the third level.

Table 5.10: Summary of ANOVA results on the difference from conditional optimal in overall re-investments.

Independent Variable	Coefficient	Standard Error	p-value
D1 (NGC)	-1679.88	544.55	0.0027
D2 (TC)	-5701.51	544.55	1.849E-17

F-stat = 13.6355

Table 5.11: Summary of ANOVA results on the difference from conditional optimal in re-investments at each level.

Independent Variable	Coefficient	Standard Error	p-value
D11 (NGC)	-249.71	865.37	0.7736
D12 (NGC)	-2020.65	797.83	0.0131
D13 (NGC)	-3270.56	1075.80	0.0031
D21 (TC)	-5148.31	630.74	1.886E-12
D22 (TC)	-6169.27	921.26	1.787E-09
D23 (TC)	-16387.60	3568.02	1.415E-05

F-stat = 7.5979

Table 5.12: Re-Investments vs Conditional Optimal - Summary of results for difference in means and variance between the two treatments.

t-test for difference in means	
t-stat	-5.2222
p-value	5.2875E-07
F-test for difference in variance	
F-stat	1.9904
p-value	0.01

To test for differences between the two treatments in this analysis, a t-test and an F-test are run. The results are provided in table 5.12. The p-value associated with the t-stat, which is negative, indicates that the amount re-invested in the NGC treatment is significantly different from the amount re-invested in the TC treatment. This means that the null hypothesis for 4.3a is rejected. The p-value of the F-stat demonstrates that there is also a significant difference in the variance of re-investments for the two treatments. This analysis shows that group re-investments for the TC treatment are significantly lower than the optimal, while there is a somewhat less significant difference in the NGC treatment. There is a significant difference between the two treatments in the amount re-invested in the co-operative.

5.2.2 Difference From Optimal Path

In the fifth set of analyses, the dependent variable is the difference between the actual re-investment and the optimal path for re-investing. The first regression creates a model taken from equation 4.1 with a dummy variable for each of the treatments. Both dummy variables are significantly different from zero, as indicated in table 5.13, which means that there is a difference between the actual re-investment and the optimal path for re-investing in both treatments, thus the null hypothesis for 4.1a is rejected. The p-values associated with the dummy variables indicate that there is a much greater probability for re-investment in the TC treatment to be different from the optimal path, as the p-value for D2 is much smaller than the p-value for D1.

The second regression again uses the six dummy variables from equation 4.2. The results from this regression, as given in table 5.14, show that there are significant differences from the optimal path at all three levels in the TC treatment, while in the NGC treatment, significant differences exist only at the second and third levels. Once again, the null hypothesis is rejected. All of the coefficients are again negative, as the actual re-investments are less than the optimal. This difference becomes greater as time goes on.

A t-test and an F-test are run to check for differences between the two treatments. The p-value for the t-stat, which again is negative, indicates a significant difference in means between the two treatments, which rejects the null hypothesis. The p-value for the F-test

Table 5.13: Summary of ANOVA results on the difference from optimal path in overall re-investments.

Independent Variable	Coefficient	Standard Error	p-value
D1 (NGC)	-2294.44	661.28	0.0008
D2 (TC)	-8699.72	661.28	4.912E-23

F-stat = 23.4553

Table 5.14: Summary of ANOVA results on the difference from optimal path in re-investments at each level.

Independent Variable	Coefficient	Standard Error	p-value
D11 (NGC)	-265.31	916.01	0.7728
D12 (NGC)	-2458.67	916.01	0.0087
D13 (NGC)	-4159.33	916.01	1.732E-05
D21 (TC)	-3660.36	916.01	0.0001
D22 (TC)	-10198.13	916.01	1.306E-18
D23 (TC)	-12240.67	916.01	4.397E-23

F-stat = 21.7188

Table 5.15: Re-investments vs Optimal Path - Summary of results for difference in means and variance between the two treatments.

t-test for difference in means	
t-stat	-6.8491
p-value	3.8023E-10
F-test for difference in variance	
F-stat	2.7256
p-value	0.0004

demonstrates that there is a significant difference in the variance between the two treatments. This analysis shows, just as above, that group re-investments for the TC treatment are significantly lower than the optimal, while there is less of a significant difference in the NGC treatment. Again, a significant difference exists between the two treatments, as groups in the NGC treatment re-invest more than do groups in the TC treatment. The main reasons for this difference are that groups in the NGC treatment have on average more profits for re-investing, as they moved up through the profit levels more rapidly, and that they were closer to the optimal in re-investment.

Table 5.16: Summary of significant results from data analysis.

Dependent Variable			Regressions		
Token Sales	**Difference**	1	NGC vs CO	TC vs CO	NGC vs TC*
		2	NGC vs OP	TC vs OP*	NGC vs TC*
	Absolute Diff.	3	NGC vs CO	TC vs CO*	NGC vs TC*
Re-Investment	**Difference**	5	NGC vs CO*	TC vs CO*	NGC vs TC*
		6	NGC vs OP*	TC vs OP*	NGC vs TC*

* significant differences exist at the 95% confidence level

There is more of a difference between actual re-investments and the optimal path for re-investing than there is between the actual and conditional optimal re-investments. This is due to the fact that the conditional optimal can never be greater than the optimal path, while the optimal path will often be greater than the conditional optimal, especially towards the end of a game where expansions did not occur as often as they could have. This difference occurs more often in the TC treatment because there are fewer expansions in this treatment, while the conditional optimal comes closer to keeping up with the optimal path in the NGC treatment.

5.2.3 Share Auction Results

An interesting pattern was found in the results from the share auctions of the New Generation Co-operative treatment. The graphs of these results (see Figures 5.5 and 5.6) seem to indicate that the prices at which the shares are sold are closer to the market maximum than to the market minimum. In fact, the price per share line closely follows the market maximum line. If this is the case, then it would seem that the seller of shares has market power. This can often be the case in a market that has one seller and many buyers. However, in this market, the buyers are aware that the seller has to sell the shares, they cannot wait around for a better price. It was thought that this knowledge could shift market power to the buyers. But it seems that this factor did not have much of

Figure 5.5: Average Share Auction Results

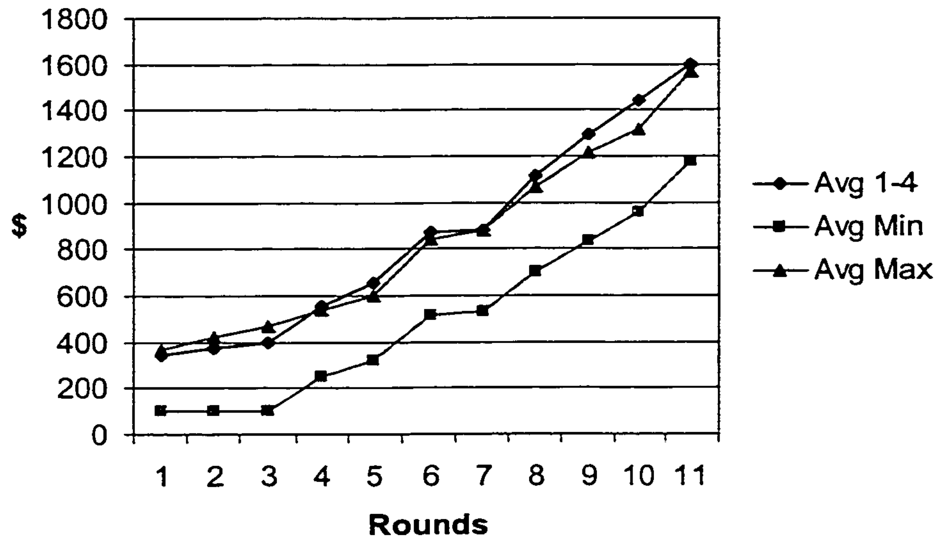
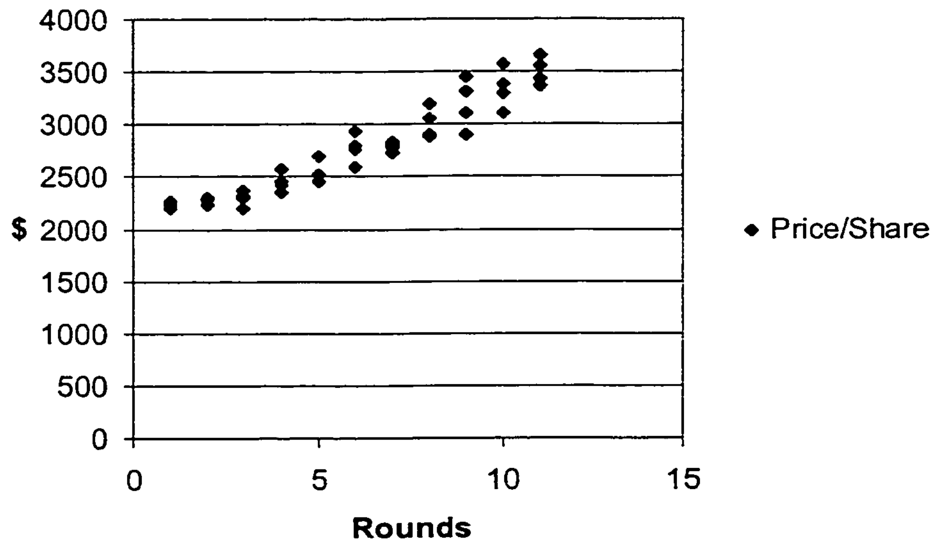


Figure 5.6: Price Per Share by Rounds



an impact on the share price results, as the desire to own shares overcame this effect and gave the market power right back to the seller.

5.3 Comparison of the Two Treatments

These results indicate that both the token sales and the re-investments from groups in the traditional co-operative treatment are significantly different from both the conditional optimal and the optimal path, while the token sales and re-investments from groups in the New Generation Co-operative treatment are not all significantly different. However, this does not necessarily mean that the two treatments are significantly different from each other. To determine this, a series of t-tests and F-tests was run to check for differences of means and variances between the two treatments. The results of these tests indicate that the TC treatment had significantly greater differences from the optimal than did the NGC treatment in both token sales and re-investments, as the null hypotheses of equal mean or equal variance are rejected in every test. The NGC treatment had more re-investment and was closer to optimal token sales in comparison to both the conditional optimal and the optimal path. This corresponds to the hypotheses set out in Chapter 2, stating that NGCs solve the horizon problem and operate closer to the optimal level than do traditional co-operatives.

The fact that the token sales and re-investments for the TC treatment are significantly different from the optimal demonstrates the problems inherent in the traditional co-operatives. The token sales are extremely variable, and do not often approach the optimal number of token sales, which reflects the problems that traditional co-operatives have with regards to fluctuating levels of product deliveries. With such variable sales to the co-op, it cannot maintain operations at an optimal level, which negatively affects its profits. With lower profits, it becomes more difficult to compete in the marketplace, and the members see less of an incentive for patronizing the co-operative. The lack of re-investment is a reflection of the lack of incentives for the members to put their money back into the co-op. This lack of incentives is due to the horizon problem, as each member in the group is at a different point in their farming life, and more of them will have an incentive to keep the money for themselves instead of re-investing it into the co-operative. Those that are set to retire before the return from the re-investment takes effect will not stand to benefit from re-investing.

The results from these experiments have shown that the NGC treatment is significantly different from the TC treatment in terms of token sales and re-investment, yet the NGC treatment is not significantly different from the optimal. This indicates that the NGC treatment is significantly more efficient in its operations with regards to product deliveries and investment, which generate increased profits. It appears as though the delivery rights structure of the New Generation Co-operatives has a definite advantage over the vaguely defined property rights structure of the traditional co-operatives. The delivery rights also create increased incentives for re-investment. There is a much greater chance of earning a return on re-investment, even with impending retirement. With this increased opportunity to benefit from re-investing, more of the members chose to re-invest over the course of the game. This allowed the co-operative to expand more often, and move up to greater payoff levels. The incentives presented by the NGC structure seemed to overcome the horizon problem. This structure also appeared to overcome the fluctuating service use problem, as the amount of grain deliveries to the co-operative remained consistent.

Even though the investment incentives seemed to be made fairly clear to the players, the investment decisions were sometimes contrary to what the incentives would imply. These are referred to as irrational decisions. In the TC treatment, the majority of these irrational decisions were votes to re-invest when there was more of an incentive to refund the profits. This could be due partly to the fact that some players felt compelled to vote for a re-investment, in order to benefit the group as a whole. In the NGC treatment, the irrational decisions were all decisions to refund the profits when there was more of an incentive to re-invest, as players in this treatment always had more of an incentive to re-

Figure 5.7: Average Irrational Actions by Group

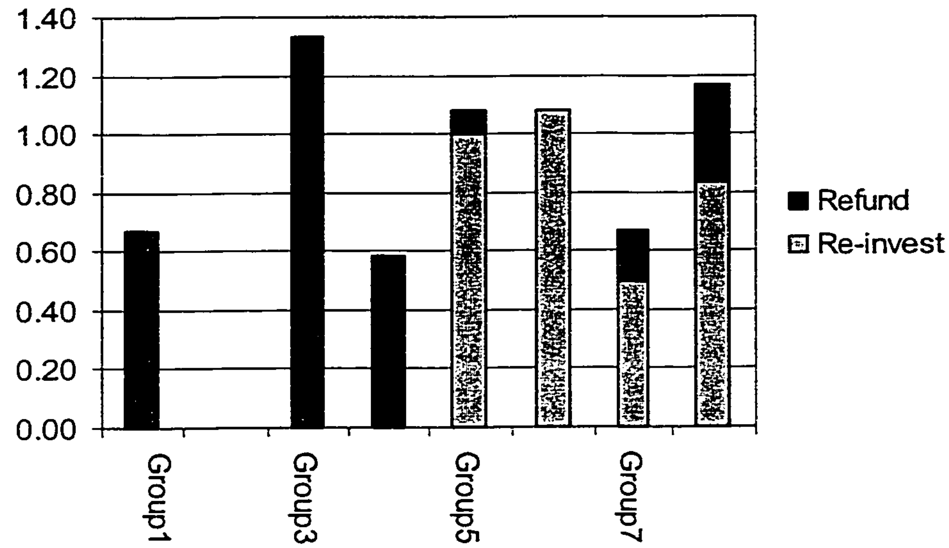
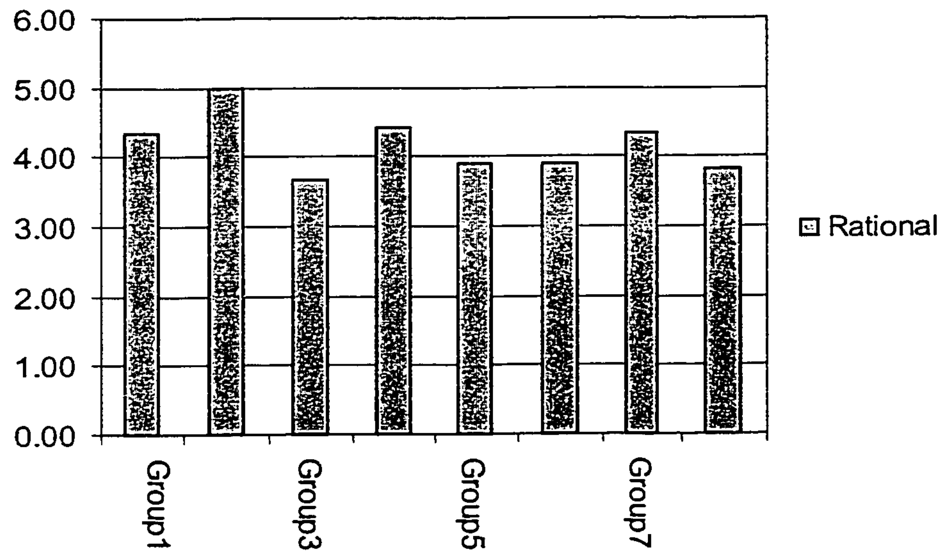


Figure 5.8: Average Rational Actions by Group



invest. The number of rational and irrational decisions made by each group is charted in Figures 5.7 and 5.8. Overall, more irrational decisions were made in the TC treatment.

This chapter discussed how the hypotheses set out in Chapter 2 were tested. The evidence from the results suggests that the hypotheses regarding the performance of New Generation Co-operatives as compared to traditional co-operatives hold true in this experiment. The most important result was that there was more re-investment in the NGC treatment, which allowed groups in this treatment to move up through the production levels more quickly than those in the TC treatment. The amount of re-investment was also closer to the optimal in the NGC treatment. This appears to support the hypothesis that the inherent incentives in the structure of NGCs allow them to solve the investment horizon problem. The share trading mechanism, which yielded prices that closely reflected the value of the shares, also supports this hypothesis.

CHAPTER SIX

CONCLUSIONS

The research objectives for this study were set out in Chapter 1. These objectives were carried out in the following ways. The inherent incentive problems in traditional co-operatives were discussed in Chapter 2. This led into a description of New Generation Co-operatives. The advantages and disadvantages of both types of co-operatives, in terms of internal incentive structures relating to investment and use of services, were also discussed in Chapter 2. Working hypotheses about the performance of NGCs as compared to traditional co-operatives in the areas of investment and use of co-operative services were developed in Chapter 2 and formalized in Chapter 4. An experimental design for simulating New Generation and traditional co-operative property rights structures and the investment horizon problem was developed in Chapter 4. The results from the testing of the working hypotheses were discussed in Chapter 5.

6.1 Summary and Implications of Major Findings

This experiment was designed with similar cost and revenue structures for both treatments, but with different incentive structures that simulated the incentives found in each type of co-operative. The results of this experiment indicate that significant differences existed between the two types of co-operatives for both token sales and re-investments. The results also indicate that the traditional co-operative treatment was less efficient than the New Generation Co-operative treatment, in terms of both token sales and re-investments, as there were significantly smaller differences from the optimals in the NGC treatment. By coming closer to the optimal for token sales, groups in the NGC treatment were able to increase the amount of profits for re-investment each round, and by re-investing closer to the optimal amount, they were able to expand the co-operative more often, thus increasing their total profits. For this reason, players in the NGC treatment earned more than did the players in the TC treatment. The results of this experiment support the hypotheses that NGCs can avoid the horizon problem and can keep the level of product deliveries close to the profit maximizing level.

The results also imply that the structure of traditional co-operatives does not allow them to operate at an optimal level. Because members can deliver to the co-operative as much of their product as they desire, the total amount delivered to the co-op is difficult, if not impossible, to control. This has a negative effect on the annual profits of the co-op, which in turn affects the amount returned to the members in the form of patronage refunds. Because the group members could not control the amount of tokens sold to the co-op, they could not maximize their returns in each round. With the constant change in group members, they could not settle into a pattern of deliveries to the co-operative. This demonstrates how fluctuating levels of product deliveries are created in traditional co-operatives.

The results indicate how the incentives created by the structure of New Generation Co-operatives allow them to operate more efficiently. The token sales and re-investments of groups in the NGC treatment were always closer to the optimal, or more efficient, amounts. The delivery rights enable the New Generation Co-operatives to maintain efficient levels of grain deliveries to the co-op and the investment incentives associated with them encourage more re-investment in the co-operative.

These results suggest that the traditional co-operatives may not be adequately prepared to face this time of transformation of the agriculture industry, as they cannot operate at efficient levels. This could potentially create problems in trying to compete with private firms, especially those that can more easily adjust their structure in the face of inefficiencies. New Generation Co-operatives were shown to have significantly more efficiency in their structure, which could allow them to maintain their competitiveness in the marketplace.

The results of this study suggest that directors of traditional co-ops may need to conduct a thorough analysis of the way that their business is set up and of the resulting incentive structures. There may be something to be learned from NGCs that could be adaptable to traditional co-operatives, in order to enhance their competitiveness with private corporations. The current changing structure of agricultural businesses in general allows increasingly less room for inefficient operations.

The results of this experimental analysis were convincing. The experiment was set up with strong incentives to reveal the investment horizon problem and to show how tradable delivery rights could potentially solve this problem. However, the experiment may not fully reflect the reality and complexity of actual situations in agricultural co-operatives. There are several limitations to the study that are discussed in section 6.2. These limitations relate in part to the strength of the incentives that actually exist. For example, the investment horizon problem may not be as severe as portrayed in this experiment. This and other limitations are discussed in the following section.

6.2 Limitations of this Study

There are some definite limitations to this type of experiment, as it is almost impossible to create a model that truly represents the co-operative setting. It is also difficult to create an experimental model that is complex enough to simulate a co-operative yet simple enough for subjects to understand. In comparing NGCs to traditional co-operatives, only two main aspects of the businesses were compared, investment in the co-operative and product deliveries. There may be other important aspects that could have been compared.

Throughout the design of this experiment, there are several allowances and assumptions made to keep things simple. It is hoped that these do not have an effect on the overall outcome of the experiment. Some examples of these include the interest-free loan for purchasing shares and the systematic retirements of old players and additions of new players. At the beginning of each game of the NGC treatment, the first five players were each assigned ten shares, which they had to pay for at the end of the game. This was easier than trying to auction them off to each player. An assumption is made that each of the players will want to own shares. Each expansion is assumed to add capacity in the co-op for ten more tokens per round. An alternative to this is to have the players decide how much capacity is to be added, and have the re-investment amount set accordingly.

In a sense, the experimental design was biased towards NGCs because of the set number of shares distributed by the co-operative. This number of shares is always set at the optimal amount. Due to this fact, players in the NGC had neither the opportunity nor the incentive to do something different from the optimal. This kind of opportunity could have been created through allowing the members of the group to vote on the number of shares that were to be distributed.

The nature of the horizon problem has been identified verbally in co-operative literature; however, this literature does not address the theory behind this problem too closely. Better knowledge of the theory along with an empirical analysis of cooperative capital structures and demographics could allow for a more precise measure of the magnitude of the horizon problem. This study assumes that this problem has severe impacts on the operations of traditional co-operatives. These impacts may not be as strong in actual co-operatives. Determining the magnitude of the horizon problem would involve the study of actual co-operative situations. This could be extremely time consuming, and could also provide information that is specific only to individual co-operatives.

The method for which the horizon problem was modeled in this experiment may also have been a limitation. The ratio of 4 to 1 against re-investment may not have been an accurate representation of the ratio found in actual traditional co-operatives. However, the focus of this experiment was not on determining the precise ratio, rather, it was on modeling the incentives against re-investment that exist in traditional co-operatives. A lower ratio, such as 3 to 2, may have reduced the observed severity of the horizon problem in this experiment. However, the main limitation regarding the modeling of the horizon problem is the lack of knowledge about its magnitude in co-operatives. Such knowledge could provide a better indication of the ratio that actual co-operative situations would suggest.

Another limitation of this study is the way that the equilibrium is set up through the payoff tables. The free riding equilibrium is the same as the profit maximizing equilibrium for the co-operative. Individual benefits are maximized at a point that is lower than this equilibrium. This decreases the incentive for overuse of the co-operative's services, an effect that is often observed with common pool resources. Part of the reason for this disparity is that the main focus of the payoff tables was to set the profit maximizing level of token sales for the co-operative at specific levels for each payoff table (i.e. 50 tokens for Level 1). In the effort to achieve these profit maximizing equilibrium levels, the free riding equilibrium ended up at a point that was equal to the co-operative's equilibrium. To have a better look at free riding in the context of co-operatives, the free riding equilibrium should be set higher in order to provide an incentive for overuse of the co-operative's services, or the profit maximizing equilibrium for the co-operative should be set at the point where individual benefits are maximized.

6.3 Suggestions for Further Research

With this type of experiment, there are many variables that can be changed to create a different study. This creates the opportunity for many related research projects. One aspect that could be changed in the design of this experiment is to give the players in the NGC treatment a budget, which would limit the amount that they could spend on shares. This study allowed the players to spend as much as they wanted, interest-free. Putting a budget in place would also affect the share auction, keeping the bids from getting too far out of line. There were some players who paid no attention to their maximum willingness to pay per share, and paid much more than they should have, just so they could own more shares. A budget may prevent this from occurring.

Another change in the design of this experiment that may be worthwhile studying is to give the players in the NGC treatment control to decide how many shares their co-operative should sell to its members, in effect, controlling how much is delivered to the co-operative. This experiment almost forced the players to deliver a certain number of tokens to the co-operative each round. In the TC treatment, the players decide for themselves each round how many tokens to sell to the co-op. The NGC treatment could be designed in a similar way by allowing the members to decide amongst themselves how many tokens should be sold to the co-op through setting the number of shares that are made available from the co-operative. However, this would be difficult to do in each round, as New Generation Co-operatives generally set the number of shares when they are first established, based on the desired capacity for the co-operative. An alternative would be to allow the members in the NGC treatment to decide as a group at the beginning of the game what the initial capacity and number of shares should be. This would give a better indication of how well the players in the NGC treatment can identify optimal strategies.

Another alternative method for this experiment is to provide the opportunity for an expansion in every period. Discount rates could be used to maintain the voting ratio of 4 to 1 against the expansion for the TC treatment. In the experiment for this study, the horizon problem arose because of the lag between the investment and the returns. With the potential for expansions in each period, the effects of the horizon problem could be studied without this lag.

There are other variations on the model for studying the effects of the horizon problem. The experiment could be redesigned with different ratios of incentives regarding re-investment. A steady state model could also be used for such an experiment. In this case, returns would decline as capital depreciates; therefore, continuous re-investment would be required to maintain returns at existing levels. Instead of re-investing to increase returns, re-investing would be necessary to prevent returns from decreasing.

This experiment only compared NGCs to traditional co-operatives. Though the results indicated that NGCs were much more efficient in their operations, there was no indication of how the performance of NGCs would compare to that of private processors. Such a comparison would provide another avenue for future research.

Some of the players in the TC treatment may have re-invested instead of refunding the profits to help out their group. This behaviour could possibly have arisen because the players were all together in the same room, which could create a sense of responsibility to the team. The results could potentially be different if the players could not see the other members of the group, and if there was absolutely no interaction among the subjects. Without the ability to put faces to the other members of the group, the subjects may behave more in their own self-interest, making decisions that maximize their benefits.

This irrational behaviour may also have been prevented if the subjects could have been made aware of how much money they lost by making an irrational decision. In further research, it may be beneficial to include on the payout cards the amount of money that the subject forfeited by making a decision that was contrary to their incentives. Without the knowledge of decreased earnings, subjects would be less likely to change the pattern of irrational actions.

The findings from this experiment may seem rather obvious, given the differing incentives in each treatment. However, the incentives associated with each treatment are modeled after the actual incentives that are involved with each type of co-operative. This study was used to show the extent to which a difference exists between the two types of co-operatives, based on their structures and inherent incentives. This study has shown that this difference is quite significant if the incentives provided in TC and NGC treatments are widely divergent. Future research should be directed toward establishing the magnitude of the investment horizon problem in traditional cooperatives so that the divergence in investments incentives in TCs and NGCs can be modeled more realistically in the experimental environment.

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APPENDICES

Appendix A: Experimental Methods and Procedures

1. Ethics Review

The proposed experiment for this study involved the use of human subjects. At the University of Alberta, such experiments cannot be run without the approval of the Human Ethics Review Committee. The quest for this approval involved filling out a detailed form stating the purpose and objectives of the study as well as a summary of the methodology and the procedures. This proposal was then brought before the committee for discussion. After demonstrating to the committee that the subjects would not experience any adverse effects as a result of the experiment and that confidentiality would be maintained, the approval was granted.

2. Recruitment of Subjects

Subjects for this experiment were recruited by making announcements in economics classes. All of the economics classes were 200 level or above, to avoid many first year students. A general announcement was made at the beginning of each class regarding the experiments, indicating that participants were needed and enforcing the fact that participants would be paid well for their participation. A sign-up sheet was passed around the class, prompting students to fill in their name, phone number and email addresses if they were interested. They could also check off the times that worked best for them to participate in the experiment, as there were four times to choose from. The sign-up sheets were picked up after class. After all the sign-up sheets had been collected, all the names were entered on a spreadsheet and then sorted randomly. Groups were then assigned from this random list. A few days before each experiment, the subjects in each of the groups were called and informed that they had been selected to participate in the experiment. They were given the necessary information such as date, time, and place. If they could not make it, the next name was taken from the randomized list. For each of the four times, sixteen players were needed to participate in the experiment, for a total of 64 players. A few replacements were also called to come in, just in case some of the players did not show up. The replacements were informed ahead of time that there was a good chance that they would not be needed, but that they would be paid a certain amount just for showing up. All of the subjects were reminded of the experiment through email a day or two before the experiment took place. Those who did not provide email addresses were called again for a reminder.

3. Experimental Rooms Set-up

Two games were played simultaneously in the same room. The room was divided in two by a row of partitions down the middle. A row of five tables was set up on each side against the side wall, separated by partitions. Pencils and decision cards were provided at each table. Numbers were taped to the wall above each table to indicate which player was to sit at each place. These numbers were changed as the game went on. Two tables were set up at the front of the room with laptop computers and printers, one on each side. These were for the computer operators, who would record the decisions made by each player in the game, and then print out reports to hand back to the players during each round of the game. A radio was set up at the front of the room to provide soft background music during the game.

All the subjects were to come first to the conference room, which was just down the hall from the experiment room. Once they arrived there, they were given a Consent Form (see Appendix B) and a Non-Disclosure Form (see Appendix C) to sign and hand back before leaving the room. They were also given a set of Payoff Tables (see Appendix E), which they were to take with them when going to the experiment room. Inside the conference room, snacks and drinks were provided for the subjects while they waited for the experiment to start. The tables were set up in the room so that all the subjects sat facing the front of the room. On the screen at the front of the room was a message asking them to refrain from talking to others in the room. Assistants were also on hand to make sure that there was no communication between subjects before the experiment started. A laptop computer and a projector were set up at the front of the room. These would be used to give the instructions before the experiment started. A printer was also set up, and would be used in carrying out practice rounds after the instructions were given. Assistants were seated along the outer wall of the room, and would provide help for the subjects during the practice rounds.

After the subjects were finished playing the game, they were required to go to the office to receive their reimbursement. One assistant was always seated at the table in the office. Money was supplied in Canadian currency, in denominations of quarters through to $20 bills. Each subject's payoff was rounded up to the next quarter, for ease of payment. There was also a Verification Sheet (see Appendix D) that each subject was to fill out, requiring their name, the amount they made, and their signature. Once this was filled out and the subject was paid, they were free to go.

We did not want the subjects to be aware before they started that they would be re-entering the games. When the games first started, ten of the sixteen subjects were taken to the experiment room. This left six subjects in the conference room, who had little idea of what was to happen. After each round, two subjects (one from each game) would be taken out of the experiment room due to retirement. Instead of bringing them back to the conference room and risk giving the remaining players in that room the idea that they would be playing more than once, thus potentially biasing their decision making process, the retiring players were brought to the classroom down the hall. They stayed there until all the other subjects were out of the conference room and had started playing the game. These retired players were then brought back to the conference room. From this point on, it did not matter if the players knew that they would re-enter the game, as they would only play the game once more. An assistant was in the classroom at all times, to ensure that there was no communication between the subjects.

4. Experimental Procedures

When the subjects arrived at the conference room, they were given consent and non-disclosure forms to sign and a set of payoff tables to look through. They were encouraged to help themselves to the food and drinks inside the room. They were also instructed not to talk to other people in the room. In order to avoid any discussion amongst subjects about the experiment, they were prevented from communicating at all. The subjects sat in the conference room until all the subjects had arrived. When the replacements arrived, they were directed to the classroom to wait there in case they were needed. This was done to prevent the replacements from mixing in with the players. They also did not need to sign any forms if they were not going to participate in the experiment. If not all sixteen original subjects arrived by ten minutes past the designated start time, the replacements were called on to fill in. At this time, they would be taken to the conference room and given the payoff tables and the forms to sign. Any remaining replacements were taken to the office to be paid for showing up. They received their money ($15) and filled in the verification sheet. When there were sixteen subjects in the conference room, the door was closed, and the subjects were welcomed to the experiment. The subjects were then taken through a presentation of the instructions for the game they were about to play. When the explanation of instructions had been completed, there was an opportunity for subjects to ask questions about any of the instructions that were not clear. The players were all informed that they would be paid based on how much they earned in the game and that their goal was to maximize their personal returns.

4.1 Traditional Co-operative Experiment

After any questions had been answered, an assistant called out the names of the first five players for each game. These players were led into the experiment room. This left six players in the conference room. Practice rounds were run in both the experiment room and the conference room. The five players in the experiment room were seated in their assigned places. They were unable to see each other, and they were not allowed to communicate with each other, to prevent players from working together or from having their decisions affected by another player. At their assigned place, they had the payoff tables, marketing decision cards, and voting decision cards. The players first filled in Marketing Decision cards, which were collected by an assistant and entered into the computer. Investment Potential forms were printed off and handed out to each player. The players were instructed to use these forms to help them make their voting decisions. On their Voting Decision cards, they were to check off either Refund or Re-Investment. These cards were collected by an assistant and entered into the computer. Payout cards were printed off and handed back to each player. At this point the round was over. The players in the experiment room were told at this time that the game was going to begin. They were instructed to fill out their first Marketing Decision card, which was provided for them at their assigned place. Once the round was over, an assistant led the retiring player out of the experiment room to the office, where they were paid according to the amount that they had earned in the game. After the player had been paid, the assistant led them to the classroom, where they were to wait until called upon to join the game again. This was done to prevent these players from mixing with the subjects in the conference room who had not played in the game yet. After Round 12, the players were told that the game was over. They were instructed to stay at their places until their name was called. An assistant called them one by one to come to the office, where they were paid based on how much they had earned in the game. They signed the verification sheet, stating how much they had been paid, then they were allowed to leave. After all the players had been paid, the assistants helped clean up and put the rooms back in order. These experiments took about an hour and a half to run.

4.2 New Generation Co-operative Experiment

After the questions had been fielded, the subjects were taken through a practice round. For the practice round, the subjects were placed into groups of two or three, and each of these groups was assigned a player number. This was done so that all sixteen subjects could participate in the practice round, which required six players. They had to decide in their groups first where to sell their tokens and then what to do with the profits from the token sales to Business Y. There was one assistant with each group to help them make their decisions and monitor their communication. The first five players had to fill out a Marketing Decision card for the practice round. They were told that they each had ten shares in Business Y. They had also been told in the instructions that the number of shares that they had should help determine how many tokens they should sell to Business Y. After the Marketing Decision cards were filled out, the assistants collected them, and the data was entered into the computer. Investment Potential forms were then printed out for each player. The subjects were advised to look at the return totals for both of the investment options, and use those totals to help them make their profit share decisions. On their Profit Share Decision cards, they were to indicate whether they wanted their profit share from Business Y refunded to them and put into a T-bill that yielded 7% or re-invested in Business Y. These cards were collected after they had been filled in, and were entered into the computer. Each group then received a payout card, which told them how much they had made during the round. At this point, Player 6 joined the game as the new player, while Player 1 would be retiring and would have to sell all of his or her shares. All six players were given a Share Auction Status card, which told them how many shares they could buy and the maximum price they would be willing to pay per share.

The share auction then began with the retiring player filling in an Offer to Sell card, stating the number of shares that were for sale and the asking price per share. These figures were written up on the Offer Board at the front of the room for all to see. The other players could then fill in an Offer to Buy card, stating the number of shares that they wanted to buy and the price that they were willing to pay per share. The assistants provided some help in filling in these cards by pointing out their maximum willingness to pay and the market minimum as found on their Share Auction Status cards. The groups were advised to use these numbers as guidelines for filling in their offer cards. Once the figures from the Offer to Buy cards were posted on the Offer Board, then the seller could fill out another Offer to Sell card. This share auction would go back and forth between the buyer and seller until the market cleared, and matching prices were reached for all the shares. At this point, the practice round was over. Any final questions were answered. Then an assistant called out the names of the first five subjects for each game, ten in total. Those subjects followed the assistant into the experiment room, where they were seated according to their player number. There were six subjects left in the conference room. These subjects would join the game at a later time.

In the experiment room, the games started. The subjects were given 30 seconds to fill in their first Marketing Decision card. Assistants collected these cards and brought them to the front of the room, where they were entered into the computers. A printout of Investment Potential forms was produced, cut up, and distributed by the assistants to the subjects. The players had another 30 seconds to read over this form and use it to help them make their Profit Share decisions. Again, the assistants collected these cards and brought them to the front of the room, where they were entered into the computers. A sheet of Payout cards was then printed off and handed back to the subjects. This individualized card told each subject how much they had earned for the round. An assistant then brought in the next player (Player 6) from the conference room. Each of the six players was given a Share Auction Status card, indicating to the retiring player (in this case, Player 1) their minimum willingness to accept per share and the market maximum and indicating to the potential buyers their maximum willingness to pay per share as well as the market minimum. The share auction then took place. Once the shares were sold, the round was over, and an assistant led the retiring player out of the experiment room to the classroom, where they were to wait until called upon to join the game again. They were not brought back to the conference room, as there were still subjects in this room that had not played in the game at all. We did not want to give them any idea that they would be playing in the game more than once, as this knowledge could potentially bias their decisions in the game. For this reason, the retired players were brought to a different room until each subject had joined the game and the conference room was empty. These procedures were repeated for each round.

There were sixteen players in each game. Five players started each game, and one player joined in place of the retiring player in each of the twelve rounds. Players 1 to 8 in one game became Players 9 to 16 in the other game. The players were not aware of this before the game began. After the last round (Round 12), the game was over, and the players were told what happened to their shares and their earnings. They were instructed to stay at their places until their names were called out. One by one the players were called into the office, where they were paid based on their earnings from the game. At this time, they also signed the verification sheet, stating the amount that they had been paid. After they had signed the sheet and been paid, they were allowed to leave. When all the subjects were gone, the assistants helped clean up and put the rooms back in order. These experiments took about three hours to run.

Appendix B: Consent Form

The major objective of this study is to compare certain institutional structures in different types of businesses. This study uses experimental economics to carry out these comparisons. This experiment requires you to work in a group and make individual investment decisions. Your decisions will be recorded and used as data for our experiment. Results from this experiment will help us determine how the differences found in these businesses might affect their efficiency.

Confidentiality will be maintained during this research project and your name will not be made available to any other researcher or persons after the conclusion of the experiment.

If at any time during the course of the experiment you feel that you do not want to continue, for whatever reasons you may have, we want you to know that we will oblige your wishes with no hard feelings. If you have any questions about how this study is being conducted, please do not hesitate to ask and we will attempt to answer as clearly as possible.

I, the undersigned, acknowledge the above information, and consent to participate in this experiment.

____ Date:_________________________

Appendix C: Request for Non-Disclosure

As researchers, we do not wish for details of this experiment to leave this room, as there are others who will be taking part in this experiment. In order to maintain an even playing field throughout all replications of this experiment, we want to give all participants access to the same information. If details of this experiment leave this room, other participants may have an unfair advantage by acquiring some of this information which is otherwise unavailable to these participants. Please honour this request as we attempt to maintain uniformity across replications. We ask that you do not discuss any details of this experiment for a period of two months.

I, the undersigned, agree to the above request.

____ Date:_________________________

Appendix D: Verification Sheet

This verifies the amount of money that I received for participating in an experiment on Monday, November 20, 2000.

Name	Amount Rec'd	Signature

Appendix E: Payoff Tables

Payoff Table - Level 1

(dollars per round)

Combined Token Sales of Other Players to Business Y

# Tokens You Sell to Bus.Y	0	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
0	1000	1240	1480	1720	1960	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
1	1007	1235	1490	1787	2051	2242	2253	2258	2259	2257	2252	2244	2234	2222	2210	2198	2185	2172	2159	2145	2132
2	1008	1224	1539	1870	2147	2290	2309	2318	2318	2312	2301	2284	2263	2238	2213	2189	2163	2137	2110	2084	2058
3	1003	1207	1615	1964	2248	2344	2368	2378	2376	2365	2345	2319	2286	2246	2211	2174	2135	2095	2056	2016	1977
4	992	1184	1709	2066	2350	2402	2429	2438	2432	2414	2386	2348	2302	2250	2203	2152	2100	2047	1994	1942	1890
5	975	1290	1816	2173	2408	2464	2491	2497	2486	2460	2422	2372	2311	2248	2188	2124	2059	1993	1926	1861	1797
6	952	1417	1931	2282	2470	2528	2553	2555	2537	2502	2452	2389	2313	2240	2166	2090	2011	1931	1852	1774	1698
7	923	1555	2050	2392	2536	2593	2615	2611	2584	2539	2478	2400	2308	2226	2139	2048	1956	1863	1771	1680	1593
8	888	1698	2172	2500	2605	2659	2676	2664	2628	2572	2497	2404	2301	2205	2105	2001	1895	1789	1684	1581	1482
9	1090	1844	2295	2574	2675	2724	2735	2714	2668	2599	2509	2400	2287	2178	2064	1946	1827	1707	1590	1475	1366
10	1296	1991	2416	2650	2746	2789	2791	2761	2703	2621	2516	2389	2267	2144	2016	1885	1752	1620	1490	1364	1243
11	1495	2136	2535	2728	2817	2852	2845	2804	2733	2636	2514	2370	2241	2104	1962	1817	1671	1526	1384	1246	1116
12	1687	2279	2651	2807	2888	2913	2896	2843	2758	2645	2506	2351	2208	2057	1901	1742	1583	1425	1271	1123	983
13	1873	2417	2740	2886	2957	2972	2943	2876	2777	2647	2489	2326	2168	2003	1833	1661	1489	1319	1153	995	845
14	2051	2551	2831	2965	3024	3028	2986	2905	2789	2642	2465	2294	2122	1942	1759	1573	1388	1206	1029	861	702
15	2222	2679	2921	3042	3089	3080	3024	2927	2795	2629	2432	2265	2069	1875	1677	1478	1281	1087	900	721	555
16	2385	2801	3010	3117	3151	3128	3057	2944	2793	2608	2401	2210	2009	1801	1589	1377	1167	962	764	577	440
17	2539	2907	3098	3190	3210	3171	3084	2954	2785	2578	2364	2168	1942	1720	1495	1270	1047	831	624	428	330
18	2686	3011	3183	3260	3264	3210	3106	2957	2768	2540	2321	2099	1869	1633	1394	1156	922	695	478	274	220
19	2823	3113	3266	3326	3314	3243	3121	2953	2743	2493	2270	2034	1789	1538	1286	1035	790	559	327	116	110
20	2951	3212	3346	3389	3360	3271	3130	2942	2710	2452	2213	1961	1701	1437	1171	909	652	405	172	0	0

payoffs increase as you sell more tokens to Business Y

payoffs decrease as you sell more tokens to Business Y

Appendix E: Payoff Tables

Payoff Table - Level 2

(dollars per round)

Combined Token Sales of Other Players to Business Y

# Tokens You Sell to Bus.Y	0	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
0	1000	1240	1480	1720	1960	2200	2440	2680	2920	2980	2980	2980	2980	2980	2980	2980	2980	2980	2980	2980	2980
1	1007	1235	1497	1802	2073	2328	2574	2814	3049	3053	3054	3051	3046	3039	3029	3017	3002	2989	2974	2958	2941
2	1008	1224	1557	1903	2195	2460	2709	2947	3121	3127	3126	3120	3109	3093	3072	3047	3018	2990	2960	2928	2894
3	1003	1207	1647	2020	2325	2596	2844	3077	3195	3201	3198	3187	3168	3142	3109	3070	3027	2984	2938	2889	2839
4	992	1198	1760	2147	2461	2733	2978	3204	3270	3275	3268	3251	3223	3186	3140	3085	3029	2970	2907	2842	2775
5	975	1324	1889	2284	2600	2870	3110	3327	3346	3348	3336	3311	3274	3224	3164	3092	3023	2948	2869	2787	2702
6	952	1470	2030	2426	2741	3007	3240	3404	3421	3419	3401	3367	3319	3256	3180	3095	3010	2919	2823	2723	2621
7	923	1630	2179	2572	2883	3143	3366	3482	3496	3489	3463	3419	3359	3282	3189	3090	2989	2881	2768	2651	2530
8	916	1800	2335	2721	3025	3276	3488	3560	3570	3556	3521	3466	3392	3300	3190	3077	2960	2835	2704	2569	2432
9	1151	1976	2494	2871	3166	3406	3605	3638	3642	3621	3576	3508	3420	3311	3182	3057	2923	2781	2632	2480	2324
10	1383	2156	2656	3022	3305	3533	3687	3715	3712	3682	3625	3545	3441	3314	3171	3029	2878	2718	2552	2381	2207
11	1613	2339	2819	3171	3442	3655	3769	3791	3780	3739	3670	3575	3454	3309	3152	2993	2824	2647	2462	2274	2082
12	1840	2522	2982	3318	3574	3772	3850	3865	3845	3792	3710	3599	3460	3295	3126	2950	2762	2567	2364	2157	1948
13	2063	2705	3143	3463	3702	3883	3930	3937	3906	3840	3743	3615	3458	3272	3091	2897	2692	2478	2257	2032	1805
14	2283	2887	3302	3604	3826	3969	4009	4005	3963	3884	3770	3625	3448	3247	3049	2837	2613	2380	2141	1898	1653
15	2499	3066	3458	3740	3944	4055	4086	4071	4015	3921	3791	3627	3428	3215	2998	2768	2525	2274	2017	1755	1493
16	2710	3242	3611	3872	4055	4140	4160	4133	4063	3953	3805	3620	3400	3174	2939	2690	2429	2159	1883	1604	1324
17	2916	3415	3759	3999	4160	4223	4231	4190	4105	3978	3811	3605	3362	3126	2872	2603	2323	2035	1740	1443	1146
18	3117	3583	3902	4119	4252	4303	4298	4243	4142	3996	3809	3581	3324	3069	2796	2508	2209	1902	1589	1274	960
19	3313	3746	4039	4233	4342	4381	4362	4291	4172	4007	3799	3548	3278	3003	2711	2404	2085	1760	1429	1096	765
20	3503	3903	4170	4339	4430	4455	4421	4333	4196	4011	3780	3505	3223	2929	2617	2291	1954	1609	1260	910	562

payoffs increase as you sell more tokens to Business Y

payoffs decrease as you sell more tokens to Business Y

Appendix E: Payoff Tables

Payoff Table - Level 3

(dollars per round)

Combined Token Sales of Other Players to Business Y

# Tokens You Sell to Bus.Y	0	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
0	1000	1240	1480	1720	1960	2200	2440	2680	2920	3160	3400	3640	3700	3700	3700	3700	3700	3700	3700	3700	3700
1	1007	1235	1465	1780	2060	2325	2580	2828	3072	3312	3548	3780	3782	3782	3778	3772	3763	3752	3739	3723	3707
2	1008	1224	1498	1864	2175	2458	2725	2979	3224	3462	3692	3862	3865	3862	3854	3840	3822	3798	3770	3739	3705
3	1003	1207	1567	1968	2302	2600	2874	3132	3377	3610	3833	3945	3947	3940	3926	3904	3874	3837	3793	3746	3694
4	992	1184	1663	2088	2439	2747	3027	3286	3528	3756	3970	4029	4028	4017	3995	3963	3921	3869	3809	3745	3674
5	975	1165	1779	2222	2584	2899	3181	3440	3678	3898	4102	4112	4108	4090	4060	4017	3961	3894	3817	3735	3644
6	952	1294	1913	2365	2735	3054	3338	3593	3825	4037	4187	4195	4186	4161	4120	4065	3995	3910	3817	3715	3605
7	923	1443	2060	2518	2892	3213	3495	3745	3970	4171	4273	4276	4261	4227	4176	4107	4021	3917	3808	3687	3555
8	888	1605	2217	2677	3053	3373	3651	3896	4111	4300	4358	4356	4334	4290	4226	4142	4039	3918	3790	3648	3494
9	865	1779	2383	2843	3218	3535	3807	4044	4248	4424	4442	4434	4403	4348	4270	4170	4049	3911	3762	3600	3424
10	1091	1961	2556	3012	3384	3696	3962	4188	4381	4512	4525	4510	4468	4401	4308	4191	4050	3895	3726	3541	3342
11	1318	2151	2734	3185	3552	3857	4114	4330	4509	4600	4606	4582	4529	4448	4339	4204	4042	3869	3679	3472	3249
12	1548	2345	2916	3360	3720	4017	4264	4467	4631	4687	4685	4650	4585	4489	4363	4208	4028	3835	3622	3392	3145
13	1778	2544	3102	3536	3888	4175	4410	4599	4746	4772	4761	4715	4636	4524	4379	4204	4005	3790	3555	3301	3029
14	2010	2746	3289	3714	4055	4330	4552	4725	4837	4855	4833	4775	4681	4551	4388	4190	3973	3736	3477	3199	2902
15	2242	2950	3478	3890	4220	4483	4690	4846	4927	4935	4902	4830	4720	4572	4387	4166	3931	3671	3389	3085	2762
16	2474	3155	3667	4066	4383	4631	4822	4961	5015	5013	4967	4880	4752	4584	4377	4137	3880	3596	3289	2960	2610
17	2705	3360	3855	4241	4543	4776	4949	5068	5101	5087	5027	4924	4777	4588	4358	4099	3818	3510	3178	2823	2447
18	2936	3566	4043	4413	4699	4915	5070	5162	5185	5157	5082	4961	4795	4584	4330	4051	3746	3414	3055	2674	2271
19	3166	3770	4229	4582	4852	5049	5184	5255	5265	5223	5132	4992	4804	4570	4290	3993	3664	3306	2921	2512	2082
20	3394	3973	4413	4748	4999	5178	5291	5344	5341	5284	5175	5015	4805	4547	4246	3924	3570	3186	2775	2338	1880

(light shading) payoffs increase as you sell more tokens to Business Y

(dark shading) payoffs decrease as you sell more tokens to Business Y

Appendix E: Payoff Tables

Payoff Table - Level 4
(dollars per round)

Combined Token Sales of Other Players to Business Y

# Tokens You Sell to Bus.Y	0	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
0	1000	1240	1480	1720	1960	2200	2440	2680	2920	3160	3400	3640	3880	4120	4360	4600	4840	4840	4840	4840	4840
1	1007	1235	1463	1725	2020	2299	2567	2828	3084	3335	3582	3825	4065	4301	4534	4763	4933	4928	4920	4910	4896
2	1008	1224	1440	1762	2102	2413	2706	2986	3255	3515	3767	4011	4248	4479	4703	4921	5024	5013	4996	4973	4944
3	1003	1207	1411	1826	2203	2541	2855	3151	3431	3698	3953	4197	4430	4653	4867	5071	5113	5094	5066	5029	4983
4	992	1184	1428	1913	2320	2683	3014	3323	3612	3883	4140	4381	4609	4824	5025	5214	5198	5170	5130	5078	5013
5	975	1155	1505	2020	2453	2835	3182	3501	3796	4071	4327	4564	4785	4989	5177	5304	5281	5242	5188	5118	5034
6	952	1120	1605	2145	2599	2998	3357	3684	3984	4260	4513	4745	4957	5149	5322	5392	5359	5308	5238	5151	5046
7	923	1079	1727	2286	2757	3169	3538	3872	4175	4450	4699	4924	5125	5303	5459	5476	5432	5367	5281	5174	5048
8	888	1135	1866	2440	2925	3349	3725	4063	4367	4639	4883	5098	5287	5450	5588	5557	5501	5420	5316	5187	5039
9	847	1284	2021	2607	3103	3535	3917	4257	4560	4828	5064	5269	5444	5591	5675	5633	5563	5466	5341	5190	5018
10	800	1449	2189	2785	3289	3728	4113	4454	4753	5016	5242	5435	5595	5723	5759	5705	5619	5504	5358	5183	4986
11	747	1628	2369	2972	3483	3926	4313	4652	4947	5201	5417	5596	5739	5847	5839	5771	5669	5533	5364	5166	4943
12	843	1819	2560	3168	3683	4128	4515	4850	5139	5384	5588	5751	5876	5962	5915	5831	5710	5553	5360	5138	4886
13	1064	2021	2761	3371	3888	4334	4718	5049	5329	5564	5753	5900	6004	6047	5986	5885	5744	5564	5345	5097	4817
14	1293	2232	2970	3581	4099	4543	4923	5247	5518	5739	5913	6041	6124	6127	6051	5931	5769	5565	5321	5045	4784
15	1529	2453	3187	3797	4313	4754	5128	5444	5703	5911	6067	6175	6235	6203	6109	5970	5785	5555	5285	4980	4637
16	1772	2681	3410	4017	4531	4966	5333	5638	5885	6077	6215	6301	6336	6273	6161	6000	5791	5534	5237	4901	4526
17	2021	2915	3639	4242	4750	5179	5538	5831	6063	6237	6355	6418	6418	6338	6206	6022	5787	5501	5177	4809	4400
18	2276	3156	3873	4470	4972	5393	5740	6020	6236	6391	6487	6525	6495	6396	6243	6034	5772	5458	5104	4703	4260
19	2536	3402	4110	4701	5195	5605	5941	6206	6404	6539	6611	6623	6566	6448	6271	6037	5745	5403	5017	4583	4103
20	2801	3653	4351	4933	5418	5817	6138	6387	6566	6679	6726	6710	6632	6492	6290	6029	5707	5336	4917	4448	3931

payoffs increase as you sell more tokens to Business Y

payoffs decrease as you sell more tokens to Business Y

Appendix F: Experimental Forms

Form 1: Marketing Decision Card

Marketing Decision Card

Group # ________ Player # _______

Round # ________

Token Sales (must sum to 20):

Business X ________________ Business Y ________________

Form 2: Investment Potential Form (example)

Player 5 Round 1

Business Y Profits:	10,000
Your Share of Profits:	3,000
Periods Left Before You Retire: (including this period)	5
Current Amount Re-Invested:	0
Amount Required for Expansion:	26,000

Return Potential

Profits Refunded every round:

3	4	5	6	7	**Total**
210	210	210	210	210	1,050

Profits Re-invested every round:

3	4	5	6	7	**Total**
500	500	500	500	1,500	3,500

- if there is Expansion by Round 6

Appendix F: Experimental Forms

Form 3: Voting Decision Card

Voting Decision Card

Group # __________ Player # ________

Round # __________

Vote on one of the following two choices:

Refund / T-bill Re-Investment

____________________ ____________________

Form 4: Profit Share Decision Card

Profit Share Decision Card

Group # __________ Player # ________

Round # __________

Check one of the following two choices:

Refund / T-bill Re-Investment

____________________ ____________________

Appendix F: Experimental Forms

Form 5: Payout Card

Round 1	
Player # 3	Tokens
Business X	6
Business Y	14
Bus.Y Total	50
Payout	2,642
Profit Share	1,982
T-bill Returns	-
Your Re-inv	1,982
Total Re-inv	7,078

Form 6: Share Auction Status Card (examples)

Player 1	
Shares	10
Shares for sale	10
Minimum willingness	
to accept	2000
Market maximum	2265

Player 5	
Shares	10
Max. # of shares	14
Shares you can buy	4
Maximum willingness	
to pay	2177
Market minimum	2000

Appendix F: Experimental Forms

Form 7: Offer to Sell Card

Offer to Sell

Player # ________

# of Shares   Price / Share

________   ________

Form 8: Offer to Buy Card

Offer to Buy

Player # ________

# of Shares   Price / Share

________   ________

Form 9: Additional Share Offering Card

Additional Share Offering

Player # ________

# of Shares you want to buy

____

Appendix G: Overlapping Generations Structure

Player	Round 1	2	3	4	5	6	7	8	9	10	11	12
1	X											
2	X	X										
3	X	X	X									
4	X	X	X	X								
5	X	X	X	X	X							
6		X	X	X	X	X						
7			X	X	X	X	X					
8				X	X	X	X	X				
9					X	X	X	X	X			
10						X	X	X	X	X		
11							X	X	X	X	X	
12								X	X	X	X	X
13									X	X	X	X
14										X	X	X
15											X	X
16												X

X - Indicates player participation

* Under this structure, one player exits the game after each round and a new player joins the game for the next round.

Appendix H: Potential Earnings From Investments ($[1])

Refund	Period 1	Period 2	Period 3	Period 4	Period 5
Level 1	495.43	495.43	495.43	495.43	495.43
Total	495.43	990.86	1486.29	1981.72	2477.15
Level 2	793.83	793.83	793.83	793.83	793.83
Total	793.83	1587.66	2381.49	3175.32	3969.15
Level 3	1147.13	1147.13	1147.13	1147.13	1147.13
Total	1147.13	2294.26	3441.39	4588.52	5735.65
Level 4	1611.74	1611.74	1611.74	1611.74	1611.74
Total	1611.74	3223.47	4835.21	6446.94	8058.68
Re-Investment	**Period 1**	**Period 2**	**Period 3**	**Period 4**	**Period 5**
Level 1 - 2	0	0	0	0	4262.90
Total	0	0	0	0	4262.90
Level 2 - 3	0	0	0	0	5047.20
Total	0	0	0	0	5047.20
Level 3 - 4	0	0	0	0	6637.20
Total	0	0	0	0	6637.20

Appendix I: Data – NGC Treatment

Group	Round	Token Sales	Conditional Optimal	Optimal Path	Re-Investment	Optimal
1	1	50	50	50	7078	7078
1	2	50	50	50	12740	14155
1	3	50	50	50	18402	21233
1	4	50	50	50	25479	28310
1	5	50	50	60	32557	39650
1	6	58	60	60	41529	50991
1	7	58	60	60	48941	62331
1	8	52	60	60	57333	73672
1	9	54	60	70	65963	90059
1	10	56	60	70	74787	106447
1	11	70	70	70	91174	122834
1	12	70	70	70	107562	139222
2	1	50	50	50	7078	7078
2	2	50	50	50	14155	14155
2	3	50	50	50	21233	21233
2	4	50	50	50	28310	28310
2	5	60	60	60	39650	39650
2	6	58	60	60	50964	50991
2	7	60	60	60	62304	62331
2	8	60	60	60	73645	73672
2	9	70	70	70	90032	90059
2	10	70	70	70	106420	106447
2	11	70	70	70	122807	122834
2	12	70	70	70	139195	139222
3	1	50	50	50	7078	7078
3	2	50	50	50	14155	14155
3	3	50	50	50	21233	21233
3	4	50	50	50	28310	28310
3	5	60	60	60	32846	39650
3	6	60	60	60	39650	50991
3	7	60	60	60	46455	62331
3	8	58	60	60	55427	73672
3	9	60	60	70	66768	90059
3	10	56	60	70	77998	106447
3	11	62	70	70	84630	122834
3	12	62	70	70	84630	139222
4	1	50	50	50	7078	7078
4	2	50	50	50	12740	14155
4	3	50	50	50	19817	21233
4	4	50	50	50	26895	28310
4	5	60	60	60	35967	39650
4	6	60	60	60	45039	50991
4	7	60	60	60	56380	62331
4	8	60	60	60	64696	73672
4	9	60	60	70	76036	90059
4	10	70	70	70	92424	106447
4	11	70	70	70	101788	122834
4	12	70	70	70	115366	139222

Appendix J: Data – TC Treatment

Group	Round	Token Sales	Conditional Optimal	Optimal Path	Re-Investment	Optimal
5	1	56	50	50	6864	7078
5	2	41	50	50	13507	14155
5	3	47	50	50	20540	21233
5	4	54	50	50	27502	28310
5	5	55	60	60	27502	39650
5	6	56	60	60	27502	50991
5	7	71	60	60	27502	62331
5	8	64	60	60	38718	73672
5	9	68	60	70	49676	90059
5	10	53	60	70	60684	106447
5	11	63	60	70	71955	122834
5	12	71	70	70	71955	139222
6	1	45	50	50	6946	7078
6	2	62	50	50	13420	14155
6	3	59	50	50	20127	21233
6	4	52	50	50	27173	28310
6	5	56	60	60	27173	39650
6	6	72	60	60	27173	50991
6	7	40	60	60	27173	62331
6	8	58	60	60	27173	73672
6	9	51	60	70	37972	90059
6	10	55	60	70	49141	106447
6	11	65	60	70	60286	122834
6	12	52	60	70	60286	139222
7	1	52	50	50	0	7078
7	2	50	50	50	0	14155
7	3	64	50	50	0	21233
7	4	60	50	50	0	28310
7	5	48	50	60	7060	39650
7	6	52	50	60	7060	50991
7	7	62	50	60	7060	62331
7	8	54	50	60	7060	73672
7	9	34	50	70	7060	90059
7	10	50	50	70	7060	106447
7	11	58	50	70	7060	122834
7	12	44	50	70	7060	139222
8	1	52	50	50	0	7078
8	2	50	50	50	0	14155
8	3	57	50	50	0	21233
8	4	44	50	50	0	28310
8	5	46	50	60	0	39650
8	6	66	50	60	0	50991
8	7	42	50	60	0	62331
8	8	50	50	60	0	73672
8	9	56	50	70	0	90059
8	10	53	50	70	0	106447
8	11	55	50	70	0	122834
8	12	62	50	70	0	139222

Appendix K: ANOVA Results

(From Section 5.1.1)

Table 1: Difference from Conditional Optimal in Overall Token Sales
(see Table 5.1)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	110.5104167	55.2552083	1.68459407	0.191130851
Residual	94	3083.229167	32.8003103		
Total	96	3193.739583			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dummy1	0.958333333	0.826643694	1.15930641	0.24926775	-0.682986264	2.599652931
Dummy2	-1.1875	0.826643694	-1.43653186	0.15417101	-2.828819598	0.453819598

Table 2: Difference from Conditional Optimal in Token Sales at each Level
(see Table 5.2)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	282.6935606	47.1155934	1.45665969	0.202329683
Residual	90	2911.046023	32.3449558		
Total	96	3193.739583			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dum1Level1	0	1.379363788	0	1	-2.740344714	2.740344714
Dum1Level2	1.5	1.271710577	1.17951366	0.24130226	-1.026472992	4.026472992
Dum1Level3	1.454545455	1.714774192	0.84824315	0.39855294	-1.952150033	4.861240942
Dum2Level1	-2.40625	1.005375487	-2.39338439	0.01877052	-4.403602275	-0.408897725
Dum2Level2	1.4	1.468444887	0.95338954	0.34294635	-1.517319724	4.317319724
Dum2Level3	-1	5.687262594	-0.17583152	0.86082133	-12.29873071	10.29873071

Table 3: Token Sales vs Conditional Optimal - t-test for Difference in Means
(see Table 5.3)

	TC Diff	*NGC Diff*
Mean	-1.1875	0.95833333
Variance	60.6662234	4.93439716
Observations	48	48
Pooled Variance	32.80031028	
Hypothesized Mean Difference	0	
df	94	
t Stat	-1.83553484	
P(T<=t) one-tail	0.034794152	
t Critical one-tail	1.661226179	
P(T<=t) two-tail	0.069588303	
t Critical two-tail	1.985522431	

Table 4: Token Sales vs Conditional Optimal - F-test for Difference in Variance
(see Table 5.3)

	TC Diff	*NGC Diff*
Mean	-1.1875	0.95833333
Variance	60.6662234	4.93439716
Observations	48	48
df	47	47
F	12.29455623	
P(F<=f) one-tail	5.94281E-15	
F Critical one-tail	1.623755352	

Appendix K: ANOVA Results

(From Section 5.1.2)

Table 5: Difference from Optimal Path in Overall Token Sales
(see Table 5.4)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	225.09375	112.546875	1.60600737	0.206202646
Residual	94	6587.395833	70.0786791		
Total	96	6812.489583			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dummy1	2.208333333	1.20829321	1.8276469	0.07077507	-0.190759938	4.607426604
Dummy2	5.270833333	1.20829321	4.36221382	3.2973E-05	2.871740062	7.669926604

Table 6: Difference from Optimal Path in Token Sales at each Level
(see Table 5.5)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	2821.552083	470.258681	10.6048469	7.36437E-09
Residual	90	3990.9375	44.34375		
Total	96	6812.489583			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dum1Level1	0	1.664777575	0	1	-3.307368563	3.307368563
Dum1Level2	1.625	1.664777575	0.97610637	0.33162815	-1.682368563	4.932368563
Dum1Level3	5	1.664777575	3.00340422	0.00345665	1.692631437	8.307368563
Dum2Level1	-2.8125	1.664777575	-1.68941488	0.0946015	-6.119868563	0.494868563
Dum2Level2	4.25	1.664777575	2.55289359	0.01236723	0.942631437	7.557368563
Dum2Level3	14.375	1.664777575	8.63478714	1.9787E-13	11.06763144	17.68236856

Table 7: Optimal Path vs Token Sales - t-test for Difference in Means
(see Table 5.6)

	TC Diff	*NGC Diff*
Mean	5.270833333	2.20833333
Variance	120.5421099	19.6152482
Observations	48	48
Pooled Variance	70.07867908	
Hypothesized Mean Difference	0	
df	94	
t Stat	1.792209457	
P(T<=t) one-tail	0.038158327	
t Critical one-tail	1.661226179	
P(T<=t) two-tail	0.076316655	
t Critical two-tail	1.985522431	

Table 8: Optimal Path vs Token Sales - F-test for Difference in Variance
(see Table 5.6)

	TC Diff	*NGC Diff*
Mean	5.270833333	2.20833333
Variance	120.5421099	19.6152482
Observations	48	48
df	47	47
F	6.145326765	
P(F<=f) one-tail	2.73812E-09	
F Critical one-tail	1.623755352	

Appendix K: ANOVA Results

(From Section 5.1.3)

Table 9: Absolute Difference from Conditional Optimal in Overall Token Sales
(see Table 5.7)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	688.0104167	344.005208	26.1151089	9.97257E-10
Residual	94	1238.229167	13.1726507		
Total	96	1926.239583			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dummy1	0.958333333	0.523860881	1.82936609	0.07051498	-0.081804197	1.998470864
Dummy2	6.3125	0.523860881	12.0499549	9.0126E-21	5.272362469	7.352637531

Table 10: Absolute Difference from Conditional Optimal in Token Sales at each Level
(see Table 5.8)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	752.0602273	125.343371	9.60747892	3.9069E-08
Residual	90	1174.179356	13.0464373		
Total	96	1926.239583			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dum1Level1	0	0.876035095	0	1	-1.740395219	1.740395219
Dum1Level2	1.5	0.80766445	1.85720691	0.06655228	-0.10456511	3.10456511
Dum1Level3	1.454545455	1.089054523	1.33560389	0.18504668	-0.709049698	3.618140607
Dum2Level1	6.09375	0.638514812	9.54363138	2.5406E-15	4.8252299	7.3622701
Dum2Level2	7.133333333	0.932610576	7.64878023	2.1459E-11	5.280541137	8.986125529
Dum2Level3	1	3.611985228	0.27685606	0.78252549	-6.175833319	8.175833319

Table 11: Token Sales vs Conditional Optimal - t-test for Difference in Means
(see Table 5.9)

	TC Abs.Diff	*NGC Abs.Diff*
Mean	6.3125	0.95833333
Variance	21.41090426	4.93439716
Observations	48	48
Pooled Variance	13.17265071	
Hypothesized Mean Difference	0	
df	94	
t Stat	7.22704766	
P(T<=t) one-tail	6.44487E-11	
t Critical one-tail	1.661226179	
P(T<=t) two-tail	1.28897E-10	
t Critical two-tail	1.985522431	

Table 12: Token Sales vs Conditional Optimal - F-test for Difference in Variance
(see Table 5.9)

	TC Abs.Diff	*NGC Abs.Diff*
Mean	6.3125	0.95833333
Variance	21.41090426	4.93439716
Observations	48	48
df	47	47
F	4.339112469	
P(F<=f) one-tail	7.75882E-07	
F Critical one-tail	1.623755352	

Appendix K: ANOVA Results

(From Section 5.2.1)

Table 13: Difference from Conditional Optimal in Overall Re-Investments
(see Table 5.10)

ANOVA

	df	SS	MS	F	Significance F
Regression	2	388164437	194082218	13.6354584	6.41192E-06
Residual	94	1337962248	14233640.9		
Total	96	1726126685			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dummy1	-1679.87793	544.549526	-3.08489467	0.00267426	-2761.093228	-598.6626313
Dummy2	-5701.509217	544.549526	-10.470139	1.8491E-17	-6782.724515	-4620.293918

Table 14: Difference from Conditional Optimal in Re-Investments at each Level
(see Table 5.11)

ANOVA

	df	SS	MS	F	Significance F
Regression	6	580359070	96726511.7	7.59786359	1.34431E-06
Residual	90	1145767615	12730751.3		
Total	96	1726126685			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dum1Level1	-249.7058824	865.3714361	-0.28855341	0.77358669	-1968.915899	1469.504134
Dum1Level2	-2020.649548	797.8330427	-2.53267218	0.01305215	-3605.682866	-435.6162297
Dum1Level3	-3270.559062	1075.797855	-3.04012417	0.00309665	-5407.817551	-1133.300572
Dum2Level1	-5148.307375	630.7424019	-8.16229789	1.8857E-12	-6401.386238	-3895.228512
Dum2Level2	-6169.267093	921.2582439	-6.6965665	1.7871E-09	-7999.505919	-4339.028268
Dum2Level3	-16387.6	3568.017836	-4.59291426	1.4152E-05	-23476.08449	-9299.115509

Table 15: Re-Investments vs Conditional Optimal - t-test for Difference in Means
(see Table 5.12)

	TC Diff	NGC Diff
Mean	-5701.509217	-1679.87793
Variance	18947689.2	9519592.68
Observations	48	48
Pooled Variance	14233640.94	
Hypothesized Mean Difference	0	
df	94	
t Stat	-5.222156331	
P(T<=t) one-tail	5.28749E-07	
t Critical one-tail	1.661226179	
P(T<=t) two-tail	1.0575E-06	
t Critical two-tail	1.985522431	

Table 16: Re-Investments vs Conditional Optimal - F-test for Difference in Variance
(see Table 5.12)

	TC Diff	NGC Diff
Mean	-5701.509217	-1679.87793
Variance	18947689.2	9519592.68
Observations	48	48
df	47	47
F	1.990388647	
P(F<=f) one-tail	0.010049024	
F Critical one-tail	1.623755352	

Appendix K: ANOVA Results

(From Section 5.2.2)

Table 17: Difference from Optimal Path in Overall Re-Investments
(see Table 5.13)

ANOVA

	df	SS	MS	F	Significance F
Regression	2	984663977.5	492331989	23.4552669	5.65474E-09
Residual	94	1973083789	20990253.1		
Total	96	2957747766			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dummy1	-2294.438346	661.2843103	-3.46967002	0.00078841	-3607.433178	-981.4435152
Dummy2	-8699.72255	661.2843103	-13.1557976	4.9118E-23	-10012.71738	-7386.727719

Table 18: Difference from Optimal Path in Re-Investments at each Level
(see Table 5.14)

ANOVA

	df	SS	MS	F	Significance F
Regression	6	1749477389	291579565	21.7187819	1.43163E-15
Residual	90	1208270378	13425226.4		
Total	96	2957747766			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Dum1Level1	-265.3125	916.0112724	-0.2896389	0.77275871	-2085.127309	1554.502309
Dum1Level2	-2458.669177	916.0112724	-2.68410362	0.00865615	-4278.483986	-638.8543674
Dum1Level3	-4159.333363	916.0112724	-4.54070107	1.7319E-05	-5979.148172	-2339.518554
Dum2Level1	-3660.36475	916.0112724	-3.99598221	0.00013158	-5480.179559	-1840.549941
Dum2Level2	-10198.13	916.0112724	-11.1331927	1.3057E-18	-12017.94481	-8378.315191
Dum2Level3	-12240.6729	916.0112724	-13.3630156	4.3974E-23	-14060.48771	-10420.85809

Table 19: Re-Investments vs Optimal Path - t-test for Difference in Means
(see Table 5.15)

	TC Diff	NGC Diff
Mean	-8699.72255	-2294.43835
Variance	30712372.65	11268133.5
Observations	48	48
Pooled Variance	20990253.07	
Hypothesized Mean Difference	0	
df	94	
t Stat	-6.849126504	
P(T<=t) one-tail	3.80234E-10	
t Critical one-tail	1.661226179	
P(T<=t) two-tail	7.60467E-10	
t Critical two-tail	1.985522431	

Table 20: Re-Investments vs Optimal Path - F-test for Difference in Variance
(see Table 5.15)

	TC Diff	NGC Diff
Mean	-8699.72255	-2294.43835
Variance	30712372.65	11268133.5
Observations	48	48
df	47	47
F	2.725595384	
P(F<=f) one-tail	0.000402097	
F Critical one-tail	1.623755352	

Appendix L: Charts

Chart 1: Token Sales To Business Y

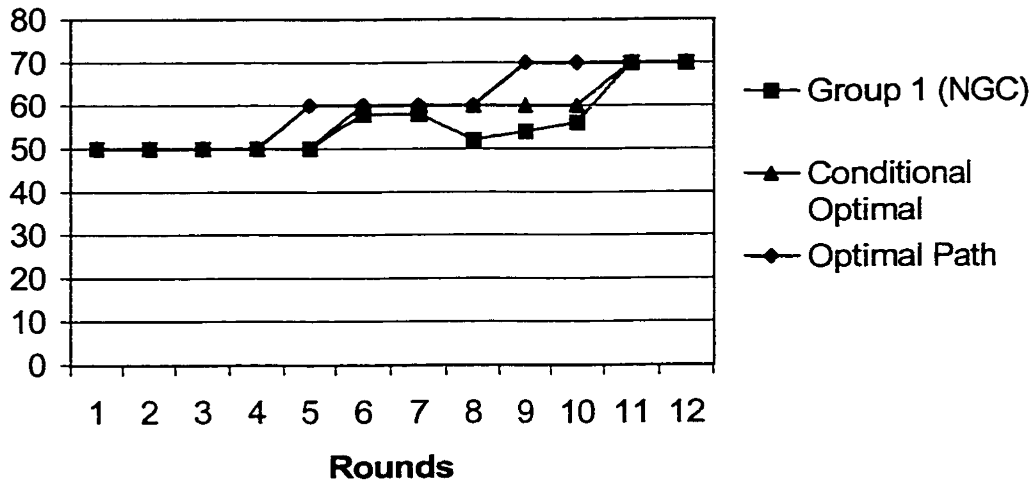
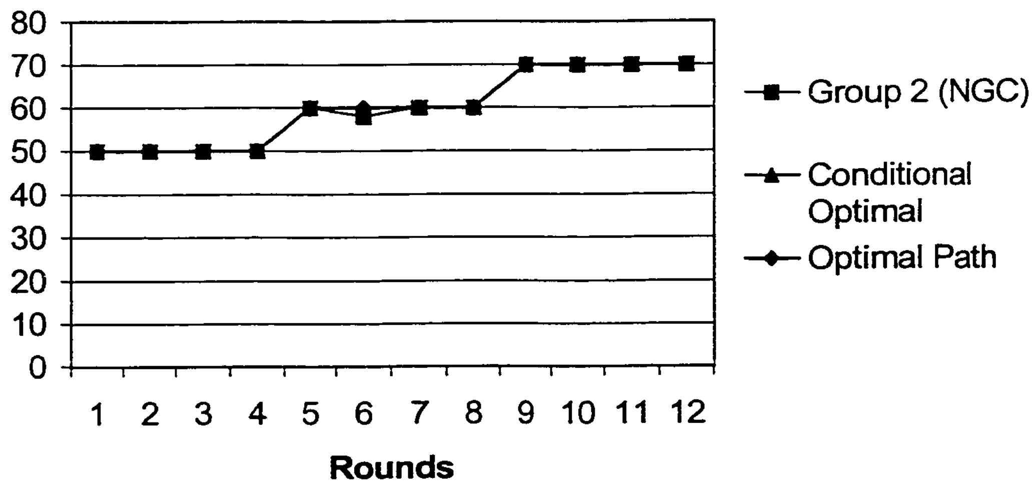


Chart 2: Token Sales To Business Y



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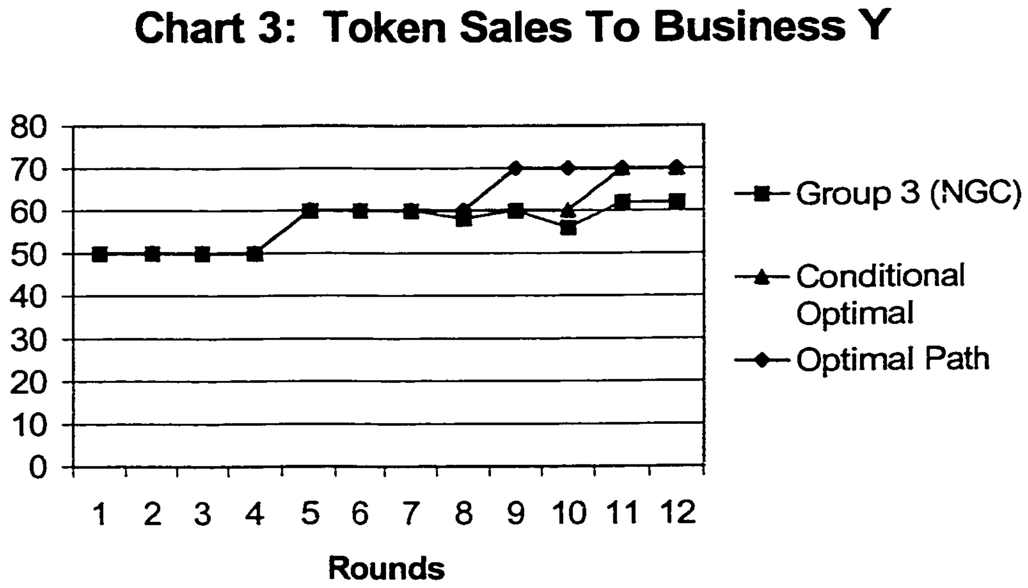

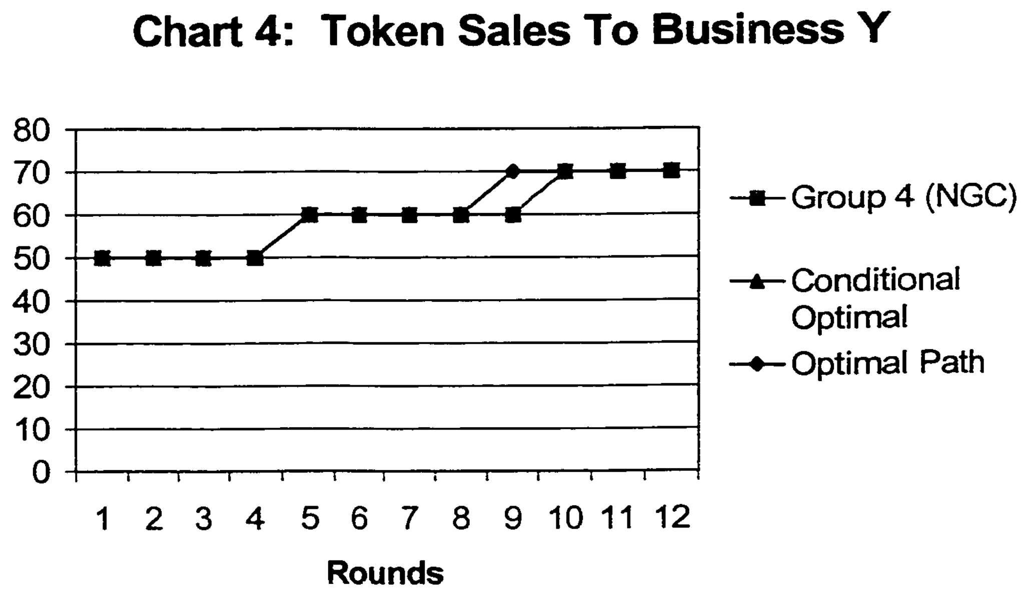

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Chart 5: Token Sales To Business Y

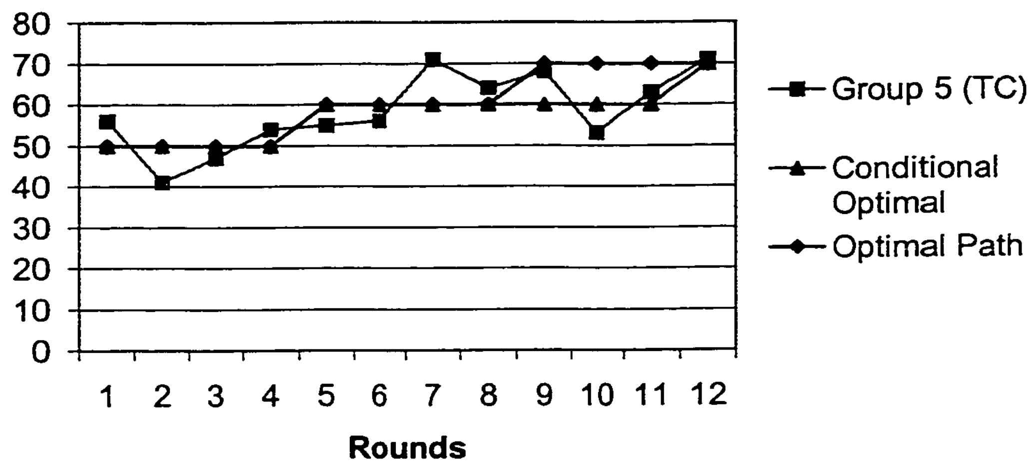

Chart 6: Token Sales To Business Y

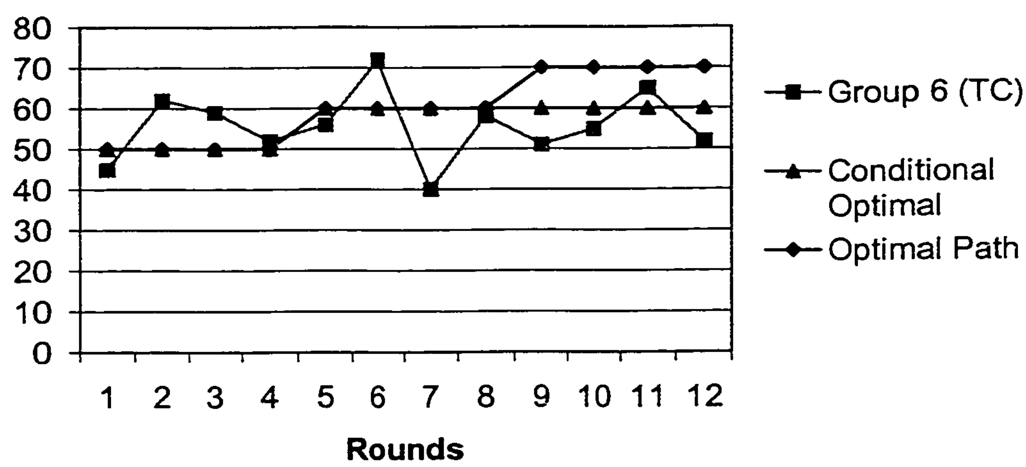

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Chart 7: Token Sales to Business Y

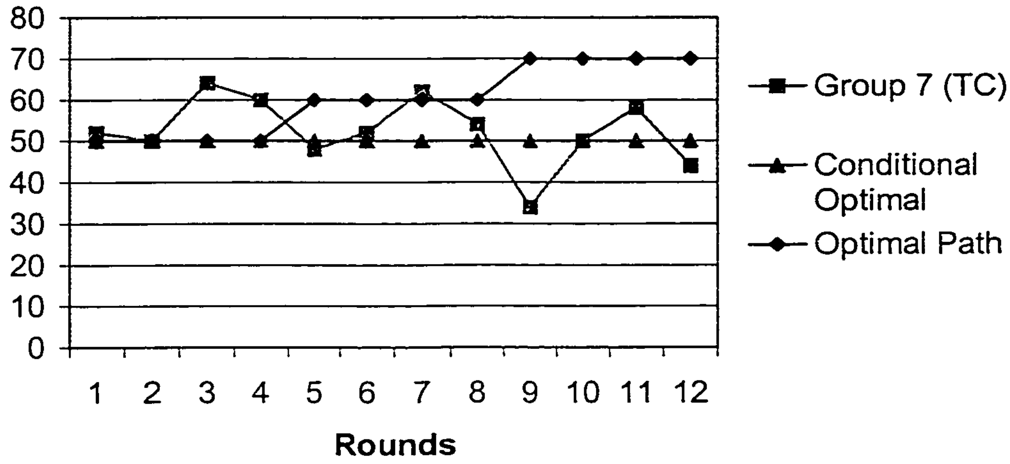

Chart 8: Token Sales to Business Y

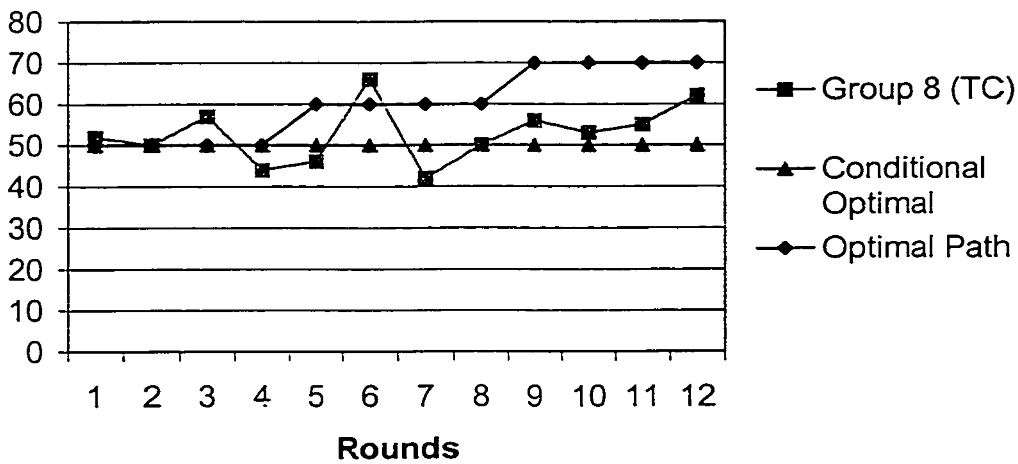

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Chart 9: Average Token Sales to Business Y

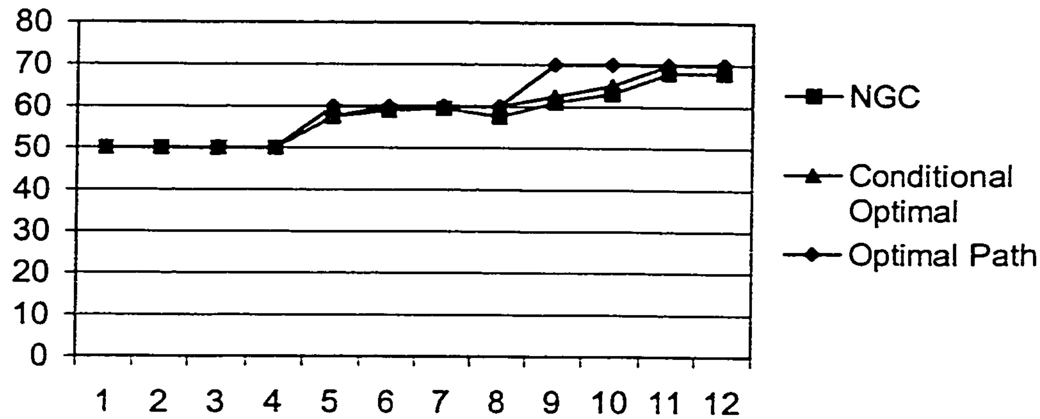
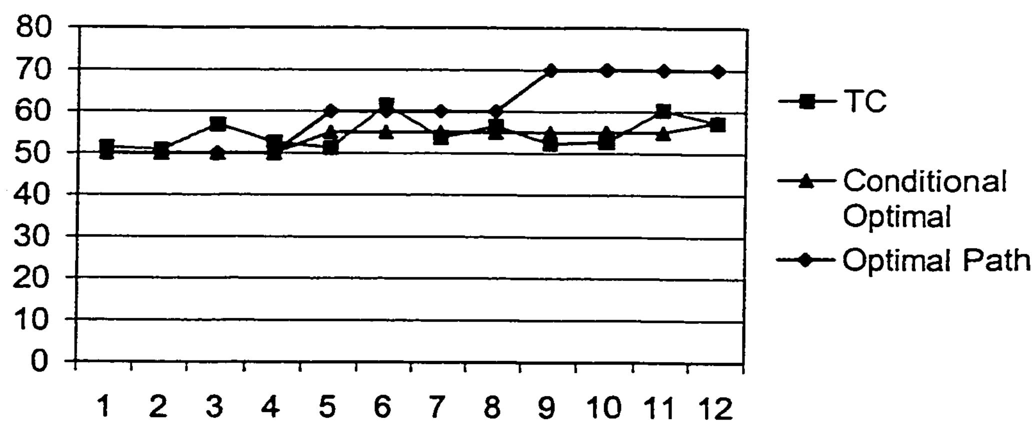


Chart 10: Average Token Sales to Business Y



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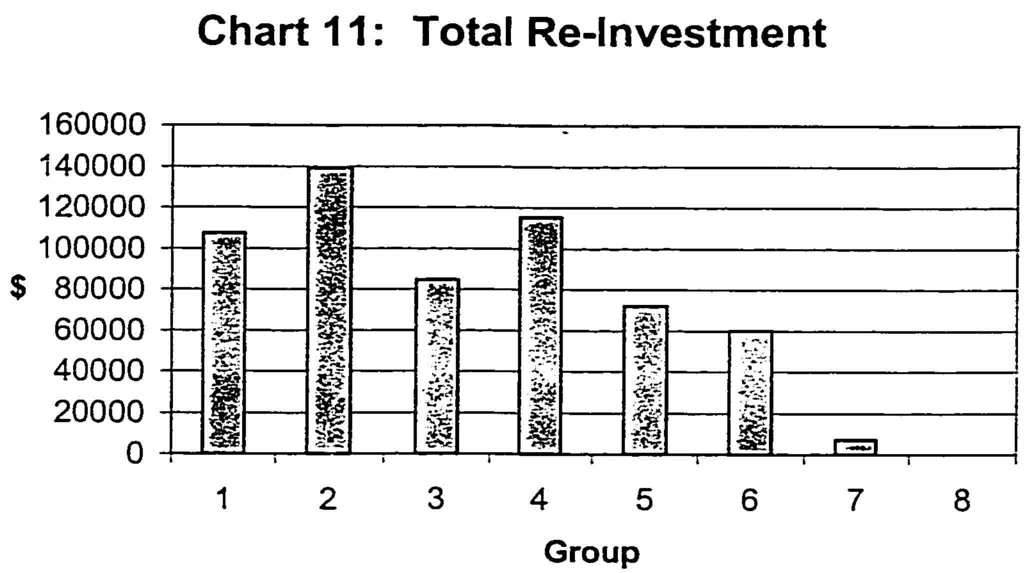
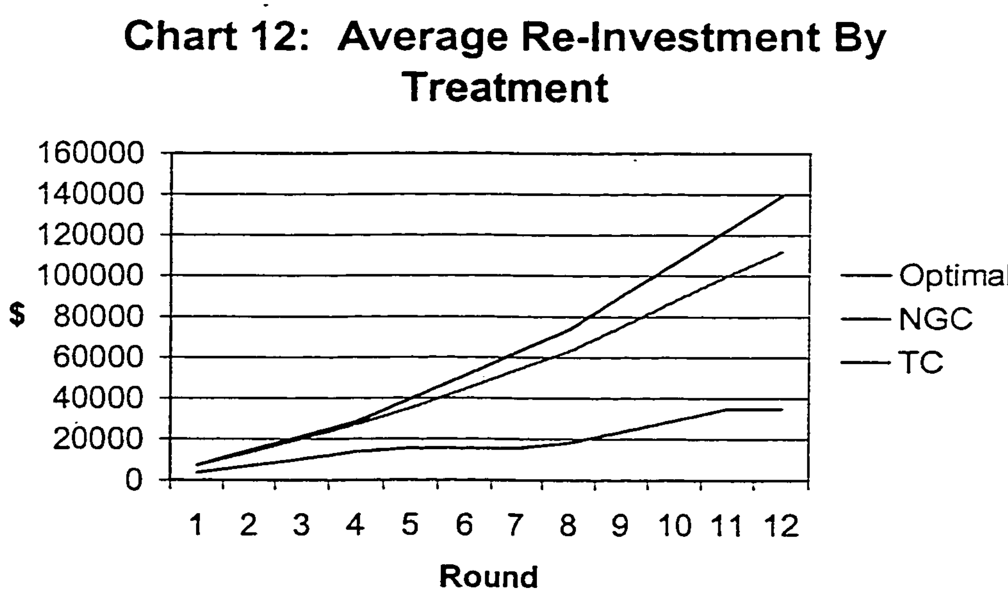




Appendix L: Charts

Chart 13: Token Sales - Difference From Conditional Optimal

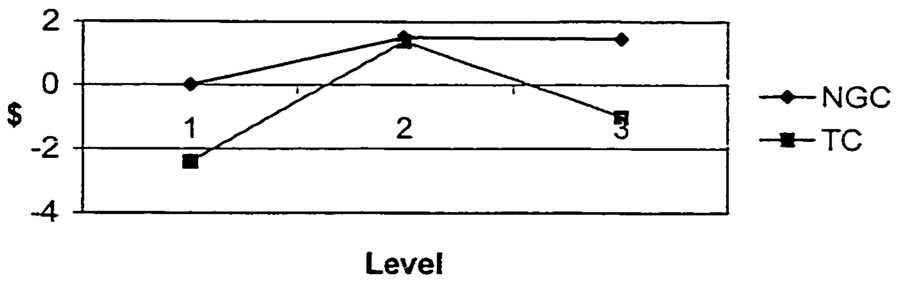


Chart 14: Token Sales - Difference From Optimal Path

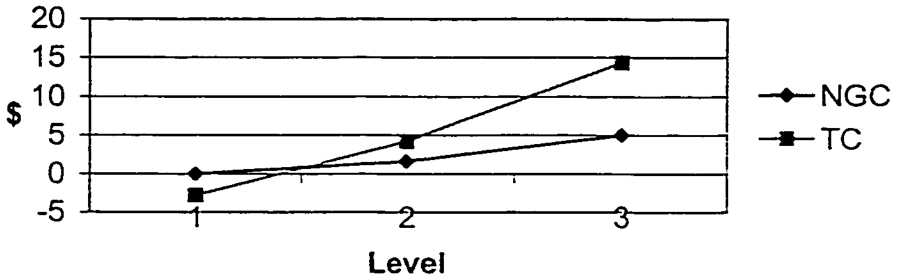
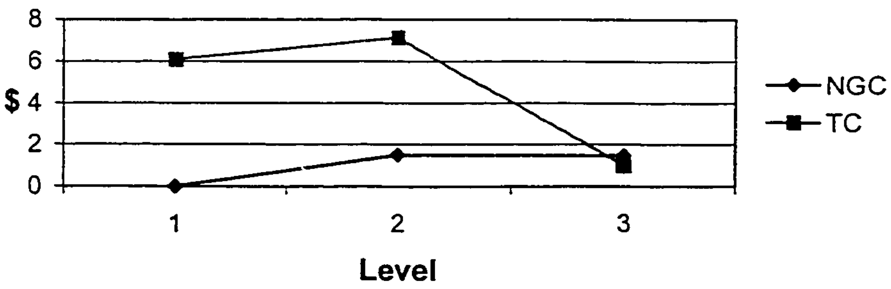


Chart 15: Token Sales - Absolute Difference From Conditional Optimal



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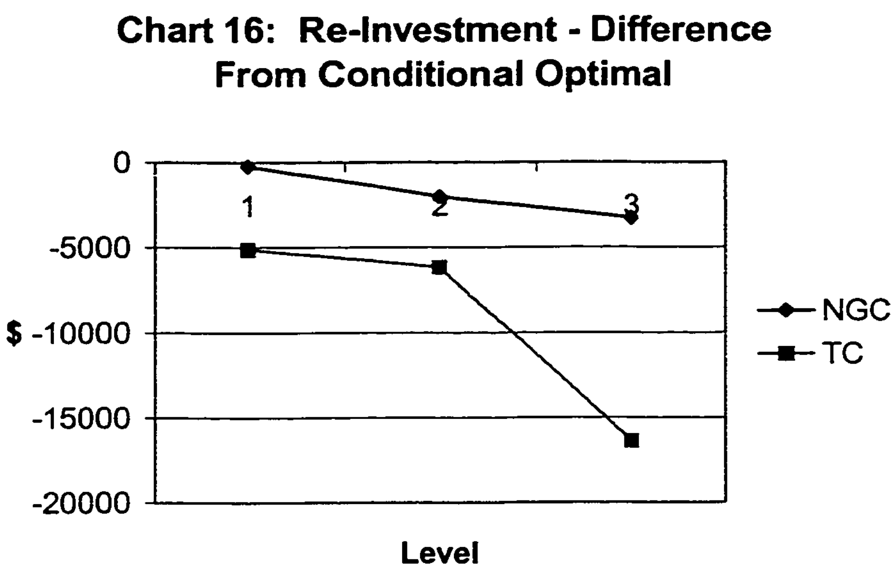
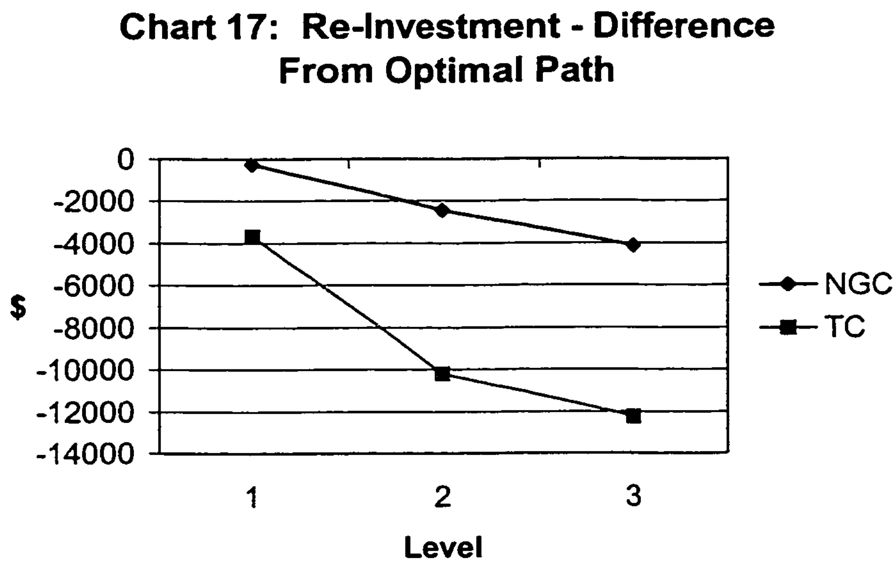




Appendix L: Charts

Chart 18: Average Irrational Actions By Group

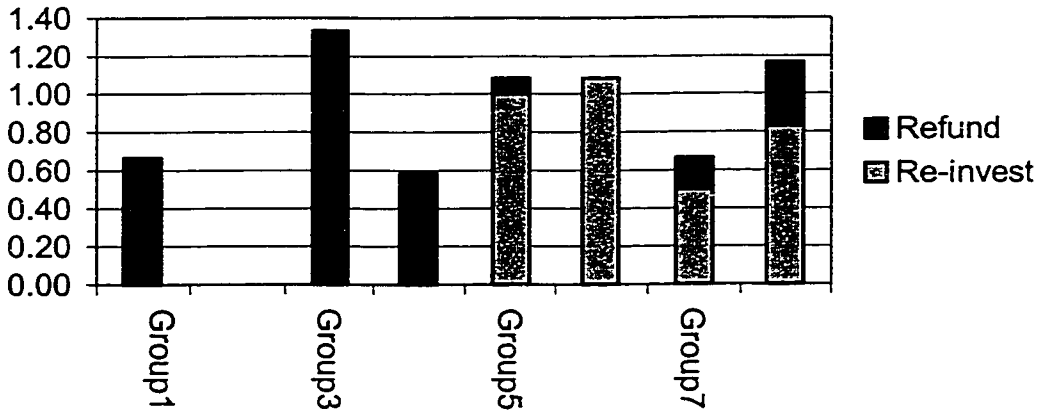
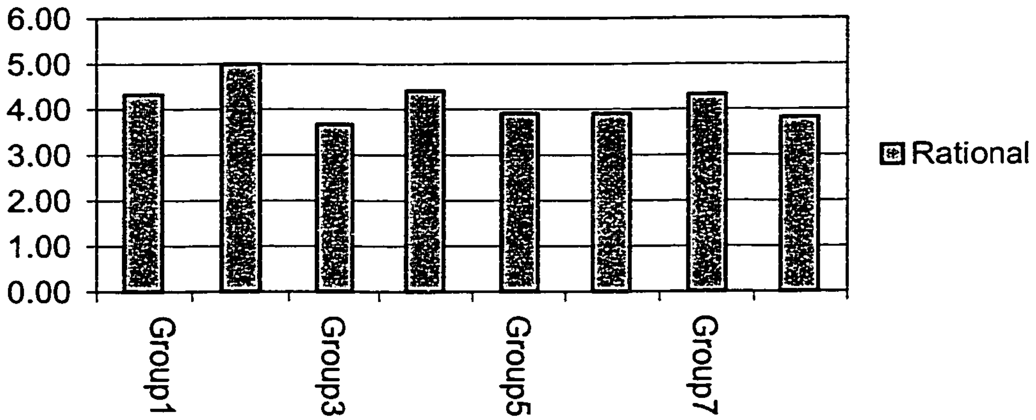
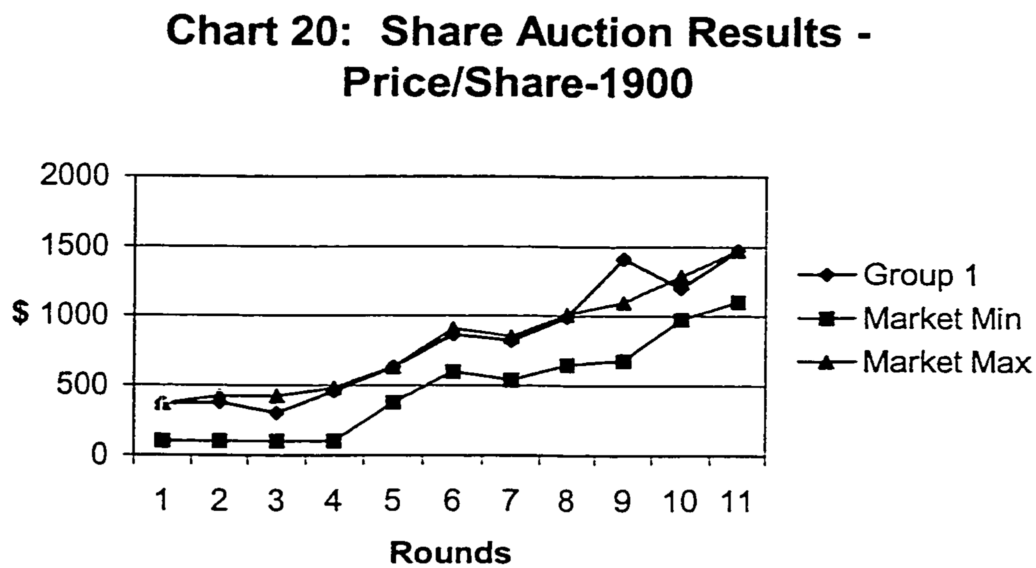
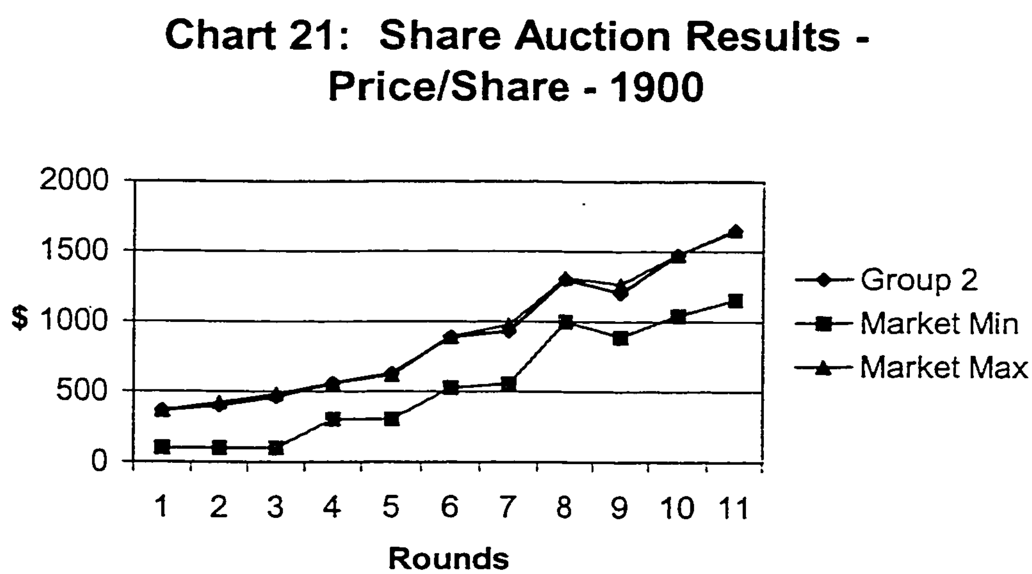


Chart 19: Average Rational Actions By Group



Appendix L: Charts





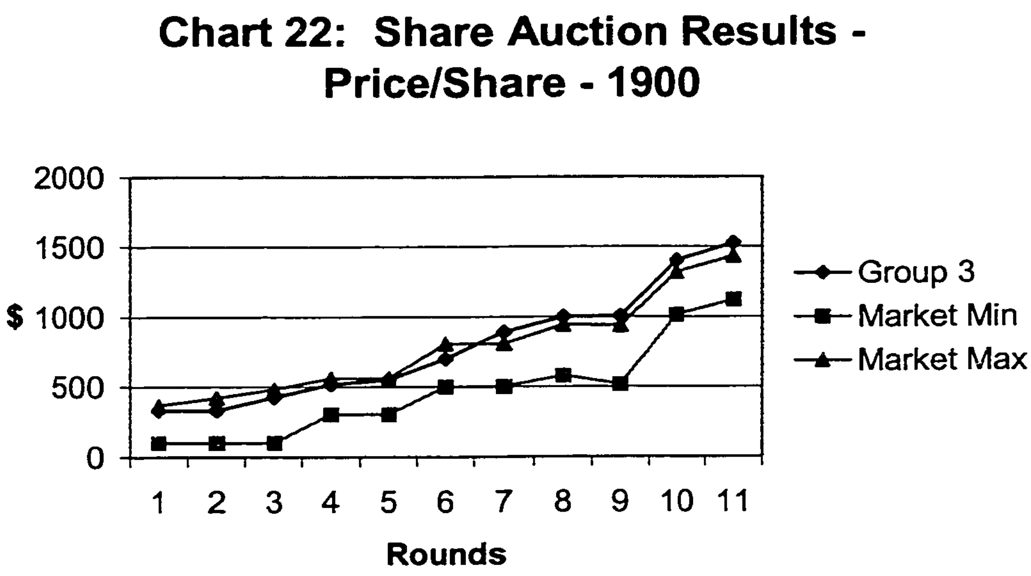


Chart 22: Share Auction Results - Price/Share - 1900
2000
1500
$ 1000
500
0
1 2 3 4 5 6 7 8 9 10 11
Rounds
Group 3
Market Min
Market Max

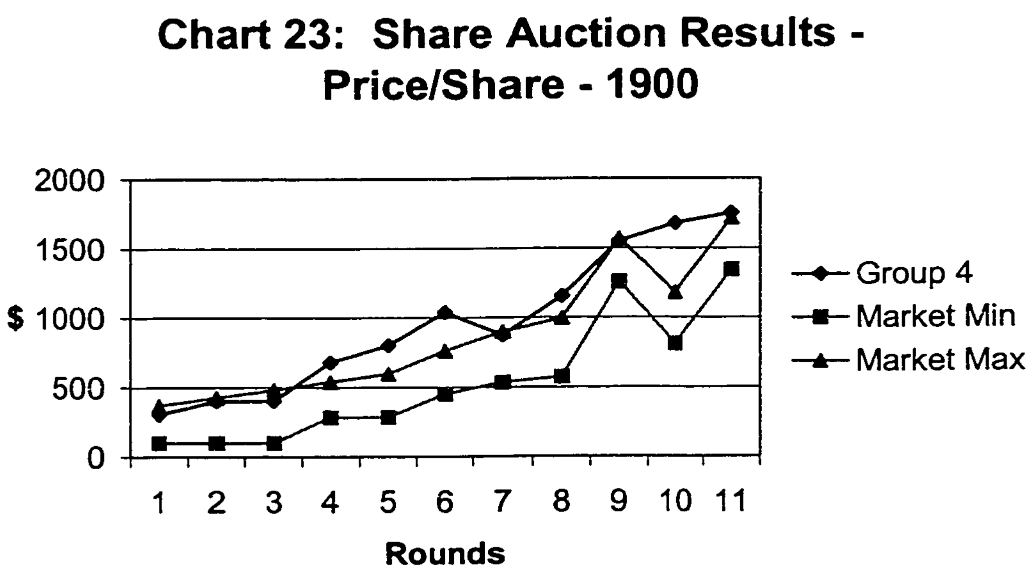


Chart 23: Share Auction Results - Price/Share - 1900
2000
1500
$ 1000
500
0
1 2 3 4 5 6 7 8 9 10 11
Rounds
Group 4
Market Min
Market Max

Chart 24: Average Share Auction Results

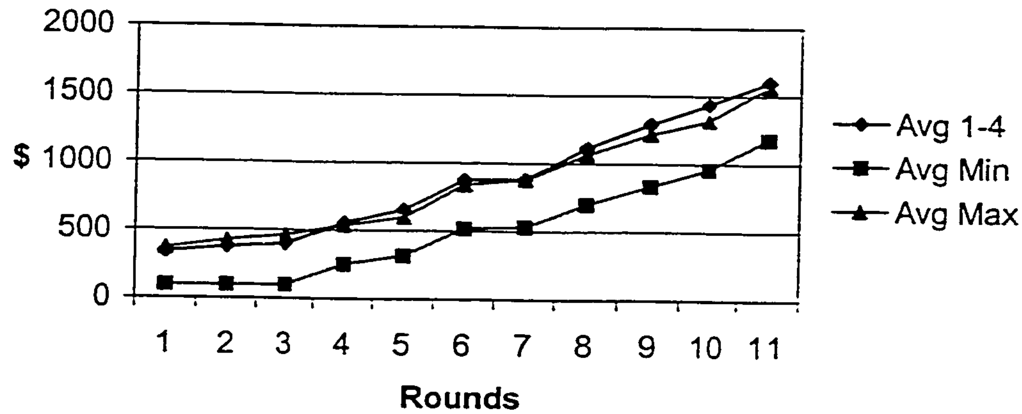
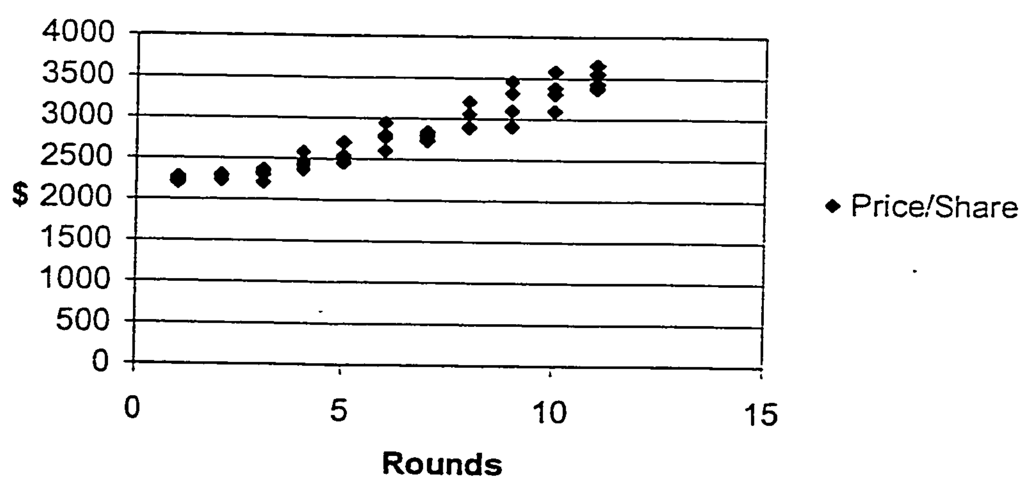


Chart 25: Price Per Share By Rounds



Appendix M: Marketing and Profit Share Decisions for NGC Treatment

Group 1

Round	1	inv	2	inv	3	inv	4	inv	5	inv	6	inv	7	inv	8	inv	9	inv	10	inv	11	inv	12	inv
P1	10	1																						
P2	10	1	10	1																				
P3	10	1	10	0	10	0																		
P4	10	1	10	1	10	1	10	1																
P5	10	1	10	1	10	1	10	1	10	1														
P6			10	1	10	1	10	1	10	1	12	0												
P7					10	1	14	1	14	1	16	1	16	1										
P8							6	1	6	1	8	1	8	0	8	1								
P9									10	1	12	1	12	0	12	0	12	0						
P10											10	1	12	1	12	1	12	1	12	0				
P11													10	1	10	1	12	1	14	1	18	1		
P12															10	1	10	1	10	1	14	1	14	1
P13																	8	1	8	1	10	1	10	1
P14																			12	1	14	1	14	1
P15																					14	1	14	1
P16																							18	1
Total	50	5	50	4	50	4	50	5	50	5	58	4	58	3	52	4	54	4	56	4	70	5	70	5
Re-Inv.		7078		12740		18402		25479		32557		8973		16385		24777		33406		42230		16388		32775

Group 2

Round	1	inv	2	inv	3	inv	4	inv	5	inv	6	inv	7	inv	8	inv	9	inv	10	inv	11	inv	12	inv
P1	10	1																						
P2	10	1	10	1																				
P3	10	1	10	1	10	1																		
P4	10	1	10	1	10	1	10	1																
P5	10	1	10	1	10	1	10	1	12	1														
P6			10	1	10	1	10	1	12	1	12	1												
P7					10	1	10	1	12	1	12	1	12	1										
P8							10	1	12	1	10	1	12	1	12	1								
P9									12	1	16	1	16	1	16	1	18	1						
P10											8	1	14	1	16	1	18	1	18	1				
P11													6	1	16	1	18	1	18	1	18	1		
P12															0	0	2	1	2	1	2	1	2	1
P13																	14	1	14	1	14	1	14	1
P14																			18	1	18	1	18	1
P15																					18	1	18	1
P16																							18	1
Total	50	5	50	5	50	5	50	5	60	5	58	5	60	5	60	4	70	5	70	5	70	5	70	5
Re-Inv.		7078		14155		21233		28310		11340		22654		33994		45335		16388		32775		49163		65550

* Under 'inv': 1 = re-invest profits, 0 = refund profits

Appendix M: Marketing and Profit Share Decisions for NGC Treatment

Group 3

Round	1	inv	2	inv	3	inv	4	inv	5	inv	6	inv	7	inv	8	inv	9	inv	10	inv	11	inv	12	inv
P1	10	1																						
P2	10	1	10	1																				
P3	10	1	10	1	10	1																		
P4	10	1	10	1	10	1	10	1																
P5	10	1	10	1	10	1	10	1	12	0														
P6			10	1	10	1	10	1	12	0	12	0												
P7					10	1	10	1	12	0	12	0	12	0										
P8							10	1	12	1	12	1	12	1	12	1								
P9									12	1	12	1	12	1	12	1	12	1						
P10											12	1	12	1	12	1	12	1	12	1				
P11													12	0	12	0	12	1	16	1	18	0		
P12															10	1	12	1	12	1	12	1	12	0
P13																	12	1	14	1	14	0	14	0
P14																			2	1	4	0	17	0
P15																					14	1	18	0
P16																							1	0
Total	50	5	50	5	50	5	50	5	60	2	60	3	60	3	58	4	60	5	56	5	62	2	62	0
Re-Inv.		7078		14155		21233		28310		4536		11340		18145		27117		38458		49688		6632		6632

Group 4

Round	1	inv	2	inv	3	inv	4	inv	5	inv	6	inv	7	inv	8	inv	9	inv	10	inv	11	inv	12	inv
P1	10	1																						
P2	10	1	10	0																				
P3	10	1	10	1	10	1																		
P4	10	1	10	1	10	1	10	1																
P5	10	1	10	1	10	1	10	1	12	1														
P6			10	1	10	1	10	1	12	0	12	0												
P7					10	1	10	1	12	1	12	1	12	1										
P8							10	1	16	1	16	1	16	1	16	1								
P9									8	1	8	1	16	1	16	1	16	1						
P10											12	1	16	1	16	0	16	1	16	1				
P11													0		12	1	12	1	18	1	18	0		
P12															0		16	1	18	1	18	1	18	1
P13																	0	0	4	1	4	1	4	1
P14																			14	1	18	1	18	1
P15																					12	0	12	0
P16																							18	1
Total	50	5	50	4	50	5	50	5	60	4	60	4	60	4	60	3	60	4	70	5	70	3	70	4
Re-Inv.		7078		12740		19817		26895		9072		18145		29485		37801		49142		16388		25752		39330

* Under 'inv': 1 = re-invest profits, 0 = refund profits

Appendix N: Marketing and Voting Decisions for TC Treatment

Group 5

Round	1	vote	2	vote	3	vote	4	vote	5	vote	6	vote	7	vote	8	vote	9	vote	10	vote	11	vote	12	vote
P1	18	0																						
P2	10	0	7	0																				
P3	10	1	10	1	8	0																		
P4	7	1	10	1	9	1	13	0																
P5	11	1	5	1	10	1	9	1	11	1														
P6			9	1	9	1	8	1	10	0	10	0												
P7					11	1	13	1	9	0	15	0	16	0										
P8							11	1	13	0	16	0	17	0	14	0								
P9									12	1	7	1	15	0	11	1	13	0						
P10											8	1	11	1	6	1	10	1	13	1				
P11													12	1	15	0	16	1	11	1	12	0		
P12															18	1	19	1	11	1	19	1	19	0
P13																	10	1	5	1	8	1	10	0
P14																			13	1	17	1	15	0
P15																					7	1	9	0
P16																							18	1
Total	56	3	41	4	47	4	54	4	55	2	56	2	71	2	64	3	68	4	53	5	63	4	71	1
Profit	6864		6643		7033		6961		11169		11231		10666		11216		10958		11008		11270		16387	
Re-Inv.		6864		13507		20540		27502		27502		27502		27502		38718		49676		60684		71955		71955

Group 6

Round	1	vote	2	vote	3	vote	4	vote	5	vote	6	vote	7	vote	8	vote	9	vote	10	vote	11	vote	12	vote
P1	9	1																						
P2	11	1	13	1																				
P3	12	1	11	1	14	1																		
P4	3	0	18	0	19	0	19	0																
P5	10	1	7	1	5	1	4	1	5	0														
P6			13	1	10	1	7	1	13	0	20	0												
P7					11	1	7	1	10	0	10	1	6	0										
P8							15	1	16	1	17	0	5	0	16	0								
P9									12	1	13	0	13	1	7	0	12	0						
P10											12	1	6	0	12	0	8	1	12	0				
P11													10	1	10	1	10	1	10	1	20	0		
P12															13	1	11	1	12	1	13	1	13	0
P13																	10	1	10	1	10	1	8	0
P14																			11	1	12	1	10	0
P15																					10	1	8	1
P16																							13	1
Total	45	4	62	4	59	4	52	4	56	2	72	2	40	2	58	2	51	4	55	4	65	4	52	2
Profit	6946		6474		6708		7045		11231		10545		8910		11313		10799		11169		11146		10910	
Re-Inv.		6946		13420		20127		27173		27173		27173		27173		27173		37972		49141		60286		60286

* Under 'vote': 1 = re-invest profits, 0 = refund profits

Appendix N: Marketing and Voting Decisions for TC Treatment

Group 7

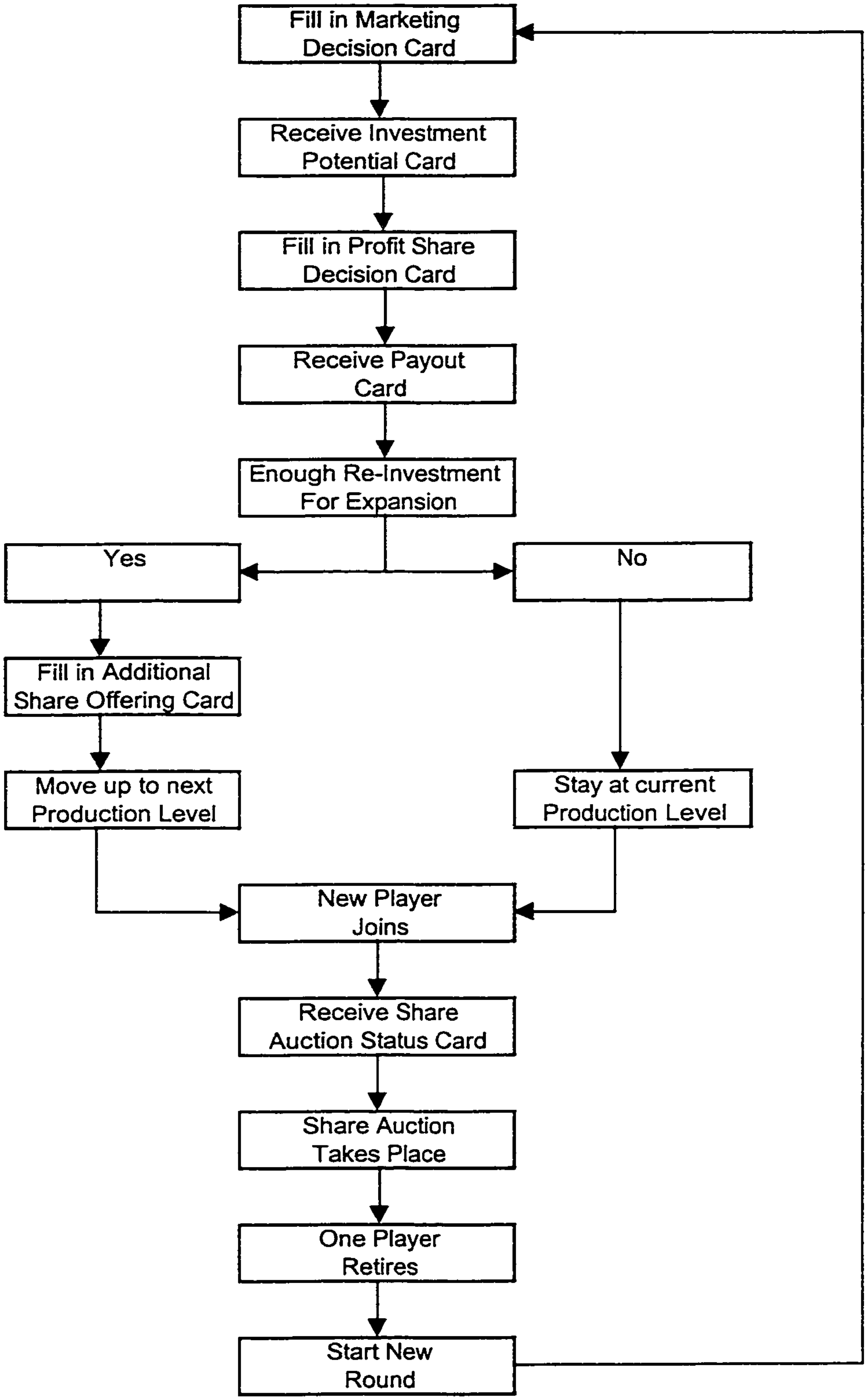
Round	1	vote	2	vote	3	vote	4	vote	5	vote	6	vote	7	vote	8	vote	9	vote	10	vote	11	vote	12	vote
P1	11	0																						
P2	6	0	14	0																				
P3	12	0	11	0	13	0																		
P4	8	0	9	0	13	0	10	0																
P5	15	1	5	1	16	1	12	0	8	0														
P6			11	1	12	0	12	0	10	0	10	0												
P7					10	1	13	1	12	1	9	0	13	0										
P8							13	1	11	1	16	0	17	0	17	0								
P9									7	1	7	1	6	0	5	0	6	0						
P10											10	1	14	1	8	1	8	0	9	0				
P11													12	1	17	0	8	0	19	0	20	0		
P12															7	1	6	1	8	0	7	0	6	0
P13																	6	1	7	1	8	0	6	0
P14																			7	1	7	1	6	0
P15																					16	1	15	1
P16																							11	0
Total	52	1	50	2	64	2	60	2	48	3	52	2	62	2	54	2	34	2	50	2	58	2	44	1
Profit	7045		7078		6276		6638		7060		7045		6474		6961		5750		7078		6768		6886	
Re-Inv.		0		0		0		0		7060		7060		7060		7060		7060		7060		7060		7060

Group 8

Round	1	vote	2	vote	3	vote	4	vote	5	vote	6	vote	7	vote	8	vote	9	vote	10	vote	11	vote	12	vote
P1	7	0																						
P2	15	0	14	0																				
P3	13	0	15	0	18	0																		
P4	10	1	8	0	9	0	7	0																
P5	7	1	7	0	6	0	7	0	5	0														
P6			6	1	7	0	5	0	6	0	9	0												
P7					17	1	14	1	10	0	14	1	7	1										
P8							11	1	10	1	12	1	8	0	12	0								
P9									15	1	18	0	10	0	10	0	16	0						
P10											13	0	6	0	12	0	12	0	12	0				
P11													11	1	10	0	11	0	10	0	10	0		
P12															6	1	9	1	8	0	8	0	9	0
P13																	8	0	13	1	17	1	19	0
P14																			10	0	10	0	10	0
P15																					10	1	8	1
P16																							16	0
Total	52	2	50	1	57	1	44	2	46	2	66	2	42	2	50	1	56	1	53	1	55	2	62	1
Profit	7045		7078		6821		6886		6995		6046		6734		7078		6864		7010		6899		6474	
Re-Inv.		0		0		0		0		0		0		0		0		0		0		0		0

* Under 'vote': 1 = re-invest profits, 0 = refund profits

Appendix O: Flow Chart for NGC Treatment



Appendix P: Flow Chart for TC Treatment