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Heterogeneity and Commitment to Collective Action: An Empirical Study of a New Zealand Dairy Co-operative

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Abstract: This paper presents and empirically tests a novel framework that links member heterogeneity with member commitment to collective action (CCA). Member heterogeneity was first decoupled into three dimensions – 1) farmer-member, 2) farm-business and 3) member-interest and was then linked to CCA and the two components that comprise it - 1) commitment to patronage (CP) and 2) commitment to governance (CG). Following which the framework was assessed by performing an empirical study of 568 members of Fonterra Co-operative Group. A total of 35 sources of heterogeneity, 9 farmer-member, 14 farm-business and 12 member-interest were used to measure heterogeneity. The study found that the membership base of this co-operative was heterogeneous because a high level of heterogeneity was found in all three dimensions - farmer-member (66%), farm-business (64%) and member-interest (83%). Moreover, as the CCA level was also high, it tends to suggest that high heterogeneity does not lead to low commitment to collective action. Several of the 35 sources showed a significant difference in CCA (n = 18), CG (n = 20) and CP (n = 12) between groups that comprised them. Further, our findings tend to indicate that there is a relationship between the farm-business and member-interest dimensions of heterogeneity and CCA, CG and CP but not the farmer-member dimension.

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1. Introduction

As voluntary organizations, co-operatives are based on a democratic decision-making process that rests upon collective participation, cohesion among members, and balance of countervailing powers (Hendrikse & Bijman, 2002). In agricultural co-operatives, an essential element for success is that the farmer-members are willing to supply the co-operatives with raw products, capital, and managerial inputs (Fulton, 1999). For this to take place member commitment is important (Staatz, 1989; Anderson & Henehan, 2005). In other words, success of the co-operative depends on the members' commitment to collective action; wherein collective action refers to initiatives taken by an identifiable group to realize their common interests (Gray & Kraenzle, 1998).

However, farmers differ in their individual commitment to participate in the co-operative (Cechin, Bijman, Pascucci, Zylbersztajn, & Omta, 2013). Importantly, co-operative scholars have reported a decrease in members' participation in co-operatives (Harte, 1997; Holmstrom, 1999; Levi & Davis, 2008; Nilsson, Svendsen, & Svendsen, 2012). Whether members behave opportunistically (Cook, 1995; Nilsson, Kihlén, & Norell, 2009) or as free-riders (Bhuyan, 2007), the main reason for this change in farmers' behaviour is attributed to the phenomenon of concentration and restructuring of agricultural co-operatives (Lang & Fulton, 2004; Nilsson et al., 2012). Österberg and Nilsson (2009) suggest that farmers find themselves in large, diversified and international co-operatives with a heterogeneous membership base; and with strategy so complex that farmers find it difficult to understand.

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This phenomenon of heterogeneity of membership has been claimed to have a negative effect on the efficiency of co-operatives (Cechin, Bijman, Pascucci, Zylbersztajn, et al., 2013). It may become particularly problematic when co-operatives become larger and/or more diverse in their activities, and where different activities of the co-operative cater to different groups of members (Fulton & Giannakas, 2001). Hansmann (1996) argues, the more heterogeneous the membership the more difficult to achieve goal congruence and, thereby, the higher will be the decision-making costs. Heterogeneity due to large memberships may also generate passivity because some member categories do not get their interests well attended to (Österberg & Nilsson, 2009). Furthermore, as the management obtains few, unclear, and conflicting signals from a heterogeneous membership, there is a risk that neither the board of directors nor the Chief Executive Officer (CEO) can interpret what the members want them to do (Cook & Iliopoulos, 2000; Hendrikse, 2007).

Increase in heterogeneity among members over the life span of a co-operative can be due to factors that are either external or internal to the co-operative organization (Cook, 2018). The external factors include divergence in farm size, multiple farming strategies, cooperative consolidation through merger and acquisition, and changing consumer demand (Bogetoft & Olesen, 2003; Cook, 2018; Weersink, 2018). Similarly, the endogenous or internal organizational processes include divergence in equity allocation, patron drift, membership growth, substitution effects, diversification and special interest groups arising internally that seek to apply pressure on management (Staatz, 1987; Cook & Burress, 2009; Iliopoulos & Valentinov, 2017; Cook, 2018). However, increasing heterogeneity due to either exogenous or endogenous factors are likely to lead to similar issues for the co-operative (Cook & Burress, 2009).

While several scholars have highlighted the role, importance and impact of heterogeneity on co-operatives, empirical studies that examine heterogeneity and map out its expression are lacking. Often, member heterogeneity appears as an assumption in theoretical models or becomes visible in significant coefficients of member, farm and product characteristics as independent variables (Hoehler & Kuehl, 2018). As a result, the picture of member heterogeneity and its impact on co-operatives is largely incomplete (Hoehler & Kuehl, 2018); and a comprehensive understanding of member heterogeneity and its dimensions is missing (Cook & Iliopoulos, 2016).

Österberg and Nilsson (2009) argue that there is an increasing need to study member behaviour within large and complex agricultural co-operatives. Moreover, given the trend towards increase in members' detachment and decrease in participation, it is important that co-operatives understand such attitudes and behaviours of its members, and what could perhaps be causing them (Fulton & Adamowicz, 1993; Birchall & Simmons, 2004; Bhuyan, 2007; Nilsson et al., 2012; Cechin, Bijman, Pascucci, Zylbersztajn, et al., 2013). Such studies are integral to the very survival of the co-operative business model (Österberg & Nilsson, 2009). However, very few studies have examined the behaviours of farmers and the antecedents of these behaviours in the specific context of agricultural co-operatives (Barraud-Didier, Henninger, & El Akremi, 2012; Cechin, Bijman, Pascucci, & Omta, 2013; Cechin, Bijman, Pascucci, Zylbersztajn, et al., 2013).

Importantly, the impact of heterogeneity on the capacity of individuals to self-organize and sustain collective action is highly contested. These concepts are generally used in the social science domain to describe the relationship between a group and a common pool resource. Although empirical studies have explored the relationship between group heterogeneity and the performance of common property institutions (Varughese & Ostrom, 2001; Poteete & Ostrom, 2004), none have explored this relationship within the context of agriculture co-operatives. Also, the relationship between heterogeneity and member commitment, which is a multidimensional attitudinal concept, has not yet, to our knowledge, been studied in the context of agricultural co-operatives. Moreover, a critical aspect to overcoming the perceived heterogeneity problem in agricultural co-operatives is to ensure members reconcile their differences and exhibit a commitment to the collective good or collective action. Yet, empirical research on this phenomenon is lacking.

We strive to address these gaps by pursuing two main objectives. First, to disentangle heterogeneity in agricultural co-operatives, and develop a measure for it. Second, to present and test a framework that explores the links between heterogeneity and members' commitment to collective action in a large New Zealand agricultural co-operative.

We contribute to the literature on member heterogeneity and commitment in at least three ways: 1) we develop a new theoretical framework for linking member heterogeneity and commitment to collective action in co-operatives; (2) based on the framework, we distinguish heterogeneity in agricultural co-operatives into three dimensions- i) farmer-member, ii) farming-business and iii) member-interest; and (3) by measuring heterogeneity and exploring its link with commitment to collective action, we provide a much-needed empirical assessment of important phenomena that have been suggested to impact co-operative performance.

The next section of this article covers the theoretical framework. This is followed by the third section which deals with the methodological aspects of the study carried out on a sample of 568 members of Fonterra Co-operative Group, a large dairy co-operative in New Zealand. The fourth section focuses on the results and the fifth section presents a discussion of these. The conclusions, limitations and possibilities for future research are presented in the sixth section.

2. Theoretical Framework

For the purpose of this research a novel framework that allows for the examination of two important phenomena in agricultural co-operatives, heterogeneity and commitment to collective action, is conceptualized. In the framework, a strong emphasis is given towards objectively examining these two phenomena in agricultural co-operatives via outcomes than can be anticipated and measured. The way in which results are measured, and demonstration of clearly observable results, are necessary to further enhance the understanding of agricultural co-operatives. To achieve this, as a first step, a description of heterogeneity and commitment to collective action, and an identification of the dimensions that comprise them is required.

2.1 Heterogeneity

A core feature of co-operatives is that they are characterised by collective decision making and self-governance (Apparao, Garnevska, & Shadbolt, 2019). As heterogeneity is perceived to affect this feature, it impacts the performance of co-operatives (Apparao et al., 2019). Moreover, the heterogeneity (diversity) of co-operatives' membership is increasing (Simmons & Birchall, 2004). For example, Elliott, Elliott, and Sluis (2018) project future changes to cooperative member heterogeneity such as greater member aging, more member asset value, greater value-added dollars at the farm level, and greater diversity of farm size. This increase in heterogeneity is because, as co-operatives become larger and more diverse in their operations, membership becomes increasingly heterogeneous (Nilsson et al., 2012). Globalisation and international expansion of co-operatives coupled with structural changes in the farming sector have led to further magnification of the differences between farmer members. Consumer demand for higher quality and more variety have resulted in an increase in diversification at farm level (Bogetoft & Olesen, 2007). Moreover, in search of efficiency gains and additional bargaining power, co-operatives are seeking new members and merging partners outside their original areas (Hoehler & Kuehl, 2018).

Increase in member heterogeneity is suggested to be a major challenge for co-operatives (Bijman, Hanisch, & Van der Sangen, 2014). Scholars have argued that members with different characteristics and conflicting interests are inclined to compete for rents (Kalogeras, Pennings, van der Lans, Garcia, & van Dijk, 2009). When members possess disparate preferences for attribute alternatives, disagreements can emerge as to which combination is most desirable (Zusman, 1992). As discussed by Vitaliano (1983), Cook (1995), and Hansmann (1996), the divergence in incentives and preferences is particularly problematic for the assignment of contractual property rights among members with diverse characteristics.

Collective decision making costs (Staatz, 1987; Bijman, 2002), agency costs (Gorton & Schmid, 1999) and influence costs (Iliopoulos & Cook, 1999) are believed to be greater in co-operatives than in investor owned firms (IOF). Increased heterogeneity of co-operatives and their members is suggested to be an important reason for further increase in these costs and resulting decrease in competitiveness of co-operatives (Fulton & Giannakas, 2001; Bijman, 2002; Bogetoft & Olesen, 2004). More specifically, since the control of co-operatives is structured democratically, heterogeneity is likely to generate transaction costs to co-operative decision-making. As argued by Hansmann (1996), an increase in these transaction costs results in higher decision-making costs in co-operatives relative to IOF's. Similarly, according to Pozzobon, Zylbersztajn, and Bijman (2011), as a consequence of heterogeneity, decision making in traditional co-operatives is likely to be more costly than in IOF's. Hansmann (1996) further posits that farmers are the most efficient owners of agricultural co-operatives because the costs of market contracting are highest for farmers while their cost of ownership is lowest. The low cost of ownership for farmers is because of high homogeneity of interest amongst farmers (Hansmann, 1996).

On the whole, increasing heterogeneity leading to conflicting preferences can generate problems in co-operatives (Kalogeras et al., 2009) such as decline in member commitment (Fulton & Giannakas, 2001), decrease in member willingness to supply equity capital (Van Bekkum, 2001), increasing costs related to damaging influence activities (Cook, 1995), tedious decision making process (Hansmann, 1996) and lack of strategic focus (Hendrikse & Bijman, 2002). Increasing heterogeneity could therefore present challenges to cooperative sustainability (Elliott et al., 2018), particularly in traditional co-operatives where structural adaptations in response to member heterogeneity have not been made (Cook & Iliopoulos, 2016). Moreover, as a result of more diverse members, it is increasingly difficult for the co-operative to demonstrate that it is acting in the best interests of all members (Fulton & Giannakas, 2001).

2.1.1 Dimensions of heterogeneity

It is important to examine the dimensions of member heterogeneity in co-operatives since it helps to identify the sources of conflict potential and adopt governance structures to meet the needs of the members e.g. by introducing advisory boards for different producers or by establishing new ways of organising and financing the co-operative (Kalogeras et al., 2009). Moreover, identifying the attributes, levels and factors of member heterogeneity enhances the co-operatives' ability to meet the needs of the members (Kalogeras et al., 2009). Despite its importance, very few scholars have taken a step in this direction.

Cook and Iliopoulos (1999), in their study of influence costs, identified eight factors that can be used to explain the degree of heterogeneity. These factors were in order of importance - 1) differences between members in terms of volume of production, 2) variance in members' education levels, 3) the geographic dispersion of membership, 4) differences between members in terms of farm objectives, 5) increased non-farm income for some members, 6) variance in members' age, 7) the number of different commodities produced by members, and 8) the number of different inputs procured by members.

Pozzobon et al. (2011) argue that member heterogeneity can be due to - 1) individual characteristics and 2) farms characteristics. The differences in individual characteristics may be due to – 1) demographic characteristics such as age and education, 2) economic characteristics such as percentage of non-farm income; business objectives; risk preference, and 3) individual beliefs. Similarly, the differences in farm characteristics may be due to – 1) farm size, 2) technology, 3) geographical, 4) types of commodities produced, and 5) types of inputs used (Pozzobon et al., 2011). More recently, Hoehler and Kuehl (2018), based on a comprehensive search of 'member heterogeneity' in economic journals, working papers and conference proceedings, suggested that member heterogeneity in agricultural co-operatives can be grouped under three categories 1) farm (e.g. size, location), 2) member (e.g. age, education) and 3) product (e.g. type and quality).

Considering the arguments and suggestions of Cook and Iliopoulos (1999), Pozzobon et al. (2011) and Hoehler and Kuehl (2018), we decouple member heterogeneity into three dimensions, 1) farmer-member, 2) farm-business and 3) member-interest. The farmer-member dimension is based on differences between members in personal characteristics, especially in their age, experience, and educational background (Cook & Iliopoulos, 1999; James & Sykuta, 2006; Höfer & Rommel, 2015). The farm-business dimension includes physical, financial and product quality related properties. It is centred on differences that pertain to the members' farming entities such as size, revenue, product quality, and location (Cook & Iliopoulos, 1999; Österberg & Nilsson, 2009; Cechin, Bijman, Pascucci, & Omta, 2013; Alho, 2015). The difference between members that arises due to their diverging interests (Hansmann, 1999; Kalogeras et al., 2009), such as price and dividend payments, sale of co-operative shares, concern for the co-operative's future, and importance of being valuable to the co-operative is captured under the member-interest dimension.

2.2 Commitment to Collective Action

Olson (1971), in his work titled *The Logic of Collective Action*, questioned the rationale and basis of the foundation of modern democratic thought, and argued that groups will not tend to form and take collective action whenever members jointly benefit. Instead, Olson strongly suggested that rational, self-interested individuals will not act to achieve their common or group interests (e.g. production of a public good), unless there is coercion or some other device to make individuals act in their common interest (Olson, 1971). This argument, which came to be known as the *"Zero Contribution Thesis"*, formed the basis of the presumption, that individuals cannot overcome collective action problems and need to have externally enforced rules to achieve their long-term self-interest. However, Ostrom (2000) argues that observations in everyday life strongly contradict the zero-contribution thesis. Empirical field work has established that individuals from all walks of life and all parts of the world voluntarily organise themselves so as to gain the benefits of trade, to provide mutual protection against risk and to create and enforce rules that protect natural resources (Ostrom, 2000).

In agriculture, co-operatives are an important collective action group. Through agricultural co-operatives, diverse producers use collective action to come together to make joint investments in processing and marketing facilities, to share a collective reputation, to bargain with supplying, processing and retailing firms, to gain access to markets, and to spread costs of extension services (Bouamra-Mechemache & Zago, 2015). In co-operatives, commitment to collective action can be viewed as the members' willingness to sacrifice short-term economic gains and make an effort towards the co-operative's long-term success (Cechin, Bijman, Pascucci, & Omta, 2013).

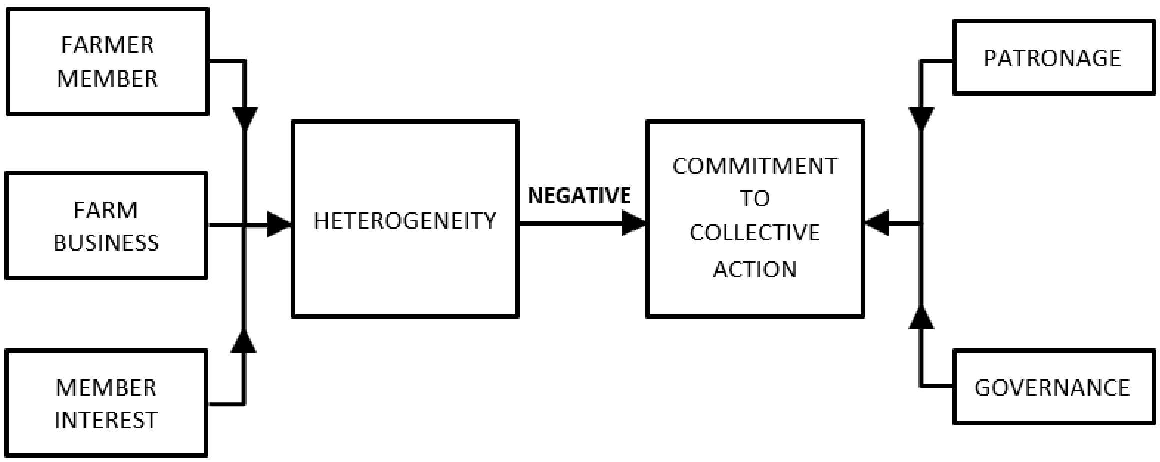
In this study, member commitment to collective action (CCA) is separated into two dimensions 1) commitment to patronage (CP) and 2) commitment to governance (CG). These two dimensions, as well as commitment to collective action in agricultural co-operatives, have already been described and analysed in an earlier research study (Apparao, Shadbolt, & Garnevska, 2020).

2.3 Framework Structure and Hypothesis

The conceptual framework brings together two important phenomena associated with agricultural co-operatives and is structured on the premise that heterogeneity has an important bearing on commitment to collective action. As indicated in Figure 1, the relationship between heterogeneity and commitment to collective action is examined by bringing together the three dimensions of heterogeneity and the two dimensions of commitment to collective action. The framework assumes that each dimension incorporates a number of components (sources) that have been emphasised in research on co-operatives. The farmer-member dimension is comprised of 9 sources, the farm-business dimension is comprised of 14 sources and the member-interest dimension is comprised of 12 sources.

It is hypothesised that the relationship between heterogeneity and commitment to collective action is negative (inverse), i.e. when heterogeneity is high, commitment to collective action is low and when heterogeneity is low, commitment to collective action is high. It is further argued that this relationship is expressed via the associated dimensions. When there is an increase in heterogeneity within one or more of the heterogeneity dimensions, there is a decrease in either or both commitment to patronage and commitment to governance, and thereby a decrease in commitment to collective action.

Figure 1: Conceptual Framework: Heterogeneity and Commitment to Collective Action



Based on the framework, we propose the following hypotheses –

Hypothesis 1: In large and complex co-operatives, there is a high level of heterogeneity, which is indicated by a majority of the sources comprising each heterogeneity dimension showing high to very high heterogeneity.

Hypothesis 2: High heterogeneity will result in a low level of commitment to collective action; as well as commitment to patronage and commitment to governance.

We further propose that if there is high heterogeneity within a source, then there will be a significant difference in CCA, as well as CP and CG between the groups that comprise the heterogeneity source. The basis for this is that heterogeneity can be linked to commitment to collective action by identifying if there is a significant difference in CCA (as well as CP and CG) between the various groups that comprise a source that has high heterogeneity. Similarly, if there is a low level of heterogeneity for a specific source, there will be no significant difference in CCA (and CP & CG) between the groups that comprise the source. Based on this rationale we propose:

Hypothesis 3: For the 9 sources of the farmer-member heterogeneity dimension that showed high or very high heterogeneity, there is a significant difference in commitment to patronage, commitment to governance and commitment to collective action between the groups that comprise the source. There is no significant difference between groups for sources that showed low or very low heterogeneity.

Hypothesis 4: For the 14 sources of the farm-business heterogeneity dimension that showed high or very high heterogeneity, there is a significant difference in commitment to patronage, commitment to governance and commitment to collective action between the groups that comprise the source. There is no significant difference between groups for sources that showed low or very low heterogeneity.

Hypothesis 5: For the 12 sources of the member-interest heterogeneity dimension that showed high or very high heterogeneity, there is a significant difference in commitment to patronage, commitment to governance and commitment to collective action between the groups that comprise the source. There is no significant difference between groups for sources that showed low or very low heterogeneity.

3. Methods

3.1 Background

3.1.1 Dairy Industry and Dairy Co-operatives in NZ

The dairy industry plays a significant role in New Zealand's economy. It provides employment to about 47,310 people and accounts for 28% of NZ's export revenues. Producing 21.3 million tonnes of milk, NZ is the 8th biggest milk producer and the largest dairy exporter in the world, accounting for over 30% of global dairy trade (Shadbolt & Apparao, 2016). In 2017/18, there were 11,590 dairy farms, 4.9 million dairy cows in NZ; and the average dairy farm size was 151 hectares.

Across the world, co-operatives play a major role in the dairy industry, accounting for over 80% of milk production in the U.S.A, Western Europe and Australia (Chaddad, 2007). In New Zealand, the first dairy co-operative was established in 1871. Since then, dairy co-operatives have played a significant role in the NZ economy, and continue to do so (Garnevska, Callagher, Apparao, Shadbolt, & Siedlok, 2017). Dairy co-operatives account for over 86% of NZ's milk processing and contribute to about 7.5% of NZ's GDP.

3.1.2 Fonterra

Fonterra Co-operative Group (Fonterra) was formed in 2001, via the merger of three entities, New Zealand Dairy Group, Kiwi Co-operative Dairies, and the New Zealand Dairy Board. With revenues of about NZ$ 20.4 billion in 2017/18, it is the largest dairy co-operative and also the largest business enterprise in NZ. Fonterra sources about 22 billion litres of milk, which is about 82% of NZ milk production. It is the largest dairy exporter in the world, exporting about 95% of its milk sourced to 140 countries. Fonterra employs 22,000 people across the world and accounts for 25% of NZ's exports. It is governed by an 11-member board (7 elected farmer shareholders and 4 appointed). Farmer shareholders vote for board members on the basis of the number of wet shares they hold, that is, one share per kilogram of milksolids supplied to the co-operative. Additionally, it has a 25 member shareholders' council which represents the views of all Fonterra farmer shareholders as suppliers, owners and investors. Each councillor is elected by farmers within the ward they represent, on the basis of one vote per shareholder farm.

Over a 10-year period, the volume of milk sourced by Fonterra increased by 28%. However, over the same 10-year period Fonterra has seen its share of NZ milk supply decrease from 94% (2007/08) to 82% (2016/17). In 2016/17, Fonterra paid its farmer owners, NZ$ 6.12 / kilograms of milk solids (kg MS) and a dividend of NZ$ 0.40 per share. Due to Fonterra's significant exposure to global markets, there has been volatility in both milk price and dividend payments. Milk price has ranged from NZ$ 3.90 /kg MS (2015/16) to NZ$ 8.40 /kg MS (2013/14); while the dividend payments have ranged from NZ$ 0.07 (2007/08) to NZ$ 0.45 (2008/09) per share.

Fonterra is owned by around 10,000 self-employed dairy farmers who are spread across NZ. Although the final element leading to the formation of Fonterra was the amalgamation of three entities mentioned earlier (i.e. New Zealand Dairy Group, Kiwi Co-operative Dairies, and the New Zealand Dairy Board), the origins of Fonterra can be traced back to the 1870's. The formation of Fonterra is hence characterised by several mergers over the course of many decades. It is reported that there were about 230 dairy co-operatives in the 1960's. These co-operatives were characterised by a unique identity, loyal membership base and strong regional specificity. More importantly there was intense competition between these co-operatives. Over the next three decades, especially in the 1980's and 1990's many dairy co-operatives gradually merged to form larger co-operatives in order to achieve economies of scale. As a result, there were just 3 dairy co-operatives in 2017/18, and the formation of Fonterra was the main outcome and culmination of this process of mergers. As explained by Nilsson and Madsen (2007) mergers between co-operatives are quite complex because a merger involves not only the integration of the business operations of the two co-operatives but also the breaking down of barriers between the members of the two co-operatives and aligning the different ways of thinking within the memberships. Moreover, the merger is further complicated by the concept of heterogeneity – heterogeneity in terms of business activities, logistics, organisational culture, leadership principles, ways of working, and other attributes (Nilsson & Madsen, 2007). Fonterra's large membership base and a foundation based on several mergers of co-operatives that once had a unique identity of their own, and strongly competed against each other, is thought to have introduced considerable member heterogeneity in the co-operative.

3.2 Data Collection

3.2.1 Sample

A survey method was used to collect data on heterogeneity and commitment to collective action. Before the survey, a pilot study was performed using 10 dairy farmers chosen by convenience to inform the development and refinement of the questionnaire. The structured questionnaire that was developed was mailed in July 2017 to a random sample of 2,000 members of Fonterra that was generated by a Fonterra manager. The researchers were blind to the members' names and only had access to the postal contact information of the members. After 6 weeks a reminder was sent out in September 2017 to those members that did not respond. Of the 2,000 surveys that were mailed 294 (15%) were returned by the postal service as being un-deliverable and 576 were returned by the respondents, giving a response rate of 34%. Of these 8 responses were classified as being incomplete and were discarded. Thus, leaving the study with a sample of 568 responses (33%) that were used in the analysis.

3.2.2 Measures

Heterogeneity: As described in the framework earlier, this study captured heterogeneity in agricultural co-operatives along three dimensions: farmer-member, farm-business and member-interest. To achieve this, each dimension was further broken down to its constituent elements or sources of heterogeneity; and the degree of heterogeneity that existed for each of these sources was measured. These sources were included because they are often associated with member heterogeneity in agricultural co-operatives (Iliopoulos & Cook, 1999; Kalogeras et al., 2009; Pozzobon et al., 2011; Hoehler & Kuehl, 2018), and are of specific relevance to heterogeneity within the membership base of NZ dairy co-operatives.

First, we considered gender, age, ethnicity, education, experience in agriculture, experience in share-milking, type of involvement with the farm-business, number of farming entities and years as co-operative member as the sources (n = 9) of farmer-member heterogeneity. Second, farm type, dairy system, seasonality, milk production, milk types, milk quality, gross farm revenue, total dairy assets, total debt, non-farm income proportion, stage of business, shares in the co-operative, share of milk supplied to co-operative and region were considered to be important sources (n = 14) of farm-business heterogeneity. Third, we considered likelihood of selling shares, seasons a low milk price is acceptable, willingness to accept lower dividend, concern for the co-operative's future, importance of being valuable to the co-operative, importance of being a respected member of the community, importance of creating opportunities for future farmers, importance of having time available for socializing with family and friends, importance of having variety in work, importance of looking after the environment, importance of maximizing farm profits, and importance of paying off debts, as the sources (n = 12) of member-interest heterogeneity.

Commitment to Collective Action: The measures used to capture commitment to collective action are explained in Apparao et al. (2020) and were based on the suggestions of Cechin, Bijman, Pascucci, and Omta (2013) and Barraud-Didier et al. (2012). Three statements, farmers' readership of annual reports, attendance at the co-operative's meetings and voting on co-operative matters were considered as an indicator of commitment to governance. Similarly, farmers' propensity for continued supply, importance placed on the relationship with the co-operative, and willingness to invest in the co-operative were considered an indicator of commitment to patronage. Respondents indicated their degree of agreement to each of the six statements on a Likert type 7-point scale (from 1: Strongly disagree to 7: Strongly agree).

3.3 Statistical Analysis

The analysis of data was done using SPSS (IBM® SPSS Statistics). First, a scale reversal was performed for the inverted scale statements. Second, a descriptive analysis of the data set was conducted by determining descriptive statistics such as the median, mode, mean, standard deviation and frequencies of the variables. Third, the construct reliability of the statements used to measure commitment to collective action was determined using the Cronbach Alpha. Fourth, a principal component analysis (PCA) was done to examine and confirm the constituent components of commitment to collective action.

Fifth, the commitment to collective action, commitment to patronage and commitment to governance scores were determined. The commitment to patronage and commitment to governance scores for each respondent was calculated by summing the responses for each of the three statements used to measure them. Since the scale length for each statement was 7, the lowest score possible is 3 (3 X 1) and the highest possible score is 21 (3 X 7). Thereafter, the commitment to collective action score for each respondent was calculated as the sum of commitment to patronage and commitment governance scores. The lowest commitment to collective action score possible is 6 (6 X 1) and the highest score is 42 (6 X 7).

Sixth, the Gini-Simpson Index was used to determine the degree of heterogeneity that existed within each source variable. This is one of the most widely used indexes to measure diversity (heterogeneity) and considers the number of different types that exist in the data field of interest and how evenly entities are distributed among those types. Although its origins lie in the field of ecology, it has been widely used in diverse disciplines, such as genetics, sociology, economics, management etc. For example, the Herfindahl-Hirschman index, which is extensively used to measure market concentration in economics and management, is based on Gini-Simpson Index (Rhoades, 1993). The equation used to determine Gini-Simpson Index is given below -

$$1 - \sum_{i=1}^{R} P^2 i$$

Where R is *richness* and quantifies the number of different types the data field of interest represents. For example, in the case of heterogeneity source variable gender, R is equal to two since the data field of interest comprises of two types, male and female. P_i represents the proportion of individuals that belong to the i^{th} type in the data field of interest. An index value of 0 indicates complete homogeneity, while an index value of 1 indicates complete heterogeneity. We classify heterogeneity in our source variables into five categories based on the index value as follows, 0 to 0.20 very low heterogeneity, > 0.20 to 0.40 low heterogeneity, > 0.40 to 0.60 moderate heterogeneity, > 0.60 to 0.80 high heterogeneity, and > 0.80 to 1.0 very high heterogeneity.

Seventh, for the heterogeneity sources for which correlations could be determined, the Spearman's correlation technique was used to determine if a correlation exists between a heterogeneity source and commitment to collective action as well as commitment to patronage and commitment to governance. Lastly, an analysis of variance (ANOVA) was performed to determine if the commitment to collective action, commitment to patronage and commitment to governance scores differed significantly between groups comprising a source of heterogeneity.

4. Results

4.1 Heterogeneity

Of the 35 heterogeneity sources 5 (14%) showed very high levels of heterogeneity (Gini-Simpson index > 0.80). Two sources each were from the farmer-member and farm-business dimension, while one was from member interest (Table 1). High heterogeneity (Gini-Simpson index > 0.60 to 0.80) was the most frequently observed heterogeneity level. It was observed for 20 (57%) sources. Of these, 4 were from farmer-member, 7 were from farm-business and 9 were from member-interest. Since a majority (71%) of the heterogeneity sources that we measured demonstrated high or very high levels of heterogeneity, the membership base of this co-operative can be considered to be heterogeneous. This finding reinforces the point made by co-operative scholars that large and complex agricultural co-operatives are characterised by a heterogeneous membership base.

Moderate levels of heterogeneity (Gini-Simpson index > 0.40 to 0.60) were observed for 3 (9%) sources, 1 from farmer-member and 2 from member-interest. Low levels of heterogeneity (Gini-Simpson index > 0.20 to 0.40) were observed for 6 (17%) sources. Of these 6 sources, 1 was from farmer-member and 5 were from farm-business. Finally, very low levels of heterogeneity (Gini-Simpson index > 0.0 to 0.20) was observed for only 1 (3%) source, belonging to the farmer-member source type. These findings indicate that some degree of homogeneity exists in the farmer-member and farm-business dimensions but not in the member-interest dimension.

Table 1: Heterogeneity Levels by Heterogeneity Dimension and Source Type

Heterogeneity Level	Gini-Simpson Index	Number of Heterogeneity Sources	Break-up by Heterogeneity Dimension		
			Farmer-Member	Farm-Business	Member-Interest
Very High Heterogeneity	> 0.80	5 (14%)	2 (22%)	2 (14%)	1 (8%)
High Heterogeneity	> 0.60 to 0.80	20 (57%)	4 (44%)	7 (50%)	9 (75%)
Moderate Heterogeneity	> 0.40 to 0.60	3 (9%)	1 (11%)	-	2 (17%)
Low Heterogeneity	> 0.20 to 0.40	6 (17%)	1 (11%)	5 (36%)	-
Very Low Heterogeneity	< 0.20	1 (3%)	1 (11%)	-	-
Total		35	9	14	12

4.2 Commitment to Collective Action

A detailed presentation of the results on commitment to collective action are provided in Apparao et al. (2020). In brief, the 6 statements used to measure CCA were found to be reliable as their Cronbach Alpha was 0.71. The principal component analysis (PCA), showed that two components had eigenvalues greater than the cut-off value of 1 and they explained 61.4% of the variance. The three statements (manifest variables) on *governance* load heavily on Component 1 and the three statements (manifest variables) on *patronage* load heavily on Component 2.

The mean and median CCA score was 26.5 (SD = 6.3) and 27.0 respectively and ranged from 6 (n = 1) to 42 (n = 1). This meant merely 0.2% of respondents obtained the potential maximum score for CCA. However, since both the mean and median scores were greater than the scale mid-point of 21, we believe that this co-operative has moderately high levels of commitment to collective action. The mean and median governance score was 14.1 (SD = 4.1) and 15.0 respectively and ranged from 3 (n = 8) to 21 (n = 16). Only 2.8% of respondents obtained the maximum possible score for governance. The mean (12.4, SD = 3.6) and median patronage score (13.0) was lesser and ranged from 3 (n = 6) to 21 (n = 3). Just 0.5% of respondents obtained the potential maximum score for patronage. Since both mean and median governance and patronage scores were above the scale mid-point (10.5), it suggests that this co-operative has moderately high levels of commitment to governance and commitment to patronage within its membership base.

4.3 Heterogeneity and Commitment to Collective Action

It was hypothesized that there is an inverse relationship between heterogeneity and CCA, CP and CG. Therefore, given that a high level of heterogeneity was observed within the membership base of this co-operative, a low level of CCA as well as CP and CG is expected. However, as explained earlier this was not the case, and moderately high levels of CCA, CP and CG were observed. Although this relationship between heterogeneity and commitment could not be statistically tested, this finding tends to suggest that high heterogeneity need not necessarily lead to low CCA, CP and CG.

Importantly, a majority of the 25 sources that showed high or very heterogeneity also showed significant differences ($P < 0.05$) in CCA (n = 16), CG (n = 16), CP (n = 12). Similarly, most of the 7 sources that showed low or very low heterogeneity did not show a significant difference ($P > 0.05$) in CCA (n = 7), CG (n = 6) and CP (n = 7). Of the three sources that showed moderate heterogeneity, there were no differences in CP but one showed differences in CG and two showed significant differences in CCA and CG. These findings are in alignment with our hypothesis that high heterogeneity will result in differences in CCA, CG and CP between the groups that comprise the heterogeneity source, while low heterogeneity will not; and tends to suggest that there is a relationship between heterogeneity and CCA, CG and CP.

4.3.1 Farmer-Member

Of the 9 farmer-member sources of heterogeneity, 2 (22%) had very high heterogeneity and 4 (44%) had high heterogeneity. Since 66% of sources showed high or very high levels of heterogeneity, the membership base of this co-operative can be considered to be heterogeneous with respect to the farmer-member dimension. Moderate (11%), low (11%) and very low (11%) heterogeneity was observed for 1 source each (Table 1). This indicates that a low degree of homogeneity also exists within this dimension. The descriptive statistics on the 9 sources is presented in Table 2.

For the source Gender, low levels of heterogeneity were observed (GSI = 0.35) and most respondents were male (77 %). Age had a high level of heterogeneity (GSI = 0.76) and most respondents (33%) belonged to the age group of 51-60 years. The source ethnicity had a very low level of heterogeneity (GSI = 0.11). This was also the lowest level of heterogeneity observed across all 35 sources. Most of the respondents were of European ethnicity (94%) and remaining were of Māori (6%) ethnicity. The question on level of education was the least answered one with only 333 (58.9%) respondents answering the question. It had a very high level of heterogeneity (GSI = 0.81) and diploma or trade certificate was the most frequent (24.3%) response. High levels of heterogeneity were observed for the source years' experience in agriculture (GSI = 0.71). Most respondents (43.4%) reported that they have 20-30 years of experience in agriculture. A very high level of heterogeneity (GSI = 0.81) was observed for the source years' share-milking experience. Most respondents (30.6%) reported that they have 0 years' experience in share-milking, but the median response was 3-5 years. Like in the case of level of education, several respondents (n = 187) did not answer the question on the type of involvement with and/or ownership of the farming business. The most frequent response was owner-operator type of involvement (45.9%), and the GSI was 0.73 indicating high levels of heterogeneity. Moderate levels of heterogeneity (GSI = 0.58) were observed for the source number of farming entities, and most respondents (55.8%) reported having only 1 farming entity. High levels of heterogeneity (GSI = 0.73) were observed for the source years co-operative member and most respondents (35.2%) reported being a member of the co-operative for 20-30 years.

Of the 6 sources for which correlations could be determined, a significant ($P < 0.05$) and positive correlation was observed between 4 sources (age, level of education, years' experience in agriculture, and number of farming entities) and commitment to collective action, as well as commitment to governance (Table 2). This finding indicates that farmers that are older, more educated, have greater experience in farming and are involved with more farming enterprises are more committed to collective action and governance of the co-operative. No significant correlations were observed with commitment to patronage. This suggests that CP is not linearly related with any of the heterogeneity sources that comprise the farmer-member dimension.

A significant difference ($P < 0.05$) was observed in the commitment to collective action scores between groups that comprised just 1 (11%) source (age) of the farmer-member dimension (Table 2). There was no difference in CCA between the groups that comprise the remaining 8 sources. Importantly, since high or very heterogeneity was observed in 5 of these 8 sources, it suggests that high level of heterogeneity was not related to a significant difference in CCA. Moreover, only four sources fit with our hypothesis of having a high level of heterogeneity and a difference in CCA or a low level of heterogeneity and no difference in CCA. These findings indicate that heterogeneity in the sources that comprise the farmer-member dimension does not lead to differences in commitment to collective action.

There was a significant difference (P < 0.05) in the commitment to governance scores between groups that comprised 4 (44%) sources (age, level of education, years experience in agriculture and number of farming entities) of the farmer-member dimension. Three of these sources had a high level of heterogeneity. Two sources that had low heterogeneity did not have a significant difference in CG. However, three sources had a high level of heterogeneity and no difference in CG; and one source (number of farming entities) had a moderate level of heterogeneity and a significant difference in CG. As 5 of the 9 sources aligned with the hypothesis, it tends to suggest that there is a weak association between heterogeneity and CG within the farmer-member dimension.

There was no significant difference (P > 0.05) in commitment to patronage scores between groups for all the 9 sources (Table 2). Since 6 of these sources showed high heterogeneity, it suggests that there is no relationship between heterogeneity and CP within the farmer-member dimension.

Table 2: Farmer-Member: Descriptive Statistics of Heterogeneity and Relationship to Commitment

#	Source Variable	N	Median	Mode	Mean	SD	GSI	ANOVA F Values (Correlation Coefficients)		
								CP	CG	CCA
1	Gender	557	NA	Male	NA	NA	0.35	0.55 (NA)	2.26 (NA)	0.18
2	Age	564	51-60 years	51-60 years	4.17	1.34	0.76	0.45 (0.06)	***4.79***** (0.19**)	***2.58**** (0.15**)
3	Ethnicity	552	NA	European	NA	NA	0.11	0.14 (NA)	2.73 (NA)	1.49
4	Level of education	333	Diploma &/or Trade Certificate	Diploma &/or Trade Certificate	2.99	1.58	0.81	0.95 (0.07)	***2.25**** (0.13*)	1.82 (0.10*)
5	Years experience in agriculture	565	30-50 years	30-50 years	4.63	1.03	0.71	0.98 (0.04)	***2.74**** (0.14**)	1.84 (0.11**)
6	Years share-milking experience	539	3-5 years	0 years	3.32	1.88	0.81	1.08 (-0.06)	0.51 (-0.04)	0.65 (-0.08)
7	Involvement / Ownership of farming business	381	NA	Owner-operator	NA	NA	0.73	1.45 (NA)	1.32 (NA)	1.19 (NA)
8	Number of Farming entities	566	One	One	1.60	0.80	0.58	0.85 (-0.00)	***3.74**** (0.14**)	1.13 (0.09*)
9	Years Co-op Member	559	20-40 years	20-40 years	3.51	1.08	0.73	0.35 (-0.02)	0.53 (0.03)	0.30 (-0.00)

GSI - Gini-Simpson Index
CP - Commitment to Patronage
CG - Commitment to Governance
CCA - Commitment to Collective Action
NA - Not Applicable
Significance level: * P < 0.05, ** P < 0.01

4.3.2 Farm-Business

Of the 14 sources comprising the farm-business dimension, 2 (14%) had very high heterogeneity and 7 (50%) had high heterogeneity (Table 1). Since 64% of sources showed high or very-high levels of heterogeneity, the membership base of the co-operative can be considered heterogeneous with respect to the farm-business dimension. None of the sources showed moderate and very low levels of heterogeneity (Table 1). However, 5 (36%) sources had low heterogeneity. This suggests that the farm-business dimension is the least heterogeneous (or most homogenous) of the three dimensions. The descriptive statistics on the 14 sources is presented in Table 3.

Farm type had a low level of heterogeneity (GSI = 0.34) and most respondents (80.5%) only had dairy farms. The question on the type of dairying farming system was the least answered amongst the farm-business questions (n = 499). The most frequent response was system 3 (32.5%) type of dairy farming system and the level of heterogeneity was high (GSI = 0.71). The seasonality of dairy farming had a low level of heterogeneity (GSI = 0.21) and most respondents (88.7%) had only a spring calving system. The volume of milk production had a high level of heterogeneity (GSI = 0.81). Over 50% of respondents had a milk production volume of less than 200,000 kg MS, but the most frequent response (25.1%) was a milk production greater than 300,000 kgMS. Most respondents (86.8%) produced only the conventional type of milk and the level of heterogeneity was low (GSI = 0.24). A low level of heterogeneity was observed for the quality of milk (GSI = 0.39) and the most frequent response (43.7%) was a somatic cell count of 100,000 to 150,000 cells per ml. Gross farm revenue (GFR) had a high level of heterogeneity (GSI = 0.79). More than 50% of respondents had a gross farm revenue of less than 1 million, and the most frequent response was NZ$ 500,000 – 1 million (27.3%). High levels of heterogeneity were observed for total dairy assets (GSI = 0.64) and most respondents (52.8%) had dairy assets in the range of NZ$ 2 – 10 million. A high level of heterogeneity (GSI = 0.70) was also observed for total level of debt. More than 50% of the respondents had a total level of debt less than 10 million and the most frequent response (45.8%) was NZ$ 2 – 10 million. Non-farm income as a percentage of total income was less than 15% for most (84.8%) respondents, and the level of heterogeneity was low (GSI = 0.27). Most respondents (54.7%) reported that they were in the consolidation stage of the farming business, but the level of heterogeneity was high (GSI = 0.64). Similar to milk production, Gini-Simpson Index for the number of shares in the co-operative was 0.81, indicating a high level of heterogeneity. More than 50% of respondents had less than 200,000 shares in the co-operative, but the most frequent response (24.8%) was greater than 300,000 shares. Most respondents (86.8%) reported that they supply 100% of their milk to Fonterra, and the level of heterogeneity was low (GSI = 0.24). The Gini-Simpson Index for region was 0.79, indicating a high level of heterogeneity. Most farming businesses belonged to the Waikato (27.6%) region; and the North Island of NZ accounted for 75% of the farming businesses in our study. This is very similar to the national NZ dairy statistics with Waikato region accounting for 28.8% and the North Island 73% of NZ's dairy farms in 2016/17 (Livestock Improvement Corporation Limited & DairyNZ Limited, 2017).

Of the 9 sources for which correlations could be determined, a significant ($P < 0.05$) and positive correlation was observed between 7 sources (dairy system, milk production, GFR, total assets, total debt, shares in the co-operative and share of milk supplied) and commitment to collective action, as well as commitment to governance. This finding indicates that higher the intensity of the dairy system and larger the milk production volumes, GFR, total assets, total debt, shares in the co-operative and share of milk supplied to the co-operative, greater will be CCA as well as CG. No significant correlations were observed with commitment to patronage, suggesting that there is no linear relationship between any of the farm-business sources of heterogeneity and a member's commitment to patronage of the co-operative.

A significant difference ($P < 0.05$) was observed in the commitment to collective action scores between groups that comprised 7 (50%) sources (dairy system, milk production, milk quality, GFR, total assets, shares in the co-operative, and region) of the farm-business dimension (Table 3). An important implication of this finding is that a member's CCA can differ based on the type of dairy system, volume of milk produced, the quality of milk produced, the gross farm revenue, total assets of the dairy business, number of shares owned in the co-operative, and the region the dairy business is located. Two sources that had high heterogeneity did not have a significant difference in CCA. But more importantly, all 7 sources for which differences in CCA were found also had a high GSI measure of heterogeneity, while 5 of the 7 sources for which no differences in CCA were found had a low measure of heterogeneity. Since 12 out of the 14 sources fit with the hypothesis, it suggests that there is a relationship between heterogeneity in the farm-business dimension and CCA.

There was a significant difference (P < 0.05) in the commitment to governance scores between groups that comprised 7 (50%) sources (dairy system, milk production, GFR, total assets, total debt, shares in the co-operative, and share of milk supplied to the co-operative) of the farm-business dimension (Table 3). Six of these had high heterogeneity while one had low heterogeneity. There was no significant difference between groups for the remaining 7 sources. Of these, 4 had low heterogeneity while 3 had high heterogeneity. As 10 of the 14 sources fit with the hypothesis, it suggests that there might be a relationship between heterogeneity in the farm-business dimension and CG.

There was a significant difference (P < 0.05) in commitment to patronage scores between groups for just 2 (14%) sources (milk quality and region). While, there was a significant difference between groups for the source dairy system at the 10% level (P = 0.06). All three sources had high levels of heterogeneity. There was no significant difference between groups for the remaining 11 sources. Of these 5 had low heterogeneity while 6 had high heterogeneity. As 8 of the 14 sources fit with our hypothesis, it indicates that there might be a weak relationship between heterogeneity in the farm-business dimension and CP.

Table 3: Farm- Business - Descriptive Statistics of Heterogeneity and Relationship to Commitment

#	Variable	N	Median	Mode	Mean	SD	GSI	ANOVA F Values (Correlation Coefficients)		
								CP	CG	CCA
1	Farm type	558	NA	Dairy	NA	NA	0.34	1.36 (NA)	0.77 (NA)	1.14 (NA)
2	Dairy system	499	System 3	System 3	2.98	1.60	0.74	1.68 (0.02)	***5.63**** (0.13**)	***3.70**** (0.10*)
3	Seasonality	565	NA	Spring calving	NA	NA	0.21	0.50 (NA)	1.34 (NA)	1.01 (NA)
4	Milk Production (kgMS/year)	565	150,000 – 200,000	> 300,000	3.92	1.63	0.81	0.68 (0.05)	***5.89**** (0.21**)	***2.83**** (0.17**)
5	Milk Types	567	NA	Conventional milk	NA	NA	0.24	0.33 (NA)	1.13 (NA)	0.07 (NA)
6	Milk Quality (SCC/ml)	556	100,000 – 150,000	100,000 – 150,000	3.01	0.91	0.69	***2.22**** (-0.60)	1.77 (-0.06)	***3.01**** (-0.08)
7	Gross Farm Revenue (NZ $)	538	500,000 – 1,000,000	500,000 – 1,000,000	3.46	1.30	0.79	0.51 (0.03)	***4.83**** (0.19**)	***2.42**** (0.14**)
8	Total Assets (NZ$)	540	2 million– 10 million	2 million – 10 million	3.64	0.96	0.64	0.53 (-0.02)	***9.07**** (0.22**)	***3.39**** (0.14**)
9	Total Debt (NZ$)	537	2 million– 10 million	2 million – 10 million	2.64	1.04	0.70	0.11 (0.00)	***3.31**** (0.14**)	1.07 (0.09*)
10	Non-Farm Income	532	< 15 %	< 15 %	1.21	0.53	0.27	1.85 (-0.08)	0.59 (-0.04)	1.75 (-0.08)
11	Stage of business	539	NA	Consolidation	NA	NA	0.64	0.36 (NA)	0.96 (NA)	0.77 (NA)
12	Shares in Co-op	557	150,000 – 200,000	> 300,000	3.88	1.65	0.81	0.60 (0.06)	***7.81**** (0.22**)	***3.73**** (0.18**)

#	Variable	N	Median	Mode	Mean	SD	GSI	ANOVA F Values (Correlation Coefficients)		
								CP	CG	CCA
13	Share of milk supplied	560	100%	100%	1.21	0.58	0.24	0.61 (0.06)	***2.92**** (0.09*)	2.19 (0.09*)
14	Region	562	NA	Waikato	NA	NA	0.79	2.03 (NA)	1.77 (NA)	***2.27**** (NA)

GSI - Gini-Simpson Index
CP - Commitment to Patronage
CG - Commitment to Governance
CCA - Commitment to Collective Action
NA - Not Applicable
Significance level: * P < 0.05, ** P < 0.01

4.3.2 Member-Interest

Of the 12 sources comprising the member-interest dimension, 9 (75%) had high heterogeneity, while 1 (8%) had very high heterogeneity. Since 83% of the sources showed high or very high heterogeneity, the membership base of this co-operative can be considered to be heterogeneous with respect to the member interest dimension. Two (16%) sources had moderate levels of heterogeneity. None of the sources showed low and very low levels of heterogeneity (Table 1). These findings indicate that of the three dimensions the member interest dimension is the most heterogeneous. The descriptive statistics on the 12 sources is presented in Table 4.

The most frequent response (33.7%) to the statement *how likely are you to sell some of your co-operative shares in the next five years* was very unlikely. The Gini-Simpson Index was 0.79, indicating a high level of heterogeneity. Most respondents (51.0%) reported that one season or less would be the *period of time a continued (< $ 5/ kg MS) low milk price payment will be acceptable.* A high level of heterogeneity was observed for this statement (GSI = 0.64). A high level of heterogeneity (GSI = 0.78) was also observed for the statement *how willing are you to accept a lower (< $ 0.20/share) dividend payment temporarily.* The most frequent response (25.6%) was slightly willing while the median response was slightly unwilling. A very high level of heterogeneity (GSI = 0.84) was observed for the statement *I am concerned about the co-operative's future (15 years from now).* The most frequent response (19.8%) was slightly agree, while the median response was agree. The Gini-Simpson Index for the *statement I think it is important to be valuable to the co-operative* was 0.72, indicating a high level of heterogeneity. The most frequent response (44.4%) was agree. A high level of heterogeneity (GSI = 0.69) was also observed for the statement *I think it is important to be a valuable member of the community.* The most frequent response (45.8%) was agree. The Gini-Simpson Index for the statement *creating opportunities for future farmers is important to me* was 0.71, indicating a high level of heterogeneity. The most frequent response (41.5%) was agree. High level of heterogeneity (GSI = 0.61) was observed for the statement *it is important that I have time available for socializing with family and friends.* The most frequent response (49.3%) was agree. Moderate level of heterogeneity (GSI = 0.59) was observed for the statement *it is important that I have variety in my work.* Most of the respondents (57.1%) agreed with the statement. Moderate level of heterogeneity (GSI = 0.55) was also observed for the statement *looking after the environment is important to me.* The most frequent response (34.5%) was agree. The Gini-Simpson Index for the statement *producing to maximise profits is important to me* was 0.66, indicating a high level of heterogeneity. The most frequent response (47.8%) was agree. A high level of heterogeneity was also observed for the statement *paying off debts is important to me* (GSI = 0.67). The most frequent response (40.7%) was agree.

A significant (P < 0.05) correlation was observed between 7 of the 12 sources of member-interest heterogeneity and CCA. The commitment to collective action was greater for members who were less likely to sell co-operative shares, more willing to accept a lower dividend, and gave higher importance to: being valuable to the co-operative, being a respected member of the community, creating opportunities for future farmers, having variety in their work, and looking after the environment. Similarly, significant (P < 0.05) correlation was observed between 7 sources of member-interest heterogeneity and commitment to governance. Six of these sources were the same as CCA. The willingness to accept a lower dividend payment was not correlated with CG. Additionally, farmers who placed greater importance on having time available to socialize with family and friends had a higher CG. Lastly, significant ($P < 0.05$) correlation was observed between 6 sources and commitment to patronage (Table 4). The CP was greater for members who were less likely to sell co-operative shares, more willing to accept a lower dividend, less concerned about the co-operative's future and gave higher importance to: being valuable to the co-operative, being a respected member of the community, and creating opportunities for future farmers.

A significant difference ($P < 0.05$) was observed in the commitment to collective action scores between groups that comprised 10 (83%) sources of the member-interest dimension (Table 4). This finding indicates that the CCA of the members can differ depending on their interests related to: selling co-operative shares, milk price, dividend payments, concern for the co-operative, being valuable to the co-operative, being respected by the community, creating opportunities for future farmers, having variety in their work, looking after the environment and producing to maximise farm profits. High heterogeneity was found in 8 of these 10 sources while 2 had moderate heterogeneity. Two sources that had high heterogeneity did not show significant difference in CCA. Since 8 out of the 12 sources fit with our proposed hypothesis, it suggests that there might be a relationship between the member-interest dimension of heterogeneity and CCA.

There was a significant difference ($P < 0.05$) in the commitment to governance scores between groups that comprised 9 (75%) sources (Table 4). High heterogeneity was observed for 7 of these sources and moderate heterogeneity for 2. Three sources that had high heterogeneity did not show differences in CG. Since 7 out of the 12 sources conformed to our hypothesis, it suggests that there might be a relationship between the member-interest dimension of heterogeneity and CG.

Similarly, there was a significant difference ($P < 0.05$) in commitment to patronage scores between groups for 9 (75%) sources of the member-interest dimension (Table 4). All 9 sources showed high heterogeneity. No difference in CP was found for two sources that showed moderate heterogeneity and one source that showed high heterogeneity. As 11 out of the 12 sources aligned well with our hypothesis, it suggests that there might be a relationship between the member-interest dimension of heterogeneity and CP.

Table 4: Member-Interest - Descriptive Statistics of Heterogeneity and Relationship to Commitment

#	Variable	N	Median	Mode	Mean	SD	GSI	ANOVA F Values (Correlation Coefficients)		
								CP	**CG**	**CCA**
1	Likelihood of selling shares	563	Very unlikely	Very unlikely	4.06	1.50	0.79	***6.45**** (0.21**)	***4.70**** (0.16**)	***8.30**** (0.22**)
2	Seasons low milk price is acceptable	552	1 season	1 season	1.87	1.19	0.64	***6.75**** (0.04)	0.65 (-0.00)	***3.56**** (0.02)
3	Willingness to accept lower dividend	563	Slightly unwilling	Slightly willing	4.17	1.28	0.78	***13.58**** (0.35**)	***4.38**** (-0.06)	***10.56**** (0.24**)
4	Concerned about Co-op's future	566	Slightly Agree	Agree	4.33	1.82	0.84	***3.78**** (-0.15**)	***3.82**** (0.06)	***3.69**** (-0.06)

#	Variable	N	Median	Mode	Mean	SD	GSI	ANOVA F Values (Correlation Coefficients)		
								CP	**CG**	**CCA**
5	Being valuable to co-op	567	Agree	Agree	5.47	1.27	0.72	***26.19**** (0.47**)	***68.63*** (0.64**)	***81.58*** (0.69**)
6	Being a respected member of the community	566	Agree	Agree	5.70	1.15	0.69	***2.86**** (0.17**)	***8.58**** (0.28**)	***7.61**** (0.26**)
7	Creating opportunities for future farmers	568	Agree	Agree	5.60	1.60	0.71	***5.34**** (0.19**)	***9.62**** (0.22**)	***10.44**** (0.25**)
8	Having time available for socializing with family & friends	566	Agree	Agree	6.11	0.86	0.61	0.82 (0.01)	1.14 (0.12**)	0.82 (0.07)
9	Having variety in work	567	Agree	Agree	6.10	0.85	0.59	1.90 (0.02)	***2.92**** (0.17**)	***2.84**** (0.11*)
10	Looking after the environment	566	Strongly Agree	Strongly Agree	6.40	1.02	0.55	1.36 (0.06)	***2.87**** (0.13**)	***2.57**** (0.11**)
11	Maximizing farm profits	565	Agree	Agree	5.80	1.31	0.66	***2.95**** (-0.05)	***3.71**** (0.15**)	***2.77**** (0.06)
12	Paying off debts	567	Agree	Agree	5.80	1.53	0.67	1.13 (0.02)	0.27 (-0.01)	0.35 (0.01)

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NA - Not Applicable
Significance level: * P < 0.05, ** P < 0.01

5. Discussion

This study had two main objectives. First, we unravelled heterogeneity in agricultural co-operatives into three dimensions, identified the sources that comprised each dimension and provided a novel measure and explanation of them. Second, we examined the relationship between the sources of heterogeneity and a member's commitment to collective action as well as commitment to patronage and governance. In pursuing these objectives, our study has generated some valuable insights that are useful in comprehending the phenomenon of member heterogeneity in agricultural co-operatives (Apparao et al., 2019). This in turn could serve as a starting point for evaluating its implications on co-operative performance and for providing suggestions for developing co-operative structures

(Kyriakopoulos, Meulenberg, & Nilsson, 2004). Further, by providing an examination of agricultural co-operatives from a socio-psychological perspective, it also aids in the understanding of the relationship between a member and the co-operative, an important aspect that influences co-operative performance (Österberg & Nilsson, 2009). For example, the insights on member heterogeneity can help inform the development of co-operative communication strategies that enhance member commitment (Trechter, King, & Walsh, 2002).

We identified 35 sources of heterogeneity that comprised the three dimensions of heterogeneity – 1) Farmer-member (n = 9), 2) Farm-business (n = 14) and 3) Member-interest (n = 12) and presented a novel measure and explanation of these using the Gini-Simpson Index. Based on this measure we found that considerable heterogeneity exists in this co-operative with all three dimensions measured showing high levels of heterogeneity. As this is a large and fairly complex co-operative a high level of heterogeneity is expected, and this finding is in line with arguments presented by several co-operative scholars (Nilsson, 2001; Birchall & Simmons, 2004; Österberg & Nilsson, 2009; Nilsson et al., 2012; Hoehler & Kuehl, 2018). Moreover, since the foundation of Fonterra was built on several mergers of co-operatives over many decades, a high level of heterogeneity is expected. This is in-line with the arguments presented by Nilsson and Madsen (2007). In addition to the amount of heterogeneity across the 35 sources, the kind of heterogeneity by dimension also showed interesting features and differences. Of the three dimensions the membership base was most heterogeneous in the member-interest dimension with 83% of sources showing high or very high levels of heterogeneity and none of the sources showing low or very low heterogeneity. This indicates that this co-operative is most diverse when it comes to its member-interests and relatively less diverse when it comes to its farmer-member and farm-business dimensions of heterogeneity. Although the term 'member interests' tends to have a range of interpretations within the context of co-operatives, similar to our findings, several scholars have highlighted the significance and impact of heterogeneity that is derived from differences in member-interests (Iliopoulos & Hendrikse, 2009; Kalogeras et al., 2009; Alho, 2015). Interestingly, the farm-business dimensions showed the greatest homogeneity of the three dimensions, with 36% of sources demonstrating low or very low heterogeneity. This suggests that the membership base tends to be more uniform with respect to farm business related properties, which is not surprising as they are all dairy farms. On the whole, as suggested by Hoehler and Kuehl (2018) this knowledge of member heterogeneity and its dimensions can help identify conflict potential and develop governance structures to meet the needs of the members, e.g. by introducing advisory boards for different producers (Kalogeras et al., 2009) or by establishing new ways of financing the co-operative.

It was hypothesised that high heterogeneity will result in low commitment to collective action in agricultural co-operatives. Since this co-operative had high levels of heterogeneity, low levels of CCA were expected. However, this was not the case as CCA, as well as CP and CG, levels were moderately high. This suggests that high heterogeneity does not lead to low commitment, which is similar to findings reported by Varughese and Ostrom (2001). Based on their work on 18 forest user groups in Nepal, Varughese and Ostrom (2001) found that there was a high degree of collective action despite there being significant heterogeneity. They identified that by having good institutional design and mechanisms to manage for heterogeneity the community was able to overcome the negative implications of heterogeneity and achieve high levels of collective action (Varughese & Ostrom, 2001). Similarly, research has indicated that inequality among certain member attributes may motivate collective action and improve team performance (Pelled, Eisenhardt, & Xin, 1999). Further, Ostrom (1990, 2005) based on her extensive work on governance of the commons presented eight design principles for the effective governance of common pool resources. These were 1. Well defined boundaries, 2. Proportional equivalence between benefits and costs, 3. Collective choice arrangements, 4. Monitoring, 5. Graduated sanctions, 6. Conflict resolution mechanisms, 7. Minimal recognition of rights to organise, and 8. Nested enterprise. According to Ostrom (1990) organizations able to design collective choice arrangements that maximize positive externalities related to diversity and reduce relative ownership costs arising from heterogeneity may effectively manage heterogeneity. Although agricultural co-operatives are different from the common pool resources that Ostrom's work is centred on, they too should benefit from the same principles, as similar to groups involved in common pool resources, members of agricultural co-operative must work together to achieve a common goal which is threatened by self-serving behaviours stemming from heterogeneity. It is therefore possible that the challenges presented by heterogeneity in this co-operative are mitigated by having well designed structures in place that are aligned with the design principles identified by Ostrom (1990). Furthermore, based on the widely accepted co-operative lifecycle and classification framework developed by Cook (1995, 2018) Fonterra can be considered to be in Stage 5 of the co-operative lifecycle and classified as a new generation co-operative or Sapiro III in structure. Fonterra has put in place mechanisms to bring in outside equity without restructuring as an IOF and developed structures such as increasing share liquidity to ameliorate the issues posed by the five property rights constraints that Cook (1995) has highlighted. As heterogeneity tends to play out via the property rights constraints, by addressing the property rights issues, Fonterra is likely to have mitigated the adverse effects of heterogeneity as well. Importantly, according to Cook (2018) the significant challenges presented by heterogeneity to a co-operative via increased ownership costs can be avoided by the co-operative genius process and the resultant tinkering which includes continuous redesign of collective choice arrangements to achieve regeneration. Fonterra took this approach by changing its ownership rights along with its purpose and culture by adopting tradeable shares (Cook, 2018).

Our study found that there tended to be a relationship between heterogeneity and CCA, CP and CG for the farm-business and member-interest dimensions but not for the farmer-member dimension. This tends to suggest that the higher the heterogeneity in the farm-business and member-interest dimensions, the more likely are there to be differences in CCA as well as CG and CP between the groups that comprise the heterogeneity sources, while heterogeneity in farmer-member sources is not likely to result in differences in CCA. Furthermore, although significant differences in CCA, CG and CP were observed between groups for several sources, it was most pronounced for sources in the member-interest dimension and less for farm-business and much less for farmer-member dimensions. This indicates that of the three dimensions it is the differences in members' interests that is most likely to result in differences in CCA as well as CG and CP. Several scholars have indicated that member-interest heterogeneity could have a significant influence on co-operatives (Hansmann, 1996; James & Sykuta, 2005; Iliopoulos & Hendrikse, 2009; Kalogeras et al., 2009; Iliopoulos & Valentinov, 2018), while differences in farmer-member related properties, such as gender, ethnicity, years as co-operative member, is least likely to result in differences in CCA, CG and CP.

Moreover, significant differences in both CP and CG were observed between groups for several heterogeneity sources in the member-interest dimension such as the likelihood of selling co-operative shares, willingness to accept a lower dividend, concern for the co-operative's future, being valuable to the co-operative and producing to maximise farm profits. However, fewer differences between groups that comprised a heterogeneity source were observed for CP as compared to CG for the farmer-member dimension followed by the farm-business dimension of heterogeneity. This indicates that with respect to famer-member and farm-business sources of heterogeneity CP is relatively more uniform across the groups that comprise the sources and is less influenced by heterogeneity when compared to CG. This is an important finding as it suggests that commitment to patronage tends to remain unaffected by most of the farmer-member and farm-business sources of heterogeneity, while a member's commitment to governance is influenced by relatively more heterogeneity sources in the farmer-member and farm-business dimensions. A member's CP is more amenable to being influenced by the co-operative via the use of both monetary (milk price and dividend payments) and non-monetary (member engagement) instruments or policies. Moreover, as these are uniformly applied to the membership base, CP is less likely to vary between member groups. However, this is not the case with commitment to governance. As there is no control, no sanction, and no reward or prize associated with a member's participation in governance, a member's commitment to governance of their co-operative is conceptually similar to an organizational citizenship behaviour of civic virtue (Barraud-Didier et al., 2012). CG is therefore more likely to be influenced by other factors such as the sources of heterogeneity (e.g. age, level of education, type of dairy system, volume of milk produced, total assets, total debt etc.), resulting in greater variability in CG between member groups.

6. Conclusions, implications and limitations

The framework that was developed brought together some relatively robust insights on heterogeneity and commitment to collective action in co-operatives into a more tightly knit and comprehensible whole, and in the specific context of agricultural co-operatives. In doing so we believe the framework serves the purpose of a reference and coordination mechanism for efficient theory testing. It is therefore a small but important and necessary step in the effort that remains to be expended in applying frameworks to the task of linking co-operative structure and processes to its performance. This is a critical challenge that co-operative scholars must address in order to progress co-operative research and enhance its managerial relevance.

We found that this co-operative had high levels of both heterogeneity and commitment to collective action. This suggests that high heterogeneity does not necessarily lead to low member commitment to collective action. Amongst the heterogeneity dimensions, the greatest heterogeneity was seen in the member-interest dimension and least in the farm-business dimension. This indicates that heterogeneity within the membership base is more likely to be a result of differences in member-interests such as likelihood of selling co-operative shares, willingness to accept a lower dividend, seasons a low milk price is acceptable, importance of being valuable to the co-operative etc.

Additionally, our findings can contribute towards addressing the challenge of strengthening member commitment in agricultural co-operatives and therefore has important managerial implications. For example, the results of the correlation analysis suggest that gains towards further enhancing commitment to collective action can be made by devising a two pronged engagement protocol that either rewards or recognises members with higher CCA and also more precisely targets members with relatively lower CCA. In the specific case of the member-interest dimension our results point out that the co-operative can bolster member commitment by acknowledging and remunerating those with higher CCA and simultaneously paying specific attention to members with lower CCA who tend to be more likely to sell co-operative shares, less willing to accept a dividend, and who give less importance to: being valuable to the co-operative, being a respected member of the community, creating opportunities for future farmers, having variety in their work, and looking after the environment.

This study had a few limitations. Firstly, due to its cross-sectional design and analysis, this study was focused on one large dairy co-operative in New Zealand. The study therefore could not test if the link between heterogeneity and commitment to collective action is statistically significant across diverse co-operatives. The results therefore are indicative at this stage and further research is required to validate them. Moreover, as most dairy co-operatives focus on only one commodity (milk) and farmer-type (dairy farmers) generalisations of the results to non-dairy co-operatives need to be made with caution. Secondly, since the data was collected over a single point in time it does not allow us to study or understand any changes in the relationship between heterogeneity and commitment that can occur. This is important because a member's psychological state can vary over time with respect to their relationship with the co-operative. Lastly, the proposed model did not take into account the important feedback loops that exist between the variables included in the model, and it did not measure the indirect impact of the heterogeneity sources on CCA through other variables. However, by measuring the stated and direct relationship between the heterogeneity sources and CCA, this study is an important first step which can inform future research on the indirect relationship that could exist via other variables. To examine the feedback loops and measure the indirect relationships, future research on heterogeneity and commitment should consider using structural equation modelling (SEM) as the analytical technique, and data collection and hypothesis testing should be devised accordingly. An important source of member-interest heterogeneity in co-operatives is the succession plan of farmers as it can introduce tension, for e.g. via the horizon and portfolio problems. Future research on heterogeneity should include succession planning as a heterogeneity source.

Despite these limitations our findings contribute towards the growing literature on heterogeneity and commitment in agricultural co-operatives. By revealing the links between heterogeneity and commitment to collective action, this study contributes towards the larger body of research aimed at identifying factors that influence member commitment in co-operatives and therefore come into play in predicting or assessing co-operative performance. We hope that the findings reported in this paper with regards to heterogeneity and commitment to collective action will encourage researchers to further expand the scope of empirical research of these two phenomena in the context of agricultural co-operatives. Lastly, the relationship between commitment to the co-operative and commitment to wider societal requirements such as animal welfare, sustainability and protecting the environment would also be a very interesting area for future research.

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