



Farmer cooperatives and competition: Who wins, who loses and why?¹

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October 13, 2015

Abstract:

Farmer-owned processing cooperatives are common in agricultural industries, but they differ from standard profit maximizing firms. The farmers who supply a cooperative are also the shareholders and a cooperative aims to maximize the overall return to its suppliers. So the presence of a cooperative can alter both market pricing and structure.

In this paper, we develop a simple model to analyze the market impact of a farmer cooperative. We show how a cooperative can intensify the competition between processors for farmers' produce and benefit all farmers, including those who do not supply the cooperative. If, however, the presence of a cooperative changes industry structure, then the effect of a cooperative on farmers is ambiguous - some farmers gain while others lose.

The potential for farmers to free ride on a cooperative raises the possibility of market instability, where a cooperative is desirable overall to farmers, but the cooperative's shareholders may find it in their own interest to 'sell out' to a for-profit processor. We show that the market has two stable outcomes, one where there are only profit maximizing processors, and a second where a cooperative coexists with profit maximizing processors.

Keywords: Cooperatives, farmer cooperative, agriculture cooperative, agriculture markets, market structure

JEL Classification Numbers: Q13, L11, L13, L30

¹ We would like to thank Martin Byford and participants at the 2015 EARIE conference and 2015 Australian Economic Theory Workshop for their useful comments. Contact details: Department of Economics, Monash University, Caulfield East, Victoria, Australia; E-mail: Stephen.King@monash.edu

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1 Introduction

Farmer-owned processing cooperatives are common in many countries.¹ Fruit growers may cooperatively own a juicing or a canning company,² dairy farmers may cooperatively own a milk processor,³ or sugar farmers may cooperatively own a mill.⁴

Despite their prominence, farmer cooperatives have received relatively little attention from industrial organization economists. In this paper, we develop a differentiated goods model to explore how a cooperative, in competition with profit-maximizing processors, changes the wholesale market for an agricultural product. We consider how and why different farmers may gain or lose from the presence of a farmer cooperative.

With a farmer-owned processor cooperative, the farmers who supply the processor also own and control the processor. The farmer-shareholders receive both a price for their produce from the cooperative and a share of the cooperative's profits as a dividend. The rules governing different cooperatives vary. In this paper we consider open membership cooperatives where any farmers who wish to supply the cooperative and become shareholders can do so.⁵

A cooperative processor can benefit farmers in at least two ways. The first is by limiting output. In a pioneering paper, Helmberger and Hoos (1963) model farmers supplying a perfectly competitive processing market. They show that a group of farmers can raise the price they receive for their produce by restricting the amount that they supply. Farmers outside the

¹For example, Cogeca, 2010 provides a comprehensive overview of agricultural cooperatives in Europe.

²For example, Ocean Spray in the US

³For example, Fonterra in New Zealand or Land O'Lakes, Inc. in the US. "Land O'Lakes, Inc. is a growing, farmer-owned food and agriculture cooperative doing business in all 50 states and more than 60 countries. (Land O'Lakes, Inc. 2013).

⁴In India, cooperative sugar mills are common, for example, accounting for over 50% of sugar processing in the state of Maharashtra. See Damodaran, 2014.

⁵As Sexton (1990, footnote 10) notes, most farmer cooperatives have an open membership policy.

group also gain as the reduced supply raises the market price.⁶

This cartel-like behaviour by ‘marketing cooperatives’ has been observed in the United States, where collective action by farmers has limited antitrust immunity under the *CapperVolstead Act of 1922*.⁷ Where also protected by state laws, farmer groups may set up sophisticated systems of rewards and penalties to try to limit farm output and raise the price of their members’ produce (Guenthner, 2012). Using a cooperative as a collusive device, however, is illegal in most jurisdictions outside the US, including Europe and Australia.

Alternatively, a cooperative may benefit farmers by altering the nature of processor competition. Cooperatives have different objectives compared to standard profit maximizing firms.⁸ As Sexton (1990) notes, a cooperative will set farm gate prices on the basis of average revenue product rather than marginal revenue product. This can lead to more aggressive pricing by both cooperative and for-profit processors, raising farm-gate prices and benefitting all farmers. Sexton refers to this as the ‘yardstick of competition’ hypothesis.

We develop a ‘circular city’ model to more fully explore the ‘yardstick of competition’ hypothesis. Our model retains the key elements of agricultural markets noted by Rogers and Sexton (1994, p.1143).⁹ However, our model is flexible enough to consider a range of market features, such as endogenous structure and price discrimination, that may alter the benefits from a cooperative to farmers.¹⁰

The aim of our analysis is two-fold.

⁶Helmberger and Hoos (1963) also briefly consider the possibility that, when facing a processor ‘oligopsony’, a farmers cooperative can raise the price received by farmers without restricting supply.

⁷7 USC 2912 (1976).

⁸This has been noted by competition authorities and the courts in a number of jurisdictions. For example see Commission of the European Communities, 2008, at paragraphs 101-103.

⁹In particular, transport costs that limit farmers’ options for sale; specialized input requirements for different processors; specialized and inelastic supply by farmers; and the presence of cooperatives.

¹⁰Sexton (1990) uses a conjectural variations approach that is unable to consider these

The first is to consider in detail the distribution of farmer gains and losses from the presence of an open membership farmer cooperative. We show that the ‘strong’ yardstick of competition effect modelled by Sexton — where all farmers gain by the presence of a cooperative — only holds if there is no price discrimination and if the establishment of a cooperative does not change the market structure of the for-profit processors. If price discrimination by for-profit processors is possible then only a subset of farmers gain from the presence of a cooperative but no farmers lose. If the aggressive pricing by the cooperative leads to exit by a for-profit processor, then some farmers gain by the presence of the cooperative while others are worse off.

The second aim is to explore the stability of different industry structures. Different industry structures, for example in milk and vegetable processing, exist in different countries. We show that there are economic incentives *both* to transform a cooperative into a profit maximizing processor, and for farmers to turn a for-profit processor into a cooperative. However, we also show that, subject to reasonable constraints on side payments and the equitable treatment of shareholders, these incentives cannot be actioned. Some winners will free-ride on any attempt to change market structure and both industry structures with and without a cooperative are stable.

In our model, farmers are uniformly distributed around a unit circle. Each farmer can produce one (and only one) unit of output. There are three processors located symmetrically around the circle. Each processor independently and simultaneously sets a ‘farm gate price’ that it offers to all farmers, and farmers decide which processor to supply taking into account the costs of supply. These costs can reflect transport costs or costs due to differences in specification from that preferred by an individual processor.

We set a benchmark where three profit maximizing processors compete for the farmers’ produce. We then allow one processor to be an open membership cooperative while two remain profit-maximizers. The farmers who supply the cooperative are also the owners of the cooperative and receive any profits as dividends. If a farmer sells her produce to a profit-maximizing market features.

processor, then she simply receives the ‘farmgate price’ set by that processor. If, however, the farmer sells to a cooperative processor, she will be paid for her produce in two ways — through the farmgate price set by the cooperative and through a dividend paid *ex post* by the cooperative. For example, in 2014 Fonterra had “a final Cash Payout [to its supplier-shareholders] of \$8.50 comprising the Farmgate Milk Price of \$8.40 per kgMS and a dividend of 10 cents per share”.¹¹ Consistent with many farmer cooperatives, a farmer’s shareholdings in the cooperative are proportionate to the amount of produce supplied by that farmer.

A cooperative does not profit maximize. Rather its objective is to maximize the return to its farmer-members. For example, “[a]s a cooperative, it is our primary responsibility to deliver value to our member-owners”.¹² The cooperative sets a farm gate price and dividend ‘pair’ to ensure that it just has sufficient revenues to cover costs. As a result, a cooperative ‘prices’ more aggressively than an equivalent profit maximizing processor. Consistent with Sexton (1990), if both profit maximizing processors remain viable, then this intensified price competition means that all farmers benefit from the cooperative even though only the farmers who supply the cooperative bear the costs of operating the cooperative.

However, by intensifying competition, the cooperative may force the exit of one (and, as we show, only one) of the profit maximizing processors. This weakens price competition on the remaining for-profit processor. In this situation, some farmers gain by the presence of a cooperative processor, while other farmers lose. Thus, unlike Sexton (1990), we develop a weaker version of the yardstick of competition hypothesis.

The gains to farmers from having a cooperative processor, in total, outweigh the monopsony profits of a single profit maximizing processor. Thus, it might be argued that an entrepreneur should be able to profitably transform a profit maximizing processor into a cooperative. We show that this is not possible without ‘side payments’ from farmers who will not be members of the cooperative. To buy out a for-profit processor, the entrepreneur has to payoff

¹¹Fonterra Co-operative Group Limited, 2014, at p.14.

¹²Land O’Lakes, Inc. 2013 at p.7.

the owner of a profit maximizing processor with the (foregone) monopsony profits up-front. However, in equilibrium, unless they receive financial support from farmers who sell to for-profit processors, the cooperative's farmer-members can only recoup this payment and keep the cooperative solvent by acting as a monopsonist against themselves. The free rider effect between farmers prevents a mutually beneficial deal when there is open membership and no inter-farmer side payments.

Similarly we show that an entrepreneur will not be able to convince a majority of farmers in a cooperative to sell their shares so that the cooperative becomes a profit maximizer. Again, this reflects free rider effects. Competitor processors gain if the cooperative becomes a profit maximizer, but 'assisting' such a deal through side payments would be likely to violate competition laws. Further, corporations laws usually require that identical shareholders are treated equally when a business, like a cooperative, is sold. While each farmer-member is paid an equal share of future profits when she sells her shares, a minority of farmer-members will decide not to sell their produce to the former cooperative once it is a for-profit processor. This minority receive a share of future profits up front but do not contribute to creating those profits post-sale. Thus, the entrepreneur is unable to provide adequate compensation up front for the majority of farmer-members and they will decline to sell their shares.

With non-discriminatory farm gate pricing, the strong 'yardstick of competition' result, where all farmers gain by the presence of a cooperative, holds so long as industry structure doesn't change. We show, however, that this result fails with price discrimination. If for-profit processors can set a different farm-gate price to potential members of the cooperative than to other farmers, some farmers are unaffected by the presence of the cooperative. Further, of the farmers who benefit, those benefits are differently distributed. This reflects that for-profit and cooperative farm gate prices move in opposite directions in equilibrium. Price discrimination allows the for-profit processors to profitably raise the farm gate price for potential cooperative members. But this reduces the cooperatives' size and lowers the cooperatives' farm gate price.

Cooperative processors may face a coordination problem. Farmers will make their supply decisions based on farm gate prices and their expectations about the cooperative's profits (and, hence, its dividend). To the degree that the profits of a cooperative are increasing in the total supply from its members, each farmer needs to consider her expectations about other farmers' behaviour when deciding whether or not to supply a cooperative. Our model captures this coordination problem. However, we show that the managers of a cooperative can overcome this problem if (a) its farmer-shareholders are covered by limited liability, so any dividend cannot be negative, and (b) the total payment to farmers is biased towards the farm gate price. In such a situation, a cooperative can commit to a high *ex ante* price to avoid the coordination issues that may lead to a low *ex post* dividend and a low total payment.

We consider an open membership cooperative where each farmer's share in the cooperative is proportional to her supply to the cooperative. We also assume that the cooperative is neither more nor less efficient than for-profit processors. In contrast, some of the literature has argued that (consumer) cooperatives "have coordination and governance costs that a [profit maximizing] firm does not face".¹³ However, it is far from obvious that the farmers, as shareholders in a cooperative processor, would face higher coordination or governance costs than the (dispersed) shareholders in a profit maximizing processor.¹⁴ Hence, in our analysis we assume that a processor's efficiency is not determined by its ownership structure. That said, we allow for each of the three processors to have different fixed costs of operation.

Our paper significantly expands on the (limited) formal literature on farmer cooperatives, particularly Sexton's (1990) analysis. Further, the stability of industry structure with a farmer cooperative has not, as far as we are aware, been formally analyzed elsewhere in the literature. We proceed as follows. Section 2 presents the model of processor competition. Section 3

¹³Heath and Moshchini, 2014, p.4. See also Innes and Sexton 1993.

¹⁴As the High Court of New Zealand, 1991 at 102,803, noted "by a system of committees, meetings and appointment of directors, the suppliers have a very effective day to day influence on the decision making processes of their their dairy company co-operatives."

discusses the issue of coordination for a cooperative processor, while section 4 analyzes the market outcomes under different processor configurations. In section 5, we address the key question: who wins and who loses from the presence of a cooperative processor, and why. Section 6 considers the stability of different industry structures. In section 7 we extend the analysis of the yardstick of competition effect when processors can price discriminate between farmers. We conclude in section 8.

2 The model

A unit mass of farmers is uniformly distributed around a circle of unit circumference. Each farmer can produce one unit of a well-specified, identical product at a cost c and can sell her product to a processor. A processor can use the product to make a final output. For example, the farmers' product may be raw milk that is sold to a dairy processor, grain that is sold to a mill, or vegetables sold to a cannery.

There are three processors, labelled A , B and C , located symmetrically around the circle. Let $x \in [0, 1]$ be a point on the circumference of the circle. For convenience we consider that processor A is located at $x = 0$, processor B is located at $x = \frac{1}{3}$ and processor C is located at $x = \frac{2}{3}$.

For one unit of the input purchased from a farmer, a processor can produce and sell one unit of output. Our aim is to consider the effects of different institutions on the competition between processors for the farmers' product, so we assume that, in the relevant output market, processors have no market power and are price takers.

Each processor's cost of transforming one unit of the input into one unit of output is constant and identical. Denote the output price faced by processors, less the constant costs of transformation, by F . Thus, F represents the 'break-even' payment that a processor could make to each farmer. Processors also have fixed costs denoted by K_j , $j \in \{A, B, C\}$.

Processors have one of two alternative organizational forms:

Profit maximizing processor: If processor j is a profit maximising pro-

cessor then, given the strategies of all other processors, it sets a single ‘farm gate’ price, P_j , that it offers to all farmers in order to maximize its expected profits. While the price, P_j set by processor j is referred to as a farm gate price, we assume that the farmers are liable for any delivery costs so that farmers receive the farm gate price less any delivery costs. Each processor j commits to a specific farm gate price P_j prior to receiving any product from any farmers. Any profits achieved by a profit-maximizing processor are paid to ‘outside shareholders’ and, as each farmer is ‘small’, we assume that no individual farmer considers that she can nontrivially alter the processor’s profits by with-holding or increasing supply.¹⁵

Farmer cooperative: If processor j is a farmer cooperative, then its objective is to maximize its total payment to its farmer members subject to not operating at a loss. Payments to farmers are the farm gate price, P_j , set by the cooperative and a dividend, d_j , that is paid to members. Any farmer who supplies the cooperative and receives the cooperative’s farm gate price, is a member, with each supplier’s share in the cooperative proportional to his or her sales to the cooperative. The cooperative is governed by a constitution or legal constraints that prevent it from refusing any farmer who seeks to supply, and become a member, the cooperative. The cooperative can also not limit or manipulate the amount of milk that it buys from any farmer member at the farm gate price.¹⁶ The dividend d_j is paid to farmer members in proportion to their shareholdings which, in turn, are proportional to the amount of product each farmer supplies to the processor. Thus the cooperative processor will seek to maximize the value of $P_j + d_j$ that it pays to its members. We assume that farmers’ shares in a cooperative are covered by limited liability so that the dividend d_j cannot be neg-

¹⁵This simply avoids issues that could arise if a major shareholder of the processor was also a major supplier and, as such, would take the processor’s profits into account when making his or her supply decision.

¹⁶This means that the cooperative cannot be used as a collusive device by farmers.

ative. However, a cooperative processor cannot commit to a dividend before receiving delivery from farmers.¹⁷

We are interested in the competitive effects of a cooperative processor on the payments that farmers receive. Thus, we will assume that processors B and C are always profit maximizing processors. However, processor A can either be a profit maximizing processor or a cooperative processor.

If all processors are profit maximizers, then there are no dividends that are relevant to farmers. The sales to a processor j will just depend on the farm gate prices set by each of the processors and are given by $Q_j = Q_j(P_A, P_B, P_C)$.

If processor A is a farmer cooperative, then farmers will have an expectation about the dividend that processor A will pay. This expectation is relevant to each farmer's supply decision. Of course, the actual dividend paid by a cooperative will depend on the funds available for distribution after it pays its costs. We assume that all farmers have the same expectation, \tilde{d}_A . The sales to processor j when processor A is a farmer cooperative will depend on the farm gate prices set by each processor and the expected dividend that will be paid by the cooperative processor so $Q_j = Q_j(P_A + \tilde{d}_A, P_B, P_C)$.

The objectives of the management of a processor will differ depending on its structure. The management of a profit maximizing processor j will set its farm gate price P_j to farmers to solve:

$$\max_{P_j} \Pi_j = (F - P_j)Q_j - K_j \quad (1)$$

¹⁷Farmer cooperatives use a variety of methods to fund fixed costs. These include retained earnings, up-front payments by farmers in return for member equity, issuing non-voting equity to farmers or outsiders, debt, or a combination of financial instruments. See Lund 2013. For convenience, in the model presented here, we assume that the cooperative covers all capital costs out of retained earnings. Alternatively, the cooperative could set an upfront membership fee that each farmer must pay in order to sell his or her product to the cooperative and that is proportional to the amount of product a farmer supplies. Our approach encompasses the case where the membership fee is set at the same time as the farm gate price. In that situation, the cooperative's farm gate price P_j can be thought of as the 'net' price after deducting the membership fee.

In contrast, if processor A is a farmers cooperative, its management wishes to maximize the total payout to its farmer members, $P_A + d_A$. Because all profits are distributed to farmer members, $P_A + d_A = F - \frac{K_A}{Q_A}$. So in order to maximize the total payout to members, given P_B and P_C , the management of the cooperative will seek to maximize the number of farmers who supply the cooperative. In other words, it will seek to maximize its membership.

We assume that a cooperative cannot set a negative farm gate price. So if processor A is a cooperative, its management will set its farm gate price P_A to farmers to maximize Q_A where:

$$(F - P_A - d_A)Q_A - K_A = 0 \quad \text{and} \quad P_A \geq 0, d_A \geq 0 \quad (2)$$

Given farm gate prices and, if relevant, the expected cooperative dividend, each farmer will independently decide which processor to supply.

Farmers have a cost of ‘transporting’ their output to a processor. We can think of this as a physical cost (for example, with raw milk transport) or a cost related to differences between a farmer’s output specifications and the optimal input specifications of the processor (for example, with fruit for juicing or vegetables for canning).

Denote the per unit cost of transport for each farmer by t . Thus if a farmer i located at x_i sells to a profit maximizing processor j located at x_j for a price P_j , the return to the farmer is given by $\pi_i = (P_j - c) - |x_i - x_j|t$. If a farmer i located at x_i sells to a cooperative processor j located at x_j for a price P_j , and the expected dividend is \tilde{d}_j , then the expected return to the farmer is given by $\pi_i = (P_j + \tilde{d}_j - c) - |x_i - x_j|t$. Each farmer will choose to sell to the processor that maximizes her individual expected return π_i , subject to her profit being positive. We assume that c and t are both sufficiently low so that all farmers choose to produce in equilibrium.

A profit maximizing processor will only choose to participate in the market if it expects to make a positive profit. This will depend on the ‘mix’ of competing processors and the specific processor’s fixed cost, K_j . We assume that each K_j is sufficiently low so that when there are three profit maximizing processors, all processors make non-negative profits in equilibrium. In particular, we assume that $K_j \leq \frac{t}{9}$.

Formally, the game played between the processors and the farmers is:

- t=0:** Nature chooses whether or not processor A will be a cooperative.
- t=1:** Each profit maximizing cooperative sequentially decides whether to continue or to drop out of production. If a processor continues then it pays its fixed cost, K_j .
- t=2:** Processors simultaneously set their farm gate prices.
- t=3:** Farmers choose which processors to supply.
- t=4:** All prices and dividends are paid.

If a profit maximizing cooperative chooses not to continue as an ‘active’ processor at $t = 1$ then it receives a payoff of zero.

We consider the subgame perfect equilibria of this game. Note that this implies that the expected and actual dividend payments by a cooperative will coincide in equilibrium. In other words, if processor A is a cooperative then $\tilde{d}_A = d_A$ in equilibrium.

For the subgame beginning at $t = 2$, we consider pure strategy equilibrium outcomes where any two processors ‘share’ the farmers located between them. Let I_A be an indicator function such that $I_A = 1$ if processor A is a cooperative and $I_A = 0$ if processor A is a profit maximizer. If all three processors participate then, given prices P_j , $j \in \{A, B, C\}$, a farmer located at $x_i \in [0, \frac{1}{3}]$ will sell to either processor A or processor B . The farmer will sell to processor A (resp. B) if $P_A + I_A \tilde{d}_A - c - x_i t$ is greater than (resp. less than) $P_B - c - (\frac{1}{3} - x_i)t$. The farmer will be indifferent if $x_i = \frac{P_A + I_A \tilde{d}_A - P_B}{2t} + \frac{1}{6}$. Similarly, considering farmers at other locations, we can calculate the amount of produce sold to each processor, given the prices set by each processor, as:

$$\begin{aligned} Q_A &= \frac{2(P_A + I_A \tilde{d}_A) - P_B - P_C}{2t} + \frac{1}{3} \\ Q_B &= \frac{2P_B - (P_A + I_A \tilde{d}_A) - P_C}{2t} + \frac{1}{3} \\ Q_C &= \frac{2P_C - P_B - (P_A + I_A \tilde{d}_A)}{2t} + \frac{1}{3} \end{aligned}$$

If there are two active processors then, without loss of generality, assume that they are processors A and B . Given prices P_j , $j \in \{A, B\}$, a farmer located at $x_i \in [0, \frac{1}{3}]$ will be indifferent between the two processors if $x_i = \frac{(P_A + I_A \tilde{d}_A) - P_B}{2t} + \frac{1}{6}$. A farmer located at $x_i \in [\frac{1}{3}, 1)$ will be indifferent between the two processors if $x_i = \frac{P_B - (P_A + I_A \tilde{d}_A)}{2t} + \frac{2}{3}$. The amount of produce sold to each processor, given the prices set by each processor, will be:

$$\begin{aligned} Q_A &= \frac{(P_A + I_A \tilde{d}_A) - P_B}{2t} + \frac{1}{2} \\ Q_B &= \frac{P_B - (P_A + I_A \tilde{d}_A)}{2t} + \frac{1}{2} \end{aligned}$$

Finally, because there is a sequential choice at $t = 1$, all active processors will make a profit in equilibrium. This avoids issues of mixed-strategies when two processors are profitable but three are not all profitable. Without loss of generality, we assume that if $K_B \neq K_C$ then $K_B < K_C$ and the order of choice is processor A , followed by processor B and then processor C , so in any sub game perfect equilibrium where only two processors are profitable, processor C will always be the processor that is inactive.

3 Preliminaries: coordination and multiple equilibria with a cooperative

If processor A is a cooperative then its management will seek to maximize the membership of the cooperative when it sets the price P_A . However, as lemma 3.1 shows, the exact choice of P_A in any subgame beginning at $t = 2$ when processor A is a cooperative, is irrelevant, in the sense that there is an equilibrium with identical outcomes for any other value of $P_A \geq 0$ so long as $d_A \geq 0$.

The reason for this is simple. Because the farmers receive all residual income of the cooperative processor as dividends, if there is an equilibrium with farm gate price P_A^0 and dividend d_A^0 then there will also be an equilibrium with farm gate price $P_A^1 = P_A^0 + \Delta$ and $d_A^1 = d_A^0 - \Delta$, so long as the non-negativity constraints are satisfied. In the new equilibrium, farmers simply

adjust their expectations about the dividend that they will receive and this expectation is met in equilibrium.

Lemma 3.1 formalises this intuition.

Lemma 3.1 *Consider an equilibrium of the subgame beginning at $t = 2$ where processor A is a cooperative. Denote the equilibrium prices and quantities in this equilibrium as (P_A^0, P_B^0, P_C^0) and (Q_A^0, Q_B^0, Q_C^0) where $P_j^0 = Q_j^0 = 0$ for any profit maximizing processor j that does not participate. Let $P_A^1 = P_A^0 + \Delta$ where $P_A^1 \geq 0$ and $F - P_A^1 - \frac{K_A}{Q_A^0} \geq 0$. Then there is an equilibrium of the subgame with prices (P_A^1, P_B^0, P_C^0) and quantities (Q_A^0, Q_B^0, Q_C^0) .*

All proofs are presented in the appendix.

Lemma 3.1 means that the management of a cooperative processor has considerable discretion. The cooperative management can arbitrarily set one of P_A or d_A . This discretion can help the cooperative deal with the potential issue of multiple equilibria.

Multiple equilibria can arise for a farmer cooperative because farmers face a coordination problem. The dividend paid by a cooperative to each farmer member is $F - P_A - \frac{K_A}{Q_A}$. But this dividend depends on the number of farmers who actually supply the cooperative, with the realized dividend falling if fewer farmers decide to sell their output to the cooperative. If farmers are ‘optimistic’ believing that Q_A will be high, then this can be self reinforcing and they will have a high expected dividend which is realized. Optimism can be an equilibrium. However, if farmers are pessimistic, expecting a small dividend, they will be less likely to supply the cooperative, given P_B and P_C . The result will be a low Q_A and a low realised dividend. So pessimism can also be an equilibrium.

To see this, suppose that at $t = 2$ processor A is a cooperative and prices (P_A^0, P_B^0, P_C^0) , quantities (Q_A^0, Q_B^0, Q_C^0) and dividend $d_A^0 = F - P_A^0 - \frac{K_A}{Q_A^0}$ are an equilibrium of the subgame. Then from lemma 3.1, prices $(0, P_B^0, P_C^0)$, quantities (Q_A^0, Q_B^0, Q_C^0) and dividend $d_A = d_A^0 + P_A^0$ is also an equilibrium of the subgame. However, given the zero price set by processor A there will also be an outcome where farmers expect a zero dividend from the cooperative

and so no farmers supply the cooperative. The lack of supply means that the cooperative's dividend is, indeed, zero.

Of course, this would not be an equilibrium because the profit maximizing processors would then seek to raise their prices. However, the possibility of a 'no supply' equilibrium for the cooperative cannot be avoided if the management of the cooperative set a 'too low' price.

While such multiple equilibria are possible, the management of the cooperative seeks to maximise the amount of produce sold to the cooperative processor. They can do this and avoid the low price equilibria by using lemma 3.1. For example, suppose prices (P_A^0, P_B^0, P_C^0) are associated with two potential equilibrium outcomes, one with a high dividend d_A^{0h} and one with a low dividend d_A^{0l} . The management of the cooperative can eliminate the 'undesirable' low dividend equilibrium simply by raising the price to $P_A^1 = P_A^0 + \Delta$ such that $d_A^{0h} - \Delta \geq 0$ but $d_A^{0l} - \Delta < 0$. By lemma 3.1, the new prices (P_A^1, P_B^0, P_C^0) will form an equilibrium with the high dividend and the low dividend equilibrium is no longer feasible.

One particular value of Δ that achieves this outcome is $\Delta = d_A^{0h}$. Thus, management of the cooperative can always avoid the problem of multiple equilibria, and maximize the value of $P_A + d_A$ by following a simple decision rule: given P_B and P_C the management of the cooperative will set the highest farm gate price that is consistent with an equilibrium where $d_A = 0$. By lemma 3.1 such a rule will not restrict the cooperative from maximizing its objective. But, by limited liability, it means that given the prices, all equilibria will involve $d_A = 0$ and each farmer can make her supply decision without concern about the number of other farmers that supply the cooperative.

In our analysis below we assume that the management of a cooperative achieves its objective in this way and simply consider outcomes where, given P_B and P_C , the cooperative sets P_A such that $d_A = 0$ in equilibrium.

4 Competition between processors

We begin by considering the alternative outcomes that can arise in the subgame beginning at $t = 2$ depending on the number and configuration of processors. These outcomes will allow us to consider when different equilibria arise depending on both the types of processors and the level of fixed costs for processors.

4.1 Competition between three profit maximizing processors

When all processors are profit maximizers, there will be a pure strategy equilibrium where the processors all set the same price to farmers and share the market equally. While processors may have different fixed costs, these do not alter the processors' decisions so long as each processor's profit is non-negative. There is an 'efficient' allocation of farmers to processors in the sense that each farmer will sell her produce to the closest processor.

Lemma 4.1 summarizes the outcome with three profit maximising processors.

Lemma 4.1 *With three profit maximizing processors, the symmetric equilibrium will involve each processor setting a price to farmers of $P_j = F - \frac{t}{3}$. The processors will share the market equally and will make profits of $\Pi_j = \frac{t}{9} - K_j$.*

By assumption, $K_j \leq \frac{t}{9}$ for each processor, so each processor will make non-negative profits in this subgame.

4.2 Competition between a farmer cooperative and two profit maximizing processors

Now suppose that processor A is a farmer cooperative while processors B and C are profit maximizers. The cooperative will maximize the return to its farmer members subject to covering all costs, including capital costs.

As noted above, by lemma 3.1, without loss of generality, we can consider outcomes where the dividend payments for the members of the cooperative are zero and farmer members are simply remunerated through the price paid by the cooperative.¹⁸ From (2), the cooperative processor will set the highest P_A so that, $(F - P_A)Q_A - K_A = 0$.

The outcome of the industry with a single cooperative processor is summarised by lemma 4.2.

Lemma 4.2 *Suppose there are two profit maximizing processors and one cooperative processor. In the equilibrium, the price received by all farmers will be at least $F - \frac{t}{3}$ and is decreasing in the fixed costs of the cooperative processor K_A . The cooperative processor will have more than one-third of farmers as members, while the profit-maximizing processors will each receive produce from less than one-third of the farmers. However, the cooperative processor's market share is decreasing in K_A . The profit of each profit-maximizing processor is increasing in K_A but will be lower than the situation where all processors are profit maximizing.*

If processor A is a farmer cooperative while processors B and C maximize profits, then the profits of processors B and C are minimized when $K_A = 0$. When $K_A = 0$, the cooperative processor will set a price of F and $\Pi_j = \frac{4t}{81} - K_j$ for each of the profit maximizing processors. As $\frac{\partial \Pi_j}{\partial K_A} > 0$ for $j \in \{B, C\}$, this means that all processors will make non-negative profits whenever $K_A \in [0, \frac{t}{9}]$ and $K_j \in [0, \frac{4t}{81}]$, $j \in \{B, C\}$.

However, if either K_B or K_C are greater than $\frac{4t}{81}$, either one or both of the private processors may not make positive profits in the subgame perfect equilibrium at $t = 2$ with three processors.

4.3 Competition between a farmer cooperative and one profit maximizing processor

Suppose that processor C chooses not to participate in the market when processor A is a farmers cooperative. Processors A and B will compete for

¹⁸As discussed in section 3 this avoids issues of multiple equilibria.

farmers. The outcome of this competition is summarised in lemma 4.3.

Lemma 4.3 *Suppose there is one profit maximizing processors and one cooperative processor. In the equilibrium, the price received by farmers is decreasing in the fixed costs of the cooperative processor K_A . The farm gate price offered by the cooperative processor is always greater than $F - \frac{t}{3}$ while the farm gate price offered by the profit maximizing processor is always less than $F - \frac{t}{3}$. The cooperative processor will have more than two-thirds of farmers as members, while the profit-maximizing processor will receive produce from less than one-third of the farmers. However, the cooperative processor's market share is decreasing in K_A . The profit of the profit-maximizing processor is increasing in K_A but will always be higher than the situation where all processors are profit maximizing.*

Note that it immediately follows from Lemma 4.3 and the assumption that $K_j \leq \frac{K}{9}$ that at least one profit maximizing processor will always be profitable in the presence of a farmer cooperative. Thus, the presence of a cooperative processor cannot drive both profit maximizing processors from the market.

4.4 Processor viability with symmetric fixed costs

As shown in section 4.3, given our assumption that $K_j \leq \frac{t}{9}$ for $j \in \{A, B, C\}$, a single profit maximizing processor is always viable in the presence of a farmers cooperative. Further, as noted in section 4.1, three profit maximizing processors are always profitable. However, the situation is more complex with two profit maximizing processors and a farmers cooperative. From section 4.2, if $K_j \in [0, \frac{4t}{81}]$, $j \in \{B, C\}$ then profit maximizing processors B and C can profitably operate even if processor A is a farmers cooperative. However, if either K_B and/or K_C is higher than $\frac{4t}{81}$ then, depending on K_A , one or both profit maximizing processors may be unprofitable.

One situation of particular interest is where the processors are equally efficient. As discussed in the introduction, there is no *a priori* reason to expect that a farmer cooperative will have either higher or lower costs than a

profit maximizing processor. Both institutions face principal-agent problems between the shareholders and the management, and it is not clear that farmer shareholders will be more or less able to hold management to account when compared to other shareholders. Lemma 4.4 considers the case when K_j is identical for all processors and analyzes when only a single profit maximizing processor is viable.

Lemma 4.4 *Suppose $K_A = K_B = K_C = K$. Then if processor A is a farmers cooperative and $K \in (\frac{4t}{49}, \frac{t}{9})$, processors B and C will make negative profits in the sub game with three processors starting at $t = 2$.*

The presence of a cooperative processor together with two profit maximizing processors can make the profit maximizing processors unprofitable even when processors have identical costs. In this situation, by construction, processor C will choose not to enter production. As lemma 4.3 showed, in that situation, the profit maximizing processor B will always be profitable in the presence of the farmers cooperative. Indeed, processor B will be more profitable than if all three processors were profit maximizers and operated in the market.

5 Who wins and who loses from a farmer cooperative?

Section 4 considered the alternative outcomes that could arise in the sub game perfect equilibria from $t = 2$. However, as discussed in section 4.2, in some of these equilibria, one of the profit maximizing processors may make negative profits. In such a situation, processor C will choose not to produce and processor B will profitably co-exist with the farmer cooperative.

The effects of a cooperative on market participants will depend on how it affects market structure and, hence, the farm gate prices and sales options, facing farmers. If both processors B and C remain viable in equilibrium then the farmer cooperative intensifies competition. Compared to a situation with

three profit maximizing processors, this intensified competition benefits all farmers, including those that do not supply the cooperative. There is a strong ‘yardstick of competition effect’. This result is formalized in proposition 5.1.

Proposition 5.1 *Suppose that at $t = 0$ nature chooses processor A to be a farmer cooperative and in the subgame starting at $t = 2$ both profit maximizing processors, B and C make non-negative profits if they are active in the market. Then in equilibrium:*

1. *There will be three active processors, including the farmer cooperative.*
2. *Compared to the equilibrium where all three processors are profit maximizers:*
 - (a) *Both profit maximizing processors will make lower profits; and*
 - (b) *All farmers receive a higher farm gate price and will be better off.*
3. *The distribution of the farmers between processors will be inefficient in the sense that some farmers will not supply their closest processor.*

Proposition 5.1 formalizes the ‘yardstick of competition effect’ and shows how the presence of a farmer cooperative can benefit all farmers by intensifying price competition. Farmers gain even if their produce is better suited to either of the profit maximizing processors, B and C .

As an example, consider the extreme case where $K_A = 0$. In this situation the cooperative does not have to cover any fixed costs and can set the maximum mix of price and dividend to its members, so $P_A + d_A = F$. Clearly this payout is higher than the farm gate price that processor A would have offered if it had been a profit maximizer.

The farm gate price set by processor A is a strategic complement to the prices set by processors B and C . So when the cooperative processor raises its farm gate price, the best response of its profit maximizing competitors is also to increase price. If $K_A = 0$ then the price set by the profit maximizing processors rises to $F - \frac{2t}{9}$ compared to a price of $F - \frac{t}{3}$ that is set when all processors are profit maximizers. These higher prices benefit all farmers who

sell to processors B or C , including those who are located between processors B and C .

The presence of a cooperative will also change the distribution of farmers between processors. From the proof of proposition 4.2, when processor A is a cooperative, it will serve all farmers located between $[0, \frac{1}{6} + \gamma)$ and $[\frac{5}{6} - \gamma, 1)$ where

$$\gamma = \frac{1}{36t} \left(-t + \sqrt{t(-216K_A + 25t)} \right)$$

Note that $\gamma > 0$ for $K_A \in [0, \frac{t}{9})$. The asymmetric distribution of farmers between processors when A is a cooperative represents a social loss in the sense that farmers who are located relatively close to either processor B or C may choose to incur extra expense to sell to the cooperative processor A . Of course, the farmer is compensated for the extra cost through the higher price set by the cooperative. However, this is a transfer, so that from a social perspective the additional ‘transport’ costs incurred by farmers who sell to processor A , despite being located closer to processors B or C , is a deadweight loss.

To continue the above example, when $K_A = 0$, $\gamma = \frac{1}{9}$. Thus, farmers located at $x_i \in (\frac{1}{6}, \frac{5}{18}]$ and $x_i \in (\frac{13}{18}, \frac{5}{6})$ will sell to processor A despite processor B and processor C respectively, being ‘closer’ for the relevant farmers. The deadweight loss due to additional ‘transportation’ costs is:

$$\int_{\frac{1}{6}}^{\frac{5}{18}} \left(xt - \left(\frac{1}{3} - x \right) t \right) dx + \int_{\frac{13}{18}}^{\frac{5}{6}} \left((1-x)t - \left(x - \frac{2}{3} \right) t \right) dx = \frac{2}{81}t$$

The farmers’ gain is a loss to the profit-maximizing processors. When $K_A = 0$ and all processors are profit maximizers, lemma 4.1 shows that each processor makes a profit of $\Pi_j = \frac{t}{9} - K_j$. In contrast, it follows from lemma 4.2, that when processor A is a cooperative with no fixed costs, the profit of the two remaining profit-maximizing processors falls to $\Pi_j = \frac{4t}{81} - K_j$, $j = B, C$.

Together, proposition 5.1 and lemma 4.2 show that higher levels of fixed costs for the cooperative processor reduce the yardstick of competition effect. As K_A increases, the farm gate prices set by all processors fall. Formally, as

$K_A \leq \frac{2}{9}$:

$$\frac{\partial P_A}{\partial K_A} = -9t(25t^2 - 216K_A t)^{-\frac{1}{2}} < 0$$

and

$$\frac{\partial P_B}{\partial K_A} = \frac{\partial P_C}{\partial K_A} = -3t(25t^2 - 216K_A t)^{-\frac{1}{2}} < 0$$

Thus the benefits to farmers from a cooperative fall as the cooperative's fixed operating costs rise. Note, however, that farmers are never worse off with a cooperative and profit maximizing processors are never better off with a cooperative, so long as three processors remain active in the market. If processor A has its highest fixed cost, $K_A = \frac{2}{9}$, then the outcome is identical to the situation with three profit maximising processors.¹⁹ In this sense, given market structure, a cooperative processor is always beneficial to farmers and harmful to competing profit-maximizing processors. This is the strong 'yardstick of competition effect'.

The strong yardstick of competition effect relies on market structure being unchanged when processor A is a cooperative. However, this may not occur.

As noted in section 4.3, because the profits of the profit maximizing processors fall when processor A is a farmer cooperative, this may lead processor C to chose not to produce. When a cooperative processor changes the industry structure, then the existence of a cooperative is ambiguous in terms of farmers' welfare.

The change in structure intensifies the competition effect in the sense that the cooperative's farm gate price in the presence of a single competitor is higher than in the presence of two competitors. However, the change in structure also reduces the direct level of competition on the remaining profit maximizing processor. As shown by lemma 4.3, a profit maximizing processor that only faces competition from the cooperative will always sets a farm gate price below the price it would set if there were three profit maximizing processors and no cooperative. This means that some farmers, such as those located near processor B , will be worse off if processor A is a cooperative than if it was a profit maximizer.

¹⁹Note that if $K_A > \frac{2}{9}$ then the cooperative processor would be unable to cover its fixed costs in equilibrium and would become insolvent.

This is the weak yardstick of competition effect. All farmers who would supply processor A and *some* farmers who would supply processors B or C when all processors are profit maximizers, are better off when processor A becomes a cooperative. But other farmers are worse off, so that the presence of a farmer cooperative has an ambiguous impact on overall farmer welfare.

This result is formalized proposition 5.2.

Proposition 5.2 *Suppose that at $t = 0$ nature chooses processor A to be a farmer cooperative and in the subgame starting at $t = 1$ only profit maximizing processor B chooses to participate. Then in equilibrium:*

1. *Compared to the equilibrium where all three processors are profit maximizers:*
 - (a) *Processor B will make higher profits;*
 - (b) *All farmers who sell to processor B when processor A is a cooperative will receive a lower farm gate price and be worse off in the equilibrium;*
 - (c) *All farmers who sell to processor A when all three processors are profit maximizers will receive a higher farm gate price and be better off in the equilibrium where processor A is a cooperative; and*
 - (d) *Of the remaining farmers, some farmers who sell to processor A when processor A is a cooperative will be better off but some farmers who sell to processor A will be worse off in the equilibrium where processor A is a farmer cooperative;*
2. *The distribution of the farmers between processors will be inefficient in the sense that some farmers will not supply their closest processor.*

The weak yardstick of competition effect highlights the key role of market structure. If there is a farmer cooperative and the presence of the cooperative leaves market structure unchanged, then the competitive effect of the cooperative is unambiguous and benefits all farmers. However, if the presence of a cooperative changes market structure, the effects on farm gate pricing and

farmer welfare are ambiguous. The cooperative will offer a higher farm gate price but the remaining profit maximizing processor will offer a lower farm gate price. This means that some farmers win and some lose. It implies that the benefits of a farmer cooperative cannot be assessed without considering potential changes to market structure.

6 Stability of market structures

Our analysis so far has taken the presence or absence of a farmer cooperative as given “by nature” at $t = 0$. However, the existence of a cooperative can be endogenous. In particular:

- A profit maximizing processor may be bought by an entrepreneur and turned into a farmer cooperative; or
- A farmer cooperative may be bought by an entrepreneur and turned into a profit maximizing processor.

Examples of both these types of change exist. In 2014, Murray Goulburn Cooperative, Australia’s largest dairy exporter, sought to purchase the for-profit Warrnambool Cheese and Butter Factory, but was stymied by competition concerns. Conversely, the Canadian for-profit grain handler, Viterra, was formed in 2007 when the Saskatchewan cooperative Wheat Pool was acquired by the for-profit Agricore United.

Incentives for both types of structural change exist in our model. Using the example of $K_A = 0$ from section 5, if processor A is for-profit then its profit is $\frac{t}{9}$ and all farmers receive a farm gate price equal to $F - \frac{t}{3}$. But suppose that processor A is a cooperative and both for-profit processors B and C are viable. Then all farmers receive a higher farm gate price. In particular, more than one third of farmers supply the cooperative at a farm gate price of F . Thus the total gain to farmers is greater than $\frac{t}{9}$ which is larger than processor A ’s ‘foregone’ profit from being a cooperative. In this sense, farmers, in total, gain more than processor A ‘loses’ when processor

A becomes a cooperative, suggesting that an entrepreneur might exploit this difference by turning a for profit processor into a cooperative.²⁰

Alternatively, if $K_j = 0$ for all processors and processor A is a cooperative, then processors B and C each make $\frac{4t}{81}$ profit so total industry profit is $\frac{8t}{81}$. If processor A is a for profit producer, then total industry profits rise to $\frac{3t}{9}$. So industry profits rise by $\frac{19t}{81}$ if processor A is a for profit producer rather than a cooperative. The farmer members of the cooperative would lose if processor A was a for profit rather than a cooperative, as the farm gate price they face falls from F to $F - \frac{t}{3}$. Remembering that when $K_A = 0$ then $\gamma = \frac{1}{9}$, the loss to the farmer members of the cooperative is no greater than $\frac{15t}{81}$ if A becomes a for profit processor.²¹ So the profit gain to all processors from transforming processor A from a cooperative to a for profit business outweighs the loss to the farmer members of the cooperative. This suggests that an entrepreneur might be able to gain by transforming a cooperative into a for profit processor.

In this section we consider both of these possibilities. Section 6.1 considers whether it is possible to profitably buy a profit maximising processor and convert it to a farmer cooperative, while section 6.2 analyses whether or not a farmer cooperative might be converted into a profit maximizing business by a vote of the farmer members.

The stability of each ownership structure will depend on the potential for ‘side payments’ and voting. We assume that:

- Side payments cannot be made between processors so that for-profit processors B and C cannot ‘assist’ an entrepreneur buy cooperative processor A ;
- Side payments cannot be made between farmers so that farmers who do not supply a cooperative processor cannot make payments to those farmers who do supply the cooperative;

²⁰This example is generalized in lemma 6.1 below.

²¹The loss in general will be less than this as some farmers who supply A when it is a cooperative will supply either B or C when all processors maximize profits, saving some transport costs.

- All farmer members of a cooperative must be treated equally, for example, through payment for their shares or through the farm gate price that they receive;
- At least 50 per cent of members by shareholding must support the conversion of a cooperative to a for profit processor for it to occur;
- An entrepreneur who seeks to buy a cooperative cannot commit in advance to the future farm gate price; and
- A change in the ownership structure of processor A does not alter K_A .

These restrictions provide a realistic framework to analyse the potential for changes to industry structure.

Side payments between processors are likely to raise antitrust concerns and will be illegal.

While side payments between farmers may not raise the same legal concerns, it is difficult to see how they could be organized and enforced given the large number of farmers. While farmers who only supply processors B and C would prefer processor A to be a cooperative, each farmer would be tempted to free-ride on any attempt to create explicit transfers to encourage a change in the ownership structure of processor A .

That all farmer members (and shareholders) of a cooperative processor must be treated equally is consistent with standard corporations law. It means that some farmers cannot be ‘guaranteed’ a higher farm gate price or other incentives to vote in favour of a change in ownership of processor A .

The voting requirement simply creates a way to combine the preferences of divergent farmers when considering whether or not they should sell cooperative processor A .

The limitation on future price commitments means that a profit maximizing processor must act to maximise profits. While future price commitments are sometimes made during takeovers, antitrust authorities view them with suspicion, particularly given the potential for *ex post* manipulation.

Finally, consistent with the analysis in the earlier part of this paper, we assume that the efficiency of processor A does not depend on the ownership

structure.

Given these assumptions, our results show that both market structures — where processor A is a for profit processor or where it is a farmer cooperative — are stable. It will not be profitable for an entrepreneur to buy a profit maximizing processor and turn it into a cooperative. Similarly, a majority of farmer members will not support selling their processor to an entrepreneur who will operate it as a profit maximizing business.

6.1 Will farmers turn a profit maximizing processor into a cooperative?

Suppose we have a market structure with three profit maximizing processors. Further, as in section 4.2, assume that two profit maximizing processors can profitably co-exist with a farmer cooperative.

In order to buy processor A , the entrepreneur will need to compensate the profit maximizing processor for its foregone profits. So a first step is to check if the total gains to *all farmers* from having a cooperative in the presence of two profit maximizing processors (as opposed to having three profit maximizing processors and no cooperative) exceed the profit of processor A when it maximizes profits. Lemma 6.1 shows that this is the case, so there are potential overall gains from trade by transforming processor A into a cooperative.

Lemma 6.1 *Let $K_j \in [0, \frac{4t}{81}]$ for $j \in \{A, B, C\}$. The total gain to farmers by having one cooperative and two profit maximizing processors is greater than the equilibrium profit of a profit maximizing processor when all processors are profit maximizers.*

Despite the gains shown by lemma 6.1, proposition 6.2 shows that, so long as an entrepreneur has to buy the processor and then simply operate it as a cooperative, treating all farmer members equally and without any transfers from farmers who do not sell produce to the cooperative, then the entrepreneur cannot profitably buy a for profit processor and turn it into a cooperative.

Proposition 6.2 *Suppose that all processors, including processor A, are profit maximizing processors. If processor A is purchased by an entrepreneur who turns it into a farmer cooperative with no loss of efficiency, and the cost of the purchase must be funded by the cooperative (so the entrepreneur makes no loss), then the equilibrium outcome is identical to the market outcome when all processors operate to maximize profits.*

Proposition 6.2 reflects that, in order to buy out a private processor with monopsony power, farmers must compensate the owner with the profits that he would have made from the exercise of monopsony power. But, if the purchase price must be funded through the revenues of the cooperative, the cooperative is only able to raise the relevant funds if it equally exercises monopsony power. In that situation, there is no gain to farmers.

Together, lemma 6.1 and proposition 6.2 highlight a problem for farmers. Overall, farmers gain from a cooperative and the size of this gain is more than enough to compensate the private owner of processor A. However, some farmers gain through a higher price and lower profits for processors B and C. These farmers are not members of the cooperative and do not sell their produce to the cooperative. They do not contribute to the cost of buying the processor and creating the cooperative. In effect, they free-ride on the farmers who supply and fund the cooperative. Because only a subset of farmers pay the cost of making processor A a cooperative, the gains to those farmers are insufficient to create a cooperative from a private processor, despite there being overall gains for farmers.

This free riding problem could be solved if farmers who never sell to the cooperative processor made a payment to encourage the creation of the cooperative. However, they have no individual incentive to do this as each farmer would prefer to free ride on the contributions of other farmers.

6.2 Can an entrepreneur turn a cooperative into a profit maximizing processor?

The gains of a cooperative to farmers are dispersed and unevenly distributed. Could an entrepreneur use these differences to convince a majority of farmer members of the cooperative to sell the cooperative so that it can be operated as a profit maximizing business?

While this harms farmers overall, only those farmers who are members of the cooperative will get to ‘vote’ on the future of the cooperative. Could an entrepreneur gain the support of enough farmer-members to transform the cooperative even though overall farmers lose?

Again, we will focus on the situation where $K_j \in [0, \frac{4t}{81}]$ for $j \in \{A, B, C\}$ so that there is an equilibrium with two profit maximizing processors and a cooperative. Initially, processor A is a cooperative. The farmer members are located between $[0, \frac{1}{6} + \gamma)$ and $[\frac{5}{6} - \gamma, 1)$. By our restriction on K_A , $\gamma > 0$.

Each farmer member has shares in the cooperative equal to the amount of produce that she supplies. In our model, this means that each farmer member has one share in the cooperative so that all farmers have an equal vote. In order for the cooperative processor to be sold to an entrepreneur, a clear majority of farmers must vote in favour of the sale. If the cooperative is sold, the sale proceeds are divided between the farmer members in proportion to their individual shareholdings, so each farmer member receives an equal share of the sale price. We assume that each farmer only votes in favour of the sale if she is at least as well off with the sale proceeding as she is if processor A remains a cooperative.

Given our assumptions, the sale of the processor cannot involve a future price commitment by the entrepreneur or a supply commitment by any farmer members. We also assume that an entrepreneur will only purchase a cooperative processor if the purchase leaves the entrepreneur no worse off than if the sale doesn’t proceed.

Proposition 6.3 shows that it is not possible for the entrepreneur to gain the support of a majority of farmers to sell the cooperative processor.

Proposition 6.3 *Suppose $K_j \in [0, \frac{4t}{81}]$ for $j \in \{A, B, C\}$, processor A is a cooperative processor with fixed cost K_A and each farmer located between $[0, \frac{1}{6} + \gamma)$ and $[\frac{5}{6} - \gamma, 1)$ is a member of the cooperative and holds a single voting share in the cooperative. It is impossible for an independent entrepreneur to gain the support of a majority of farmer members to sell the cooperative for any price that does not make the entrepreneur worse off than if the sale does not proceed.*

The sale fails because, even if the entrepreneur ‘passes back’ all profits to the farmers as part of the sale price, post-sale, a minority of farmers will switch to supplying a different processor. These farmers receive a share of processor A ’s profits through the sale price but do not contribute to those profits by selling their produce to the profit maximizing processor A . Thus the majority of the farmers do not receive back the full profits that they generate for the profit maximizing processor A and so those farmers are made strictly worse off by the sale.

6.3 Discussion on stability and market structure

Propositions 6.2 and 6.3 imply that alternative processor structures can co-exist in otherwise identical markets. In this sense, history matters. If a market has developed with a cooperative processor then this can be a stable structure. Similarly, a market with only for profit processors can be stable. There is no *a priori* reason why we would expect a market to move towards one or other structure.

Such divergence is consistent with observed market structures. However, in reality, the ownership structure and objectives of processors do change over time. Such changes will reflect situations where our assumptions do not hold.

Most obviously, if processor efficiency depends on the ownership structure (i.e. K_A changes with ownership) then this may make it possible to change structure in a way that improves efficiency.

Alternatively, if our assumed restrictions on pricing and contracting do not hold, then a change in processor structure may be possible.

For example, if a contract to sell a cooperative processor to an entrepreneur could include a binding future farm gate price, then this may make the sale possible. In this case, the contract of sale could be used to create a first mover pricing advantage for processor A . The entrepreneur and the farmer members could use the contract of sale as a strategic device to alter post-sale competition and create mutually profitable opportunities.

In this sense, our analysis provides two key results. First, it shows why divergent processor structures may co-exist in otherwise similar markets. Second, it provides a starting point for analysing situations when structure does change.

7 Price discrimination and a farmer cooperative

Our analysis in section 5 assumed that each processor could only set a single farm gate price. However, in the case of three processors, only one of which is a farmer cooperative, it may be possible for profit maximizing processors to price discriminate between those farmers who are ‘contestable’ and for whom the cooperative is a viable alternative and those farmers who are ‘captured’ by the profit maximizing processors.

For example, a for-profit dairy processor may be able to set different farm gate prices to farmers who can and cannot ‘easily’ access a cooperative processor. It would be difficult for farmers to arbitrage any price difference as it could be based on the farm location for milk delivery. Given the cost and potential loss of quality (due to bacterial levels) for transporting milk between farms for storage and later re-transport to a processor, arbitraging the different farm gate prices would generally be uneconomic for farmers.

To see the effects of price discrimination, suppose that two profit maximizing processors, B and C , compete against a cooperative processor A . The profit maximizing processors can identify a farmer’s location by the ‘third’ of the circle, and can establish different prices for farmers located at $x_i \in (\frac{1}{3}, \frac{2}{3}]$

(i.e. between the two profit maximizing processors) compared to farmers located either at $x_i \in [0, \frac{1}{3}]$ (for processor B) or at $x_i \in (\frac{2}{3}, 0)$ (for processor C). Let P_B^R be the farm gate price that processor B sets to farmers located at $x_i \in [0, \frac{1}{3}]$ while P_B^L is the farm gate price that processor B sets to farmers located at $x_i \in (\frac{1}{3}, \frac{2}{3}]$. Let P_C^L be the farm gate price that processor C sets to farmers located at $x_i \in (\frac{2}{3}, 0)$ while P_C^R is the farm gate price that processor C sets to farmers located at $x_i \in (\frac{1}{3}, \frac{2}{3}]$. The cooperative processor A only sets one farm gate price.

Lemma 7.1 looks at the equilibrium behaviour with price discrimination, assuming that the two for-profit processors, B and C behave symmetrically.

Lemma 7.1 *Suppose that in the subgame at $t = 2$ there are two profit maximizing processors and one farmer cooperative. If the profit maximizing processors can price discriminate, the equilibrium will involve the cooperative setting a farm gate price of $P_A = \frac{1}{2}(2F - t + \sqrt{-8K_A t + t^2})$. The prices set by the profit maximizing processors will be $P_B^L = P_C^R = F - \frac{t}{3}$ and $P_B^R = P_C^L = \frac{1}{6}(6F - \frac{5t}{2} + \frac{3}{2}\sqrt{-8K_A t + t^2})$.*

The ability of the profit maximizing processors to price discriminate significantly alters the nature of competition. In particular, it changes the ‘yardstick of competition effect’ so that only farmers who are ‘contestable’ by the cooperative and are located either at $x_i \in [0, \frac{1}{3}]$ or at $x_i \in (\frac{2}{3}, 0)$ benefit from the competition created by the cooperative.

Proposition 7.2 *Suppose that at $t = 0$ nature chooses processor A to be a farmer cooperative and that in the subgame starting at $t = 2$ both profit maximizing processors B and C can price discriminate and make non-negative profits if they are active in the market. Then, compared to the equilibrium where all three processors are profit maximizers, all farmers located either at $x_i \in [0, \frac{1}{3}]$ or at $x_i \in (\frac{2}{3}, 0)$ receive a higher farm gate price and will be better off. All farmers located at $x_i \in (\frac{1}{3}, \frac{2}{3}]$ receive the same farm gate price and are indifferent to the presence or absence of a cooperative.*

The potential for price discrimination changes the nature of the yardstick of competition effect. Unlike the ‘strong’ yardstick of competition effect

discussed in section 5, not all farmers ‘win’ from the presence of a farmer cooperative. Only those farmers who can ‘play off’ the cooperative against a for-profit processor gain from the competitive influence of the cooperative.

However, unlike the ‘weak’ yardstick of competition effect discussed in section 5, the presence of a cooperative cannot make any farmers worse off when there is price discrimination but no change in market structure. The continued presence of two for-profit processors means that competition does not weaken for any farmers. While those farmers ‘captured’ by the profit maximizing processors do not gain any spillover benefits from the farmer cooperative, they are also not made worse off by the presence of the cooperative.

Contestable farmers located either at $x_i \in [0, \frac{1}{3}]$ or at $x_i \in (\frac{2}{3}, 0)$ gain when there is a cooperative and two profit maximising processors, regardless of price discrimination. But the distribution of gains is different.

Using lemma 7.1 and comparing the farm gate price set by the cooperative with and without price discrimination, we can see that the cooperative sets a lower price when the for-profit processors price discriminate. The cooperative’s farm gate price with price discrimination less the price without price discrimination, is given by:

$$\Delta P_A = \frac{1}{12}(-11t + 6\sqrt{t(-8K_A + t)} + \sqrt{t(-216K_A + 25t)})$$

As $\frac{\partial \Delta P_A}{\partial K_A} < 0$ for $K_A \in [0, \frac{t}{9}]$ and $\Delta P_A = 0$ when $K_A = 0$, $\Delta P_A \leq 0$.

Conversely, if we consider the farm gate price set by each of the for-profit processors to farmers located either at $x_i \in [0, \frac{1}{3}]$ or at $x_i \in (\frac{2}{3}, 0)$, then this is higher with price discrimination.

For example, the difference between P_B^R with price discrimination and P_B in the absence of price discrimination is given by:

$$\Delta P_B^R = \frac{1}{36} \left(-2t + 9\sqrt{t(-8K_A + t)} - \sqrt{t(-216K_A + 25t)} \right)$$

But, as $\frac{\partial \Delta P_B^R}{\partial K_A} < 0$ for $K_A \in [0, \frac{t}{9}]$ and $\Delta P_B^R = 0$ when $K_A = \frac{t}{9}$, $\Delta P_B^R \geq 0$.

These differences reflect the increased intensity of the competition from for-profit processors when they can price discriminate. As processors B and

C set higher farms gate prices to ‘contestable’ farmers, this reduces the membership of the cooperative processor A . Given the fixed costs K_A are allocated between fewer farmers, this means that farmers who continue to supply the cooperative receive a lower total return. Of course, these farmers are still better off with the cooperative than if they faced three for-profit processors.

8 Conclusion

In this paper we have developed a formal model to explore the effects of a cooperatively-owned processor on a market for the supply of farm produce. We have formalized the ‘yardstick of competition’ effect and shown how and when farmers can gain or lose from the presence of a cooperative processor. In particular, we have highlighted the importance of both market structure and price discrimination for the yardstick of competition effect. The strong effect, where all farmers gain, only holds if the presence of a cooperative does not alter market structure and if there is no price discrimination. If the formation of a farmer cooperative leads to exit by a for-profit processor, then some farmers will lose.

We have also shown that alternative market structures, with and without a cooperative processor, can be stable. This suggests that history matters for industry structure in agricultural markets. The presence or absence of a farmer cooperative in a processing market may simply depend on how the industry structure evolved.

While our model builds on the insights of earlier researchers, particularly Sexton (1990), there is still considerable work that needs to be done in this area. For example, our model assumed that processor efficiency does not depend on ownership structure. This is consistent with evidence from the courts in New Zealand. However, the cost efficiency of a farmer cooperative compared to an equivalent for-profit processor is an open question that requires further empirical analysis.

Similarly, while our analysis showed that an industry structure either with or without a farmer cooperative can be stable, as we noted in section 6, actual

market structures sometimes change. This could reflect a variety of factors. For example, improvements in logistics may reduce the monopsony power that drives the benefits to farmers from a cooperative processor. Thus technological change may make the ‘yardstick of competition’ effect less relevant and encourage farmers to sell their shares in a cooperative to a for-profit processor. Alternatively, issues of funding may limit the ability of a cooperative to compete, or farmers may face liquidity constraints that encourage them to sell their shares in a cooperative. Understanding why industry structures change and how this affects farmers is a key issue for agricultural markets. While we have provided a first step, a full analysis of this issue is beyond the scope of this paper.

References

Cogeca (2010) *Agricultural cooperatives in Europe: Main issues and trends*, Brussels, 15 September.

Commission of the European Communities (2008) *Commission decision of 17.12.2008 declaring a concentration to be compatible with the common market and the EEA Agreement (Friesland Foods/Campina)*, Case No COMP/M.5046.

Damodaran, H. (2014), “Another Maharashtra verdict: Sugar goes private”, *Indian Express*, October 22.

Fonterra Co-operative Group Limited (2104) *Fonterra Annual Review 2014*.

Guenther, J. (2012), ‘The Development of the United Potato Growers Cooperatives’, *Journal of Cooperatives*, 26, 1-16.

Helmberger, R.G. and S. Hoos (1963) “Economic theory of bargaining in agriculture”, *Journal of Farm Economics*, 45, 1272-1280.

High Court of New Zealand (1991) “The New Zealand Co-operative Dairy Company Limited & Anor v Commerce Commission”, *New Zealand Business Law Cases*, 99-219.

Hueth, B., and G. Moschini, (2014) “Endogenous market structure and the cooperative firm”, *Working Paper 14-WP 547*, Centre for Agricultural and Rural Development, Iowa State University, Ames.

Innes, R., and R. Sexton, (1993) “Customer coalitions, monopoly price discrimination and generic entry deterrence”, *European Economic Review*, 37, 1569-1597.

Land O’Lakes, Inc. (2013) *2013 Annual Report*.

Lund, M. (2013) “Cooperative equity and ownership: An introduction”, University of Wisconsin Center for cooperatives, University of Wisconsin-Madison, April.

Sexton, R. (1990) “Imperfect competition in agricultural markets and the role of cooperatives: A spatial analysis”, *American Journal of Agricultural Economics*, 72(3), 709-720.

Sexton, R. and N. Lavoie (2001) “Food processing and distribution: An industrial organization approach”, *Handbook of Agricultural Economics*, v.1B., (B. Gardner and G. Raiser, eds), Chapter 15, North Holland.

Appendix: Proofs

Proof of lemma 3.1: First, note that in the original equilibrium, the expected and actual dividend paid by the cooperative processor at $t = 4$ is $F - P_A^0 - \frac{K_A}{Q_A^0} \geq 0$. Denote this by d_A^0 . Note that $F - P_A^1 - \frac{K_A}{Q_A^0} = d_A^0 - \Delta$.

Second, if at $t = 3$, farmers observe farm gate prices (P_A^1, P_B^0, P_C^0) and have dividend expectations $\tilde{d}_A^1 = d_A^0 - \Delta$, then all farmers will make the same choice as in the original equilibrium. So sales to each processor will be given by (Q_A^0, Q_B^0, Q_C^0) . Further, farmers’ dividend expectations will be met in equilibrium as the new dividend payment will be $F - P_A^1 - \frac{K_A}{Q_A^0} = d_A^0 - \Delta = \tilde{d}_A^1$. Thus, the farmers actions and expectations are a subgame perfect equilibrium for the subgame beginning at $t = 3$ where prices are (P_A^1, P_B^0, P_C^0) .

Third, for the subgame beginning at $t = 2$, as farmers' responses are the same as in the original equilibrium, P_B^0 and P_C^0 remain best responses when processor A sets a farm gate price of P_A^1 and farmers expect a dividend from processor A of \tilde{d}_A^1 . Thus, P_B^0 and P_C^0 remain equilibrium strategies for the subgame beginning at $t = 2$. Also, given P_B and P_C are unchanged, and as $P_A^0 + d_A^0 = P_A^1 + d_A^1$, setting P_A^1 must continue to maximise the membership of the processor and so remains an equilibrium strategy for the cooperative processor A .

As the strategies form an equilibrium in each subgame from $t = 2$, there is an equilibrium of the subgame at $t = 2$ where the cooperative sets a farm gate price $P_A^1 = P_A^0 + \Delta$, farmers who are members of the cooperative expect to receive, and do receive, a dividend from the cooperative of $d_A^1 = d_A^0 - \Delta$, the private processors set prices P_B^0 and P_C^0 and quantities supplied to each processor are (Q_A^0, Q_B^0, Q_C^0) . \square

Proof of lemma 4.1: Note that, given P_B and P_C , processor A will set P_A to maximise $(F - P_A)Q_A - K_A$. Substituting in for Q_A , processor A will set P_A to maximize:

$$(F - P_A) \left(\frac{2P_A - P_B - P_C}{2t} + \frac{1}{3} \right) - K_A$$

The first order condition is:

$$\frac{1}{2t} \left(2F - 4P_A + P_B + P_C - \frac{2t}{3} \right) = 0$$

But in a symmetric equilibrium, $P_A = P_B = P_C = F - \frac{t}{3}$ with $Q_A = Q_B = Q_C = \frac{1}{3}$. Substituting back into the profit function, each processor makes profit $\Pi_j = \frac{t}{9} - K_j$. \square

Proof of lemma 4.2: Given P_B and P_C , the cooperative processor A will set P_A such that:

$$(F - P_A) \left(\frac{2P_A - P_B - P_C}{2t} + \frac{1}{3} \right) - K_A = 0$$

From the first order condition for the profit maximising processors we know that:

$$2F - 4P_B + P_A + P_C - \frac{2t}{3} = 0 \quad \text{and} \quad 2F - 4P_C + P_A + P_B - \frac{2t}{3} = 0$$

By symmetry $P_B = P_C$. Simultaneously solving the equations gives two potential solutions for P_A . However, from the cooperative processor's objective function we know that if $K_A = 0$ then $P_A = F$, leaving the solution:

$$P_A = F - \frac{1}{12} \left(5t - \sqrt{t(-216K_A + 25t)} \right)$$

and

$$P_B = P_C = F - \frac{1}{36} \left(13t - \sqrt{t(-216K_A + 25t)} \right)$$

It immediately follows that the equilibrium price offered by each of the processors to farmers is decreasing in K_A . By substitution:

$$Q_A = \frac{1}{3} + \frac{-t + \sqrt{t(-216K_A + 25t)}}{18t}$$

$$Q_B = Q_C = \frac{1}{3} + \frac{t - \sqrt{t(-216K_A + 25t)}}{36t}$$

Note that Q_A is decreasing in K_A while Q_B and Q_C are increasing in K_A .

By construction, the profits of the cooperative processor are always zero. The profits of the profit maximizing processors are given by $(F - P_j)Q_j - K_j$. Noting that P_j is decreasing in K_A and Q_j is increasing in K_A for $j = B, C$, it immediately follows that Π_B and Π_C are increasing in K_A .

Finally, to show that farmers receive a price of at least $F - \frac{t}{3}$, $Q_B = Q_C \leq \frac{1}{3}$ while $Q_A \geq \frac{1}{3}$ and $\Pi_j \leq \frac{t}{9} - K_j$, $j = B, C$, note that $K_A \leq \frac{t}{9}$. By substitution, when $K_A = \frac{t}{9}$, the outcome is identical to the equilibrium with three profit maximising processors so that $P_A = P_B = P_C = F - \frac{t}{3}$, with each processor buying one-third of farmers' produce and $\Pi_j = \frac{t}{9} - K_j$, $j = B, C$. The inequalities follow directly from the changes to prices, profits and markets shares as K_A decreases. \square

Proof of lemma 4.3: Given P_A and P_B , the total sales to each processor are given by:

$$Q_A = \frac{(P_A - P_B)}{2t} + \frac{1}{2} \quad \text{and} \quad Q_B = \frac{(P_B - P_A)}{2t} + \frac{1}{2}$$

The cooperative processor A will set P_A such that:

$$(F - P_A) \left(\frac{P_A - P_B}{2t} + \frac{1}{2} \right) - K_A = 0$$

The profit of processor B is given by $\Pi_B = (F - P_B) \left(\frac{P_B - P_A}{2t} + \frac{1}{2} \right) - K_B$. Maximizing with respect to P_B gives the first order condition $P_B = \frac{F + P_A}{2} - \frac{t}{2}$.

Simultaneously solving for P_A and P_B (and choosing the highest value of P_A) gives:

$$P_A = F - \frac{1}{2} \left(3t - \sqrt{t(-16K_A + 9t)} \right)$$

and

$$P_B = F - \frac{1}{4} \left(5t - \sqrt{t(-16K_A + 9t)} \right)$$

It immediately follows that the equilibrium price offered by each of the processors to farmers is decreasing in K_A . By substitution:

$$Q_A = \frac{3}{8} + \frac{\sqrt{t(-16K_A + 9t)}}{8t}$$

$$Q_B = \frac{5}{8} - \frac{\sqrt{t(-16K_A + 9t)}}{8t}$$

Note that Q_A is decreasing in K_A while Q_B is increasing in K_A .

By construction, the profits of the cooperative processor are always zero. The profits of the profit maximizing processor B are given by $(F - P_B)Q_B - K_B$. Noting that P_B is falling in K_A and Q_B is increasing in K_A , it immediately follows that Π_B is increasing in K_A .

To show that processor A always offers a farm gate price above $F - \frac{t}{3}$, remember that $K_A \leq \frac{t}{9}$ and the price offered by processor A is decreasing in K_A . If $K_A = \frac{t}{9}$, then by substitution $P_A = F - \frac{t}{6}(9 - \sqrt{65}) > F - \frac{t}{3}$. Thus, processor A always offers a farm gate price above $F - \frac{t}{3}$.

For processor B , note that its price is decreasing in K_A . If $K_A = 0$, $P_B = F - \frac{t}{2} < F - \frac{t}{3}$. Thus, processor B always offers a farm gate price less than $F - \frac{t}{3}$.

For market shares, when $K_A = \frac{t}{9}$, $Q_A = \frac{3}{8} + \frac{\sqrt{65}}{24} > \frac{2}{3}$. As Q_A is decreasing in K_A it follows that the cooperative processor will have more than two-thirds of farmers as members while $Q_B < \frac{1}{3}$.

Processor B 's profit is minimized when $K_A = 0$ at $\Pi_B = \frac{t}{8} - K_B$. This is greater than the profit that processor B makes when all three processors are profit maximizers. So the profit of processor B when it is the only profit

maximizing processor and is competing against a cooperative processor is always higher than where all processors are profit maximizing. \square

Proof of lemma 4.4: From the proof of lemma 4.2, the private processors profits are given by:

$$\Pi_B = \Pi_C = \frac{1}{648} \left(-108K_A + 97t - 13\sqrt{t(-216K_A + 25t)} \right) - K_j \quad j \in \{B, C\}$$

Setting $K_A = K_B = K_C = K$, $\Pi_B = 0$ and solving for K gives $K = \frac{4t}{49}$ and $K = \frac{t}{9}$. Noting that $\frac{\partial \Pi_B}{\partial K} < 0$ when $K = \frac{4t}{49}$, it follows that profits are negative for both private processors when $K_A = K_B = K_C$, $K_j \in (\frac{4t}{49}, \frac{t}{9})$ \square

Proof of proposition 5.1: Part (1) of the proposition immediately follows from subgame perfection. If processor A is a farmer cooperative but, in the subgame starting at $t = 2$, both B and C make non-negative profits, then both B and C will be at least as well off by continuing to be active as if they dropped out. As such, each of processors B and C will choose to continue at $t = 1$ and there will be three active processors in the market.

Part (2a) follows immediately from lemma 4.2.

For part (2b) of the proposition, let P_j^n be the equilibrium price set by processor j when all competing processors are profit maximizers, while P_j^c is the equilibrium price of processor j when processors B and C are profit maximizers but processor A is a farmer cooperative. Using the prices derived in lemma 4.1 and 4.2 we can find $\Delta P_j = P_j^c - P_j^n$ for $j \in \{A, B, C\}$:

$$\Delta P_A = \frac{1}{12} \left(-t + \sqrt{t(-216K_A + 25t)} \right)$$

$$\Delta P_B = \Delta P_C = \frac{1}{36} \left(-t + \sqrt{t(-216K_A + 25t)} \right)$$

As $\Delta P_A = \Delta P_B = \Delta P_C = 0$ when $K_A = \frac{t}{9}$ (which is the maximum value by assumption); $\frac{\partial \Delta P_A}{\partial K_A} < 0$; and $\frac{\partial \Delta P_B}{\partial K_A} = \frac{\partial \Delta P_C}{\partial K_A} < 0$, it immediately follows that farm gate prices are higher for all farmers when one processor is a cooperative. Further, as all processors operate, each farmer could choose to sell to the same processor when A is a cooperative as that farmer sells to when A is a profit maximizing processor. Thus, each farmer can gain a farm gate

price but pay no greater transport costs when A is a cooperative as when A is a profit maximizer, so each farmer will be better off when processor A is a farmer cooperative.

Part (3) of the proposition follows directly from lemma 4.2, noting that cooperative processor A is supplied by more than one third of farmers in equilibrium. \square

Proof of proposition 5.2: Part (1a) follows directly from lemma 4.3.

For part (1b), note that, by lemma 4.1 and lemma 4.3, all farmers who sell to processor B in the equilibrium when processor A is a cooperative and processor C chooses not to participate would have sold to either processor B or C when all three processors maximize profits. Further, the farm gate price set by processor B is lower when processor A is a cooperative than the farm gate price set by both processor B and processor C when processor A maximizes profits. It immediately follows that all farmers who sell to processor B receive a lower farm gate price in the equilibrium where processor A is a farmer cooperative rather than a profit maximizer. As each farmer's transport costs are no lower than when there are three profit maximising processors, this means that these farmers are all strictly worse off when processor A is a cooperative than in the equilibrium with three profit maximizing processors.

For part (1c), from lemma 4.3, all farmers who sell to processor A when it is a cooperative will receive a higher farm gate price strictly above $F - \frac{t}{3}$ in the equilibrium where processor A is a farmer cooperative. By lemma 4.1 this is greater than the farm gate price farmers receive when all processors maximize profits. As the transport costs are unchanged for these farmers, they will be strictly better off.

For part (1d), note from lemma 4.3 that the farm gate price for cooperative processor A is strictly greater than the farm gate price for processor B . This means that there is a set of farmers \mathcal{X} located between $x_i = \frac{1}{6}$ and $x_i = \bar{x}$ where $\bar{x} \in (\frac{1}{6}, \frac{1}{3})$ that would supply processor B if all three processors maximize profits, but that sell to processor A when A is a cooperative. Define \bar{x} by the value $x_i < \frac{1}{3}$ such that the farmer at x_i is just indifferent between

selling to processor B and processor A when A is a cooperative. By linear transport costs and the fact that processor B purchases a positive quantity when A is a cooperative, we know that such an x_i exists. By continuity, the set \mathcal{X} contains a positive mass of farmers.

Consider the farmer at $x_i = \frac{1}{3}$. With three profit maximizing processors, this farmer was indifferent between selling to processor A or B . But when A is a cooperative, the farmer strictly prefers to sell to processor A and receives a higher farm gate price than when all processors are profit maximizers. The farmer is strictly better off when A is a cooperative. But, by continuity, this means that there must be farmers who are in \mathcal{X} and located close to $x_i = \frac{1}{3}$ who are also better off when A is a cooperative.

Consider the farmer at $x_i = \bar{x}$. With three profit maximizing processors, this farmer sold to processor B . When A is a cooperative, this farmer is indifferent between selling to processor A or B . But Processor B sets a lower farm gate prices when A is a cooperative than with three profit maximizing processors. Given that transport costs to processor B are unchanged, this means that the farmer at \bar{x} must be strictly worse off when A is a cooperative. By continuity, this means that there must be farmers who are in \mathcal{X} who are located close to \bar{x} who are also worse off when A is a cooperative.

By construction, all farmers in \mathcal{X} sell to processor A when A is a cooperative. However, some of these farmers will be better off and some worse off than in the equilibrium when there are three profit maximizing processors, as required by (1d).

Finally, part (2) of the proposition follows directly from lemma 4.3, noting that processor A is supplied by more than two thirds of farmers in equilibrium. \square

Proof of lemma 6.1: When there are three profit maximising processors, each processor serves exactly one-third of farmers. When processor A is a cooperative, it will serve all farmers located between $[0, \frac{1}{6} + \gamma)$ and $[\frac{5}{6} - \gamma, 1)$. As $K_A < \frac{t}{9}$, $\gamma > 0$.

From lemma 4.1, in the absence of a cooperative processor, $P_A = P_B =$

$P_C = F - \frac{t}{3}$ with profit $\Pi_j = \frac{t}{9} - K_j$, $j \in \{A, B, C\}$.

We need to show that, if A is a cooperative, then the total gain to farmers exceeds $\frac{t}{9} - K_A$. To do this we divided the farmers into two sets:

- Farmers who sell to processor A when it is profit maximizing.
- Other farmers.

First, consider the farmers who sell to processor A when it is profit maximizing. They continue to sell to processor A when it is a cooperative. When the processor is profit maximizing, these farmers in total received a benefit (after the costs of producing their crop) of

$$\frac{1}{3} \left(F - \frac{t}{3} - c \right) - \int_0^{\frac{1}{6}} x t dx - \int_{\frac{5}{6}}^1 (1-x) t dx \quad (3)$$

When processor A is a cooperative, and noting that the fixed cost K_A is shared by cooperative members which are at least $\frac{1}{3}$ of farmers, these farmers receive at least a benefit of:

$$\frac{1}{3} (F - 3K_A - c) - \int_0^{\frac{1}{6}} x t dx - \int_{\frac{5}{6}}^1 (1-x) t dx \quad (4)$$

The difference between (3) and (4) is at least $\frac{t}{9} - K_A$. But, this is just Π_A . So the total gain to farmers who always sell to processor A is at least the private processor's profit. It just remains to show that other farmers are better off in total when processor A is a cooperative compared to when it is profit maximizing. But this follows directly from the proof of proposition 5.1 noting that $K_A < \frac{t}{9}$. \square

Proof of proposition 6.2: Suppose the entrepreneur pays the private owner of processor A a price k to purchase the processor and turn it into a cooperative. In order to buy the processor from its private owner, the owner must at least be compensated for any lost profit $\Pi_A = \frac{t}{9} - K_A$. Thus $k \geq \frac{t}{9} - K_A$.

The price k will be part of the capital costs of the processor. Thus, we can define an augmented capital cost to the cooperative as $K_A^* = k + K_A$. Note that $K_A^* \geq \frac{t}{9}$.

There are two cases that follow from lemmas 4.1 and 4.2:

- If $K_A^* > \frac{t}{9}$ the cooperative will never be able to recover its capital costs in equilibrium. Thus if $k > \frac{t}{9} - K_A$ the entrepreneur will make a loss, violating the condition of the proposition.
- If $K_A^* = \frac{t}{9}$ the equilibrium with the cooperative processor is identical to the equilibrium when all processors are profit maximizers.

Thus an entrepreneur can only purchase the private processor A and convert it to a cooperative processor with no loss if the outcome with the cooperative is identical to the situation with three profit maximizing processors. \square

Proof of proposition 6.3: Consider the farmer members located between $[0, \frac{1}{6}]$ and $[\frac{5}{6}, 1)$. Note that these farmers will sell to processor A regardless of whether it is a cooperative or a profit maximizing processor. As such, these farmers will get identical gains from the sale of the cooperative. Further, these farmers make up more than 50 per cent of the members of the cooperative. It follows that these farmers will always vote the same way, and if these farmers favour a sale, then the sale will occur but if these farmers oppose a sale, the cooperative will not be sold.

When processor A is a cooperative and net of transport costs (which do not vary whether the processor is a cooperative or a profit maximizer), these farmers receive a return on their produce of:

$$G_C = F - \frac{K_A}{\frac{1}{3} + 2\gamma}$$

where $\frac{1}{3} + 2\gamma$ is the total number of farmer members in the cooperative.

If the cooperative is sold, the maximum price that an entrepreneur can pay and be no worse off is the profit that a profit maximizing processor will earn in equilibrium when there are three competing profit maximizing processors. Thus, the maximum payment in total that the farmer members can receive from a sale is $\Pi_A = (\frac{t}{9} - K_A)$.

Suppose this payment is made for the processor. It remains to show that the farmers located between $[0, \frac{1}{6}]$ and $[\frac{5}{6}, 1)$ are worse off if this sale proceeds.

Noting: (1) that the payment for the cooperative is shared equally by all farmer members; and (2) that the relevant farmers will continue to supply processor A in equilibrium after the sale and will receive a price of $F - \frac{t}{3}$ for their produce, if the sale proceeds each farmer member located between $[0, \frac{1}{6}]$ and $[\frac{5}{6}, 1)$ receives:

$$G_N = F - \frac{t}{3} + \left(\frac{t}{9} - K_A \right) \frac{1}{\frac{1}{3} + 2\gamma}$$

Simplifying,

$$G_C = F - K_A \left(\frac{3}{1 + 6\gamma} \right)$$

and

$$G_N = F - K_A \left(\frac{3}{1 + 6\gamma} \right) - \frac{t}{3} \left(\frac{6\gamma}{1 + 6\gamma} \right)$$

It immediately follows that the return to each farmer located between $[0, \frac{1}{6}]$ and $[\frac{5}{6}, 1)$ is negative. Thus these farmers will always oppose the sale and the sale can never receive majority support for any price that does not make the entrepreneur worse off than if the sale does not proceed. \square

Proof of lemma 7.1: With price discrimination, the profit maximizing processors can set different prices to different farmers depending on whether the farmer is located to the ‘left’ or ‘right’ of the processor. Using L and R to denote left and right we have demands for each processor:

$$Q_A = \frac{2P_A - P_B^R - P_C^L}{2t} + 1/3$$

$$Q_B^R = \frac{P_B^R - P_A}{2t} + 1/6$$

$$Q_B^L = \frac{P_B^L - P_C^R}{2t} + 1/6$$

$$Q_C^R = \frac{P_C^R - P_B^L}{2t} + 1/6$$

$$Q_C^L = \frac{P_C^L - P_A}{2t} + 1/6$$

As before, the cooperative sets its price, P_A , such that $(F - P_A)Q_A - K_A = 0$. Each for-profit processor j solves:

$$\max_{P_j^R, P_j^L} [(F - P_j^R)Q_j^R + (F - P_j^L)Q_j^L - K_j]$$

The first order conditions for profit maximization for the for-profit processors are:

$$\begin{aligned} \frac{3F + 3P_A - 6P_B^R + t}{6t} &= 0, & \frac{3F + 3P_C^R - 6P_B^L + t}{6t} &= 0 \\ \frac{3F + 3P_A - 6P_C^L + t}{6t} &= 0, & \frac{3F + 3P_B^L - 6P_C^R + t}{6t} &= 0 \end{aligned}$$

Solving simultaneously we find prices to be:

$$\begin{aligned} P_A &= \frac{1}{2}(2F - t + \sqrt{-8K_A t + t^2}) \\ P_B^L &= P_C^R = F - \frac{t}{3} \\ P_B^R &= P_C^L = \frac{1}{6}(6F - \frac{5t}{2} + \frac{3}{2}\sqrt{-8K_A t + t^2}) \end{aligned}$$

as required. \square

Proof of proposition 7.2: The proposition follows directly from lemma 4.1 and lemma 7.1.

With three profit maximizing processors, all farmers receive a farm gate price of $F - \frac{t}{3}$. With a cooperative and price discrimination, farmers located at $x \in (\frac{1}{3}, \frac{2}{3}]$ continue to receive a farm gate price of $F - \frac{t}{3}$ and will choose to supply the same processor as when all processors maximize profits. Thus these farmers receive the same farm gate price and are indifferent to the presence or absence of a cooperative.

With a cooperative and price discrimination, farmers located either at $x \in [0, \frac{1}{3}]$ or at $x \in (\frac{2}{3}, 0)$ can choose to either supply the cooperative or a profit maximizing processor. Note that the cooperative's farm gate price is decreasing in K_A and $P_A = F - \frac{t}{3}$ when $K_A = \frac{t}{9}$. Similarly, P_B^R and P_C^L are decreasing in K_A and $P_B^R = P_C^L = F - \frac{t}{3}$ when $K_A = \frac{t}{9}$. Remembering that $K_A \leq \frac{t}{9}$, this means that all farmers located either at $x \in [0, \frac{1}{3}]$ or at $x \in (\frac{2}{3}, 0)$ receive a higher farm gate price when processor A is a cooperative

rather than when all three processors maximize profits, so that these farmers will be better off when processor A is a cooperative. \square