Regulation, Incentives and Ownership

Richard Meade*

Draft: 14 March 2013

Abstract

We extend the theory of monopoly regulation under imperfect information to the case of customer, rather than investor, ownership. Customer ownership of a monopoly, in which a risk-averse manager can exert non-contractable effort to reduce uncertain costs, increases the optimal power of managerial incentives relative to the case of investor ownership when customer owners are risk averse. This remains true whether or not the monopoly is subject to price regulation. However, with regulation, the welfare maximising price is higher and consumer surplus lower under customer ownership than under investor ownership, reflecting these stronger incentives. Unlike other studies predicting greater managerial slack and weaker financial performance under customer ownership, we find ambiguous implications for managerial effort, and expected costs, profitability and wages, relative to investor ownership. These differences vanish – i.e. customer owners behave like investor owners – if customer owners are risk neutral. Finally, our analysis of unregulated customer ownership highlights how differences in risk preferences between customers and regulators can distort regulated prices, which are lower than unregulated prices even under customer ownership. While we predict that managerial slack and cost efficiency will be lower under unregulated customer ownership than regulated customer ownership, this better reflects the trade-offs that would be made by the very parties the regulator is presumed to serve. Our findings illustrate that ownership affects both the interaction between incentives and regulation, as well as the rationale for regulation.

JEL Classifications: D82, J33, L51, L94, L95, P13.
Keywords: Moral Hazard, Profit Sharing, Regulation, Electric Utilities, Gas, Water Utilities, Cooperatives.

*Toulouse School of Economics, New Zealand Institute for the Study of Competition and Regulation, Cognitus Advisory Services Limited. Contact email: richard.meade@cognitus.co.nz. The author gratefully acknowledges helpful comments from Claude Crampes. As usual, any remaining errors or omissions are the author's.

1 Introduction

The modern theory of regulation and incentives examines how best to regulate a profit-maximising firm when the regulator has imperfect information (e.g. Baron and Myerson (1982), Laffont and Tirole (1986, 1993)). Such a focus is justified for investor-owned firms, since profit-maximisation can reasonably be assumed.[1] However, many monopolies are customer-owned (or municipally-owned), in which case different risk preferences and objectives can arise. Hence, this paper extends the theory of regulation and incentives by examining how customer ownership, relative to investor ownership, changes or substitutes for the regulation of monopolies under imperfect information.

Regulation is frequently motivated by concerns to protect consumers against the abuse of market power in imperfectly competitive or monopolistic industries. These circumstances characterise many utility sectors, such as in the long-distance (i.e. transimssion) or shorter-distance (i.e. distribution) transportation of electricity, water or gas, as well as in telecommunications. Many firms operating in such sectors are investor owned, particularly in large and dense customer centres, and in developed areas, both of which features support profitable investment. However, in smaller or less dense customer centres, or in developing areas, investment profitability can be poor, in which case other forms of ownership often dominate. These include government, municipal and customer ownership, as comprehensively surveyed and explained for the US in Hansmann (1996).

For example, using 2010 data from NRECA (2012), Table 1 overleaf presents summary statistics on US electric utilities, highlighting the dominance of investor-owned firms, but showing that rural electric cooperatives (i.e. customer-owned firms) are almost as significant as publicly-owned (i.e. municipal) firms in terms of customers and sales, and rival even investor-owned firms in terms of network size (i.e. line length). Conversely, customer-owned firms dominate in terms of distribution assets per customer, reflecting their relatively much lower customer density. Notably, the 912 customer-owned electric utilities can be found in 47 US states, with networks covering 75% of the US landmass, generating annual revenues in the order of US$40 billion from assets worth US$140 billion (NRECA (2012)).

Customer ownership of electricity distribution firms is also significant in parts of Europe (Italy and Spain), Latin America (Argentina, Bolivia, Brazil and Chile), and Asia (India, the Philippines and Bangladesh) (NRECA International (2010)). It is the dominant form of ownership in the New Zealand electricity distribution sector (Talosaga and Howell (2012)). Similarly, cooperatives are important providers of telecommunications and water services in the rural US (Deller et al. (2009)), for example with 260 telephone cooperatives supplying just 5% of subscribers, but covering more than 40% of the US landmass. Water cooperatives are also common in rural parts of New South Wales and Tasmania in Australia (ACIL Tasman (2005)) and also in certain horticultural regions of New Zealand (Le Prou (2007)). They are also common in Finland, as are energy coop-

[1] The theory of corporate finance would substitute shareholder wealth maximisation for profit maximisation (e.g. Brealey et al. (2011)). Setting aside issues of intertemporal profit manipulation, and assuming economic rather than accounting-based profits, profit maximisation should serve as a reasonable proxy.

Table 1: Significance of Customer-Owned Electric Utilities in the US (2010)

	Investor-Owned	*Publicly-Owned*	*Customer-Owned*
No. Organisations	200	2,000	912
No. Customers (million)	104	21	18.5
Revenue (US$billion)	273	53	40
Share of Distribution Lines Length	50%	7%	43%
Customers/Line Mile (i.e. density)	34	48	7.4
Distribution Assets/Customer (US$)	2,798	2,740	3,290

eratives.[2] Finally, aside from their importance in developed countries, customer-owned firms and other forms of cooperatives are regarded as important for development in less-developed countries.[3] In particular customer-owned firms have played important roles in rural electrification in Bangladesh, Costa Rica, Kenya, the Philippines, and other developing countries (Barnes and Foley (2004), Kirubi et al. (2009), NRECA International (2010)).

Importantly, there is a diversity of regulatory treatment for customer-owned utilities. While investor-owned electricity distribution firms in the US are subject to price regulation, customer-owned electricity firms are regulated in just 16 of the 47 states in which they arise (NRECA International (2010)). Likewise, customer-owned US telephone firms are often not subject to price regulation, unlike their investor-owned counterparts, while customer-owned US water firms are free of price regulation (Deller et al. (2009)).[4] In New Zealand, 19 out of 29 electricity distribution firms return some part of their profits to a significant proportion of their customers in proportion to their patronage (Ministry of Economic Development (2010)), or are customer-controlled to some degree, and hence bear the hallmarks of customer-owned firms. However, only 11 of these 19 satisfy legal requirements enabling them to opt out of price regulation (Commerce Commission (2010)).

The fact that many customer-owned electricity and telephone firms (and all such water firms) in the US are unregulated is attributed to them being operated as "not for profits" – instead, existing to provide "service at cost" – and also because they are customer-controlled and hence in a large part "self-regulating" (Deller et al. (2009), NRECA International (2010)). However, all such firms must be run profitably in order to remain viable and to fund required investments, so in practice they accumulate "margins" – an excess of revenues over costs, i.e. profits (Deller et al. (2009)).[5] Margins that are not needed for

[2]Finland had 938 water cooperatives and 74 energy cooperatives as at December 2008, from www.pallervo.fi (downloaded September 2010).

[3]Indeed, in 2010 the UN General Assembly resolved to declare 2012 the International Year of Cooperatives, in recognition of the contribution of cooperatives to socio-economic development.

[4]Similarly, credit unions – a form of depositor cooperative – were exempted from the interest rate ceilings that applied to investor-owned banks in the US for many years (Hansmann (1996)).

[5]Indeed, customer-owned US electric utilities often covenent in their loan contracts to charge output tariffs that are sufficiently high to enable them to repay their lenders (NRECA International (2010)). While the influence of debt financing on the interaction between regulation and incentives for customer-

investments are eventually returned to customer-owners in the form of "capital credits", in proportion to their patronage of the relevant firm, usually via a credit on their bill. Such returns amount to some US$600 million annually just for US electricity cooperatives (NRECA (2012)).[6]

Given the prevalence and scale of such customer-owned, imperfectly competitive firms, the questions of whether and how they should be regulated are potentially of considerable economic importance. The answers to these questions can be predicted to depend on both the circumstances of such firms, as well as their ownership. Profit-maximising investor-owned firms may be more prone to exploiting their market power if they operate in highly profitable markets. Conversely, in less profitable or undeveloped markets they may find it unprofitable to invest, or will only invest if they can reduce service quality so as to achive profitability. Conversely, customer-owned firms may be less likely to exploit their customers, but instead choose to service markets at levels that are unprofitable for investor-owned firms (Hueth et al. (2004)). They can do so by charging their customer-owners potentially higher prices than customers in more profitable markets serviced by investor-owned firms. Market abuse concerns need not arise in this case, however, since any resulting profits can be returned to the customer-owners in proportion to their patronage (i.e. via higher service levels, or through profit distributions such as price rebates). A possible trade-off they make, however, is that diffuse customer ownership may not provide as strong managerial performance incentives as more concentrated investor-ownership (Schleifer and Vishny (1997)), or might otherwise suffer from poor incentives (Jensen and Meckling (1976)), each of which might manifest as cost inefficiency. Hence, while investor-owned firms may warrant price regulation to limit customers being subjected to market power abuse, customer-owned firms might benefit from regulation if it induces stronger managerial performance.

This paper explores how optimal price regulation of a monopoly differs under customer- and investor-ownership. Incentive problems arise because the risk-averse manager of the monopoly can exert non-contractible effort which reduces uncertain costs and hence affects profitability despite revenues being fixed by regulation. Key to our analysis are the assumptions that customer-owners are more risk-averse than investor-owners when setting fixed and variable (i.e. profit-related) incentives for the manager, and that they care about expected profits to some degree (as well as consumer surplus). These features cause customer-owners to offer the manager higher-powered incentives than do investor-owners.

owned firms is not the focus of this research, lending considerations further underscore that customer-owners will act to ensure that their firm's remain profitable, and thus value profits.

[6]The fact that customer-owned electric utilities in the US distribute such large annual amounts to their customer-owners highlights that their oft-used "not-for-profit" label might cause confusion. As explained in Hansmann (1996), traditionally this term is used for voluntary (e.g. charitable) organisations which rely on donor contributions to fund their activities. Even in this context such organisations must remain profitable in order to remain viable – instead the "not-for-profit" status refers to the fact that their operating surpluses *cannot* be distributed (so as to protect donors' interests). Instead, in the present context, "not-for-profit" status appears to be relevant for US tax purposes, in that US customer-owned utilities typically qualify for tax exemptions along the lines of those enjoyed by more traditional "not-for-profit" organisations (Deller et al. (2009)). Such tax advantages are not always available in other jurisdictions, such as New Zealand (Evans and Meade (2005)).

They also cause the regulator to set a higher regulated price (and hence lower quantity and consumer surplus) under customer-ownership than under investor-ownership, resulting in ambiguous implications for managerial effort and cost efficiency. These differences vanish – i.e. customer-owners behave and are regulated like investor-owners – if customer-owners are assumed to effectively share the risk preferences of investor-owners.

Finally, we consider the case of unregulated customer ownership, with customer-owners setting price instead of the risk-neutral regulator. Even if such owners value expected profits to the same degree as would a regulator, we find that risk-aversion on their part causes them to choose a higher price than the regulator's price, trading off consumer surplus against the expected utility of profits to a greater degree.

Taken together our findings indicate that if customer-owned monopolies featuring incentive problems are to be regulated, they should be less tightly regulated than investor-owned firms. Indeed, if customer-owned monopolies do not generate negative production externalities, and truly reflect the preferences of their customers, then it may be preferable to leave customer-owned firms unregulated despite the resulting higher prices and lower consumer surplus. Regulating such firms may simply impose regulatory distortions (in the form of regulatory rather than customer preferences) without improving the welfare of those it is intended to protect.

The literature closest to ours includes three-tier regulatory incentives models such as those in Laffont and Tirole (1993), Demski and Sappington (1987) and Spiller (1990). The latter considers incentive issues in the context of politicians and interest groups competing to influence the effort choice of a regulator. The others involve a principal, regulator and firm, focusing on the provision of incentives to the regulator (with the possibility of regulatory capture in Laffont and Tirole). None of these papers considers how different forms of ownership will affect the interaction between regulation and managerial incentives, and to our knowledge there is currently no other formal research on this question.

Our paper is structured as follows. Section 3 describes our setup, and in particular discusses why customer-owners can be predicted to be more risk-averse than investor-owners. Section 4 derives our findings in the regulated customer-ownership (RCO) and regulated investor-ownership (RIO) cases. It also extends the analysis to the case of unregulated customer ownership (UCO). Finally, Section 5 summarises and concludes.

2 Setup

2.1 The Monopoly

A regulated monopoly produces a single good or service facing demand function $q(p)$ and given regulated output price p, with $q' < 0$ and $q'' \geq 0$.[7] The form of demand is common knowledge. The monopoly's unit marginal cost is $\theta - e + u$, where θ is an observible technical efficiency parameter, but random cost element $u \sim N(0, \sigma_u^2)$ is unobservible ex

[7]Examples of demand functions having this form include Cobb-Douglas, log-linear and linear demand – i.e. any demand function not concave in price.

post to both owners and the regulator.[8] Cost-reducing effort e is exerted by the manager of the monopoly, at private cost $\psi(e) = c_m e^2/2$, with the manager's intensity of private effort cost $c_m > 0$. While known to the manager, this effort is unobservible and hence non-contractible to both owners and the regulator, since they do not observe u even ex post (or e is simply assumed to be otherwise non-contractible).[9]

For expositional purposes, fixed costs other than the manager's (non-sunk) fixed wage are normalised to zero. Modelling additional (sunk) fixed costs would enable an analysis of the impact of ownership on regulation and incentives in the presence of (e.g.) stranded assets, particularly in the context of dynamic issues such as investment and entry, neither of which are the focus of this paper. Furthermore, introducing such costs would complicate the present analysis without fundamentally altering its qualitative conclusions.

2.2 The Owners' Problem

Since managerial effort is non-contractible, to induce the manager to exert cost-reducing effort the monopoly's owners offer the manager both fixed and variable (i.e. pre-wage profit-related) incentives. They do so subject to ensuring that in expected utility terms the manager achieves his or her reservation wage $\overline{w}$ (i.e. subject to satisfying the manager's individual rationality constraint) with $\overline{w}$ normalised to zero.[10] Adopting the convention that all ownership-related choice variables in the case of regulated customer ownership (i.e. RCO) are subscripted "c", while such variables remain unsubscripted in the case of regulated investor-ownership (i.e. RIO), the manager's wage in the RCO case, which is uncertain ex ante, writes as:

$$w_c = t_c + \beta_c[q(p_c)(p_c - (\theta - e_c + u))] \tag{1}$$

Here t_c is the manager's fixed wage, and β_c is the sensitivity of the manager's wage to pre-wage profits (i.e. the power of managerial incentives).[11] The manager's wage in the RIO case is defined analogously:

$$w = t + \beta[q(p)(p - (\theta - e + u))] \tag{2}$$

Investor-owners are treated as being risk-neutral, and so choose fixed wage t and pre-wage profit-sensitivity β to maximise expected post-wage profits:

$$E\{\Pi(t, \beta)\} = E\{q(p)(p - (\theta - e_c + u)) - w\} \tag{3}$$

[8]For example, u could represent the effect of random weather variation on a utility's network maintenance costs, which effect is either not fully observible or completely understood except, perhaps, by the manager (ex post).

[9]Similar incentive problem specifications were adopted in Raith (2003), Graziano and Parigi (1998) and Beiner et al. (2011).

[10]In effect it is asumed that the manager is made a take-it-or-leave-it offer by the owners, but since individual rationality is satisfied the manager will always accept that offer.

[11]A linear incentive contract of this form is considered reasonable given customer-owned firms are normally not listed on stock exchanges and hence, in the absence of an observible share price, cannot offer managers non-linear incentive components such as share options. Furthermore, fixed wages plus performance-related (e.g. profit-based) bonuses are feasible and common incentive components for senior managers in both customer- and investor-owned firms in a wide range of industries.

which, after substitution for w, simplifies as:

$$E\{q(p)(p-(\theta-e_c+u))(1-\beta)-t\} \tag{4}$$

In contrast, customer-owners are assumed to be risk-averse, with risk-aversion parameter $\rho_c \geq 0$ and CARA preferences. Like investor-owners they are assumed to care about post-wage expected profits, though with weight $\alpha_c > 0$. We assume that α_c is sufficiently large that the firm is expected to at least break even. Unlike investor-owners – but as we shall see, like regulators – customer-owners are assume to also value (net) consumer surplus $CS(p_c) \equiv \int_{p_c}^{\infty} q(P)dP$. Thus customer-owners choose t_c and β_c to maximise their expected utility from consumer surplus and weighted profits, namely:

$$E\{U_{\rho_c}(CS(p_c)+\alpha_c\Pi_c(t_c,\beta_c))\} \tag{5}$$

which writes as:

$$-exp\{-\rho_c(\int_{p_c}^{\infty} q(P)dP+\alpha_c[q(p_c)(p_c-(\theta-e_c+u))(1-\beta_c)-t_c])\} \tag{6}$$

However, since $CS(p_c)$ is determined by the regulator's price choice under RCO, in effect customer-owners in this case choose t_c and β_c to maximise their expected utility from α_c-weighted profits. This highlights that customer-owners choose the manager's incentive parameters to maximise the same objective function as investor owners in the special case where $\rho_c \to 0$ and $\alpha_c = 1$.[12] As we will see later, under unregulated customer-ownership (i.e. UCO), price becomes a choice variable of customer-owners. Hence in that case consumer surplus plays a role in the choice of the manager's incentive parameters, which role is influenced by the customer-owners.

In each case we assume owners operate in a unitary fashion, so we abstract from collective decision-making problems among either investor-owners or customer-owners.

2.3 The Manager's Problem

The manager is assumed to be risk-averse with risk-aversion parameter $\rho \geq 0$ and CARA preferences. He or she thus chooses cost-reducing effort to maximise the expected utility of wages net of effort costs. In the RCO case this writes as (with the RIO case defined analogously by omitting subscripts "c"):

$$E\{U_\rho(w_c-\psi(e_c))\} = -exp\{-\rho(t_c+\beta_c[q(p_c)(p_c-(\theta-e_c+u))]-\frac{c_m}{2}e_c^2)\} \tag{7}$$

We assume either that there is a single manager of the monopoly, or that managers capable of reducing the firm's costs through their private effort choices do so in a unitary fashion. Thus we abstract from incentive issues within teams or intra-firm hierarchies.

[12] Indeed, imposing $\alpha_c = 1$ is superfluous to ensure coincidence of the customer-owners' and investor-owners' objective functions, for two reasons. Firstly, as we shall see, as $\rho_c \to 0$ it becomes clear that α_c plays no independent role in the choice of the manager's incentives, with $\rho_c\alpha_c$ being the relevant distinguishing parameter. Secondly, since α_c is a positive scalar, in the absence of risk-aversion, maximising $\alpha_c E\{\Pi_c\}$ with respect to the manager's incentive parameters is equivalent to maximising $E\{\Pi_c\}$.

2.4 The Regulator's Problem

The regulator is assumed to be risk-neutral, and cares about both consumer surplus and post-wage profits.[13] Unlike customer-owners, however, the regulator applies a weight $\alpha_r > 0$ to profits, with $\alpha_r \lesseqgtr \alpha_c$.[14] As for α_c in the customer-owners' problem, we assume α_r is sufficiently large that the firm is expected to at least break even.[15] Thus the regulator chooses the monopoly's price so as to maximise the expected value of consumer surplus and α_r-weighted profits, which in the RCO case writes as (with the RIO case defined analogously by omitting subscripts "c"):

$$E\{CS(p_c) + \alpha_r \Pi_c\} = E\{\int_{p_c}^{\infty} q(P)dP + \alpha_r[q(p_c)(p_c - (\theta - e_c + u))(1 - \beta_c) - t_c]\} \quad (8)$$

Aside from potentially applying a profit weight that differs to that applied by customer-owners, we make no assumption as to whether the regulator acts either with or without bias when seeking to serve the interests of the customers it is assumed to protect. Thus we abstract from possible incentive issues as between regulators and either their appointers (e.g. politicians) or stakeholders (i.e. customers, managers, environmentalists, etc).

2.5 Timing

In the cases of regulated customer-ownership and investor-ownership (i.e. RCO and RIO), timing is illustrated as in Figure 1. Since cost uncertainty u is not resolved until after all agents have taken their decisions, all expectations are taken with respect to u. Our timing is thus:

1. First, anticipating the incentive parameter choices of the monopoly's owners and the effort choice of its manager, the regulator chooses the monopoly's output price to maximise expected consumer surplus and α_r-weighted profits.

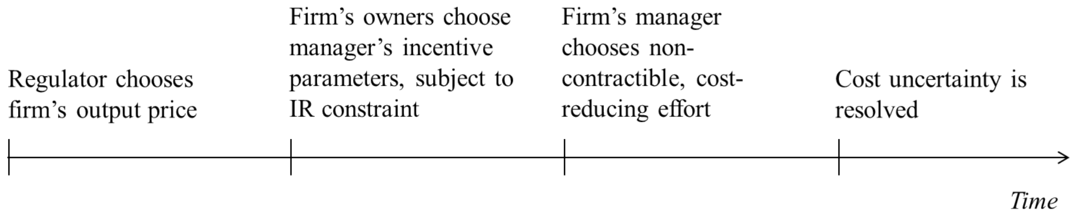
2. Second, taking the regulator's price choice as given, and anticipating the manager's optimal effort choice, the monopoly's owners choose the manager's incentive parameters subject to meeting the manager's reservation wage. In the RCO case this choice is made to maximise the expected utility of consumer suplus and α_c-weighted profits, while in the RIO case it is made to maximise expected profits.

[13] In principal a regulator might also care about the manager's wage, perhaps with some weighting other than one. In reality this could prove politically untenable, and examples of such an approach being used in practice are not apparent. Hence, the manager's wage is not separately specified in our regulator's assumed objective function.

[14] Allowing α_r to differ from α_c is not important for our results. Later, when we present the UCO case, we assume $\alpha_r = \alpha_c$ to show that even when customer-owners and the regulator weight profits to the same degree, customer-owners may still optimally choose a monopoly price that differs from the regulated price.

[15] Also as for α_c, we treat α_r as exogenous (e.g. influenced by political considerations, among others). As such, we characterise both customer ownership and regulation in positive rather than normative terms.

Figure 1: Timing



3. Third, given the regulator's price choice and owners' choice of incentive parameters, the manager chooses cost-reducing effort to maximise the expected utility of wages net of private effort costs.

4. Finally, cost uncertainty u is resolved, at which point marginal costs, wages and profits are realised. Since u remains unobservible to owners and the regulator, the manager's effort choice cannot be inferred ex post, and so remains non-contractible.

This timing is natural on several grounds. Regulated prices are typically chosen to apply over regulatory periods often spanning several years.[16] Conversely, a manager's incentive arrangements are often set more frequently, such as annually. In turn, a manager's effort choice can be varied on an intra-day basis. Hence, while our model is essentially static, these considerations support the timing as assumed.

Also note that this assumed timing simplifies the nature of the managerial incentive problem confronting owners and the regulator in our setup. Specifically, since we assume that the manager makes his or her effort choice facing the same cost uncertainty u as owners and regulators, this means the only information asymmetry affecting our agents' choices relates to the manager's effort choice. As such we have a situation of pure moral hazard. Conversely, if the manager was assumed to observe cost uncertainty u prior to making his or her effort choice, this would introduce an informational advantage for the manager – relative to the owners and regulator – in respect of marginal cost. Since the manager could then condition his or her effort choice on such information, while the owners and regulator could not, this would introduce an additional adverse selection dimension to the model. Modelling this additional dimension is left to future work.

2.6 Relative Risk Preferences

Since customer-owner risk-aversion is an important element of our setup, here we discuss the justification for our asumed relative levels of risk-aversion as between customer-owners, investor-owners, the manager and the regulator. Readers can proceed directly to our model's solution in Section 3 if this is preferred.

[16] In practice this is because regulated firms often make long-lived investments, or require a reasonable time-frame over which to benefit from efficiency gains. Either could be prejudiced by more frequent regulatory reviews.

Assuming investor-owners to be risk-neutral is not unusual in the contracting literature (e.g. see Bolton and Dewatripont (2005)). It is justified as an approximation using arguments such as investors being able to hold well-diversified investment portfolios, so the incremental risk of any given investment can be treated as zero. Likewise, regulators are commonly assumed to be risk-neutral rather than risk-averse.[17]

It is also common in the contracting literature to assume that managers are risk-averse in respect of their firm-related choices. This can be justified in terms of the manager being unable to properly diversify their human and financial capital risks when both are tied to outcomes at the same firm, particularly given prohibitions on slavery (i.e. forward selling of labour services). Hence, whether or not investors are truly risk-neutral, in any case it should be expected that managers should be relatively more risk-averse than investors. As an approximation this can be represented by assuming risk-neutral investors (and regulators) but risk-averse managers.

Similarly, in relation to customer-owners there are reasons to believe that such owners will be risk-averse, or at least more so than investor-owners (and regulators). For example, Staatz (1987) argues that customer-ownership represents a deepening of the relationship between those customers and the firm, rather than a diversification of their firm-related risks. Hence, if the firm should fail, they stand to lose their investment stake in addition to their benefits from patronising that firm (particularly if investor-owned firms are less likely to service them than customer-owned firms, as is often the case in which customer-owned firms arise). This causes customer-owners to be more risk-averse than investor-owners.[18] Furthermore, Hendrikse (1998) argues that this deeper exposure causes customer-owners to internally organise their firms so as to better protect their multiple interests. He represents this as additional levels of project screening relative to investor-owned firms, with the effect that customer-owned firms are relatively more risk-averse in their strategic choices. The non-tradability of customer-owners' interests relative to investor-owned firms – since ongoing firm patronage requires ongoing firm ownership – is also argued to increase customer-owners' relative level of risk-aversion, as are other features particular to customer-owned firms (Van der Krogt et al. (2007)).[19] Using data on EU dairy firm reorganisations, they find evidence of greater risk aversion among customer-owned relative to investor-owned firms in terms of consolidation and collaboration strategies. Similarly, Katz (1997) finds evidence of customer-owned agribusinesses adopting more risk-averse business strategies than their investor-owned counterparts.

Hence on both theoretical and empirical grounds it should be expected that customer-owned firms – like managers – should exhibit greater levels of risk-aversion than investor-owners and regulators. As before, whether investor-owners and regulators are strictly

[17]While regulators face a variety of risks in the execution of their remit, these are largely political rather than economic in nature, and regulators conventionally (should) have no direct or indirect economic interest in the firm's that they regulate.

[18]Indeed, Fama and Jensen (1983a, 1983b) stress the importance for incentives of investors having a comparative advantage in risk-bearing, which advantage cannot in general be assumed of firms' customers.

[19]In a related vein, Karpoff and Rice (1989) found that native Alaskan incorporations with non-tradable shares tended to adopt greater levels of firm-level diversification than firms with tradable shares, compensating for the "imposed fund manager" nature of such entities.

risk-neutral or not is open to debate, but the essential point is that they should be less risk-averse than managers or customer-owners. We take this as justification of our assumed relative levels of risk-aversion, with strict risk-neutrality on the part of investor-owned firms and regulators assumed for convenience. Just as managerial risk-aversion is an important element of the incentive (i.e. moral hazard) problem arising in our setup, customer-owner risk-aversion will prove to affect both optimal managerial incentives, and optimal regulation, in customer-owned firms relative to investor-owned firms.

3 Solution

It is convenient to present the solution of the regulated customer ownership (i.e. RCO) case, since regulated investor ownership (i.e. RIO) represents the special case of this in which $\rho_c \to 0$ and $\alpha_c = 1$ (since then customer-owners simply maximise expected profits, as would investor-owners, with revenues fixed by the regulator in either case). For comparison purposes, however, we begin by deriving optimal effort under the first best benchmark. Later in this section we also solve the special case of unregulated customer ownership (i.e. UCO). As usual, we proceed to solve the model in reverse.

3.1 First Best Benchmark

Absent incentive and market power issues, a planner would choose $\{q, e\}$ to maximise the expected value of net surplus $S(q, e)$, being gross consumer surplus net of production and effort costs. Assuming inverse demand $p(q) = q^{-1}(p)$, this writes as:

$$E\{S(q,e)\} = E\{\int_0^q p(Q)dQ - q.(\theta - e + u) - \frac{c_m}{2}e^2\} \tag{9}$$

or, since $E\{u\} = 0$, as:

$$E\{S(q,e)\} = \int_0^q p(Q)dQ - q.(\theta - e) - \frac{c_m}{2}e^2 \tag{10}$$

Taking the first order condition with respect to$e$ and assuming second order conditions are satisfied yields:

$$e_{FB} = \frac{q_{FB}}{c_m} \tag{11}$$

while taking the first order condition with respect to q and assuming second order conditions yields, after substituting for e_{FB}, an expression implicitly defining q_{FB}:

$$p(q) - (\theta - \frac{q}{c_m}) = 0 \tag{12}$$

3.2 Stage 3 – Manager's Optimal Effort Choice

The manager's problem is to choose effort so as to maximise expected utility (7), given the price choice of the regulator, and the owners' choice of fixed and variable incentive parameters. The manager's objective function can be rewritten, in the RCO case, as:

$$E\{U_\rho(w_c - \psi(e_c))\} = E\{-exp(-\rho[A_m(e_c, p_c, t_c, \beta_c) + B_m(p_c, \beta_c)u])\} \tag{13}$$

where:

$$A_m(e_c, p_c, t_c, \beta_c) \equiv t_c + \beta_c q(p_c)(p_c - (\theta - e_c)) - \frac{c_m}{2}e_c^2$$
$$B_m(p_c, \beta_c) \equiv -\beta_c q(p_c)$$

Since the only uncertainty derives from u, this expected utility writes as:

$$E\{U_\rho(w_c - \psi(e_c))\} = -exp(-\rho[A_m(e_c, p_c, t_c, \beta_c)])E\{exp(-\rho B_m(p_c, \beta_c)u)\} \tag{14}$$

By standard results we know that if $u \sim N(0, \sigma_u^2)$ then $E\{e^{\gamma u}\} = e^{\frac{1}{2}\gamma^2\sigma_u^2}$,[20] so taking the above expectation and rearranging terms produces:

$$E\{U_\rho(w_c - \psi(e_c))\} = -exp(-\rho[A_m(e_c, p_c, t_c, \beta_c) - \frac{\rho}{2}B_m(p_c, \beta_c)^2\sigma_u^2]) \tag{15}$$

where $CE(w_c - \psi(e_c)) \equiv A_m(e_c, p_c, t_c, \beta_c) - \frac{\rho}{2}B_m(p_c, \beta_c)^2\sigma_u^2$ is the manager's certainty equivalent of wages net of effort costs. Given the monotonicity of the assumed utility function, the manager's utility-maximising effort choice can be found by maximising this certainty equivalent, which in the RCO case writes as:

$$CE(w_c - \psi(e_c)) = t_c + \beta_c q(p_c)(p_c - (\theta - e_c)) - \frac{c_m}{2}e_c^2 - \frac{\rho}{2}\beta_c^2 q(p_c)^2\sigma_u^2 \tag{16}$$

This is clearly concave in e_c, so taking the manager's first order condition with respect to e_c yields the manager's optimal effort choice:

$$e_c(p_c, \beta_c) = \frac{\beta_c q(p_c)}{c_m} \tag{17}$$

while in the RIO case, since $e_c(p_c)$ depends on neither ρ_c nor α_c, it immediately follows that:

$$e(p, \beta) = \frac{\beta q(p)}{c_m} \tag{18}$$

In either case the manager can directly improve the non-stochastic part of profit on which he or she is variably compensated through exerting marginal-cost reducing effort. The manager is induced to do so in proportion to total demand scaled by variable incentive pay, relative to the intensity of private effort cost. Notice that depending on the level of variable incentives, this optimal effort level may be above or below e_{FB}, which depends only on total demand relative to private effort cost intensity.

[20] See, for example, Bolton and Dewatripont (2005, p. 138).

3.3 Stage 2 – Owners' Optimal Incentives Choice

Given the regulator's price choice, and anticipating the manager's optimal effort choice, the owners at this stage choose their optimal fixed and variable incentive parameters, subject to the manager accepting that choice.[21] To solve for the optimal fixed wage t_c in the RCO case we use the manager's individual rationality constraint, namely $E\{U_\rho(w_c - \psi(e)\} \geq E\{U_\rho(\overline{w})\}$, and assume that owners set this fixed wage so that the constraint binds with equality. With $\overline{w}$ normalised to zero this is equivalent to setting $CE(w_c - \psi(e)) = 0$, with $CE(.)$ as above, which can then be solved for the optimal fixed wage. In the RCO case this yields:

$$t_c(p_c, \beta_c) = \frac{\beta_c^2}{2c_m}(\rho\sigma_u^2 c_m - 1)q(p_c)^2 - \beta_c(p_c - \theta)q(p_c) \tag{19}$$

while in the RIO case we find:

$$t(p, \beta) = \frac{\beta^2}{2c_m}(\rho\sigma_u^2 c_m - 1)q(p)^2 - \beta(p - \theta)q(p) \tag{20}$$

Substituting w_c from (1) and $e_c(p_c, \beta_c)$ and $t_c(p_c, \beta_c)$ from above into the customer owners' expected utility function (6) yields expected utility of the form:

$$E\{U_{\rho_c}(CS(p_c) + \alpha_c\Pi_c(p_c, \beta_c))\} = E\{-exp(-\rho_c[A_c(p_c, \beta_c) + B_c(p_c, \beta_c)u])\} \tag{21}$$

where (noting, for discussion below, the factorisation of α_c in each term):

$$A_c(p_c, \beta_c) \equiv CS(p_c) + \alpha_c[(p_c - \theta)q(p_c) + \frac{q(p_c)^2}{c_m}\beta_c - \frac{q(p_c)^2(\rho\sigma_u^2 c_m + 1)}{2c_m}\beta_c^2]$$

$$B_c(p_c, \beta_c) \equiv \alpha_c[q(p_c)\beta_c - q(p_c)]$$

Following the arguments as in Section 3.2, the customer-owners' expected-utility maximising choice of variable incentive β_c can be found by maximising their certainty equivalent of consumer surplus and weighted profits, which is $CE(CS(p_c) + \alpha_c\Pi_c(p_c, \beta_c)) \equiv A_c(p_c, \beta_c) - \frac{\rho_c}{2}B_c(p_c, \beta_c)^2\sigma_u^2$. Substituting for $A_c(p_c, \beta_c)$ and $B_c(p_c, \beta_c)$ this certainty-equivalent has the following form:

$$CS(p_c) + \alpha_c\{\Delta(p_c) + \frac{q(p_c)^2}{c_m}(1 + \rho_c\alpha_c\sigma_u^2 c_m)\beta_c - \frac{q(p_c)^2}{2c_m}[1 + (\rho + \rho_c\alpha_c)\sigma_u^2 c_m]\beta_c^2\} \tag{22}$$

with $\Delta(p_c) \equiv q(p_c)[(p_c - \theta) - \frac{1}{2}\rho_c\alpha_c\sigma_u^2 q(p_c)]$. Given the customer-owners' certainty equivalent is concave in β_c, it is sufficient to take the first order condition of this expression to derive the optimal variable incentive choice, leading us to the following lemma (with the optimal variable incentive in the RIO case found by taking $\rho_c \to 0$ and $\alpha_c = 1$):

[21] By choosing incentive parameters in anticipation of the manager's optimal effort choice, the owners are also, in effect, conditioning their incentives choices on the manager's incentive compatability constraint – namely that the manager will be choosing his or her privately utility-maximising effort choice, given those incentive parameters.

Lemma 1 (Optimal variable incentive parameters):
The optimal variable incentive parameter in the RCO case is, provided $\rho_c\alpha_c > 0$:

$$\beta_c = \frac{1 + \rho_c\alpha_c\sigma_u^2 c_m}{[1 + (\rho + \rho_c\alpha_c)\sigma_u^2 c_m]} \tag{23}$$

while in the RIO case it is:

$$\beta = \frac{1}{1 + \rho\sigma_u^2 c_m} \tag{24}$$

Thus the variable incentive parameter in the RIO case is positive but less than unity. As expected, it is decreasing in the manager's risk-aversion, intensity of private effort cost, and marginal cost variability.[22] In order to induce the manager to exert effort, the investor-owners must share some of the firm's risky profit with the manager. However, since the manager's risk-aversion is higher than the owners', it is not efficient for the manager to bear all profit risk.

Likewise, the variable incentive in the RCO case is also positive but les than unity, for similar reason. There is an additional risk consideration in this case, however, introduced by the $\rho_c\alpha_c$ term. Since customer-owners are also risk-averse, and have some taste for profits (as measured by positive α_c), the optimal risk sharing between the manager and customer-owners reflects a balancing of their respective levels of risk-aversion, and the extent to which customer-owners care for profits.

To explore this further, we rearrange the customer-owners' expected utility (21) as:

$$E\{-exp(-\rho_c CS(p_c) - \rho_c\alpha_c[(A_c(p_c, \beta_c) - CS(p_c) + B_c(p_c, \beta_c)u)/\alpha_c])\}$$

from which we see that all terms relating to the variable incentive choice variable share a factor of $\rho_c\alpha_c$. This means the customer-owners' *effective* risk-aversion parameter when choosing β_c is not just ρ_c, but $\rho_c\alpha_c$ (i.e. risk-aversion weighted by the extent to which profits matter to customer-owners). Hence differences in variable incentives choices between investor- and customer-owned firms derive from this effective risk-aversion.[23]

Notice also that the above expressions for β_c and β are not affected by either demand or regulated price. This means the regulator's choice of price is predicted to have no effect on the optimal sensitivity of wages to pre-wage profits in either of the RCO or RIO cases, with the difference deriving solely from differences in effective risk-aversion between owner types. Moreover, by computing β/β_c it is clear that $\beta_c \geq \beta$ – given customer-owners' own effective risk-aversion, they optimally seek to share a greater level

[22]See section 4.2 of Bolton and Dewatripont (2005) for a comparable problem and result.

[23]As discussed in Van der Krogt et al. (2007), the democratic (i.e. one-member-one-vote) nature of traditional customer-owned firms can result in difficulties balancing diverse customer-owner interests. In such cases customer-owned firms can de-emphasise the pursuit of profit-maximisation in favour of other goals. As noted in Section 1, however, this does not relieve cooperatives of the need to remain profitable in order to remain viable, and to fund required investments. Moreover, US customer-owned electric utilities in fact distribute large amounts of operating excess annually. Hence, even if profit-maximisation is not formally a stated aim of such "not-for-profit" organisations, in practice profits are pursued and achieved to at least some degree, though perhaps less so than in investor-owned firms.

of profit risk with the manager than do the less risk-averse investor-owners. This leads to the following proposition:

Proposition 1 (Sensitivity of wages to pre-wage profits):

The optimal sensitivity of the manager's wage to pre-wage profits (i.e. β_c or β under RCO and RIO respectively) is:

1. Positive but less than unity under either customer-ownership or investor-ownership;
2. Higher under customer ownership than under investor ownership if the customer-owners' effective risk-aversion parameter is positive (i.e. $\rho_c\alpha_c > 0$), but identical otherwise (i.e. if $\rho_c\alpha_c = 0$); and
3. Unaffected by the regulator's choice of price.

Substituting the above expressions for β_c into (19) we find (taking $\rho_c \to 0$ and $\alpha_c = 1$ for the RIO case):

Lemma 2 (Optimal fixed wages as a function of demand and hence regulated price):

In the RCO case the optimal fixed wage as a function of demand and hence regulated price is:

$$t_c(p_c) = \frac{(1+\rho_c\alpha_c\sigma_u^2 c_m)^2(\rho\sigma_u^2 c_m - 1)}{2[1+(\rho+\rho_c\alpha_c)\sigma_u^2 c_m]^2 c_m} q(p_c)^2 - \frac{(1+\rho_c\alpha_c\sigma_u^2 c_m)(p_c-\theta)}{[1+(\rho+\rho_c\alpha_c)\sigma_u^2 c_m]} q(p_c) \tag{25}$$

while in the RIO case it is:

$$t(p) = \frac{\rho\sigma_u^2 c_m - 1}{2[1+\rho\sigma_u^2 c_m]^2 c_m} q(p)^2 - \frac{p_c-\theta}{[1+\rho\sigma_u^2 c_m]} q(p) \tag{26}$$

Thus, despite variable incentives being independent of regulated price, fixed wages are directly affected by regulated price in both the RCO and RIO cases. Once again, the source of the difference between the RCO and RIO cases is the customer-owners' effective risk-aversion rate $\rho_c\alpha_c$. We can also find optimal effort as a function of regulated price:

Lemma 3 (Optimal effort as a function of demand and hence regulated price):

In the RCO case the manager's optimal effort as a function of demand and hence regulated price is:

$$e_c(p_c) = \frac{1+\rho_c\alpha\sigma_u^2 c_m}{[1+(\rho+\rho_c\alpha)\sigma_u^2 c_m]c_m} q(p_c) \tag{27}$$

while in the IO case it is:

$$e(p) = \frac{1}{[1+\rho\sigma_u^2 c_m]c_m} q(p) \tag{28}$$

In each case it is easily verified that the sensitivity of optimal effort to demand is less than or equal to that in the First Best (i.e. $1/c_m$), reflecting the impacts of managerial and/or customer-owner (effective) risk-aversion.

3.4 Stage 1 – Regulator's Optimal Price Choice

Anticipating the owners' optimal incentives choice, and manager's optimal effort choice, the regulator chooses the monopoly's price so as to maximise expected consumer surplus (which is non-stochastic) and α_r-weighted post-wage profits. In the RCO case, substituting $\beta_c(p_c)$, $t_c(p_c)$ and $e_c(p_c)$ from (23), (25) and (27) respectively into the regulator's objective function (8) yields, after taking expectations and simplifying:

$$E\{CS(p_c) + \alpha_r \Pi_c(p_c)\} = \int_{p_c}^{\infty} q(P)dP + \alpha_r[q(p_c)(p_c - \theta) + \frac{1}{2}M_c(\alpha_c)q(p_c)^2] \tag{29}$$

where:

$$M_c(\alpha_c) \equiv M_c \equiv \frac{1 + \rho_c\alpha_c\sigma_u^2 c_m}{[1 + (\rho + \rho_c\alpha_c)\sigma_u^2 c_m]c_m}\left[1 - \frac{\rho_c\alpha_c\sigma_u^4 c_m^2\rho}{[1 + (\rho + \rho_c\alpha_c)\sigma_u^2 c_m]}\right] \tag{30}$$

Assuming the regulator's second order condition is satisfied, we take the regulator's first order condition of (29) with respect to p_c (applying Leibniz's rule in respect of $CS(p_c)$). This yields the following expression, implicitly defining the regulator's optimal price p_c^* in the RCO case:

$$-q(p) + \alpha_r[q(p) + q'(p)(p - \theta)] + \alpha_r M_c q(p)q'(p) = 0 \tag{31}$$

The first order condition thus comprises three elements – the impact of price on consumer surplus, its impact on α_r-weighted profits ignoring incentive and risk considerations, and lastly the impact of price on α_r-weighted expected profits attributable to incentive and risk considerations.

Similarly, in the RIO case the regulator's optimal price p^* is implicitly defined by the corresponding and almost identical first order condition:

$$-q(p) + \alpha_r[q(p) + q'(p)(p - \theta)] + \alpha_r M q(p)q'(p) = 0 \tag{32}$$

where M is found from M_c, as usual, by taking $\rho_c \to 0$ and $\alpha_c = 1$:

$$M \equiv \frac{1}{[1 + \rho\sigma_u^2 c_m]c_m} > 0$$

Note the following relationship between the incentive- and risk-related components of the regulator's first order conditions under RCO and RIO:

$$M_c = M - \frac{1}{2}\frac{\rho_c^2\alpha_c^2\sigma_u^8 c_m^3\rho^2}{[1 + (\rho + \rho_c\alpha_c)\sigma_u^2 c_m]^2[1 + \rho\sigma_u^2 c_m]} \leq M$$

These components summarise how a change in the firm's price affect the manager's incentives and effort choice, and hence the firm's expected marginal costs, after accounting for the risk-aversion of the manager and/or the firm's owners, the taste of the firm's owners for profit, uncertainty as to marginal costs, and the intensity of the manager's private effort cost.

We observe that the regulator's first order condition is of the same form in both the RCO and RIO cases, with only the incentive- and risk-related components $M_c(\alpha_c)$ and M differing when the customer-owners' effective risk-aversion parameter $\rho_c\alpha_c$ is positive. Because of this difference, and in particular because $M_c \leq M$, the regulator optimally sets a higher price under RCO than under RIO, as stated in the following proposition:

Proposition 2 (Optimal regulated price, demand, and consumer surplus under RCO and RIO):

Assuming the regulator's second order conditions are satisfied in both the RCO and RIO cases:

1. If customer-owners are effectively risk-averse (i.e.$\rho_c\alpha_c > 0$) then:
   (a) $p_c^* > p^*$
   (b) $q(p_c^*) < q(p^*)$
   (c) $CS(p_c^*) < CS(p^*)$.
2. Conversely, if customer-owners are risk-neutral (i.e. $\rho_c\alpha_c = 0$) then:
   (a) $p_c^* = p^*$
   (b) $q(p_c^*) = q(p^*)$
   (c) $CS(p_c^*) = CS(p^*)$.

Hence, if the customer-owner's effective risk-aversion rate is $\rho_c\alpha_c = 0$, then (and only then) both customer-owned and investor-owned types of firm are optimally subjected to the same regulated price. In that case optimal incentives and effort choices are also identical for both types of firms. However, if $\rho_c\alpha_c > 0$ then the regulator optimally sets a higher price for the customer-owned firm than for the investor-owned firm, resulting in lower output and consumer surplus. This curious finding – that consumer surplus should optimally be lower under RCO than RIO – stems from the fact that customer-owners' effective risk-aversion rate is positive (while it is assumed to be nil in the RIO case). Given this, the regulator must provide a greater expected profit to customer-owners than to investor-owners to leave enough certainty-equivalent profit for them to then provide adequate effort incentives to the manager. In other words, due to customer-owners' assumed greater level of risk aversion than investor-owners, they require a higher level of profit (i.e. greater risk-premium) to induce them to provide the manager with efficient performance incentives. This requires the sacrifice of a greater level of consumer surplus (through higher price) in the RCO case than in the RIO case.

Before proceeding to the proof of Proposition 2, we first present the following definitions and lemmas:

Definition 1: $g(p) \equiv -q(p) + \alpha_r[q(p) + q'(p)(p - \theta)]$

Lemma 4: $g(p) > 0$ and $M_c > 0$.

Proof: Using Definition 1 we can write the regulator's first order conditions (31) and (32) in the RCO and RIO cases respectively as:

$$g(p) + \alpha_r M_c q(p) q'(p) = 0$$

$$g(p) + \alpha_r M q(p) q'(p) = 0$$

By assumption $q'(p) < 0$, while $\alpha_r > 0$, $M > 0$ and $q(p) > 0$. Thus $\alpha_r M q(p) q'(p) < 0$ and so we find that $g(p) > 0$.

Moreover, by this fact, and the RCO case first order condition, we have $0 < g(p) = -\alpha_r M_c q(p) q'(p)$. This establishes that $M_c > 0$. QED.

Definition 2: $h_c(p)$ and $h(p)$:

$$h_c(p) \equiv -\alpha_r M_c q(p) q'(p)$$

$$h(p) \equiv -\alpha_r M q(p) q'(p)$$

Note that by combining Definitions 1 and 2, we see that $g(p) = h_c(p)$ when $p = p_c^*$, while $g(p) = h(p)$ when $p = p^*$. This is key to the final step in proving Proposition 2.

Lemma 5: $0 < M_c \leq M$, and $0 < h_c(p) \leq h(p)$.

Proof: On inspection we see that $M > 0$, and from above we have that $M_c \leq M$. From Lemma 4 we also have that $M_c > 0$, so the first part of the lemma is established. The fact that each of $h_c(p)$ and $h(p)$ are positive follows directly from Definition 2, given that $\alpha_r > 0$, $q(p) > 0$ and $q'(p) < 0$ by assumption. Finally, $h_c(p) \leq h(p)$ by virtue of the facts that each function is positive and $0 < M_c \leq M$. QED.

Note that given Definition 1, assuming satisfaction of the regulator's second order conditions equates in the RCO and RIO cases to respectively assuming:

$$g'(p) + \alpha_r M_c[q'(p)^2 + q(p)q''(p)] < 0 \tag{33}$$

$$g'(p) + \alpha_r M[q'(p)^2 + q(p)q''(p)] < 0 \tag{34}$$

Lemma 6: $g'(p) < min\{h_c'(p), h'(p)\}$.

Proof: From Definition 2 we have:

$$h_c'(p) = -\alpha_r M_c[q'(p)^2 + q(p)q''(p)]$$

$$h'(p) = -\alpha_r M[q'(p)^2 + q(p)q''(p)]$$

Thus by the assumed second order conditions (33) and (34) we have:

$$g'(p) - h_c'(p) < 0$$

$$g'(p) - h'(p) < 0$$

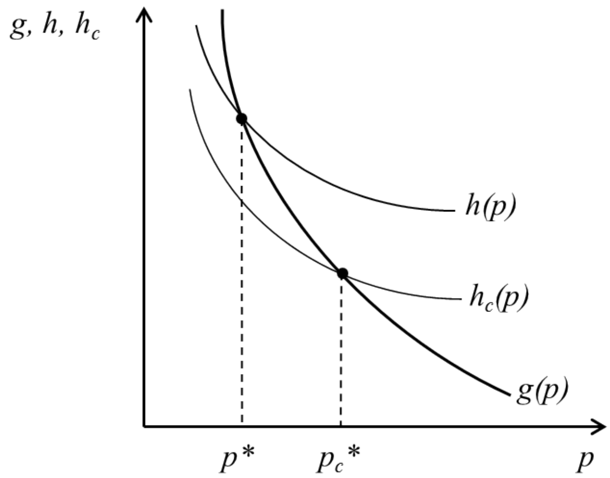
which can be simultaneously true if and only if $g'(p) < min\{h_c'(p), h'(p)\}$. QED.

Lemma 7: $h'(p) \leq h_c'(p) < 0$.

Proof: By assumption $\alpha_r > 0$, $q(p) > 0$, $q'(p) < 0$ and $q''(p) \geq 0$. Thus, by Definition 2 (and thus the forms of $h_c'(p)$ and $h'(p)$), we see that $h_c'(p) < 0$ and $h'(p) < 0$. Moreover, by Lemma 5 we have $0 < M_c \leq M$, whence $h'(p) \leq h_c'(p)$. QED.

Proof of Proposition 2:

Figure 2: Regulated Prices under RCO and RIO



Assuming initially that $\rho_c\alpha_c > 0$, from Definitions 1 and 2 we know that the regulator's optimal prices in the RCO and RIO cases are given by the intersection of $g(p)$ with each of $h_c(p)$ and $h(p)$ respectively. By Lemma 4 we know that $g(p)$ plots in the positive quadrant, and by Lemmas 6 and 7 it plots with a negative slope. By Lemma 5 each of $h_c(p)$ and $h(p)$ also plot in the positive quadrant, with $h(p)$ plotting above $h_c(p)$. By Lemma 7 each of these functions also have a negative slope, with $h(p)$ more negatively sloped than $h_c(p)$. Finally, by Lemma 6 we know that $g(p)$ is more negatively sloped than both of $h_c(p)$ and $h(p)$. Combining these facts we have Figure 2.

The fact that $p_c^* > p^*$ then follows directly, as does the result that $q(p_c^*) < q(p^*)$, given that $q'(p) < 0$. Finally, with price higher and quantity lower in the RCO case than in the RIO case, it follows that $CS(p_c^*) < CS(p^*)$.

Conversely, assume that $\rho_c\alpha_c = 0$. By the definition of M_c we see that $M_c = M$ now, in which case the regulator's first order conditions are identical in the RCO and RIO cases. Following the above arguments we conclude that $h(p)$ and $h_c(p)$ coincide, and thus their common intersection with $g(p)$ yields $p_c^* = p^*$, with $q(p_c^*) = q(p^*)$ and $CS(p_c^*) = CS(p^*)$. QED.

3.4.1 Relative Effort Choices, Expected Marginal Costs, and Fixed Wages

It is sometimes contended that customer-owned firms – due to their possibly greater agency issues, in particular due to their lack of tradable ownership rights – are prone to greater managerial slack (e.g. lower effort), and hence lower cost efficiency and profitability, than comparable investor-owned firms.[24] The following corollary to Proposition 2 does not support these contentions.

[24] For studies comparing the relative efficiency and incentive effects of customer ownership in electricity, see Berry (2004), Hjalmarsson and Veiderpass (1992), and Hollas and Stansell (1988). For studies in relation to other sectors, see Hart and Moore (1996, 1998), Porter and Scully (1987), and Boyle (2004).

Corollary 1 (Indeterminacy of relative effort choices, and of expected marginal costs, profits and wages):

1. If $\rho_c \alpha_c = 0$ then managerial effort choices, expected marginal costs, fixed salaries and variable salaries are predicted to be the same under both RCO and RIO.
2. Otherwise, if $\rho_c \alpha_c > 0$ then the differences between RCO and RIO for each of these variables are in general of indeterminate sign.

Proof:

Effort choice – holding p constant, we see from direct calculation using (27) and (28) that $e_c(p) \geq e(p)$. However, by Proposition 2 we know that $p_c^* \geq p^*$, and so $q(p_c^*) \leq q(p^*)$. Thus whether or not $e_c(p_c^*) \lesseqgtr e(p^*)$ depends on the form of $q(.)$ and the relative sizes of p_c^* and p^*, which cannot be determined from the model.

Expected marginal costs – are $E\{\theta - e_c(p_c^*) + u\}$ and $E\{\theta - e(p^*) + u\}$ under RCO and RIO respectively. Since the relative sizes of $e_c(p_c^*)$ and $e(p^*)$ are indeterminate, so too are the relative sizes of expected marginal costs.

Fixed wages – (25) and (26) can be rewritten with obvious notation as:

$$t_c(p_c^*) = D_c q(p_c^*)^2 - E_c q(p_c^*)$$

$$t(p^*) = Dq(p^*) - Eq(p^*)$$

By direct calculation of D_c/D it is easily verified that $D_c \geq D$. Likewise, by direct calculation of E_c/E and use of the fact that $p_c^* \geq p^*$ it is easily verified that $E_c \geq E$. However, as above we have that $q(p_c^*) \leq q(p^*)$, hence the relative sizes of $t_c(p_c^*)$ and $t(p^*)$ are indeterminate.

Expected profits – By (4), expected post-wage profits write as:

$$E\{q(p)(p - (\theta - e + u)(1 - \beta) - t\} = q(p)(p - \theta + e)(1 - \beta) - t$$

Lemma 1 states that $\beta_c \geq \beta$, and we know that $q(p_c^*) \leq q(p^*)$ while θ is assumed common to both RCO and RIO. However, to the contrary we know that $p_c^* \geq p^*$, while we have just shown that $e_c(p_c^*) \lesseqgtr e(p^*)$ and $t_c(p_c^*) \lesseqgtr t(p^*)$. Hence the relative size of expected profits under RCO and RIO is also indeterminate.

Expected variable wages – From Lemma 1 we know that $\beta_c \geq \beta$. So whether or not expected variable wages are higher or lower under RCO relative to RIO depends on whether expected pre-wage profits under RCO are sufficiently high relative to RIO. These profits write as $E\{q(p)(p - (\theta - e + u)\} = q(p)(p - \theta + e)$. For the same reasons that the relative sizes of expected post-wage profits under RCO and RIO are indeterminate, we also find that the relative sizes of expected pre-wage profits are indeterminate. Thus, the relative sizes of expected variable wages under RCO and RIO are also indeterminate. QED.

3.5 Unregulated Customer Ownership

The preceding analysis compared two regulated cases, RCO and RIO, revealing how differences in effective risk aversion between customer-owned and investor-owned firms – i.e. $\rho_c\alpha_c > 0$ – affected optimal price regulation, and hence managerial incentives. While Proposition 2 presented clear results in terms of regulated prices, output and consumer surplus, Corollary 1 revealed no clear differences between customer- and investor-owned firms in terms of managerial effort, and expected costs, profits and wages. In this subsection we extend the earlier RCO analysis to that of unregulated customer ownership (i.e. UCO). We show that while the relative sizes of expected profits and wages under RCO and UCO are also indeterminate, clear differences emerge in terms of managerial effort and expected costs, as well as in terms of price, output and consumer surplus.

Observe that in Proposition 2 the weight attached by the regulator to profits, α_r, played no role in determining which of p_c^* or p^* was higher. Furthermore, while the pivotal variable in the proof of Proposition 2 – $M_c(\alpha_c)$ as defined in (30) – depends on the weight α_c applied to profits in the objective function of customer-owners (6), the results in Proposition 2 were not determined by any difference between α_r and α_c. Hence any difference in these parameters will affect the size but not the direction of differences between p_c^* and p^*. In particular, if α_r should differ to α_c by virtue of distortions in the regulatory process, for example, we predict that this will not affect the ranking of regulated prices under RCO and RIO.

Here we abstract from any such considerations by imposing that $\alpha_c = \alpha_r$. Instead we show how customer-owners' effective risk aversion – in this case $\rho_c\alpha_r$ – causes a divergence between regulated prices p_c^* and p_{cu}^* under RCO and UCO respectively. We also show how this clearly affects managerial effort and expected marginal costs under each of these cases.

To analyse UCO we set $\alpha_c = \alpha_r$ as above, and amend the timing of our model by now having customer-owners instead of the regulator set the firm's price in Stage 1. All other stages are as before, hence we proceed by re-solving just Stage 1 of the model, taking the relevant customer-ownership solutions of Stages 2 and 3 as given.

While before in Stage 1 the regulator chose the firm's price to maximise expected consumer surplus and α_r-weighted profits, now the customer-owners maximise their expected utility of consumer surplus and α_r-weighted profits. Modifying (6) by replacing α_c with α_r, and substituting for $\beta_c(p_{cu})$, $t_c(p_{cu})$ and $e_c(p_{cu})$ using (23), (25) and (27) as before, the unregulated customer-owners' objective function can be written as:

$$E\{-exp(-\rho_c[A_{cu}(p_{cu}) + B_{cu}(p_{cu})u])\} \tag{35}$$

where, defining $M_c(\alpha_r)$ by replacing α_c with α_r in (30):

$$A_{cu}(p_{cu}) \equiv \int_{p_{cu}}^{\infty} q(P)dP + \alpha_r[q(p_{cu})(p_{cu} - \theta) + \frac{1}{2}M_c(\alpha_r)q(p_{cu})^2]$$

$$B_{cu}(p_{cu}) \equiv -\frac{\alpha_r\rho\sigma_u^2 c_m q(p_{cu})}{[1 + (\rho + \rho_c\alpha_r)\sigma_u^2 c_m]}$$

Following the arguments in Sections 3.2 and 3.3, the choice of p_{cu} maximising (35) is the same as that maximising the certainty equivalent of consumer surplus and α_r-weighted profits, namely $A_{cu}(p_{cu}) - \frac{\rho_c}{2}B_{cu}(p_{cu})^2\sigma_u^2$, which writes as:

$$\int_{p_{cu}}^{\infty} q(P)dP + \alpha_r[q(p_{cu})(p_{cu} - \theta) + \frac{1}{2}M_{cu}(\alpha_r)q(p_{cu})^2]$$

where:

$$M_{cu}(\alpha_r) \equiv M_{cu} \equiv \frac{1 + \rho_c\alpha_r\sigma_u^2 c_m(1 - \rho\sigma_u^2 c_m)}{[1 + (\rho + \rho_c\alpha_r)\sigma_u^2 c_m]c_m} = M_c(\alpha_r) - \frac{\rho_c\alpha_r\sigma_u^6 c_m^2\rho^2}{[1 + (\rho + \rho_c\alpha_r)\sigma_u^2 c_m]^2} \leq M_c(\alpha_r)$$

As in Section 3.4 for the regulator's problem, we assume the customer-owners' second order condition holds, and take their first order condition with respect to p_{cu} to derive their expected-utility maximising price, which is given implicitly by:

$$-q(p) + \alpha_r[q(p) + q'(p)(p - \theta)] + \alpha_r M_{cu} q(p)q'(p) = 0$$

This expression shares the same form as the regulator's first order conditions in the RCO and RIO cases, namely (31) and (32) respectively. As before this first order condition can be rewritten as $g(p) - h_{cu}(p) = 0$ with $h_{cu}(p) \equiv -\alpha_r M_{cu} q(p)q'(p)$, and $g(p)$ as per Definition 1. Directly following the arguments in relation to Proposition 2, but with $\alpha_c = \alpha_r$ and now comparing RCO and UCO, we have the following extension of Proposition 2:

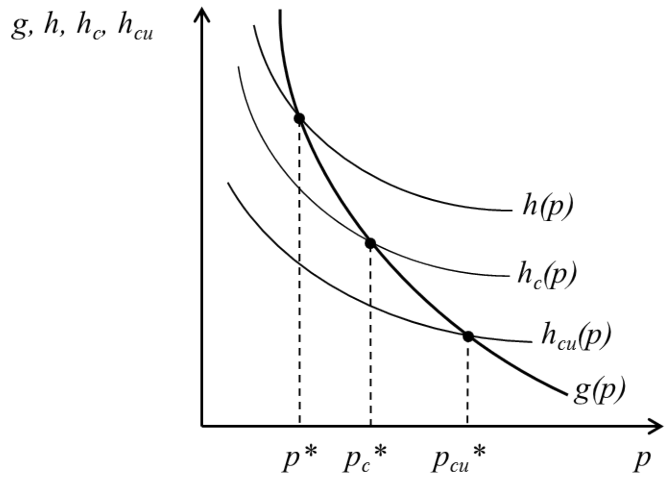
Proposition 3 (Optimal regulated price, demand, and consumer surplus under UCO, RCO and RIO):

Assuming the regulator's second order conditions are satisfied in the UCO, RCO and RIO cases:

1. If customer-owners are effectively risk-averse (i.e.$\rho_c\alpha_r > 0$) then:
   (a) $p_{cu}^* > p_c^* > p^*$
   (b) $q(p_{cu}^*) < q(p_c^*) < q(p^*)$
   (c) $CS(p_{cu}^*) < CS(p_c^*) < CS(p^*)$.
2. Conversely, if customer-owners are risk-neutral (i.e. $\rho_c\alpha_r = 0$) then:
   (a) $p_{cu}^* = p_c^* = p^*$
   (b) $q(p_{cu}^*) = q(p_c^*) = q(p^*)$
   (c) $CS(p_{cu}^*) = CS(p_c^*) = CS(p^*)$.

The second part of Proposition 3 follows directly from the recognition that all three types of ownership – UCO, RCO and RIO – exhibit identical behaviours on the part of owners, the regulator and the manager when customer-owners' are assumed to be effectively risk-neutral. The first part, in particular the prediction that the customer-owners' freely-chosen monopoly price under UCO will exceed that chosen by the regulator under RCO,

Figure 3: Regulated Prices under RCO and RIO, and Unregulated Price under UCO



reflects an extension of the argument for why the regulated price was found to be higher under RCO than RIO in Proposition 2. Specifically, if (effectively) risk-averse customer-owners instead of a risk-neutral regulator set the monopoly's price, then they will choose that price to generate a higher level of risky profit (i.e. higher risk-premium), even though this involves sacrifice of non-risky consumer surplus. This not only reflects their desire for both consumer surplus and profit, with additional profit relative to the regulated case required to compensate them for bearing risk. It also reflects the need for risk-averse customer-owners to optimally share a greater proportion of risky profit with the firm's risk-averse manager.

While only this latter consideration lay beneath the result in Proposition 2, both considerations lie beneath the new findings in Proposition 3. With customer-owners choosing price as well as incentives, higher price is required than under price regulation to better reflect the risk-aversion of customer owners, which risk-aversion the regulator does not internalise in its price choice. Thus, despite assuming $\alpha_c = \alpha_r$, we see that simple differences in relative risk appetite between a regulator and customer-owners can distort regulated price relative to that preferred by the parties whom regulation is presumed to serve.

Proof of Proposition 3: Omitted, since it is a simple repetition of the proof of Proposition 2, but now comparing UCO and RCO. The key details are that $0 < M_{cu} \leq M_c \leq M$, hence $0 < h_{cu}(p) \leq h_c(p) \leq h(p)$. Also, $g'(p) < min\{h'_{cu}(p), h'_c(p), h'(p)\}$ and $h'(p) \leq h'_c(p) \leq h'_{cu}(p) < 0$. The resulting situation is represented in Figure 3, from which the relative prices follow, and hence also the relative outputs and consumer surpluses.

Importantly, while it was not possible to make clear predictions regarding key variables in the RCO and RIO cases beyond those made in Propositions 1 and 2, when comparing UCO and RCO it is possible to make such predictions in relation to managerial effort and expected costs. These are summarised in Corollary 2.

Corollary 2 (Managerial effort, and expected marginal costs under UCO and RCO):

1. If $\rho_c\alpha_r = 0$ then managerial effort choices, and expected marginal costs, are predicted to coincide under UCO, RCO and RIO.

2. Otherwise, if $\rho_c\alpha_r > 0$ then:

   (a) Managerial effort is predicted to be lower under UCO than RCO – i.e. $e_c(p^*_{cu}) < e_c(p^*_c)$; and

   (b) Expected marginal cost is predicted to be higher under UCO than RCO – i.e. $E\{\theta - e_c(p^*_{cu}) + u\} > E\{\theta - e_c(p^*_c) + u\}$.

Proof: Omitted, since the corollary follows trivially from direct comparisons of $e_c(p)$ using (27), and our definition of marginal cost.

Given Corollary 1 it is unclear whether a regulated customer-owned firm should be expected to be more or less efficient than an investor-owned firm. Likewise, it is unclear whether RCO or RIO should involve greater managerial slack (i.e. lower managerial effort). In contrast, here it is clear that managerial effort should be lower, and expected marginal costs higher (i.e. expected cost efficiency lower) under UCO than RCO. This difference flows from the greater sacrifice of output under UCO than under RCO in order to increase certainty-equivalent profits (i.e. to provide customer-owners with a greater risk-premium). While the power of variable incentives is the same in either case (i.e. β_c remains the same under both UCO and RCO), the unregulated firm's manager faces a relatively lower output on which to generate variable wages, and thus optimally exerts lesser effort. As before, it is not possible to rank profits, fixed wages or variable wages under UCO and RCO.

4 Conclusions

Our contribution has been to explore how different forms of ownership affect the interaction between regulation and incentives. We did so in the context of a monopoly that can be owned by either investors or its customers, in which incentive issues arise because the firm's risk-averse manager makes a non-contractible effort choice which affects uncertain costs. We have compared the cases of regulated customer- and investor-ownership, and both of these cases with unregulated customer ownership. We show that the key driver of differences between these scenarios is the effective risk aversion of customer-owners, i.e. the product of their formal risk-aversion coefficient and their taste for profits.

Proposition 1 predicts that variable incentives will be stronger under customer-ownership than investor-ownership, irrespective of whether the firm's price is regulated or freely chosen. This is because customer-owners' greater assumed effective risk-aversion means they optimally seek to share a higher proportion of risky profits with the manager than do risk-neutral investor-owners. This prediction stands in contrast to the limited evidence on managerial incentives in cooperative firms, which suggests managerial compensation is at best weakly tied to performance in such firms.[25] Proposition 2 shows that this dif-

[25] See Kopel and Marini (2012) for a survey, and explanation in terms of customer-owned firms sharing features of true "non-profit" organisations.

ference in risk-aversion between the two owner types results in a risk-neutral regulator setting a higher price under customer-ownership than under investor-ownership, despite this involving lower consumer surplus. This is because higher certainty equivalent profit (i.e. a greater risk-premium to customer-owners) is required under RCO than RIO in order to induce customer-owners to efficiently incentivise the manager. Corollary 2 shows, however, that this leads to no clear ranking between RCO and RIO in terms of managerial effort, cost efficiency, profitability or wages.

Conversely, Proposition 3 shows that customer-owner effective risk-aversion means that unregulated customer-owners would choose an even higher price, and hence lower consumer surplus, than would a regulator. While Corollary 2 shows that this means managerial slack should be higher and cost efficiency lower under UCO than RCO, this does not imply that regulation is warranted on incentive and efficiency grounds. Rather, it suggests that a regulator will not fully internalise the risk trade-offs that would optimally be made by the very customers the regulator is presumed to serve. Hence, even if the regulator and customer-owners are assumed to value profits to the same degree, a failure to account for this difference in customer-owner risk-preferences could give rise to regulatory distortion.

Our findings have been derived in the context of a given firm that could be either customer- or investor-owned. In reality investor- and customer-ownership can each arise in different settings – for example with investor-ownership predominating in more profitable or developed environments, and customer-ownership predominating in less profitable or developing environments. Also, in some jurisdictions (notably the US) if not universally, customer-owned firms benefit from different tax and financing treatments relative to investor-owned firms. This suggests that future research would usefully consider how these additional considerations affect the influence of ownership on incentives and regulation, particularly with endogenous ownership choice. Furthermore, given the importance of customer-owner effective risk-aversion to our results, further evidence on this parameter is desirable. Finally, much research has examined the relative cost efficiency and profitability of customer- and investor-owned firms. Our research provides additional guidance for such research, but also highlights that an equally interesting question is to compare the relative efficiency of regulated and unregulated customer-owned firms.

These extensions are left to future research. Such research should help to determine if, and how, customer-owned firms should be regulated, and whether they should be regulated differently to investor-owned firms. Given the importance of customer-ownership in a variety of key sectors, and the possible importance of regulatory distortions when the characteristics of customer-ownership are ignored, these questions would appear to be economically important.

References

[1] ACIL Tasman, 2005, *Institutional Arrangements in the Australian Water Sector*, December.

[2] Armstrong, M. and D. Sappington, 2007, "Recent Developments in the Theory of Regulation", in Armstrong, M. and R. Porter (eds), *Handbook of Industrial Organization*, Vol. 3, Elsevier B.V.

[3] Barnes, D. and G. Foley, 2004, *Rural Electrification in the Developing World: A Summary of Lessons from Successful Programs*, Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), World Bank, December.

[4] Baron, D. and R. Myerson, 1982, "Regulating a Monopolist with Unknown Costs", *Econometrica*, 50(4), 911–930.

[5] Beiner, S., Schmid, M. and G. Wanzenried, 2011, "Product Market Competition, Managerial Incentives and Firm Valuation", *European Financial Management*, 17(2), 331–366.

[6] Berry, D., 1994, "Private Ownership Form and Productive Efficiency: Electric Cooperatives versus Investor-Owned Utilities", *Journal of Regulatory Economics*, 6, 399–420.

[7] Bolton, P. and M. Dewatripont, 2005, *Contract Theory*, MIT Press, Cambridge, MA.

[8] Boyle, G., 2004, "The Economic Efficiency of Irish Dairy Marketing Co-operatives", *Agribusiness*, 20(2), 143–153.

[9] Brealey, R., Myers, S. and F. Allen, 2011, *Principles of Corporate Finance*, 10 ed., McGraw-Hill/Irwin.

[10] Commerce Commission, 2010, *Treatment of Consumer-Owned Electricity Distribution Businesses* (downloaded September 2010).

[11] Deller, S., Hoyt, A., Hueth, B. and R. Sundaram-Stukel, 2009, *Research on the Economic Impact of Cooperatives*, University of Wisconsin Center for Cooperatives.

[12] Demski, J. and D. Sappington, 1987, "Hierarchical Regulatory Control", *RAND Journal of Economics*, 18(3), Autumn, 369–383.

[13] Evans, L. and R. Meade, 2005, *The Role and Significance of Cooperatives in New Zealand Agriculture: A Comparative Institutional Analysis*, report prepared for the New Zealand Ministry of Agriculture and Forestry, New Zealand Institute for the Study of Competition and Regulation, December.

[14] Fama, E. and M. Jensen, 1983a, "Separation of Ownership and Control", *Journal of Law & Economics*, Vol. XXVI, June, 301–325.

[15] Fama, E. and M. Jensen, 1983b, "Agency Problems and Residual Claims", *Journal of Law & Economics*, Vol. XXVI, June, 327–349.

[16] Graziano, C. and B. Parigi, 1998, "Do Managers Work Harder in Competitive Industries?", *Journal of Economic Behavior & Organization*, 34, 489–498.

[17] Hansmann, H., 1996, *The Ownership of Enterprise*, Belknap Harvard, Cambridge, MA.

[18] Hart, O. and J. Moore, 1996, "The Governance of Exchanges: Members' Cooperatives versus Outside Ownership", *Oxford Review of Economic Policy*, 12 (4), 53–69.

[19] Hart, O. and J. Moore, 1998, *Cooperatives vs. Outside Ownership*. National Bureau of Economic Research Working Paper 6421.

[20] Hendrikse, G., 1998, "Screening, Competition and the Choice of the Cooperative as as Organisational Form", *Journal of Agricultural Economics*, 49, 202–217.

[21] Hjalmarsson, L. and A. Veiderpass, 1992, "Productivity in Swedish Electricity Retail Distribution", *Scandinavian Journal of Economics*, 94, supplement, 193–205.

[22] Hollas, D. and S. Stansell, 1988, "An Examination of the Effect of Ownership Form on Price Efficiency: Proprietary, Cooperative and Municipal Electric Utilities", *Southern Economic Journal*, 55(2), October, 336–350.

[23] Hueth, B., Marcoul, P. and R. Ginder, 2004, *Cooperative Formation and Financial Contracting in Agricultural Markets*, University of Iowa Working Paper 03–WP 349, October.

[24] Jensen, M. and W. Meckling, 1976, "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure", *Journal of Financial Economics*, 3, 305–360.

[25] Karpoff, J. and E. Rice, 1989, "Organizational Form, Share Transferability, and Firm Performance: Evidence from the ANCSA Corporations", *Journal of Financial Economics*, 24, 69–105.

[26] Katz, J., 1997, "Managerial Behavior and Strategy Choices in Agribusiness Cooperatives", *Agribusiness*, 13(5), 483–495.

[27] Kirubi, C., Jacobson, A., Kammen, D. M. and A. Mills, 2009, "Community-Based Electric Micro-Grids Can Contribute to Rural Development: Evidence from Kenya", *World Development*, online version.

[28] Kopel, M. and M. Marini, 2012, *Optimal Compensation Structure in Consumer Cooperatives under Mixed Oligopoly*, June.

[29] Laffont, J.-J. and J. Tirole, 1986, "Using Cost Information to Regulate Firms", *Journal of Political Economy*, 94(3), 614–641.

[30] Laffont, J.-J. and J. Tirole, 1993, *A Theory of Incentives in Procurement and Regulation*, MIT Press, Cambridge, MA.

[31] Le Prou, R., 2007, *The Administration of New Zealand Irrigation: History and Analysis*, New Zealand Institute for the Study of Competition and Regulation.

[32] Ministry of Economic Development, 2010, *Estimates of Lines Company Discount and Distribution Payments* (downloaded September 2010).

[33] NRECA, 2012, *America's Cooperative Electric Utilities: The Nation's Consumer-Owned Electric Utility Network* (downloaded March 2013).

[34] NRECA International, 2010, *Guides for Electric Cooperative Development and Rural Electrification* (downloaded March 2013).

[35] Porter, P. and G. Scully, 1987, "Economic Efficiency in Co-operatives", *Journal of Law and Economics*, XXX, 489–512.

[36] Raith, M., 2003, "Competition, Risk, and Managerial Incentives", *American Economic Review*, 93(4), September, 1425–1436.

[37] Shleifer, A. and R. Vishny, 1997, "A Survey of Corporate Governance", *The Journal of Finance*, 52(2), June, 737–783.

[38] Spiller, P., 1990, "Politicians, Interest Groups, and Regulators: A Multiple-Principals Agency Theory of Regulation, or 'Let Them Be Bribed"', *Journal of Law and Economics*, 33(1), April, 65–101.

[39] Staatz, J., 1987, "The Structural Characteristics of Farmer Cooperatives and their Behavioural Consequences", in J. Royer (ed.), *Cooperative Theory: New Approaches*, ACS Service Report 18, USDA, Washington DC, 33-60.

[40] Talosaga, T. and B. Howell, 2012, *New Zealand's Electricity Lines Companies: An Ownership Analysis*, New Zealand Institute for the Study of Competition and Regulation.

[41] Van der Krogt, D., Nilsson, J. and V. Host, 2007, "The Impact of Cooperatives' Risk Aversion and Equity Capital Constraints on their Inter-Firm Consolidation and Collaboration Strategies – With an Empirical Study of the European Dairy Industry", *Agribusiness*, 23(4), 453–472.