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Pricing Policies under Different Objectives: Implications for the Pricing Behaviour of AWB Ltd.[φ]

by

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ABSTRACT

This study is motivated by the suggestion that the objectives of the AWB Ltd have changed since semi-privatisation of the Australian Wheat Board under the Wheat Marketing Act, 1989. Conceptualising this change of objectives as a shift from revenue maximization to profit maximization, this study examines the impact of such a change on the pricing policies of a multi-market price-setting firm. More specifically, this study investigates, for two hypothetical objective functions, a risk averse firm's price-setting behaviour in an "overseas" and a "domestic" market, given differing costs of supply, uncertain demand functions and differing price elasticities of demand in each market. The aim is to generate empirically testable hypotheses relating to the impact of a change of objectives on pricing behaviour.

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INTRODUCTION

Historically, the Australian Wheat Industry has been the beneficiary of considerable government-funded support. However, commencing with the cessation of the Guaranteed Minimum Price Scheme in 1989 this support has been in the process of being removed, with the aim of leaving the industry exposed to economic realities. Over this period a central player in the Industry has been the former Australian Wheat Board (AWB), and its activities have been particularly targeted in relation to the removal of government-funded support and the encouragement to adopt fully commercial practices.

In this context the changes imposed on the AWB have been similar to those imposed by governments on former public enterprises in the privatisation process. This process has been the subject of a considerable economics literature, with one of the interests of this literature being the impact of privatisation on the objectives of the firm, and consequently on its behaviour (Fraser, 1989; Vickers & Yarrow, 1989; Bishop et al., 1994; Fraser, 1991; Fraser, 1994(a) and Fraser, 1996). However, one key difference is that whereas the privatisation of public enterprises that retain considerable monopoly power has been associated with post-privatisation regulation of their behaviour, typically of the "price-cap" variety, the AWB Ltd, by virtue of trading across national boundaries, is not subjected to any price regulation.

This observation raises the question of whether an examination of the AWB Ltd's situation using the methods of the privatisation literature might reveal insights regarding how its behaviour is likely to have been modified by the removal of government-funded support to the Industry. The aim of this paper is to undertake such an analysis, focusing in particular on how the government's push of the AWB towards fully commercial practices can be expected to have affected its pricing behaviour.

The structure of the paper is as follows. Section 1 develops a model of a price-setting firm operating in segmented markets. These segmented markets are characterised in such a way as to capture essential differences between the AWB's overseas and domestic markets. Specifically, the "overseas" market is characterised as being more costly to

supply to, and its demand is characterised as being both more elastic and more uncertain than the "domestic" market. Given this market framework, the model incorporates a "before" and "after" commercialisation pair of objectives for the firm, where the "before" objective focuses on size, and the "after" on profits. Note that this type of "before" and "after" characterisation of objectives is common in the privatisation literature (for example, Fraser, 1994(a) and Fraser, 1994(b)). For each objective function the optimal pricing behaviour of the firm is derived, with a view to analysing numerically the impact of the change in objective functions on this behaviour. This analysis is undertaken in Section 2. In particular it is shown first how the change in objectives affects optimal prices when the firm's markets differ in only one of the characteristics outlined above. Subsequently, the combined effect of the full set of differences is examined. The specific aim of this section is to generate empirically-testable hypotheses regarding the likely impact of the changes imposed on the AWB by the Australian government on its overseas and domestic pricing behaviour. The paper concludes with a brief summary.

SECTION 1: The Model

The model developed in this section is based on that outlined in Fraser (1989) of a size-orientated price-setting firm operating in multiple markets. In that case little was done to specify the firm's alternative markets other than for them to differ in terms of the extent to which demand was uncertain. In this case, in order to characterize more fully the differences between the AWB's domestic and overseas markets, the following market-based assumptions are made:

(a)   The product is a homogenous good;

(b)   three markets exist: "overseas", "domestic" and residual production ("dump market") in which revenue just covers costs;

(c)   costs to supply are greater in the overseas market than the domestic;

(d)   demand in the overseas market is more elastic than in the domestic market;

(e)   demand in the overseas market is more uncertain than in the domestic market.

Regarding the specification of the firm's objective, based on Fraser (1989), it is assumed that "before" commercialization the objective of the firm is to maximize the expected utility of sales revenue (EU(Rev)$_T$) subject to an expected profit constraint (E($\prod$)$_T$) and a total production constraint ($\overline{Q}$). Note that in what follows consideration of revenue from the sale of residual production is omitted in order to simplify the analysis. In this context it can be shown that because the firm's pricing behaviour is always constrained, this residual revenue source has a negligible effect on behaviour, even if the firm is very risk averse. In this case the firm's objective is given by:

$$\text{Max} \quad EU(\mathrm{Re}\,v) \qquad\qquad\qquad \ldots(1)$$

By choice of overseas (p_o) and domestic (p_d) prices.
Subject to:

$$\overline{Q} = E(q_o) + E(q_d) + q_x \qquad\qquad \ldots(2)$$

and,

$$E(\Pi)_T \geq z \qquad \qquad \ldots(3)$$

$$E(\Pi)_T = p_o E(q_o) - c_o E(q_o) + p_d E(q_d) - c_d E(q_d) \qquad \ldots(4)$$

where: $E(q_o)$ = expected sales in the overseas market;

            $E(q_d)$ = expected sales in the domestic market;

            q_x = sales of residual production;

            c_o = costs of supply per unit to the overseas market;

            c_d = costs of supply per unit to the domestic market;

            z = minimum feasible expected profit level.

Demand in both the overseas and domestic markets is assumed to be characterised by constant elasticity (b_i) demand functions subject to additive uncertainty (u_i, where i is either o or d).

$$q_i = a_i p_i^{-b_i} + u_i \qquad \qquad \ldots(5)$$

and where price is chosen as an optimal mark-up (λ) on per unit costs of supply:

$$p_i = (1 + \lambda_i)c_i \qquad \qquad \ldots(6)$$

where:

            a_i = scaling factor in each market

            $E(u_i) = 0$

and demand is assumed to be uncorrelated in the two markets.

As a consequence:

$$E(q_i) = a_i p_i^{-b_i} \qquad \qquad \ldots(7)$$

and expected revenue ($E(Rev)_T$) is given by:

$$E(Rev)_T = p_o(E(q_o) + p_d(E(q_d) \qquad \qquad \ldots(8)$$

While the variance of revenue (Var(Rev)$_T$) is given by:

$$Var(\mathrm{Re}v)_T = p_o{}^2 Var(u_o) + p_d{}^2 Var(u_d) \qquad \dots(9)$$

where:

$Var(u_i)$ = variance of demand in each market.

On this basis, using the mean-variance specification of expected utility, the firm's objective is to maximize[1]:

$$EU(\mathrm{Re}v)_T = U(E(\mathrm{Re}v)_T) + \frac{1}{2}U''(E(\mathrm{Re}v)_T)Var(\mathrm{Re}v)_T \qquad \dots(10)$$

Subject to:

$$\overline{Q} = E(q_o) + E(q_d) + q_x \qquad \dots(11)$$

and,

$$E(\Pi)_T \geq z$$

$$E(\Pi)_T = (p_o E(q_o) - c_o E(q_o)) + (p_d E(q_d) - c_d E(q_d)) \qquad \dots(12)$$

The first order conditions for the optimal prices, subject to the expected profit and total production constraints are as follows:

$$foc_i = U'(E(\mathrm{Re}v))_T * E'(\mathrm{Re}v)_i + \frac{1}{2}\left[U'''(E(\mathrm{Re}v))_T * Var\,\mathrm{Re}\,v_T * E'(\mathrm{Re}v)_i\right] + \frac{1}{2}\left[U''(E(\mathrm{Re}v))_T * Var'\,\mathrm{Re}\,v_i\right]$$
$$=0$$

$$\dots(13)$$

where,

[1] See Hanson & Ladd, 1991 for empirical support for this assumption.

$$E'(\mathrm{Re}\,v)_i = c_i(E(q_i))(1 - b_i)$$

$$\ldots(14)$$

$$Var'\mathrm{Re}\,v_i = c_i p_i(Var(u_i))$$

$$\ldots(15)$$

The "after" commercialization situation is assumed to be represented by a focus on profit rather than revenue, in which case the firm's objective is to maximize the expected utility of profit, subject only to the total production constraint (Fraser, 1994(a)).

$$\mathrm{Max} \quad EU(\Pi)_T = E(U(\sum p_i E(q_i) - \sum c_i E(q_i))) \qquad \ldots(16)$$

Subject to:

$$\overline{Q} = E(q_o) + E(q_d) + q_x \qquad \ldots(17)$$

Using the same specification of the demand functions, expected profit is given by:

$$E(\Pi)_T = p_o E(q_o) + p_d E(q_d) - c_o E(q_o) - c_d E(q_d) \qquad \ldots(18)$$

and the variance of profit is given by:

$$Var(\Pi)_T = (p_o - c_o)^2 Var(u_o) + (p_d - c_d)^2 Var(u_d) \qquad \ldots(19)$$

Once again using the mean-variance formulation gives:

$$\mathrm{Max} \quad EU(\Pi)_T = U(E(\Pi)_T + \frac{1}{2}U''(E(\Pi)_T)Var(\Pi)_T \qquad \ldots(21)$$

Subject to:

$$\overline{Q} = E(q_o) + E(q_d) + q_x \qquad \ldots(22)$$

On this basis, the first order conditions for the optimal prices subject to the total production constraint are given by:

$$foc_i = U'(E(\Pi))_T * E'(\Pi)_i + \frac{1}{2}\left[U'''(E(\Pi))_T * Var\,\Pi_T * E'(\Pi)_i\right] + \frac{1}{2}\left[U''(E(\Pi))_T * Var'\,\Pi_i\right]$$
$$= 0$$

$$\ldots(23)$$

where,

$$E'(\Pi)_i = c_i E(q_i) - \lambda_i b_i c_i^{\ 2} a_i ((1+\lambda_i)c_i)^{-b_i-1} \qquad \ldots(24)$$

$$Var'\,\Pi_i = 2\lambda_i c_i^{\ 2} Var(u_i) \qquad \ldots(25)$$

This completes the specification of the model on which the numerical analysis of the next section is based.

SECTION 2: Numerical Analysis

In order to undertake a numerical analysis of the model developed in the previous section is it necessary to specify a functional form for the firm's utility function, and a set of base case parameter values. In what follows, use is made of the constant relative risk aversion utility function (see Fraser 1994a and b). On this basis, total utility for the "before" commercialization case ($U(\text{Re}v)_T$) is given by:

$$U(\text{Re}v)_T = (\text{Re}v)_T^{1-R}\bigg/ 1-R \qquad \ldots(26)$$

And in the "after" commercialization case, the firm's utility is given by:

$$U(\Pi)_T = \Pi_T^{1-R}\bigg/ 1-R \qquad \ldots(27)$$

The parameter values used for the 'base case' in the numerical analysis are as follows:

Overseas Market	Domestic Market	Residual Market
$a_o = 10000$	$a_d = 10000$	$\bar{p}_x = c_x = 1$
$b_o = 1.5$	$b_d = 1.3$	$\bar{Q} = 240$
$c_o = 10$	$c_d = 10$	
$u_o = 5$	$u_d = 5$	

Note that the only difference in the characterization of the two markets in the base case is in the elasticity of demand, with demand being more elastic in the overseas market. In addition, the relative risk aversion coefficient is set at $R = 0.5$ and the expected profit constraint (z) for the expected utility of revenue maximiser is set at 95% of that achieved by the expected utility of profit maximiser. This is an arbitrary assumption, which is made for simplicity, and in order to keep the two types of pricing behaviour "close" to each other.

On this basis, Table 1 shows the "before" and "after" scenarios for the firm.

Table 1: **Differences in elasticities (b_i)**

	Before $b_o=1.5$ $b_d=1.3$	*After* $b_o=1.5$ $b_d=1.3$
p_o	$24.00	$30.00
p_d	$26.30	$43.30
Q_T	227.6	135.4
$E(\Pi)_{Total}$	$3514.77	$3700.35

This table shows that the shift to a profit-orientated objective results in an increase in price in both markets, with an associated decrease in sales overall. Note that the increase in price is greater in the less elastic market[2].

Table 2, shows the impact of allowing for differences in the costs of supply on pricing behaviour. Elasticities and variances are held at the same levels as in the first case.

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[2] Note also that the expected utility of revenue maximiser will choose to lower prices until it is constrained by the expected profit constraint. Because of this the first order conditions are not equal to zero for the expected utility of revenue maximiser. However, they must be equal to each other in order for the best contribution to be made to increasing the expect utility of the revenue maximiser.

Table 2: **Differences in costs (c_i) and elasticities (b_i)**

	Before	After
	$c_o=15$	$c_o=15$
	$c_d=10$	$c_d=10$
p_o	$32.70	$44.85
p_d	$27.60	$43.30
Q_T	187.4	107.9
$E(\Pi)_{Total}$	$3303.41	$3476.99

The results for case 2 differ to those in the first case with $p_o > p_d$ for both objectives. However, there are also similar movements in prices and sales between the before and after scenarios. Table 3, indicates the impacts that occur where elasticities and costs differ between the two markets as with the previous scenario ($b_o=1.5$, $b_d=1.3$ and $c_o=15$, $c_d=10$) but with the inclusion of the final market difference: a difference in the variances on the demand functions, with this variance being greater for the overseas market ($Var(u_o)=500$, $Var(u_d)=5$).

Table 3: **Differences in variances (u_i), costs (c_i) and elasticities (b_i)**

	Before	After
	$Var(u_o)=500$	$Var(u_o)=500$
	$Var(u_d)=5$	$Var(u_d)=5$
p_o	$33.00	$41.10
p_d	$27.40	$43.30
Q_T	187.9	112.5
$E(\Pi)_{Total}$	$3301.71	$3473.74

With this increase in the variance of the overseas market's demand there is a minimal impact on the pricing behaviour of the expected utility of revenue maximiser compared with the results for the prices in case 2. This is due to the fact that this firm's choice of prices is constrained by the expected profit constraint. Whereas, in the "after" scenario, the firm is free to adjust its prices to reflect the increased demand uncertainty in the overseas market. Given the firm's risk aversion, this results in the overseas market being

perceived as less attractive, and the price set for that market is lowered in order to reduce the variability of profits. Note that this decrease is sufficient to reverse the relative level of domestic and overseas prices for the expected utility of profit maximiser from that in case 2.

In order to examine these issues further a sensitivity analysis of the impacts of different levels of risk aversion was undertaken. The results of such an analysis are recorded below in Table 4.

Table 4: **Sensitivity to changes in the relative risk aversion coefficient.**

	Before	*After*
R=0.1		
p_o	$32.70	$43.90
p_d	$27.60	$43.30
Q_T	187.4	108.9
R=0.9		
p_o	$33.20	$39.10
p_d	$27.10	$43.30
Q_T	189.7	115.4

The results in Table 4 show once again the insensitivity of the pricing behaviour of the expected utility of revenue maximiser, although there is a slight inclination for the more risk averse firm to concentrate on increasing sales (by lowering price), in the less risky (domestic) market The effects for the expected utility of profit maximiser indicate that varying risk aversion reverses the rankings of p_o and p_d which is consistent with the sensitivity of this ratio to the variance of demand identified in Table 3. Nevertheless, the previous findings that the shift from a size-orientated objective to a profit-orientated objective results in increases in prices in both markets, and an associated decrease in total sales, remains robust.

It follows from the numerical analysis that the following three hypotheses can be developed:

H1: $p_o(\Pi) > p_o(\mathrm{Re}v)$

H2: $p_d(\Pi) > p_d(\mathrm{Re}v)$

H3: $Q_T(\Pi) < Q_T(\mathrm{Re}v)$

Based on the numerical analysis, there are also several ambiguities regarding relative price levels, whereby relative prices were shown to be dependent on differences in elasticity and in costs, and in the variance of demand or the risk aversion of the firm. In particular:

$$p_o(\mathrm{Re}v) > or < p_d(\mathrm{Re}v)$$

In the numerical analysis, this ratio was shown to be dependent on market-based differences elasticities and costs of supply.

In addition:

$$p_o(\Pi) > or < p_d(\Pi)$$

The above ratio was also shown to be ambiguous and dependent on market-based differences between elasticities, costs and on both the variance of demand in each market and the risk aversion of the firm.

CONCLUSION

In this paper a model has been developed to investigate the impact on multi-market pricing behaviour as the objective of a firm is shifted from a revenue-orientated public enterprise to a semi-regulated profit maximiser. The motivation for the paper has been the Australian government's push of the former AWB towards fully commercial practices and the question of how this can be expected to have affected its pricing behaviour in domestic and overseas markets. Empirically testable hypotheses have been developed through the algebraic and numerical analysis of a risk averse firm's price-setting behaviour for two different objective functions and given differing costs of supply, uncertainty of demand and differing price elasticities of demand for the firm's markets.

Adaptation of Fraser's (1989) modelling framework was outlined in Section 1. The model is of a size-orientated price-setting firm operating in multiple and segmented markets. These markets are specified to capture the differences between the AWB Ltd's overseas and domestic markets. The overseas market is characterised as being a higher cost market, with more elastic and more uncertain demand than the domestic market. With this structure, the model incorporates a "before" and "after" commercialisation pair of objectives for the monopolist, where revenue and profits are the two objectives respectively.

Results of the numerical analysis were presented in Section 2. Three empirically-testable hypotheses were generated identifying the likely impact on the AWB Ltd's overseas and domestic pricing behaviour of the changes imposed on it by the Australian government. In particular, it was suggested that the impact of commercialisation would have been to increase prices in both domestic and overseas markets, with an associated decrease in total sales. This section also showed how the change in objective affects optimal prices when the firm's markets differ in each respect as well as the combined effect of all differences. This and a further sensitivity analysis of the effect of the firm's level of risk aversion was conducted which confirmed the robustness of the three hypotheses, but also

indicated a set of inconclusive results that will require further attention in an empirical context.

In conclusion, this study has developed a modelling framework that has been adapted from previous privatisation literature and has been applied to an aspect of the privatisation process not yet fully investigated. The AWB Ltd represents a useful case study for further empirical work on this application due to the likely shift in its objectives following changes in Australian federal government policy.

REFERENCES

Bishop, M., Kay, J. & Mayer, C. (eds.) (1994), <u>Privatisation and Economic Performance</u>, Oxford University Press, Oxford, UK

Fraser, R.W. (1989), "Uncertainty and the Positive Theory of Public Enterprise", *Bulletin of Economic Research*, 41(2), pp147-155

Fraser, R. (1991), "Privatisation in the United Kingdom: Lessons for Australia?", *Economic Papers*, September 1991, 10(3), pp30-37

Fraser, R. (1994a), "Privatisation: Price-capping and Reliability", *Utilities Policy*, April 1994, 4(2), pp121-127

Fraser, R. (1994b), "Price, Quality and Regulation: An Analysis of Price-Capping and the Reliability of Electricity Supply, *Energy Economics*, July 1994, 16(3), pp 175-183

Fraser, R. (1996), "Privatisation in the United Kingdom: Lessons for Australia 2", *Economic Papers*, December 1996, 15(4), pp14-19

Hanson, S.D. and Ladd, G.W., (1991), "Robustness of the Mean-Variance Model with Truncated Probability Distribution", *American Journal of Agricultural Economics*, May 1991, 73(2), pp436-445

Vickers, J. & Yarrow, G., (1989), <u>Privatization – An Economic Analysis</u>, The MIT Press, Cambridge, MA, USA