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Measuring the marginal welfare impacts of government regulation: the case of supply management

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Abstract. The focus in this paper is on the income leakage or loss that occurs when income is transferred from consumers to producers in regulated industries. The marginal leakage measure that is developed only requires knowledge about the demand price, the supply price, and the point elasticity of demand; and it can be used to estimate the degree of monopoly power exercised by the regulated firms. In the empirical section, the Canadian supply-managed agricultural sectors are examined.

Sur la mesure des effets à la marge sur le niveau de bien-être de la réglementation gouvernementale: le cas de la gestion de l'offre. Le mémoire porte sur le coulage ou la perte de revenu qui se produit quand du revenu est transféré des consommateurs aux producteurs dans les industries réglementées. La mesure de cette perte est développée à partir d'une connaissance limitée au prix demandé, au prix offert, et à l'élasticité de la demande en un point; cette mesure peut être utilisée pour mesurer le degré de monopole exercé par les firmes réglementées. Dans la section empirique du mémoire, on examine des secteurs de l'agriculture canadienne où il y a gestion de l'offre.

Regulatory agencies often exist to make decisions regarding the prices to be charged for a commodity or service that is produced under conditions of monopoly. The pricing of the regulated product frequently occurs in a political atmosphere – in the case of utilities, via rate-setting hearings – and the objective of the regulation is to channel income from consumers (or taxpayers) to themselves. This is also true of supply-managed agricultural industries, where regulation occurs via quantity restrictions. In this case, industry and government effectively bargain over output price by haggling over the amount of domestic production and imports to permit. Unfortunately, the arguments used for settling upon final price in regulated industries pay scant regard to economics, and when they do, marginal concepts regarding social costs and benefits are ignored. One reason why social welfare arguments might be ignored is the difficulty in measuring social welfare.

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Our purpose is to provide a simple method for summarizing information about social welfare costs in regulated industries, particularly the supply-managed agricultural sectors. The criterion that we develop employs Arthur Okun's concept of income leakages. Okun defines a leakage as the amount of \$1 that is lost when that dollar is transferred from one group to another (e.g., from rich to poor). This leakage is usually the welfare loss due to allocative inefficiency plus any administrative costs of making the transfer. Okun also provides some bounds regarding maximum acceptable leakages depending upon the income levels of the recipient group and the giving group. Studies by Browning (1976 and 1987), Browning and Johnson (1984), and Stuart (1984) indicate that, in the case of income distribution through taxation, the marginal welfare costs are much higher than the average welfare costs. While average leakages in transferring income from high to low-income groups via the tax system may be within Okun's range of acceptability; marginal leakages are not.

Our focus is on the marginal welfare leakages of regulation because the average welfare cost of regulation, which is what most analysts measure, provides little useful information in an environment where (i) the current industry structure is not about to be changed, and (ii) the existing structure has been in place for such a long time that it would not be an easy task to find the competitive equilibrium, assuming it did exist sometime in the past or could now be implemented. The advantage of the marginal leakage criterion developed in this paper is that only knowledge about the demand price, the supply price, and the point elasticity of demand is required. Information about demand and supply prices appears to be readily available to the regulatory authority, while data on the elasticity of demand are generally available from published sources. However, some regulations ostensibly have goals other than enrichment of producers. In this case, the marginal leakage measure by itself is not enough to evaluate the policy, although it may still be useful in that setting.

We begin by providing formulae for calculating the average and marginal leakages in a market where price and quantity deviate from the perfectly competitive equilibrium. Several interesting results are demonstrated, including the effect that curvature of the demand function has on the marginal versus average welfare leakages. Finally, we apply our concepts to supply management in several Canadian agricultural sectors, comparing the magnitudes of the average and marginal welfare costs (leakages).

MEASURING AVERAGE AND MARGINAL WELFARE LEAKAGES

For the purposes of this analysis, consider the situation where a producer marketing board does not have absolute control over its own price owing to government regulation.¹ Control over price may be considered complete if the board can achieve the price and quantity that would exist under monopoly. Government intervention may be sufficient to prevent the marketing board from attaining the monopoly

¹ The discussion and analysis in this section could apply equally well to the case of regulated utilities. While we consider quantity restrictions, the analysis is the same if the focus is on price as opposed to output.

solution, but the marketing board has some ability to haggle over price with the appropriate regulatory agency. In this situation and since the marketing system is not about to be abandoned, it is important for policy purposes that the marginal rather than the average social welfare cost of output decisions are considered; that is, it is necessary to estimate the marginal as opposed to the average welfare leakage for every dollar consumers give up by transferring income to producers.

The average and marginal welfare leakages of quantity restrictions can be calculated using figure 1. The supply price is given by $S(q)$ and the demand price by $D(q)$. It is assumed that $S'(q) > 0$ and $D'(q) < 0$.

Consider a supply-restricting marketing board which initially restricts output to q_1 but now proposes to restrict quantity to q_0 , with $0 < q_0 < q_1 \leq q_c$, where q_c is the competitive equilibrium. We can measure the social welfare changes as follows. If supply restrictions are changed from q_1 to q_0 , say, then there is a change in societal welfare (W) given by

$$\begin{aligned}\Delta W(q_0, q_1) &= \int_{q_1}^{q_0} [D(q) - S(q)] dq \\ &= - \int_{q_0}^{q_1} [D(q) - S(q)] dq \\ &= -(a + b + f).\end{aligned}$$

The industry supply curve $S(q)$ is the sum of the marginal cost of resources hired by the industry, and the marginal alternative cost of resources owned by the industry. We assume that the marginal cost for hired inputs is infinitely elastic, so that all producer surplus accrues to the regulated producers themselves, not to resource suppliers.² The change in producers' net revenue (R) can then be considered to consist of two components in figure 1, namely, the pure profit gain ($c + g - b$) and the producer surplus loss ($g + f$). Thus,

$$\begin{aligned}\Delta R(q_0, q_1) &= D(q_0)q_0 - D(q_1)q_1 + \int_{q_0}^{q_1} S(q) dq \\ &= (c + g - b) - (g + f) = c - b - f.\end{aligned}$$

Finally, the change in consumer surplus (C) when supply is restricted from q_1 to q_0 is

$$\Delta C(q_0, q_1) = -(a + c) = \Delta W - \Delta R.$$

The leakage in going from q_1 to q_0 is the proportion of each dollar given up by

2 In agricultural sectors characterized by supply management (see below), it is reasonable to assume that the prices of hired resources will not change as sector output changes. Inputs consist primarily of machinery, labour, animals, and feed, and there is no reason to suspect that marginal changes in their use will change their price. It is also assumed that the marginal quota holder owns resources with the highest opportunity cost, that all quota holders are alike, and that changes in quota are shared equally across quota owners.

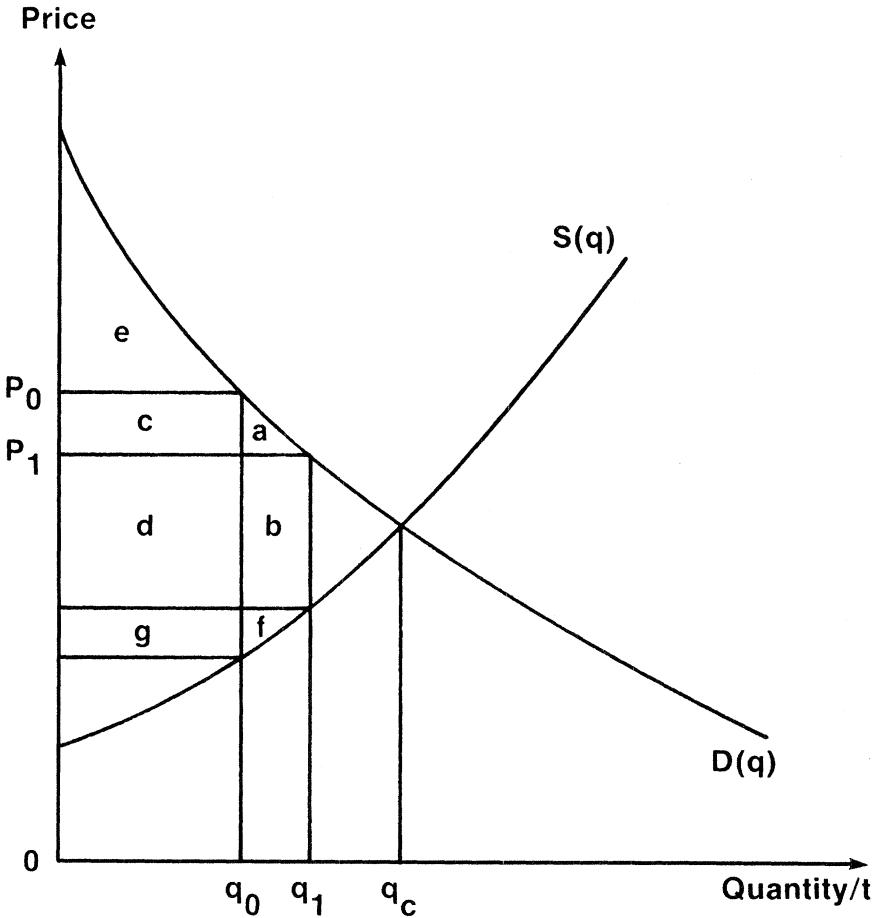


FIGURE 1

consumers that does not accrue to producers. That is, it is the proportion of each dollar lost by consumers which is also lost to society as a whole. (For convenience, administrative costs are ignored.) This leakage is given by

$$\begin{aligned}
 L(q_0, q_1) &= \frac{\Delta W(q_0, q_1)}{\Delta C(q_0, q_1)} = \frac{\int_{q_0}^{q_1} [D(q) - S(q)] dq}{D(q_0)q_0 - D(q_1)q_1 + \int_{q_0}^{q_1} D(q) dq} \\
 &= \frac{a + b + f}{a + c}.
 \end{aligned}$$

The average leakage is the special case where $q_1 = q_c$. Let $AL(q_0) = L(q_0, q_c)$,

which is useful to express as

$$AL(q_0) = \frac{\int_{q_0}^{q_c} [D(q) - S(q)] dq}{D(q_0)q_0 - D(q_c)q_c + \int_{q_0}^{q_c} D(q) dq} \quad (1)$$

Now consider the marginal welfare leakage that occurs as q_1 approaches q_0 . Let

$$ML(q_0) = \lim_{q_1 \rightarrow q_0} L(q_0, q_1).$$

This can be interpreted as the leakage that takes place when a single unit decrease in production from $q_0 + 1$ to q_0 occurs. To get a more useful formula for $ML(q_0)$, note that

$$dW/dq(q_0) = D(q_0) - S(q_0)$$

and

$$dR/dq(q_0) = D'(q_0)q_0 + D(q_0) - S(q_0).$$

Using these two expressions,

$$\begin{aligned} ML(q_0) &= \lim_{q_1 \rightarrow q_0} \frac{[W(q_0) - W(q_1)]/(q_0 - q_1)}{\{[W(q_0) - W(q_1)] - [R(q_0) - R(q_1)]\}/(q_0 - q_1)} \\ &= \frac{dW/dq(q_0)}{dW/dq(q_0) - dR/dq(q_0)} = \frac{D(q_0) - S(q_0)}{-D'(q_0)q_0} \end{aligned} \quad (2)$$

$$= -\varepsilon \left[1 - \frac{S(q_0)}{D(q_0)} \right] = -\varepsilon \delta, \quad (3)$$

where $\varepsilon = D(q_0)/[D'(q_0)q_0]$ is the point price elasticity of demand and $\delta = [p_0 - S(q_0)]/p_0$ is the fraction of the selling price that is variable profit.³ Recognizing that $S(q)$ is MC, it is clear that δ is simply the Lerner Index.

In the formula for the marginal leakage, only the elasticity of demand matters, not the elasticity of supply. This is unlike the more familiar case of excise taxes, where both supply and demand elasticities affect total and marginal losses. With taxes, the focus is on how a change in the tax rate (equal to the difference between the demand and supply prices) affects the welfare loss; here the concern is over how a one unit change in quantity or a given increment in consumer price affects the welfare loss. In equation (3), supply elasticity does not matter because all producer surplus is assumed to accrue to the quota owners – the marginal cost of inputs remains constant as output expands. None the less, the difference between demand and supply prices does matter.

3 At rate-setting hearings, the rate of return on investment is often provided. Then, given that output price and quantity are known, it is possible to determine the supply price. In the case of supply management, the cost of production (supply price) is often determined from a survey of producers.

Several additional conclusions also follow. (1) Note that, when the marginal leakage becomes 1.0, producers receive no additional revenue from a reduction in output. This must be the monopoly solution q_m ; that is, from equation (2), q_m satisfies $D(q_m) - S(q_m) = -D'(q_m)q_m$.⁴ (2) From equation (3), for a given ε , the greater the difference between the demand price and the supply price, the greater is the marginal social welfare leakage. (3) The marginal leakage is unaffected by the elasticity of supply; with regards to supply, only the supply price affects the marginal welfare leakage. (4) Also from equation (3), the greater the elasticity of demand, the larger is the marginal social welfare leakage, *ceteris paribus*.

Now consider the special case of linear demand and supply functions. Suppose

$$S(q) = a + bq \quad \text{and} \quad D(q) = \alpha - \beta q, \text{ with } a, b, \alpha, \beta > 0.$$

The competitive equilibrium supply q_c is given by

$$q_c = \frac{\alpha - a}{\beta + b}.$$

For any $q_0 < q_c$, it is possible to compute $AL(q_0)$ and $ML(q_0)$ using equations (1) and (2), respectively, with the special form of linear supply and demand. This gives

$$AL(q_0) = \frac{(\beta + b)}{\beta} \left[\frac{2q_c}{q_c + q_0} - 1 \right] = \frac{\beta + b}{\beta} \left[\frac{q_c - q_0}{q_c + q_0} \right].$$

$$ML(q_0) = \frac{(\alpha - a)}{\beta q_0} - \frac{(\beta + b)}{\beta} = \frac{(\beta + b)(q_c - q_0)}{\beta q_0}.$$

Several interesting results can be derived from these equations.

- (i) $\lim_{q_0 \rightarrow q_c} AL(q_0) = 0 = \lim_{q_0 \rightarrow q_c} ML(q_0)$.
- (ii) $\lim_{q_0 \rightarrow 0} ML(q_0) = \infty$
- (iii) $\lim_{q_0 \rightarrow 0} AL(q_0) = \frac{\beta + b}{\beta}$
- (iv) $\frac{ML(q_0)}{AL(q_0)} = \frac{q_c + q_0}{q_0} > 2$ if $0 < q_0 < q_c$.

These results hold for all upward-sloping supply and downward-sloping demand functions. Result (i) states that the competitive solution is Pareto optimal, since there is no situation that can improve one group without harming the other; indeed, there is a net loss to society in moving away from q_c . Results (ii) and (iii) are illustrated in figure 2. The marginal welfare leakage increases to infinity as quantity is reduced to zero, while the average welfare leakage has a definite intercept at zero output. This

4 Since $ML = (\text{marginal social loss}) / (\text{marginal loss to consumers})$, an alternative measure might be $K = (\text{marginal gain to producers}) / (\text{marginal loss to consumers}) = 1 - ML = 1 + \varepsilon\delta$. Note that $K = 1$ at q_c and $K = 0$ for monopoly.

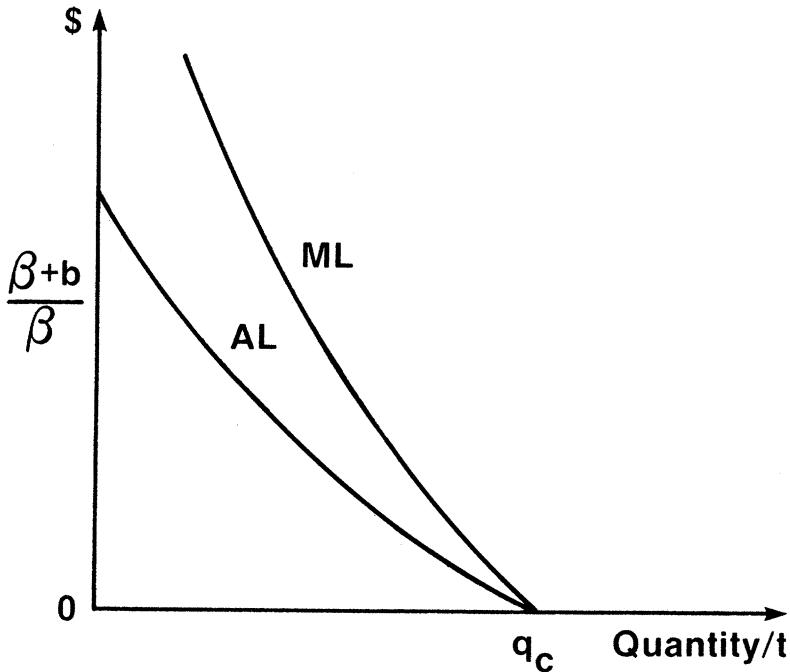


FIGURE 2

intercept is dependent only on the slopes of the demand and supply curves. Result (iv) indicates that, for linear supply and demand curves, the marginal welfare leakage is always at least twice as large as the average welfare leakage.⁵

Before turning to some empirical evidence from Canadian agriculture, consider the following example, which illustrates the point that the differences between average and marginal leakages are amplified if the demand curve is concave toward the origin. For simplicity, we employ a linear supply curve and a piecewise linear demand function.

Suppose supply is given by $S(q) = 15 + 1/2q$ and the demand function is

$$D(q) = \begin{cases} 100 - 1/5q & \text{for } 0 \leq q \leq 100 \\ 180 - q & \text{for } q \geq 100. \end{cases}$$

The competitive quantity and price are $q_c = 110$ and $p_c = 70$, respectively. The calculations in the following table indicate that $ML(q)$ has a discontinuity at $q = 100$, rising from 0.15 to 0.75, while $AL(q)$ is continuous at $q = 100$ and remains rather low.

5 With quadratic functional forms for both supply and demand, it was possible to verify results (i) and (ii), but results (iii) and (iv) are very difficult to verify because the expression for AL becomes extremely complex.

q_0	AL(q_0)	ML(q_0)
110	0	0
105	0.035	0.07
100+	0.07	0.15
100-	0.07	0.75
95	0.14	0.97

The monopoly solution is at $q = 94.4$. Note that if quantity is restricted from 100 to 95 units, consumers give up 97.5 units of their surplus, but producers gain only 13.75 units of welfare. The difference of 83.75 units of welfare is lost because of allocative inefficiency, even though the average leakage at $q = 95$ is still only 0.14.

EMPIRICAL ESTIMATES OF AVERAGE AND MARGINAL WELFARE LEAKAGES: THE CASE OF SUPPLY MANAGEMENT IN CANADIAN AGRICULTURE

Supply management has been employed by the Canadian government as a means of stabilizing prices and transferring income to the agricultural sector. This institution developed as a result of the success of the Canadian Wheat Board and the establishment of the Canadian Dairy Commission (CDC) in 1966. The CDC employed a more restrictive form of supply management than the Wheat Board, but this also resulted in higher incomes for producers. This success encouraged agricultural groups to lobby the government to establish national marketing schemes for other agricultural commodities. The enabling legislation, the Farm Products Marketing Agencies Act, was passed in 1972, and national supply-management marketing boards were established for turkeys, eggs, and broilers in 1973, 1975, and 1978, respectively.

Using partial equilibrium analysis, economists have subsequently measured the size of the deadweight loss triangle resulting from the distortion created by a marketing board (Barichello, 1982; Harling and Thompson, 1985; Lerner and Stanbury, 1985; Veeman, 1982). For Canada, estimates of the leakages in transferring income from consumers to producers range from \$0.03–\$0.35 for poultry products (including eggs) and \$0.14–\$0.26 for dairy products. These estimates of income leakages are based on average costs of transferring income. Since the supply management boards are controlled by producers, with public review and subsequent haggling over the actual pricing policies, the relevant measure should not be based on average welfare costs but, rather, on marginal welfare costs. Thus, in analysing marketing boards, one can conceive of different levels of support; that is, the regulatory body chooses the consumer price (or the degree of supply restriction) and, hence, must consider marginal welfare effects to determine the optimal level of the program, if any.⁶ Governments have favoured this institution for stabilizing

6 To determine the optimal level of the program, the authority must equate its marginal valuation of the benefit of transferring income with its marginal valuation of the cost of doing so.

TABLE 1

Assumptions employed in comparing the average and marginal welfare costs of supply management in poultry, eggs, and dairy

Item	Poultry ^a	Eggs ^a	Dairy ^b
Undistorted or competitive price	\$1,065.00/tonne	\$ 893.34/tonne	\$0.555/qt
Quota constrained price	\$1,512.30/tonne	\$1,218.48/tonne	\$0.60/qt
Consumption under supply management	457 mil. tonnes	307 mil. tonnes	160 mil. qt
Elasticity of demand			
High	-0.44	-0.22	-0.90
Low	-0.31	-0.11	-0.20
Elasticity of supply			
High	1.01	0.94	1.00
Low	0.12	0.03	0.25

a Source: Harling and Thompson (1983)

b Source: Van Kooten and Spriggs (1984)

prices because it transfers income to producers with no expense to the treasury; the costs are borne by consumers.

Since previous studies have examined only the average welfare costs of regulation in agriculture, we provide estimates of both the average and the marginal welfare costs for comparison. In doing so, we employ the concept of leakages. The assumptions employed in the analysis are found in table 1. Information regarding the quota-constrained quantity and price, and the estimate of the competitive price, for the poultry and egg sectors is obtained from Harling and Thompson (1983, 158, 174). Similar data for the dairy sector are obtained from Van Kooten and Spriggs (1984, 227). The data for poultry products and eggs are for all Canada, but the data for dairy products are for the province of British Columbia only. While estimates of demand and supply elasticities for poultry and eggs are obtained from Harling and Thompson (1983, 176), the high and low estimates of the supply and demand elasticities for dairy are simply our 'guesstimates.' Albon reports an elasticity of supply for dairy products in BC of 0.5 and a demand elasticity of -0.35 . Other estimates of supply and demand elasticities exist, but they cannot be considered very good, because supply management has characterized the industry since 1966, and price and expenditure data are available since 1960 on an annual basis only.

The average and marginal leakages are calculated using equations (1) and (2), respectively, along with the assumptions in table 1.⁷ The results are provided in table 2. It is evident from table 2 that the marginal leakages associated with transferring income from consumers to producers are substantial, and at least double the average

⁷ The average leakage calculation does not include the administrative costs of supply management, but these are generally less than 5 per cent of output price.

TABLE 2

Comparison of average and marginal welfare leakages in transferring income from consumers to producers in poultry, eggs, and dairy products^a

Product	Assumptions about elasticities			
	Supply elasticity is high		Supply elasticity is low	
	Demand elasticity		Demand elasticity	
	High	Low	High	Low
<i>Poultry</i>				
Estimate of Competitive				
Consumption (mil. tonnes)	516.5	498.9	516.5	498.9
Average Leakage (\$)	0.078	0.053	0.201	0.117
Marginal Leakage (\$)	0.165	0.110	0.427	0.244
<i>Eggs</i>				
Estimate of Competitive				
Consumption (mil. tonnes)	325.0	316.0	325.0	316.0
Average Leakage (\$)	0.033	0.016	0.173	0.052
Marginal Leakage (\$)	0.068	0.032	0.357	0.106
<i>Dairy</i>				
Estimate of Competitive				
Consumption (mil. quarts)	170.8	162.4	170.8	162.4
Average Leakage (\$)	0.058	0.009	0.134	0.013
Marginal Leakage (\$)	0.120	0.018	0.278	0.026

^a All estimates are based on linear demand and supply curves calculated from elasticity estimates. The demand elasticity estimate is assumed to be for the quota constrained price and quantity; the estimate of supply elasticity is for the competitive price and quantity as estimated from the demand function.

leakages.⁸ For poultry, eggs, and dairy products, the marginal leakages may be as high as 42.7, 35.7, and 27.8 per cent, respectively. Assuming that the linearity assumptions are approximately valid – and Van Kooten provides empirical support for the validity of this assumption – it is apparent that the marketing boards have not been able to capture all the monopoly rents. However, it appears that monopolization has occurred to a greater extent in the poultry sector than in either the eggs or dairy sectors.

Okun (1975, 91–6) argues that he would accept a maximum leakage of 60 per cent in the case where income is transferred from those whose earnings are in the top 5 percentile of income to those in the lowest 20 percentile. However, if income was transferred from those in the quantile immediately above the mean income to those in the quantile immediately below the mean, he would find unacceptable a leakage greater than 10 per cent. Attempts to determine the average incomes of poultry, egg and dairy producers were unsuccessful.⁹ If we assume that we are making a transfer from those in the income quintile immediately above the mean to those in the quintile

⁸ Including administration costs will, however, increase the magnitude of the average leakages, but they are unlikely to affect the marginal leakages.

⁹ Statistics Canada does not collect data of this nature, and we did not have access to tax return files.

immediately below the mean, then, following Okun's criterion, it appears that the marginal welfare costs of making income transfers via marketing boards is unacceptable to society. It is just as likely, however, that supply management transfers income from lower to higher-income groups, from rich to poor.

These results have a greater implication for agricultural programs that just indicated for marketing boards. Given the extent of government intervention in both Canada and the United States (as well as in Europe), it may be time to ask: What are the marginal welfare leakages when consumers or taxpayers give up an additional \$1 of income in order to redistribute income in favour of agricultural producers through agricultural programs such as quotas, deficiency payments, and other subsidy programs? As with the studies of Browning, Stuart, and others, it appears that the marginal leakages of many agricultural programs may simply be unacceptable to society.

CONCLUSIONS

In regulated industries, the regulating authority is often called upon to decide changes to existing, previously determined, prices or quantities (e.g., import restrictions). This decision is often made on the basis of ad hoc rules or political power, and the overall welfare of society – in particular the consumer – is often ignored. Perhaps this is due to the perceived complexity of gathering the required data for making welfare calculations, or it is the result of the public's inability to understand what economists mean when they talk about welfare losses. To overcome these difficulties, we urge the adoption of a marginal welfare leakage criterion of the kind developed in this paper.

The criterion presented here has several advantages for use in the setting of rates for utilities and in other cases where governments regulate the market prices of commodities. (1) The marginal welfare leakage focuses on local data – on data at the point of decision. (2) The data required to calculate the marginal leakage are few and easy to obtain. Regulatory agencies already have information on the supply price and the demand price, which they are in the process of setting. Information on the elasticity of demand can be obtained from published sources, or a reasonable range of demand elasticities can be agreed upon in the absence of published data. (3) Finally, the public and the regulators can readily understand what is meant by an income leakage. The only decision that then remains concerns the acceptable range of leakages that will be allowed. It is at this point that the economist qua economist must beg off.

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