Australian Journal of Agricultural Economics, Vol. 33, No. 3 (December 1989), pp. 187–202

SOCIAL COSTS OF REGULATION OF PRIMARY INDUSTRY: AN APPLICATION TO ANIMAL WELFARE REGULATION OF THE VICTORIAN PIG INDUSTRY*

CHRISTOPHER J. WILCOX
Department of Agriculture and Rural Affairs, East Melbourne, Vic. 3002

The effects of state government regulation of primary industry are modelled. An analytical framework is presented for estimating the costs of regulation in terms of changes in economic surplus. The model permits trade between regions of the total market. An illustrative application of the framework is applied to proposed animal welfare regulation of the Victorian pig industry. Some regulations that may provide large gains with regard to the welfare of farm animals involve only small social costs compared to the gross value of production of the industry. Conversely, other regulations that potentially confer only small gains in animal welfare impose large social costs. The distribution of these costs is important. In general, consumers lose, as do some producers. Other producers gain. In some cases, producers in aggregate gain from regulation. Major beneficiaries, such as advocates of animal welfare regulations, are likely to bear little of the cost of regulation.

Regulation has significant implications for primary production. It imposes costs upon the operation of firms and hence on industries, often with substantial private and social costs. Politicians, business leaders, primary producers and the public in general are questioning existing government regulations. At the same time, new regulations are being proposed. Regulations that specify farming practices aiming to ensure minimum levels of welfare for farm animals are examples that have received considerable attention recently.

In Australia, under the Commonwealth Constitution, power to legislate over purely domestic production issues resides with the individual state governments. As a result, regulations can vary among states. Any such variation in regulations will have implications for the magnitude and incidence of the social costs and benefits of regulation.

The objective of this paper is to develop a framework for analysing the general question of the effects of regulating production practices in part of an industry. This framework is applied to the specific issue of animal welfare regulations in Victorian piggeries in an illustrative application.

The underlying assumption of this framework is that social regulation raises costs and shifts the industry supply curve upwards. Linear programming is used to estimate with- and without-regulation price-quantity combinations for different producer groups and producers in aggregate. Linear supply functions for each set of regulations and for the without-regulation case are then estimated. Finally, changes in

*An earlier version of this paper was presented to the 30th Annual Conference of the Australian Agricultural Economics Society, Canberra, 3–5 February 1986. I would like to thank Julian Alston, John Freebairn, Daniel Sumner and the two referees for their constructive and instructive comments. However, I remain solely responsible for any persisting errors of fact or logic.

producer and consumer surpluses due to each set of regulations are assessed. The effect of relaxing key assumptions is also considered, revealing several policy implications.

Estimating the Social Costs of Regulation

Four components of a full economic evaluation of animal welfare regulation may be identified. These include the effect of the regulation on the supply, demand and price of goods, the benefits of changes in animal welfare, the costs of adjustment in changing from one production system to another, and the administrative costs of regulation.

The present study considers only the first component in detail. The adjustment and administrative costs of regulation are ignored, as are the benefits. An analytical model of industry response to regulation is presented below. This model owes much to similar models developed to analyse research benefits (Lindner and Jarrett 1978, 1980; Rose 1980; Johnston 1981; Edwards and Freebairn 1983). The model is used to estimate the social costs of regulation in terms of the changes in economic surplus, and its distribution. Harberger's (1971) three postulates are assumed to hold.

The analysis is a comparative static, partial equilibrium model of movements from one long-run (without-regulation) equilibrium position to another long-run (with-regulation) equilibrium position for the regulated industry. The model permits trade between spatial or geopolitical regions of the total market. The framework provides a measure of consumer surplus which is not in fact the surplus of end users. It is an aggregate measure for beyond the farm gate and includes surplus to middlemen and processors as well as to final consumers.[1]

The basic proposition of this study is that regulation shifts the supply curve up to the left, the opposite of the effect of research. Essentially, regulations reduce the number of options and flexibility available to the producer and in so doing raise production costs per unit output. For simplicity, linear supply and demand curves are assumed, and the size of the shift is assumed to be measured by an absolute increase in costs on unregulated output (a parallel shift of the supply curve).[2] The resulting changes in consumer and producer surpluses are aggregated to represent the total annual social costs (TASC).

The total market for a commodity is disaggregated into two regions. By employing this model, the allocative and distributional consequences of a regulation-induced cost increase for an industry producing an internationally traded good can be ascertained. Alternatively, as in the present application, this model may be applied to region-specific regulations within a country.

Six situations may be envisaged for the introduction of social regulation in a world or country divided into two regions. These can be grouped under two broad headings, with the first region (region 1) as an

[1] Under special circumstances this measure will in fact be a measure of consumer surplus; namely, perfect elasticity of supply of inputs to the middleman, no excess profits, and constant retail output technology. Note that the method does not include transport costs.

[2] The model has been developed in Wilcox (1985) for other types of supply curve shifts (that is, pivotal, convergent and divergent). In the example case of animal welfare regulation presented here, simple regression tests for the nature of the shift, in addition to the extent of the shift, proved inconclusive. Henceforth, parallel shifts are assumed.

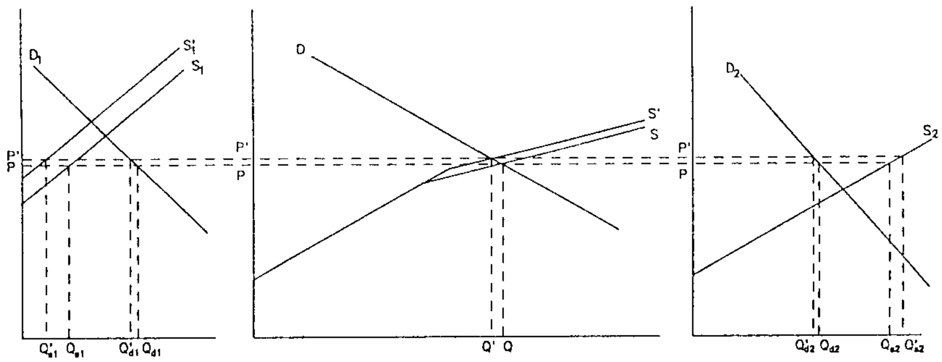

FIGURE 1—Impact of Regulation in Region 1: Region 1 as Importer.

exporter or as an importer. In either case, the regulation could be introduced into region 1, the second region, or both regions. The total effects and the between-region distributional consequences of social regulation vary depending upon these situations. Figure 1 presents the case of regulation in region 1, with region 1 as an importer.

Without-regulation demand and supply curves for region 1 are given by D_1 and S_1, and for region 2 by D_2 and S_2. The initial equilibrium point is given by the intersection of the total market demand (D) and supply (S) curves, giving initial output (Q) and price (P).

The introduction of a regulation in region 1 shifts the supply curve of region 1 upwards to S_1' and thus shifts the total market supply curve upwards to S', giving a new equilibrium price, P', and output, Q'. Each region's consumption falls as a result of the price increase: from Q_{d1} to Q_{d1}' for region 1, and Q_{d2} to Q_{d2}' for region 2. Production falls in region 1 to Q_{s1}' as a result of the cost increase associated with the regulation. Production rises in region 2 to Q_{s2}' because of the price rise.

Algebraically, the equations of this model ($i=1,2$) may be represented as:

(1) $Q_{si}=a_i+b_i(1+k_i)P$

(2) $Q_{di}=c_i+d_iP$

where Q_{si} and Q_{di} are supply and demand in the i-th region; a_i, b_i, c_i and d_i are the model parameters; and k_i is the shift in the supply curve from regulation. The aggregate supply and demand curves are obtained as the horizontal (algebraic) sums across regions and the market clearing condition is:

(3) $Q_{s1}+Q_{s2}=Q_{d1}+Q_{d2}$

Using estimates of the parameters of this model (a_i, b_i, c_i and d_i), the supply shifts due to regulation (k_iP), and the without-regulation prices and quantities, we can estimate the effects of regulation on prices and quantities in each region and the associated changes in economic surpluses. For further details of the model, see Wilcox (1985).

The loss to consumers in region i (L_{Ci}) can be represented as:

(4) $L_{Ci} = \frac{1}{2}(P' - P)(Q_{di} + Q'_{di})$

where P and P' are the total economy product prices without and with regulation respectively, and Q_{di} and Q'_{di} are the equilibrium demands without and with regulation for each region i.

Regulations are likely to affect firms differently, due to variations in production techniques and resource-use combinations employed by firms. Hence, a regulation may increase substantially production costs of one type of firm, while leaving another's relatively unchanged. Given that the industry can be disaggregated into relatively homogeneous groups, these differential impacts can be assessed.

For any given regulation the producer groups can be disaggregated by region, i, and by enterprise type, j. For the latter, some producers in region i already conform to the requirements of the new regulations in their production practices and are therefore not directly affected by the regulation (that is, $k_{ij} = 0$). On the other hand, other producers in region i must modify their current practices to conform to the requirements of the new regulation (that is, $k_{ij} > 0$). The general equation for this then is:

(5) $L_{Pij} = \frac{1}{2}[k_{ij}P - (P' - P)](Q_{sij} + Q'_{sij})$

Total annual social costs for each region are computed by summing across producers and consumers in that region:

(6) $TASC_{ij} = L_{Cij} + \Sigma L_{Pij}$

Similarly, costs to producers or consumers may be aggregated across regions. The national social costs are then given by:

(7) $TASC = \Sigma TASC_i$

Animal Welfare and the Australian Pig Industry

Animal welfare is at present seen as a major policy issue by farming organisations, attracting considerable media and political attention in Australia since the mid-1970s, including the current Senate Select Committee inquiry. Particular concern has been with intensive pig and poultry farms, and the export of live sheep. Producer groups have refuted some of the claims by animal welfare groups, and have financed research into the question of farm animal welfare (see, for example, Sybesma 1981; Blackshaw and McVeigh 1983, 1984; Winfield 1983; Barnett, Winfield, Hemsworth and Cronin 1984). Voluntary national codes of practice designed to improve the welfare of animals in both the pig and poultry industries have also been released (Australian Bureau of Animal Health 1983).

While it is generally believed that the introduction of animal welfare regulations will have significant economic implications for the industry concerned, particularly in relation to increased production costs and commodity prices, few studies have considered these effects directly. Several studies contain discussions of the principal elements involved in evaluating the effects of animal welfare regulations (Turner and Strak 1981, 1982; Griffith 1984; Griffith, Smith and Burgess 1984).

The effects on the direct costs of production have been considered in some previous studies. In these studies, simple cost comparisons were made of intensive and less intensive methods of production and, in some cases, implications for the whole industry drawn (see, for example, Eidman and Greene 1980; Webster 1982; Carnell 1983; Australian Pig Industry Research Committee 1984).

Sandiford (1985) assessed the likely effects on the United Kingdom pig and poultry industries of certain legislative measures. Both the impacts on the direct costs of production and adjustment were considered, the latter in terms of accelerated depreciation of certain capital items. The impacts of the legislation on supply, demand and prices were only cursorily considered.

A more recent study by Griffith (1987) considers the dynamic and long-run effects of animal welfare regulations on the New South Wales pig industry. Previously published estimates of the potential static impacts of these regulations are used; these estimates include estimates made in undertaking the research reported in this paper.

Besides the work by Griffith, no study has attempted to address and quantify all components of a full assessment of animal welfare regulations. From an industry perspective many previous studies do not allow for differences in the technology employed currently in the industry, and thus may overstate the impact of a given regulation. In addition, the farm-level effects are often not, as they must be, incorporated into a framework that allows for output response, interaction between producers and consumers, and inter-regional and international trade. The study by Griffith adopts an approach different to that taken in this paper.

The production technology used on Australian piggeries varies widely. Pigs can be either housed in some form of pen with shelter (intensive housing) or run extensively in paddocks with only minimal shelter. In turn, the form of intensive housing can range from covered yards with no walls, to fully enclosed sheds with some climate control. Thus, intensive housing can be divided into two broad groups: fully intensive housing and semi-intensive housing. Wright (1985), in a survey of state departments of agriculture industry extension officers throughout Australia, reports that up to 90 per cent of pigs are housed intensively. While no distinction was made in this survey between fully intensive and semi-intensive housing, industry sources suggest that most piggeries house farrowing sows and litters, weaners and growers/finishers in fully-intensive housing. Dry sows and boars are often housed in semi-intensive housing or run extensively.

It is the fully intensive housing of pigs, particularly the high stocking densities of all pigs when group housed (common for fattening pigs and dry sows), the use of individual stalls, where movement is limited (for farrowing sows in particular, and in some cases dry sows), and the use of controlled and less 'natural' environments, which underlies much of the concern expressed by animal welfare groups. The prime targets of animal welfare groups are stocking rates, individual sow stalls, farrowing crates, sow tethering, tail docking and castration, and stock transport (Griffith *et al.* 1984).

The Australian pig industry is a relatively small industry producing primarily for the domestic market. As shown in Table 1, New South Wales and Queensland are the major states in terms of pig numbers in

Australia: in 1983–84 around 54 per cent of Australian pig numbers were in these two states. In terms of meat production, however, Victoria is the largest state, accounting for nearly 70 000 tonnes of pigmeat. Pigs are transported to Victoria from New South Wales and South Australia for slaughter. It is estimated that around 60 per cent of pigs marketed and slaughtered in Victoria originate from that state (Rogerson and Wilcox 1981). Thus, Victorian-sourced production for 1983–84 was around 41 000 tonnes.

Adoption by the industry of the recently introduced code of practice for the pig (Australian Bureau of Animal Health 1983) is unlikely to satisfy the demands of the animal welfare movement. The difficulties of self-regulation by industry will not be lost on the movement, which will continue to demand direct regulation of the industry by state governments. Recommendation for such regulation is likely to come from the Senate Select Committee inquiry into animal welfare issues (Neales 1985).

Four types of regulation of piggery practices are considered here. These are regulations of stocking densities in growing pig pens, banning of the use of individual sow stalls, banning of the use of farrowing crates, and a 'package' of regulations.

Effects of Regulations at the Farm Level

Parametric linear programming (LP) of individual firms was used to estimate synthetic with- and without-regulation price-quantity relationships for different producer groups, and producers in aggregate. Using the results of the LP models, information can be obtained on the extent of the region or industry supply curve shift and the elasticities of supply at the producer group and aggregate levels.

While the ideal approach to simulating the decision-making and operations of farms with LP is to derive representative farm input–output matrices from a detailed survey of real farms, such a survey was not possible. Instead, information obtained from the Department of Agriculture, Victoria was used to construct the representative farm LP models. Models were developed to represent farms in both the Australian and Victorian industries. Animal welfare regulations are

TABLE 1

Pig Numbers and Production by States, 1983–84[a]

	Pig numbers		Production	
	Sows	Total pigs	Slaughterings	Pigmeat
	('000 head)	('000 head)	('000 head)	('000 tonnes)
NSW	112	799	1106	59 151
Vic.	52	404	1236	69 620
Qld	70	550	921	57 164
SA	52	417	550	34 740
WA	41	300	480	26 936
Tas.	7	48	80	4319
Aust.[b]	335	2527	4401	253 289

[a] Australian Bureau of Statistics, *Livestock and Livestock Products Australia, 1983–84.*
[b] Includes Northern Territory and ACT.

unlikely to be introduced uniformly across Australia as only each state government has the regulatory power to promulgate such regulations. What seems likely is that one or more state governments will introduce the regulation, while the remaining states will not. The analysis below considers the effect on both Victoria and the rest of Australia (ROA) of regulation being introduced into Victoria only.

Farms in the Australian and Victorian pig industries were classified according to size (breeding sow numbers) and farm type (housing technology employed). These two criteria appear to be most important in stratifying the industry into relatively homogeneous groups and allowing for the differential impacts of animal welfare regulations. Piggeries were classified according to three size categories and three housing technology categories.

Thus, nine representative farm groups were identified. Of these, the large specialist semi-extensive group was excluded from further consideration as it was also assumed to constitute only a small proportion of output. Similarly, piggeries with less than 15 sows were also excluded.

Statistical information on the number of piggeries in each representative farm group or on the mean piggery size in each group is not available for Australia and Victoria. The Australian Bureau of Statistics does, however, provide information on the number of establishments in each size group. The Victorian Department of Agriculture provided information on the proportions of piggeries in each size group using each form of housing. The eight representative farm groups, the code numbers used for each, and the number of farms in each group for Victoria and Australia are shown in Table 2.

TABLE 2

Representative Farm Group, Description and Code Numbers

Representative farm group	Description	Assumed number of farms[a]	
		Aust.	Vic.
1	Non-specialist, herd size between 15 and 30 sows, intensive housing	925	120
2	Small specialist, herd size between 60 and 150 sows, intensive housing	253	42
3	Large specialist, herd size greater than 150 sows, intensive housing	144	22
4	Non-specialist, herd size between 15 and 60 sows, semi-intensive housing	955	124
5	Small specialist, herd size between 60 and 150 sows, semi-intensive housing	270	46
6	Large specialist, herd size greater than 150 sows, semi-intensive housing	193	29
7	Non-specialist, herd size between 15 and 60 cows, semi-extensive housing	1105	143
8	Small specialist, herd size between 60 and 150 sows, semi-extensive housing	294	49
	Total (all farm groups)	4139	575

[a] Australian Bureau of Statistics (1984), *Livestock and Livestock Products Australia, 1983–84*; Australian Bureau of Statistics (unpublished); Wilcox (1985).

Parametric LP matrices were constructed for each farm type for Australia and for Victoria using information supplied by pig industry experts of the Victorian Department of Agriculture, industry sources and some individual producers. The data are averages for the two years 1982–83 and 1983–84.

All matrices include the activities and constraints associated with a typical pig enterprise. The matrices for the non-specialist piggeries also include the additional activities and constraints associated with the other enterprises assumed to be operated, cereal cropping and sheep. The LP models are designed to represent the longer-run situation for each farm and the industry. It is assumed that only the managerial capacity of the operator, and his supply of labour, constrains the piggery operation. To account for this, a limit is imposed on both the amount of operator labour and a normalised constraint of 'management'. In addition, a step function of decreasing piggery production efficiency with increasing breeding sow herd size was included in each representative farm matrix, reflecting the impact of different managerial capacities.

The objective function of each LP matrix is assumed to be profit maximisation, subject to the relevant input–output coefficients, resource constraints and prices. All costs, other than the operator's labour and management, are included in the objective function values of each activity. Thus, the resultant net return provided on solution of each model gives a return to the operator's labour and management. It is in effect the rent to the fixed factors, or the producer surplus.

Synthetic price–output combinations for each producer group were obtained for the without-regulation case and for eight with-regulation cases. The regulations and the producer groups they are assumed to affect are shown in Table 3.

TABLE 3

Description of Regulation and Representative Farm Groups Affected

Reg. no.	Description	Affected group
1	Force use of area allowances[a] of *at least* 0·25, 0·49 and 0·68 m²/growing pig[b]	All farm groups
2	Force use of area allowances[c] of *at least* 0·35, 0·69 and 0·96 m²/growing pig[b]	All farm groups
3	Force use of area allowances[d] of *at least* 0·70, 1·38 and 1·92 m²/growing pig[b]	All farm groups
4	Force use of area allowances[e] of *at least* 3·0 m²/growing pig[b]	All farm groups
5	Ban individual sow stalls, no effect on sow feed consumption	Farm group nos 2 & 3
6	Ban individual sow stalls, increase sow feed consumption	Farm group nos 2 & 3
7	Ban farrowing crates	All farm groups except nos 4, 7 & 8
8	'Package' of regulations incorporating regulations 2, 5 and 7	All farm groups

[a] 'Minimum' levels suggested by Petherick and Baxter (1982).
[b] Weaner, grower and finisher pigs respectively.
[c] 'Adequate' levels suggested by Petherick and Baxter (1982).
[d] Double the 'adequate' levels.
[e] Areas suggested by the animal welfare groups, Australian Federation of Animal Societies (1985).

Although one effect of regulation may be to encourage some producers to leave the industry, the model did not allow any off-farm work or shifts to another industry. Thus, the structural adjustments suggested by the model are conservative.

Regression analysis was applied to the derived data sets, firstly to estimate the without-regulation supply response functions for each group and the aggregate, and secondly to determine the extent of shifts arising from each regulation. The supply elasticity and shift estimates thus obtained were then used to estimate the value and distribution of the social costs of each regulation.

Effects at the Industry Level

Linear supply equations were estimated by ordinary least squares regressions of output against price for without-regulation data representing the industry aggregate (Australia, Victoria or ROA) and each representative farm group. The parametric results were treated as independent observations in the regressions.

The estimated regression equations for Victoria for each representative farm group and for the aggregate (industry) are shown in Table 4. The long-run own-price elasticities are also given. The output

TABLE 4

Victoria and ROA Without-Regulation Regression Equations

Rep. farm group[c]	Parameter estimates[a] Intercept (α)	Price (β)	R^2	Group quantity at $1.65/kg (kt)	Long-run[b] elasticity
1	−11·25 (−10·30)	9·12 (13·12)	0·92	3·8	4·0
2	−10·06 (−10·50)	8·00 (13·78)	0·95	3·2	4·2
3	−74·55 (−11·04)	53·97 (13·27)	0·92	14·5	6·1
4	−11·42 (−13·37)	8·85 (16·76)	0·95	3·2	4·6
5	−8·56 (−9·75)	6·97 (12·87)	0·95	3·3	3·9
6	−57·56 (−9·65)	42·19 (11·74)	0·90	12·1	5·8
7	−11·67 (−16·90)	8·97 (20·91)	0·97	3·1	4·7
8	−6·76 (−5·33)	5·54 (7·08)	0·86	2·4	3·8
Vic. industry aggregate	−180·06 (−32·64)	136·01 (40·23)	0·97	43·7	5·1
ROA industry aggregate	−814·06 (−32·80)	618·79 (44·60)	0·97	206·9	4·9
Aust. industry aggregate	−995·34 (−32·86)	755·77 (40·51)	0·97	251·7	5·0

Note: t-values are in parentheses. All parameters are significantly different from zero at the 95 per cent confidence level.

[a] $Q = \alpha + \beta P$ where Q is production in kt and P is price in $/kg.

[b] At the without-regulation price of $1.65/kg.

[c] As defined in Table 2.

quantities for each aggregate estimated by the equations are similar to the actual average output for the two years (1982–83 and 1983–84) in question. The actual average outputs were 246 kt, around 40 kt and around 206 kt per annum for Australia, Victoria and ROA respectively (Australian Bureau of Statistics 1983, 1984).

The estimated supply elasticities of around 5 seem high when compared with previous econometric estimates. These estimates, presenting price elasticity estimates of sow numbers, range from 0·55 to 2·23 for the Australian and NSW industry (see, for example, Richardson and O'Connor 1978; Griffith and Burgess 1983; Griffith and Gellatly 1982; West 1980). Besides these aggregate estimates, Richardson and O'Connor disaggregate the industry into grain growing and dairy regions using Victorian data. The resultant long-run price elasticities of sow numbers were 2·94 and 3·68 for dairy and grain regions. In addition, the estimates provided by other studies (Griffith and Gellatly, and West) are based on quarterly data, whereas the Richardson and O'Connor study is based on annual data. By way of comparison, the estimates provided by the models used in this study are long-run based on annual data, with few resources being limited.

To estimate the extent of the shifts in the supply functions arising from each regulation, with- and without-regulation data were pooled and a regression was estimated including a dummy variable to represent the presence or absence of regulation. Thus:

(8) $Q_i = a_i + b_i P + c_{im} R_{im}$

where Q_i is the derived vector of pigmeat output for region i, P is the pigmeat price vector, and R_{im} is a zero/one dummy variable denoting without- and with-regulation m (as described in Table 3) respectively. The parameter c_{im} provides an estimate of the horizontal shift in the regional supply function arising from regulation m. The equivalent vertical shift $k_{im}P$ can be obtained from:

(9) $k_{im}P = c_{im}/b_i$

The derived absolute vertical shifts for the case of regulation in Victoria only are shown in Table 5. These vertical shifts represent the

TABLE 5

Derived Shifts in Victorian Supply Functions from Pre-Regulation Outputs ($/tonne)

	Representative farm group[a]								
Reg. no.[b]	1	2	3	4	5	6	7	8	Aggregate
1	5·2	3·0	1·8	3·7	1·9	1·4	1·8	2·2	2·8
2	9·4	11·9	10·6	9·5	9·5	7·5	8·6	9·9	8·2
3	70·8	82·3	78·6	67·6	69·6	68·6	65·3	67·3	70·9
4	245·8	263·3	263·0	198·6	196·3	230·7	203·3	198·9	235·0
5	—	5·6	2·5	—	—	—	—	—	0·9
6	—	21·5	21·5	—	—	—	—	—	7·9
7	32·1	31·8	33·1	—	36·9	25·7	—	—	25·7
8	37·7	37·8	36·7	9·5	43·8	30·7	8·6	9·9	32·0

[a] See Table 2 for a description of these representative farms.
[b] See Table 3 for a description of these regulations.

increases in farm-level production costs caused by the regulation. For example, the forced use of a specific area allowance for growing pigs (regulation 1) raises production costs in farm type 1 by an average of $5.20 per tonne of pigmeat produced. The regulations that cause the biggest increase in production costs are those specifying very restrictive area allowances (regulations 3 and 4).

The size and distribution of the social costs of these regulations are dependent upon several factors. The initial size of industry output and the magnitude of the cost increase associated with the regulation are two principal determinants of the size of TASC. Distribution of TASC between consumers and producers, between producer groups and among producers and consumers in different regions is dependent on market shares, supply and demand elasticities, and the location of the regulatory intervention. Both the size and distribution of the costs also depend on the nature of the supply shift, although it has been assumed here that the shift is parallel.

Estimates and the distribution of TASC for Australia for regulations introduced solely in Victoria are shown in Table 6, under four sets of supply and demand elasticities. Supply elasticities of 5·0 and 2·2 were chosen, based on the estimates made in this study and that reported by Richardson and O'Connor (1978). Demand elasticities of −4·0 and −1·5 were used, representing the range of estimates reported in the literature (see, for example, Papadopoulos 1971; Pender and Erwood 1970; Griffith and Burgess 1983; Gruen 1967; Fisher 1979). While the absolute level of TASC does not vary much with the changes in the assumed elasticities of supply and demand, its distribution between producers and consumers does.

It was found that four of the regulations considered cause large annual social costs. These regulations are those specifying the most restrictive minimum pen area allowances (regulations 3 and 4), that banning the use of farrowing crates (regulation 7), and the 'package' of measures (regulation 8). The remaining four regulations cause relatively small costs. They also cause only small shifts of the supply curve. The level of TASC represents between 0·01 and 2·1 per cent of the gross value of production for the Australian pig industry; the level of Victorian producer surplus loss represents between 0·04 and 11·4 per cent of Victorian gross value of production.

The analysis becomes more interesting and has greater policy implications when the distribution of TASC is considered. Producers, in aggregate, have the lowest share of TASC when supply is more elastic, at 5·0, relative to demand, at −1·5. Aggregate producers' share of TASC is highest when supply is less elastic relative to demand. Even with the combination of elasticities most favourable to consumers (more elastic demand, less elastic supply) the consumers' share of the costs of regulation was still around 40 per cent. For the least favourable combination (less elastic demand, more elastic supply), consumer loss was 75 to 114 per cent of TASC, with producers gaining in some cases.

In all cases, ROA producers gain from regulation in Victoria as a result of the price increase. This is at the expense of Victorian producers and aggregate consumers. From the point of view of ROA producers, the most favourable elasticity combination is more elastic supply and less elastic demand, the same as that for producers in

TABLE 6

Distribution of Australian TASC Between Consumers and Producers and Among Producers: Regulation in Victoria only[a]

Reg. no.	Group		More elastic supply[b] demand elasticity		Less elastic supply[b] demand elasticity	
			−4·0	−1·5	−4·0	−1·5
			$m	$m	$m	$m
1	Consumers		0·07	0·10	0·04	0·08
	Producers:	Total	0·05	0·02	0·08	0·05
		ROA	−0·06	−0·08	−0·04	−0·06
		Victoria	0·11	0·10	0·11	0·11
2	Consumers		0·21	0·29	0·13	0·22
	Producers:	Total	0·15	0·07	0·23	0·14
		ROA	−0·17	−0·24	−0·11	−0·18
		Victoria	0·32	0·31	0·33	0·32
3	Consumers		1·76	2·45	1·13	1·90
	Producers:	Total	1·03	0·35	1·83	1·07
		ROA	−1·48	−2·06	−0·94	−1·58
		Victoria	2·51	2·41	2·77	2·65
4	Consumers		5·71	8·03	3·70	6·24
	Producers:	Total	1·17	−1·01	5·05	2·58
		ROA	−5·03	−7·06	−3·14	−5·30
		Victoria	6·20	6·06	8·20	7·88
5	Consumers		0·02	0·03	0·01	0·02
	Producers:	Total	0·01	0·01	0·02	0·01
		ROA	−0·02	−0·02	−0·01	−0·02
		Victoria	0·03	0·03	0·04	0·03
6	Consumers		0·20	0·28	0·13	0·21
	Producers:	Total	0·14	0·07	0·22	0·13
		ROA	−0·16	−0·23	−0·11	−0·18
		Victoria	0·31	0·30	0·32	0·31
7	Consumers		0·64	0·89	0·41	0·69
	Producers:	Total	0·44	0·19	0·69	0·41
		ROA	−0·53	−0·74	−0·34	−0·57
		Victoria	0·97	0·93	1·03	0·98
8	Consumers		0·80	1·11	0·51	0·86
	Producers:	Total	0·54	0·23	0·86	0·51
		ROA	−0·67	−0·92	−0·42	−0·71
		Victoria	1·20	1·15	1·28	1·23

[a] Negative values indicate a *gain* to that group.
[b] More elastic supply at 5·0, 4·9 and 5·1 for Australia, ROA and Victoria respectively. Less elastic supply at 2·2 for both regions and Australia. Point elasticities at the initial equilibrium.

aggregate. The *gain* to these producers with this combination is some 120 per cent greater than for the least favourable combination (less elastic supply and more elastic demand).

Victorian producers, on the other hand, suffer substantial losses as a result of regulation. In most cases, this group are the principal losers from the regulation, losing more than aggregate consumers. The exceptions are for the elasticity combination most favourable to producers (more elastic supply, less elastic demand) for regulations 3 and 4, where aggregate consumers lose most. For the latter of these two regulations and for this elasticity combination, the gain to ROA producers outweighs the loss accruing to Victorian producers, resulting in a net gain to producers in aggregate.

This result may appear surprising at first. However, it is intuitively plausible that the loss to producers in the region in which regulation is promulgated may be outweighed by the gain to producers in the other region(s). For example, if supply in the regulated region is perfectly elastic while supply in the unregulated region is perfectly inelastic, then a shift in the regulated region's supply curve will clearly result in an aggregate producer gain. Generally, an increase in aggregate producer surplus is more likely (i) the smaller is the market share of the region in which regulation is promulgated; (ii) the larger is the supply elasticity in this region; (iii) the smaller is the aggregate demand elasticity; and (iv) the larger is the region supply curve shift resulting from the regulation. Thus, for regulation which entails a large shift in the Victorian supply curve (regulation 4) and with more elastic supply in both regions and relatively less elastic demand, a net gain to producers in aggregate arises.

A further notable point from these tables is that the loss to Victorian producers is relatively insensitive to changes in elasticity combinations. For example, the loss to this group is only 5 to 20 per cent greater for the least favourable elasticity combination than for the most favourable elasticity combination. The producer surplus loss caused by the production cost increase far outweighs the gain from the price increase for this group. As only the price increase is sensitive to changing elasticities, the net loss is insensitive to this variation.

The distribution of the Victorian share of the producer surplus change between the representative producer groups identified in this study is shown in Table 7. Those groups which have the largest share of the without-regulation output generally have the largest share of the

TABLE 7

Distribution[a] of Victorian Aggregate Producer Surplus Change Between Victorian Producer Groups: All Regulations, Regulation in Victoria only

Reg. no.[c]	With-reg. price[d]	Representative farm group[b] 1	2	3	4	5	6	7	8
	$/t	$'000	$'000	$'000	$'000	$'000	$'000	$'000	$'000
1	1650	18·0	8·2	19·9	10·6	4·3	12·5	4·4	4·0
2	1651	31·0	33·3	134·2	26·3	24·3	75·4	23·1	20·7
3	1660	214·5	206·8	896·6	169·5	163·3	635·8	160·2	128·1
4	1683	601·8	512·7	1908·5	407·9	388·0	1559·7	404·7	319·4
5	1650	−0·5	17·2	34·4	−0·4	−0·4	−1·5	−0·4	−0·3
6	1651	−4·2	59·1	285·0	−3·5	−3·2	−13·3	−3·5	−2·6
7	1654	104·7	85·5	404·6	−11·4	94·1	256·8	−11·2	−8·5
8	1654	121·2	100·3	439·6	16·0	110·2	301·9	12·9	13·0

[a] A negative value represents a *gain* to that group.
[b] See Table 2 for a description of these representative farms.
[c] See Table 3 for a description of these regulations.
[d] Some prices shown are the same as assumed in the without-regulation situation. There are in fact price increases for these at one decimal place.

producer costs of the regulations when affected. Some producer groups *gain* from the regulations if they are unaffected by the regulations. No producer group gains if it is at all affected by the regulations. That is, in no case does the price increase offset the production cost increase which arises for a producer group from a regulation.

Concluding Remarks

The analysis presented partly supports producer opinion that the costs of animal welfare regulation in the pig industry would be substantial. Four of the regulations introduced into only one relatively small region of Australia would result in Australian social costs of more than $1 million per year. Other regulations, however, would cause only small social costs.

The majority of regulations considered in this study, and the practices assumed to replace the prohibited practices, are relatively mild when compared to the proposals made by Animal Liberation and other groups (see, for example, Australian Federation of Animal Societies 1984). In addition, neither the administration costs nor the adjustment costs are included. Thus, it may be expected that estimates presented here represent somewhat conservative measures of TASC.

More important than the absolute level of TASC is the incidence of these costs. Producers in the rest of Australia gain from all regulations at the expense of both Victorian producers and Australian consumers. However, Australian and Victorian consumers may benefit from the promulgation of animal welfare regulations in Victoria, if they are concerned about the welfare of animals under the production practices which are prohibited. Victorian producers may then be seen as the major losers from this policy. More to the point, intensive and semi-intensive specialist producers bear large costs. State governments must be aware of these effects when considering the implementation of regulations where other states do not have similar policies. Incentives exist for producers of one state to encourage the introduction of regulation in other states, as these producers gain from the resultant higher pigmeat price. Of course, such action is only likely when producers believe introduction of regulation is inevitable and if there is no chance of the regulation being introduced more widely.

The estimates of TASC presented in this study rest on certain assumptions regarding the production techniques used in place of the prohibited practices and the resultant effects of the input–output coefficients. The current debate on animal welfare has already resulted in a shift in research emphasis in the pig industry towards projects with implications for animal welfare. With the promulgation of animal welfare regulations this shift in emphasis is likely to increase. In the longer term this research may result in the development of technologies which comply with the regulations and which result in technical efficiencies comparable to current practices. Thus, the estimated horizontal and vertical shifts may overstate the actual shift. The actual level of TASC would therefore be lower than the estimates presented in this study.

The framework developed here has many similar uses in the field of social regulation and policy advice. It provides a general methodology which is broadly applicable in many *ex ante* situations. With some modification it may similarly be applied in *ex post* evaluations.

Developments are probably necessary in order to maximise the model's usefulness in policy advice. For example, the methodology does not enable prediction of the effect of regulation on industry structure, and development and adoption of technology. The results of the model provide evidence that the approach has considerable merits and warrants further study.

References

Australian Bureau of Animal Health (1983), *Model Code of Practice for the Welfare of Animals*, ABAH, Canberra.

Australian Bureau of Statistics (1984), *Livestock and Livestock Products, Australia, 1983–84*, ABS, Canberra (and previous issues).

Australian Federation of Animal Societies (1985), Submission of the Australian Federation of Animal Societies to the Senate Select Committee of Inquiry into Animal Welfare in Australia, AFAS, Melbourne.

Australian Pig Industry Research Committee (1984), *Annual Report, 1982–83*, APIRC, Canberra.

Barnett, J. L., Winfield, C. G., Hemsworth, P. H. and Cronin, G. M. (1984), 'The welfare of adult pigs: responses to contrasting housing systems', *Animal Production in Australia* 15, 83.

Blackshaw, J. K. and McVeigh, J. F. (1983), 'Welfare aspects of pig husbandry: husbandry systems for sows', in *Proceedings of the 2nd Pig Production and Marketing Review Conference*, Standing Committee on Agriculture, Hobart.

—— and McVeigh, J. F. (1984), The behaviour of sows and gilts housed in stalls, tethers and groups. Paper presented at the Australian Society of Animal Production Pig Satellite Seminar, Gunnedah.

Carnell, P. (1983), *Alternatives to Factory Farming: An Economic Appraisal*, Earth Resources Research Publication, London.

Edwards, G. W. and Freebairn, J. W. (1983), *Measuring a Country's Gains from Research: Theory and Application to Rural Research in Australia*. Report to the Commonwealth Council for Rural Research and Extension, AGPS, Canberra.

Eidman, V. R. and Greene, D. D. (1980), *An Economic Analysis of Three Confinement Hog Finishing Systems*, Agricultural Experiment Station Bulletin 535, University of Minnesota.

Fisher, B. S. (1979), 'The demand for meat – an example of an incomplete commodity demand system', *Australian Journal of Agricultural Economics* 23(3), 220–30.

Griffith, G. R. (1984), 'Economic considerations in evaluating alternative pig production technologies', *Commodity Bulletin* 13(4), 1–8, NSW Department of Agriculture.

—— (1987), 'The dynamic effects on the New South Wales pig industry of possible animal welfare regulations', Unpublished discussion paper, NSW Department of Agriculture.

—— and Burgess, D. M. N. (1983), *The Specification and Estimates of a Quarterly Econometric Model of the NSW Pig Industry: Progress Report*, Research Workpaper No. 1/83, NSW Department of Agriculture.

—— and Gellatly, C. (1982), *The Development and Testing of a Quarterly Econometric Model of the Australian Pig Industry*, Agricultural Economics Bulletin 36, NSW Department of Agriculture.

——, Smith, S. P. W. and Burgess, D. M. N. (1984), *The Animal Welfare Debate and Some Economic Implications for the Australian Pig Industry: A Review*, Miscellaneous Bulletin 46, NSW Department of Agriculture.

Gruen, F. H. (1967), *Long-term Projections of Agricultural Supply and Demand: Australia 1965 to 1980*, Monash University.

Harberger, A. C. (1971), 'Three basic postulates for applied welfare economics', *Journal of Economic Literature* 9, 785–97.

Johnston, B. G. (1981), 'Public and private interests in government funded research', Unpublished Ph.D. thesis, Australian National University, Canberra.

Lindner, R. K. and Jarrett, F. G. (1978), 'Supply shifts and the size of research benefits', *American Journal of Agricultural Economics* 60(1), 48–58.

—— and Jarrett, F. G. (1980), 'Supply shifts and the size of research benefits: reply', *American Journal of Agricultural Economics* 62(4), 841–4.

Neales, S. (1985), ''Welfare' farming might not be too bad', *National Farmer*, 7–20 March, pp. 64–5.

Papadopoulos, C. (1971), 'A model of the Australian meat market', Unpublished B.Ec. (Hons) thesis, University of Adelaide (original not seen).

Pender, R. W. and Erwood, V. (1970), 'Developments in the pig industry and factors in the Australian meat market affecting demand for pigmeat', *Quarterly Review of Agricultural Economics* 23(2), 19–34.

Petherick, C. and Baxter, S. (1982), 'Space requirements for pigs', *Pig Farming (Supplement)*, 93.

Richardson, R. A. and O'Connor, J. G. (1978), 'Changes in the structure of supply responses in the Australian pig industry', *Review of Marketing and Agricultural Economics* 46(3), 220–37.

Rogerson, J. C. and Wilcox, C. J. (1981), Submission by the Department of Agriculture, Victoria to the Industries Assistance Commission Inquiry on Preparations, Extracts and Juices of Meat, Melbourne.

Rose, R. N. (1980), 'Supply shifts and research benefits: comment', *American Journal of Agricultural Economics* 62(4), 834–7.

Sandiford, F. (1985), *An Economic Analysis of the Introduction of Legislation Governing the Welfare of Farm Animals*, Bulletin 201, Department of Agricultural Economics, University of Manchester, U.K.

Sybesma, W. (ed.) (1981), *The Welfare of Pigs*, Martinus Nijhoff, The Hague.

Turner, F. and Strak, J. (1981), 'Farm animal welfare: some economic considerations', *International Journal for the Study of Animal Problems* 2(1), 15–8.

—— and Strak, J. (1982), 'Economics and animal welfare', *Span* 25(3), 132.

Webster, A. J. F. (1982), 'The economics of farm animal welfare', *International Journal for the Study of Animal Problems* 3(4), 301–6.

West, C. (1980), A model of the Australian pig industry. Paper presented to the 24th Annual Conference of the Australian Agricultural Economics Society, Brisbane.

Wilcox, C. J. (1981), *Pigmeats Situation and Outlook, 1981*, Technical Report 46, Department of Agriculture, Victoria.

—— (1985), 'The costs of social regulation: theory and application to the Australian pig industry', Unpublished M.Ag.Sc. thesis, LaTrobe University.

Winfield, C. G. (1983), 'Welfare aspects of pig husbandry', in *Proceedings of the 2nd National Pig Production and Marketing Review Conference*, Standing Committee on Agriculture, Hobart.

Wright, G. (1985), Report to the Animal Production Committee by the Working Party on Pig Housing and Energy Conservation, unpublished.