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Estimating The Cost Of Food Safety Regulation To The New Zealand Seafood Industry[1]

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Abstract

In New Zealand, the Animal Products Act (1999) required all animal product processing businesses to have a Hazard Analysis and Critical Control Points (HACCP) based Risk Management Program (RMP) by the end of 2002. The purpose of the Act is to manage food safety risks and to facilitate overseas market access. However the new regulation will potentially bring costs to businesses. This paper attempts to measure the effects of RMP requirements on the variable cost of production of the New Zealand seafood industry. Using the framework developed by Antle (2000), a cost function is estimated using census of production data from 1929 to 1998. Results show that variable costs could increase from 2 percent to 22 percent or from 2 cents to 19 cents per kilogram.

Keywords: HACCP/RMP, compliance costs, seafood

Introduction

The Animal Products Act 1999, which came into force in November 2002, reformed the New Zealand law that regulates the production and processing of animal products. The purposes of this legislative change are to manage associated risks and to facilitate overseas market access. It is stated in Section 2 of the Act that the instituted measures will ensure that all traded animal products are fit for their intended purpose and that risks to human or animal health arising from the production and processing of animal material and products will be minimised. The new legislation will also facilitate the entry of animal material and products into overseas markets by providing the controls and mechanisms needed to safeguard official assurances for entry into those markets (NZFSA, 2002).

A core requirement of the Animal Products Act (1999) is that primary animal processing businesses must have a registered Risk Management Programme (RMP) by the end of 2002. As a RMP is based on the principles of HACCP, this requirement means that businesses are responsible for the design and development, evaluation, and registration of the RMP. They also have to assure that the RMP is operating as planned and achieving specified outcomes. A summary of business responsibilities regarding the implementation of RMP is provided in Table 1.

Table 1: Risk Management Programs

RMP Task	Responsibility	Description
Design & Development of RMP	Business Operator (hereinafter Operator). The Operator may also hire External Consultants to do this task	Designing all the components of RMP which are based on the 7 principles of HACCP
Validation of RMP	Operator	Required when RMP is first developed to verify that it complies with requirements and is capable of achieving its outcomes
Independent Evaluation of RMP	Operator must contract a MAF accredited evaluator	On-site assessment to recognise the validity of the developed RMP with the intent of recommending registration
Registration of RMP -Application for registration -Registration approval	 -Operator -MAF (NZFSA)	Business Operator to apply to the Director of Animal Products, NZFSA to register RMP
Operation of RMP -Specific operational duties (e.g. sampling/testing, record-keeping) -Ongoing verification activities -Independent verification -Application for amendments to RMP when there are major changes in the production process -Updates and notification of minor amendments to	 -Operator -Operator -Operator must contract an accredited verifier -Operator -Operator	Business operators in general are responsible for RMP operational tasks such as monitoring, testing or record-keeping. They are also in charge of ongoing verification activities such as internal audits or reviewing of monitoring records. When there are major changes in their production process (e.g changes that modify product outcomes), operators must apply for the approval of RMP amendments. Minor changes do not need to be registered.

RMP -Re-registration of RMP after 3 years	-Operator	
Cessation of RMP -Surrender of registration -Suspension of registration or Deregistration	-Operator -MAF (NZFSA)	RMP are terminated when the operation no longer exists or it is suspended by NZFSA due to dissatisfaction with APA requirements or deregistered due to failures.

Source: adapted from RMP Manual (MAF, 2000)

The Animal Products Act 1999 applies to all animal materials and products derived from animals that are traded and used in New Zealand or exported from New Zealand. Industries covered by the Act include the meat and seafood industry. The dairy industry is not included as it is covered under the Dairy Industry Act 1952.

The New Zealand seafood industry is a billion-dollar industry. Seafood exports in 2001 were worth a total of $1.4 billion (SeaFIC, 2002), which makes the industry the fourth largest export earner of the country. Having a robust food safety assurance system such as a HACCP-based RMP means that the industry can be confident it will be able to retain its overseas markets and gain access to some new ones. However, RMP will also bring extra costs to the production process.

This paper attempts to measure this increase in the production costs of the seafood industry due to the implementation of RMP. The study uses the econometric approach developed by Antle (2000) to measure the impacts of HACCP-based RMP on the variable costs of production. A recent study on the costs of food safety management in the New Zealand meat industry has shown that HACCP/RMP could affect the operating efficiency of plants by slowing down the production process and this effect could make a significant proportion in the total cost of HACCP/RMP implementation (Cao *et al*, 2002). The paper is constructed into three major parts. Part 1 reviews the recent literature on quantifying food safety compliance costs. Part 2 discusses the model used, data sources and the model estimation. Part 3 provides the estimates on cost of HACCP/RMP.

Review of Methods Used to Quantify Food Safety Costs

The literature on quantifying food safety compliance costs can be categorised into three different approaches: (1) accounting approach, (2) economic-engineering approach, and (3) econometric approach.

Accounting Approach

In the accounting approach, costs are identified and calculated, without estimating a parametric representation of the cost function. Examples of recent studies using the accounting method include: the study of the Food Safety Inspection Service (FSIS) on the costs of HACCP to the US meat and poultry industry (Crutchfield *et al*, 1997) and the study of Colatore and Caswell on costs of HACCP to the US breaded fish industry (Colatore and Caswell, 2000). The FSIS study provides an ex ante estimate on the cost of HACCP regulation in the US meat and poultry industry which ranges from US$1 to US$1.2 billion over 20 years. Their estimate would be higher if the cost of production process modification was included (Robert *et al*, 1996). Ex post estimates of food safety costs are often higher than ex ante estimates. For example, Colatore and Caswell (2000) have shown that the cost of implementing only the minimum HACCP requirements comprises only 30 percent of the actual costs companies incurred. The incremental cost attributable to the regulation was estimated to be 20 percent of total costs.

It has been argued that the accounting approach is unlikely to provide estimates of average costs for the whole industry due to the limited number of plants surveyed (Antle, 1999). Moreover, the accounting approach often underestimates costs, as the method is unable to measure effects of regulation on the overall operating efficiency of a plant.

Economic-Engineering Approach

The economic-engineering approach is described by Antle (1999) as a method using detailed engineering data combined with data on input costs to construct a quantitative model of the production process. This approach can provide a detailed picture of a plant's production process, but it is costly to implement for each plant studied. Therefore, it may fail to capture the heterogeneity of the industry and may not provide cost information that is representative for the industry. The study of Jensen and Unnevehr (2000) on the cost of implementing HACCP to the US pork industry provides an example of this approach. It estimated the cost of individual technologies based on data from input supply firms and drew estimates of pathogen reduction from selected meat science studies. The cost of individual interventions varies from 3 cents per carcass for a cold water wash to 20 cents per carcass for hot water pasteurization. The study also found that to reduce pathogens to very low levels, the highest cost combination of rinses and sprays would cost 47 cents per carcass.

Econometric Approach

With the econometric approach, production cost functions are estimated and the estimation results are then used to measure potential costs of regulation. Although the method cannot provide cost details as in the other two methods, its advantages are that the cost function can capture the actual production behaviour of the firm and provide a statistical basis to test for related hypotheses. Moreover, regulatory impacts on productive efficiency can be measured. Antle (2000) has provided a detail framework of using this approach to measure the cost of HACCP to the US meat and poultry industry. HACCP cost estimate ranges from $535 million to $4.8 billion, or an average of 1 cent to 9 cents per pound for all meats.

Model, data, and estimation of quality-adjusted cost function

Cao *et al* (2002), following Antle (2000), discussed the theoretical framework to estimate changes in variable costs of production due to the implementation of a food safety management programme like HACCP. A similar approach will be used in this paper. Firstly, an empirical cost function, which incorporates quality and safety variables as well as other traditional variables such as input prices and output quantity, is specified and then estimated. Secondly, based on the estimates of the cost function, elasticity of cost with respect to safety is calculated, which is subsequently used to estimate changes in costs.

Model

If we characterised the quality-differentiated product by the triplet (y,s,q), where y is output quantity (i.e tonnes of seafood), s is product safety (i.e the level of microbial contamination), and q is a vector of other non-safety quality attributes (e.g nutrition, value, package, process), then the variable cost function which depends on both product quantity and quality can be specified as: VC = f(y,s,q,w,k). Here, w is a vector of input prices and k is the value of capital stock.

Assuming input variables as consisting of labour (L) and other materials (M), the empirical cost function written in log-linear form, incorporating a time variable, can be specified as:

where

wM, wL are prices of materials and labour respectively, y is output quantity,

k is the value of capital stock at the beginning of the year,

t is a time variable, which captures change in technology overtime,

qman is a quality variable, which is defined as the ratio on non-production labour to production labour,

qmix is another quality variable, which measures the proportion of processed products in total output,

s is a safety variable, which is unobserved but can be estimated using other observable variables.

The cost share equation, derived using Shephard's Lemma[2], is specified as follows:

(2)

where

CL is the labour cost share.

Following Antle (2000), assuming firms are price-takers in a competitive market, a measure for product safety s can be derived and specified as: s = g(q,p,z,w,k).

Here, p is the unit price of the product, z is a vector of other demand variables. Using the same approach as that of Cao *et al* (2002), we use New Zealand income per capita as a demand variable for the estimation. Empirically, the safety function can be written in log-liner form as:

(3)

Substitute (3) into (1) and (2) we have a cost function and a cost share function that consist of all observed variables, namely, wM, wL, y, k, qman, qmix, z, p.

Data

Production data (wM, wL, y, k, qman, qmix,, p) were taken from New Zealand census of production for the seafood industry in the period from 1929 to 1998. Years with missing data are excluded, this leads to a total number of observations of 63. Deflators based on the Consumer Price Index were collected from the New Zealand Official Yearbook 2000. New Zealand per capita income for the period was taken from Maddison (1995) and the Penn World Table (Heston and Summers, 2002). A statistical summary of the variables is presented in Table 2.

Estimation

The translog cost function (1) and cost share equation (2) are estimated with the conditions for linear homogeneity[3] of the cost function imposed. A test for food safety exogeneity was also conducted. Safety exogeneity holds if food safety regulation does not affect productive efficiency and hence production cost of the seafood industry. For the cost function (1), safety exogeneity holds if and only if all safety coefficients are equal to zero ($\gamma S = \gamma Si$ (i = y, M, L, k, t) = 0). Our test results strongly reject this hypothesis (p = 0). Further estimation results are presented in Table 3.

Table 2. Statistical summary of variables (a)

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
wM	- (b)	470	536	67	1,645
wL	$ (1,000) (c)	14	8	6	31
y	T (1,000)	140	222	15	730
k	$ (1,000)	65,941	121,610	420	533,860
qman	-	0.26	0.075	0.09	0.60
qmix	-	0.76	0.11	0.44	0.96
p	$/T	790	844	61	3451
z	$ (d)	9,876	3,278	4,349	15,085
VC	$ (1,000)	120,950	211,430	957	727,460
CL	-	0.23	0.091	0.09	0.57

Note:

(a) All price variables are expressed in 1999 NZ$ unless stated otherwise,

(b) wM is measured by Producer Price Index, base year 1982 (PPI=1000)

(c) average annual salary

(d) income variable is measured in 1990 international dollars

Table 3. Estimation results (Standard errors in parentheses)

Coefficient	Estimate	Coefficient	Estimate
α0	2.75 (3.30)	βmant	-0.0035 (0.0061)
αL	-0.0079 (0.26)	δkk	-0.11 (0.075)
αLL	0.056 (0.031)	δkL	-0.039 (0.031)
βy	0.61 (0.82)	γS	1.27 (0.28)
βyy	-0.57 (0.35)	γSL	-0.089 (0.042)
βyL	0.0061 (0.075)	γsk	-0.045 (0.064)
βyk	-0.027 (0.14)	γsy	-0.17 (0.18)
βt	0.023 (0.069)	τM	-0.79 (0.11)
βtt	-0.00029 (0.00035)	τL	-0.43 (0.10)

βMt	0.0047 (0.0017)	τk	-0.97 (0.25)
βst	0.02 (0.0081)	τman	0.26 (0.35)
βLt	-0.0047 (0.0017)	τz	-0.20 (0.28)
βkt	0.011 (0.0085)	θmix	0.74 (0.50)
βyt	0.027 (0.011)	θman	-0.58 (0.57)

The interaction term of safety and labour price γsL is negative which means that a higher labour price lowers the marginal cost of safety. On the contrary, as γsM has an opposite sign from γsL, a higher material price leads to higher marginal cost of safety. These results are similar to those estimated by Cao *et al* (2002) for the meat industry. However, in the case of the seafood industry, the interaction term of safety and capital γsk is negative which means that increasing capital stock leads to decreasing marginal cost of safety. Also, γsy being negative means higher rates of production are associated with lower marginal cost of safety.

The interaction term of time and material βMt is positive which shows that, for seafood, technical change is material using. On the contrary, βLt is negative which implies that technical change is labour saving.

In order to estimate impacts of food safety regulation on variable cost, elasticity of cost with respect to safety is calculated. Mean elasticity is derived based on safety elasticity at each observation[4]. Results show that food safety cost elasticities lie in the range of 0.67 to 1.37, with a mean of 1.11. The fact that the mean safety cost elasticity is positive shows that costs of production rise as the safety level increases.

Cost of food safety regulation

To estimate the cost of food safety regulation, changes in variable cost of production due to food safety regulation such as HACCP are then calculated as follows:

$$\Delta VC = VC.E.e.(100-s)/s \qquad (4)$$

where

VC is variable cost of production

E is mean safety cost elasticity

e is the effectiveness of the regulation in enhancing food safety (or reducing microbial pathogen as in the case of HACCP) ($0 < e < 100$)

s is the level of product safety before the introduction of the new regulation, here s is defined as the percentage of negative outcomes when product is tested for microbial contamination in a unit of time ($0 < s \leq 100$)

The change in unit cost can be calculated as:

$$u = \Delta VC/y \qquad (5)$$

where

y is output volume

Food safety cost is estimated for three different scenarios where the base safety levels (s) are 50%, 70%, and 90% respectively. The observed values of the independent variables in equation (4) and (5) for each scenario are presented in Table 4 below.

Table 4. Variables for estimating food safety regulation (HACCP) cost

Scenario	VC(a) ($ 1000)	E	e(b) (%)	s (%)	y(c) (T)
1	120,950	1.11	20	50	140,360
2	120,950	1.11	20	70	140,360
3	120,950	1.11	20	90	140,360

Note:

(a) mean value of VC in 1999 dollars as in Table 2

(b) based on assumption on regulation effectiveness (Antle, 2000)

(c) mean value of y as in Table 2

Estimation results (Table 5) show that for a mean variable cost of about $120 million, the increase in variable cost due to regulation would be in the range of $3 million to $27 million (or 2.5% to 22.5% respectively), depending on the product safety level of the plant before regulation. The unit cost estimate is in the range of 2 cents to 19 cents per kilogram. Cost incurred decreases as plant base safety level increases. Plants with a good product safety record (s = 90%) bear the least change in unit cost (2 cents) (Scenario 3), while plants with a relatively worse safety record (s = 50%) bear the highest cost (19 cents) (Scenario 1).

Table 5. Increases in variable cost and unit cost for a 20% improvement in product safety (in 1999 dollars)

Scenario	Base safety level (s, percent)	Change in variable cost (ΔVC, $)	Change in unit cost (u, $/kg)
1	s = 50%	26,965,000	0.19
2	s = 70%	11,556,000	0.082
3	s = 90%	2,996,000	0.021

Conclusion

Using seafood census of production data from 1929 to 1998, we have estimated a model of quality-adjusted translog cost function for the New Zealand seafood industry. Estimation results are then used to estimate the increase in variable cost of production due to the implementation of HACCP/RMP. The elasticity of cost with respect to safety is estimated to be 1.11 for the study period. Hence, for a level of annual variable cost of about $120 million, the increase in variable cost is estimated to be in the range of $3 million to $27 million (2.5% to 22.5%). Cost per unit is estimated to be in the range of 2 cents to 19 cents per kilogram. Cao *et al* (2002) estimated changes in variable cost of production for the New Zealand meat industry due to HACCP/RMP to be from 5 cents to 48 cents per kilogram. The findings in this study show that food safety cost for the seafood industry is somewhat lower than the cost estimate for the meat industry. Further detailed analysis on industry production characteristics is needed to analyse this difference in food safety costs.

The increase in cost represents the impact of regulation on the operating efficiency of firms. It could be additional variable costs (i.e. labour and material costs) associated with the slowdown of the slaughtering line due to monitoring, sampling and testing. These costs constitute just a part of the total cost of regulation, which includes other items such as costs of HACCP/RMP plan design and new capital investment.

The study estimates costs of food safety regulation based on time series data. Similar estimations can be done for cross-sectional data or panel data. The advantages of cross-sectional data or panel data are that the effect of data aggregation is reduced and the impact on different firm sizes is revealed. However, a comprehensive survey of the industry is required in order to collect this type of data.

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[2] Shephard's Lema states that the private derivates of the cost function, with respect to the input prices, give the corresponding conditional input demand functions, which are the economically optimal input levels to produce the given output quantity ($\partial c/\partial w_i = x_i$). Apply this to the elasticity of cost w.r.t input price of the translog cost function yields the cost share equation (2). For more information, see for example, Coelli et al (1998).

[3] For the translog cost function to be homogeneous of degree one, the following restrictions need to be applied to the parameters: $\sum\beta_i=1$; $\sum\beta_{ij}=0$; $\sum\beta_{iy}=0$.

[4] Safety elasticity at each observation point $E=\gamma_s - \gamma_{sl}*\ln w_m + \gamma_s l*\ln w_l + \gamma_{sy}*\ln y + \gamma_{sk}*\ln k + \beta_{st}*t$

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