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# THE ECONOMICS OF HACCP (HAZARD ANALYSIS & CRITICAL CONTROL POINT): A LITERATURE REVIEW

**Kay Cao, Oswin Maurer, Frank Scrimgeour and Chris Drake**
Kay Cao, Department of Economics, Waikato University Management School, New Zealand. Email: kaycao@waikato.ac.nz
Oswin Maurer, School of Economics and Management, Free University of Bozen – Bolzano, Italy. Email: omaurer@unibz.it
Frank Scrimgeour, Department of Economics, Waikato University Management School, New Zealand. Email: scrim@waikato.ac.nz
Chris Dake, Systems Modelling, AgResearch Ltd, Ruakura Research Centre, New Zealand. Email:chris.dake@agresearch.co.nz

## Abstract

This paper focuses on important issues associated with the implementation of HACCP regulation and provides an overview on recent literature published on the economic effects of food safety regulation and HACCP implementation that maybe of relevant for food safety regulation and implementation in a New Zealand context. The structure of the paper follows four groupings of issues as identified in the international literature as being of relevant in the assessment of economics effects of food safety regulation: (1) HACCP as a food safety regulation; (2) HACCP as a business management tool; (3) HACCP as an international trade standard; and (4) the impacts of HACCP on welfare distribution and market structure. The paper concludes with some implications for future research.

## 1. Introduction

HACCP or Hazard Analysis and Critical Control Point is a systematic approach to the identification, evaluation, and control of food safety hazards (National Advisory Committee on Microbiological Criteria for Foods (NACMCF), 1997). The approach was first started in 1959 with the Pillsbury Company's manufacture of food products for the NASA space program (Peirson, 1995). Since then, HACCP has been strongly suggested as an effective approach to prevent food safety hazards by many national and international scientific groups, corporations, government agencies and academic organizations (Peirson, 1995). The joint FAO/WHO Codex Alimentarius Commission endorsed HACCP in 1993.

HACCP has been and being mandated into law in many nations all over the world. In the EU, HACCP was adopted through the Directive 93/43 in 1993 (Ziggers, 2000). In the US, HACCP was mandated for seafood in 1995, for meat and poultry in 1998, and for the juice industry in 2001 (FDA, 2001). The Australian Food Standard Code required HACCP-based food safety programs from January 2003 onwards (Food Standards Australia New Zealand, 2002). In New Zealand, the Animal Products Act 1999 requires all primary animal product processing businesses to have a HACCP-based risk management program in place by November 2002 (MAF, 2002).

The concept of HACCP is actually to focus on preventing hazards that could cause foodborn illnesses by applying science-based controls, from raw materials to finished products. It involves seven principles:

1. A hazard analysis, which involves collecting and evaluating information on hazards associated with the food under consideration to decide the significant hazards to be addressed in the HACCP plan.
2. Determination of critical control points (CCPs), which are steps where controls can be applied and are essential to prevent or eliminate or reduce a hazard to an acceptable level.
3. Establishing critical limits, which are maximum/minimum values to which a biological, chemical, or physical parameter must be controlled at a CCP.
4. Establishing monitoring procedures to assess whether a CCP is under control and to create an accurate record for future use in verification.
5. Establishing corrective actions, in case there is a deviation from an established critical limit.
6. Establishing verification procedures to verify that the HACCP system is working correctly.
7. Establishing record-keeping and documentation procedures to document the HACCP system.

Each food processing establishment is required to have its own HACCP plan tailored to its individual products. Moreover, there are required prerequisite programs prior to the implementation of HACCP. Prerequisite programs such as Good Manufacturing Practices are an essential foundation for the success of a HACCP plan (NACMCF, 1997).

As HACCP is increasingly used as food safety assurance program, concerns have been put forward about its effectiveness in enhancing food safety as well as on the impacts it may have on food markets, industry, and consumers. The purpose of this paper is to discuss issues associated with the adoption of HACCP and its impacts, which include: (1) HACCP as food safety regulation; (2) benefits and costs of HACCP; (3) impacts on market structure and in the distribution of regulation costs; and (4) HACCP as an international trade standard. The paper concludes with some implications for future research.

## 2. HACCP as a food safety regulation

Government intervention in the food market is justified by the lack and high cost of information associated with food safety and the resulting consequences for public health (Unnevehr and Jensen, 1996). There are alternative interventions ranging from consumer education, mandatory labelling to statutory regulation, or even ex post regulation such as the liability system. Consumer education on safe food handling depends on consumer's ability to make choices and their control over food safety (food at home vs. food away from home). Liability systems depend on the ability to trace back the source of problems.

Statutory regulation is arguably a preferred approach. Statutory regulation is implemented in the form of either process standards or performance standards. A process standard specifies the technology or procedures a firm must follow in production while a performance standard imposes requirements on the final product. Process standards do not allow firms to choose an efficient production technology and are therefore believed to be less efficient than performance standards. However, performance standards involve end product testing, which may be very costly as, for example, in the case of microbiological tests of meat products. This explains why HACCP is widely preferred as a process design to prevent food safety hazards. Moreover, HACCP also permits more efficient and effective government oversight (FDA, 2001). Thus, HACCP could be an efficient regulatory tool regardless of being a command-and-control process standard (Unnevehr and Jensen, 1996).

### 2.1. Is HACCP a cost-effective approach to food safety hazards?

There have been several studies on the benefits and costs of HACCP regulation (Crutchfield et al, 1997). In general, HACCP benefits to society are reductions in risks of morbidity and mortality associated with consuming unsafe foods (Antle, 1999). Costs associated with these risks are costs of treating foodborn illnesses, forgone income due to lost work time, costs of averting illnesses; and disutility of illnesses. Enhancing food safety would result in reductions of these costs and hence benefit society. Costs of HACCP are: (1) costs of implementation; and (2) costs of HACCP maintenance. Examples of costs of implementation are costs of HACCP planning and training employees, maintenance costs are costs of monitoring, sampling and testing, and costs associated with process modification.

The Food Safety Inspection Service (FSIS) of the US Department of Agriculture (USDA) used the cost-of-illness method to estimate the benefits of HACCP regulation for meat and poultry. The present value of medical costs and productivity losses due to foodborn illnesses associated with seven main pathogens is estimated to be in the range of US$1.9 to US$171.8 billion over 20 years (Crutchfield et al, 1997). The lower bound was estimated with 7% discount rate, 20% reduction in illnesses, and using a lower value of a statistical life. The upper bound was associated with 3% discount rate, 90% reduction in illnesses, and a higher value of life. The cost-of-illness approach is said to provide the lower-bound estimate of HACCP benefits as consumers would be willing to pay for risk reduction even if they are not actually ill (Unnevehr, 1996). FSIS also estimated the costs of HACCP to range from US$1 to US$1.2 billion over 20 years (Roberts et al, 1996). Therefore FSIS concluded that HACCP results in positive net benefits in all scenarios (Crutchfield et al, 1997).

The study of FSIS, however, has received some criticisms. Firstly, FSIS's estimated costs are criticized as being underestimated. Robert et al (1996) voice skepticisms about the low cost estimated by FSIS and argue that this maybe due to the lack of data on process modification. Belzer (2000) also remarks that the estimate, based on a sample of 9 establishments, maybe too small to represent the industry as a whole. Colatore and Caswell (2000) performed an ex post estimate of the costs of HACCP in the breaded fish industry, and concluded that ex ante estimates are usually underestimated due to the diversity of HACCP applications. The study of Antle (2000) provides an estimate of the increase in variable cost of production, which ranges from $535 million to $4.8 billion, with the upper limit being four times as high as the FSIS estimate. However, Antle's study includes costs not captured in a normal accounting approach. Secondly, FSIS's estimate of HACCP benefits was based on debatable assumptions of HACCP effectiveness and the positive relationship between pathogen reduction and illness reduction. Further scientifically based research about these relationships is required to actually prove a strong correlation between both factors as assumed by FSIS.

Whether or not HACCP brings net benefits still remains a unanswered question. As the cost-of-illness approach just provides a lower-bound estimate, benefits of reducing food safety risks are considered potentially much higher (Unnevehr and Jensen, 1996). However, studies concerning the impacts of HACCP on food markets, industry structure, and distributional impacts are just emerging. This implies that careful consideration must be taken in measuring the benefits and costs of HACCP. As noted by Antle (2001), a short-run and static analysis could lead to misleading results.

### 2.2 Private incentives to adopt HACCP

It is important to note the motivation of firms adopting HACCP. Some researchers argue that the costs of HACCP regulation could be reduced if firms, due to some private incentives, adopt HACCP in the absence of a regulation (Martin and Anderson, 2000).

There are several factors which motivate firms to adopt a quality management system such as HACCP. According to Holleran et al (1999), these factors could be grouped into internal and external factors. Internal factors include improving product quality and shelf life, reducing

product failure and wastage, or improving control of production process. External factors are customer requirements, the objective to gain market share, or the threat of regulatory requirements.

A study of HACCP adoption in the UK dairy industry shows that firms are adopting HACCP in order to meet customer requirements and legal requirements, and to gain improvements in operating efficiency (Henson et al, 2000). It is also argued that firms have incentives in reducing sanitary deficiencies due to the threat of huge costs and loss of reputation incurring from the sale of contaminated products (Ollinger, 2000). In the event of an outbreak of a food safety related illness, firms may consider not just losses in sales, but also costs associated with tort liability, fines, potential future supply restrictions and stricter future government regulation (Worth, 2000).

## 3. HACCP as a business management tool

HACCP as a process design also functions as a management tool (Mazzocco, 1996; Cato, 2000). As a process control tool, HACCP is part of a total quality management system which generates benefits for firms, if properly implemented. These benefits include improvements in operational efficiency, reduction of transaction costs, and the creation of competitive advantage (Caswell et al, 1998; Bredahl et al., 2001; Farina and Reardon, 2000).

An efficiency analysis of HACCP conducted by Nganje and Mazzocco (2000) for the (US) meat industry concluded that: (1) firms have lower marginal costs compared with their marginal cost prior to HACCP implementation; (2) firms without HACCP systems are less cost efficient than firms with HACCP systems; and (3) firms with HACCP systems have greater technical efficiency than firms without HACCP systems. They argue that HACCP can improve allocative and technical efficiency by reducing product reworks and inefficiency in the use of inputs. Henson et al (2000) in their study of HACCP adoption in the UK dairy industry also report similar benefits such as the reduction in wastage, increases in product shelf life, and decreases in production costs.

The implementation of HACCP systems can also help to reduce the costs of searching for competent suppliers, thus reduce transaction costs. Transaction costs are costs of undertaking an exchange between customers (buyers) and suppliers (sellers) (Holleran et al., 1999). Transaction costs include items such as costs of supplier identification, contract negotiation, contract verification and contract enforcement. As Mazzocco (1996) points out, HACCP systems enable supplier firms to reduce costs of raw materials inspection, specification, inventory, and other costs associated with inputs. This phenomena of 'downstream costs, upstream benefits' has recently become an issue associated with food safety requirements.

It is also argued that transmitting HACCP system requirements to consumers or suppliers can also reduce costs of marketing and sales costs (Cato, 2000; Mazzocco, 1996). By adopting a food quality/food safety management system like HACCP and being able to signal it to consumers, firms can prevent the problem of imperfect information at the buyer side and hence enjoy a premium for their products. HACCP therefore can bring marketing advantage. The use of HACCP as a marketing tool is also reported in Bungay (1999),showing that Canadian HACCP-registered food businesses have requested permission to use HACCP in advertising materials, labeling claims, and promotional materials. HACCP may also bring competitive advantages. Potential gains in international markets are discussed in the next section.

## 4. HACCP as an international trade standard

Over recent years, traditional trade barriers such as tariffs have been reduced significantly through bilateral and multilateral trade agreements. However, non-tariff barriers have proliferated. Food safety regulations, intentionally or unintentionally, act as non-tariff barriers to trade, and studies have shown that food safety measures account for a significant portion of technical barriers to trade of agricultural and food products (Crutchfield et al., 2000). Also, differences in particular food safety measures adopted by countries have distorting effects on trade. These differences are results of the dissimilarities in countries' perceptions of food safety risks which in turn depend on many factors such as perception of science and risk assessments, knowledge and access to food technologies, and past experiences with food safety incidents (Buzby, 2001; Crutchfield et al., 2000).

Attempts to manage these differences in food safety regulations are generally termed rapprochement efforts. Strategies for rapprochement can be grouped into three categories: (1) harmonization, (2) mutual recognition, and (3) coordination (Hooker and Caswell, 1996; Henson and Caswell, 1999; Hooker, 1999). Harmonization involves the standardization of regulations in identical forms, with harmonization being the strongest effort. The bilateral agreement between Australia and New Zealand managed by the Australia New Zealand Food Authority (ANZFA) is cited by Hooker (1999) as one of this type. Mutual recognition involves the acceptance of regulatory diversity in order to meet common goals or equivalency. A recent example is the rapprochement effort of the European Union (Hooker and Caswell, 1996). In contrast, coordination aims to gradually narrow the differences between regulatory systems, often based on voluntary international codes of practice. Examples of this type include those trade agreements of North American Free Trade Agreement (NAFTA) and World Trade Organization (WTO).

It is argued that the growing international use of HACCP can facilitate trade of food products once countries have adopted similar food safety assurance system (Caswell and Hooker, 1996). However, the degree to which HACCP could facilitate trade depends on the coordination efforts of nations. In other words, countries need to reconcile the differences in their HACCP regimes.

The flexibility of HACCP is a challenge to this harmonization task. HACCP is said to be a combination of performance and process standards (Antle, 1999; Unnevehr and Jensen, 1999). It certainly is a performance standard if governments require its implementation, but do not specify its details (Cato, 2000; Caswell and Hooker, 1996). On the other hand, it is a process standard if the details of implementation are specified. Hence it is obvious that HACCP as a performance standard can facilitate trade better than HACCP as a process standard.

Harmonizing HACCP regimes also require the reconciliation of differences in prerequisite requirements. According to NACMCF (1997), prerequisite programs are the foundations for an effective HACCP implementation. These programs often cover in detail the requirements of the environment for the production process regarding product quality and safety. Examples are Standard Sanitary Operating Procedures (SSOPs) and Good Manufacturing Practices (GMPs). Caswell and Hooker (1996) argue that prerequisite programs alone already create non-tariff barriers to trade, quoting as an example the differences in prerequisite programs between the Canadian and the US HACCP regimes.

In practice, there have been different degrees of HACCP rapprochement, with the EU has the strongest level of HACCP rapprochement, where HACCP-based regulatory regimes have been hamonised across countries through EU Directive 93/43 (Caswell and Hooker, 1996; Ziggers, 2000). WTO and North American approaches to rapprochement for HACCP are much weaker forms of coordination. The WTO encourages member countries to adopt the Codex HACCP standards. However, Codex HACCP is just a set of minimum HACCP principles and does not provide detailed guidance on how it should be implemented (Caswell and Hooker, 1996). As a matter of fact, countries usually implement programs which are stricter than Codex HACCP standards.

Once HACCP and prerequisite programs are coordinated, trade can be facilitated. Some recent studies have focused on the impacts of HACCP adoption on gains in trade (Zaibet, 2000; Alpay et al, 2001). Zaibet (2000) analyses the relationship between compliance to HACCP and the competitiveness of Oman fish processing industry, using an export model, in which firm export penetration index (measured as the proportion of export volume in total production) is a function of the status of HACCP adoption, sanitation requirement, labor (number of employees), and capital stock. Results of this study found a positive impact of HACCP adoption has on export performance.

Alpay et al (2001) studied the impacts of HACCP and other quality control systems on the export performance of Turkish food processing firms. Export value is specified as a function of the compliance with quality and safety standards, HACCP adoption levels, the compliance with environmental standards, the degree of vertical integration, and firm experience in the export markets. Although using a different approach than Zaibet (2000), the study also reveals a positive relationship between HACCP adoption and export performance.

## 5. Impacts on market structure and distributional impacts

It has been argued that small food processing plants may bear higher HACCP cost per output unit than large plants, given their smaller production scale (Unnevehr, 1996; Roberts et al, 1996). Hence, there are concerns that HACCP regulation would lead to small plants reducing their throughput or even to make them exit the market (Siebert et al, 2000; Muth et al, 2001). Using plant level data of firms under federal inspection, the study of Muth et al (2001) compares the rate of plant entry and exit prior to and during the implementation of HACCP regulation (1996-2000). It is found that the rates of exit of meat slaughtering plants increased substantially during HACCP implementation, with particular effects on very small meat slaughtering plants* (from 12.5% to 20%). Through interviewing industry representatives and HACCP experts, the study found that small slaughtering plants in fact made fewer changes to their production process than large plants. However, the authors argue that even if per unit costs are less for small plants, they may still exit at a faster rate than larger firms due to lack of expertise in HACCP implementation or because of revenues decreasing in a way that those businesses were no longer profitable. Small businesses generally have to cut down on the number of their products, especially on those that fetch a price premium in the market. The loss of higher product specialty, seasonal and ethnic product assortments significantly reduces the profitability of smaller firms. The study also examines the factors contributing to the probability of a plant exiting the market during HACCP implementation. Using a probit model, in which the probability of plant exit is a function of plant characteristics (e.g slaughter volume, plant age, HACCP size), company characteristics (e.g number of plants), regional characteristics (e.g entry rate), and supply conditions (e.g wage rate, cattle price), the study reveals that HACCP size designation does considerably affect the probability of exit, with small plants 55% more likely to exit than large plants. The study concludes that policy interventions should be used to help alleviating the economic effects of HACCP implementation, especially for those plants with a higher probability of exit.

Siebert et al (2000) studied the impacts of HACCP upon small and very small meat processors. Three models were constructed, with the first model being concerned with the factors that affect the level of HACCP implementation costs (e.g plant size, process complexity). The second model considers the probability of HACCP leading to products being withdrawn, with the third model taking into account the number of products withdrawn due to HACCP implementation. The study found that: (1) implementation costs are significantly related to the addition of new facilities, custom exempt status, and the starting date of required implementation; (2) the probability of product withdrawal is affected by the addition of new facility and staff due to HACCP and the require starting date; (3) the number of product withdrawal is also related to the building or expansion of facilities due to HACCP and the number of items within a sales mix.

### Distributional impacts

It is argued that the welfare distribution of regulatory costs is also an important issue as it may affect future industry structure (Unnevehr et al, 1998). This secondary impact is usually not included in regulatory impact assessments and is therefore of some concern to food safety economists (Unnevehr et al, 1998; Goodwin and Shiptsova, 2000).

Unnevehr et al (1998) argue that production cost rises due to regulations would lead to the supply curve shifting upward, thus increasing product price. Higher prices in turn would lead to substitution effects among products. For example, higher beef prices would lead to consumers shifting to other meat products such as pork and poultry or other non-meat products, with this adjustment leading to a new equilibrium in meat markets. To measure changes in producer welfare Unnevehr et al (1998) employed a multi-market model, comparing the initial with the final equilibrium. The study found significant producer welfare losses due to HACCP regulation. Due to substitution

effects among meat products, total meat producer welfare losses account for US$72 to US$733 million per year. Estimated losses for individual industries are at US$5 to US$52 million for poultry, US$24 to US$263 million for pork, and US$40 to US$426 million for beef producers, respectively. Without substitution effects among meat products, producer welfare losses are even higher, with total losses estimated to be in the rage of $95 to $748 million. Poultry producers incur the lowest losses as demand elasticity estimates show that consumers are in favour of poultry when beef prices increase. The authors concluded that substantial producer welfare losses occur as product prices increase due to food safety regulation. Interestingly, in the case of the meat industry, these losses tend to be reduced with substitution effects among meat products, which implies that the structure of demand has a significant influence on actual market outcomes following regulation. Additionally, there will also be consumer welfare losses as price increases, but according to Unnevehr et al (1998) these losses are insignificant compared to the benefits gained by reducing food safety risk.

Goodwin and Shiptsova (2000) studied producer welfare losses in the poultry industry due to HACCP regulation. Although using a similar framework as Unnevehr et al (1998), this study utilized ex post estimates of HACCP costs. The study also found significant producer welfare losses, which range from US$4 to US$23 million without taking substitution effects to poultry products into account, and from US$31 to US$63 million per year if demand substitution is accounted for. Consumer welfare losses were estimated between US$49 to US$73 million with substitution effects, and from US$79 to US$93 million without substitution effects.

## 6. Conclusion

The study discusses issues associated with the implementation of HACCP as a food safety management system. Overall, HACCP brings benefits to society by reducing costs associated with food safety risks, but also imposes additional costs on the food industry. HACCP could also function as a business management tool and has a positive influence on firm export performance. Moreover, in the long term, HACCP could affect market structure and reduce producer surplus. As HACCP has just been introduced into the New Zealand food legislation system, the time seems to be right for a benefit-cost analysis of the system. This could be done for each individual industry which is required to have HACCP in place by the end of 2002. However, ongoing and future research into the economic effects of HACCP implementation in the food industry should consider:

1. The benefits of HACCP as the reduction in costs associated with health risk;
2. The costs of HACCP, which include implementation costs, maintenance costs, and the impacts on productive efficiency;
3. The gain in export values and market share due to the adoption of HACCP; and
4. The welfare impacts on producers, on different firm sizes and the changes in market structure that are due to HACCP implementation.

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*less than 10 employees or less than $2.5 million in sales. Small plants are those with 10 to 500 employees. Large plants are those with more than 500 employees.

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Maintainer: Nanette Esparon, Agriculture and Food Systems
Email: webmaster@landfood.unimelb.edu.au