# RISK PERCEPTIONS, IMPORTANCE RANKINGS AND A CONTINGENCY VALUATION ANALYSIS: RESULTS FROM A SURVEY OF QUEBEC PRODUCERS ON FARM ENVIRONMENTAL MANAGEMENT

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## ABSTRACT

This research studied Quebec producers' environmental attitudes and perceptions on environmentally friendly practices on farm, such as an environmental management system (EMS), using a survey. The contingency valuation method (CVM) was applied to elicit producers' mean willingness to accept compensation (WTA) of adopting an EMS on farm, in terms of the percentage of direct costs of implementation. Factors affecting the mean WTA were studied to examine their influences. The results show that Quebec producers adopt environmental practices extensively and face many challenges in agro-environmental management. The results also show that producers have mixed perceptions in the benefits and difficulties of environmentally friendly practices and a negative attitude towards environmental regulations. The mean WTA of Quebec producers is estimated at 79.73%. French speaking and English speaking farmers have the mean WTA of 79.91% and 71.75%, respectively. The regression analysis identifies that producers' knowledge level on EMS, their attitudes towards the benefits and difficulties, internet access and the use of a computer in farm management are significant variables with respect to the mean WTA.

**Résumé**

Cette recherche a pour but l'étude de la perception et l'attitude des producteurs agricoles du Québec sur les pratiques culturales respectueuses de l'environnement tel que le système de la gestion environnementale (SGE) à partir d'un sondage. La méthode l'evaluation contingente est utilisée afin de mesurer la volonté d'accepté la compensation (VAC) d'adopter le systeme de gestion environnementale au sein de l'entreprise en terme de pourcentage de coûts directs d'adoption comme compensation. Dans cette recherche, les facteurs influençant la moyenne de la VAC seront étudiés. Les résultats de l'analyse montrent que bon nombre de producteurs québécois adoptent déjà les pratiques respectueuses de l'environnement et font face à de nombreux défis en gestion agro-environnementale. Ces résultats montrent également que les producteurs confondent leur perception concernant les avantages et les difficultés des pratiques culturales respectueuses de l'environnement et une attitude peu négative envers les lois environnementales. La moyenne de la VAC des agriculteurs québécois est estimé à 79,73%. Les agriculteurs francophones démontre une VAC de 79,91% alors que celui des agriculteurs anglophones est de 71,75%, respectivement. D'après cette étude, le niveau de connaissance des agriculteurs sur le SGE, leurs attitudes envers les avantages et difficultés, l'accès à l'internet et l'usage d'un ordinateur dans la gestion de l'entreprise sont des facteurs significatifs qui influencent la moyenne de la VAC.

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**To my family**

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# CHAPTER 1 INTRODUCTION

## 1.1 Overview

With population growth, changing demands for agricultural products and technology development, modern agriculture is becoming more specialized and intensive in production, accompanied by over-use of chemical fertilizers and pesticides as well as inadequate storage and handling of animal wastes (AAFC, 1995). These problems result in an imbalance in the ecosystem, causing environmental pollution and degradation in soil, water, air and bio-diversity and threats to food safety and production potential as well as rural development. The hog industry in Quebec is a typical case of intensive feeding operations that generate sources of air pollution and water contamination (Desroches et al, 2000). Moreover, international agricultural trade may create environmental barriers for exports, along with the reduction of traditional tariffs or non-tariff barriers based on the General Agreement on Tariffs and Trade (GATT) and trade negotiations (Morton, 2001).

These problems have raised public concern and brought new challenges in agro-environmental and agricultural development. Strict environmental regulations and sound environmental management are required for sustainable agriculture in order to combine environmental requirements into agricultural practices to guarantee the agricultural needs of the current generation without compromising the endowments of the future. Progress and realization of sustainability at the farm level depend upon systematic farm practices in implementing, monitoring and improving the agro-environment.

An Environmental Management System (EMS) on farm fulfills the needs of building a sustainable agriculture sector, including a systematic and continuous cycle of planning, implementation, review and improvement with commitments to increase environmental performance over time as a voluntary compliance with environmental regulations. An EMS is also a necessary step towards ISO 14000 certification, the international standard of environmental management, which recognizes farmers' commitment to environmentally sound efficient practices.

ISO oriented EMSs have been adopted in 90 countries since the early 1990s. In the agricultural sector, farmers can achieve benefits of value-added products, improved competitiveness and more access to global markets through successful implementation and certification, besides better environmental stewardship. In Canada, a number of EMS programs have been established through governmental supports and producer organizations, such as the Ontario Environmental Farm Plan (EFP) (Wall, 1997).

The Quebec government also encourages its farmers to implement EMS for the control of agricultural pollution. However, regulations are mainly focusing on the livestock sectors (Canadian Pork Council, 2002). Since environmental problems are essentially interconnected and comprehensive, broad applications of an EMS should be established within all agricultural sectors. EMSs vary in form in different regions according to agricultural conditions and farmers' needs and rely on farmers' voluntary compliance, which is based on farmers' perception of priorities of environmental risks and production (Schulman et al, 2000). Furthermore, differences in culture and attitudes may lead to various perceptions of the environment (Salamon, 1992; Dennis et al, 1996). Since Quebec has different regions in terms of its geographical, agricultural and cultural environments, it is essential to initiate a comprehensive study of Quebec farmers' attitudes concerning the agro-environment and environmental management in order to promote EMSs in the province.

Previous work by Baker et al (1999) on a small number of farmers in Quebec found that the cost of establishing an operational EMS is the biggest barrier to adoption. Thus, it is necessary to estimate farmers' perceived costs to establish EMSs through a broad survey. The elicited costs of an EMS can be used for policy development. The possible differences in the estimated costs based on production type and farm size suggests that a stratified sample of farmers should be selected for an accurate study (Baker, 2001).

## 1.2 Problem statement

This study focuses on the producer aspect of the study: "Environmental Risk Perceptions of Agricultural Producers and Consumers in Quebec", funded by Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ). It is designed to provide information on Quebec farmers' attitudes on the environment. It also aims to determine the farmers' willingness to accept compensation (WTA) to develop an EMS on their farms.

## 1.3 Objectives:

This study is designed to determine what factors affect Quebec farmers' perceptions to environmental risks through a survey. It pursues four sub-objectives as follows:

(1) Identifying and ranking environmental risks of Quebec farmers;

(2) Analyzing and summarizing barriers for farmers' to the implementation of EMSs;

(3) Analyzing and summarizing possible benefits of EMSs for farmers;

(4) Determining farmers' WTA to implement an EMS.

## 1.4 Hypothesis:

Based on previous studies (Baker et al, 1999), it was hypothesized that farmers' perceptions of environmental risk and WTP/WTA will be positively related to characteristics such as income and education levels and vary by commodity type, and region.

## 1.5 The scope of the Study:

The scope of the study includes a mail survey to 4,500 farmers across Quebec. The names and the addresses were randomly selected by MAPAQ, and were divided throughout the 17 agricultural regions and 4 main categories of production in Quebec: dairy, hog, cereal and others products.

## 1.6 The structure of the thesis

The remaining chapters of this thesis follow the structure of a literature review, method of analysis, results of the survey and conclusions. In Chapter 2, a literature review is carried out for four aspects related to EMS and ISO 14000: agro-environmental challenges in Quebec, holistic agro-environmental management, the analysis of EMS and ISO 14000 and the contingency valuation method (CVM). These sections provide the background to agro-environmental problems in Quebec, possible solutions as well as characteristics, and costs and benefits of EMSs. The development, implementation and mechanism of the CVM are also studied in order to lay the theoretical foundation to value EMSs in this survey.

Chapter 3 outlines the method of analyses used in this study. It is divided into three parts: survey development, specification and the analytical model. These parts provide the framework of the survey and sample design, implementation, the choice of survey instrument as well as the model design, variable choice and hypothesis.

Chapter 4 presents the statistical results of the survey, including the representativeness of the survey, the lists and comparisons of information on demography, farm operations and environmental attitudes. The results of the regression models and the mean WTA to adopt an EMS on farm are also presented and compared in accordance with the hypothesis.

Chapter 5 provides the conclusions of this study. This includes a summary of results, implications for policy development, as well as the limitations of the study and possible future research.

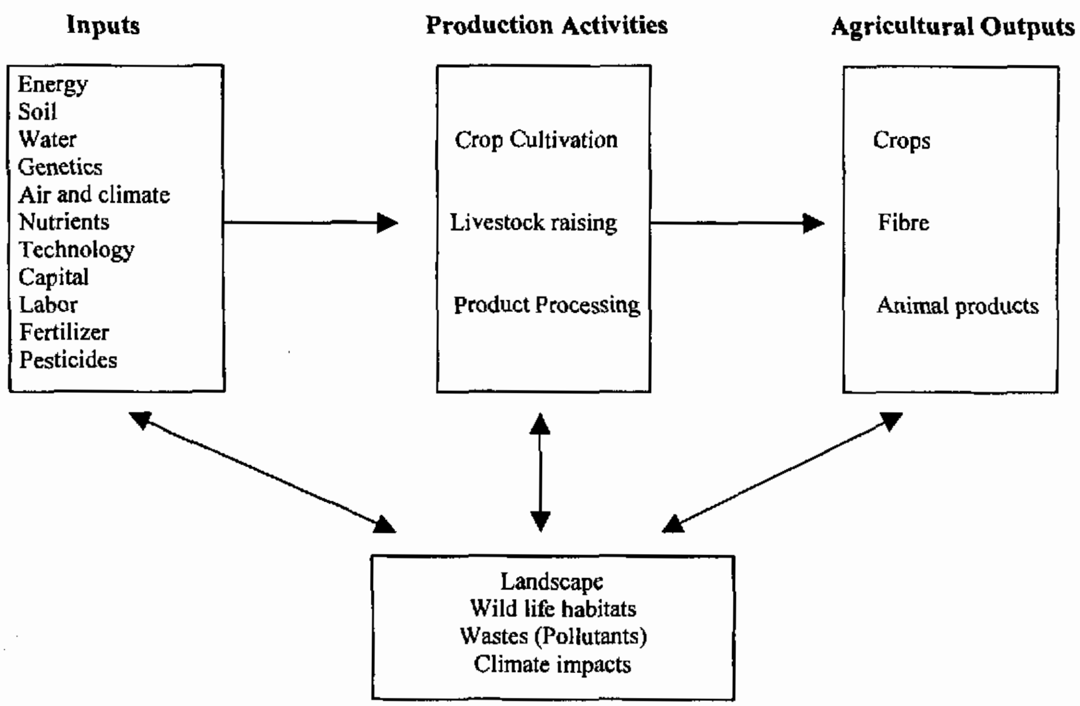
# CHAPTER 2 LITERATURE REVIEW

## 2.1 Environmental challenges in Quebec Agriculture

### 2.1.1 The interactions between agriculture, environment and society

Agriculture, as one of the main natural resource-based industries, is the major source of food and fibre products for human beings. Agricultural activities integrate inputs of crop seeds, soil, water, natural nutrients and solar radiation to create outputs, while interacting with the environment in the farming process. A conceptual cycle of input-output and related environmental impacts in agricultural production is shown in Figure 2.1.

**Figure 2.1 A conceptual cycle of agricultural production and environmental impacts (adapted from AAFC, 2000, P9)**



In the input stage, agricultural production integrates different natural resources with human inputs such as labour, capital, pesticides and fertilizer. In the stage of production, different inputs are applied to cultivate crops and livestock. Finally, in the output stage, mature crops and animal products are harvested or processed. In the meantime, agricultural practices interact with the environment, with solar energy being transformed into nutrients and inputs transformed into end products. While agriculture can enhance the environment, e.g. creating wildlife habitats and sequestering greenhouse gases (GHG) through carbon sinks, it raises more concerns from negative environmental impacts (AAFC, 2000).

The overexploitation of soil and water in crop cultivation may change their properties and availability. Crop and livestock production can reduce wildlife habitats and affect the landscape. The overuse of fertilizers, pesticides and animal wastes can create a nutrient imbalance that results in a contamination of soil and water. Furthermore, these problems are often interrelated and worsen the environmental impacts through intensive farming. For instance, over-tillage can cause soil erosion and fertility loss, which also increase the possibility of runoff and water pollution. These environmental impacts disturb the dynamics in the cycle of natural resources and energy, cause degradation in the ecosystem, reduce production potential of agriculture, as well as threaten human safety and the sustainability of agriculture.

In addition, agriculture and the agro-environment have impacts on society. Besides the primary needs of agricultural products in society, suppliers deal with farmers in business, rural communities live in the agro-environment and the general public is often exposed to the agro-environment through visits, purchases of agricultural goods, and potential effects from agriculture, such as livestock odour and water contamination. Conversely, social behavior can also influence agriculture and the agro-environment. Demands for agricultural products affect supply and production as well as the agro-environment accordingly. The increase in non-farm population may also contribute to changes in the rural society and its relationship with the agro-environment.

### 2.1.2 Environmental concerns in Quebec agriculture

Quebec has an agricultural area of 3,500,000 hectares, covering three eco-zones: Mixed Wood Plains, Boreal Shield and Atlantic Maritime, with the main agricultural areas being in the St. Lawrence Lowlands in the Mixed Wood Plains (Quebec Government, 2003). Agricultural production in Quebec is mainly in forage, livestock and cash crops, e.g. corn, cereals and vegetables. Livestock production is the most important activity in the province. AAFC (2000) estimated that dairy and hog production accounted for 30.5% of the cattle number and 31% of the revenue in the Canadian industry in 1996, both of which were the highest among provinces. Quebec produced 17% of the total primary agriculture GDP on only 5.1% of agricultural land in Canada (AAFC, 2000). Intensification, specialization and concentration are significant features of agricultural production in Quebec, because of the limited amount of the arable land and increasing competition with urbanization.

Intensive production increases environmental risks, including air pollution, soil erosion, water contamination and loss of biodiversity (AAFC, 2000). Compared with dust problems in the Prairie Provinces, air pollution is primarily associated with livestock and manure odour in Quebec agriculture (Baker et al, 1999). Soil erosion is fairly severe in Quebec due to over-tillage and mono-cropping practices in addition to natural patterns of soil dryness, precipitation, exposed area and wind speeds (Tabi et al, 1990). AAFC (2000) showed that 88% and 75% of the cropland suffered from water and tillage erosion at the tolerable or serious risk level in Quebec in 1996, respectively. This was higher than the national averages. Soil erosion can result in a reduction of productivity and capacity to absorb carbon, as well as losses of organic matter (AAFC, 2001).

Water contamination and nutrient imbalance in soil are predominant concerns in Quebec agriculture from overuse of chemical fertilizers and pesticides in crop cultivation and animal wastes from intensive livestock production. In 1996 the areas treated with commercial fertilizer and herbicides reached 985,181 hectares and 557,796 hectares respectively in Quebec (Statistics Canada, 1997). Quebec Environment Ministry (1993) recorded constant uses of insecticides, fungicides and herbicides in Quebec from 1986 to 1991. Statistics Canada (2002b) showed that the number of cattle and hogs increased to 1.36 million and 4.3 million respectively in 2001.

Over-use of fertilizer, pesticides and manure can lead to water contamination through water runoff, which creates high concentrations of phosphorus and nitrogen as well as an increase of pathogens in the water, leading to eutrophication and deoxygenization as well as destruction of aquatic habitats (AAFC, 1995). AAFC (2000) showed that water contamination from nitrogen increased 77% and 71% in the intensive livestock and corn production regions respectively, while 81% of the provincial farmland is at risk of water contamination from phosphorus in Quebec. Water contamination from agriculture has become a serious health risk in drinking water. It is difficult to manage because it is a non-point source of pollution. The Walkerton tragedy in 1999 was associated with bio-pollution from agriculture in drinking water, resulting in the death of several people and illness of more than 2000 (Davey, 1999).

The loss of biodiversity is also severe in Quebec. From 1981-1996, 74% of the wildlife habitat areas declined due to intensified agriculture activities in the province, which is also higher than the national average (AAFC, 2000). Losses of bio-diversity in genetics, species and habitats are related to improper use of chemical fertilizer and pesticides as well as the expansion of agricultural lands. This threatens the biological balance in the environment by reducing the activities of living organisms, increasing pests and affecting crop health (AAFC, 2001).

### 2.1.3. Economic and social concerns in Quebec agriculture

The increasing environmental problems, due to intensive farming, are also associated with the economic situation in recent years. Recently, agriculture has seen declining product prices and increasing input prices over time. This has increased production costs and decreased profit margins in agriculture. From 1996 to 2001, prices for agriculture products increased 7.3% compared to an 8.7% increase in the cost of fuel and fertilizer in Canada (Statistics Canada, 2002a). In Quebec, the same pattern was evident, leading to the average ratio of operating expenses to gross farm receipts increasing from 0.8:1 in 1995 to 0.83:1 in 2000 (Statistics Canada, 2002b).

These economic difficulties brought economic and social changes to rural areas. Some unprofitable farmers had to quit the industry, while others had to expand farm size and increase productivity through intensification and specialisation, based on economies of scale. The trend is even more apparent in Quebec. Statistics Canada (2002b) showed that the total number of farms in 2001 had dropped by 10.7% to 32,139 in Quebec since 1996, which was 33.2% lower than that in 1981, declining at a higher rate than the national average. From 1996 to 2001, all farms in different income categories experienced decreases in numbers, except farms with annual gross receipts of $250,000 or larger, which account for 70% of the agricultural gross receipts with only 20% of the total farm numbers in the province (Statistics Canada, 2002b).

Although the average farm size in Quebec increased by 1/3 to 263 acres from 1981 to 2001 (Thompson, 2002), Quebec farmers have relied on intensified production for higher productivity and revenue (Quebec Government, 2003). In addition, Statistics Canada (2002b) showed that the average number of dairy cows per farm in Quebec reached 50 in 2001, and the number of hogs increased by 24% since 1996.

Intensive production with increased farm size has become a major source of environmental risk and arouses increased social concerns. For example, non-farming rural communities complain of odours from livestock farms (Baker et al, 1999). People are worried about water contamination and food poisoning from fertilizer and pesticides (The Center for Food Safety, 2002). The Quebec government had to strengthen regulations in the agro-environmental management. The Quebec Agriculture Ministry (MAPAQ) implemented an obligatory Plan agro-environmental de fertilisation (PAEF) in manure and fertilizer management in 2002 (Canadian Pork Council, 2002). The Quebec Environment Ministry (2003) implemented the Quebec Water Act in 2003, including strict requirements of water management in agriculture. These trends put farmers under social, economic and regulatory pressure to mitigate environmental problems, improve public relations, ensure consumer confidence, and comply with regulations.

### 2.2 Systematic management and sustainable agriculture

#### 2.2.1 Systematic management in agriculture

Since environmental problems are complex, evolving and interconnected in every aspect of agricultural production, traditional ways of pollution treatment on a commodity or disciplinary basis cannot mitigate the overall impacts (Baker et al, 1999). Traditional treatment of "command and control" and "end of the pipe" is not only ineffective, but also costly and burdensome in environmental management (Hite et al, 2002). A systematic and proactive approach is needed to combine environmental stewardship with agricultural practices towards agriculture sustainability.

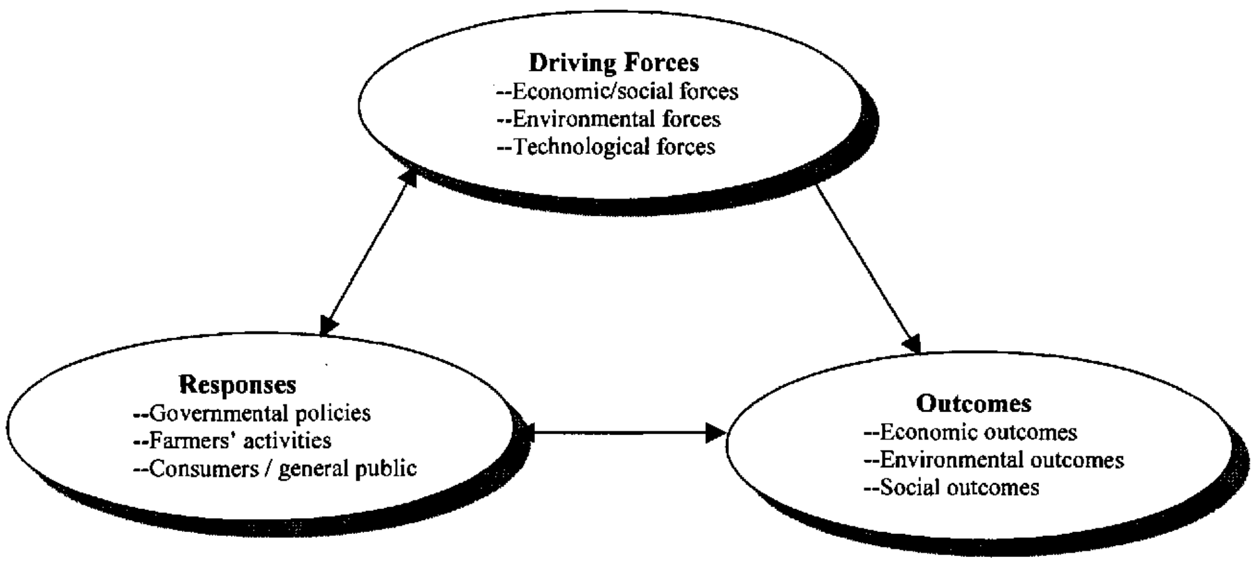
Agricultural management has attempted to deal with environmental problems in a systematic manner, through each stage of production and in the context of the agro-ecosystem, including practices, crops, livestock, natural resources and their interactions on and off the farm (Altieri, 1987). In a systematic farm management approach, producers can take a combination of measures to reduce environmental impacts in soil, water, air and bio-diversity at the same time (AAFC, 1995). Soil erosion and degradation can be reduced by soil assessment, conservation tillage, proper management of crop residue and rotation as well as proper nutrient management. Water contamination can be mitigated by sound management of livestock wastes and chemical inputs on the fields. Efficient and proper livestock and manure management can contribute to improvement of air quality. Integrated pest management (IPM), conservation and creation of habitats by building windbreaks and shelter belts as well as mixed cropping can promote bio-diversity and reduce the use of pesticides and fertilizers.

At the same time, because agro-environmental management may incur additional economic benefits and costs besides environmental benefits, it should be integrated with farm business operations in a more efficient and cost effective manner (MAPAQ, 1997). On the other hand, Wall (1997) and Vanslembrouck et al (2002) showed that agro-environmental management contributes to the environment, which is a public good, so that farmers should be compensated by society. Thus, business viability and the sustainability of systematic farm management depend not only on producers but also on society as a whole.

### 2.2.2 A new partnership to promote sustainable agriculture

The ultimate objective of farm management in the agro-environment is to promote sustainable agriculture, which aims at improving the social well-being of current and future generations through agricultural development towards consistent economic, social and environment improvements in consideration of the whole agro-ecosystem (AAFC, 2001). Although agro-management is the farmer's responsibility, its effectiveness and feasibility towards sustainable agriculture depends on the endeavor of the whole society. Figure 2.2 (adapted from AAFC, 2000, p9) illustrates stakeholders and their dynamics in promoting sustainable agriculture and a systematic management. There are mainly three fundamental stakeholders: agricultural producers, governments and the general public, with different objectives and priorities in agriculture. Producers have been regarded as profit maximizers in economic theory (Grant, 1989; Hoag and Hollaway, 1991). However, recent studies showed that producers also care about the agro-environment (Willock et al, 1999; Vanslembrouck et al, 2002). The general public needs healthy and nutritious products from agricultural production as well as a healthy agro-environmental management. Governments aim to maximize social welfare in combination with social efficiency and equity.

**Figure 2.2 The Model of Relationship and Dynamics of stakeholders in Agriculture**




The dynamics of the stakeholders in agriculture follow the model of "Driving forces—Responses—Outcomes" illustrated in Figure 2.2 (adapted from AAFC, 2000, p9), with the roles of stakeholders, their relationship, and possible outcomes of the practices. Driving forces direct the development of agriculture including changes in economic, social, environmental and technological conditions, e.g. market demands, technological development, consumer preferences and public concerns, which lead to stakeholders' different priorities. For example, global demands for agricultural products increase significantly with population growth, which is expected to be between 8 and 12 billion people by 2050 (AAFC, 2001). Canada's agriculture industry has set new targets to increase agricultural exports from $21billion in 1998 to $30-40billion in 2005 (AAFC, 2000). Stakeholders may respond to this trend differently. Farmers will increase intensive production to fulfil this objective, which in turn may increase agro-environmental risks and concerns of the general public. Governments have to address the needs of the producers in production expansion as well as the concerns in the agro-environment from the public by developing related regulations and services. Different outcomes will occur depending on the performance of the responses and co-ordination.

In cases where each stakeholder in agriculture only focuses on their own priorities, systematic farm management and sustainable agriculture will be difficult to achieve. The traditional "command and control" in agro-environmental management brings with it high social costs associated with pollution treatment, punishing polluters and passing on environmental damages to the public (Schulman et al, 2000). In addition, the business difficulty of farmers due to strict regulations and public pressure may transform into rural unemployment and shortages in the supply of agricultural products in the market so that governments and consumers will have to face these consequences. This demonstrates the inefficiency and ineffectiveness of the mechanism and creates mistrust among stakeholders over time.

To address concerns of different stakeholders successfully, multiple balances and compromises and a new partnership among stakeholders in the dynamics of agriculture are needed to promote sustainable agriculture towards economic development, social congeniality and environmental stewardship (AAFC, 2003). The initiation of systematic farm management is a pro-active, preventive rather than reactive measure in compliance with governmental regulations and public concerns, as a start of co-operation and partnership building with other stakeholders. Through the endeavor in systematic management, producers demonstrate their responsibility to improve environmental stewardship and lay the foundation of mutual understanding with governments and the public. When producers implement systematic management and incur extra costs, compensatory mechanisms should be adopted in society to address producers' financial and technical concerns in return for the environmental benefits. Governments and the public can compensate and support producers through subsidies, technical support and price premiums (Schulman et al, 2000). These mechanisms can also contribute to a better agro-environment as well as consensus and partnership building towards long-term co-operation among the stakeholders.

Furthermore, pollution prevention practices, such as systematic environmental management, are socially more efficient than penalty-after-pollution approaches (Schulman et al, 2000). In doing so, this mechanism improves the effectiveness of problem solving as well as reduces the transaction costs of enforcement. Producers can benefit from the reduction of punitive costs and regulatory burdens in agro-environmental management through self-regulation and prevention (Wall, 1997). Governments can save expenses in monitoring and pollution treatment, while consumers can benefit from environmentally friendly agricultural products and practices.

The new approach is objective-oriented including environmental considerations. The mechanism of partnership can also adjust in accordance with outcomes and changes of the driving forces through adjustments objectives and practics as well as co-operative responses. The co-operation will also strengthen information exchanges and mutual trust.

In the long run, static and inter-temporal multiple equilibria of "eco-efficiency" towards sustainable agriculture can be reached through this mechanism (AAFC, 2001).

### 2.2.3 The role of the government in agro-environment

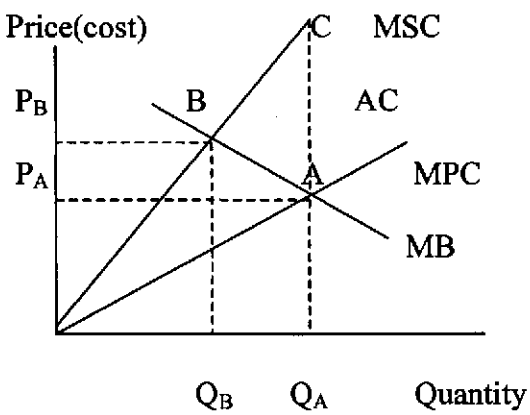
Environmental problems are examples of market failure because the environment tends to be characterized as non-rival and non-exclusive. These characteristics can result in externalities. Market failure is the inability of an unregulated market to achieve allocation efficiency (Parkin and Bade, 1994). Non-rival and non-excludable goods cause the problem of free riding. Externalities arise from activities of transactions with extra costs or benefits on a third party rather than the parties undertaking the transaction (Parkin and Bade, 1994). Environmental pollution often causes negative externalities to the third party, e.g. hog ordours affecting neighbors of hog producers.

Many possible solutions to correct market failures fall within the domain of governmental regulations (Parkin and Bade, 1994). One is to establish and enforce effective property rights by governments, e.g. private rights or common rights, so as to minimize market failure. In this way, environmental management can be optimized. However, these institutional changes are difficult for market failure associated with water or air because of high transaction costs in seeking information, contracting and enforcement.

The other way to address this market failure is for the government to use taxes or subsidies to reduce (increase) negative externalities (positive externalities). The mechanism is illustrated in Figure 2.3.1 and Figure 2.3.2 ( Parkin and Bade, 1994, P537, P540). Figure 2.3.1 demonstrates that governments can use a tax to reduce a negative externality in production. When dealing with environmental problems under a competitive market, the marginal benefit (MB) curve denotes the social demand for the good, e.g. grain products. The curves of MPC and MSC denote marginal private cost and marginal social cost to produce this good, respectively. Without governmental interventions, a competitive market reaches a competitive equilibrium at point A when MPC equals MB at the quantity $Q_A$ and price $P_A$. However, stakeholders other than the consumer endure the difference between MSC and MPC, shown as AC, such as a negative environmental externality, e.g. social treatment costs related to water contamination from pesticide use in grain production.

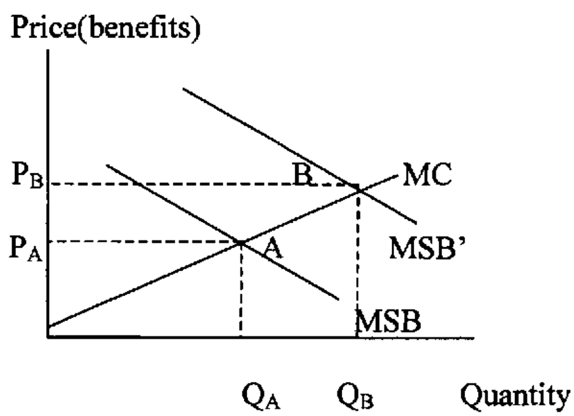
**Figure 2.3 Impacts of a tax and a subsidy on externality**

**Figure 2.3.1**




**Using a tax to reduce negative externality**

**Figure 2.3.2**




**Using a subsidy to increase positive externality**

When governments impose taxes on grain production to include environmental costs, a new social equilibrium can be reached at point B (assuming no changes in MB). At this point, consumers will pay the full social cost to buy grain products, including environmental costs, at the amount $Q_B$ and a price of $P_B$. Thus, the tax increases the price and reduces the demand for the good as well as reducing the externality accompanying grain production. However, since the tax leads to a decrease in quantity demanded because of price increases, grain farmers as price takers may suffer from an income loss due to the homogeneity of the agricultural product. Thus, this instrument may not be economically and politically feasible and sustainable.

Figure 2.3.2 demonstrates the effects of a subsidy on increasing positive environmental benefits. The curve MC represents the marginal costs of establishing environmentally friendly practices on farms. The marginal social benefit curve (MSB) represents the social demand for the environmental benefits from these practices. At point A, the initial competitive equilibrium, and a price level of $P_A$ farmers can only afford to provide the amount $Q_A$ of environmentally friendly products. With subsidies increasing prices from $P_A$ to $P_B$, the amount of production can reach a higher level of $Q_B$ so that a new equilibrium can be reached at point B with the higher marginal social benefit (MSB'). Thus, a government subsidy can promote the establishment of environmentally friendly practices in agriculture.

Farmers internalize the cost of environmental externalities with environmentally friendly practices. These practices have higher costs than traditional operations but provide environmental benefits to society (Vanslembrouck et al, 2002). Therefore, farmers should be compensated by society for these practices. Furthermore, from a historical perspective, modern agriculture is subsidized rather than taxed, based on political concerns for agriculture and rural development (Runge, 1997). Although agricultural agreements such as the General Agreement on Tariffs and Trade (GATT) limit the use of direct price and income subsidies in agriculture, environmental investments are allowed according to the Green Box Principle at the World Trade Organization (Shi, 2001). Both the 2002 U.S. Farm Bill and the Common Agriculture Policy in the European Union contain programs that compensate for conservation and agro-environmental practices in agriculture (Culver et al, 2001; Jacquet, 2003).

AAFC (1995) has agreed to work with provincial governments to promote environmentally friendly practices in agriculture, by providing farmers with financial and technical support as well as educating consumers to promote the market for environmentally friendly products. AAFC (2003) outlined the Environmental Farm Plan (EFP) as an environmental management system (EMS) on farm under the Agricultural Policy Framework (APF) of agricultural development in the 21st Century. The APF forms the foundation for the co-operation of federal and provincial governments with farmers as well as the general public (AAFC, 2003).

In Quebec, systematic soil and manure management have been promoted with the use of crop cover and residues that reduce water run-off and soil erosion, as well as livestock management (AAFC, 2000). The Quebec government has put $319 million into the Agro-Environmental Investment Assistance Program to encourage resource conservation and environmental protection practices in manure management and agro-environmental consulting services (Manure Net, 2002). This study on environmental management systems in Quebec agriculture, supported by MAPAQ, also indicates that the Quebec government is paying attention to agro-environmental management.

Farm management that incorporates EMS focuses on preventing and minimizing environmental risks as well as complying with regulations efficiently in a manageable, measurable and voluntary manner towards environmental stewardship. EMS is highly site specific and its performance depends on farmers' inputs and effort. Since farmers are experts on their own farm environment and business, it is reasonable to promote EMS according to their own perception of environmental problems. Successful EMS, e.g. Ontario EFP has been initiated by farmer organisations, based on workshop training, self-assessment and peer review (Ontario Ministry of Agriculture and Food, 2003).

Schulman et al (2000) carried out case studies of EMS programs world-wide and concluded that the conditions necessary for a successful EMS are: (1) strict environmental regulations; (2) subsidies or financial supports to help the producers in the implementation phase, and (3) consumers' support for environmentally friendly products. Besides the role in subsidizing farmers, governments have significant roles in development and enforcement of environmental regulations, which direct EMSs in agriculture. In the long run, governments can have a role in educating consumers to buy environmentally friendly products that favor the agro-environment (AAFC, 1995).

Governments must address farmers' attitudes in the agro-environment and EMSs to develop appropriate policies and programs in a cost-effective manner. One of the important issues is how to subsidize farmers to start an EMS. Since there is no associated market for an EMS which can be used to determine its value, a possible way is to ask farmers directly for their willingness to accept (WTA) compensation to establish an EMS. This study serves these purposes by examining Quebec farmers' environmental attitudes, their concerns about EMSs, as well as their WTA to establish an EMS. This information will support policy development in this area.

However, compared with the US$9 billion in the US Farm Bill 2002 (Peters and Kaplan, 2002) and 20% of the total agricultural payments in 2002 in the European Union

(Jacquet, 2003) as agro-environment payment, the commitment from the Canadian federal government is only $100million over five years starting in 2003 to promote EFP (AAFC, 2003). Thus, the partnership between farmers, governmental agencies and social organizations is more important in the EFP programs in Canada based on the budget constraint. AAFC (2002) estimated that 8% of farms across Canada have implemented different formats of EFP, with technical and financial assistance provided by provincial and federal governments in co-operation with farm organizations. EFP programs in Ontario, Alberta and Atlantic Canada focus on farmers' self-assessment and workshop training, while in Nova Scotia, EFP coordinators visit farms and help to develop EFP. In Quebec, "Club Conseils En Agroenvironnment" helps member farmers to develop an EFP (AAFC, 2002).

However, farmers' self initiated EFP may cause inconsistency and incomparability in assessing and solving problems, because of different production types, regions as well as levels of knowledge and preferences. This can be improved in two ways. A commonly recognized guideline is needed to direct and verify an EFP or an EMS. ISO 14000 Environmental Management Systems (EMS) is developed to fulfil these needs, which will be discussed in the next section. On the other hand, AAFC (2002) started a project of Basic Environmental Scan and developed agro-environmental indicators to standardise the assessment of the agro-environment, which can provide more objective and accurate information on the agro-environment.

## 2.3 Farmers' attitudes and agro-environmental management

### 2.3.1 Farmers' attitudes on agro-environment

In a voluntary EMS program, the farmers' decision concerning participation and implementation are crucial. Decision making is the key point between the process connecting psychological attitudes and behaviours, which combine objectives, constraints, preferences and attitudes and have influential and direct effects on behavior and outcomes (Willock et al, 1999). Although how attitudes affect decision-making and behavior has been in debate among social scientists, studies have shown that attitudes may have significant effects on decision-making (Vanslembrouck et al, 2002). Attitudes are responses towards an object based on the perception of the individual about the object. The perception may be knowledge or emotion based (Willock et al, 1999). Two categories of attitudes and preferences towards farming and the agro-environment have been found in farmers. Farmers treating farming as a business tend to be profit maximizers with less concerns for the agro-environment (Rogers, 1983), while those who believe farming is a way of life may be more environmentally conscious despite economic concerns (Chamala, 1987).

Literature has also recorded differences in farmers' perceptions and attitudes towards the agro-environment in association with different geographic features, production types, and cultural heritages. Baker and Thomassin (2002) showed that Quebec farmers' concern for odours is different from the Prairie counterparts' concern for smoke from crop residue burning. Even in the same region, farmers may have various perceptions because of production type. Dennis et al (1996) demonstrated the differences of Tennessee farmers' perceptions towards environmental problems, with 55% of the farmers regarding it as important and 40% as unimportant. Cultural heritage may also play a role in attitude differences. Salamon (1992) found different attitudes in environmental issues between English and German heritages in the Midwest of the United States.

Different attitudes of farmers may lead to different agro-environmental management, reflecting site specific and practical concerns. Thus, a thorough understanding of farmers' environmental attitudes is important to promote EMS.

In Quebec, few studies have examined farmers' attitudes on the agro-environment. Baker et al (1999) carried out a study on producers' environmental attitudes in Southern Quebec. However, the research had limited information and representativeness with small sample groups in certain regions in Quebec. A broad survey is needed to study Quebec farmers' environmental perceptions throughout the province in order to promote EMS.

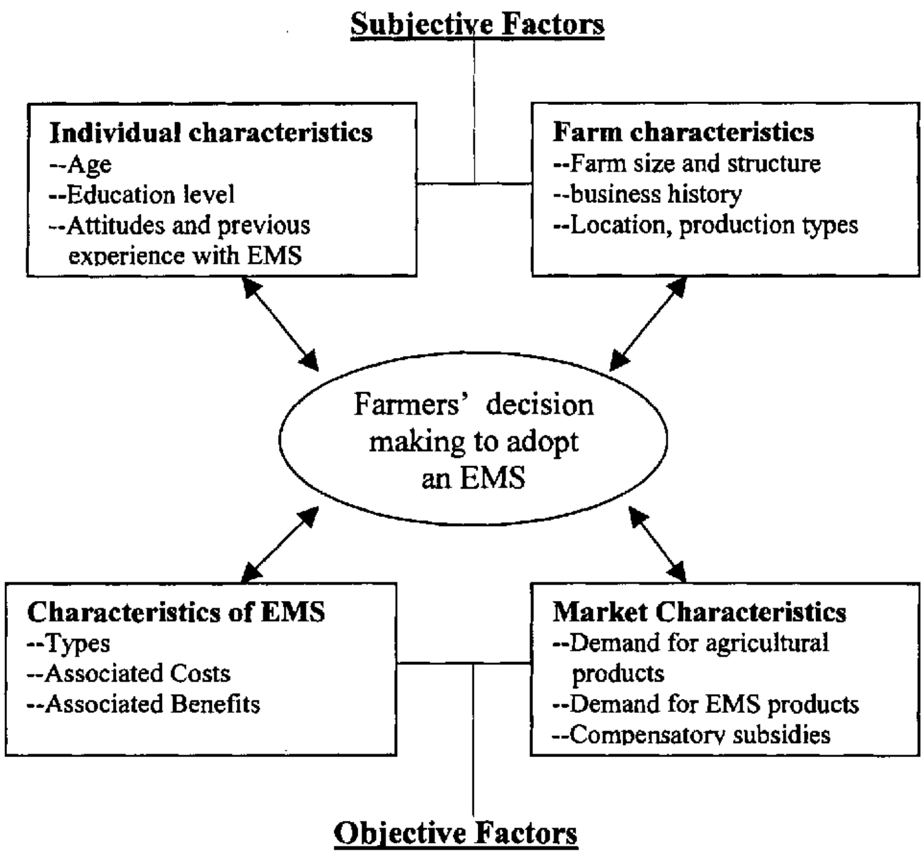
### 2.3.2 Modelling producers' decision making to participate in EMS

It is necessary to determine how attitudes and other socio-economic factors influence farmers' decision-making and behavior related to EMSs. There exist several theories and related empirical work on the relationship between attitudes, decision-making, and behavior. Fishbein and Ajzen (1975) provided the framework based on the Theory of Reasoned Action (TRA) to model the indirect effects of attitudes on behaviors through influences on decision-making. Empirical studies using this model have shown mixed outcomes to predict behavior from attitudes with successes and limitations in studying farmers and the agro-environment (Carr and Tait 1991; Kantola et al, 1983). Lazarus and Folkman (1984) developed the transactional model (TM) based on TRA to provide a direct or indirect relationship between predictive behaviour and attitudes. In this model, there are three kinds of variables—antecedent, mediating, and outcome variables interacting with each other along with multilevel causal chains. Attitudes can be included in antecedent variables and mediating variables are perceptions and objectives, while outcome variables are behaviors and outcomes. There could be causal chains directly connecting attitudes to behaviors or through perceptions.

Willock et al (1999) employed the TM model in their study and showed that behaviour or decision-making is a function of attitudes, norms, habits and expectations of outcomes. They also showed that the relationships and effects among attitudes, decision-making and behavior are interactive rather than responsive. Furthermore, Vanslembrouck et al (2002) developed and examined a conceptual model of farmers' decision making affected by their attitudes about adopting environmental practices. They also identified that subject characteristics including attitudes, objective characteristics such as socio-economic and business factors, as well as the form of the practice and the outcome expectation play collective roles in decision making. This finding was consistent with the study by Willock et al (1999) and Hudson and Hite (2003). This model, shown in Figure 2.4 (adapted from Vanslembrouck et al, 2002), illustrates the relationship and roles of subjective and objective factors in farmers' decision making to adopt an EMS.

In Figure 2.4, there are two categories of characteristics in either subjective or objective factors. Under the farmers' subjective factors, there are individual characteristics and farm characteristics, which contribute to the farmers' attitudes and preferences. Important individual factors which may affect decision-making are the farmers' age, education level and attitude, and experience with EMS, while variables in close association with the farm business and the agro-environment are listed as farm size and structure, business history, farm location, and production type.

**Figure 2.4 A conceptual model of farmers' decision making to adopt an EMS**
(adapted from Vanslembrouck et al, 2002)




Objective factors include the characteristics of the EMS and the market. There are many factors influencing farmers' perception of EMSs, including the types and associated costs and benefits, which may affect farmers' attitudes on business and the agro-environment. Market situations are also expected to affect decision-making concerning adoption. For instance, an increase in demand and higher price for EMS products than conventional products may promote the decision to adopt.

Subjective and objective factors jointly influence farmers' decision making to adopt an EMS. Furthermore, the decision-making and action-taking may also have counter effects on these factors afterwards because of the dynamic and interactive nature of decision-making (Willock et al, 1999), as shown by the arrow directions in Figure 2.4. Farmers are supposed to be reach an optimal decision for themselves, with objective factors as constraints and subjective factors as their preference.

Decision-making is assumed to be an optimisation process of maximising farmers' utility U based on economics and can be illustrated with economic modelling. It is assumed that farmers care about both business and the environment instead of being either a pure profit maximizer or environmentalist. Thus, $\pi$ and $Q_E$ are included in the utility function U ($\pi$, $Q_E$), where $\pi$ and $Q_E$ are profits and environmental threshold, which can be reached through an EMS adoption. It is also assumed that producers are rewarded in implementing an EMS in terms of compensatory payments from either the market or the government. A model is adapted from Vanslembrouck et al (2002) to illustrate the decision-making process in Formula (2.1).

$$\max_{x_e, x_f} U(\pi, Q_E) \tag{2.1}$$

$$\text{s.t. } \pi \leq P_F \times f(X_F, Z) + P_E \times Q_E - w \times (X_E + X_F) - r \times Z$$

Farmers' U includes business profits, compensatory payments, and environmental benefits from adopting EMS. $f(X_F, Z)$ is the function of conventional production. $X_E$, $X_F$ and Z are variable inputs for an EMS, production, and for fixed inputs in production, respectively. $P_E$, $P_F$ and r are the price vectors for level of EMS payment, products, and unit costs for the fixed inputs, respectively.

## 2.4 Environmental Management System (EMS) and ISO 14000 in Agriculture

### 2.4.1 Environmental Management System and Third Party Monitoring

The Environmental Farm Plan (EFP) can be regarded as the agro-environmental management system on a farm, which is a kind of Environmental Management System (EMS). An EMS is a continuous cycle of planning, implementing, reviewing, and improving process in the environmental management of an organization to meet environmental obligations (NSF International, 2001). As shown in the Driving force-Response-Outcome model in section 2.2.2, an EMS can be regarded as a farmer's response to environmental concerns (driving forces) from governments and the public, in terms of environmental regulations and demands for environmentally sound production. The adoption of an EMS is a preventive, voluntary, and proactive measure by farmers to improve the agro-environment in consideration of penalties, social pressure, and access to emerging "green markets".

Farmers have started adopting EMSs in various forms in accordance with different concerns. For instance, the Ontario Environmental Farm Plan was initiated to encourage better compliance with governmental regulations. The Linking Environment and Farming Program was motivated by increasing consumers' "green demand" in Britain and Europe (Schulman et al, 2000). Le ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) implemented an Agro-Environment Fertilizer Plan (PAEF) for better fertilizer and manure manage in Quebec agriculture (Canadian Pork Council, 2002).

From the farmers' point of view, business operations in combination with an EMS can only be financially viable and profitable with additional financial support from governments and consumers to compensate costs in an EMS (Vanslembrouck et al, 2002). According to the Driving Force-Response-Outcome model in section 2.2.2, a social partnership should be established to address farmers' financial needs in implementing an EMS in the form of a collective payment mechanism from governments, farmers, and consumers.

These payments can only occur as rewards or guarantees for proper practices implemented towards agro-environmental improvements. However, many current EMS programs are farmer-initiated or voluntarily adopted and accredited by the initiating organizations, such as the Ontario EFP (OMAF, 2003). This may cause uncertainties in EMSs in terms of compatibility and consistency with governmental regulations and public perceptions, because of the asymmetric information on the implementation between farmers and the public (McCluskey, 2000). These uncertainties can also cause moral hazard and adverse selection in implementation (McCluskey, 2000). Moral hazard happens when farms take advantage of their claim of EMSs to benefit from governmental subsidies or consumers' price premiums without actual adoption. Adverse selection happens when the whole payment program may end up producing less than expected when moral hazard prevails in the adoption.

In addition, asymmetric information may cause market failure of environmentally friendly products because of farmers' information advantages and consumers' inability to verify the claims of the products from these practices (McCluskey, 2000). This is based on the characteristics of an environmentally friendly good. There are three kinds of goods in the market based on the consumer's ability to judge the quality and claims of the good: search good, experienced goods, and credence goods (Darby and Karni, 1973). Search goods can be easily judged by consumers when purchasing, such as vegetables.

Experienced goods can be judged after consumption, such as canned food. However, credence goods can hardly be determined for their claims, such as organic goods and goods from environmentally friendly production. Farmers may claim their products to be from production with an EMS without actual adoption and benefit from a price premium for those goods. Since there is no way to verify the farmers' claims, consumers may decline to buy these products so that this market could collapse.

Under this situation, McCluskey (2000) argued that it is necessary to adopt third party monitoring to restore market efficiency. Since goods from EMS farms are credence goods, the verification from a credible third party may assure the claims of EMS goods and increase consumers' confidence so that a market can operate. Compared with different private verification programs, national standards and assurance programs may work in terms of standardization. However, they may lead to high transaction and enforcement costs and reduce the incentives of farmers to make improvements continuously in the program (McCluskey, 2000). Thus, ISO 14000, an industry initiated international guideline for implementation and certification is expected to address the verification concern of EMSs.

### 2.4.2 Development of ISO 14000

ISO 14000 is an international standard for EMSs, featuring a consistent environmental assurance and promoting innovative compliance to environmental obligations. ISO 14000 was developed by the International Organization for Standardization (ISO), which was established in 1946/47 as the industrial association to address issues of international standardization in order to enhance transfers and exchanges of goods and services internationally (Stauffer, 1997). ISO started with the standardization of product quality and expanded to production processes in quality management with the initiation of the ISO 9000 standard in the 1980s (Gleckman and Krut, 1997). Through world-wide implementation, the ISO 9000 certification has become a benchmark to address consumers' quality concerns and a necessary step for industrial producers to enter many international markets (Mehta and Wilcock, 1996).

The increasing environmental concerns, as well as the success of ISO 9000 based on certification of production processes in quality management, promoted the development of similar standards for systematic environmental management. ISO promulgated the ISO 14000 standard in 1996, after the Business Council for sustainable development of the United Nations advocated the creation of international environmental standards at the Earth Summit Conference in Rio de Janeiro in 1992 (Stauffer, 1997).

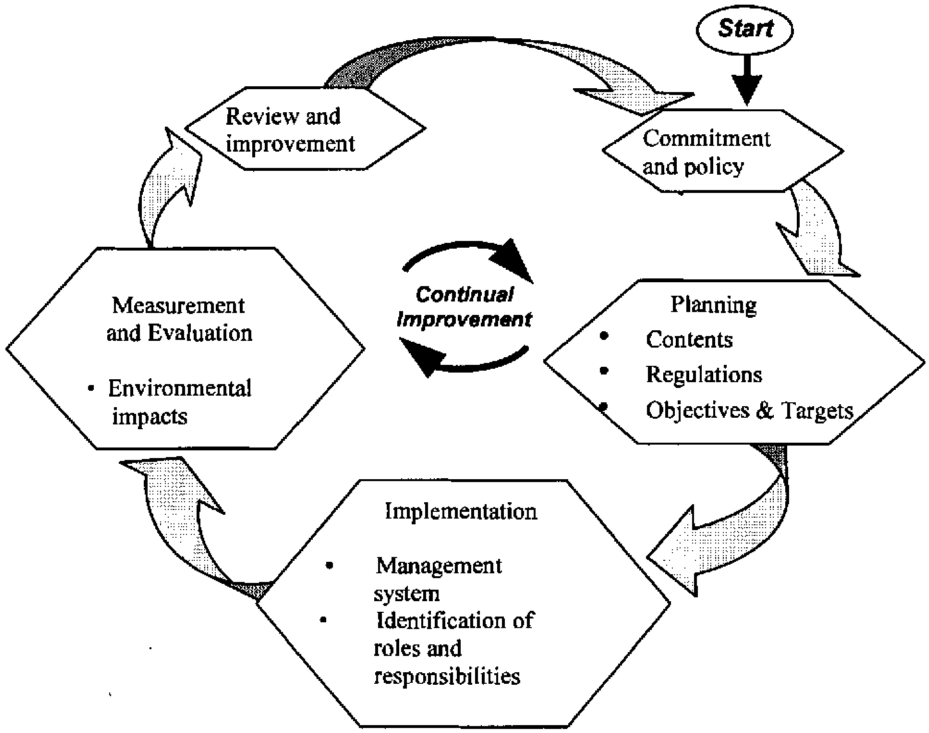
### 2.4.3 ISO 14000 Guidelines and Elements

The ISO 14000 standard is a systematic process for environmental management in organizational operations. ISO 14000 does not provide specific prescriptive measures. Instead, it provides general guidelines for developing an EMS, including ISO 14001 (EMS, specification with guidance), ISO 14004 (EMS, general guidelines on principles), as well as guidelines for environmental auditing (ISO 14010-14015), environmental performance evaluation (ISO 14031), life-cycle assessment (ISO 14041-14044), environmental labeling (ISO 14020-24024), and environmental aspects in product standards (ISO 14060) (National ISO 9000 Support Group, 1995; Kuhre, 1995).

ISO 14001 is the only certified component of the ISO 14000 series at present, and includes five steps to establish an EMS: commitment and policy, planning, implementation, measurement and evaluation, and review and improvement (Canadian Standards Association, 1996). Figure.2.5 illustrates the procedure of an ISO 14001 EMS. Initially, the implementing organization issues an appropriate environmental policy statement with a commitment and policy of improving the environment continuously, pollution prevention, and compliance with laws and regulations.

**Figure 2.5 An ISO 14001EMS Model**

(adapted from NSF International, 2001, P14)




The planning stage of an EMS defines the environmental targets in the short run and objectives in the long run for the organization, based on governmental regulations and the current environmental situations in the organization. In this stage, the organization identifies environmental impacts of their operations and products in a measurable manner, and develops objectives, targets and priorities to deal with these impacts. This stage includes information collection, problem identification, and analysis in order to develop objectives and goals.

Rodriguez et al (1999) provided a method to identify and evaluate environmental impacts in farm operations, measured by severity in terms of intensity, frequency, and extent. These measures were ranked by sequential numbers so that impacts could be evaluated in quantitative and qualitative manners. Lussier et al (1997) summarized applicable environmental laws, regulations, and policies in Quebec Agriculture.

In the implementation stage, a program or a management system should be developed to assign responsibilities and specify means and a timeframe to achieve the objectives and targets with appropriate actions. When the management system is functional, on-going monitoring information should be recorded and documented to track performance for the use of measurement and evaluation on the environment.

At the review and improvement stage, operations of an EMS should be verified according to the initial plan whether the targets and objectives have been satisfied. Otherwise, additional actions are required to improve the operations. Adjustments of the objectives and targets should be made according to changing environmental conditions and regulations and lead to the start of a new cycle. This step is completed through an audit of the EMS on a periodic basis to assure that the commitments are met. This step also forms the base for continual improvement of the EMS.

ISO 14001 EMSs rely on this systematic and continuous procedure with feedback and traceable documents and records from each step, which also forms the foundation for certification. ISO 14001 certification is awarded by a third party auditor accredited by the ISO. In Canada, Quality Management Institute (QMI), an affiliate of the Canadian Standards Association (CSA) is such an auditor (Wall, 1997). ISO 14001 certification demonstrates that proper procedures have been carried out in an EMS with the management plans and necessary documents to satisfy ISO14000 standards. A detailed description of how to establish and maintain an EMS based on ISO 14001 at the farm level in Quebec can be found in Lussier et al (1997).

### 2.4.4 Implications of ISO 14001

Similar to ISO 9000, ISO 14001 only certifies the process of an EMS rather than its environmental performance. However, ISO 14001 EMSs are based on compliance with regulatory and voluntary requirements with commitments to continual improvement of the environment in the business. The rationale is that an ISO 14001 EMS is expected to contribute to minimising environmental impacts and improving environmental performance (Wall, 1997).

In this manner, ISO 14001 inherits the essence of ISO 9000 in the flexibility to certify processes rather than products and thus avoids the differences in environmental standards and regulations for different jurisdictions (Kuhre, 1995). However, Stauffer (1997) pointed out that the certification itself guarantees no environmental improvements. Schulman et al (2000) also identified no persuasive evidence showing products from an EMS to be more environmentally sound than coventional products. This is different with ISO 9000, which can provide more credibility for product quality through process certification. This difference is due to greater complexity in the environment than that in man-made products.

Since ISO 14001 EMSs are designed to conform with local governmental regulations, environmental regulations in different countries lead to inconsistency and uncertainty in the certification of ISO 14001 as an "international standard" (Benchmark Environmental Consulting, 1996). These concerns question the credibility of ISO 14001 and imply time and extensive applications are needed to make conclusive evaluations on its effectiveness. In addition, development in ISO 14000 standards is needed in environmental performance and life cycle assessment, to address the complexity of environmental problems.

### 2.4.5 Cost-benefit analysis of implementation of an ISO 14001 EMS

An EMS in agriculture is the result of voluntary efforts of farmers to integrate environmental considerations into their business management. In the establishment of an EMS, one of the major concerns of farmers' is the extra cost of improving their environmental management (Baker et al, 1999). The implementation of an EMS should be cost-effective to achieve net benefits to encourage farmers' acceptance. This is related to the costs and benefits of implementing an EMS.

#### 2.4.5.1 Costs of implementing an ISO 14001 oriented EMS

The costs concerning implementation of an ISO 14001 EMS include capital inputs for changing practices in accordance with the EMS, auditing fees for the initial certification and annual verification, opportunity costs in terms of time value in paper work, documentation, training and reviewing of records and audit (Rodriguez et al, 1999). In addition, since the market for agricultural products with an EMS is still in the emerging stage, marketing expenses may be needed to enhance consumers' awareness (Wall et al, 2001). Altogether, these costs may add up to a significant amount for farmers. Schulman et al (2000) estimated that in the U.S, the certification fee of a farm is US$25,000, which may account for the limited number of ISO 14000 certifications on American farms at present.

#### 2.4.5.2 Benefits from ISO 14000 certified EMS

In spite of costs and burdens, farmers can also expect benefits from an EMS. Lussier et al (1997) summarized benefits of implementing an ISO 14001 EMS in agriculture. Besides environmental benefits, enhancing competitive advantages, improving compliance with regulations and public relations, cost saving, and gaining more market access are also possible benefits from an EMS. For a thorough list of benefits in agriculture from environmentally friendly practices, please refer to Question 4 in the survey, presented in Appendix II.

There are several ways that ISO certified producers can benefit from enhanced competitive advantages, including product differentiation, cost saving, and new market access. Porter and van der Linde (1995) pointed out that innovative and efficient operations through the implementation of an ISO EMS can assist producers in creating product differentiation and added value from ISO certification as well as save costs from reducing inputs and developing new products from waste. Schulman et al (2000) also showed that certified farmers can save costs from lower premiums paid for insurance and financial loans because the implementation of an EMS can reduce overall environmental risks.

As ISO 14001 has a similar management structure to ISO 9000, with a focus on environmental management, ISO 9000 certified companies will have advantages to adopt ISO 14001 without significant adjustments. Stauffer (1997) demonstrated that the expansion of ISO 9000 certification has pushed manufacturing industries, including food-processing sectors, to implement ISO 14001 EMSs to address environmental concerns. In addition, ISO 14001 certification may also have impacts on the supply chain as has happened after ISO 9000 implementation. Baker and Thomassin (2002) noted that Ford requires its auto part suppliers to adopt ISO 14000 to comply with Ford's own ISO 14000 requirements. Similarly, food processors with ISO 14000 certification may require farmers to adopt ISO 14001 in the future. Since a significant share of agricultural products goes to the processing industry, ISO 14001 certified farmers would gain a competitive advantage by accessing the market to certified processors.

Furthermore, ISO 14001 certification can help producers to expand access to international markets. Schulman et al (2000) showed that ISO certification helped American farmers to export grain to Europe and Japan. Baker and Thomassin (2002) also showed that ISO 14001 certification helped a strawberry farmer in Quebec to enter the U.S. markets. Along with the trend of liberalisation of international trade, environmental and health regulations are expected to replace tariffs and quotas as new trade barriers (Morton, 2001). With increasing environmental concerns in international trade, the integration of environmental requirements into trade will push the adoption of internationally recognized standards to solve controversies in different environmental management regimes. Wall et al (2001) pointed out that it is natural to accept ISO 14001 as the common environmental standard in international trade, because ISO 14001 was promoted by the international industrial organization based on consensus. It means that the adoption of ISO 14001 may have significant influence on global competitiveness and it is in farmers' self-interest to gain ISO certification.

The implementation of an ISO 14000 EMS based on certification also provides farmers with benefits in reducing regulatory risks and burdens as well as improving public relations. Wall (1997) pointed out that the implementation and certification of an EMS indicates that certified producers have made substantial efforts to comply with governmental regulations, as evidence of "due diligence". This is the only defensible and favourable measure under current environmental legislation against regulatory penalties for pollution.

Furthermore, Morelli (1999) identified that certified producers are able to lessen regulatory burdens in a proactive rather than reactive manner by adapting to the changing regulations through the continuous improvement in their EMSs. The self-regulation of producers also eases governmental administration and contributes to deregulation in environmental management. In addition, these proactive operations demonstrate co-operative commitments of farmers in building a new partnership with governments and the public to improve the environment.

### 2.4.6 Some concerns of cost-effectiveness of the implementation of an EMS

Although there appears to be many benefits from implementation and certification of an EMS, there are doubts as to its economic cost-effectiveness. Many economic benefits are possible only when there is a market for EMS products. The emerging market, with insufficient demand at present, may be associated with high costs for EMS products. Schulman et al (2000) found that the reason is because consumers are confused and not confident about products from EMSs and other environmental practices and would not pay a premium for them, despite their environmental concerns. However, governments have committed to face these concerns. AAFC (1995) and AAFC (2003) acknowledged these concerns and promoted governmental subsidies to initiate EMSs as well as devoted funds to educate the public to be more environmentally conscious and supportive of EMSs. The credibility of ISO is also expected to improve consumers' perception of EMSs through wide adoption and certification.

The return risk from the market and costs of the establishment of EMSs have become farmers' major concerns with the implementation of EMSs (Baker et al, 1999), which was echoed by agricultural academics, consultants, and ISO 14000 auditors in the survey conducted by Morhardt (2000). However, there are innovative ways to reduce costs and increase the effectiveness of an EMS. Hillary (1997) found that organized farmers can co-operate more efficiently and effectively than individual farmers in the implementation of EMSs through group discussion, information dissemination, and peer study. In addition, group certification and auditing are allowed with the potential of substantial cost savings in ISO certification (Wall et al, 2001). In a group certification, only a few farmers are audited and charged, representing the whole group. Thus, certification costs can be shared and reduced substantially among group members. The ENVERO-AG program in New Zealand is a typical case of group implementation of ISO 14001 EMSs, which can also contribute to a strong partnership among farmers and communities (North Ontago Sustainable Land Management Group, 2000).

Producers are expected to combine environmental considerations into their management system in the implementation of ISO EMSs, with measures of cost control and innovative practices in farm management. Baker and Thomassin (2002) compared ISO EMSs and farm business management (FBM) procedures and found that an EMS can be integrated into farm management without significant adjustments. The operational cycles of FBM and EMSs are compatible in each stage of planning, implementation and reviewing.

With increasing food safety and environmental concerns, many other management programs have been promoted or required in agriculture, which can be implemented jointly with EMSs in a systematic and cost-effective manner, because of their similarities. For example, the standard of Hazard Analysis and Critical Control Point (HACCP) addresses food safety and hazard management with a similar procedure to EMS, based on record taking, step control and reviews (FAO, 1997). In Quebec, a PAEF focuses on nutrient management of livestock manure and fertilizer with similar requirements and processes to an EMS (Canadian Pork Council, 2002).

### 2.5 Contingent Valuation Method

### 2.5.1 Economic attributes of an ISO 14001 EMS

As discussed in the previous sections, it is necessary for governments to promote EMSs by subsidising farmers. Thus, the amount of subsidies for an EMS should be identified to compensate for implementation costs. Afterwards, governments have to assess the budget and policy priorities so as to make the subsidy available based on the compensation cost. Thus, it is necessary to understand the economic attributes of an EMS before a proper valuation method can be chosen for valuation of an EMS.

An EMS is a private good because it is rival and excludable. An EMS is rival because once a farmer implements an EMS on farm, there is no need to implement another one. An EMS is excludable, as a farmer's ownership of an EMS can exclude other farmers from owning it. As a private good, it is normal to derive its monetary value through market transactions. However, an EMS cannot be valued in this way because few direct transactions of EMSs or EMS farms have happened. In addition, although an EMS can be valued based on direct implementation costs, there are opportunity costs, which are difficult to determine.

Thus, methods of revealed preferences rather than observed behaviors have to be used to derive the economic value of an EMS. Several methods may be used, such as travel cost, hedonic pricing, and the contingent valuation method (CVM) (Bishop et al, 1995). The travel cost method (TCM) is used to examine the value of recreational sites by travel costs as associated price signals. This is not an appropriate method for EMS studies, because the values derived from the TCM for recreational sites are based on the respondents' travel costs. The hedonic pricing (HP) method values the good without a direct market but from an associated market, e.g. the value for environmental amenities associated with transactions of lands or properties, on which the amenities are based. For the use of HP to evaluate an EMS, a market for the transaction of farms with EMSs is needed so that the EMS can be valued from the differences in prices between a conventional farm and the one with an EMS. However, HP is not appropriate because there are few market transactions of EMS farms. On the other hand, since EMSs depend on individual farmers' experience and familiarity with their farms, new owners of EMS farms may not inherit this knowledge and experience to maintain the EMS so that they may undervalue the EMS because of this uncertainty. In addition, market transactions tend to capture only monetary values of farms, despite option values, non-use values or existence values of EMSs.

The CVM is a non-market valuation method using surveys to elicit respondents' values directly on public or environmental amenities, which is based on preferences revealed through the survey and is suitable for valuing goods with non-use values and without associated markets (Mitchell and Carson, 1989). An EMS creates environmental values as well as economic impacts for farmers with no way to capture its value in the market. Thus, the CVM can be applied to valuation of an EMS on farm through surveys to derive the value or compensation for the adoption of the EMS.

### 2.5.2 Welfare economics of CVM

The theoretical framework that can be used to justify compensation for farmers is welfare economics. In economics, utility is the measure of an individual's welfare. Utility maximization, under a budget constraint, is the fundamental principle to optimize welfare of a rational and self-interested person. In welfare economics, the impact of development of an EMS on farmers' welfare can be related to changes of utility levels, which can be measured through Hicksian compensated demand in terms of compensating variation (CV) or equivalent variation (EV), based on income changes (Bishop and Woodward, 1995).

Figure 2.6 illustrates CV and EV as measures of changes of utility levels after a price increase in a two-good (Q and G) world. The initial individual utility ($U_0$) is maximized tangent to the budget constraint line $M_0p_0$ at point A. If the price of G increases from $p_0$ to $p_1$ with no change of the price of Q, the budget line will pivot from $M_0p_0$ to $M_0p_1$ and a new maximized level of utility $U_1$ can be reached subject to $M_0p_1$ tangent at point B, which is lower than $U_0$. The CV is the amount of income required to restore the initial utility level $U_0$ at the new price level of $p_1$. This is illustrated by an upward shift of the $M_0p_1$ budget line to make a new budget line $M_1p_{1'}$ tangent to the original utility curve $U_0$ at point C at the price $p_1$ level and parallel to $M_0p_1$. The income difference of the budget lines of $M_1p_{1'}$ and $M_0p_1$ is the CV, which can be measured by the difference between $M_0$ and $M_1$ on the Q axis (in terms of good Q).

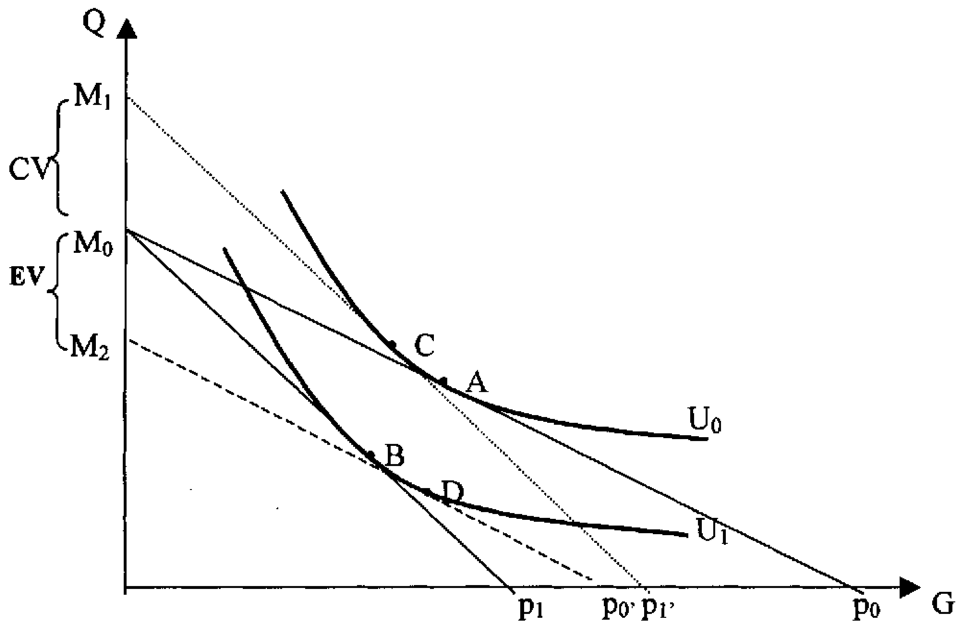
The EV is defined as the amount of income decrease from a utility shift down from $U_0$ to $U_1$, caused by an increase of the price G from $p_0$ to $p_1$, but measured at the initial price level of $p_0$, assuming that the price of Q remain unchanged. In Figure 2.6, EV is illustrated when a new budget line $M_2p_{0'}$ is drawn parallel to $M_0p_0$ and tangent to $U_1$ at point D. The EV can be measured as the income changes, on the Q axis by the difference between $M_0$ and $M_2$ in terms of good Q.

A similar argument can be made on CV or EV when price decreases. When there is an income change without price variation (only with parallel shifts of budget lines), the

EV equals the CV. For instance, when individual's income decreases from the level of $M_0p_0$ to $M_2p_0$' without price changes, the CV and the EV are equal to the distance of $M_0$ $M_2$ measured on the Q axis with utility reduced from $U_0$ to $U_1$.

**Figure 2.6 Compensating variation and equivalent variation after a price increase**

(Adapted from Johansson 1991, p. 50; De Maio Sukic, 2001, p16).




As discussed in the previous sections, farmers may incur a net welfare loss in terms of a downward shift of their utility curve because of the net costs from EMS implementation. This is illustrated in Figure 2.6 as the downward shift of the utility curve from $U_0$ to $U_1$. Thus, economic compensation from governments is needed to restore the original utility, when there are not enough rewards from the market for EMS products.

The contingent valuation method (CVM) is consistent with welfare economics as it asks for an estimate of their willingness to pay (WTP) or willingness to accept (WTA) compensation for a new practice. The WTP is the maximum amount of money which can be paid by the individuals for a higher level of utility, while the WTA is the minimum amount of money asked by individuals after their utility level is lowered from changes of environmental amenities to return them to the initial utility level. WTP and WTA can be used to estimate respondents' CV or EV in the form of income compensation to restore the initial welfare level, contingent on the hypothetical situations (Bishop et al, 1995).

### 2.5.3 Development and concerns of the contingent valuation method (CVM)

#### 2.5.3.1 Development and application of CVM

CVM originated from Ciriacy-Wantrup who began to use interview methods to estimate the value of natural resources in 1947 (Mitchell and Carson, 1989). Since then, CVM has become a non-market valuation method with broad applications in valuing public goods and environmental amenities. The range of CVM varies from valuation of outdoor recreations (US Water Resources Council, 1983), national parks (Gunning-Trant, 1996), pollution from plant emissions (Bowker and MacDonald, 1993), applications of new technology (Hudson and Hite, 2003) to subsidizing agro-environmental measurement (Vanslembrouck et al, 2002). More applications of CVM can be found in Carson et al (1994) of over 1,600 contingent valuation studies.

Besides these CVM applications, comparisons with other valuation methods and theoretical studies have also demonstrated the reliability of CVM. The results from CVM studies are not significantly different from other methods that rely on market behaviors, such as TCM and HP (Ready et al, 1995). Mitchell and Carson (1989) validated the theoretical foundation of CVM, based on individual attitude-behaviour relationships.

Thus, CVM has gained wide recognition in predicting welfare changes. For instance, the US Environmental Protection Agency (EPA) lists CVM as one of the four basic methods for valuing environmental benefits of proposed regulations (US Environmental Protection Agency, 1983). A panel of distinguished experts, including two Nobel Laureates in Economics, organized by the National Oceanic and Atmospheric Administration (NOAA) of the US Department of Commerce, supported the use of CVM for non-use value, stating "CV studies can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive-use values." (US Department of Commerce, 1993, p. 4610).

**2.5.3.2 Validity concerns of CVM**

In economics, it is often assumed that preferences observed from market behaviors are credible, e.g. market prices. From a psychological perspective, valuation through a survey method is more difficult than through a market because respondents are unfamiliar with the procedure (Bishop et al, 1995). Under CVM scenarios, respondents have few references for valuation as they do in the real market. The value elicited from CVM is often under suspicion and often questioned on its accuracy, since it is based on subjective judgment in the survey rather than objective observations from the market. The NOAA panel also expressed concerns about the reliability of the values from CVM, which is sensitive to the details of the survey (US Department of Commerce, 1993).

CVM is controversial also because of the potential for bias. To elicit valid values, respondents should be willing and able to reveal the values in the survey, which can be categorized into value formulation and value statement and form two sources of bias (Bishop et al, 1995). The bias associated with value formulation may arise from limited time and information in valuation under the hypothetical context of a CVM. The bias associated with value statement is related to mistakes in statement, e.g. choosing a wrong number or eliciting untrue values. Since people are always sensitive when stating economic values, they may act strategically to give a higher value for WTA or lower value for WTP than their true values, when they realize their values may have an effect on their welfare (Mitchell and Carson, 1989).

Additional incentives and more information from a thorough description as well as enough response time are expected to improve elicitation and reduce bias in CVM (Ready et al, 1995). However, these measures may incur high costs without eliminating biases in design and implementation. This is because the theoretical construct under valuation in CVM is unobservable and represented by the WTP or WTA, such as utility changes from the change in environmental amenity. This causes inherent uncertainties for a respondent to elicit their values, which include the uncertainty in the utility, the uncertainty in assigning economic values to the change in environmental amenity, and the uncertainty in the trade-off of money to compensate for utility changes (Ready et al, 1995). In addition, CVM elicits a series of different individual estimates to certain change of amenity. However, unlike psychologists focusing on individual subjects, economists focus on aggregates and averages in terms of the mean WTA or WTP (Bishop et al, 1995). Therefore, a sound framework and an appropriate CVM elicitation method should be applied to provide sufficient information and incentives to the respondents.

### 2.5.4 The mechanism and framework of CVM

In CVM, surveys are used to gather individual welfare estimates from a selected sample of a target population. The data then are aggregated to determine the value for the whole population for a qualitative or quantitative change of a non-market good, e.g. the mean WTP/WTA. After examining the aggregate values in accordance with different levels of amenity changes in the good for valuation, an aggregate demand curve can also be developed.

The CVM framework includes sampling, survey and scenario design, survey implementation and data collection, statistical analysis and elicitation of WTA or WTP as well as validity analysis (Mitchell and Carson, 1989). Validity analysis is used to measure reliability in terms of the degree to which CVM matches the theoretical construct. Attention should be paid to each step to guarantee the validity of CVM.

#### 2.5.4.1 Sampling population and survey types

The theoretical objective of CVM is to find an aggregate value for everyone associated with a change in environmental amenity. In order to assure the selection of a representative sample, Dillman (2000) suggests the necessary principles for a correct sampling frame. Probability sampling techniques are preferred in choosing the sample with equal chances out of the total population. In addition, a sufficiently large and representative sample is needed for robust statistical inferences.

It is also crucial to choose a proper survey instrument to gather enough accurate information from the respondents. There are several options available: personal interviews, telephone contacts, and a mail survey. Each has its own strengths and weaknesses. Although the first two are recommended for gathering accurate information with high response rates, they are costly and time-consuming, and not suitable for a large sample in a survey with many questions. Conversely, a mail survey can be applied to a large sample size, with a large number of questions at a low cost. A mail survey also allocates respondents more time to determine their valuation. However, a disadvantage of this method is a low response rate, high non-item response rates, and delays in responses (Dillman, 2000).

#### 2.5.4.2 Scenario design

Scenario design provides the content of the survey, including the hypothetical situation, the good for valuation and the questions of valuation, as well as questions about respondents' characteristics and knowledge of the good, which may influence the values elicited (Mitchell and Carson, 1989). CVM should fulfill the requirements of three types of validity: content validity, construct validity, and criteria validity (Bishop et al, 1995). Content validity deals with information reliability in the scenario design. Construct validity and criteria validity are the measures of consistency of CVM values with the theoretical construct and other valuation methods, which will be discussed in the next section.

A well-defined scenario should be understandable with appropriate information on the hypothesized changes of the non-market good so that respondents can evaluate the welfare changes and elicit their true WTP/WTA values. Although insufficient information for valuation is often a major concern, "information overload" may make respondents bored with the survey questions, so as to lower the response rate and the accuracy of the answers (Grether and Weilde, 1983). There are many ways to encourage respondents' participation in the survey. A bonus or gift sent with the survey and follow-up mailings may help to raise response rates (Dillman, 2000). However, a more effective way is to make respondents understand that the survey they are filling is of importance (Baker, 2001). Qualitative and quantitative pre-testing is required to examine communication effectiveness of the survey and to improve the response rate before the formal survey is implemented, especially in a survey with a large sample (Bishop et al, 1995).

Effective scenario design needs to specifically focus on the good, the payment mechanism, and the context of the valuation. The good should be explicitly defined in the following aspects: attributes of the good, reference and target levels, the source of the changes, the extent and time of changes, and the certainty of the change (Bishop et al, 1995). The payment mechanism is sensitive to respondents in valuation and should be considered in the following four aspects to ensure accuracy: the payment vehicle, decision-making unit, timing of the payment, and relevant prices (Mitchell and Carson, 1989). Bateman et al (1996) found that WTP elicited from entrance fees were higher than by an annual tax for the valuation of recreational sites. Therefore, the payment mechanism should be neutral with respect to respondents to reduce the bias in WTA/WTP. The context of valuation should also be specified, e.g. valuation of private goods or public goods, including participants, in terms of WTP or WTA (Bishop et al, 1995). Mitchell and Carson (1989) found that WTP tends to have downward biases while WTA has upward biases, compared with values from simulated markets. The choice of

WTP or WTA should be based on the attributes of the good, the hypothetical scenario and the survey subjects.

### 2.5.4.3 Construct validity and criteria validity

Construct validity deals with the degree the measure from CVM is related to other measures from theories. Mitchell and Carson (1989) showed two forms of construct validity: convergent validity and theoretical validity. Convergent validity measures the degree of convergence that the measures from CVM coincide with measures from other methods. For example, the results from empirical studies of CVM can be compared to those from the travel cost method. Bishop et al (1983) concluded with studies that CVM and the other two methods have consistent results in their studies. Thus, convergent validity can be treated as a first sign of construct validity.

Theoretical validity evaluates the degree to which the results from CVM are consistent with economic theories. It is usually measured by regressing the WTP/WTA on a group of socioeconomic variables that may influence people's WTP/WTA. The sign and size of the parameters will be compared to see whether they are in accordance with theoretical explanations.

Criterion validity examines the degree to which the CVM measure is consistent with existing criteria, which is close to the underlying construct of the good. For non-market goods, results from simulated markets can be treated as criteria for CVM measures (Kealy et al, 1990). Mitchell and Carson (1989) and Kealy et al (1990) examined values from CVM and simulated market experiments and found criteria validity of CVM in private goods.

### 2.5.5 Elicitation methods

In CVM studies, several methods can be used to elicit respondents' WTP/WTA. These can be classified into continuous and discrete methods (Mitchell and Carson, 1989). Continuous methods ask respondents to provide continuous values for WTP/WTA. This approach includes the open-ended (OE), bidding game (BG) and the payment card (PC) methods. Discrete choice methods ask respondents if they accept the given discrete bids as their WTP/WTA and create intervals of WTP/WTA. Discrete choice methods include dichotomous choice (DC). In addition, uncertainty in responses has become a major concern in CVM and several methods have been developed to deal with this concern, such as polychotomous choice (POC) and the multiple bounded discrete method (MB).

#### 2.5.5.1 Elicitation methods without consideration of uncertainty

Elicitation methods without considering uncertainty include OE, PC, BG and DC. OE questions ask respondents to give their WTP/WTA in monetary terms directly. PC questions ask respondents to choose a certain value from a set of given amounts as their WTP/WTA. DC methods ask respondents to answer whether they accept the given values as their WTP/WTA or not. These methods can be applied in interviews or by mail. BG asks respondents in interviews to judge their WTP or WTA by adjusting values given to them until they accept a value. Since BG needs a great deal of feedback from respondents, it cannot be used in a mail survey.

Beside the variations in elicited values from respondents' different preferences, studies have demonstrated that different elicitation formats can lead to different value estimates and different response rates for the same good (Ready et al, 1996; Welsh and

Poe, 1998). Brown et al (1996) found that there are systematic and significant differences between values elicited by continuous and discrete methods for the same good because of their own source and stimuli of biases. There are strengths and weaknesses in each approach, with respective proponents and opponents.

From the point of view of statistical analysis and precision, continuous methods, e.g. PC and OE, have an advantage over discrete methods with more elicited values, compared with the DC method, which can only create intervals by determining if certain given values are lower or higher than an individual's WTP/WTA. Elicited values from DC were found to be consistently higher than those from continuous methods in WTP (Brown et al, 1996; Bateman et al, 1999). In addition, the given values are difficult to determine according to the respondents' WTP/WTA before the survey (Ready et al, 1996; Loomis, 1990). DC can also cause biases from the respondents since the initial value is given. These biases take the form of "yea saying", anchoring, starting points, and first response effects (Mitchell and Carson, 1989).

From the point of view of administration ease and response rates, the DC method has greater similarity to an actual purchase or voting decision. As a result, respondents are more comfortable in responding to this format than to the continuous format (Arrow et al, 1993). In addition, Bateman et al (1999) found that with continuous methods, especially OE, respondents may respond based on risk-averse strategies and to understate their WTP values. This creates the "free riding" effect.

Thus, a balance should be reached between accuracy and ease in the choice of a CVM format. Ready et al (1996) suggested four factors in choosing an appropriate elicitation method. These include: ease of administration, respondents' burdens from the survey, precision of the estimates for the provided WTP/WTA, and the bias of the method in the estimates of WTP/WTA.

### 2.5.5.2 Elicitation methods with consideration of uncertainty

#### 2.5.5.2 .1 The polychotomous choice method

The elicitation methods discussed above assume that there is no uncertainty in respondents' valuation and choices. However, uncertainties are normal among respondents in CVM surveys. Some discrete methods have been developed with consideration of uncertainty, including POC and MB, assuming that people have uncertainties in their exact WTP/WTA, but within a range in which the actual value lies (Ready et al, 1995).

In the process of POC, respondents are provided with bid values to be compared with their true WTP/WTA, as with the DC method. However, instead of choosing from yes or no for a given value, respondents select their degree of certainty from a set of certainty levels, e.g. definitely yes, probably yes, not sure, probably no, and definitely no. An ambivalence region can be constructed in which the real value could fall, by the data gathered on respondents' choices over bid values, e.g. between a bid value with a high degree of certainty of yes and another bid value with high degree of certainty of no. The real value is assumed to be within the boundaries of this ambivalence region.

#### 2.5.5.2.2 The multiple bounded method

Welsh and Poe (1998) developed the multiple bounded discrete method (MB), which has a format of a two dimensional matrix. The first column in the left provides a series of bid values to be judged from low to high. In the top row, different levels of certainty are identified, e.g. "definitely yes", "probably yes", "uncertain", "probably no" and "definitely no". Like the POC method, respondents are asked to choose a degree of certainty on each bid value. Compared with the POC method, that only identifies a rough ambivalent region from a few bid values, the MB method divides a series of interval values into smaller ranges of ambivalence with lower level of uncertainty (De Maio Sukic, 2001). Thus, the MB method can locate true values more precisely than from the POC.

In addition, MB has the associated characteristics of efficiency and generality over other elicitation methods. Welsh and Poe (1998) compared the results from MB and other methods: OE, PC and DC, and found that consistent inferences of these methods fall into the range of MB estimates. These three methods can act as special forms of the MB method without considerations of uncertainty.

On the other hand, questions are also raised for MB as well as POC methods in dealing with uncertainty. Loomis and Ekstrand (1997) found that the same degree of certainty people choose may not reflect their real levels so that the accuracy of the ambivalent region derived from POC or MB may not be consistent. In addition, respondents may be confused with the formats and need more time and mental work to make choices in MB or POC questions. However, the empirical work using MB for valuation (Welsh and Poe, 1998; De Maio Sukic, 2001), has demonstrated advantages of accuracy of estimation with consideration of uncertainty, which can trade off its disadvantages for broader application in CVM studies.

The bid values are often given in monetary values for WTA questions in MB. However, in this EMS study, the WTA may vary dramatically among respondents because capital inputs and opportunity costs of the implementation of EMS vary according to production types, farm sizes, as well as the environmental situation on the farms in different regions. This problem causes difficulty in assigning bid values. Instead, bid values in forms of percentages of direct costs of EMS are provided in Question 12 in the survey. The intervals range from 0% to 120% of the direct expense on the implementation of an EMS on farm, at increments of 20%. Intervals less than 100% provide farmers with options of the net costs less than total direct costs because of the benefits related to EMS. The intervals over 100% give farmers choices to estimate their additional opportunity cost beyond total direct expenses in the implementation of an EMS. Besides the concerns of the MB method, bid values in the percentage format may increase uncertainties of respondents, especially when the whole direct costs and related opportunity costs are unknown when farmers fill out the survey. Upward biases in WTA are expected due to farmers' risk-averse reactions to these uncertainties. In addition, a low response rate or a high number of non-response items were also expected for this question.

# CHAPTER 3 METHOD

The method chapter includes sections on survey development, implementation and analysis of Quebec farmers' perception and attitudes concerning the agro-environment and an Environmental Management System (EMS), as well as the estimation of their mean willingness to accept compensation (WTA) to adopt an EMS. Since the survey is designed to achieve qualitative and quantitative validity, a recognized procedure should be followed. In the stages of survey development and implementation, the Tailored Design Method (TDM) was followed. The TDM is based on the social exchange theory of informative and effective communication. For detailed information on TDM, please refer to Dillman (2000).

## 3.1 Survey development

Survey development includes choosing the target population, sample design, survey technique and questionnaire development. Attention should be paid to reduce four types of errors: the coverage error, the sampling error, the measurement error, and the non-response error (Dillman, 2000). The coverage error happens when everyone in the population does not have an equal probability of being chosen. Sampling errors occur when the sampling misses some subsection of the target population. Measurement errors occur when the answers from the survey are not comparable among the respondents. Non-response errors refer to the situation where the opinions from the sampled people are different from those outside the sample.

### 3.1.1 Population and the survey sampling

This sample design was aimed at reducing the four types of errors and ensuring the validity of the study, in a cost effective manner. The target population of this survey was 28,459 Quebec farms. The number is the result of dropping farms with annual farm receipts less than $10,000 from the total number of farms (32,139) in the Census of Agriculture (Statistics Canada, 2002b). The total sample number was 4500, which was chosen from the target population following a process of stratification and probability sampling. Sample farms were divided into four categories with 1,125 farms in each, according to production type: cereal, dairy, pork and others. Cereal, dairy and pork were singled out because they are the most important productions in Quebec, in terms of economic and environmental influences (Cloutier, 2003). The overall sampling rate was 15.8% (4,500/28,459) and those for each type of production were 29% (1,125/3,828) cereal, 12% (1,125/9,109) dairy, 51%(1,125/ 2,185) pork and 8% (1,125/13,337) others.

Furthermore, each category was divided into six subsections according to annual farm cash receipts, before probability sampling was used in each subsection. The sample ratio of each subsection in the production category was designed to be equal to the portion of the category in the population. Thus, farms from each income category have the same chance of being chosen in the same production category. For example, the number of cereal farms with an income level of $10,000-24,999 is 696, which accounts for 18% of all 3,828 cereal farms. Accordingly, 203 (18% of 1,125) cereal farms at this income level were chosen as the sample of cereal farms. This sample framework maintains the structure of farm income in each production category. For sample structure and specific numbers, please refer to the sample design in Table 4.2 (Page 83).

Dillman (2000) describes four factors deserving of consideration to choose the sample size in probability sampling: the required level of the sampling error, the population size, the variation in the population and the confidence level of the sample for the population. Equation (3.1) was used to choose the proper sample size: Ns represents the sample size, Np represents the population size, P*(1-P) represents the variation level, B represents the accepted sampling error and C represents the value for the confident level. For example, for the 95% confident level, the value of C equals 1.96.

$$Ns = \frac{Np*P*(1-P)}{(Np-1)*(B/C^2)+ P*(1-P)} \qquad (3.1)$$

Compared with the sample size based on the calculation from Equation (3.1) (Dillman 2000, pp207-208), the absolute numbers and proportional shares of the sample in each category of this study are large enough to ensure a low coverage error and sampling error. In addition, because of the large size of the sample, the survey covers all seventeen agricultural regions in Quebec. Thus, it becomes one of a few surveys studying regional differences in Quebec Agriculture (Baker, 2003).

Random sampling is favored to acquire precise and representative information from a population in terms of a statistical distribution in a cost effective manner (Bishop et al, 1995). However, the heterogeneity of the population and the size of the sample can affect the accuracy and robustness of the sampling significantly (Groves, 1989; Salant and Dillman, 1994). The combination of stratification and probability sampling can reduce the sampling error, the measurement error, and the non-response error. This categorization ensures that Quebec farms in the same category have an equal probability of being chosen in the sample.

### 3.1.2 Survey technique

Self-administered techniques, such as mailing, are popular in survey studies. Their advantages over other methods such as interviews, by telephone or in person, are in terms of their cost-effectiveness, coverage of content, and sample sizes (Dillman, 2000). Since this survey includes 4,500 farmers in Quebec and contains many questions, a mail survey was chosen as the survey technique.

### 3.1.3 Questionnaire development

Questionnaire development is the key to content validity of a survey. The aims of questionnaire development are to improve communication and interest of the respondents, through facilitating cognitive processes and creating incentives in a reader-friendly manner. The principles of motivation were adopted in accordance with Dillman (2000) in pretest and questionnaire design. A multidisciplinary team with expertise in agriculture, economics and psychology was formed to deal with this complex social issue.

The pretest and the questionnaire design were conducted by Brunson (2002). The procedure of the pretest followed Dillman (2000, pp.141-146). Initially, questions were prepared concerning the agro-environment in Quebec based on previous studies and consultation with experts. Four French-speaking farmers and eight English speaking farmers who had different production types were chosen to complete the preliminary survey. Their selection was based on intentional sampling from the Quebec Farmers' Association and other partners in the industry. After completing the survey, an in-depth interview was carried out with the pre-testers using broader questions on agro-environmental and management issues. The comments and suggestions were recorded to revise the questionnaire. This step is called a "cognitive interview" by Dillman (2000, pp.142-143). After the interview, four experts reviewed and commented on the questions and survey formats before revisions were made. After several rounds of pre-tests using different subjects, the questionnaire was finalized.

## 3.2 Survey implementation and instruments

### 3.2.1 Survey implementation

The design of the survey instrument included an introductory letter, questionnaire, and reminder post cards. Survey implementation included the procedures of mailing and time control. Multiple mailing was used to increase attention to the survey and provide an incentive for respondents to complete the survey and improve response rate (Dillman, 2000).

The introductory letter was mailed in March, 2003 to the selected producers. Three days later, the formal questionnaire was sent along with a prepaid self-addressed envelope. The questionnaire contained an incentive to encourage participation. The respondents could choose between four charities that would receive a $1 donation for each completed and returned questionnaire. Two reminder postcards were sent after the deadline date for return of the questionnaire to remind the respondents. Multiple mailing, prepaid return envelopes, and the financial incentive were recommended by Dillman (2000) to increase the response rate of the survey.

### 3.2.2 Introductory letter

Survey instrument design followed the recommendations of Dillman (2000) to build trust through enhancing incentives for the respondents. The letter identified the universities that were undertaking the research--McGill University and l'Université du Québec à Montréal (UQAM), and the support for the research--Ministère de l'Agriculture, des Pécheries et l'Alimentation du Québec (MAPAQ). The professors in charge of the research signed the letter. This was expected to improve the legitimacy and credibility of the survey.

The letter explained that the purpose of the survey was to study producers' environmental perceptions and priorities for the agro-environment management on their farms. The salient topics of the agro-environment were expected to arouse interest in the respondents. The importance of their participation was explained in terms of their opinions being used for research and policy development. It was stressed that their opinions would represent many other producers in Quebec who were not in the sample. This was supposed to strengthen the respondents' responsibility in representing values of all Quebec farmers. In addition, it was also stated that each returned survey would result in a one-dollar contribution to a designated charity organization. In this way, this survey provided not only financial incentives for the respondents, but also social validation, which were suggested by Dillman (2000). The concern of privacy was affirmed in the letter that personal information would be kept confidential and links to the respondents would be destroyed after the study, with only group information shown in the study results.

### 3.2.3 The questionnaire

The questionnaire was designed to reduce non-response errors and measurement errors and is included in Appendix II. The questionnaire is a booklet of 12 pages starting with a cover page that had the survey logo, a title "McGill-UQAM Survey on Farm Environmental Management— A Survey of Quebec Producers", a map of the 17 agricultural regions in Quebec and a notice of the deadline date to return the survey, as well as appreciation and donation information. The second page is the instruction information, which basically repeats the introduction letter with additional explanations on how to fill out the survey and that there is no wrong or right answer for each question.

From page 3 to page 12, there are 7 sections and 33 questions. The first section includes question 1, asking which charity from the list the respondents would like to support. Section 2 includes question 2 and question 3 on farm environmental management. Question 2 asks respondents to choose environmental management practices that they have adopted by choosing "Yes", "No" or "Not applicable" to identified practices. Question 3 asks respondents to rank the top three environmental challenges on their own farms. These questions were expected to provide information on what are the current priorities in the agro-environment from the producers' view and what practices they have adopted so that acceptable practices or policies can be developed.

Section 3, including question 4 and 5, asks about the benefits and difficulties in adopting environmentally friendly farming practice. These questions follow a Likert scale, which ask respondents to express their levels of support for a statement by choosing from five options, ranging from "strongly agree" to "strongly disagree", represented by 1 to 5, respectively. Since the adoption of environmentally friendly farming practices is expected to happen when there are net benefits to farmers, it is necessary to collect producers' opinions on the costs and benefits of these practices.

Section 4 includes question 6, dealing with farmers' perceptions of environmental regulations for farms. It also follows a Likert scale in asking respondents' attitudes towards statements on environmental regulations on farms ranging from "strongly agree" to "strongly disagree", represented by 1 to 5. This section was developed through pretest and previous study that farmers have significant concerns with environmental and agricultural regulations in Quebec (Brunson, 2002; Baker et al, 1999.) The statements consist of regulation development and enforcement. Since ISO 14000 EMS is an example of voluntary compliance to regulations, it is necessary to examine Quebec farmers' attitudes towards the regulation to promote an EMS on which institutional improvements can be based.

Section 5 includes questions from 7 to 12, which deal with farmers' knowledge on environmentally friendly farming practices and willingness to accept compensation (WTA) for an EMS. Questions 7 and 8 ask if respondents know about the Plan agro-environmental de fertilization (PAEF) and whether they are satisfied with it. Since PAEF has been mandatory in Quebec for fertilizer management on farm by 2002 (Canadian Pork Council, 2002), many farmers should be familiar with it. In addition, since a PAEF has similarities with an EMS in many aspects, an EMS can be introduced based on the application and satisfaction of a PAEF. Question 9 asks respondents how familiar they are with the concept of ISO 14000. Respondents can choose from "very knowledgeable" to "Not previously heard" rated 1 to 4. In question 10, the concept of an EMS was introduced and respondents were asked how familiar they are with it in a similar format as that in Question 9.

In Questions 11 and 12, respondents' WTA to adopt an EMS were examined. Question 11 asks the respondents who have no experience with EMS on their farms to continue directly to Question 12, while those who have implemented an EMS to leave out question 12. This is to reduce biases and maintain the hypothetical nature of the contingent valuation method. In Question 12, the hypothetical situation was identified by the statement: "How likely is it that you would be able to implement an EMS on your farm if the following subsidies were available to cover the direct costs of implementation." The good to be valued is an EMS on farm and the payment is the level of a subsidy for the direct costs of implementation. The following multiple-choice question has a two dimensional format with the first column listing the percentage of the subsidy from 0% to 120%. For each given value, there is a Likert scale with five choices representing a level of certainty, varying from "Definitely No" to "Definitely Yes", represented by 1 to 5. Respondents were supposed to choose a certain level of certainty for each bid value. The certainty of choice level was supposed to increase along with the increase in the bid value. For example, respondents may choose "absolutely no" to 0% in the adoption of an EMS, while choosing "probably no" with respect to a 20% subsidy.

This question was essential to calculate Quebec farmers' WTA to adopt an EMS on their farms. The WTA context was used based on many EMS programs with subsidies (Schulman et al, 2000) as well as from pre-tests in consideration of the low response rate if a willingness to pay format was used (Brunson, 2002). In addition, many uncertainties in costs and benefits related to an EMS encouraged us to use the percentage format rather than specific monetary amounts (Thomassin, 2002).

Section 6 asks general information of the respondents, including demographic information on age, education, and gender as well as business information on ownership, size of farm, farm cash receipts in 2002, production type, years in business, the region in which the business is located and other questions such as computer use and Internet access. These questions were necessary to examine the criteria validity of the survey. Section 7 asks for additional comments from respondents on farm environmental management, and the survey. Finally, our appreciation was expressed once more and affirmed the date and the address for returning the questionnaire in case of the loss of the return envelope.

### 3.3 Model specification

Model specification includes model construction as well as choosing and defining variables to be involved as explanatory variables besides the given bids in a maximum likelihood estimation model. The choice and definition of these variables are based on economic theory and common sense that may affect the respondent's willingness to accept compensation (WTA) to adopt an EMS. Three domains of independent variables were considered, following Vanslembrouck et al (2002): attitudes and perceptions towards the agro-environment, farm operational variables, and demographic variables. To examine the mean WTA of Quebec producers, French-speaking producers and English-speaking producers, three models are established accordingly: Model ALL, Model French and Model English. Table 3.1 categorizes explanatory variables with names and hypothesized impacts on WTA, which will be explained in detail following the sequences of the survey questions.

### 3.3.1 Variables

**Dependent variable**

The dependent variable is defined as the probability that a producer does not accept a given bid value as the WTA compensation to adopt an EMS. It is assumed that this variable follows a logistic cumulative distribution, which means that the probability of refusing a given bid decreases as the given bid value increases. The parameters of the logistic curve from the regression were then used to estimate producers' mean WTA compensation to adopt an EMS.

**Table 3.1 Classifications of the explanatory variables**

| Attitudes and perceptions | | Farm operation variables | | Demographic variables | |
|---|---|---|---|---|---|
| **Name** | **Impacts** | **Name** | **Impacts** | **Name** | **Impacts** |
| **Pa--Pi** | Not clear (NC) | **Land** | Positive | **Lan** | NC |
| **Cha--Chi** | Positive | **Worker** | Positive | **Birth** | Negative |
| **ABEFP** | Positive | **Organ** | Negative | **Gender** | NC |
| **ADEFP** | Negative | **Sole** | Positive | **Local-17** | NC |
| **AER** | Positive | **Partn** | NC | **EDU1-5** | NC |
| **PAEF** | Negative | **Incorp** | Negative | **Post** | NC |
| **SPAEF** | Positive | **Prod1--8** | NC | **Comp** | NC |
| **ISO** | Negative | **Reven** | NC | **Inter** | NC |
| **EMS** | Positive | **FCR** | Negative | | |
| **Bid** | Negative | **Own** | Positive | | |
| | | **Situ1-4** | +, -, +, + | | |
| | | **Tran1-3** | -,-,+ | | |

**Bid**

Bid value is important to construct the dependent variable in the maximum likelihood estimation regression and to calculate the WTA. Bid was hypothesized to have a negative impact on the probability of rejecting the bid. This means the larger the given bid value, the smaller the probability that the respondent would reject compensation and the greater the possibility their WTAs was less than the bid value.

**Language (Lan)**

This is a dummy variable that represents the English and French speaking producers in the survey. A French respondent is represented by "1", while an English respondent is represented by "2", in compliance with the original dataset. There is no implication of this variable in economic theory. However, it was expected to reveal the impacts of different language groups on the mean WTA. This variable was only used in the Model ALL.

**Practices (Pa--Pi)**

These nine variables were in accordance with sub-questions a to i in Question 2 in the survey on whether these environmentally friendly practices were adopted on farm. Each of these variables were defined as dummies, which use "1" when respondents choose "yes" or "0" when they choose "No" or "Not Applicable" to a certain practice. The adoption of these practices may reduce the additional work required in an EMS so as to reduce the WTA demand, while maintaining these practices may need more effort with additional costs so that it may increase the WTA. Thus, the impacts of these variables were not clear in the hypothesis.

**Challenges (Cha--Chi)**

These nine variables were related to sub-question a to i in Question 3 in the survey on producers' perceptions of environmental management challenges. The respondents were asked to choose the three most serious challenges they faced. Empty response, represented by "0", means no serious challenge to the sub-question, while "3", "2" and "1" represent the first, second and third most important challenge on farm (This sequence is adjusted from that in the survey for the use of regression). It is assumed that for a certain sub-question, the higher degree of seriousness, the more additional effort would be needed in EMS and the higher the WTA. Thus, this variable was hypothesized to have a positive influence on the WTA.

**The attitude on benefits of environmentally friendly practices (ABEFP) and the attitude on difficulties of environmentally friendly practices (ADEFP)**

These two variables are in accordance with Questions 4 and 5 respectively in the survey. Each uses the average of the responses of its sub-questions to represent respondents' attitudes on the benefits/difficulties of environmentally friendly farming practices. This approach to analyzing these questions is based on Willock et al (1999). With this approach, the general attitude towards a subject includes the perceptions to its subsets. The same weight is used for each sub-question without differentiating its effect on respondents' attitudes towards environmentally friendly practices. These two variables follow a Likert scale using five values from "1" to "5" to represent the degree of agreement to the description of the sub-question, from "strongly agree", "agree", "neutral", "disagree" to "strongly disagree". According to Willock et al (1999), attitudes have an effect on people's judgement and behaviour. Thus, it was assumed that the higher the degree of agreement to the benefits or the lower the degree of agreement to the difficulties of environmentally friendly practices, the lower the compensation would be asked by the respondent. Thus, ABEFP and ADEFP were hypothesized to have a positive and negative impact on the WTA, respectively.

**The attitude towards environmental regulations for farms (AER)**

This variable is associated with Question 6 in the survey. It follows a similar Likert scale as Questions 4 and 5 and uses the average of the responses to eleven sub-questions to represent respondents' attitudes on environmental regulations for farms. It is assumed that the higher the degree of agreement to the descriptions concerning the regulations in each sub-question, the lower the compensation that would be asked to adopt an EMS. This is because an EMS is a voluntary measure to comply with regulations and the acceptance of the regulations was expected to improve the incentive in the adoption.

Thus, this variable was hypothesized to have a positive impact on the WTA compensation.

**Plan agro-environmental de fertilisation (PAEF)**

This is a dummy variable associated with Question 7. It asks respondents if they have adopted a PAEF on their farm, where "1" represents "Yes" and "0" represents "No". It assumes that producers adopting a PAEF have a lower WTA compensation to adopt an EMS because that producer's familiarity with a similar system will reduce additional work needed in implementing an EMS. Thus, this variable was hypothesized to have a negative impact on the level of WTA compensation.

**Satisfaction with PAEF (SPAEF)**

This variable comes from the response to Question 8 in the survey. This question follows a Likert scale using "1", "2" and "3" to represent decreasing levels of satisfaction. It assumed that the higher the level of satisfaction with a PAEF, the lower would be the WTA compensation for adopting an EMS. Thus, this variable was hypothesized to have a positive impact on the WTA compensation.

**Knowledge on ISO14000 (ISO) and Knowledge on EMS (EMS)**

These two variables come from Questions 9 and 10 in the survey, respectively. These questions use a Likert scale from "1" to "4" to represent decreasing levels of knowledge on ISO 14000 and EMS. It is assumed that the more knowledgeable the producers are on EMS, the more benefits they can have from the adoption, so that they will have a lower WTA. Thus, this variable was hypothesized to have a positive impact on accepting WTA compensation. Since ISO 14000 is associated with large certification costs and expenses, more knowledge about it may lead to a higher WTA compensation. Thus, a negative relation between the amount of WTA and the level of knowledge on ISO 14000 was hypothesised.

**Farmland in operation (Land) and Full time workers (Worker)**

These variables are derived from Questions 13 and 15. In Question 13, the responses were all converted into hectares. It is assumed that the larger the farmland, the more additional work would be needed in adopting an EMS, so that a higher WTA would be needed. Thus, the variable "Land" was hypothesized to have a positive influence on the WTA compensation. More full time workers on farm working on an EMS may cause additional labour costs so that a higher level of WTA compensation would be asked. Thus, the variable "Worker" was hypothesized to have a positive impact on the WTA.

**Organic production (Organ)**

This dummy variable is associated with Question 14, which asks respondents if they have or are pursuing organic certification, where "1" represents "Yes" and "0" represents "No". It assumes that organic producers are more concerned with the agro-environment than conventional producers so that they may more easily accept an EMS with lower compensation. Thus, this variable was hypothesized to have a negative impact on the WTA.

**Farm legal structure (Sole, Partn and Incorp)**

Three dummy variables were used for farm legal structures of sole proprietorship, partnership or incorporated business in accordance with Question 16, where "1" represents "Yes" and "0" represents "No" for each legal structure. These variables were included to investigate the effect of legal structure on the mean WTA compensation. It assumes that respondents from larger farms with more complicated legal structures have more resources and capacity to adopt an EMS so that they ask for a lower WTA compensation. Generally, the incorporated business is associated with large farms. Thus, the variable "Incorp" is hypothesized to have a negative impact on the WTA. Conversely, smaller farmers with simpler legal structure such as sole proprietorship have a higher WTA compensation for the adoption based on business constraints associated with their smaller size. Thus, the variable "Sole" is expected to have a positive impact on the WTA compensation. In addition, the legal structure of partnership may not have a clear impact on the WTA compensation because various sizes of business may have this legal structure.

**Production types (Prod1--8) and Revenue rate (Reven)**

Eight dummy variables are used for production types listed in Question 17 ranging from "Dairy", "Cash crops", to "Other" as the most important enterprise on farm. For each category, choosing "1" means "Yes" and "0" means "No". The revenue percentage of total farm receipts from the primary type of production is used as a variable in accordance with Question 18. These variables were included to reveal the effect of each production type and the revenue on the mean WTA compensation. It was not clear as to their hypothesized impacts on WTA compensation.

**Farm cash receipts (FCR)**

This variable was developed from Question 21, which asked respondents about their farm cash receipts in 2002, representing the farm size. A Likert scale from "1" to "10" was established for each of the ten income categories in an increasing sequence. It is assumed that large farms with more income would have more resources available to adopt and benefit from an EMS so that they would ask for a lower level of compensation. Thus, it was hypothesized to have a negative impact on the WTA compensation.

**The starting year of ownership (Own)**

This variable was derived from Question 22, representing the starting year of ownership. This variable was hypothesized to have a positive influence on the WTA compensation based on the assumption that longer term owners have established businesses and are more concerned with the agro-environment and have a lower WTA compensation than the more recent owners with more financial concerns.

**Farm situation (Situ1--4)**

Four dummy variables were used to describe the development stage of a farm in accordance with the four choices in Question 23 of "just getting established", "established and planning to expand", "established and no plan to change operations" and "plan to scale down", where "1" represent "Yes" and "0" represent "No" for each category. It was assumed that farms in the stage of "established and planning to expand" may be more receptive of an EMS and this would lower the WTA compensation, given the potential benefits from an EMS. Conversely, farms in the other stages may tend to be less interested in an EMS because of their operational constraints or concerns of the implementation costs. The variables Situ1, 3, 4 are each expected to have a positive impact on the WTA compensation.

**Farm transfer (Tran1--3)**

Three dummy variables are used in accordance with the choices in Question 24 concerning the farm transfer plan: "To child or relatives", "To a specific farm employee" and "To any willing buyer", where "1" represents "Yes" and "0" represents "No" for each category. Farms in the first two categories tend to have a specific plan for the farm transfer and have some consideration for the agro-environment. It is expected that producers from these two categories would accept an EMS more readily with less WTA than those in the last category. Thus, it was hypothesized that Tran1 and Tran2 would have a negative impact on WTA, while Tran3 has a positive impact on WTA.

**Birth year (Birth), Gender (Gender) and farm location (Local--17)**

These dummy demographic variables are in accordance with Questions 25, 26 and 31. Giannakopoulos (2000) and Bonnieux et al (1998) found that young farmers may be more environmentally conscious, thus, younger farmers are expected to demand less compensation. Birth is hypothesized to have a negative impact on WTA compensation. However, it is not clear what impacts Gender and Location variables may have on the WTA. A "1" represents "Yes" and a "0" represents "No" for each category in these variables except the variable Gender. For Gender, "1" represents male and "2" represents female. These designs are in accordance with the original databset.

**Education (EDU1--5)**

Five dummy variables are used to represent the five categories of education in Question 27 from Primary School to Postgraduate degree, where "1" represents "Yes" and “0” represents “No” for each category. It was assumed that more education would increase respondents’ environmental benefits from an EMS and reduce the WTA compensation because of more awareness and knowledge. However, a higher level of education may also lead to more information on an EMS and perceived costs so that it may cause a positive influence on the WTA compensation. Thus, no clear hypothesis was made on these variables.

**Post-secondary education (Post), computer use (Comp) and the internet (Inter)**

These three dummy variables are used in association with Question 28—30 to examine the impact of having someone working on the farm with post-secondary education, computer used in farm management, and access to the internet, where “1” represents “Yes” and “0” represents “No” for each category. Similar to the impact of education, these variables may have mixed impacts on the WTA compensation because of the awareness of EMS-related costs and benefits. Thus, no clear hypothesis was made on these variables.

### 3.3.2 Model construction

Three regression models were estimated to determine and compare the mean WTA compensation of different groups of respondents with the variables introduced above. Model ALL includes observations of all respondents and all variables listed and Bid. Model English and Model French include observations of English speaking and French speaking producers respectively, as well as all variables listed and Bid except Lan. These models are illustrated as follows:

Model ALL

WTA =f (Lan, Pa—Pi, Cha—Chi, ABEFP, ADEFP, AER, PAEF, SPAEF, ISO, EMS, Land, Worker, Organ, Sole, Partn, Incorp, Prod1—8, Reven, Own, Situ1-4, Tran1-3, Birth, Gender, Loc1-17, EDU1-5, Post, Comp, Inter, Bid)

Model ENGLISH/ Model FRENCH

WTA =f (Pa—Pi, Cha—Chi, ABEFP, ADEFP, AER, PAEF, SPAEF, ISO, EMS, Land, Worker, Organ, Sole, Partn, Incorp, Prod1—8, Reven, Own, Situ1-4, Tran1-3, Birth, Gender, Loc1-17, EDU1-5, Post, Comp, Inter, Bid)

### 3.4 The mechanism of the multiple bounded discrete model

The multiple bounded discrete model (MB) was adopted in this study to calculate the mean willingness to accept (WTA) compensation and examine the validity through testing the explanatory variables chosen. The analysis of the mechanism of the MB model follows Welsh and Poe (1998), Poe and Welsh (1995) and De Maio Sukic (2001). The MB is based on maximum likelihood estimation (MLE) to estimate the coefficients of independent variables, which are used for the calculation of the mean WTA compensation. A GAUSS program was used to perform the calculation and statistical inference, which was developed by Welsh and Poe (1998) and provided by De Maio Sukic.

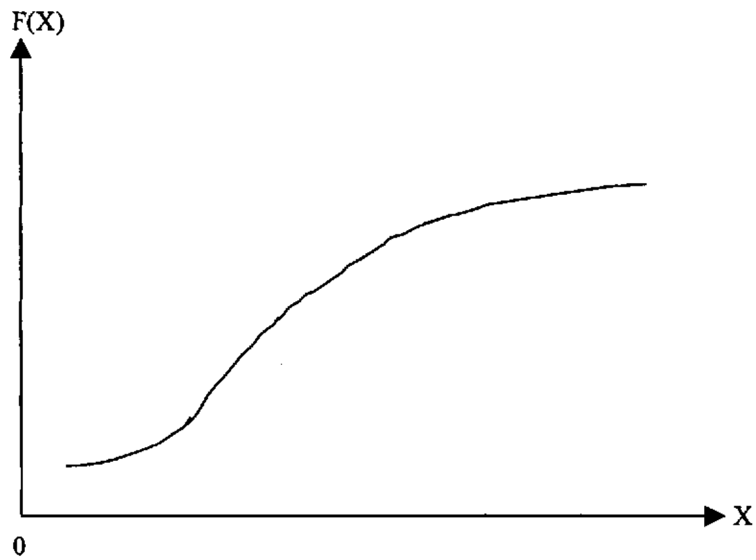
In this MB analysis, the dependent variable was defined as the probability that a producer will not accept the bid value as the compensation to adopt an EMS. In other words, it is the probability that the respondent's WTA is assumed to be higher than the given value. It can be illustrated in Equation (3.2):

$$P\,(WTA > X) = 1 - F(X,\beta) = 1 - 1\,/\,(1+e)^{-(\alpha+\beta X)} \qquad (3.2)$$

$$P\,(WTA < X) = F(X,\beta) = 1\,/\,(1+e)^{-(\alpha+\beta X)} \qquad (3.3)$$

Where X is the given bid value, β is a vector of coefficients of independent variables hypothesized to affect the respondent's WTA. F(X,β) represents the probability that producers will accept the bid X, which is assumed to happen when the producer's WTA compensation is less than the bid value X. F(X,β) was assumed to follow a logistic cumulative distribution, as shown in Equation (3.3). F(X,β) increases along with the increase of the bid value, as illustrated in Figure 3.1, adapted from Welsh and Poe (1998):

**Figure 3.1 The distribution of F(X)**




In the MB regression, the dependent variable is defined to be equal to the probability that the respondent's WTA compensation falls within two bid values. This was done in order to increase the precision of where the WTA compensation located. It can be illustrated using the cumulative probability density function of the WTA compensation in Equations (3.4)—(3.6) (Poe and Welsh, 1995):

$$P(X_{iL}<WTA<X_{iU})= P(WTA<X_{iU}) - P(WTA<X_{iL})= F(X_{iU},\beta) - F(X_{iL},\beta) \quad (3.4)$$

$$P(WTA<X_{min})=P(-\infty<WTA<X_{min})= F(X_{min},\beta) \quad (3.5)$$

$$P(WTA>X_{max})=P(X_{max} <WT<+\infty)= 1- F(X_{max},\beta) \quad (3.6)$$

Where i represents a respondent, and $X_{iL}$ and $X_{iU}$ represent respectively the lower and upper bid values, within which the WTA compensation of the respondent lies, and $X_{min}$ and $X_{max}$ represent the minimum and maximum bid values.

Assuming each observation of individual choice in the WTA compensation question represents an independent draw from the same probability distribution function, the likelihood of the selected sample used in MLE is equal to the product of these probabilities, which is illustrated in Equation 3.7:

$$\text{Likelihood} = \prod_{i=1}^{n} [\, F(X_{iU},\beta) - F(X_{iL},\beta)] \quad (3.7)$$

$$\ln(\text{Likelihood})= \sum_{i=1}^{n} \ln [\, F(X_{iU},\beta) - F(X_{iL},\beta)] \quad (3.8)$$

Since analytical solutions are not available for this likelihood function, a natural logarithm transformation of the function is often applied to achieve the values of parameters by maximizing the natural logarithmic likelihood function (Equation (3.8)). These parameters also maximize the original function because it is a monotonic transformation.

The dependent variable was then regressed on the given bid variable and other independent variables in the MLE. The outputs of the MLE are the likelihood value, the coefficient vector of explanatory variables that maximizes the likelihood and the variance-covariance matrix of these coefficients (Poe and Welsh, 1995). These were used to calculate the mean WTA compensation and examine the statistical significance of variables.

The calculation of the mean WTA compensation follows the method of Hanemann (1989) and is given in Equation 3.9:

$$\text{Mean WTA} = (1/\delta)^{*} \ln (1+e^{\gamma\mu}) \tag{3.9}$$

Where $\delta$ is the coefficient of the bid variable, $\gamma$ and $\mu$ are the vectors of coefficients from the MLE, and means of independent variables other than the bid.

### 3.5 Hypothesis tests

#### 3.5.1 Goodness of fit

Tests of the goodness of fit of the MB model are important to examine the validity of the model and statistical significance of the variables. T-tests are generally used to examine the statistical significance of each independent variable. For the overall significance of the independent variables, three methods are available: the Wald statistic, the likelihood ratio test, and the Lagrange multiplier test. The Wald test is advantageous to the other two methods in the MB model because it only requires the computation of the unrestricted likelihood function (Cuthbertson et al, 1992).

$$W=[\, R\beta - r]' \,[\, R(V)R' \,]^{-1} [\, R\beta - r] \sim \chi^2_Q \tag{3.10}$$

The Wald test (W) can be specified from Equation (3.10). R is a Q by K matrix with Q restrictions and K estimated parameters, $\beta$ is a Kx1 vector of estimated coefficients, r is a Qx1 vector of constants, and V is the estimated variance-covariance matrix of $\beta$. W asymptotically follows the $\chi^2$ distribution with Q degrees of freedom.

The null hypothesis is that the coefficients of all independent variables are equal to zero simultaneously. The calculated W value can be compared with the value of a $\chi^2(Q)$ distribution to test the null hypothesis. The null hypothesis is rejected if W is larger than the $\chi^2(Q)$ value, as a sign of joint significance of the model, and is accepted otherwise as the joint insignificance of the model.

### 3.5.2 Confidence intervals

A confidence interval (CI) of the mean WTA compensation is normally required for the statistical significance test and the validity examination compared with results from other methods (Park et al, 1991). An analytical CI using the estimated standard deviation of the mean WTA compensation is achievable, using the method developed by Cameron (1991). However, it is based on the assumption that the mean WTA follows an asymptotic normal distribution, which may not always be the case. Haab and McConnell (2002) argued that the mean WTP/WTA is often skewed from a normal distribution, based on the variation from the differences of the sample, the uncertainties in utility and the variation of the estimated vector of coefficients-- $\beta$. Instead, an empirical distribution of CI is calculated, developed by Park et al (1991), to avoid the normality assumption.

In this method, Krinsky-Robb simulations are performed to calculate the vector of the parameters of the explanatory variables and associated mean WTA through random draws, using the estimated parameter vector $\beta$ and the variance-covariance matrix V from the MLE. An empirical distribution of the mean WTA is then created after the multiple draws by ranking the simulated results. A (1-α) CI can be constructed by dropping the α/2 values from each tail of the ranked distribution.

### 3.5.3 Measuring the distribution difference

Comparisons between various groups or different levels of amenities are of interest in policy development (Poe et al, 1994). The difference between two distributions can be measured in order to compare the two distributions with a convolution method developed by Poe et al (1994). This method avoids the assumption of normality of the distributions and can be used for the empirical distributions of the mean WTA compensation with its empirical evidence of accuracy (Poe et al, 1994).

The null hypothesis of two distributions is: "$H_0$: X—Y=0", which tests the difference of the mean WTA compensation values of the two distributions X and Y. The convolution method can be illustrated in Equation 3.11. X and Y represent independent random variables with probability density functions $f_X(x)$ and $f_Y(y)$. If V= X—Y, the probability of the event V= v is all the possible combinations of x and y, which result in a difference of v.

$$P(V = v) = f_V(v) = \int_{-\infty}^{+\infty} f_X(v + y) \cdot f_Y(y)\ dy \tag{3.11}$$

The cumulative distribution functions of V for continuous and discrete observations are shown in Equation (3.12) and (3.13):

$$F_V(v^0) = \int_{-\infty}^{v^0} f_V(v)\, dv \tag{3.12}$$

$$F_V(v^0) = \sum_{\min(X-Y)}^{v^0} f_V(v)\, \Delta v \tag{3.13}$$

The two empirical distributions in comparison can be used to estimate the probability functions and the cumulative distribution functions for the convolution V. Finally, empirical confidence intervals can be estimated for the convolution distribution from Equation (3.14) and (3.15):

$$L_{1-\alpha}(V) = F_V^{-1}(\alpha / 2) \tag{3.14}$$

$$U_{1-\alpha}(V) = F_V^{-1}(1 - \alpha / 2) \tag{3.15}$$

Where L is the lower bound value and U is the upper bound value of the (1-$\alpha$) confidence interval of V. The null hypothesis is accepted if the (1-$\alpha$) confidence interval of the convolution includes zero at the $\alpha$ level of significance, which means that the two distributions for comparison are not significantly different. The null hypothesis is rejected if the (1-$\alpha$) confidence interval of the convolution distribution does not include zero, which demonstrates that the two distributions for comparison are significantly different.

# CHAPTER 4. RESULTS AND ANALYSIS

## 4.1 Survey results and analysis

### 4.1.1 Survey responses

Of the 4,500 surveys sent to Quebec producers, 1,496 copies were returned. The response rate was 33.2%, which was lower than the satisfactory response rate of over 50% in a mail survey, suggested by Bishop et al (1995). However, it was still regarded as a good result for such a large survey, considering the number received from all seventeen regions in the province, the large extent of the survey questions, and the busy spring season for producers when the survey was delivered. Among the received surveys, 23 copies were blank, because of wrong address or duplicate copies, 1,473 copies were usable for the analysis of environmental perceptions and attitudes of producers and 1,004 copies were acceptable for the question of WTA compensation. The portions are illustrated in Table 4.1:

**Table 4.1 Returned surveys and the response rate**

| Surveys | The number | Portions (%) |
|---|---|---|
| Total surveys | 4,500 | 100 |
| Surveys returned | 1,496 | 33.2 |
| Usable for attitude analysis | 1,473 | 32.7 |
| Usable for the WTA question | 1,004 | 22.3 |
| Returned blank surveys | 23 | 0.5 |

The effectiveness of the survey was also revealed from the producers' responses in the survey. Most of the returned surveys were filled out and finished, even with a large number of questions in the survey. Many respondents noted that they spent considerable time to fill out the survey and gave additional comments on agro-environmental and regulatory issues. Their comments demonstrated a wide range of concerns for the agro-environment and environmental management, including manure management, water pollution and water quality, soil erosion and run off, pollution from pesticides and fertilizer, farmers' public image and relationship with rural neighbors and the public at large as well as paper work required for environmental management.

#### 4.1.2 The representativeness of the respondents

The credibility of the survey results depends on the representativeness of the respondent sample to the whole population. Structural characteristics of the respondents were compared with those of the Quebec producer population to determine credibility. Table 4.2 and Table 4.3 compare the structures of farm types and income, while Table 4.4 compares regional distributions.

From the comparison of Table 4.2 and Table 4.3, it shows that the structures of farm types and income of the respondents are compatible with those of the population. The average farm cash receipts in the year of 2002 was in the category of $150,000 to 199,999, which included the average farm receipt of $189,800 in 2000 in Quebec, according to Statistics Canada (2002b).

## Table 4.2 The structure of Quebec producers (a)

| Total farm receipt ($) | Subtotal (b) (b1) | % | Cereal (b2) | % | Dairy (b3) | % | Hog (b4) | % | Other (b5) | % |
|---|---|---|---|---|---|---|---|---|---|---|
| 10,000-24,999 (1) | 5231 | 18 | 696 | 18 | 80 | 1 | 72 | 3 | 4383 | 33 |
| 25,000-49,999 (2) | 4161 | 15 | 697 | 18 | 259 | 3 | 105 | 5 | 3100 | 23 |
| 50,000-99,999 (3) | 4557 | 16 | 775 | 20 | 1189 | 13 | 247 | 11 | 2346 | 18 |
| 100,000-249,999 (4) | 8735 | 31 | 1040 | 27 | 5277 | 58 | 552 | 25 | 1866 | 14 |
| 250,000-499,999 (5) | 3839 | 13 | 417 | 11 | 1982 | 22 | 609 | 28 | 831 | 6 |
| 500,000 or more (6) | 1936 | 7 | 203 | 5 | 322 | 4 | 600 | 27 | 811 | 6 |
| **Total** | 28459 | 100 | 3828 | 100 | 9109 | 100 | 2185 | 100 | 13337 | 100 |
| **Total (%)** | N/A | 100 | N/A | 13 | N/A | 32 | N/A | 8 | N/A | 47 |

(a) This information is from MAPAQ, 2003. (b) (b1) = (b2)+(b3)+(b4)+(b5).

## Table 4. 3 The structure of the respondents

| Total farm receipt ($) | Subtotal (a) (a1) | % | Cereal (a2) | % | Dairy (a3) | % | Hog (a4) | % | Other (a5) | % |
|---|---|---|---|---|---|---|---|---|---|---|
| 10,000-24,999 (1) | 133 | 10 | 44 | 14 | 8 | 2 | 13 | 4 | 68 | 25 |
| 25,000-49,999 (2) | 156 | 11 | 61 | 19 | 18 | 4 | 16 | 5 | 61 | 23 |
| 50,000-99,999 (3) | 183 | 13 | 64 | 20 | 38 | 9 | 31 | 9 | 50 | 19 |
| 100,000-249,999(4) | 459 | 34 | 95 | 30 | 226 | 51 | 88 | 26 | 50 | 19 |
| 250,000-499,999(5) | 240 | 18 | 34 | 11 | 108 | 24 | 84 | 25 | 14 | 5 |
| 500,000 or more(6) | 198 | 14 | 19 | 6 | 43 | 10 | 109 | 32 | 27 | 10 |
| **Total** | 1369 | 100 | 317 | 100 | 441 | 100 | 341 | 100 | 270 | 100 |
| **Total (%)** | N/A | 100 | N/A | 23 | N/A | 32 | N/A | 25 | N/A | 20 |

(a) (a1)= (a2)+(a3)+(a4)+(a5).

First, the farm type distributions of the respondents were comparable with that of all farms in Quebec. Among all the respondents, the portion of dairy farms to all farms is the same as that in the population—32%. Cereal and hog respondents account for higher portions than those in the population (23% vs. 13% and 25% vs. 8% respectively) and other types of farmers have a lower portion than that in the population (20% vs. 47%). These results indicate that dairy, hog and cereal farmers may have more concerns for the agro-environment than other types, due to recent environmental problems with these farm types. This also confirms the initial design of the survey to put more weight on these three types of producers.

Second, the respondents' income distributions conform to those of the population. The portions of each income category of the respondents resemble those of the population. The income category of 100,000-249,999 (4) has the highest portion and other ones remain flat. Higher income categories (4), (5) and (6) account for higher portions, while lower income categories (1), (2) and (3) have lower portions in the respondents than the population, respectively. These results demonstrate that large producers are more concerned with agro-environment and environmental management than small producers, maybe because of their attitudes or capability for environmental management.

Third, the income distributions under the same farm type for the respondents also resemble those of the population. In each of cereal, hog and dairy types, the income distribution follows the pattern of having a large portions in the categories (4) and (5) and smaller portions in the other income categories. For other types of farms, the respondents mostly fall in the categories of (1), (2) and (3). However, the portion in the income category of (1) is lower than that in the population.

**Table 4.4 The comparison of regional distributions (a)**

| Region | Numbers in the population | % of the population | Numbers in respondents | % of the respondents |
|---|---|---|---|---|
| **Québec (1)** | 1,085 | 3.6 | 61 | 4.2 |
| **Mauricie (2)** | 1,169 | 3.8 | 62 | 4.3 |
| **Lanaudière (3)** | 1,700 | 5.6 | 89 | 6.1 |
| **Laurentides (4)** | 1,446 | 4.7 | 35 | 2.4 |
| **Outaouais (5)** | 1,191 | 3.9 | 25 | 1.7 |
| **Abitibi-Témiscamingue/ Nord-du-Québec (6)** | 767 | 2.5 | 28 | 1.9 |
| **Saguenay--Lac-Saint-Jean/Côte-Nord (7)** | 1,166 | 3.8 | 61 | 4.2 |
| **Montréal/Laval (8)** | 205 | 0.7 | 6 | 0.4 |
| **Montérégie (9 )** | 7,352 | 24.1 | 396 | 27.2 |
| **Centre-du-Québec (10)** | 3,588 | 11.7 | 184 | 12.6 |
| **Estrie (11)** | 2,661 | 8.7 | 151 | 10.4 |
| **Chaudière-Appalaches (12)** | 5,588 | 18.3 | 255 | 17.5 |
| **Bas-Saint-Laurent (13)** | 2,340 | 7.7 | 97 | 6.7 |
| **Gaspésie--Îles-de-la-Madeleine (14)** | 281 | 0.9 | 8 | 0.5 |
| **Total** | 30,539 | 100 | 1,458 | 100.0 |

(a)The information of the population is from 2001 Census Agriculture, Statistics Canada (2002c). http://www.statcan.ca/english/freepub/95F0301XIE/tables.htm

Table 4.4 lists the comparison of the regional distributions of farms in the province and the respondents in the survey, which coincide proportionally. The respondents cover all fourteen agricultural regions in Quebec (In order to be comparable, respondent numbers are combined in regions--Abitibi-Témiscamingue/Nord-du-Québec, Saguenay--Lac-Saint-Jean/Côte-Nord and Montérégie (East/West), respectively.). Montérégie and

Chaudière-Appalaches have the largest portions of farms, while Gaspésie--Îles-de-la-Madeleine and Montréal/Laval have the lowest portions, which are also reflected in the survey respondents.

These comparisons demonstrate that the sample of respondents is representative of the target population in terms of regional distribution and structure of income and farm types. The characteristics of the sample can be regarded as a credible proxy of the population.

### 4.1.3 Statistical results

#### 4.1.3.1 Demographic and operational results

Table 4.5 (including Table 4.5.1-- Table 4.5.4) summarizes the statistics of the respondents' demographic, education, and computer application information. The average birth year of the respondents was 1955 with the standard deviation (SD) of 11 years, which approximates the Quebec farmers' average age (Statistics Canada, 2002b). Of the respondents, 4% were English-speaking farmers, which is comparable with the agricultural population distribution—4.4% in Quebec (Quebec Farmers' Association, 2004). Of the respondents, 10% were female respondents, compared with the female farm operator population of 25.7% in Quebec (Statistics Canada, 2002b). This may be because male farm managers filled out the surveys.

The average education level of the respondents is high school, the largest portion in farm operators. The numbers of farmers having lower or higher education than high school are almost equal, each at the 30% level. This is also confirmed by the result of about 29% respondents working with someone with post-secondary education on farm.

## Table 4.5 Respondents' demographic and education information

### Table 4.5.1 Birth year

| | Average | Standard Deviation | Total number |
|---|---|---|---|
| **Birth year** | 1955 | 11 | 1448 |

### Table 4.5.2 Languages and genders

| | **English** | **(%) in total** | **French** | **(%) in total** | **Total** | **%** |
|---|---|---|---|---|---|---|
| **Language** | 59 | 4 | 1414 | 96 | 1473 | 100 |
| | **Male** | **(%) in total** | **Female** | **(%) in total** | **Total** | **%** |
| **Gender** | 1326 | 90 | 142 | 10 | 1468 | 100 |

### Table 4.5.3 Education levels

| Education | < high school | High school | College | University | Postgraduate | Total |
|---|---|---|---|---|---|---|
| **Number** | 434 | 563 | 323 | 119 | 18 | 1457 |
| **%** | 30 | 39 | 22 | 8 | 1 | 100 |

### Table 4.5.4 Information on education and computer use

| | YES | (%) in total | NO | (%) in total | Total | % |
|---|---|---|---|---|---|---|
| **Post-secondary education** | 412 | 29 | 1033 | 71 | 1445 | 100 |
| **Computer** | 952 | 65 | 517 | 35 | 1469 | 100 |
| **Internet** | 1037 | 70 | 433 | 30 | 1470 | 100 |

Computers are used by 65% of respondents to manage farm business, which is higher than the average level in the province--47.7% (Statistics Canada, 2002b). However, it is consistent with the result in 2001 Census Agriculture (Statistics Canada, 2002a) that the computer use rate increases among higher income producers. This can be explained because the sample has a higher portion of respondents in higher income categories than those of the population. Similarly, 70% of the respondents have access to the internet, compared with the provincial average of 62%. In addition, the number of respondents who have access to the internet is higher than that who use computers in farm management at home, which implies that respondents may have other access to the internet out of home.

#### 4.1.3.2 Results of farm operations

Table 4.6 (including Table 4.6.1-4.6.4) illustrates farm operation information of the respondents. The average land area of the respondents is 181 hectares, which is larger than the provincial average of 110 hectares (Statistics Canada, 2002b). However, the SD is 2,020 hectares, which shows that the land size distribution is wide among large and small owners in the respondents. The average numbers of full time and part time workers on farm are 2 and 1.5 respectively, which is also compatible with the average of 1.5 farmers on farm in Quebec, based on the fact that there are 47,390 farm operators on 32,139 farms in Quebec (Statistics Canada, 2002b). The average of the starting year to own the farm was 1926 among the respondents. There are 122 organic producers, accounting for 8% of the respondents, which is much higher than the provincial average of 1.2% (Statistics Canada, 2002b). It is not surprising to see this number because organic producers are more environmentally conscious and thus would be keen to respond in this survey. In addition, 71% of the respondents had a PAEF on farm.

Of the three legal structures, Sole Proprietorship and Incorporated Business had the largest and second largest numbers, which implies that a majority of respondent farms are family farms and incorporated farms also have a significant number in the province (See Table 4.6.2). Table 4.6.3 shows that farms getting established are only 7% of the respondents, while 2 out of 3 farms had no plan to expand or with plans to scale down.

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Concerning the transfer plans of the sample farms, half of the respondents plan to transfer their farms to children or relatives, while approximately one quarter of respondents had no transfer plan (See Table 4.6.4).

**Table 4.6 Farm business information**

**Table 4.6.1 Farm operational information**

| | Average | Standard Deviation | The respondent number |
|---|---|---|---|
| **Land** | 181 hectares | 2020 hectares | 1366 |
| **The year to own** | 1926 | 245 | 1417 |
| | **Number** | **Total respondents** | **%** |
| **Organic producers** | 122 | 1473 | 8 |
| **PAEF** | 1041 | 1473 | 71 |

**Table 4.6.2 Farm legal structures**

| Farm legal structure | Numbers | % in the respondents |
|---|---|---|
| **Sole Proprietorship** | 598 | 41.3 |
| **Partnership** | 383 | 26.4 |
| **Incorporated business** | 468 | 32.3 |
| **Total** | 1449 | 100 |

**Table 4.6.3 Farm current situations**

| Farm situation | Numbers | % in the respondents |
|---|---|---|
| **Getting established** | 103 | 7 |
| **Planning to expand** | 408 | 28 |
| **No plan to change** | 487 | 34 |
| **Planning to scale down** | 452 | 31 |
| **Total** | 1450 | 100 |

**Table 4.6.4 Farm transfer plans**

| Transfer plan | Numbers | % in the respondents |
|---|---|---|
| **To children or relatives** | 759 | 52 |
| **To farm employee** | 9 | 1 |
| **To any buyer** | 325 | 23 |
| **Don't know** | 348 | 24 |
| **Total** | 1441 | 100 |

#### 4.1.3.3 Results of environmental perceptions and attitudes

Table 4.7.1 and Table 4.7.2 list respondents' environmental perceptions and attitudes. Here, each sub-question of each question in the survey is represented by a code. For instance, 2a represents sub-question "a" of Question 2 in the survey. Please refer to the survey for the specific question (See Appendix II). Of the environmental practices adopted on farm listed in Question 2 as shown in Table 4.7.1, most have been adopted by a majority of the respondents. The largest adopted practices were: "Practise soil conservation techniques" (2a, 85%), "Conduct soil tests and or water quality tests." (2c, 90%), "Recycle packaging such as cardboard boxes or plastic containers." (2f, 85%) and "Use special disposal procedures for hazardous materials" (2g, 73%). Only a small portion of respondents participated in the Hazardous Analysis and Critical Control Points (HACCP) program (2e, 26%) or had taken training or courses on environmental farm management topics (2i, 21%). In addition, about half of the respondents belong to an agro-environmental club (2h, 48%), have a manure pit or manure treatment system (2d, 56%), or have anti-erosion measures (2b, 54%).

**Table 4.7.1 Farm environmental practices adopted**

| Question 2 | 2a | 2b | 2c | 2d | 2e | 2f | 2g | 2h | 2i |
|---|---|---|---|---|---|---|---|---|---|
| **Number** | 1240 | 788 | 1308 | 803 | 367 | 1238 | 1061 | 696 | 303 |
| **Total response** | 1457 | 1447 | 1458 | 1436 | 1407 | 1461 | 1453 | 1454 | 1441 |
| **%** | 85 | 54 | 90 | 56 | 26 | 85 | 73 | 48 | 21 |

Of the environmental management challenges on farm listed in Question 3, as shown in Table 4.7.2, each sub-question was responded to by nearly 40% of all the respondents (560/1,474). The sub-questions with largest numbers chosen as challenges are "Soil erosion and/ or soil compaction" (3e, 681) and "Manure handling and storage" (3d, 632). The three levels of importance in each sub-question (reading percentages horizontally ) were almost evenly chosen, except that 51% of the respondents chose (3d) as the most important challenge and 44% of the respondents chose "Conflicts with neighbours" (3f) as the least important challenge.

**Table 4.7.2 Top three environmental management challenges on farm**

| Question 3 | Total Responses | Most important 1 | % | Second most important 2 | % | Third most important 3 | % |
|---|---|---|---|---|---|---|---|
| **3a** | 596 | 240 | 40 | 167 | 28 | 189 | 32 |
| **3b** | 518 | 199 | 38 | 152 | 29 | 167 | 32 |
| **3c** | 569 | 174 | 31 | 226 | 40 | 169 | 29 |
| **3d** | 632 | 312 | 51 | 176 | 28 | 135 | 21 |
| **3e** | 681 | 250 | 37 | 226 | 33 | 205 | 30 |
| **3f** | 425 | 133 | 31 | 104 | 25 | 188 | 44 |
| **3g** | 496 | 145 | 29 | 165 | 33 | 186 | 38 |
| **3h** | 385 | 116 | 30 | 113 | 29 | 156 | 41 |
| **3i** | 531 | 192 | 36 | 145 | 27 | 194 | 37 |

The perceptions and attitudes towards environmentally friendly farming practices and environmental regulations are listed in Table 4.8. The mean and SD of each sub-question and each question were calculated and listed. The mean of each sub-question reflects respondents' specific perception and the average of the question reveals the attitudes towards each question—the perceived benefits or difficulties in the environmentally friendly farming practices and environmental regulations, based on Willock et al (1999).

**Table 4.8 Attitudes towards environmental practices and regulations**

| Question 4 ABEFP | Mean (SD) | Question 5 ADEFP | Mean (SD) | Question 6 AER | Mean (SD) |
|---|---|---|---|---|---|
| 4a | 2.77(1.29) | 5a | 1.86(0.95) | 6a | 2.15(0.95) |
| 4b | 2.52(1.07) | 5b | 2.13(0.99) | 6b | 3.18(1.02) |
| 4c | 2.60(1.24) | 5c | 2.47(1.08) | 6c | 3.41(1.02) |
| 4d | 3.06(1.36) | 5d | 1.92(0.89) | 6d | 2.74(1.04) |
| 4e | 3.37(1.25) | 5e | 1.96(0.92) | 6e | 3.47(1.09) |
| 4f | 3.09(1.23) | 5f | 2.71(1.16) | 6f | 3.72(0.95) |
| 4g | 2.53(1.10) | 5g | 2.70(1.15) | 6g | 3.49(1.03) |
| 4h | 2.11(0.99) | 5h | 2.51(1.06) | 6h | 4.05(0.96) |
| 4i | 2.14(0.98) | 5i | 2.12(0.97) | 6i | 3.65(1.00) |
| 4j | 1.93(0.94) | 5j | 2.85(1.03) | 6j | 2.51(1.10) |
| 4k | 1.89(0.81) | 5k | 2.97(1.11) | 6k | 2.57(0.96) |
| 4l | 2.23(1.05) | 5l | 3.10(1.08) | | |
| 4m | 1.96(0.87) | 5m | 4.12(0.87) | | |
| 4n | 3.71(1.08) | 5n | 3.88(1.01) | | |
| Average | 2.60(0.75) | Average | 2.72(0.64) | Average | 3.15(0.61) |

As shown in Table 4.8, the attitudes value towards the benefits of environmentally friendly farming practices (Question 4) is 2.60, which is between the degree of "Agree" and "Neutral" and towards "Neutral". Among the sub-questions, average respondents tend to agree with the benefits of environmentally friendly practices: "help improve consumers' perceptions of farmers" (4j), "help improve soil quality" (4k) and "reflect principles and values that are important to me"(4m), which have values less than 2. Respondents tend to disagree with the description of environmentally friendly practices: "are only necessary when the government mandate them." (4n), which has a value of 3.71 and shows that respondents perceive the value of these practices and may take them voluntarily.

As shown in Table 4.8, the attitude value towards the difficulties in the environmentally friendly farming practices is 2.72, which is towards "Neutral" (Question 5). In the sub-questions, average respondents agree that these practices "are expensive" (5a), require additional machinery/equipment (5d) and increase management complexity (5e), which have values under 2. At the same time, they disagree with the descriptions: "Other people have encouraged or pressured me not to use environmentally friendly farming practices" (5m) and "I am not interested in changing my farming practices." (5n), with mean values of 4.12 and 3.88, respectively. This means that respondents have an interest in changing farming practices to adopt environmentally friendly farming practices.

The attitude value towards environmental regulations on farm is 3.15, between "Neutral" and "Disagree" and towards "Neutral" (Question 6). In the sub-questions, there is no mean value under 2, which reflects respondents' dissatisfaction with environmental regulations. Respondents disagree that environmental regulations for farms "reflect farmers' needs and preferences"(6f), "are tailored to the needs of my region" (6g), "Producers are sufficiently consulted before environmental regulations for farms are introduced" (6h), and "Government programs and policies reward farmers for addressing farm environmental issues proactively" (6i), which have values over or close to 3.5. These perceptions show that respondents are dissatisfied with the regulations, without sufficient consideration and involvement of producers in the stage of regulation development.

**Table 4.8.1 Correlations of perceptions of benefits of EFP**

| | 4a | 4b | 4c | 4d | 4e | 4f | 4g |
|---|---|---|---|---|---|---|---|
| 4a | 1.0000 | | | | | | |
| 4b | 0.4487 | 1.0000 | | | | | |
| 4c | 0.6553 | 0.4367 | 1.0000 | | | | |
| 4d | 0.5693 | 0.5417 | 0.4889 | 1.0000 | | | |
| 4e | 0.4979 | 0.4000 | 0.4137 | 0.6674 | 1.0000 | | |
| 4f | 0.3844 | 0.2941 | 0.2987 | 0.4642 | 0.6262 | 1.0000 | |
| 4g | 0.2413 | 0.2623 | 0.2355 | 0.3343 | 0.4243 | 0.5872 | 1.0000 |
| 4h | 0.2299 | 0.3122 | 0.2524 | 0.2663 | 0.3130 | 0.3691 | 0.3706 |
| 4i | 0.4458 | 0.4151 | 0.4056 | 0.4115 | 0.4186 | 0.3974 | 0.2919 |
| 4j | 0.3002 | 0.3433 | 0.3197 | 0.3193 | 0.2802 | 0.2347 | 0.3097 |
| 4k | 0.3450 | 0.3119 | 0.3728 | 0.2889 | 0.2294 | 0.2399 | 0.2245 |
| 4l | 0.4704 | 0.4574 | 0.4191 | 0.5157 | 0.4311 | 0.3526 | 0.2624 |
| 4m | 0.3437 | 0.3149 | 0.3378 | 0.2952 | 0.2663 | 0.2776 | 0.2105 |
| 4n | -0.0738 | -0.0811 | -0.0958 | 0.0237 | 0.0584 | 0.0203 | -0.0067 |
| FCR | 0.1424 | 0.0788 | 0.0891 | 0.2056 | 0.1474 | 0.0772 | 0.0322 |

| | 4h | 4i | 4j | 4k | 4l | 4m | 4n |
|---|---|---|---|---|---|---|---|
| 4h | 1.0000 | | | | | | |
| 4i | 0.5078 | 1.0000 | | | | | |
| 4j | 0.5348 | 0.4548 | 1.0000 | | | | |
| 4k | 0.3748 | 0.4654 | 0.4126 | 1.0000 | | | |
| 4l | 0.3734 | 0.5763 | 0.3857 | 0.4940 | 1.0000 | | |
| 4m | 0.4237 | 0.5162 | 0.4187 | 0.5246 | 0.5268 | 1.0000 | |
| 4n | -0.1405 | -0.1523 | -0.1538 | -0.1973 | -0.1326 | -0.3594 | 1.0000 |
| FCR | -0.0114 | 0.1021 | -0.0387 | 0.0129 | 0.1395 | 0.0085 | 0.0690 |

| | FCR |
|---|---|
| FCR | 1.0000 |

In Table 4.8.1, the correlations of the respondents' perceptions among the attitude on the benefits of EFP as well as the correlations of these perceptions with farm cash receipts are listed. There is no significant correlation between the perceptions and farm size. However, it indicates that large producers tend to have negative perceptions on EFP in almost all the benefit aspects listed indicated by the positive coefficients between FCR and sub-questions, except 4h and 4j, which indicates that large producers tend to agree with the benefit of EFP to improve relationships with neighbours and consumer perceptions. Among the perceptions of the benefits, there are many significant correlations. 4a is positively correlated with 4c, 4d and 4e, which indicates that respondents who perceive that an EFP can make the farm more profitable tend to feel that an EFP can reduce the costs of farming operations, and result in better prices for farm products and make it easier or cheaper to get insurance.

In addition, 4d is positively correlated with 4a, 4b, 4c, 4e and 4l, which indicates that producers who believe that an EFP results in better prices for farm products also believe that an EFP makes the farm more profitable, provide access to niche markets for agricultural products, help to reduce the costs of farming operations, make it easier or cheaper to get insurance and help improve food quality. 4f is positively correlated with 4e and 4g, which indicates that respondents who believe that an EFP can make it easier to get loans from lending agencies also believe EFP can make it easier or cheaper to get insurance and make it easier to get certain government subsidies. Meanwhile, 4h is positively correlated with 4i and 4j, which indicates that producers who perceive that an EFP can improve relationships with neighbours also believe EFPs make farms safer for farmers and their families and help improve consumers' perception of farmers. In addition, 4m is positively correlated with 4i, 4k and 4l. It indicates that producers who believe EFPs reflect principles and values that are important also believe that EFPs make farms safer for farmers and their families, help improve soil quality and help improve food quality. Finally, 4l is positively correlated with 4i, which indicates that respondents who believe that an EFP makes safer for farmers also tend to believe that an EFP help improve food quality.

**Table 4.8.2 Correlations of perceptions of difficulties of EFP**

| | 5a | 5b | 5c | 5d | 5e | 5f | 5g |
|---|---|---|---|---|---|---|---|
| 5a | 1.0000 | | | | | | |
| 5b | 0.5417 | 1.0000 | | | | | |
| 5c | 0.4263 | 0.5364 | 1.0000 | | | | |
| 5d | 0.4633 | 0.3983 | 0.4481 | 1.0000 | | | |
| 5e | 0.4015 | 0.4255 | 0.4429 | 0.4919 | 1.0000 | | |
| 5f | 0.2237 | 0.2275 | 0.2858 | 0.2472 | 0.3093 | 1.0000 | |
| 5g | 0.3070 | 0.2774 | 0.3595 | 0.3081 | 0.3718 | 0.5295 | 1.0000 |
| 5h | 0.3005 | 0.2721 | 0.3333 | 0.3260 | 0.3605 | 0.4096 | 0.4658 |
| 5i | 0.2914 | 0.2547 | 0.3046 | 0.3186 | 0.3760 | 0.2547 | 0.3173 |
| 5j | 0.2839 | 0.2174 | 0.3008 | 0.2042 | 0.2412 | 0.2309 | 0.2750 |
| 5k | 0.2085 | 0.1840 | 0.2437 | 0.1219 | 0.1689 | 0.2242 | 0.2538 |
| 56 | 0.0818 | 0.0679 | 0.1532 | 0.0262 | 0.0873 | 0.1417 | 0.1117 |
| 5m | 0.0386 | 0.0646 | 0.1291 | 0.0213 | 0.0095 | 0.1158 | 0.1042 |
| 5n | 0.1139 | 0.0744 | 0.1358 | 0.0527 | 0.0740 | 0.1688 | 0.1310 |
| FCR | -0.0817 | -0.1180 | -0.0704 | -0.1178 | -0.1616 | -0.0583 | -0.1103 |

| | 5h | 5i | 5j | 5k | 5l | 5m | 5n |
|---|---|---|---|---|---|---|---|
| 5h | 1.0000 | | | | | | |
| 5i | 0.4255 | 1.0000 | | | | | |
| 5j | 0.3156 | 0.3244 | 1.0000 | | | | |
| 5k | 0.2626 | 0.2659 | 0.4894 | 1.0000 | | | |
| 5l | 0.1109 | 0.1306 | 0.2622 | 0.4589 | 1.0000 | | |
| 5m | 0.1256 | 0.0505 | 0.1367 | 0.1566 | 0.2045 | 1.0000 | |
| 5n | 0.1775 | 0.0994 | 0.1493 | 0.1600 | 0.1044 | 0.3723 | 1.0000 |
| FCR | -0.0564 | -0.0582 | -0.0232 | 0.0500 | 0.1194 | 0.1193 | 0.1782 |

| | FCR |
|---|---|
| FCR | 1.0000 |

In Table 4.8.2, the correlations of the respondents' perceptions among the attitude towards the difficulties of EFPs as well as the correlations of these perceptions with farm size are listed. There is no significant correlation among the perceptions and farm cash receipts. However, it indicates that large producers tend to agree with the difficulties of

EFPs in most aspects listed, indicated by the negative coefficients between FCR and the sub-questions, except 5k, 5l, 5m and 5n, which indicates that large producers may not feel it difficult to find trustworthy information on EFPs and enough technical support or become interested in changing farming practices.

Among the perceptions of difficulties, there are some significant correlations. 5b is positively correlated with 5a and 5c, which indicates that producers who regard adding a new EFP is time consuming also tend to believe that it is expensive and requires additional manpower. Meanwhile, 5d and 5e are positively correlated, which indicates that producers who regard adding a new EFP requires additional machinery also tend to believe that it increases management complexity. Similarly, 5f and 5g, as well as 5j and 5k, are positively correlated. These indicate that producers who believe adding a new EFP can decrease production yields tend to believe that it can also reduce the competitiveness of the farm. They also indicate that producers who believe technology that is available to solve farm environmental problems is generally not very effective. They tend to believe that it is difficult to find trustworthy information about environmentally friendly farming practices.

The correlations of the respondents' perceptions among the attitude towards environmental regulations as well as the correlations of these perceptions with the farm size are listed in Table 4.8.3. There is no significant correlation among the perceptions and farm cash receipts. However, large producers tend to have negative perceptions toward environmental regulations in most aspects, indicated by the positive coefficients between FCR and sub-questions, except 6b, 6d and 6j, which indicates that large producers may tend to believe that existing environmental regulations for farms are adequately enforced and they have enough information about environmental regulations on the farm, as well as current environmental regulations make Quebec farmers less competitive on world markets.

**Table 4.8.3 Correlations of perceptions of environmental regulations**

| | 6a | 6b | 6c | 6d | 6e | 6f | 6g |
|---|---|---|---|---|---|---|---|
| 6a | 1.0000 | | | | | | |
| 6b | 0.1110 | 1.0000 | | | | | |
| 6c | 0.2542 | 0.2370 | 1.0000 | | | | |
| 6d | 0.0815 | 0.2470 | 0.3170 | 1.0000 | | | |
| 6e | 0.2828 | 0.2260 | 0.4198 | 0.3985 | 1.0000 | | |
| 6f | 0.3008 | 0.2672 | 0.4530 | 0.2361 | 0.5351 | 1.0000 | |
| 6g | 0.2733 | 0.2468 | 0.4514 | 0.2495 | 0.4846 | 0.5884 | 1.0000 |
| 6h | 0.2406 | 0.1832 | 0.4122 | 0.2342 | 0.4717 | 0.5009 | 0.4683 |
| 6i | 0.2263 | 0.1340 | 0.3645 | 0.1668 | 0.4314 | 0.4557 | 0.4222 |
| 6j | -0.1459 | 0.0022 | -0.1859 | -0.0294 | -0.2317 | -0.2319 | -0.2135 |
| 6k | 0.2554 | -0.0169 | 0.0718 | 0.0075 | 0.0871 | 0.0883 | 0.0863 |
| FCR | 0.0123 | -0.0243 | 0.0986 | -0.0405 | 0.1119 | 0.1689 | 0.1315 |

| | 6h | 6i | 6j | 6k | FCR |
|---|---|---|---|---|---|
| 6h | 1.0000 | | | | |
| 6i | 0.4980 | 1.0000 | | | |
| 6j | -0.2242 | -0.2107 | 1.0000 | | |
| 6k | 0.0924 | 0.0936 | 0.0047 | 1.0000 | |
| FCR | 0.1555 | 0.1762 | -0.1414 | 0.0388 | 1.0000 |

Among the perceptions of environmental regulations, there are some significant correlations, listed in Table 4.8.3. 6e is positively correlated with 6f and 6g. This indicates that producers, who felt that the government does a good job of explaining why new environmental regulations for farms are needed, tend to believe that environmental regulations for farms reflect farmer's needs and preferences and are tailored to the needs of the region. 6f is positively correlated with 6g, indicating that producers who believe that environmental regulations for farms reflect farmer's needs and preferences tend to believe that these regulations are tailored to the needs of the region. In addition, 6h is positively correlated with 6f and 6i. It indicates that producers who believe they are sufficiently consulted before environmental regulations for farms are introduced also tend to believe that these regulations reflect farmers' needs and preferences and government programs and policies reward farmers for addressing farm environmental issues proactively.

Table 4.9.1 lists levels of satisfaction towards the PAEF. Of all the respondents adopting a PAEF, 85% are satisfied with PAEF, while 15% of them are dissatisfied, which is about equal to those who are very satisfied. However, respondents choosing "somewhat satisfied" account for two thirds of the total, meaning that there may be some room for improvement to increase the satisfaction level. In Table 4.9.2, levels of knowledge of ISO 14000 and EMS are listed. Significant portions of the respondents had never heard of ISO 14000 (55%) and EMS (43%). Within those who responded with some knowledge on them, most only have little knowledge, while only about 7% and 13% percent of respondents are on or above the levels of "somewhat knowledgeable" of EMSs and ISO 14000, respectively.

**Table 4.9.1 Levels of satisfaction towards PAEF**

| Levels of satisfaction | Number | % |
|---|---|---|
| **Very satisfied** | 196 | 19 |
| **Somewhat satisfied** | 679 | 66 |
| **Not at all satisfied** | 153 | 15 |
| **Total** | 1028 | 100 |

**Table 4.9.2 Levels of knowledge on ISO 14000 and EMS**

| | ISO 14000 | | EMS | |
|---|---|---|---|---|
| **Levels of knowledge** | **Number** | **%** | **Number** | **%** |
| **Very knowledgeable** | 10 | 0.7 | 24 | 1.7 |
| **Somewhat knowledgeable** | 96 | 6.7 | 167 | 11.5 |
| **A little knowledgeable** | 545 | 37.7 | 635 | 43.8 |
| **Not previously heard** | 793 | 54.9 | 623 | 43 |
| **Total** | 1444 | 100 | 1449 | 100 |

#### 4.1.3.4 Results of the WTA responses

Acceptable responses of the WTA compensation question (Question 12) are listed in Table 4.10. There were 1004 acceptable observations for the WTA compensation question. The response rate for this question was lower for several reasons: non-response, partial completion or inconsistent answers. Answers were deemed inconsistent when respondents chose NO with a high degree of certainty for a large bid value and then chose YES with a high degree of certainty for a small bid value.

In Table 4.10, the numbers of responses for each degree of certainty under different bid values are listed, as well as the percentages over the total of responses for each bid value. The numbers and percentages choosing "Definitely no" decline, while the numbers choosing "Definitely yes" increase, as the bid value goes from "0%" to "120%". This confirms the hypothesis that the probability of rejecting a given bid declines with an increase of the given bid value.

**Table 4.10 List of responses to the bid values**

| Responses / Bids | Definitely no | Probably no | Uncertain | Probably yes | Definitely yes | Total |
|---|---|---|---|---|---|---|
| **0% of Direct cost** | 714 | 140 | 105 | 35 | 10 | 1004 |
| **(%)** | 71 | 14 | 10 | 4 | 1 | 100 |
| **20% of Direct cost** | 601 | 230 | 126 | 36 | 11 | 1004 |
| **(%)** | 60 | 23 | 13 | 3 | 1 | 100 |
| **40% of Direct cost** | 467 | 242 | 210 | 65 | 20 | 1004 |
| **(%)** | 47 | 24 | 21 | 6 | 2 | 100 |
| **60% of Direct cost** | 331 | 163 | 274 | 185 | 51 | 1004 |
| **(%)** | 33 | 16 | 27 | 19 | 5 | 100 |
| **80% Numbers** | 213 | 78 | 205 | 355 | 151 | 1004 |
| **%** | 21 | 8 | 20 | 35 | 15 | 100 |
| **100% Numbers** | 81 | 26 | 80 | 316 | 500 | 1004 |
| **%** | 8 | 2 | 8 | 32 | 50 | 100 |
| **120% Numbers** | 62 | 22 | 70 | 173 | 661 | 1004 |
| **%** | 6 | 2 | 7 | 18 | 67 | 100 |

### 4.2 Regression analysis

### 4.2.1 Regression analysis of Model ALL

#### 4.2.1.1 Regression results of Model ALL

521 surveys were chosen in the regression of Model ALL, including French and English speaking producers and all the independent variables except EDU1, which was dropped to avoid perfect co-linearity with variables EDU2—EDU5. The rest of the observations were dropped because of missing values in the variables. The final regression results are listed in Table 4.11 with Bid and 32 other independent variables, which demonstrate statistical or theoretical significance of the model. Some variables were dropped from the final model after the initial regression in order to reach a valid result. The initial regression showed that each of the variables Loca 1—17 (except Loca 7, 9, 10, and 17), which were deleted due to a small number of observations and were not significant at the 10% level by the T test. The likelihood test failed to reject the hypothesis that these thirteen variables were simultaneously equal to zero at the 90% level (LR=7.44~$\chi^2(13)$). These results indicate that producers' location does not have a significant effect on their WTA compensation to adopt an EMS. Similarly, variables Pa—Pi and Cha—Chi (except Chh) were not significant at the 10% level. The likelihood test result also failed to reject the hypothesis that these variables were simultaneously equal to zero at the 90% level in (LR=18.37~$\chi^2(17)$). This result indicates that producers' current environmental practices and perceptions on agro-environmental management challenges do not have significant impacts on their WTA compensation to adopt an EMS.

Similar results also hold for the variables of farm legal structures: Sole, Partn, Incorp. None of them were significant at the 10% level and they also failed in the likelihood test to reject the hypothesis that they were simultaneously equal to zero at the 90% level (LR=0.61~$\chi^2(3)$). This showed that none of the three farm legal structures and the legal structure as a variable was significant in affecting producers' WTA compensation to implement an EMS. Similarly, the variables Situ 1—4 and Tran1—3 also showed that they were not significant at the 10% level and failed in the likelihood test at the 90% level (LR=10.79~$\chi^2(7)$) to reject that these variables were simultaneously equal to zero. This result indicates that the current operational situation and the plan to transfer the farm were not significant in affecting producers' WTA compensation to implement an EMS. Thus, these variables were dropped.

**Table 4.11 Regression Results of Model ALL**

```
-2*Log Likelihood:    1650.052813
Wald Statistic:       599.792811
Probability of a larger Wald Stat:    0.000000
Observations:        521     Degrees of freedom:      488
```

| Var | < Coef | < Std. Error | < T-Stat | < P-Value(a) |
|---|---|---|---|---|
| CONST | 14.458613 | 16.315741 | 0.886176 | 0.376 |
| Lan | -0.583328 | 0.527865 | -1.105069 | 0.270 |
| Chh | 0.181035 | 0.099826 | 1.813515 | 0.070 * |
| ABEFP | 0.454015 | 0.133632 | 3.397494 | 0.001 *** |
| ADEFP | -0.425474 | 0.140426 | -3.029879 | 0.003 *** |
| AER | 0.027758 | 0.151372 | 0.183378 | 0.855 |
| PAEF | 0.743209 | 0.897494 | 0.828094 | 0.408 |
| SPAEF | 0.266761 | 0.154924 | 1.721881 | 0.086 * |
| ISO | -0.123073 | 0.139033 | -0.885208 | 0.376 |
| EMS | 0.324657 | 0.138727 | 2.340265 | 0.020 ** |
| Organ | -0.108455 | 0.358156 | -0.302814 | 0.762 |
| Prod1 | 0.125649 | 0.551702 | 0.227747 | 0.820 |
| Prod2 | -0.069939 | 0.554555 | -0.126117 | 0.900 |
| Prod3 | -0.184918 | 0.823836 | -0.224460 | 0.822 |
| Prod4 | -0.028789 | 0.565693 | -0.050891 | 0.959 |
| Prod5 | 0.358459 | 0.630110 | 0.568884 | 0.570 |
| Prod6 | -1.345982 | 0.889240 | -1.513631 | 0.131 |
| Prod7 | 0.065362 | 1.287889 | 0.050751 | 0.960 |
| Prod8 | -0.310117 | 1.038065 | -0.298745 | 0.765 |
| FCR | 0.002868 | 0.045709 | 0.062746 | 0.950 |
| Own | -0.000432 | 0.002028 | -0.212942 | 0.831 |
| Birth | -0.004556 | 0.008443 | -0.539641 | 0.590 |
| Gender | -0.169782 | 0.317149 | -0.535339 | 0.593 |
| edu2 | -0.044057 | 0.211485 | -0.208322 | 0.835 |
| edu3 | -0.154637 | 0.244282 | -0.633025 | 0.527 |
| edu4 | -0.533884 | 0.378794 | -1.409431 | 0.159 |
| edu5 | -0.160583 | 0.818123 | -0.196282 | 0.844 |
| Post | -0.287970 | 0.184652 | -1.559528 | 0.120 |
| Inter | -0.435444 | 0.224917 | -1.936021 | 0.053 * |
| Land | 0.000544 | 0.000627 | 0.868175 | 0.386 |
| Reven | -0.002292 | 0.004515 | -0.507548 | 0.612 |
| Comp | -0.147530 | 0.221865 | -0.664954 | 0.506 |
| Worker | 0.101031 | 0.068586 | 1.473056 | 0.141 |
| BID | -0.070089 | 0.002868 | -24.439762 | 0.000 *** |

Note (a): "***", "**"and "*" denote that the variables are significant at the 1%, 5% and 10% level, respectively.

The final result shows in Table 4.11 that the model achieved a high level of overall significance with the Wald statistic significant at the 1% level and reject the null hypothesis that all the coefficients were equal to zero simultaneously (W=599.79~$\chi^2(33)$). In addition, most variables had expected signs as hypothesized.

The variable BID was significant at the 1% level with a negative coefficient. It showed a negative relationship between the bid value and the probability of not accepting this value, which was in accordance with the hypothesis. The variable CONST had no theoretical meaning. Among the 32 explanatory variables chosen in the final model, there were six variables significant at least at the 10% level—Chh, ABEFP, ADEFP, SPAEF, EMS and Inter.

The variable Chh had a positive sign as expected and was significant at the 10% level. This variable was the only significant one contrasting with other dropped variables related to environmental management challenges and practices. This result demonstrated that producers with increasing concerns about the procedures for disposal of solid wastes would demand a higher WTA compensation in the adoption of an EMS. It reflected producers' concerns for the additional work and costs in disposing of solid waste in an EMS implementation. The variable ABEFP was significant at the 1% level with a positive sign as expected. It showed that producers would ask for a higher WTA compensation for an EMS if they had a negative attitude to the benefits related to environmentally friendly practices because of less perceived benefits compared with the costs for an EMS. Similarly, the variable ADEFP was significant at the 1% level with a negative sign as expected, which demonstrated that producers with less concerns for difficulties in environmentally friendly practices would demand a lower WTA compensation. The significance of both variables shows that producers' attitudes towards environmentally friendly practices have important effects on their WTA compensation for adopting an EMS.

The variable SPEAF was significant at the 10% level with a positive sign as hypothesized, which indicates that the increasing degrees of dissatisfaction towards the PAEF would lead to higher levels of WTA compensation for adopting an EMS. The variable EMS was significant at the 5% level with an expected positive sign, which meant farmers would have a lower WTA compensation if they had more knowledge of EMS. This may be because more knowledge of EMS may reduce the uncertainty and potential costs. Interestingly, the variable Inter had a negative sign at the 10% level of significance, compared with the insignificant variable Comp with a negative sign. It demonstrates that producers with access to the internet would have a lower WTA compensation, while using a computer in farm management might lead to a lower compensation demand. This may be because producers with access to the internet are more knowledgeable about EMSs. This result reveals the effect of the internet on EMS implementation in terms of information distribution and reflects the need to introduce the concepts of EMSs to producers by various means including the internet.

Other variables were not statistically significant but were included because of their theoretical or practical importance. The variable Lan had a negative sign, which showed that English speaking producers may have a lower WTA compensation than French speaking ones. The sign of PAEF was positive, opposite to the hypothesized negative, which might imply a concern for increasing costs as experienced in the PAEF. The variable ISO had a negative sign, as expected, because of the large costs associated with

ISO 14000 EMS implementation. Thus, producers with knowledge of ISO 14000 might demand more WTA compensation in an EMS.

Production types had different effects on the WTA compensation. Dairy, beef cattle and maple syrup producers had positive signs on their variables, demanding a higher WTA compensation, while producers of pork, fruits/vegetables and cash crops, poultry/eggs and other types had negative signs on their variables, with a lower WTA compensation. This may reflect differences of perceived levels of losses and gains associated with their EMSs. The variables FCR, Land and Worker had insignificant positive signs, which demonstrated that producers with higher total farm cash receipts or larger sizes might require a higher WTA compensation because of the possible additional higher costs in implementing an EMS. The positive sign of FCR indicates that large farms demand more WTA, which is opposite to the hypothesis, because of the cost and benefit concerns. Meanwhile, the negative sign of Reven indicates that farms with a large portion of revenue from their primary production might reduce the demand for WTA compensation.

The variables Own, Birth and Gender had negative signs, indicating that young or female producers might require a lower WTA than senior or male ones, because young or female producers are more environmentally conscious and more knowledgeable about EMSs. The variables of EDU2--4 and Post had negative signs and demonstrated that producers with education of high school or above or having someone with post-secondary education working on farm might have environmental consciousness and knowledge of an EMS so that they might demand less WTA for EMS adoption.

#### 4.2.1.2 Correlations of the explanatory variables in Model ALL

No evidence of multicolinearity among independent variables in Model ALL is found through analysis of the variance-covariance matrix in Table 1 in Appendix III. Only Prod 1 and Prod 2 have a significant negative correlation, indicating that a dairy producer is less likely to be a hog producer at the same time. In addition, edu2 and edu3 have a noticeable negative correlation, indicating that producers with a highest education level of high school do not have a highest education of the college level. Inter and Comp have a noticeable positive correlation, indicating that producers who have internet access may also use a computer in farm management. In this analysis, two variables are significant correlated when they have a correlation coefficient with the absolute value equal to or larger than 0.5. This also applies to other correlation studies in this thesis.

Among other independent variables, there are also some noticeable correlations. The negative correlation coefficient between ABEFP and ADEFP indicates that respondents who have negative attitudes towards benefits from environmentally friendly practices (EFP) tend to display difficulties in adopting an EFP. The positive correlation coefficients between ABEFP and AER as well as between ABEFP and SPAEF indicate that these respondents also tend to have negative perceptions on environmental regulations on farms and tend to be less satisfied with the PAEF. In the meantime, farm size tends to be related to attitudes, which is represent by FCR. The positive coefficients between FCR and ABEFP, ADEFP and AER indicate that large producers tend to have negative attitudes towards the benefits of an EFP and environmental regulations, while they tend to be optimistic about their ability to deal with the difficulties related to an EFP. The negative coefficients between FCR and SPAEF, ISO and EMS indicate that large producers also tend to be satisfied with the PAEF, along with more knowledge on ISO 14000 and EMS. The correlation coefficients also indicate that farm types are related to farm size. While dairy, hog and poultry/egg producers tend to have a large size, indicated by the positive coefficients between FCR and Prod1, 2 and 6, other types of producers tend to have a small size.

Among different farm types, hog and cash crop producers tend to have a negative perception on the benefits of EFP, indicated by the positive coefficients between ABEFP and Prod 2 and Prod 4. Meanwhile, the negative coefficients between ADEFP and Prod 2, 5 and 7 indicate that hog, beef and maple syrup producers tend to display difficulties related to an EFP. Concerning environmental regulations, the positive coefficients between ABEFP and Prod 1, 3 and 7 indicate that only dairy, fruit/vegetable and maple syrup producer tends to have a positive attitude. Although producers of many farm types tend to be satisfied with the PAEF, fruit/vegetable, cash crop, beef and poultry producers tend to be less satisfied, indicated by the positive coefficients between SPAEF and Prod 3, 4, 5 and 6. Concerning ISO 14000, the positive coefficients between ISO and Prod 2, 5 and 6 indicate that hog, poultry and maple syrup producers tend to be less knowledgeable, compared with other types of producers. Meanwhile, major types of producers tend to be less knowledgeable on EMS, such as dairy, hog, and beef producers, indicated by the positive coefficients between ISO and Prod 1, 2 and 5.

### 4.2.2 Regression analysis of the Model French

507 surveys were chosen for the regression of the model French, including French speaking producers and all the independent variables except the variable EDU1, which was dropped due to perfect colinearity with variables EDU2—EDU5. This result was similar to that of the Model ALL because only 14 observations were dropped as English speaking producers from Model ALL. The final regression results are listed in Table 4.12 with Bid and 31 other independent variables as well as the constant.

The rest of the variables were dropped from the final model after the initial regression. The initial regression showed that each of the variables Loca 1—17 was not significant at the 10% level and the likelihood test result failed to reject the hypothesis that the seventeen variables were simultaneously equal to zero at the 90% level ($LR=9.7 \sim \chi^2(17)$). This result showed that producers' locations and the location as a variable do not have significant effects on French-speaking producers' WTA compensation to adopt an EMS. Similarly, variables Pa—Pi and Cha—Chi (except Chh) were not significant at the 10% level and likelihood test at the 90% level ($LR=18.67 \sim \chi^2(17)$). This demonstrated that French-speaking producers' current environmental practices and perceptions of environmental problems on farm do not have significant impacts on their WTA compensation to adopt an EMS.

This also happened to the variables of farm legal structures: Sole, Partn and Incorp. None of them were significant at the 10% level and they also failed in the likelihood test to reject the hypothesis that they were simultaneously equal to zero at the 90% level ($LR=0.8 \sim \chi^2(3)$). This result shows that neither of the three farm legal structures nor the legal structure itself as a variable is significant in affecting French-speaking producers'

**Table 4.12 Regression Results of Model French**

-2*Log Likelihood: 1603.595693
Wald Statistic: 581.766058
Probability of a larger Wald Stat: 0.000000
Observations: 507 Degrees of freedom: 475

| Var < | Coef | < Std. Error | < T-Stat | < P-Value (a) |
|---|---|---|---|---|
| CONST | 12.896206 | 16.389645 | 0.786851 | 0.432 |
| Chh | 0.178881 | 0.101466 | 1.762968 | 0.079 * |
| ABEFP | 0.461208 | 0.135229 | 3.410569 | 0.001 *** |
| ADEFP | -0.416443 | 0.142592 | -2.920527 | 0.004 *** |
| AER | 0.077202 | 0.154308 | 0.500313 | 0.617 |
| PAEF | 0.763435 | 0.900051 | 0.848213 | 0.397 |
| SPAEF | 0.292924 | 0.157595 | 1.858716 | 0.064 * |
| ISO | -0.090811 | 0.141182 | -0.643220 | 0.520 |
| EMS | 0.284200 | 0.142541 | 1.993811 | 0.047 ** |
| Organ | -0.033913 | 0.363015 | -0.093421 | 0.926 |
| Prod1 | 0.143250 | 0.551936 | 0.259540 | 0.795 |
| Prod2 | -0.069437 | 0.554287 | -0.125272 | 0.900 |
| Prod3 | -0.196742 | 0.826095 | -0.238159 | 0.812 |
| Prod4 | 0.037977 | 0.565821 | 0.067119 | 0.947 |
| Prod5 | 0.353798 | 0.637925 | 0.554607 | 0.579 |
| Prod6 | -1.717140 | 0.916486 | -1.873613 | 0.062 * |
| Prod7 | 0.864700 | 1.642821 | 0.526351 | 0.599 |
| Prod8 | -0.342465 | 1.039717 | -0.329383 | 0.742 |
| FCR | 0.013998 | 0.046118 | 0.303518 | 0.762 |
| Own | -0.000283 | 0.002083 | -0.135971 | 0.892 |
| Birth | -0.004328 | 0.008559 | -0.505708 | 0.613 |
| Gender | -0.107313 | 0.320732 | -0.334588 | 0.738 |
| EDU2 | -0.068282 | 0.213915 | -0.319203 | 0.750 |
| EDU3 | -0.143530 | 0.246992 | -0.581109 | 0.561 |
| EDU4 | -0.530802 | 0.383995 | -1.382313 | 0.168 |
| EDU5 | -0.161118 | 0.819700 | -0.196558 | 0.844 |
| Post | -0.306849 | 0.186415 | -1.646051 | 0.100 * |
| Comp | -0.205980 | 0.225112 | -0.915013 | 0.361 |
| Inter | -0.448651 | 0.227636 | -1.970910 | 0.049 ** |
| Land | 0.000360 | 0.000634 | 0.568985 | 0.570 |
| Worker | 0.097412 | 0.068874 | 1.414359 | 0.158 |
| Reven | -0.002997 | 0.004598 | -0.651867 | 0.515 |
| BID | -0.070280 | 0.002920 | -24.067713 | 0.000*** |

Note (a): "***", "**"and "*" denote that the variables are significant at the 1%, 5% and 10% level, respectively.

WTA compensation to implement an EMS. In addition, the variables of farm operational situations Situ 1—4 and the plan to transfer the farm business Tran1—3 also showed insignificance at the 10% level and likelihood test at the 90% level (LR=10.73~$\chi^2(7)$).

This demonstrates that current operational situations and the farm transfer plan are not significant to affect French-speaking producers' WTA compensation in EMS implementation. Thus, these variables were dropped.

The results show that the final model achieves a high level of overall significance with the Wald statistic significant at 1% level, which rejects the null hypothesis that all the coefficients were equal to zero simultaneously (W=581.77~$\chi^2$(32)). Most variables chosen have expected signs in accordance with those of the model ALL except the variable Prod 4, which means that opposite to the negative effect of being a cash crop producer on the increase of the WTA compensation to adopt an EMS, being a French-speaking cash crop producer tends to have a positive effect on the increase of WTA.

The variable BID is significant at the 1% level with a negative coefficient, which is in accordance with the hypothesis. Among the 31 variables chosen in the final model, there are eight variables significant at least at the 10% level—Chh, ABEFP, ADEFP, SPAEF, EMS and Inter, which also appear to be significant in the model ALL, as well as Prod 6 and Post, which are insignificant in the model ALL.

French-speaking producers' perception of the disposal of solid waste as a significant challenge tends to raise the WTA compensation at the 10% level of significance and the positive sign of the variable Chh. In the meantime, their attitudes towards the benefits and difficulties of environmentally friendly practices ABEFP and ADEFP also affect their WTA compensation, as both are significant at the 1% level with expected positive and negative signs respectively. Similar to the Model ALL, French-speaking producers' attitudes towards the satisfaction of PAEF and knowledge on EMSs are significant at the 10% level with expected positive signs shown as SPEAF and an

EMS. In addition, access to the internet would help to reduce the WTA compensation to adopt an EMS, as shown by the significance of the variable at the 5% level in the variable Inter.

Compared with their insignificance and signs in the model ALL, variables Prod 6 and Post are significant at the 10% level with negative signs in the model French. This result shows that French-speaking poultry/egg producers or producers working with people with post secondary education on farm would require less WTA compensation to adopt an EMS. The large size of Prod 6 indicates that French-speaking poultry/egg producers may have a much lower WTA compensation. As many poultry/egg farmers have large revenues, they may expect to benefit more from EMS adoption than other types of farmers. It also shows that producers working with people with post-secondary education on farm may have more knowledge of EMS and expect to have more benefits from an EMS.

Other variables have the same signs as those of Model ALL and also appear insignificant. The results show that French-speaking producers who are dissatisfied and had a PAEF on farm would tend to require higher WTA compensation, as shown by the positive sign of SPAEF. The negative sign of ISO demonstrates that French-speaking producer with more knowledge on ISO 14000 may demand higher WTA compensation for EMS adoption because of the high certification costs of ISO 14000 and additional work in an EMS. As expected, French-speaking organic producer would require less WTA compensation, as shown by the negative sign of the variable Organ because of their environmentally friendly attitudes.

The positive signs of FCR, Land and Worker indicate that large French-speaking farmers with larger revenues, lands and more full time workers may require a higher WTA compensation because of the additional costs and work of an EMS. The negative sign of Reven shows that the higher portion of the main production revenue would lead to less demand for WTA compensation because of net benefit from an EMS due to economies of scale in one type of production. The negative signs of variables Own, Birth, Gender show that young and female producers might be more environmentally conscious to require a lower WTA compensation. Similarly, the negative signs of EDU2—5 and Comp demonstrate that high school or higher education and the use of a computer in farm management can lead to more knowledge on EMSs and environmental awareness so as to require less WTA compensation.

No evidence of multicolinearity among independent variables in Model French is found through the variance-covariance matrix analysis in Table 2 in Appendix III. Only Prod 1 and Prod 2 have a significant negative correlation, indicating that a French speaking dairy producer is less likely to be a hog producer at the same time. In addition, edu2 and edu3 have a noticeable negative correlation, indicating that French speaking producers with a highest education level of high school are less possible to have a highest education level of college. Inter and Comp have a noticeable positive correlation, indicating that French speaking producers who have internet access may also use a computer in farm management.

### 4.2.3 Regression analysis of the Model English and Model French 2

Only 14 usable observations were included in the Model English because of the small number of English-speaking farmers in Quebec and thus fewer English surveys received. However, the portion of English speaking respondents to French speaking ones in the WTA compensation models is compatible with that in the population. Due to the low number of observations, the overall significance of the Model English could only be realized by including fewer variables. Seven variables, including Bid, were included in the final model shown in Table 4.13.1. The result shows that the overall significance in terms of the Wald statistic is significant at the 5% level and rejects the null hypothesis that all the coefficients were equal to zero simultaneously ($W=15.70\sim\chi^2(7)$). The decreased level of the overall significance compared with the other two models is due to the number of observations in this model.

**Table 4.13.1 Regression Results of Model English**

-2*Log Likelihood: 40.362260
Wald Statistic: 15.704856
Probability of a larger Wald Stat: 0.027954
Observations: 14 Degrees of freedom: 7

| Var | Coef | Std. Error | T-Stat | P-Value (a) |
|---|---|---|---|---|
| CONST | 8.456526 | 5.273445 | 1.603606 | 0.153 |
| FCR | -0.248850 | 0.218791 | -1.137387 | 0.293 |
| ISO | -1.847126 | 1.384822 | -1.333837 | 0.224 |
| EMS | 1.691266 | 0.765277 | 2.210006 | 0.063 * |
| POST | 0.931944 | 1.346974 | 0.691880 | 0.511 |
| INTER | 0.492440 | 1.478386 | 0.333093 | 0.749 |
| EDU2 | -0.743385 | 1.310702 | -0.567166 | 0.588 |
| BID | -0.085999 | 0.021853 | -3.935330 | 0.006 *** |

Note (a): "***", "**"and "*" denote that the variables are significant at the 1%, 5% and 10% level, respectively.

The variable Bid has the expected negative sign and is significant at the 1% level. The sizes of the variables in Model English are larger than those in the other two models, which reveals the larger influence of these variables on English-speaking farmers' WTA compensation due to the fewer variables and observations in this model. Variables POST and INTER have positive signs, suggesting that English speaking producers who have access to the internet or work with someone with post-secondary education may have higher WTA compensation than those who do not. These results are opposite to those in the other two models and demonstrate that English-speaking producers may perceive higher costs in an EMS than French speaking farmers. FCR has a negative sign as expected but opposite to those of FCR in the other two models, which suggests that English speaking farmers perceive more benefits than French speaking counterparts and might demand less WTA compensation. Other explanatory variables have expected signs, which are also compatible with those in other two models. Only the variable EMS is significant at 10% level, which confirms the importance of more knowledge on an EMS to reduce WTA compensation.

No evidence of multicolinearity among independent variables in Model English is found through analysis of the variance-covariance matrix in Table 3 in Appendix III. Only two groups of variables demonstrate significant correlation. The positive correlation between AER and SPEAF indicates that producers who are dissatisfied with the PAEF also tend to have a negative attitude towards environmental regulations. The negative correlation between ADEFP and EMS indicates that producers who have little knowledge on EMSs tend to have a negative attitude towards Environmentally friendly practices

(EFP). Meanwhile, SPAEF also has a noticeably positive correlation with ISO, indicating that producers who are less satisfied with PAEF tend to have less knowledge on ISO.

**Table 4.13.2 Regression results of Model French 2**

-2*Log Likelihood: 1671.087982 - 125.663706i
Wald Statistic: 592.749891
Probability of a larger Wald Stat: 0.000000
Observations: 507 Degrees of freedom: 500

| Var | Coef | Std. Error | T-Stat | P-Value (a) |
|---|---|---|---|---|
| CONST | 5.050186 | 0.621090 | 8.131172 | 0.000 |
| FCR | 0.020698 | 0.036133 | 0.572815 | 0.567 |
| ISO | -0.110423 | 0.137542 | -0.802832 | 0.422 |
| EMS | 0.260393 | 0.137762 | 1.890171 | 0.059 * |
| POST | -0.231513 | 0.171602 | -1.349124 | 0.178 |
| INTER | -0.589822 | 0.204428 | -2.885231 | 0.004 *** |
| EDU2 | 0.071281 | 0.165069 | 0.431828 | 0.666 |
| BID | -0.064828 | 0.002664 | -24.332720 | 0.000 *** |

Note (a): "***", "**"and "*" denote that the variables are significant at the 1%, 5% and 10% level, respectively.

It is of interest to examine the similarity and difference of the mean WTA compensation and impacts of explanatory variables between French speaking and English speaking groups. However, the extra numbers of variables in Model French make the two models incomparable. Thus, a modified French group model was established for this purpose, Model French2 as shown in Table 4.13.2. In this model, only six independent variables that were selected in Model English, were included in the French speaking group. Table 4.13.2 shows the overall significance in terms of the Wald statistic at the 1% level and the result rejected the null hypothesis that all the coefficients were equal to zero simultaneously ($W=592.75 \sim \chi^2(7)$). The bid variable has a negative sign and is significant at the 1% level. Other independent variables have the same signs with those in Model French except EDU2 with a positive sign, which is opposite. However, EDU2 is not significant at the 10% level. In addition, EMS and Inter remain significant at the 10% and the 1% level. These results demonstrate the consistency between Model French and Model French 2. Thus, the comparison of these variables (except EDU2) between Model French and Model English remains between Model French2 and Model English.

### 4.2.4 Producers' mean WTA to adopt EMS

The mean WTA of Quebec producers, French speaking and English speaking producers to adopt an EMS on farm were estimated using Equation 3.7 from Hanemann (1989) with parameters of the independent variables from the four models described above and listed in Table 4.14. Since only the levels of subsidy of the direct implementation costs were provided in the survey question in terms of percentage, the mean WTA compensation estimated is also in the form of a percentage. The mean WTA of Model ALL was 79.73% of the total direct implementation cost of an EMS with a Standard Deviation (SD) of 1.10%. The mean WTA of Model French was 79.91% of the total direct cost with a SD of 1.10%. The mean WTA of Model French 2 was 80.29% of the total direct cost with a SD of 1.21%. The mean WTA of Model English was 71.75% of the total direct cost with a Standard Deviation (SD) of 24.64%. The much larger SD of the mean WTA from Model English demonstrates the weak robustness and lower reliability due to fewer variables and observations, which is in accordance with its weaker level of overall significance compared with the other models.

In the meantime, confidence intervals (CI) of the estimated mean WTA were also calculated with the simulation method developed by Park et al (1991) in absence of the normality assumption of the distribution. The 95% level CI was estimated through 5000 draws using the variance-covariance matrix of the parameters to calculate the WTA compensation and ordering. The mean WTA compensation from Model French, Model French 2 and Model English are slightly skewed to the left of the median of the CI, opposite to that of Model ALL, which shows that the WTA compensation does not quite follow a normal distribution. The range of the CI of Model English is greater than that of the other models, which confirms its weak explanatory power. The similarity of CIs of Model ALL, Model French and Model French 2 demonstrate their similarity of the mean WTA compensation.

**Table 4.14 The mean WTA and confidence intervals of the four models**

| Model | Mean WTA (%) | SD (%) | Lower Bound | Median | Upper Bound |
|---|---|---|---|---|---|
| | | | 95% level Confidence Intervals (%) | | |
| **ALL** | 79.73 | 1.10 | 77.66 | 79.66 | 81.88 |
| **French** | 79.91 | 1.10 | 77.82 | 79.93 | 82.13 |
| **French2** | 80.29 | 1.21 | 77.91 | 80.30 | 82.61 |
| **English** | 71.75 | 24.64 | 59.58 | 71.89 | 84.69 |

The mean WTA compensation from Model French 2 has a higher value than the one from Model English, while Model ALL has a slightly lower WTA compensation value than the one from Model French. These results are consistent with the regression analysis of the variable Lan in Model ALL that English-speaking farmers had a lower WTA than French-speaking ones. However, the variable Lan is not statistically significant, which was different to that shown here between the mean WTA compensation of English-speaking and French-speaking producers.

Thus, the convolution method was used to examine the difference between the mean WTA compensation of two chosen groups, shown in Table 4.15 (including Table 4.15.1—4.1.5.3). In Table 4.15.1, the 95% level of convolution distribution for the two groups did not include zero, which rejects the hypothesis that the mean WTA compensation of the two groups are equal at the 95% level of significance. In addition, the significance level of the differences of the WTA compensation distributions in the two groups is at a high level, 66.67%. Similarly, the convolution distribution was computed for Model French 2 and Model English shown in Table 4.15.2, both with the same model structure. The 95% level of convolution distribution for the two distributions does not include zero, rejecting the hypothesis that the mean WTA compensation of the two groups are equal at the 95% level of significance. These conclusions demonstrate a significant difference between the two language groups despite the model structures, which is opposite to the weak difference conclusion from the variable Lan in Model All. This can be attributed to the large CI distribution of the mean WTA compensation from Model English due to fewer observations. In addition, distributions of Model All and Model French are also compared with the convolution method, shown in Table 4.15.3. The convolution distribution included zero, showing that their mean WTA compensation were not significantly different.

**Table 4.15 confidence interval of the convolutions**

**Table 4.15.1 95% level confidence interval of the convolution of Model English and Model French**

| Lower Bound (%) | Upper Bound (%) | The level of significance |
|---|---|---|
| 30.40 | 39.30 | 66.67% |

**Table 4.15.2 95% level confidence interval of the convolution of Model English and Model French 2**

| Lower Bound (%) | Upper Bound (%) | The level of significance |
|---|---|---|
| 32.8 | 38.9 | 44.44% |

**Table 4.15.3 95% level confidence interval of the convolution of Model All and Model French**

| Lower Bound (%) | Upper Bound (%) | The level of significance |
|---|---|---|
| 0 | 1 | 22.22% |

### 4.2.5 The generalization of the three models

Three regression models were developed to estimate producers' mean WTA compensation to adopt an EMS for all producers, French-speaking and English-speaking producers in Quebec. These models achieved high overall significance and expected signs for most variables. The results show that Model ALL and Model French had higher significance levels than Model English. This was due to the larger samples and more observations. Model ALL and Model French have similar numbers of variables and observations, as well as similar levels of robustness, signs, and sizes of individual variables.

**Table 4.16 A List of significant variables (except the Bid) in each model [(a)]**

| VARIABLE \ MODEL | ALL | FRENCH | ENGLISH |
|---|---|---|---|
| Chh | * | * | |
| ABEFP | *** | *** | |
| ADEFP | *** | *** | |
| SPAEF | * | * | |
| EMS | ** | ** | * |
| Prod 6 | | * | |
| Post | | * | |
| Inter | * | ** | |

Note (a): "***", "**"and "*" denote that the variables are significant at the 1%, 5% and 10% level, respectively.

Table 4.16 lists significant variables at least at the 10% level (except Bid) in the three models. The variable Lan in Model All shows that English-speaking producers demand less WTA compensation than French-speaking ones, although it is not significant. Variables concerning producers' environmental perceptions and attitudes were found to be significant in affecting their WTA compensation for adopting an EMS. These findings coincide with Willock et al (1999) that producers' attitudes have significant influences on their decisions. The variable EMS is the sole variable significant in all three models with a positive sign, which indicates the importance of knowledge on an EMS to reduce producers' demand for compensation to adopt an EMS. Oppositely, although insignificant, the variable ISO shows that people with more knowledge of ISO 14000 demand more WTA compensation in EMS in consideration of costs. Other variables of producers' attitudes on environmentally friendly agricultural practices ABEFP, ADEFP and SPAEF were significant in Model ALL and Model French, which indicates that producers who have positive attitudes to environmental practices would demand less compensation. However, the variable AER, although insignificant, shows that producers who have negative attitudes towards environmental regulations would demand more compensation for adopting an EMS.

Farm operations were also found to have a significant influence on producers' WTA compensation in EMS implementation, which is consistent with Vanslembrouck et al (2002). Although many variables of farm environmental practices and agro-environmental risks are not significant in the models, the variable Chh was found to be significant in both Model ALL and Model French. This indicates the effect of producers' concerns for the disposal of solid wastes on their WTA compensation in an EMS. Similarly, although farm types are not significant overall, the variable Prod 6 was significant in affecting the WTA compensation in Model French, showing poultry/egg producers to have less demand for their WTA. Despite their insignificance, variables PAEF, FCR and Land show that large producers who adopted the PAEF may ask for more compensation for adopting an EMS in consideration of additional costs in the EMS. The variables-- Organ and Own show that organic producers or young owners demand less compensation because of their positive environmental attitudes towards the EMS. However, in Model English, FCR was found to have opposite effects on WTA compensation, which demonstrates large English speaking producers might reduce their WTA compensation.

Most demographic variables were found to be insignificant. However, the variable Inter is significant in both Model ALL and Model French, which indicates that the internet access has become an important source of information for producers, affecting their environmental attitudes and reducing their demand for compensation. In addition, the variable Post was significant in Model French, which demonstrates that French-speaking producers working with someone with post-secondary education require less compensation for an EMS. However, Model English showed that the variables Inter and Post have opposite effects to those from the other two models, which means that more knowledge may increase English producers' demand for compensation because of their awareness of additional costs in an EMS.

Results on other demographic variables indicate that education (from high school level or above), being young or female producers, using computers in farm management have positive effects on reducing the WTA compensation. This is due to more knowledge on the agro-environment and environmental practices as well as positive environmental attitudes. These results were consistent with Vanslembrouck et al (2002) and Hudson and Hite (2003) on adopting environmental programs.

The mean WTA was calculated from the three models. From Model ALL, Quebec producers' WTA compensation to adopt an EMS was 79.73% of total direct costs of implementation. From Model French and English, the WTA compensation of French-speaking and English-speaking producers for adopting an EMS was 79.91% and 71.75% of total direct costs of implementation, respectively. The confidence intervals of Model ALL and French were overlapping. The Model English indicates the weak robustness of Model English due to fewer observations. The convolution model indicates that the values of the mean WTA compensation from Model English and French have significant statistical difference.

# CHAPTER 5 CONCLUSIONS

## 5.1 Summary of the study

This research studied Quebec producers' environmental attitudes and perceptions on environmentally friendly practices such as an environmental management system (EMS) on farm. The mean willingness to accept (WTA) compensation, in terms of a subsidy, for adopting an EMS was also elicited in terms of the percentage of direct costs of implementation. In addition, factors affecting the WTA were studied to examine their influences.

A sample of 4,500 farms was selected out of 32,139 farms in the province. There were in total 1,473 and 1,004 useful surveys for the attitude and WTA analysis, respectively. The useful responses came from all 17 agricultural regions in the province covering major production types including cereal, dairy, hog and other productions. The demographic characteristics as well as operational and regional structures of the effective respondents were consistent with those in the target population. However, the respondents showed higher levels of environmental consciousness, as well as larger revenues and farm sizes than the general averages.

The survey results show that Quebec producers extensively adopt environmental practices, including soil tests and conservation, recycling and hazardous waste management. At the same time, many of them have a manure management system and belong to an agro-environmental club. However, they lack training and knowledge on environmental farm management and HACCP. Respondents also acknowledged many environmental challenges on farm from the agro-environment, management practices, public relations and safety and working conditions. The top challenge is soil erosion and compaction, followed by manure handling and storage, run-off from fields and conflicts with neighbors about noises, dusts and odors from farming.

The results show that producers have mixed perceptions of the benefits of environmentally friendly practices. They agree that these practices reflect their principles and values and may adopt them voluntarily in spite of governmental mandates. Producers also believe that these practices help to improve consumers' perceptions of farmers and relations with neighbors as well as improve soil quality and make farms safer. However, producers are unsure about other possible benefits from these practices such as increased profitability, access to niche market, cost reduction in farming, better prices for the products, and availability of governmental subsidies.

In terms of the difficulties of environmentally friendly practices, producers also have mixed attitudes. They believe that these practices are expensive and time consuming, requiring additional equipment and machinery, and increase management complexity. However, producers showed interest in changing practices to be more environmentally friendly. At the same time, they were not sure of the other possible problems that may result from these practices, such as decreasing production yields, reducing the competitiveness of the farm, and lack of trustworthy information and technical support.

In the meantime, Quebec producers show a negative attitude towards environmental regulations. They do not believe that current environmental regulations and programs for farms reflect and are tailored to their needs and preferences or reward farmers for addressing environmental issues proactively. Farmers were not sufficiently consulted before the introduction of these regulations although they basically believe that these regulations are necessary to protect the environment. Producers also do not believe that these regulations have realistic compliance deadlines or that governments explain these regulations to farmers properly. At the same time, producers are unsure whether the information they have on these regulations is enough and whether the consequences of these regulations can improve the international competitiveness for Quebec farmers.

The contingency valuation method (CVM) was applied in this study to elicit producers' mean WTA compensation to adopt an EMS on farm. The mean WTA was estimated at 79.73% of the total direct costs of implementation, which means that on average Quebec farmers would be willing to contribute about 20% of the direct costs in the implementation of an EMS, if subsidies are granted. French speaking and English speaking farmers have a mean WTA of 79.91% and 71.75%, respectively, which demonstrates that different language groups can have different mean WTA values. However, the results from the regression model and those from convolution methods to examine the difference of the mean WTA show that this difference may or may not be significant because of the small share of English speaking producers in Quebec.

The regression analysis identifies that among the examined factors, producers' knowledge level of EMS is the most significant variable to affect their WTA. As knowledge concerning EMS is increased, the mean WTA decreases. Producers' attitudes towards the benefits and difficulties as well as PAEF also play important roles in influencing their WTA. Their positive attitudes on these issues help to reduce their WTA. Internet access and the use of a computer in farm management also contribute to the reduction of their WTA. In addition, other demographic factors such as education, age and gender may also affect the WTA but appear to be insignificant, showing that young or female farmers with an education may ask for less compensation. Other farm factors, such as farm size, indicate that large farmers may require more compensation (or less in the regression of Model English), although their impacts are not significant. Factors of location, production type, and practice are not significant. The factor related to challenges in environmental management, e.g. the procedure to dispose solid waste, was significant in Model All and Model French and increased the level of compensation. Generally, the influence of these factors is compatible with hypotheses and supported by results from previous studies, which contributes to the theoretical and convergent validity of the study.

### 5.2 Implications for policy development

The results from this study have many implications for policy makers. First, the results show that Quebec farmers are interested in environmentally friendly practices such as EMSs because they care about the agro-environment and the relationship with neighbors and the public. They also show that they would like to change their current practices to be more environmentally friendly. The WTA study also reveals their willingness to implement an EMS with their own monetary input, besides additional work and business risks if proper compensation is available. In addition, Quebec producers have adopted many environmental practices and some management systems in their operations, such as PAEF, which may have laid the foundation for the implementation of other EMS policies in the future.

Second, the results demonstrate that Quebec farmers feel that they have a lack of knowledge supports as well as attention in policy consultation and implementation on environmental management from governments. They are also not persuaded that an EMS will improve their competitiveness and help access to new markets. The negative attitude towards environmental regulations focuses on the separation of policy development and implementation from farmers' needs and capacity. They also worry about the shortage of technology and subsidies. However, farmers still believe environmental regulations are necessary to protect the environment. These concerns reveal the future role of the government in policy development and partnership building with producers and consumers. This could include improving extension services such as environment-related training, information dissemination through conventional and electronic media. This could also include public consultation in policy development and implementation, committing to provide financial and technical supports, cultivating consumer awareness and "green markets", as well as supporting and promoting certification and labelling in agro-environmental management.

Third, the mean WTA compensation of 79.73% of total direct costs to establish an EMS, elicited from the study provides a reference for budget analysis for EMS policy development. The farmers' response of providing 20% of the total direct cost was comparable with that in some current programs in Quebec. For example, members of Club- conseils en agro-environment pay $750 to the club to hire an agronomist in farm management including agro-environmental management in combination with additional support of $1,000 from the government (Dupuis, 2004). Since the actual implementation cost of an EMS on a specific farm may vary significantly, the total budget to initiate such a program is not available at present. Rodriguez et al (1999) estimated the management cost of an EMS on a hog farm to be $8,544. Using this number as a proxy for the average cost of implementing an EMS on farm, multiplied by 32,139 farms in Quebec, we can estimate the total cost of the program to be $274.6 million for the province. Based on this analysis, governments need to commit $219 million and farmers need to commit the remaining $55.6 million, representing an average contribution of $6,812 and $1,732 per farm, respectively.

### 5.3 Limitations and future research

The main limitation of this study is that no specific monetary amount was calculated for the WTA compensation elicitation question. This was due to the fact that direct costs on EMS implementation would vary by farm type and region. Thus, there is a need for a study to find out the real direct costs of implementing an EMS. How to assess the real direct costs becomes a concern in policy implementation in terms of compensation payment and high transaction costs. Areas of future research can include the following. First, under the EMS program, it is possible that producers could self-declare. This could substantially reduce the cost of the EMS program, but increases the level of moral hazard. Second, the impact of a one-time voluntary program could be estimated. This would be similar to the Ontario Environmental Farm Plan undertaken in Ontario. The analysis could include the distributional effects for large farms as they usually have more resources and capacity than small farms.

Third, there are other expenses and opportunity costs related to changing practices as well as business risks from adopting an EMS. For example, will EMS products attract higher prices in the marketplace? An ISO 14000 EMS has high certification and auditing costs. Without ISO certification, EMS products will be less attractive to consumers.

Whether and how ISO certification can be realized in a cost-effective manner and what role governments can play to promote ISO certification could be studied.

Fourth, environmental attitudes, and influences of specific factors on the WTA compensation should be studied by region and by farm type so that site-specific and type-specific programs can be developed. Such a study could direct policies that would fit producers' needs and improve the effectiveness of the programs.

Finally, the application of CVM in this study demonstrates its feasibility as a revealed preference method to evaluate non-market goods and environmental amenities. In particular, this study showed that when real monetary values are unavailable, bid values given in terms of percentages can be used to elicit of WTA estimates. This approach to compensation questions could be tested on other environmental situations.

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# APPENDIX I

## The Ethics Certificate for the Survey

**Certificate of Ethical Acceptability for**
**Research Involving Humans**

Project Title: Environmental risk perceptions of agricultural producers in Quebec

Applicant's Name: Dr. Laurie Baker
Supervisor (if applicable):

Type of Review: Expedited

Decision: APPROVAL HAS BEEN GRANTED

Paula Ribeiro
Chair
Research Ethics Committee
Faculty of Agricultural and Environmental Sciences

March 25, 2002

Tel: 514-398-7607
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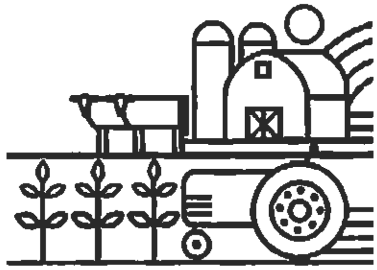
E-mail; paula_ribeiro@maclan.mcgill.ca

# APPENDIX II

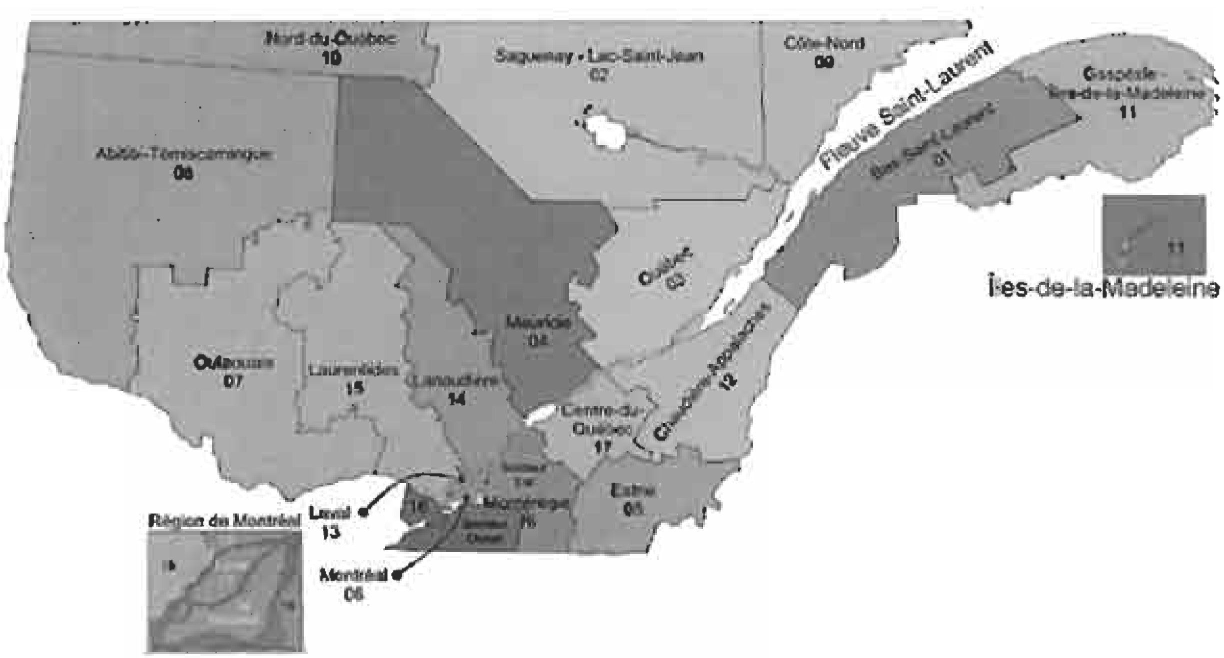
## The Survey Questionnaire



# McGill - UQAM Survey on

# Farm Environmental Management

*A Survey of Quebec Producers*




***Please return this survey by April 25, 2003.***

**We will donate one dollar to a charity of your choice to thank you for completing and returning this survey!**

# Instructions

This is a survey about environmental management on Quebec farms. Your participation in this survey is completely voluntary and anonymous. The survey should take about 30 minutes to complete.

Please follow these general instructions to complete the survey.

1. There are no right or wrong answers to the questions on this survey. We are just interested in your opinion.

2. Use either pencil or pen, but please mark your answers clearly.

3. If you are not sure of an exact answer, please give a guess at your best answer. If there are any questions you do not wish to answer, leave them blank.

4. Do not put your name or any identifying information (e.g., return address) on the survey or on the return envelope.

5. If you have any questions, please contact us at (514) 987-3324, extension 9398# or via email at: sondageproducteurs@hotmail.com

6. Please return your completed survey by inserting it into the enclosed postage-paid envelope. Please mail the completed survey by **April 25, 2003**.

   If the envelope is missing, mail the survey to:

   McGill-UQAM Survey on Farm Environmental Management
   Centre de recherche en gestion
   UQAM
   C.P. 8888 Succ. Centre-ville
   Montréal, Québec H3C 3P8

Please Note: Your name and address were obtained from the *ministère de l'Agriculture des Pêcheries et de l'Alimentation du Québec* (MAPAQ), after receiving authorization from the *Commission d'accès à l'information* (dossier N/Réf: 02 08 58). Your name and address are only accessible to the research team in a restricted manner during this research project. This information is not available to anyone outside the research team, and this information will be destroyed as soon as the administration of the surveys is complete. The survey is completely anonymous, so you should not put any personal identifying information anywhere on the survey.

In addition, the survey is completely voluntary, and you will not be penalized in any way if you decide not to respond to the questionnaire.

1. When you return this survey, one dollar will be given to a charity of your choice. Which charity would you like to receive a $1 donation in appreciation for your completed survey?
*Please choose one.*

Moissons du Québec (Québec food bank association)

Centraide (Québec United Way)

Hema-Québec (Québec blood bank)

Canadian Cancer Society

2. Which, if any, of the following practices do you use on your farm?

| *Please circle one response on each row.* | ***Is practice used on your farm?*** Yes | No | Practice is Not Applicable to our operations |
|---|---|---|---|
| a. Practice soil conservation techniques (such as conservation tillage practices, crop rotations, grazing rotations). | Y | N | N/A |
| b. Have anti-erosion measures in place (such as grassy buffer strips between fields and waterways, restricted animal access to waterways, windbreaks). | Y | N | N/A |
| c. Conduct soil tests and/or water quality tests. | Y | N | N/A |
| d. Have manure pit or manure treatment system. | Y | N | N/A |
| e. Participate in Hazardous Analysis and Critical Control Points (HACCP) program. | Y | N | N/A |
| f. Recycle packaging such as cardboard boxes or plastic containers. | Y | N | N/A |
| g. Use special disposal procedures for hazardous materials (e.g., chemical containers, batteries, used machine oil, used needles or scalpels). | Y | N | N/A |
| h. Belong to agro-environmental club. | Y | N | N/A |
| i. Have taken training or courses on environmental farm management topics. | Y | N | N/A |
| j. Other (please specify): | | | |

3. **In your opinion, what are the top three environmental management challenges that you face on your farm?**

*The following is a list of environmental management issues that may or may not be a problem on different farms.* ***Please choose the THREE problems that present the greatest challenges to you on YOUR farm.*** *Place a 1 by the most important challenge, a 2 beside the second most important challenge, and a 3 beside the third most important challenge on your farm.*

***Rank the top 3 environmental challenges on your farm (#1, #2, #3)***

a. ________ **Runoff** from fields (e.g. runoff from fertilizers, manure, pesticides, etc.).

b. ________ **Quantity or type of biocides** used (e.g., pesticides, herbicides, fungicides).

c. ________ **Quantity or type of fertilizers** used.

d. ________ **Manure handling and storage.**

e. ________ **Soil erosion and/or soil compaction** (e.g., from heavy equipment).

f. ________ **Conflicts with neighbours about noise, dust, odours** from farm activities.

g. ________ Procedures for **handling, storing, and disposing of toxic wastes** such as surplus chemicals, chemical containers, machine oil, batteries, used needles, expired vaccines.

h. ________ Procedures for **disposal of solid wastes** such as trash, spent plastics, packaging.

i. ________ **Safety and security of working conditions** such as exposure to chemicals, poor air quality, high noise levels, safety around machinery or livestock).

j. ________ **Other** (Please specify): ______________________________

**4. What are some of the benefits to using environmentally friendly farming practices?**

*Please rate how much you agree with each statement by circling one answer on each row.*

| Environmentally friendly farming practices... | *Strongly agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
|---|---|---|---|---|---|
| a. ...make farms **more profitable.** | 1 | 2 | 3 | 4 | 5 |
| b. ...provide **access to niche markets** for agricultural products. | 1 | 2 | 3 | 4 | 5 |
| c. ...help **reduce the costs of farming operations** because of better management of inputs. | 1 | 2 | 3 | 4 | 5 |
| d. ...result in **better prices** for farm products. | 1 | 2 | 3 | 4 | 5 |
| e. ...make it **easier or cheaper to get insurance**. | 1 | 2 | 3 | 4 | 5 |
| f. ...make it **easier to get loans** from lending agencies. | 1 | 2 | 3 | 4 | 5 |
| g. ...make it **easier to get certain government subsidies.** | 1 | 2 | 3 | 4 | 5 |
| h. ...**improve relationships with neighbours.** | 1 | 2 | 3 | 4 | 5 |
| i. ...**make farms safer** for farmers and their families. | 1 | 2 | 3 | 4 | 5 |
| j. ...help **improve consumers' perceptions** of farmers. | 1 | 2 | 3 | 4 | 5 |
| k. ...help **improve soil quality.** | 1 | 2 | 3 | 4 | 5 |
| l. ...help **improve food quality**. | 1 | 2 | 3 | 4 | 5 |
| m. ...**reflect principles and values** that are important to me. | 1 | 2 | 3 | 4 | 5 |
| n. ...are **only necessary when the government mandates them** | 1 | 2 | 3 | 4 | 5 |

5. **What are some of the difficulties in implementing environmentally friendly farming practices?**

*Please rate how much you agree with each statement by circling one answer on each row.*

| | *Strongly Agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
|---|---|---|---|---|---|
| a. Adding new environmentally friendly farming practices is **expensive**. | 1 | 2 | 3 | 4 | 5 |
| b. Adding new environmentally friendly farming practices is **time consuming**. | 1 | 2 | 3 | 4 | 5 |
| c. Adding new environmentally friendly farming practices **requires additional manpower.** | 1 | 2 | 3 | 4 | 5 |
| d. Adding new environmentally friendly farming practices **requires additional machinery/equipment.** | 1 | 2 | 3 | 4 | 5 |
| e. Adding new environmentally friendly farming practices increases **management complexity.** | 1 | 2 | 3 | 4 | 5 |
| f. Adding new environmentally friendly farming practices can **decrease production yields.** | 1 | 2 | 3 | 4 | 5 |
| g. Adding new environmentally friendly farming practices can **reduce the competitiveness of farm enterprises.** | 1 | 2 | 3 | 4 | 5 |
| h. Adding new environmentally friendly farming practices **often causes new problems**. | 1 | 2 | 3 | 4 | 5 |
| i. Environmentally friendly farming practices can be difficult to implement **because of timing or weather.** | 1 | 2 | 3 | 4 | 5 |
| j. Technology that is available to solve farm environmental problems **is generally not very effective**. | 1 | 2 | 3 | 4 | 5 |
| k. It is difficult to find **trustworthy information** about environmentally friendly farm practices. | 1 | 2 | 3 | 4 | 5 |
| l. There is **not enough technical support** available to support environmentally friendly farming practices. | 1 | 2 | 3 | 4 | 5 |
| m. **Other people have encouraged or pressured me NOT to use** environmentally friendly farming practices. | 1 | 2 | 3 | 4 | 5 |
| n. I am **not interested** in changing my farming practices. | 1 | 2 | 3 | 4 | 5 |

6. **What are your opinions about environmental regulations for farms?**

*Please rate how much you agree with each statement by circling one answer on each row.*

| | *Strongly Agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
|---|---|---|---|---|---|
| a. Environmental regulations for farms are necessary to help protect the environment. | 1 | 2 | 3 | 4 | 5 |
| b. Existing environmental regulations for farms are adequately enforced. | 1 | 2 | 3 | 4 | 5 |
| c. Environmental regulations for farms have realistic compliance deadlines. | 1 | 2 | 3 | 4 | 5 |
| d. I generally feel that I have enough information about environmental regulations I must follow on the farm. | 1 | 2 | 3 | 4 | 5 |
| e. The government does a good job of explaining why new environmental regulations for farms are needed. | 1 | 2 | 3 | 4 | 5 |
| f. Environmental regulations for farms reflect farmers' needs and preferences. | 1 | 2 | 3 | 4 | 5 |
| g. Environmental regulations for farms are tailored to the needs of my region. | 1 | 2 | 3 | 4 | 5 |
| h. Producers are sufficiently consulted before environmental regulations for farms are introduced. | 1 | 2 | 3 | 4 | 5 |
| i. Government programs and policies reward farmers for addressing farm environmental issues proactively. | 1 | 2 | 3 | 4 | 5 |
| j. Current environmental regulations make Québec farmers less competitive on world markets. | 1 | 2 | 3 | 4 | 5 |
| k. Within the next 10 years, farmers are likely to face restrictions on agricultural exports based on environmental practices. | 1 | 2 | 3 | 4 | 5 |

7. Some farms in Quebec have implemented a *Plan agro-environmental de fertilisation* (PAEF), a plan for fertilizer and manure management. Do you currently have a PAEF for your farm?

Yes

No ------------------> ***IF NO, PLEASE SKIP TO QUESTION 9 BELOW***

8. How satisfied are you with your PAEF?

Very satisfied    Somewhat satisfied    Not at all satisfied

9. How knowledgeable do you feel you are about ISO 14000 certification?

Very knowledgeable

Somewhat knowledgeable

A little knowledgeable

I had not previously heard of ISO 14000 certification.

10. An **Environmental Management System** (EMS) is a management system that allows farmers to incorporate farm environmental issues into their everyday farm management process. How knowledgeable do you feel you are about Environmental Management Systems (EMS)?

Very knowledgeable

Somewhat knowledgeable

A little knowledgeable

I had not previously heard of Environmental Management Systems (before reading the statement above).

11. Do you currently have an Environmental Management System (EMS) that covers most or all aspects of your farm operations?

Yes ---------> *IF YES, PLEASE* ***SKIP TO QUESTION 13 ON THE NEXT PAGE***

No

**12.** Please tell us about the level of support that you would need to be able to implement an Environmental Management System (EMS) on your farm.

**How likely is it that you would be able to implement an EMS on your farm if the following subsidies were available to cover the direct costs of implementation?**

*To allow us to analyse these results, it is very important to circle one answer on EVERY row.*

| | ***Likelihood that you would be able to implement an EMS*** | | | | |
|---|---|---|---|---|---|
| Would you be able to implement an EMS... | ***Definitely NO*** | ***Probably NO*** | ***Uncertain*** | ***Probably YES*** | ***Definitely YES*** |
| ...if **0%** of your direct costs were subsidized? | 1 | 2 | 3 | 4 | 5 |
| ...if **20%** of your direct costs were subsidized? | 1 | 2 | 3 | 4 | 5 |
| ...if **40%** of your direct costs were subsidized? | 1 | 2 | 3 | 4 | 5 |
| ...if **60%** of your direct costs were subsidized? | 1 | 2 | 3 | 4 | 5 |
| ...if **80%** of your direct costs were subsidized? | 1 | 2 | 3 | 4 | 5 |
| ...if **100%** of your direct costs were subsidized? | 1 | 2 | 3 | 4 | 5 |
| ...if **120%** of your direct costs were subsidized? | 1 | 2 | 3 | 4 | 5 |

***Please make sure that one answer is circled on every row***

***To help us better understand the environmental issues you face, please tell us about your farm.***

**13.** How much total farmland do you operate (including land you own and rent)?

_______________ hectares OR _____________ acres

**14.** Is any part of your farm's operations certified organic, or in the process of obtaining organic certification?

Yes No

**15.** Including yourself, your family, and all farm employees, how many people work on the farm?

_____________ full-time workers AND ________________part-time workers

**16.** Which legal structure best describes your farm business (as registered with the province of Québec)?

Sole proprietorship Partnership Incorporated business

**17.** What is the most important enterprise on your farm (the enterprise that normally accounts for the largest proportion of your farm revenue during the year)? *Please choose one.*

Dairy
Beef cattle
Pork
Poultry/eggs
Fruits/vegetables
Maple syrup
Cash crops (cereals & oilseed crops)
Other -- please specify: ______________________________

**18.** Approximately what percentage of your total yearly farm revenue is derived from this primary enterprise? *Please write in a number from 1 to 100%.*

__________%

**19.** What enterprise accounts for the <u>second</u> largest proportion of your farm revenue? *Choose one.*

Dairy
Beef cattle
Pork
Poultry/eggs
Fruits/vegetables
Maple syrup
Cash crops (cereals & oilseed crops)
None – the farm relies only on one enterprise
Other -- please specify: ______________________________

**20.** Approximately what percentage of your total yearly farm revenue is derived from this secondary enterprise? *Please write in a number from 1 to 100%.*

__________%

**21.** Your answers to this question will help us understand whether environmental management issues on a farm are linked to the economics of farming. **Which category best describes your <u>farm cash receipts</u> last year (2002)?** By farm cash receipts, we mean sales from farm products plus government/insurance payments.

*Please choose one. If you do not have an exact number, just give your best estimate.*

Less than $10,000
$100,000 to $149,999
$10,000 to $24,999
$150,000 to $199,999
$25,000 to $49,999
$200,000 to $249,999
$50,000 to $74,999
$250,000 to $500,000
$75,000 to $99,999
more than $500,000

**22.** Since what year has the farm been owned by your family (all generations)?

Our family has owned the farm since ______________ (*please write in year*).

We do not own the farm.

**23.** Which of the following statements best describes your current situation?

I am just getting established in farming.

I am established and planning to expand operations.

I am established and do not currently plan to change the size of my operations.

I plan to scale down operations or retire from farming within the next five to ten years.

**24.** To whom do you plan to transfer the farm business when you retire?

To child(ren) or other relative(s)

To a specific farm employee

To any willing buyer

Don't know

**25.** In what year were you born? ____________ (*please write in year).*

**26.** What is your gender? Male Female

**27.** What is the highest level of education that you have completed?

Primary school or some high school

High school degree

Cégep/college degree

University degree

Postgraduate degree (master's, MBA, etc.)

**28.** Is there anyone working on the farm who has completed a cégep, technical college, or university agriculture training program within the past 10 years, or who is currently enrolled?

Yes No

**29.** Do you use a computer for managing your farm business? Yes No

**30.** Do you have access to the Internet? Yes No

**PLEASE CONTINUE TO QUESTIONS ON THE BACK OF THIS PAGE**

**31.** In which region is your farm located? *Please choose one region. You can refer to the map of regions on the front cover of the survey booklet if needed.*

| **Regions north of the St. Lawrence River** | **Regions south of the St. Lawrence River** |
|---|---|
| Québec | Montréal / Laval |
| Mauricie | Montérégie East |
| Lanaudière | Montérégie West |
| Laurentides | Centre du Québec |
| Outaouais | Estrie |
| Abitibi-Témiscamingue | Chaudières-Appalaches |
| Nord du Québec | Bas St-Laurent |
| Saguenay-Lac-St-Jean | Gaspésie-Iles de la Madeleine |
| Côte-Nord | |

**32.** In your own words, what is the most important environmental issue on your farm that you would like to be able to manage better?

**33.** Do you have any other comments about the topics covered on this survey?

# THANK YOU!

**Thank you for taking the time to complete this survey! It is only with the generous help of people like you that our research can be successful.**

**Please return this survey by April 25, 2003 to**

McGill-UQAM Survey on Farm Environmental Management
Centre de recherche en gestion
UQAM
C.P. 8888 Succ. Centre-ville
Montréal, Québec H3C 3P8

## APPENDIX III

## Variance-covariance Matrix of the Explanatory Variables in the Regression Models

### Table 1. Variance-covariance Matrix of the Explanatory Variables in Model ALL

| | lan | chh | ABEFP | ADEFP | AER | PAEF | SPAEF |
|---|---|---|---|---|---|---|---|
| lan | 1.0000 | | | | | | |
| chh | 0.0130 | 1.0000 | | | | | |
| ABEFP | -0.0432 | -0.0885 | 1.0000 | | | | |
| ADEFP | -0.0536 | -0.1171 | -0.2594 | 1.0000 | | | |
| AER | -0.0056 | -0.0750 | 0.3475 | -0.2323 | 1.0000 | | |
| PAEF | 0.0179 | -0.0367 | 0.0797 | 0.0348 | 0.0729 | 1.0000 | |
| SPAEF | 0.0668 | 0.0181 | 0.2731 | -0.2365 | 0.1859 | -0.0969 | 1.0000 |
| ISO | 0.0353 | 0.0313 | -0.0243 | -0.0037 | -0.0154 | -0.0381 | 0.0239 |
| EMS | -0.0434 | -0.0227 | 0.0285 | 0.0253 | 0.0308 | -0.1025 | -0.0182 |
| Land | 0.0084 | 0.0545 | -0.0480 | 0.0572 | -0.0993 | -0.1249 | -0.0488 |
| Prod1 | -0.0162 | 0.0545 | -0.0492 | 0.0101 | -0.0818 | 0.0890 | -0.0431 |
| Prod2 | -0.1012 | -0.0413 | 0.0677 | -0.0176 | 0.0072 | 0.0657 | -0.0042 |
| Prod3 | -0.0232 | 0.0289 | -0.0364 | 0.0457 | -0.0081 | -0.2471 | 0.0042 |
| Prod4 | 0.0358 | -0.0159 | 0.0078 | 0.0026 | 0.0619 | -0.0811 | 0.0400 |
| Prod5 | 0.1150 | 0.0310 | -0.0091 | -0.0715 | 0.0735 | -0.0523 | 0.0945 |
| Prod6 | 0.0758 | -0.0460 | -0.0101 | 0.0864 | 0.0033 | 0.0135 | -0.0234 |
| Prod7 | 0.1816 | -0.0306 | -0.0162 | -0.0200 | -0.0768 | 0.0067 | -0.1059 |
| Prod8 | -0.0146 | -0.0434 | 0.0087 | -0.0284 | 0.0023 | 0.0095 | 0.0408 |
| FCR | -0.0671 | -0.0615 | 0.0937 | 0.0105 | 0.0167 | 0.1565 | -0.0566 |
| Own | -0.1780 | 0.0255 | -0.0011 | 0.0010 | 0.0189 | 0.0318 | 0.0015 |
| birth | -0.1009 | -0.0456 | 0.1189 | 0.0167 | -0.0040 | 0.1077 | 0.0623 |
| edu2 | -0.0175 | -0.0081 | -0.0400 | -0.0432 | 0.0403 | -0.0566 | 0.0249 |
| edu3 | 0.0634 | -0.0485 | 0.0961 | 0.0779 | -0.0210 | 0.0642 | -0.0201 |
| edu4 | 0.0015 | -0.0739 | 0.0485 | -0.0141 | 0.0710 | 0.0294 | 0.0739 |
| edu5 | -0.0146 | -0.0434 | 0.0087 | -0.0284 | -0.0347 | 0.0095 | 0.0026 |
| post | 0.0021 | -0.0373 | 0.0306 | 0.0205 | 0.1365 | 0.0417 | 0.0151 |
| Inter | 0.0056 | -0.0105 | 0.0071 | -0.0064 | -0.0010 | 0.1984 | -0.0560 |
| Organ | 0.0460 | 0.0222 | 0.0952 | -0.0773 | 0.1153 | 0.0364 | -0.0438 |
| comp | -0.0688 | -0.0705 | 0.0737 | 0.0131 | 0.0257 | 0.0625 | -0.0943 |
| worker | -0.0175 | -0.0353 | 0.0897 | -0.0967 | 0.1006 | 0.0502 | -0.0112 |
| reven | -0.0169 | -0.0317 | 0.0554 | -0.0111 | 0.0313 | 0.0589 | -0.0205 |
| gender | -0.0044 | -0.0363 | -0.0293 | -0.0411 | -0.0070 | 0.0307 | -0.0156 |

| | ISO | EMS | Land | Prod1 | Prod2 | Prod3 | Prod4 |
|---|---|---|---|---|---|---|---|
| ISO | 1.0000 | | | | | | |
| EMS | 0.3917 | 1.0000 | | | | | |
| Land | -0.0873 | -0.0363 | 1.0000 | | | | |
| Prod1 | -0.0250 | 0.0543 | -0.0422 | 1.0000 | | | |
| Prod2 | 0.0425 | 0.0191 | -0.0984 | -0.5025 | 1.0000 | | |
| Prod3 | -0.0058 | 0.0035 | 0.0831 | -0.1154 | -0.0852 | 1.0000 | |
| Prod4 | -0.0179 | -0.0513 | 0.0977 | -0.4120 | -0.3042 | -0.0699 | 1.0000 |
| Prod5 | 0.0693 | 0.0241 | -0.0611 | -0.2003 | -0.1479 | -0.0340 | -0.1212 |
| Prod6 | 0.0133 | -0.0258 | 0.0346 | -0.1030 | -0.0761 | -0.0175 | -0.0624 |
| Prod7 | -0.0393 | -0.0367 | 0.1156 | -0.0512 | -0.0378 | -0.0087 | -0.0310 |
| Prod8 | -0.1535 | -0.1199 | -0.0221 | -0.0726 | -0.0536 | -0.0123 | -0.0439 |
| FCR | -0.0778 | -0.0324 | -0.0043 | 0.1198 | 0.2151 | -0.0540 | -0.1920 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Own | 0.0170 | -0.0352 | -0.0645 | -0.2201 | 0.1738 | -0.0436 | 0.0302 |
| birth | 0.0437 | 0.0211 | -0.0145 | 0.1111 | 0.0588 | -0.0085 | -0.1757 |
| edu2 | 0.0106 | -0.0949 | -0.0276 | -0.0578 | -0.0145 | -0.0310 | 0.0731 |
| edu3 | -0.0531 | 0.0660 | -0.0386 | 0.1506 | -0.0473 | -0.0513 | -0.1000 |
| edu4 | -0.0830 | -0.0679 | -0.0685 | -0.1477 | 0.0896 | 0.0722 | -0.0225 |
| edu5 | -0.0232 | -0.0182 | -0.0221 | -0.0278 | -0.0041 | -0.0123 | 0.0661 |
| post | -0.0972 | -0.0697 | 0.0019 | 0.1957 | -0.0229 | -0.0736 | -0.1059 |
| Inter | -0.0682 | -0.0516 | -0.0758 | 0.0111 | 0.1256 | -0.0905 | -0.1058 |
| Organ | -0.0408 | -0.0517 | 0.0635 | -0.0126 | -0.1677 | -0.0781 | 0.2597 |
| comp | -0.0483 | -0.0348 | 0.0138 | -0.0122 | 0.1216 | -0.0163 | -0.0782 |
| worker | -0.1096 | -0.1303 | 0.0495 | 0.0457 | 0.0729 | 0.0961 | -0.1216 |
| reven | -0.0248 | 0.0194 | -0.0802 | 0.1248 | 0.0420 | 0.0060 | -0.0633 |
| gender | -0.0262 | -0.0936 | -0.0423 | -0.0652 | 0.1080 | 0.0614 | -0.0727 |

| | Prod5 | Prod6 | Prod7 | Prod8 | FCR | Own | birth |
|---|---|---|---|---|---|---|---|
| Prod5 | 1.0000 | | | | | | |
| Prod6 | -0.0303 | 1.0000 | | | | | |
| Prod7 | -0.0151 | -0.0078 | 1.0000 | | | | |
| Prod8 | -0.0214 | -0.0110 | -0.0055 | 1.0000 | | | |
| FCR | -0.3109 | 0.1057 | -0.0214 | -0.1032 | 1.0000 | | |
| Own | 0.0659 | -0.0167 | -0.0550 | 0.0756 | -0.0821 | 1.0000 | |
| birth | -0.0342 | -0.0362 | -0.0013 | 0.0046 | 0.1639 | 0.1344 | 1.0000 |
| edu2 | -0.0146 | 0.0232 | 0.0746 | -0.0284 | -0.0384 | -0.0527 | 0.0193 |
| edu3 | -0.0109 | -0.0031 | -0.0369 | -0.0022 | 0.1192 | 0.0065 | 0.2240 |
| edu4 | 0.0329 | 0.0891 | -0.0169 | 0.1494 | 0.0190 | 0.0879 | 0.0244 |
| edu5 | -0.0214 | -0.0110 | -0.0055 | -0.0077 | 0.0335 | -0.0120 | -0.0813 |
| post | -0.0910 | -0.0265 | -0.0457 | 0.0274 | 0.1770 | -0.0904 | 0.0547 |
| Inter | -0.0474 | 0.0308 | 0.0338 | -0.0045 | 0.3021 | 0.0131 | 0.1319 |
| Organ | -0.0550 | -0.0007 | 0.0345 | -0.0316 | 0.3134 | -0.0640 | -0.0626 |
| comp | -0.0728 | 0.0720 | 0.0358 | -0.1017 | 0.3458 | 0.0372 | 0.1808 |
| worker | -0.1521 | 0.1555 | -0.0289 | -0.0409 | 0.4058 | -0.0486 | -0.0366 |
| reven | -0.0548 | -0.0035 | -0.1037 | -0.0213 | 0.1116 | -0.0312 | 0.1095 |
| gender | -0.0388 | -0.0356 | 0.0947 | 0.1341 | -0.0910 | 0.0466 | -0.0173 |

| | edu2 | edu3 | edu4 | edu5 | post | Inter | Organ |
|---|---|---|---|---|---|---|---|
| edu2 | 1.0000 | | | | | | |
| edu3 | -0.4943 | 1.0000 | | | | | |
| edu4 | -0.2266 | -0.1619 | 1.0000 | | | | |
| edu5 | -0.0731 | -0.0523 | -0.0240 | 1.0000 | | | |
| post | -0.1866 | 0.2584 | 0.0373 | -0.0187 | 1.0000 | | |
| Inter | -0.0590 | 0.1360 | 0.1302 | -0.0045 | 0.0747 | 1.0000 | |
| Organ | 0.0240 | -0.0158 | -0.0460 | 0.0226 | 0.0770 | 0.0800 | 1.0000 |
| comp | -0.0257 | 0.1609 | 0.0871 | 0.0507 | 0.1734 | 0.4576 | 0.1532 |
| worker | -0.0030 | -0.0026 | -0.0177 | 0.0383 | 0.1804 | 0.0934 | 0.3547 |
| reven | -0.0483 | 0.0627 | -0.0295 | -0.0442 | 0.0040 | 0.0644 | -0.1282 |
| gender | -0.0108 | 0.0205 | 0.1963 | -0.0251 | -0.0349 | 0.0722 | -0.0758 |

| | comp | worker | reven | gender |
|---|---|---|---|---|
| comp | 1.0000 | | | |
| worker | 0.1979 | 1.0000 | | |
| reven | -0.0318 | -0.0220 | 1.0000 | |
| gender | -0.0124 | 0.0101 | 0.0545 | 1.0000 |

**Table 2. Variance-covariance Matrix of the Explanatory Variables in Model French**

| | Chh | ABEFP | ADEFP | AER | PAEF | SPAEF | EMS |
|---|---|---|---|---|---|---|---|
| Chh | 1.0000 | | | | | | |
| ABEFP | -0.0902 | 1.0000 | | | | | |
| ADEFP | -0.1198 | -0.2621 | 1.0000 | | | | |
| AER | -0.0883 | 0.3409 | -0.2323 | 1.0000 | | | |
| PAEF | -0.0375 | 0.0815 | 0.0363 | 0.0743 | 1.0000 | | |
| SPAEF | 0.0065 | 0.2779 | -0.2332 | 0.1741 | -0.1002 | 1.0000 | |
| EMS | 0.0244 | -0.0273 | -0.0018 | -0.0219 | -0.0391 | 0.0106 | 1.0000 |
| ISO | -0.0268 | 0.0253 | 0.0462 | 0.0350 | -0.1039 | -0.0179 | 0.3988 |
| Land | 0.0608 | -0.0430 | 0.0527 | -0.0855 | -0.1272 | -0.0335 | -0.0827 |
| Prod1 | 0.0475 | -0.0540 | 0.0062 | -0.0907 | 0.0905 | -0.0430 | -0.0317 |
| Prod2 | -0.0407 | 0.0644 | -0.0235 | 0.0067 | 0.0679 | 0.0026 | 0.0467 |
| Prod3 | 0.0296 | -0.0379 | 0.0452 | -0.0083 | -0.2468 | 0.0059 | -0.0050 |
| Prod4 | -0.0105 | 0.0097 | 0.0128 | 0.0548 | -0.0833 | 0.0379 | -0.0103 |
| Prod5 | 0.0289 | -0.0108 | -0.0627 | 0.0892 | -0.0572 | 0.0722 | 0.0655 |
| Prod6 | -0.0412 | 0.0047 | 0.0844 | 0.0102 | 0.0129 | -0.0247 | 0.0008 |
| Prod7 | -0.0218 | 0.0200 | -0.0509 | -0.0177 | 0.0049 | -0.0759 | -0.0278 |
| Prod8 | -0.0438 | 0.0081 | -0.0296 | 0.0023 | 0.0098 | 0.0427 | -0.1542 |
| FCR | -0.0637 | 0.0909 | -0.0002 | 0.0060 | 0.1611 | -0.0543 | -0.0790 |
| Own | 0.0167 | -0.0115 | -0.0002 | 0.0097 | 0.0365 | -0.0171 | 0.0251 |
| Birth | -0.0415 | 0.1034 | 0.0078 | -0.0138 | 0.1113 | 0.0705 | 0.0402 |
| edu2 | 0.0034 | -0.0504 | -0.0421 | 0.0487 | -0.0570 | 0.0486 | 0.0224 |
| edu3 | -0.0580 | 0.1020 | 0.0695 | -0.0345 | 0.0643 | -0.0389 | -0.0674 |
| edu4 | -0.0715 | 0.0555 | -0.0082 | 0.0893 | 0.0298 | 0.0657 | -0.0898 |
| edu5 | -0.0438 | 0.0081 | -0.0296 | -0.0354 | 0.0098 | 0.0037 | -0.0229 |
| post | -0.0472 | 0.0285 | 0.0179 | 0.1344 | 0.0423 | 0.0088 | -0.1003 |
| inter | -0.0048 | 0.0042 | -0.0177 | 0.0097 | 0.2009 | -0.0554 | -0.0747 |
| organ | 0.0060 | 0.0957 | -0.0692 | 0.1080 | 0.0361 | -0.0560 | -0.0426 |
| comp | -0.0647 | 0.0730 | 0.0023 | 0.0396 | 0.0650 | -0.0958 | -0.0434 |
| worker | -0.0472 | 0.0890 | -0.0957 | 0.0963 | 0.0511 | -0.0154 | -0.1131 |
| reven | -0.0226 | 0.0523 | -0.0186 | 0.0221 | 0.0605 | -0.0147 | -0.0251 |
| gender | -0.0331 | -0.0353 | -0.0367 | -0.0167 | 0.0312 | -0.0256 | -0.0311 |

| | ISO | Land | Prod1 | Prod2 | Prod3 | Prod4 | Prod5 |
|---|---|---|---|---|---|---|---|
| ISO | 1.0000 | | | | | | |
| Land | -0.0345 | 1.0000 | | | | | |
| Prod1 | 0.0558 | -0.0373 | 1.0000 | | | | |
| Prod2 | 0.0151 | -0.0997 | -0.5135 | 1.0000 | | | |
| Prod3 | 0.0025 | 0.0847 | -0.1173 | -0.0880 | 1.0000 | | |
| Prod4 | -0.0451 | 0.1068 | -0.4101 | -0.3077 | -0.0703 | 1.0000 | |
| Prod5 | 0.0263 | -0.0583 | -0.1923 | -0.1443 | -0.0330 | -0.1152 | 1.0000 |
| Prod6 | -0.0451 | 0.0420 | -0.0979 | -0.0734 | -0.0168 | -0.0586 | -0.0275 |
| Prod7 | -0.0268 | -0.0111 | -0.0368 | -0.0276 | -0.0063 | -0.0220 | -0.0103 |
| Prod8 | -0.1230 | -0.0224 | -0.0738 | -0.0553 | -0.0126 | -0.0442 | -0.0207 |
| FCR | -0.0380 | -0.0027 | 0.1124 | 0.2139 | -0.0568 | -0.2047 | -0.2775 |
| Own | -0.0377 | -0.0553 | -0.2214 | 0.1637 | -0.0499 | 0.0253 | 0.0557 |
| Birth | 0.0133 | -0.0145 | 0.1086 | 0.0497 | -0.0110 | -0.1733 | -0.0115 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| edu2 | -0.0985 | -0.0392 | -0.0532 | -0.0165 | -0.0318 | 0.0703 | -0.0121 |
| edu3 | 0.0805 | -0.0324 | 0.1396 | -0.0419 | -0.0508 | -0.0981 | 0.0068 |
| edu4 | -0.0797 | -0.0683 | -0.1461 | 0.0914 | 0.0733 | -0.0177 | 0.0072 |
| edu5 | -0.0192 | -0.0224 | -0.0284 | -0.0056 | -0.0126 | 0.0679 | -0.0207 |
| post | -0.0716 | 0.0082 | 0.1824 | -0.0231 | -0.0746 | -0.1050 | -0.0773 |
| inter | -0.0505 | -0.0823 | 0.0013 | 0.1285 | -0.0916 | -0.0958 | -0.0437 |
| organ | -0.0582 | 0.0691 | -0.0203 | -0.1667 | -0.0783 | 0.2606 | -0.0476 |
| comp | -0.0414 | 0.0066 | -0.0058 | 0.1176 | -0.0183 | -0.0754 | -0.0757 |
| worker | -0.1441 | 0.0511 | 0.0350 | 0.0723 | 0.0968 | -0.1210 | -0.1407 |
| reven | 0.0303 | -0.0655 | 0.1165 | 0.0414 | 0.0058 | -0.0779 | -0.0168 |
| gender | -0.0945 | -0.0413 | -0.0762 | 0.1093 | 0.0621 | -0.0697 | -0.0340 |

| | Prod6 | Prod7 | Prod8 | FCR | Own | Birth | edu2 |
|---|---|---|---|---|---|---|---|
| Prod6 | 1.0000 | | | | | | |
| Prod7 | -0.0053 | 1.0000 | | | | | |
| Prod8 | -0.0106 | -0.0040 | 1.0000 | | | | |
| FCR | 0.0952 | -0.0067 | -0.1064 | 1.0000 | | | |
| Own | 0.0319 | 0.0283 | 0.0763 | -0.0843 | 1.0000 | | |
| Birth | -0.0534 | 0.0222 | 0.0031 | 0.1467 | 0.1406 | 1.0000 | |
| edu2 | 0.0388 | 0.0533 | -0.0291 | -0.0363 | -0.0487 | 0.0151 | 1.0000 |
| edu3 | -0.0308 | -0.0261 | -0.0013 | 0.1025 | 0.0261 | 0.2265 | -0.4898 |
| edu4 | 0.1011 | -0.0121 | 0.1516 | 0.0339 | 0.0769 | 0.0334 | -0.2271 |
| edu5 | -0.0106 | -0.0040 | -0.0080 | 0.0332 | -0.0153 | -0.0842 | -0.0744 |
| post | -0.0162 | -0.0327 | 0.0278 | 0.1658 | -0.0891 | 0.0519 | -0.1850 |
| inter | 0.0242 | 0.0242 | -0.0045 | 0.3012 | 0.0269 | 0.1234 | -0.0612 |
| organ | 0.0124 | 0.0578 | -0.0315 | 0.3138 | -0.0735 | -0.0589 | 0.0287 |
| comp | 0.0673 | 0.0253 | -0.1049 | 0.3439 | 0.0182 | 0.1736 | -0.0292 |
| worker | 0.1694 | -0.0367 | -0.0416 | 0.4009 | -0.0564 | -0.0428 | 0.0024 |
| reven | -0.0182 | -0.0517 | -0.0220 | 0.0909 | -0.0186 | 0.1009 | -0.0521 |
| gender | -0.0337 | 0.1479 | 0.1357 | -0.0963 | 0.0567 | -0.0242 | -0.0059 |

| | edu3 | edu4 | edu5 | post | inter | organ | comp |
|---|---|---|---|---|---|---|---|
| edu3 | 1.0000 | | | | | | |
| edu4 | -0.1599 | 1.0000 | | | | | |
| edu5 | -0.0524 | -0.0243 | 1.0000 | | | | |
| post | 0.2495 | 0.0442 | -0.0189 | 1.0000 | | | |
| inter | 0.1263 | 0.1298 | -0.0045 | 0.0662 | 1.0000 | | |
| organ | -0.0267 | -0.0397 | 0.0237 | 0.0676 | 0.0808 | 1.0000 | |
| comp | 0.1660 | 0.0825 | 0.0507 | 0.1782 | 0.4548 | 0.1532 | 1.0000 |
| worker | -0.0146 | -0.0126 | 0.0384 | 0.1731 | 0.0890 | 0.3418 | 0.1931 |
| reven | 0.0482 | -0.0182 | -0.0454 | -0.0086 | 0.0555 | -0.1356 | -0.0323 |
| gender | 0.0121 | 0.2035 | -0.0254 | -0.0454 | 0.0704 | -0.0719 | -0.0036 |

| | worker | reven | gender |
|---|---|---|---|
| worker | 1.0000 | | |
| reven | -0.0267 | 1.0000 | |
| gender | 0.0103 | 0.0489 | 1.0000 |

**Table 3. Variance-covariance Matrix of the Explanatory Variables in Model English**

| | ADEFP | AER | SPAEF | ISO | EMS | FCR | Inter |
|---|---|---|---|---|---|---|---|
| ADEFP | 1.0000 | | | | | | |
| AER | -0.2537 | 1.0000 | | | | | |
| SPEAF | -0.2537 | 0.5281 | 1.0000 | | | | |
| ISO | 0.0000 | 0.2754 | 0.4896 | 1.0000 | | | |
| EMS | -0.6637 | -0.0882 | 0.0490 | 0.2402 | 1.0000 | | |
| FCR | 0.2204 | 0.2955 | -0.0027 | 0.0580 | 0.0302 | 1.0000 | |
| Inter | 0.2303 | -0.3672 | 0.0612 | -0.1667 | 0.0534 | 0.3118 | 1.0000 |