Nutrient Management Regulation and Farm Level Profitability: the Case of Ontario Dairy Farms

by

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ABSTRACT

NUTRIENT MANAGEMENT REGULATION AND FARM LEVEL PROFITABILITY: THE CASE OF ONTARIO DAIRY FARMS

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The purpose of this study is to estimate the effect of Ontario’s Nutrient Management Act (NMA) on farm level profitability of dairy sector. NMA came into force in 2003 and sets standards for the storage and handling of nutrients for regulating farms that fit certain criteria to reduce the risk of nutrients entering surface water or groundwater, especially for farms with herd size that can produce Nutrient Units above a certain level (i.e. 300 Nutrient Units). While the Act may affect its regulated farms by incorporating additional compliance costs, it may not have the same effect on unregulated farms. Increase in the weighted-average production costs of all farms may lead to elevated milk price within a national cost of production (COP) pricing formula for dairy industry. A theoretical framework that describes the pathway by which farms’ economic performance can be affected by NMA is developed in this study. To empirically test whether NMA has effect on farm level profitability, a RE model is estimated by using the unbalanced panel data from Ontario Dairy Farm Accounting Project (ODFAP) from year 2000 to 2010. The empirical results of this study indicate that NMA may not have statistically significant effect on the profitability of regulated farms with no less than 300 Nutrient Units (NUs). A discussion is further developed to take into consideration factors that may affect this empirical results.
Acknowledgements

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Chapter 1 Introduction

1.1 Background

The environmental consequences of agricultural production are of increasing public concern (Organisation for Economic Co-operation and Development, 2004). Nutrient management is a major target of agricultural-specific environmental policies. Organisation for Economic Co-operation and Development (hereafter “OECD”) claims that improper use of nutrients, especially nitrogen and phosphorus resulted from manure and other fertilizers on crop production are key contributors to water, soil and air pollution (OCED, 2004). Spillover of nutrients and excess manure on land can result in nutrient runoff to streams and lakes, or leaching to groundwater. The ecological consequences are water contamination, surface water eutrophication, ammonia emissions and unsafe groundwater for drinking, etc.

OECD (2004) reported that Canada bears a low risk of nitrogen pollution from dairy cow manure at the national level. However, regional nutrient pollution may be high due to the existence of variations in nutrient balance, climate, management practices and soil type across different counties (OCED, 2004). OECD also implies that water pollution in dairy sector may be associated with production intensity since a higher risk of water pollution has been found in certain areas of Europe and Japan, where the milk production is highly concentrated (OCED, 2004). The intensity of milk production (refers to both geographic concentration and farm level production density) in Ontario has increased slowly with the number of dairy cows
reported per farm increasing over the years. Although the number of farms have declined over years, the size of each farm is increasing dramatically. Dairy farms with 1,200 cattle are increasingly common (Miller, 2000). Thus, nutrient pollution could be a concern in Ontario with increasing production intensity in dairy sector. Evidence shows that water quality in Ontario has already been affected by nutrients from agricultural practices. In May, 2000, the contamination of drinking water with E. coli, which caused the death of several Ontario’s residents in Walkerton, were suspected to be correlated with livestock manure (Miller, 2000). During that time, there were no systematic provincial regulations to govern the use of nutrient in agricultural production. Numerous townships and countries across rural Ontario had attempted to urge provincial governments to use legislative tools necessary to deal with nutrient management.

A range of policy instruments, such as command and control (CAC) instrument and market-based instruments (MBIs) related to nutrient management, have been used worldwide in dairy farming to address nutrient pollution issues. Command and control instrument is also referred to standards or regulations. It is one of the most common forms of environmental policies. ‘Command instrument sets maximum permitted level of pollution, while ‘control’ instrument monitors and enforces the standards. An alternative to the CAC approach is market-based instruments (MBIs). MBIs use price and other economic variables to provide incentives for the producers to reduce pollution. Charges (taxes), subsidies and tradable permits are frequently used in MBIs. Examples of these instruments can be found in European (e.g., EU Nitrate Directive), the United States (Clean Water Act, Nutrient Management Act, etc.), Mexico (LFDMA 1998) New Zealand (e.g., Resource Management Act), and Canada (Nutrient Management Act).

Environmental instruments, including nutrient management regulations, may entail changes in agricultural sector (Sunding, 1996). Changes led by environ-
mental policies could affect dairy operation in either a positive way or a negative way. Supporters of environmental policies argue that strict environmental regulations can encourage innovation, induce efficiency in production, and finally enhance business performance and nation’s competitiveness of the industry (Porter, 1990). Producers could experience increase in economic performance, such as technical efficiency, profitability, economic efficiency or productivity after the implementation of environmental policies (Porter and Van der Linde, 1995; Bauman, 2004). On the other side, environmental policies could have introduced additional production costs (e.g., pollution abatement cost) on agricultural production (Palmer et al., 1995; Pizer and Kopp, 2005, Piot-Lepetit and Moing, 2007a). Examples of compliance cost resulted from environmental policies will be developed later in this study. Among all the existing environmental regulations, nutrient (manure) management regulations are seen as the most comprehensive and costly for dairy farmers (OCED, 2004).

In Ontario, one of the major provincial agricultural-specific environmental policies associated with nutrient management is Nutrient Management Act, 2002 (hereafter NMA). NMA was developed by the Ministry of the Environment (MOE) and the Ministry of Agriculture, Food and Rural Affairs (OMAFRA), as part of the government’s Clean Water program. The purpose of NMA is to ‘provide for the management of materials containing nutrients in ways that will enhance protection of the natural environment and provide a sustainable future for agricultural operations and rural development’ (OMAFRA). A more comprehensive description of NMA will be developed in the following chapter. In brief, NMA sets out legal requirements for the storage and handling of nutrients, which refer to materials that are applied to land for the purpose of crop growth. The practices and standards listed in the Act associate primarily with three areas of nutrient management: application of agricultural source materials (such as manure, runoff and digestate
from regulated mixed anaerobic digesters), application of non-agricultural source materials (such as sewage biosolids, pulp and paper mill biosolids, food processing residuals) and disposal of dead farm animals. NMA was passed in 2002, and became effective since July, 2003. During the same year, the General Regulation (O.Reg 267/03) under NMA came into force since September 30th. O.Reg 267/03 was amended by O.Reg 511/05 and the amendment became effective since December 31st, 2005.

Not all agricultural operations are being phased in NMA. The Act only targets farms with certain criteria, including (1) large farm operations with Nutrient Unit\(^1\) no less than 300; (2) farms that are seeking a building permit with respect to a livestock or manure storage facilities or creating an earthen manure pit; (3) farms receiving non-agricultural source materials (NASM)\(^2\); and (4) farms that locates within 100 meters of municipal wells.

Prior to the implementation of this Act, only voluntary practices, such as the Best Management Practices (BMPs), were used for nutrient management in agricultural production. After NMA became effective, regulated farms have to undertake mandatory practices, such as preparing required paperwork (e.g., a Nutrient Management Strategy or a Nutrient Management Plan), conducting soil and nutrient testing by accredited laboratories and constructing or upgrading facilities if required. Thus, complying with NMA can be costly for regulated farms (Poon, 2009).

Production cost is associated with milk price under Canada’s cost of production (COP) pricing system. This system is a key point in this study since how milk price

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\(^1\)According to the O.Reg 511/05, a nutrient unit is defined as the number of livestock that gives the fertilizer replacement value of the lower of 43 kilograms (95 lbs.) of nitrogen or 55 kilograms (121 lbs.) of phosphate. Nutrient unit allows the same comparison of nutrient values generated by different types of livestock operations. Typically, 300 NU equals to 300 milking Jersey cows and 210 milking Holstein cows.

\(^2\)NASM includes yard waste, fruit and vegetable peels, food processing waste, pulp and paper biosolids and sewage biosolids.
received by farmers have been set would affect economic performance. The COP formula will be introduced in the theoretical framework. In brief, holding other variables constant, a higher milk price will be set by relevant milking boards along with elevated production costs to give producers fair economic return under the COP pricing system.

Therefore, contradictory effects of nutrient regulations could exist. On one hand, complying with nutrient management regulations may increase production costs (OECD, 2004; Palmer et al., 1995; Pizer and Kopp, 2005; Piot-Lepetit and Moing, 2007a; Poon, 2009). On the other hand, increase in production costs may enhance a farm’s economic performance by elevating the milk price that a producer receives under the COP pricing formula. The relationship between NMA and farm level profitability will be investigated in this study. Few researches have been done so far to empirically estimate the effect of NMA on farm level profitability for Ontario’s dairy sector.

1.2 Economic Research Problem

As mentioned above, the impact of NMA on economic performance is unknown. The existence of both negative effect and positive effect are possible with the implementation of NMA. Negative effect of NMA may be incorporated by regulatory compliance costs. Previous studies have indicated that nutrient management regulations can impose compliance costs in the form of nutrient application cost, land rental cost, nutrient export cost, investment cost and administration cost, etc. (Poon, 2009, Cassells and Meister, 2001). Positive effect refers to the increase in milk price led by higher cost of production.

The Canadian Dairy Commissions (CDC) has introduced a national Cost of Production (COP) formula to set the support price for butterfat and skim milk
since 1988. As the milking board in Ontario, Dairy Farmers of Ontario (DFO) is responsible for setting the milk price paid by processors. DFO uses the support price announced by the CDC as the basic reference when setting price for both fluid milk and industrial milk. Prices for ‘raw’ milk components (butterfat, protein and other solids) are the same for all the dairy producers in Ontario. The COP formula aims to give producers fair economic return and recover the loss from increasing cost\(^3\) by setting a higher milk price. Therefore, if milk prices are raised by additional compliance costs of regulated farms imposed by NMA, then unregulated farms can share the same elevated milk price with regulated farms without experiencing additional compliance costs. Higher milk prices would thus bring economic benefit for those farms that do not bear the increase in production costs. But the effect of NMA on regulated farms’ economic performance remains less clear since regulated farms may face additional costs and elevated milk price. The economic research problem addressed in this study is whether NMA has significant effect on the profitability of regulated farms.

The initiative of understanding the relationship between nutrient management policy and economic performance for dairy production is to provide useful information for the CDC, Ministry of Environment, OMAFRA and the government of Ontario when examining the economic consequences of environmental policies. It can also provide incentive for dairy producers to adjust their nutrient management practices and seek a trade-off between the compliance of environmental policies and the improvement of farm level economic performance. Part of the methods used in this study can also be applied to other agricultural operations that are subject to environmental regulations.

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\(^3\)The cost refers to the weighted-average production cost of all producers selected by the CDC when set milk prices. Detail discussions of the COP formula will be developed in the following chapter.
1.3 Purpose and Objective

The purpose of this study is to examine the economic impact of NMA on farm level profitability. The objectives of this study are to:

1. understand nutrient management regulations imposed on dairy sector with a focus on NMA by reviewing current nutrient management policies pertinent to agricultural production in Ontario and other places around the world;

2. understand theories used for analyzing the effect of nutrient management regulations on farm level profitability by compiling literature reviews on the economic effect of environmental policies in agricultural sector.

3. understand the pathway by which NMA may affect profitability by classifying compliances costs and developing conceptual framework for analyzing the economic effect of NMA;

4. empirically test whether and to which extent NMA affects the profitability of regulated farms by specifying empirical framework with variables that represent the implementation of NMA.

1.4 Chapter Outline

Chapter 2: Review of nutrient management policies

This part will provide an overview of nutrient management policies, and pinpoint provisions in NMA relevant to Ontario’s dairy production.

Chapter 3: Literature review on environmental policies and farm level economic performance

The chapter will highlight theories and researches on the impact of agricultural-specific environmental policies on farm level economic performance. Compliance
costs generated under NMA based on previous studies on the measurement of compliance costs of nutrient management regulations will also be classified.

Chapter 4: Conceptual Framework

This part will develop the conceptual framework which describes how farm level profitability is affected by NMA and come up with the hypothesis of this study.

Chapter 5: Empirical Framework

This chapter will provide data source used in this study, and elaborates empirical framework employed to empirically test the hypothesis.

Chapter 6: Empirical Results and Discussion

This part will provide empirical results and discusses the implication of these results.

Chapter 7: Summary and Conclusion

The part will conclude methods applied in the thesis, major findings and their implications for Ontario’s dairy production, as well as Ministry of Environment and OMAFRA. Limitation of this study and suggestions for future research will also be provided in this chapter.
Chapter 2  Nutrient Management Regulation Review

2.1 Introduction

To provide a general framework of how the nutrient management actives are regulated in agricultural production, this section will review main existing nutrient management regulations across different countries and time periods with an emphasize on the introduction of Ontario’s nutrient regulation policy. This chapter will then pinpoints main provisions listed in NMA associated with dairy production by introducing scenarios of farms that are being phased in NMA, main clauses that restrict dairy production, and solutions for non-compliance.

2.2 General Review on Environmental Policies

The main objective of environmental regulations in agriculture is to enhance the protection of environment and to provide sustainable agricultural operation and rural development (NMA, O.Reg 267/03). Environmental polices have been issued across different countries over years. Water contamination is one of the major problems targeted by agricultural environmental policy. Since improper management of nutrients, including nutrient storage, application rate, application timing, handling system, treatment system, etc., is among the factors that contribute to water
pollution, management of nutrients plays a critical role in environmental policies.

Europe has a long history of environmental policies associated with nutrient management. EU Nitrate Directive (91/676/EEC) sets a spreading limit of organic manure at 170kg/ha\(^4\) for non-grass crops and 250kg/ha on grassland. European Drinking Water Directive of 1980 introduced upper limits on the concentrations of nitrate and pesticides in drinking water. Farmers could face mandatory constraints on the use of fertilizers and pesticides under this regulation (Latacz-Lohmann and Hodge, 2003). UK responded to European Drinking Water Directive by introducing controls of Nitrate Vulnerable Zones (NVZs). Farmers with land in NVZs have to follow mandatory rules to tackle nitrate losses from agriculture and to controls the type, quantity and timing of applications of inorganic fertilizer and organic manure.

Similar regulations governing rates and timing of nutrient application have been long established in Germany, Denmark and Netherlands. For example, in Netherlands, the maximum quantity of manure (measured in kilogram phosphate) applied to land has been restricted under a manure quota system since 1986. All farms producing \(P_2O_5\) above 125 kilogram per hectare paid a yearly surplus levy of \(EUR\) 0.11 to \(EUR\) 0.23 per kg \(P_2O_5\). Provisions governing methods, equipment (e.g., low emission machine) and timing of nutrient application (e.g., winter application was forbidden) also came into effect gradually from 1990 to 1998. In 1998, Netherlands government introduced a new levy system (called MINAS) on the nitrogen and phosphate surplus of pig, poultry and dairy farms and the system became compulsory since 2001. Farms with phosphate and nitrogen surplus higher than levy-free surpluses have to pay levy fees.

The example of Netherlands illustrates how the market-based environmental instrument works for nutrient management: it restricts nutrient application by incorporating additional costs of production through charges or taxes on excessive

\(^4\)1 ha = 1 hectare
nutrients produced. A different approach of nutrient regulation would be command-and-control instrument, such as the LFDMA issued by Mexico. Mexico introduced a legislative framework of national discharges in 1996. The framework combined with Federal Water Rights Law and became LFDMA in 1998. Farmers are required to present the ‘plan of action’ to the regulatory authority for improving the quality of residual water. The plan should be fulfilled through either the change in production process or the control of treatment system of farm discharges (Drucker and Latacz-Lohmann, 2003).

Resource Management Act came into force in 1991 in New Zealand. The amount of nitrogen application, the depth of application, facilities requirements are all being regulated in the act. For example, no more than 150 kg nitrogen can be applied to land per hectare; any ponds or holding facilities must be sealed to prevent leakage; each nitrogen application must not be more than 25 mm deep.

The United States also issued policies to control nutrient application in agricultural sector. Concentrated Animal Feeding Operations (CAFOs) are required by EPA (Environmental Protection agency) to develop and implement a manure and wastewater handling plan (Nutrient Management Plan).

Unlike many other countries that have their nutrient management regulated within a national framework, the federal government in Canada has little direct control over water quality issues associated with nutrient application as natural resource management falls under provincial and municipal jurisdiction (Poon, 2009). Nutrient management activities used to be regulated by a complex system of laws and policies with gaps and overlaps (McRobert, 2004). There was a lack of systematic tools necessary to regulate the use of nutrients in agricultural production (Miller, 2000). This is why an array of new policies, such as Clean Water Act

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5A CAFO is an animal feeding operation that (a) confines animals for more than 45 days during a growing season; (b) in an area that does not produce vegetation; (c) meets certain size thresholds.
Clean Water Act treats farming nutrients (especially the application of nitrogen and phosphorus at 15% above crop requirement per hectare) as threats to water quality. CWA regulates application of nutrient on land that is considered as aquifer recharge zones and vulnerable areas. Compared to NMA, the definition of regulated entities of CWA is more vague. The size and location of the protection zones regulated under CWA are still being determined (Poon, 2009). But NMA has clear targets of farms being regulated. In addition, NMA provides a comprehensive, enforceable and province-wide nutrient management framework for Ontario’s agricultural operations, gives the best management practices the force of law, and sets out detailed environmental protection guidelines. These are reasons why this study chooses NMA for analysis over the CWA or any other nutrient management regulations. For a better understanding of the pathway through which NMA affects economic performance, following section elaborates the major provisions listed in NMA associated with dairy production.

2.3 Review of Nutrient Management Act

2.3.1 General introduction of Nutrient Management Act

This section will explore the regulatory history of NMA, introduce criteria of farms being phased in NMA and state provisions in NMA that could affect farm level economic performance. Provisions of NMA have been changed since it was first implemented, as well as the criteria set for regulated farms. Understanding these changes help to develop more accurate definitions of variables representing regulation timing and regulated farms, which will be used in the empirical analysis.

In general, NMA is a ‘command and control’ regulation that sets standards for the storage and handling of nutrients for farms of different sizes and qualifications.
to reduce the risk of nutrients entering surface water or groundwater. Nutrients are defined as materials applied on land for the purpose of crop growth (NMA, O.Reg 267/03).

Since NMA is a preventive and proactive planning approach, key processes of complying with NMA are the preparation and submission of Nutrient Management Plan (NMP), Nutrient Management Strategy (NMS) and Non-agricultural source materials (NASM) plan. A NMS is a working document that describes the generation, storage and destination of prescribed materials produced by a farm unit. A NMS may include information such as description of farm unit, farm sketch, location of sensitive features and municipal wells, agreement, list of prescribed materials, information on regulated mixed anaerobic digestion (‘AD’) facilities, material storage information, contingency plan and sign-off form. The determination of new or expanding storages/buildings, if needed, should also be presented in NMS for OMAFRA’s approval. A NMP outlines management approaches that optimize the utilization of nutrients by crops. The NMP is required for providing nutrient information, analysis of nutrient content, field information (field properties, field sketch and soil sampling analysis), crop practices, crop rotations and expected crop yields, and the application of commercial fertilizer and prescribed materials. Application rate of commercial fertilizer and prescribed materials should be in accordance with limits set by NMA. Starting from January 1, 2011, a non-agricultural source material (NASM) plan should be required for farm units that have NASM listed in the Nutrient Management Act applied to land.

In summary, the documents (NMS, NMP and NASM plan) listed above are key tools to comply with NMA. Regulated farms should prepare and submit required documents to OMAFRA. The NMS documents nutrient type, nutrient quantity produced and nutrient storage facilities. A NMP outlines nutrient analysis and ap-

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6Prescribe materials refer to agricultural and non-agricultural materials from the management of livestock or the by-product of a treatment process.
plication rate that optimizes nutrient utilization. NASM is similar to NMP in that it addresses field application of nutrients, but NASM plan also includes nutrients from off-farm sources. Adopting farming practices as listed in these documents are required by NMA since these documents are believed to help farmers optimize the use of nutrients on the farm, while protecting nearby water resources.

The general regulation of NMA became effective since September, 2003 and it was amended several times after that. The major amendment O. Reg 511/05 happened in 2005. The criteria for ‘phased-in’ farms that are required to submit NMS/NMP or NASM plan have been changed under the amendment. Table 2.1 summarizes major scenarios that fall under NMA, and compares these scenarios under the original regulation O.Reg 267/03 and the amendment O. Reg 511/05.

2.1

Under both regulations O. Reg 267/03 and O.Reg 511/05, NMA mandates all farm units\(^7\) that generate more than 300 Nutrient Units any time after July 1st, 2005 to complete a Nutrient Management Strategy (NMS) and a Nutrient Management Plan (NMP)\(^8\). The amendment also requires any farm operations seeking a building permit with respect to a livestock or manure storage facilities or creating an earthen manure pit to have nutrient management strategies (NMS) approved by OMAFRA, while a NMS is not required in original regulation for such farms. To prevent water contamination, any dairy operation that requires a NMS and locates within 100 meters of municipal well also needs to submit a NMP under the new regulation. According to the amendment, NMS and NMP are required to be reviewed, summarized and updated annually if necessary. A renewal of NMS/NMP happens every five years. By comparing the ‘phased-in’ scenarios under two regulations...
<table>
<thead>
<tr>
<th>Scenarios</th>
<th>O. Reg 267/03 (During September 30th, 2003 and December 31st, 2005)</th>
<th>O. Reg 511/05 (After December 31st, 2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. $NU \geq 300$</td>
<td>NMS/NMP required if operating after July 1st, 2005</td>
<td>NMS and NMP required if operating after July 1st, 2005</td>
</tr>
<tr>
<td>2. $5 &lt; NU &lt; 300$</td>
<td>NMS/NMP required only if operations are new</td>
<td>NMS/NMP not required</td>
</tr>
<tr>
<td>3. Applies for building permit with respect to a livestock or manure storage facilities or creates an earthen manure pit</td>
<td>NMS/NMP not required unless captured under another scenario</td>
<td>NMS required</td>
</tr>
<tr>
<td>4. Change ownership/control that affects capacity to implement the NMS</td>
<td>NMS updated, OMAFRA approval required</td>
<td>NMS updated, OMAFRA approval required</td>
</tr>
<tr>
<td>5. Locates with 100 meters of municipal well and NMS required</td>
<td>NMS/NMP not required unless captured under another scenario</td>
<td>NMP required</td>
</tr>
<tr>
<td>6. Receives non-agricultural source materials and is required for NMS</td>
<td>NMP required</td>
<td>NMP required</td>
</tr>
<tr>
<td>7. Has significant changes to NMS/NMP</td>
<td>Annual updates not required</td>
<td>Annual updates required</td>
</tr>
</tbody>
</table>

Source: Environmental Commissioner of Ontario Annual Report 2005-06
lations, I can conclude that O. Reg 267/03 and O. Reg 511/05 appear to be equally restrictive for scenario 1, 4 and 6. For farms fall under scenario 2, O. Reg 267/03 is more restrictive. The amendment requires farms under scenario 3, 5, 7 to submit and update relevant documents while O. Reg 267/03 does not have such terms.

Among all the scenarios, farms with more than 300 NU is the most important scenario and would be chosen as the only ‘regulated group’ in the empirical analysis. Reasons are as follows: 1) unlike other scenarios, this is the only scenario that can be clearly identified based on the data that we have; 2) As long as farms do not have dramatic changes in the numbers and types of their livestock, the NUs would be relatively stable. On the contrary, the other scenarios may be temporary and change more frequently over time. For instance, the change of ownership and the application for building permit may only be a one-time incident. Thus, choosing farms with more than 300 NUs for empirical analysis is desirable and statistically feasible. Since such large farms are required to submit NMS/NMP only if they operate after July 1st, 2005 under both regulations, year after 2005 will be regarded as the ‘post-implementation period’ during which NMA is binding for regulated farms with more than 300 NUs. A detailed discussion on the set of regulation timing will be developed in the empirical framework.

Following sections will highlight provisions in NMA associated with dairy production. Understanding provisions helps to investigate how the additional costs are incorporated in the dairy production. When preparing NMS/NMP under NMA, farmers need to make sure that the contents of these documents are in accordance with these provisions, such as maximum application rate and requirements on nutrient storage facilities, application methods and application timing.
2.3.2 Maximum application rate of nutrients

Nutrient Management Act sets maximum application rates for two nutrients, which are major sources for water contamination: phosphorus and nitrogen. Maximum application rates of phosphorus are as follows:

The maximum application rate of total plant available phosphate to land per hectare for NASM (non-agricultural source materials), manure or the anaerobic digestion output\(^9\) during any consecutive five-year period does not exceed the greater of,

1. the crop production requirements per hectare plus 85 kilograms of phosphate per hectare for that five-year period; and

2. the phosphate removed from the land per hectare in the harvested portion of the crop during that five-year period plus 390 kilograms of phosphate per hectare.

The Maximum application rate of nitrogen to land for NASM and anaerobic digestion output is:

1. The total plant available nitrogen applied does not exceed 200 kilograms per hectare for any 12 months period.

2.3.3 Requirements on Nutrient Storage Facilities, Application Methods and Application Timing

Nutrient Management Act sets a series of specific standards with regards to land application and nutrient storage. Setbacks from wells, application methods, concrete quality of the facilities, requirements for the construction and expanding of nutrient storage facilities and capacity of storage facilities are all listed.

\(^9\)Anaerobic digestion (AD) means the decomposition of organic matter in an oxygen limiting environment.
For instance, according to NMA, high trajectory irrigation guns that are capable of spraying liquid more than 10 meters cannot be used for applying manure or non-agricultural nutrient resources; no person shall apply manure or non-agricultural source materials directly from a storage facility to land by a direct flow application system unless the system fits certain criteria listed in NMA. NMA also has provisions that target especially dairy operation. For example, types of constructions in dairy operations that may require building permit include: milking parlour, milkroom, sediment tank, treatment trench system and milking center washwater storage facilities. Milking center washwater facilities should be equipped with runoff management system before they can be used to store milking washwater. Dairy operations should also have a permanent nutrient storage facility or a combination of such facilities that is capable of containing all of the milk washwater generated or received during 240 days. Either a sediment tank or a treatment trench system can be used to dispose milk washwater.

2.3.4 Other requirements

There are other miscellaneous requirements in NMA. For instance, each person who is required to prepare a NMP should take samples from manure and AD output and have the nutrient contents tested by accredited laboratories. Soil testing is also necessary for operations that applied non-agricultural source materials as categorized in the Act. Nutrients are not allowed to be applied to land closer than 100 metres to a municipal well.

2.3.5 Contingency Plan

Preparing NMS/NMP and NASM plan according to terms listed above and following the practices in these documents are main tools to comply with NMA. However, in the event that NMS, NMP and NASM plan cannot be followed, a contingency
A contingency plan is written to set out actions to be taken. It may change NMS, NMP or NASM plan. The major problem addressed by a contingency plan is excess nutrients. When nutrients are more than the NMS/NMP/NASM plan or storage capacities have addressed, the excess nutrients can be either applied to land (if maximum application rates in the strategies and plans are not the maximum application rate) or to set up alternative uses for the nutrients (if the application rates in the strategies and plans are maximum). Actions taken under the alternative uses can be (1) find a broker who can take the excess nutrients through a Broker Agreement; (2) find an intermediate generator who will accept the nutrients with a Nutrient Transfer Agreement; (3) acquire more land and transfer nutrients to an available storage facility with excess capacity.

In addition, a contingency plan also addresses problems such as the change in application timing, fertilizer application and management of off-farm materials. For example, for any materials that cannot be used in a AD facility, the operator may consider other disposal methods such as landfilling, composting or other processing methods.

2.4 Compliance with the Nutrient Management Act

Based on the review of NMA in the last section, complying with NMA requires the following actions to be taken: first of all, ‘phased-in’ farms have to register with OMAFRA, prepare and submit required NMS and/or NMP/NASM plan. Some of these ‘phased-in’ farms have to get their strategies and plans approved by OMAFRA (e.g., farms that locate within 100 meters of municipal wells). Preparation of NMS/NMP/NASM plan should be in accordance with terms under NMA. Generally speaking, the requirements of NMA lie in two aspects: first, nutrient
application should not exceed the maximum application rate, In addition, other nutrient management practices, such as the construction, sitting and capacity of nutrient storage should follow certain protocols.

As long as the phased-in regulations continue to generate manure, their NMS, NMP or NASM plan needs to be renewed every five years upon approval. There is no need for farms to re-submit the documents every year, but they have to keep these strategies and plans updated for inspection if requested. The annual update should reflect anticipated operation on the farm unit during the following year.

**2.5 Non-compliance with the Nutrient Management Act**

Since NMA is more of a preventive regulation, whether the compliance and enforcement of NMA should be accountable has been one of the most contentious issues raised by commenters (ECO, 2006). Many farms stressed that complying with NMA should be positive and cooperative rather than punitive. Farmers are not required to self-report non-compliance but would be charged penalty if the non-compliance is inspected. The penalty are now still calculated on a ‘case-by-case’ basis, depending on whether the violations are inspected and the severity of violation. OMAFRA shares responsibility for policy and standards development with the Ministry of the Environment, and sole responsibility for outreach, training, certification and approvals. The Ministry of the Environment has sole responsibility for compliance and enforcement (OMAFRA). The Ministry of the Environment (MOE) Agricultural Environmental Officers (AEOs) are provincial officers with specialized agricultural training and are responsible for working with farmers to encourage compliance with NMA.

Offences of NMA with correspondence to the compliance practices listed in the
last section can be summarized as: incompletion of required documents (NMS/NMP/NASM plan); the required documents are completed but their contents violate NMA provisions; farming practices violate NMA and have caused undesirable pollutions. For instance, excess nutrients have not been properly addressed. Once the violations exist, the Ministry of Environment would have to utilize different types of compliance tools, including education and outreach, amending approval conditions of NMS/NMP, introducing voluntary abatement programs, issuing a Provincial Officer’s Order, issuing a Provincial Offenses Act Summons and referring to investigations and enforcement branch, to correct the violations. How these tools work for non-compliance of different levels of severity will be elaborated below. These tools can help understand how additional costs are imposed in dairy operation when farming operations are inspected to violate NMA.

1. Education and outreach

An AEO may assist farm operations by identifying required operations and present options through education and outreach. For instance, when the annual update of a farm is not completed, an AEO can provide guidance in assisting the update. There is no penalty generated for farmers under this condition.

2. Amend approval conditions of NMS/NMP

If the approved NMS/NMP did not accurately reflect reality or provide a sufficient level of protection based on local conditions, an AEO may request OMAFRA to amend NMS/NMP in response to non-compliance led by the inaccuracy of NMS/NMP. The penalty generated under this circumstance should be low as well.

3. Voluntary abatement program

If the violation of NMA has caused nutrient pollutions, an AEO can make an oral or written request to the person responsible for correcting non-compliance practice to undertake abatement programs. This request is typically used for minor issues where the cause is a lack of information or knowledge and the corrective action is
simple to achieve in a short period of time with a low potential for environmental consequences if the action is not performed.

4. Provincial Officer’s Order

When the offence of NMA may cause severe nutrient pollutions and no voluntary abatement programs are believed to be taken within the agreed time, an AEO can issue a Provincial Officer’s Order. This is a legally binding document that sets out obligations for specific person associated with specific operations.

5. Provincial Offenses Act Summon

When there are serious environmental consequences or lack of willingness to comply with an order or abatement program from OMAFRA, a Provincial Offences Act Ticket can be issued to the farm operators, the person to whom the ticket is issued may choose to plead guilty, pay the fine or to defend themselves in Provincial Offences Court. For example, a farm that has ongoing violations and unwillingness to submit any required documents may be issued the Summons.

6. Refer to investigations and enforcement branch

When non-compliance are not reported properly by the responsible person and have caused serious environmental problems, a referral to the Ministry’s Investigations and Enforcement Branch (IEB) may be made for investigation or prosecution. This may result in summons under the Provincial Offenses Act. Costs generated could be relevant legal fee and abatement costs.

2.6 Summary of the Nutrient Management Act

In summary, NMA applies a number of mandatory standards and reporting requirements for farms that fit certain criteria. It includes rules on nutrient storage capacities, application loads of nutrients per hectare of land and reporting requirements, etc. Farm units which fall under NMA are not limited in the amount of
manure they generate (in the sense of an emission standard: $e.g., e \leq \bar{e}$) but, instead, under NMA farm units (who must comply) are required to manage waste following the mandatory guidelines set forth in NMA. Compliance practices are enforced and inspected by MOE officer, while non-compliance behaviours would be required to be corrected and penalty can be charged by the officer. Complying with NMA alters the fixed and variable costs associated with milk production and the way nutrients are applied but leave the decision of herd size and total nutrients generated to the farmer. Next chapter will review studies on the economic impact of nutrient management regulations on agricultural production, as well as researches on the classification of compliance costs associated with the compliance of nutrient management regulations.
Chapter 3  Literature review on environmental policy and farm level economic performance

3.1  Introduction

There is currently no study that measures specifically the economic impact of NMA on Ontario’s dairy sector, but various researches have been done in measuring the effect of nutrient management policy instruments employed in different areas. This section will provide overviews of literatures with regards to the economic impact of nutrient management regulations. By claiming that the major pathway through which the nutrient management regulations affect economic performance is imposing compliance costs, this section will also review previous studies on the compliance costs of nutrient management regulations. Based on previous studies, a classification of compliance costs under NMA will also be developed in this chapter.

3.2  General review on the economic impact of environmental policies

Most researches on the economic impact of environmental policies focuses on measuring the effect of these policies on productivity, growth and competitiveness at
the industry level, or the effect on efficiency, profitability, cost and revenue, etc. at the farm level (Poon, 2009). Valentine et al. (2004) utilized actual farm level economic and Best Management Practices (BMPs) adoption data and developed a regression model to examine the relationship between the use of BMP and farm level profitability. Their empirical results indicated that the adoption of nutrient management BMPs has a significant and positive effect on the net farm income for wheat and corn. Le Moing and Piot-Lepetit (2007) examined the effect of EU Nitrate Directive on efficiency indices for French pig farms. The EU Nitrate Directive limits the amount of organic manure being spread on land, as well as the amount of nitrogen surplus. Farm level efficiency indices for production (production efficiency) and environmental performance (environmental efficiency) were created using directional distance function. The study concluded that complying with mandatory standards of EU Nitrate Directive lead to the increase in farm revenue and decrease in bad output (nitrogen surplus). A large part of the studies on the economic impact of nutrient regulations was built on researches of compliance costs.

### 3.3 Review on the Compliance Costs of Environmental Policy

It is proposed that firms subject to tighter environmental regulation will incur higher costs than firms subject to lower, or non-existent environmental regulation (Cassells and Meister, 2001). In other words, if two firms were identical in all aspects except environmental regulation, the firm with weaker or non-existent regulation

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10 The use of Best Management Practices(BMPs) is recognized as an acceptable method of reducing non-point source pollution (mainly nutrients, pesticides and sediments) by Environmental Protection agency in the United States and has been developed by landowners, environmentalists, environmental regulatory agencies and other Extensions over years.
will offer cost advantage and have better economic performance. Hence, a major path through which environmental regulation can affect economic performance is imposing cost in production. Whether and to which extent a policy imposes costs in production can be a concern when measuring the economic impact of this policy.

Nutrient management policies are believed to have imposed costs in production (OCED, 2004; Palmer et al., 1995; Pizer and Kopp, 2005, Piot-Lepetit and Moing, 2007a; Poon, 2009). For instance, Fleming et al. (1996) stated that policy designed to address the livestock manure nutrients is associated with and depends partly on the on-farm cost of alternative manure handling facilities. Studies have also been done to measure the compliance costs of nutrient management regulations.

It is proposed that compliance costs of nutrient management regulations can be classified as direct compliance cost and indirect compliance cost (Piot-Lepetit and Moing, 2007b; Pizer and Kopp, 2005). Direct compliance cost reveals the change in production costs entailed by the policy, while indirect cost can be interpreted as the opportunity cost (e.g., forgone milk revenue) of regulatory compliance. Cassells and Meister (2001) listed five types of costs in dairy sector associated with manure management regulations, including manure storage facility cost, application on-farm cost, application off-farm cost, administration cost, and value of nutrient in manure. Bezlepkina et al. (2008) concluded that costs of complying with Common Agricultural Policy (CAP) for dairy sector were: investment cost, production cost (e.g., additional labor cost, manure management cost), administrative cost and non-compliance cost.

Compliance costs of nutrient management regulations were measured for different industries in previous studies. Two generalization can be drawn from those studies: firstly, the magnitude and scope of regulatory compliance costs tends to be

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11The nutrients provided in the manure are benefits to farmers rather than cost. The value of nutrients is based on the shadow price of commercial fertilizer and maximum legally required utilization rate of fertilizer.
low when compared with other production costs (Meyer, 1995). Cassells and Meis-ter (2001) measured the industry level cost of the adoption of land-based effluent disposal system under water quality regulation (Resource Management Act 2001) on New Zealand dairy sector. A model was developed to simulate the production process and to measure the capital and labor cost associated with the compliance. It turned out that the environmental cost is only a small portion of total milk production cost at 2.1% - 3.2%.

Jongeneel et al. (2007) and Jongeneel et al. (2008) had a similar conclusion. In their study, the additional cost borne by EU agricultural producers under EU’s agricultural-specific nutrient standards, especially Nitrate Directive, are on average very low. For EU’s dairy sector, production cost was estimated to have increased by 0.1% to 0.6% with the enforcement of Nitrate Directive. The compliance with Nitrate Directive was expected to reduce dairy export by less than 1%, indicating an insignificant effect of this regulation on the industry’s economic performance (Jongeneel et al., 2007; Jongeneel et al., 2008). EU agricultural production standards are believed to be stricter than that of Canada. Hence, compared with EU, the loss with compliance is expected to shrink to a lower degree in Canada (Jongeneel et al., 2007; Jongeneel et al., 2008). OECD conducted a comparative analysis of the nutrient management costs with the storage, disposal and application of manure in the following six countries/regions: Netherlands, Denmark, Ontario (Canada), Japan, Switzerland and Waikato (New Zealand). Results showed that compliance cost for dairy sector contribute to 2%-4% of all the production costs. Another generalization is that reductions in output caused by environmental control cost are small and insignificant on average (Dean, 1992). The empirical results from OECD’s (2004) comparative study for the six countries/regions indicated that the differences in nutrient management costs for dairy sector do not explain the differences in competitiveness among countries/regions being studied.
Most researches measuring environmental costs were done for manufacturing industries rather than agriculture. One reason is that most agricultural-specific environmental policies, including NMA in Ontario, may regulate non-point source pollution\(^{12}\), and the damage of non-point source pollution is hard to measure (Cassells and Meister, 2001). Another reason is that environmental regulations targeting agriculture is often ‘vague, subject to interpretation and lacking in concrete policy prescriptions’ (Bredahl et al., 1996). This reinforces the difficulty in empirically testing the relationship between policy and farm profitability (Valentin et al., 2004).

In summary, types of compliance costs of nutrient management policies diverse across regimes and areas, but it is common that compliance costs of environmental regulations are generally low as compared to the overall production costs. It can be hard to measure such compliance costs since the effect of non-point source pollutions addressed by nutrient management policies is hard to assess. Meanwhile, the lack of clarity in most nutrient management regulations reinforces the difficulty in measuring the compliance costs. Due to the problems mentioned above, the compliance costs generated under NMA will not be measured empirically but are still categorized in the following sector. Built on previous studies, discussions on the additional costs incurred under NMA will be drawn in the following section.

### 3.4 Categorization of Compliance Costs

Compliance costs generated under NMA include direct compliance cost and indirect compliance cost (Piot-Lepetit and Moing, 2007b; Pizer and Kopp, 2005). Direct compliance cost is the change in production costs entailed by NMA and can be divided further into fixed costs and variable costs. Fixed compliance cost is independent of the milk production, while the magnitude of variable costs depends

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\(^{12}\)Non-point source pollution comes from diffuse sources, such as excess fertilizer, herbicide, pesticide, sediments from crop lands, bacteria and nutrients from livestock, etc.
on the amount of excess nutrients generated. Indirect cost refers to unaccounted economic burden generated under NMA.

### 3.4.1 Fixed costs

Fix costs \( FC_{NMA} \) of NMA can appear in the form of investment cost and administrative cost. Investment costs may include the purchase, repair, construction and expanding, interests paid for the construction and expanding of nutrient storage facilities and buildings. Administrative cost can be incorporated in the process of preparing relevant documents and paperwork of NMA.

1. **Investment costs** \( I \): A large proportion of compliance costs borne by farmers with the adoption of these technologies is identified as investment cost (Piot-Lepetit and Le Moing, 2007). Investment cost can arise from the introduction of treatment system (Drucker and Latacz-Lohmann, 2003) and the adoption of other facilities required by environmental regulations. Restrictions on the nutrient application method, treatment system, processing equipment, and storage facilities in NMA can directly affect the adoption of farming technologies. There is no immediate return for the investment unless financial supports are provided by government for encouraging the adoption of new technologies. Fixed costs diverse across farms, and are determined by the current technologies and facilities that each farm owns.

2. **Administration cost** \( C_{\text{admin}} \): Part of the administration cost is determined by the required timing of nutrient planning, nutrient accounting and nutrient trading (nutrient export and import), etc. (Drucker and Latacz-Lohmann, 2003). Under NMA, the administration cost is incorporated in the process of preparing NMS/ NMP/ NASM plan. People are required to take courses and get certificates issued by OMAFRA before they are eligible to prepare NMS/NMP/NASM plan. The preparation of legal documents (such as a Broker Agreement) associated with NMS/NMP must be completed correctly and may require a lawyer’s review.
This could also generate costs. Administration cost is a concern when measuring compliance cost since it is hard to capture (Schmalensee, 1993).

### 3.4.2 Variable costs

Under NMA, additional variable costs ($VC_{NMA}$) are correlated with the amount of excess nutrients generated. One way to understand the variable costs of nutrient regulation is to consider the channels through which excess nutrients can be stored and the nutrient pollution can be reduced (Pizer and Kopp, 2005). NMA and the contingency plan (if required by NMA) list channels that address excess nutrients. The channels include: (1) transferring nutrient to another farm operation, nutrient storage facilities or broker; (2) expanding the land-base of nutrient application; (3) practicing abatement activities. Compliance costs corresponding to the first channel are nutrient export and transfer fees (through Broker’s Agreement and Nutrient Transfer Agreement). The second channel would lead to compliance costs that appear in the form of land rent (by acquiring extra land). The last channel would incur pollution abatement costs.

Meanwhile, violation of NMA may also generate compliance cost, depends on the probability of offences being inspected by an AEO officer and severity of non-compliance. The variable costs can also be incorporated by protocols that require farms to take certain practices (e.g., the collection and analysis of materials containing nutrients and studies of soil type). In general, variable costs of the compliance of NMA may include nutrient export cost, land rental, non-compliance cost and other variable costs.

1. **Nutrient export or transfer cost** $C_{exp}$: Transferring nutrients through agreements is an option to manage excess nutrients. Nutrients can be transferred through three agreements: Nutrient Transfer Agreement, Application Agreement and Broker Agreement. Producers can choose to transfer the nutrients to other
operation through Nutrient Transfer Agreement. When nutrients are applied to land that is not owned or rented by the generator of the nutrients, an Application Agreement is needed. The Application Agreement demonstrates that the generator of the nutrients should manage the application with the consent from the land owner. Nutrients can also be sold to a broker who is responsible for finding a suitable use for the material through a Broker Agreement. Costs for transferring nutrients can be either positive or negative. If nutrients are sold as marketable goods, the costs is thus ‘negative’ ($C_{exp} < 0$) and should be considered as economic benefits. On the other hand, if producers are paying to have the nutrients removed, this cost becomes additional economic burden for producers and is positive ($C_{exp} > 0$). Distance of nutrient hauling can be a major determinant of the nutrient export/transfer cost under this condition. In summary, $C_{exp}$ is subject to the amount of excess nutrient generated, marketability of nutrients, and hauling distance for nutrient export/transfer.

2. **Land rental** $C_{\text{land}}$: NMA sets the maximum application rate of nutrients per hectare. One way to manage excess nutrients is to expand land base for manure application by purchasing or renting more land. However, it should be noted that land expansion is associated with various factors and may not necessarily be led by NMA.

3. **Non-compliance cost** $C_{\text{non}}$: As mentioned in the last chapter, when non-compliance of NMA are inspected by an AEO, additional costs can be charged in the form of: (1) fine issued by Ministry of Environment (MOE); (2) abatement program costs; and (3) other legal fee (court fee for instance). Non-compliance cost is associated with the probability of violation being inspected and severity of environmental consequences detected by AEOs. The measurement of non-compliance cost could be a concern since non-compliance is dealt with a case-by-case basis. NMA is a preventive approach and does not have a clear set of protocols for penalty. No at-
tempt has been made to measure legal fee for non-compliance due to environmental regulations (Schmalensee, 1994).

4. **Other variable cost** $C_{other}$: Other variable costs associated with nutrient management can be: additional labour cost, manure and fertilizer application cost, and testing costs. Additional labour may be required to address the change in farming practices. The restrictions of application area can affect nutrient application costs. Soil and nutrient testing in accredited laboratories are required by NMA, which could also be a challenge to arrange in areas where there are no such labs around.

Therefore, total direct compliance costs can be considered as the summation of fixed costs and variable costs. The compliance costs can be described as:

$$C_{NMA} = FC_{NMA} + VC_{NMA} = (I + C_{admin}) + (C_{exp} + C_{land} + C_{non} + C_{other}) \quad (3.4.1)$$

Where $I$, $C_{admin}$, $C_{exp}$, $C_{land}$, $C_{non}$, $C_{other}$ denote investment cost, administrative cost, nutrient export/transfer cost, land rental, non-compliance cost and other variable costs, respectively.

### 3.4.3 Indirect Cost and Indirect Benefits

Indirect cost refers to unaccounted economic burden generated under nutrient regulation. Regulations that require capital expenditure could crowd other productive investment (Rose, 1983). Regulations could also discourage newer and more productive investment (Nelson et al., 1993). In addition, implementation of regulations could also reduce operating flexibility and slow productivity improvements in general (Pizer and Kopp, 2003). Reducing livestock number is an alternative to reduce the amount of nutrients despite there shall be no restrictions on the number of farm animals that may be managed in the course of an agricultural operation. Under
this circumstance, forgone milk production and milk revenue could be regarded as indirect costs in this study. However, due to the supply management system in Canada’s dairy sector, milk production should be relatively stable regardless of quota exchange. Therefore, reduction in livestock number and decrease in milk production should not be a big concern when considering indirect costs.

In addition to direct cost and indirect cost that induce ‘economic burden’ for regulated individual, negative cost was suggested (Pizer and Kopp, 2005; Piot-Lepetit and Moing, 2007). Negative cost can be interpreted as ‘indirect benefits’ for the producer in terms of increasing productivity and efficiency led by regulation (Pizer and Kopp, 2005).

One of the ‘indirect benefits’ that has not been discussed often in previous literature is the potential increase in milk price. As I have mentioned earlier in the economic research problem, milk price paid by processors is positively associated with the weighted-average production costs of all milk producers within a COP pricing framework in Canada. The production costs imposed under NMA may raise the milk price. The existence of such ‘indirect benefits’ would be further discussed in the following chapter.

Despite the possibility of some cost-saving offsets under nutrient management regulations, the ‘negative cost’ still remains skeptical. The neoclassical view that treats firms as profit-maximizing entity is not consistent with the existence of ‘indirect benefit’. This means that if changes suggested by regulation were indeed profit-enhancing, farms would always be willing to implement the changes without the prompt of regulation. Therefore, it is proposed by some of the previous studies that the compliance costs of nutrient management regulations are expected to be positive, and should decrease the profitability (Palmer et al., 1995).
3.5 Measurement of Compliance Costs

There are several ways to measure the direct compliance cost. Prospective cost analysis and retrospective cost studies are used most often. The collection of observed or reported data on expenditures on environmental protection is a retrospective way to measure the compliance costs. However, this survey approach can be problematic in the sense that sample size, response rate, difficulty to differentiate environmental expenditures and farmers’ misinterpretation of survey questions can all affect the accuracy of the collected data (Portney, 1981, Streitwieser, 1996).

The alternative to retrospective cost studies is to apply econometric method or mathematical programming in predicting direct compliance cost. Historical data can be used to estimate relationships between the production cost and emissions (e.g. nitrogen surplus, phosphate surplus) (Pizer and Kopp, 2005). However, the absence of historical experience in agriculture sector makes it difficult to estimate such additional production cost (direct compliance cost). Another concern associated with econometric method is that compliance costs may fall over time as farmers learn and adjust through investments, change in practices or location (Jongeneel et al., 2007; Jongeneel et al., 2008). Meanwhile, changes in production decisions can lead to unanticipated changes in farm production activities that regression analysis may not be able to capture (van Ham, 1995; Drucker and Latacz-Lohmann, 2003; Bonham et al., 2006). Mathematical programming is used in industrial scale cost analysis, especially simulation models (Poon, 2008; Cassells and Meister, 2001; Drucker and Latacz-Lohmann, 2003). Simulating approach is powerful in the sense that simulation models can reveal changes in production activities and provide respective changes in revenue and cost (Poon, 2009). However, manipulation of representative farms in the simulating approach may not be able to reveal actual field-by-field data. Production in agriculture is a complex, stochastic and dynamic
process, in which farms may have different characteristics that are difficult to be captured in mathematical programming.

Another way to measure direct compliance cost is to pose questions to engineers who are familiar with abatement technology. This engineering approach has been used to measure the costs of environmental regulation or alternative policies (Atkinson and Lewis, 1974; Seskin et al., 1983; Perl and Dunbar, 1982, U.S. EPA 1985, 1992; Tietenber, 2000; Morgenstern, 1997). However, technologies differ across farms in dairy sector. This makes the approach of engineer estimates problematic (Pizer and Kopp, 2005).

NMA can be considered as a prescriptive ‘command and control’ regulation instrument. One problem of the command and control instruments is that the compliance would be subject to the interpretation of an MOE Agricultural Environmental officer, who is responsible for helping farmers to comply with the law. The penalty of non-compliance of NMA is issued on a case-by-case basis. Thus, neither prospective nor retrospective methods can accurately measure the non-compliance costs.

Considering problems mentioned above in measuring compliance costs and the availability of data, the compliance costs generated under NMA with not be measured empirically in this study under either retrospective or prospective way. Instead, the econometric method will be applied to examine the economic effect of NMA on profitability in the empirical framework.

### 3.6 Summary

This chapter provides literature reviews on the economic impact of nutrient regulations. No consistent conclusions have been found in the effect of nutrient regulations on farm level economic performance. Since one of the major methods used
to examine the economic impact of environmental regulations is through the measurement of compliance costs, this chapter also provides review on studies on the compliance costs of environmental regulations. Compliance costs of nutrient management regulations are found to be low in general, and few evidence has been found to show that industry-wide economic performance was affected by the environmental regulations in agricultural sector. The measurement of compliance costs of environmental regulations in agricultural sector is found to be relatively difficult as compared to that of other industries due to the lack of clarity.

Two major methods used in measuring compliance cost are retrospective studies and prospective studies. Retrospective studies require the collection of historical or survey data, while prospective studies calls for the application of econometric method and mathematical programming. Cost estimation from engineer who is familiar with the technology adopted under new environmental policy can also provide useful information in measuring compliance costs. Both retrospective and prospective approaches could be problematic in the sense that farming activities involves with various factors that may not be observed. It is difficult for producers to differentiate the compliance cost of nutrient regulations from the other production cost. The lack of historical data also incurs difficulties for econometrically estimating the compliance cost.

Due to the difficulties mentioned above and restrictions on data availability, this study will not empirically measure the compliance costs of NMA but still elaborated the classification of such costs. Nutrient management regulations are expected to impose cost in either direct or indirect ways in dairy production. Direct compliance costs generated could be: investment cost, administrative cost, nutrient export cost, land rental, non-compliance cost and other variable costs. Although indirect costs (such as forgone milk output) have been suggested in previous literature, the existence of such costs remains skeptical with few empirical and supportive
evidence. Indirect benefits of NMA may exist in the form of elevated milk price within a national COP pricing formula. The existence of both direct compliance costs and benefits will be discussed in the following chapter.
Chapter 4  Theoretical Framework

4.1  Introduction

A framework that tracks the pathway by which NMA may affect the profitability is developed in this chapter by introducing a national Cost of Production (COP) pricing formula, in which the weighted-average production cost of all dairy farms is positively associated with milk price received by dairy producers. While NMA may incorporate production costs for regulated farms, it does not have the same effect on unregulated farms. This induce different economic effects, which will be elaborated in this chapter, for regulated and unregulated farms. A summary of major findings from the theoretical framework will be provided.

4.2  Cost of Production Formula

Cost of production is taken into consideration by the Canadian Dairy Commissions (hereafter ‘CDC’) when setting support prices for butterfat and skimmed milk powder (CDC, 1994). Cost of production (COP) here is a periodic calculation and represents a farm’s total costs to produce a hectolitre\(^{13}\) of milk. Every year, CDC con-

\(^{13}\)1 hectolitre of milk=100 liter of milk
ducts a uniform collection of data survey of the cost of production across Canada\textsuperscript{14}. Ontario’s data used by the CDC to determine the support price is ODFAP (Ontario Dairy Farm Accounting Project)\textsuperscript{15} and the average milk production share for Ontario each year is around $1/3$ (Lippert, 2001). The production-weighted average COP for each province is then weighted nationally based on provincial share of total milk production. The support price is determined by applying the calculated national cost of production to COP formula (the CDC, 1994), which can be expressed as below:

$$p = 0.4COP + 0.3CPI + 0.3PDI$$ \hspace{1cm} (4.2.1)

In which $p$ is the support price for butterfat and skim milk powder\textsuperscript{16}, COP is the nationally weighted cost of production on a per hectolitre basis (1 hectolitre=100 litre). COP is weighted as the most important factor in this formula and accounts for 40\% of the change in the support price. As compared to CPI and PDI, COP is also the only factor that dairy producers can have direct control of. Cost of production includes cash cost, capital cost and producer labor used for milk production (See table 4.1 for detail).

Compliance costs discussed in the previous chapter may find their corresponding items in table 4.1. For instance, capital cost may be categorized as fixed compliance cost. Transportation fee, purchased feed, cash cost for land and plants, custom work, fertilizers, building repairs, hired labor and other miscellaneous fee may contain variable costs that are affected by NMA.

\textsuperscript{14}Samples of efficient producers for COP calculation are selected randomly from eligible producers based on three principles: 1. Selected producers should have annual milk shipments at or above 60\% of the average provincial yearly production for the most recent available dairy year; 2. The COP of producers selected should be within 2 standard deviation of COP in the sample; 3. Producers with the highest 30\% of the cost of production per hectolitre of milk in the sample surveyed should be eliminated.

\textsuperscript{15}ODFAP is a joint program of DFO, the Ontario Ministry of Agriculture and Food, the Canadian Dairy Commission and the University of Guelph.

\textsuperscript{16}$p$ is first calculated based on the COP formula, and then being decomposed into price of butterfat and price of skim milk powder.
Table 4.1: Cost of production components

<table>
<thead>
<tr>
<th>Cash cost</th>
<th>Purchased feed, artificial insemination, transportation, fees &amp; promotion, machinery &amp; equipment repairs, fuel &amp; oil, custom work, fertilizers &amp; herbicide, seeds &amp; plants, land &amp; building repairs, property tax and insurance, hydro and telephone, hired labor and other miscellaneous fees.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cost</td>
<td>Interests paid, building and depreciation, machinery &amp; equipment depreciation, cow depreciation and return on equity.</td>
</tr>
<tr>
<td>Producer cost</td>
<td>Direct labor, return to management</td>
</tr>
</tbody>
</table>

Source: Canadian Dairy Commissions Cost of Production Final Results

CPI refers to Consumers Price Index. It reflects the consumer price changes of a basket of commodities\(^{17}\). PDI refers to personal disposable income. PDI measures the amount of money after direct taxes (including income tax, social insurance and other fees)\(^{18}\). CPI and PDI can measure changes in prices for goods and services, as well as changes in private income. CPI and PDI are included in the formula to take into consideration the effect of inflation.

Support prices are announced by the CDC by mid-December based on the data collected in the previous year and become effective in the next February (the CDC, 2004). The basic principle of the national COP pricing is to set support price for industrial milk that efficient milk producers would have received to cover their cash cost, labour and investment costs related to milk production. This is the rationale why cost of production affects milk price positively. According to national COP formula (4.2.1), milk price is a function of the production costs and is positively related with the COP.

\[
p = p(COP) \text{ and } \frac{\partial p}{\partial COP} = 0.4 > 0 \quad (4.2.2)
\]

\(^{17}\)Change in the sum of the CPI for most recent 12 months, as compared to the sum of CPI for the previous 12 months, measures milk price change. The data is provided by Statistics Canada.  
\(^{18}\)The percentage change of total PDI of the most recent 12 months as compared to the total PDI for the previous 12 months is indexed to indicate the change in milk price. The data is collected from Statistics Canada.
These support prices are basis for the prices set by the provincial marketing boards for industrial milk\textsuperscript{19} and fluid milk\textsuperscript{20}. Dairy Farmers of Ontario (DFO) is the milking board in Ontario and has the authority to set prices paid by the processors for both industrial milk and fluid milk. DFO buys all the milk from producers and then sells them to the processors. Instead of recalculating the milk prices based on provincial data, DFO uses support prices of CDC as the basic reference to set prices for industrial milk and fluid milk paid by processors, and the support prices \textsuperscript{21} may be adjusted based on stakeholder negotiation (Goldfarb, 2009)\textsuperscript{22}. DFO then invoices processor and returns the ‘blended price’ of industrial milk and fluid milk to producers after the marketing costs\textsuperscript{23} have been subtracted. Therefore, every farm should receive the same blended milk price. This implies that both regulated and unregulated farms under NMA share the same milk price. While all farms receive the same milk price, their production costs may vary. With the implementation of NMA, regulated farms may have to bear additional production costs, while the unregulated farms do not have to experience such increase in production costs. The cost of production data used by the CDC to set milk price is the weighted-average production costs of all selected sample farms. Increase in COP of regulated farms may contribute to the increase in weighted-average production cost and could lead to elevated milk price shared by all producers. Hence, unregulated farms would be benefited from the Act. However, effect of NMA on regulated farms’ profit remains unknown since regulated farms may face increase

\begin{itemize}
\item \textsuperscript{19} Industrial milk refers to the milk used in the production of dairy products, such as butter, cheese and yogurt.
\item \textsuperscript{20} Fluid milk includes flavoured milk and creams.
\item \textsuperscript{21} According to DFO, a new pricing formula for fluid milk replaced the following formula since February, 2011. The new pricing formula relies 50 percent on Consumer Price Index and 50 percent on cost of production. The personal disposable income is taken off for more stability in milk price.
\item \textsuperscript{22} The negotiation plays a critical role especially in determining the fluid milk prices.
\item \textsuperscript{23} Marketing costs include milk promotion, milk transportation fees, DFO administration fees, and research fees, These deductions accounts fro 6\% of the price paid to the farmers and are shared by five provinces (P5), including Ontario, Quebec, New Brunswick, Nova Scotia and Prince Edward Island.
\end{itemize}
in both milk price and production costs. To solve this problem, farm level profit of regulated and unregulated farms will be defined mathematically and in figures.

### 4.3 Farm level profitability

Under NMA, dairy producers are divided into two groups: regulated farms and unregulated farms (see table 2.1 for the criteria of regulated farms). Following assumptions are made to develop the theoretical analysis:

1. Milk output is fixed under supply management, and there is no quota exchange.

2. COP formula is the only determinant of support prices. There are no unpredictable adjustments, such as stakeholders’ negotiation. CPI, PDI and other province’s cost of production data are constant.

\[ \Delta p = \Delta COP \]

3. All farms in Ontario produces milk of the same quality and receive the same price for every hectolitre of milk. Milk prices received by farmers equal to the support prices announced by the CDC.

Assuming total number of farms surveyed by the CDC to set support price is \( N \).

In the absence of NMA, profit of each individual dairy farm can be expressed as:

\[ \pi_i = p(COP)\bar{y}_i - C_i(\bar{y}_i, G) \]

in which \( p \) is the price of ‘raw’ milk received by farmers. \( COP \) is the national weighted-average production costs per hectolitre calculated by the CDC. \( C_i \) denotes
the individual cost of production for farm $i$.

$$COP = \sum_{i=1}^{N} \frac{C_i w_i w_p}{\bar{y}_i} \text{ for } i = 1, ..., N$$  (4.3.1)

The weighted average cost of production $COP$ is determined by each farm’s production cost and their production share. $w_i$ is each individual farms production share within the province, and $w_p$ is provincial milk production share\textsuperscript{24}. $p(COP)$ represents that milk price received by farmers is a function of the nationally weighted production costs. $\bar{y}_i$ is the output (milk) of each farm. Under the supply management system, $y_i$ is assumed to be fixed. $G$ represents the dairy production technology (e.g., treatment system, milking system). Total cost of production $C_i(\bar{y}_i, T)$ is a function of both milk output and technology.

After NMA became effective, farms regulated by the Act may bear additional production cost in the form of variable costs and fixed cost. As showed in equation (3.4.1), the direct compliance cost equals to:

$$C_i^{NMA} = VC_i^{NMA} + FC_i^{NMA} = (C_{exp} + C_{land} + C_{non} + C_{others}) + (I + C_{admin});$$

where $C_{exp}$, $C_{land}$, $C_{non}$ and $C_{others}$ are variables costs and represent nutrient export/transfer fee, land rental, non-compliance cost and other variable cost, respectively. $C_{non} = 0$ when there is no violations of NMA or the farm is not inspected to have non-compliance. Fixed compliance costs include investment cost $I$ and administrative cost $C_{admin}$.

With these additional compliance costs, the new cost of production (the indirect compliance cost is not taken into consideration in this study) for each farm becomes:

$$C_{i}^{new} = C_i + C_i^{NMA}$$

\textsuperscript{24}Provinces surveyed by the CDC include: Prince Edward Island, New Brunswick, Nova Scotia, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia
Despite the potential existence of ‘negative compliance costs’, such as the sales from excess nutrients, the direct compliance costs are still hypothesized to be positive for regulated farms under NMA($C_i > 0$). Assuming that NMA incorporate production costs only for regulated farms and the possibility of unregulated farms voluntarily undertaking NMA practices are excluded, then $C^{NMA}_i > 0$ for regulated farms and $C^{NMA}_i = 0$ for unregulated farms. Hence, the new production cost $C^{new}_i > C_i$ for regulated farms and $C^{new}_i = C_i$ for unregulated farms. The weighted-average cost of production for all farms is still going to increase under this condition. Suppose the new national weighted-average cost of production is $COP_a$. I would have:

$$COP_a > COP$$

According to the COP formula, milk price should be positively related with national weighted-average cost of production. Suppose that the new milk price is $p_a$ and all the assumptions mentioned at the beginning of this section hold, then $p_a$ would be larger than price $p$ when $COP_a > COP$:

$$p_a(COP_a) > p(COP)$$

Assume that technologies of regulated farms also change under the implementation of regulation, $G$ becomes $G_a$. Similarly, $G_a = G$ for unregulated farms and $G_a \neq G$ for regulated farms. The new profit $\pi^{new}_i$ for each individual farm becomes:

$$\pi^{new}_i = p_a(COP_a)\bar{y}_i - C^{new}_i(\bar{y}_i, G_a)$$
Total change in profit of regulated farms can be expressed as:

\[ \Delta \pi_l = \pi_i^{NMA} - \pi_i = [p_a(COP_a)\bar{y}_i - C_{i}^{new}(\bar{y}_i, G_a)] - [p(COP)\bar{y}_i - C_i(\bar{y}_i, G)] \]

\[ = [p_a(COP_a) - p(COP)]\bar{y}_i - C_{i}^{NMA} = \Delta p\bar{y}_i - C_{i}^{NMA} \]  

(4.3.2)

While the change in profit for unregulated farm is:

\[ \Delta \pi_s = \pi_i^{NMA} - \pi_i = [p_a(COP_a)\bar{y}_i - C_{i}(\bar{y}_i, G)] - [p(COP)\bar{y}_i - C_i(\bar{y}_i, G)] \]

\[ = [p_a(COP_a) - p(COP)]\bar{y}_i = \Delta p\bar{y}_i \]  

(4.3.3)

Since \( p_a > p \), \( p_a - p = \Delta p > 0 \). Hence, change in profit of unregulated farms \( \Delta \pi_s \) is positive. Meanwhile, the sign of \( \Delta \pi_l \) is uncertain. It depends on which one is greater, the change in milk revenue (\( \Delta p\bar{y}_i \)) or the change in production costs (\( C_{i}^{NMA} \)).

Compare \( \Delta \pi_l \) with \( \Delta \pi_s \), I am able to find out that:

\[ \frac{\Delta \pi_l}{\bar{y}_i} = \Delta p - \frac{C_{i}^{NMA}}{y_i} < \frac{\Delta \pi_s}{\bar{y}_i} = \Delta p \]  

(4.3.4)

The equations listed above imply that unregulated farms would benefit from NMA, while the economic effect of NMA on regulated farms remains uncertain. The change in profit per output for regulated farms is small than that of unregulated farms.

The change in profit, milk price and production costs associated with NMA can be revealed by Figure 4.1. The left hand figure represents cost curves, output level and milk prices faced by regulated farms, while the right figure represents unregulated farms. Before the implementation of NMA, regulated and unregulated farms produce at \( y_l \) and \( y_s \) respectively. All farms face the same milk price at \( P \).
Figure 4.1: Comparisons of price, profitability and production costs of regulated farms and unregulated farms

and \( ATC \) are the marginal cost curve and average total cost curve, respectively\(^{25}\). The shadow areas \( \pi_l = Peba \) and \( \pi_s = Pihg \) are the economic profits of regulated farms and unregulated farms respectively.

The implementation of NMA incorporates additional compliance costs for regulated farms. Therefore, production costs of regulated farms increase. Compliance costs borne by regulated large farms will lead their cost curves, \( MC_l \) and \( ATC_l \), shift upwards to \( MC_a \) and \( ATC_a \). In contrast, although receiving the same milk price as regulated farms, unregulated farms do not have to change their cost curves since their productions are not affected by NMA.

Since production costs contribute to 40% of the change in milk price, as indicated in the milk price formula, the additional costs generated by regulated farms under NMA will increase the weighted-average cost of production of both regulated and unregulated farms. Milk price increases from \( p \) to \( p_a \) with the increase in

\(^{25}\)Unregulated entities and regulated entities may have different cost curves due to the difference in production scale, technology and efficiency, but this will not affect the analysis within this framework.
weighted-average production costs of all farms. Under the new milk price $p_a$ and costs, economic profit of regulated entity equals to area $P_{afcd}$. Change in profit equals to $\Delta \pi_l = P_{afcd} - P_{eba}$. This figure does not tell whether the new profit $P_{afcd}$ is greater than the original profit $P_{eba}$ or not. Thus, effect of the implementation of NMA on profitability of regulated farms remains unknown. New profit of unregulated farms is area $P_{a,jhg}$ after the implementation of NMA. Change in profit for unregulated farms can be written as: $\Delta \pi_s = P_{ihg} - P_{a,jhg} = P_{a,jip}$. $\Delta \pi_s$ is positive. Therefore, unregulated farms benefits from the implementation since they can share the same elevated milk price with regulated farms without experiencing any additional compliance costs. In summary, if the assumptions came up at the beginning of this section are satisfied, summaries from the conceptual framework can be addressed as following:

1. Additional cost of production incurred by NMA on regulated farms would increase milk price received by all farmers.

2. The effect of NMA on regulated farms’ profitability remains unknown.

3. The implementation of NMA increases profitability of unregulated farms.

4. After the implementation of NMA, change in profitability per output of regulated farms is smaller than that of unregulated entities. In other words, profit per output of unregulated increases to a larger degree due to the implementation of NMA.

$$\frac{\Delta \pi_l}{y_l} < \frac{\Delta \pi_s}{y_s}$$

4.4 Hypothesis

According to the conceptual framework, the null hypothesis that will be tested in the empirical framework can be drawn as: the profitability of regulated farms are
not affected by NMA, while the alternative hypothesis is that NMA has significant effect on regulated farms’ profitability. If I reject the null hypothesis, then NMA should have a statistically significant impact on profitability. Therefore, complying with NMA may decrease/increase regulated farm’s profit. On the contrary, failing to reject the null hypothesis indicates that NMA may not have statistically significant impact on regulated farms’ profitability. According to the COP formula, milk price received by all farms increases with the national weighted-average production costs when holding CPI and PDI constant. NMA has a positive effect on the profit of unregulated farms, but its economic impact on regulated farms remains unknown.

4.5 Summary

A theoretical framework is developed to analyze the economic effect of NMA. A key factor discussed in the framework is the national COP formula, in which a higher weighted-average production cost may lead to elevated milk price. Under this COP pricing policy, farm level profitability of unregulated farms are found to increase when NMA imposes production costs on regulated farms. Meanwhile, the economic effect of the Act on regulated farms remains unknown. Both negative effect (increased production costs) and positive effect (elevated milk price) are found to exist for regulated farms. Based on the theoretical framework, the null hypothesis can be addressed as: NMA does not have significant effect on regulated farms’ profitability, while the alternative hypothesis is that regulated farm’s profitability is significantly affected by NMA. The hypothesis will be tested empirically in the following chapter.


Chapter 5  Empirical Framework

5.1  Introduction

To empirically test the null hypothesis that NMA does not have significant effect on profitability of regulated farms, an econometric model is specified with the introduction of variables that represent the implementation of NMA. I will explain the set up of model, specify sources of data and summarize variables used in the model.

The basic set up used for estimating the effect of NMA on farm level profitability of regulated dairy operations in Ontario is to assume that profit is a liner function of a vector of explanatory variables, including variables that represent the implementation of NMA. An unbalanced panel data regression model will be run using the $i^{th}$ farm’s dairy profit per cow during $t^{th}$ period $\pi_{it}$ as the dependent variable. Main independent variables are three dummy variables - $DUM.SIZE_{it}$, $DUM.REGTIME_{it}$, and $DUM.NMA_{it}$ - that represent the farm size, regulation timing of NMA and regulated farms respectively. Definitions of these dummy variables will be provided later in this chapter. According to previous studies, factors that capture the determinants of profitability, including farm operator characteristics, farm management characteristics, technology and time variables, are also used
as explanatory variables. The profit function of dairy operation during is:

\[
\pi_{it} = \beta_0 + \beta_1 DUM.SIZE_{it} + \beta_2 DUM.REGTIME_{it} + \beta_3 DUM.NMA_{it} \\
+ \beta_4 Others_{it} + \beta_t T + C_i + u_{it}; i = 1, \ldots, N; T = 1, \ldots, M
\]  

(5.1.1)

Where \(i\) indexes farm and \(t\) indexes time period. The total number of farms are \(N\) and the time period covers \(M\) years. \(\pi_{it}\) is the profit of farm \(i\) at period \(t\). \(\beta_0\) is the intercept. \(\beta_1, \beta_2, \beta_3, \beta_4\) and \(\beta_t\) are coefficients to be estimated. Others_{it} are factors that capture the determinants of profitability. \(t\) represents time variable(s). \(C_i\) denotes unobservable factors that are constant over time. \(u_{it}\) represents the error term, and is assumed to be an independent identically-distributed random variable sampled from a normal distribution. \(u_{it} \sim N(0, \sigma^2)\) where \(\sigma^2\) is the variance. More comprehensive definitions of variables will be developed later in this chapter.

### 5.2 Data

Farm level data of 2000-2010 is taken from ODFAP (Ontario Dairy Farm Accounting Project). It is an unbalanced panel data which maintains a sample of farms representing typical Ontario dairy situations and different levels of technology, regional differences and other significant factors. Each farm remains in the panel for one to five years. Given this study’s interest in the profitability of dairy operation, a subset of sample farms was chosen following the principle that a farm should be selected only if more than 80% of the farm’s revenue is derived from cow (dairy) enterprise\(^{26}\) (Moschini, 1988). Thus, profitability could be compared in a relatively homogeneous group that specializes in milk production and has similar production structure (Sipiläinen, 2007; Reinhard, 1999). After the subset was chosen, total 723 samples are included in the unbalanced panel data.

\(^{26}\)There are seven enterprises in the dataset, including cow, replacement, general farm, corn, hay, corn and overhead.
CPI deflator used in this study is the CPI for all items in Ontario. The data range from year 2000 to 2010 and are taken from Statistics Canada. The conversion factors between the nutrient units and livestock numbers are available in the O. Reg 511/06 in Nutrient Management Act.

5.3 Variable Description

5.3.1 Dependent variable

Profit per cow: Typically, ODFAP consists of seven enterprises: general farm, cows, replacement, small grain, hay, corn and overhead. Based on this study’s interest in dairy production, dairy revenue is defined as the direct revenue from cow enterprise\(^\text{27}\). The pricing formula, accounting process and policies surrounding COP have changed over time since 1988 when the national COP study came into place. This leads to difficulty in accurately measure the individual COP results from the sample farms. Based on the data that I have, farm level dairy production cost is calculated as the summation of: (1) total direct expenses for cow enterprise (including supplies, milk trucking, marketing, livestock registration, livestock insurance, \textit{etc.}); (2) total allocation expenses for cow enterprise (such as taxes allocation expense, labour allocation expense and repair allocation expenses); (3) intermediate expenses for crops and replacement enterprises\(^\text{28}\). All the data are available in ODFAP. Profit per cow is then calculated by using the total revenue less cost, and then deflated by CPI deflator(index 2002=100).

Farm level profit is calculated on a per cow basis. NMA should have similar

\(^{27}\)It is difficult to separate the inputs used in milk production from inputs used jointly in animal operations from the dataset. Therefore, direct revenue from cow enterprise, which include milk revenue and livestock (cull cows, breeding cows and bulls) sold, is used as a proxy of dairy revenue. Milk revenue consists of over 95\% of the total direct revenue from cow enterprise on average.

\(^{28}\)Intermediate costs from crop(replacement) enterprises=total allocation expenses from crop(replacement) enterprises+total direct expenses from cop(replacement) enterprise-total direct revenue from crop(replacement) enterprises
effects on gross profit and profit per cow if the productivity per cow is relatively stable. Herd size is used as a proxy of output and is assumed to be positively related with milk production. Therefore, it is reasonable to use profit per cow as the dependent variable.

5.3.2 Independent variables

Independent variables that capture the profitability relationship in dairy operation consist of five parts: (1) the implementation of NMA; (2) farm operators’ characteristics; (3) farm management characteristics; (4) technology and (5) time variables. A summary of variable descriptions is presented in table 5.1

**Farm size:** Farm size measured by NU is a major determinant for identifying whether a farm should be phased in NMA. A dummy variable is established to represent the threshold number of NUs for farms being regulated by NMA. In this study, farms with not less than 300 NUs are considered as regulated entities. Hence, the variable $DUM.SIZE_{it}$ equals to one for farms identified as with nutrient units (NUs) no less than 300, and equals to 0 otherwise ($NU < 300$).

$$DUM.SIZE_{it} = 0 \text{ if } NU_{it} < 300$$
$$DUM.SIZE_{it} = 1 \text{ if } NU_{it} \geq 300$$ (5.3.1)

Farm size is usually believed to have positive effects on profitability due to the cost advantages that large operations have under economies of scale (Foltz et al., 2002; Postel et al., 2009)

**Regulation timing:** A dummy variable is established to capture the effect of regulation timing on profitability. The general regulation of NMA, O. Reg 267/03, was first put in place in September, 2003 and was amended at the end of 2005 as O. Reg 511/05. As stated in Chapter 2, major practices of compliance are based on NMP/NMS. However, under both O. Reg 267/03 and O. Reg 511/05, large farms
with no less than 300 NUs \((NU \geq 300)\) are required to fulfil the requirements of submitting NMS/NMP only if they operates in/after July 1\(^{st}\), 2005. No protocols were made in the O. Reg 267/03 to require large farms \((NU \geq 300)\) operated before July 1\(^{st}\), 2005 to submit their NMS/NMP and follow the practices of NMS/NMP. Therefore, these two general regulations under NMA appear to be equally restrictive for regulated farms with NUs no less than 300. The assumption made in this study is: it is not until July 1\(^{st}\), 2005 that all large dairy producers with no less than 300 NUs began to be restricted by NMA. Since monthly data is not available, the dummy variable representing regulation timing \(DUM.REGTIME\) is set to be one if sample farms operate after 2005. Since data used in this study covers time period 2000 to 2010, \(DUM.REGTIME_{it} = 1\) if a farm operates during 2006-2010, and \(DUM.REGTIME_{it} = 0\) if the farm operates during 2000-2005. In other words, time period 2000-2005 is considered as the “pre-implementation” period, 2006-2010 is the “post-implementation” period.

\[
DUM.REGTIME_{it} = 0 \text{ if } T = 2000, 2001, ..., 2005 \\
DUM.REGTIME_{it} = 1 \text{ if } T = 2006, 2007, ..., 2010 
\tag{5.3.2}
\]

This dummy variable may capture any time-varying factors. Therefore, the effect of this variable on profitability is unknown.

**Implementation of NMA:** To examine the effect of NMA on profit for regulated dairy operations, farms are divided into two groups based on their nutrient units: regulated (large) farms with NUs equal to or greater than 300 and unregulated (small) farms with NUs less than 300. To be phased in the Act, a large farm with no less than 300 NUs must also operate after 2005 (operates during ‘post-implementation period’ from 2006 to 2010). Therefore, the dummy variable established to represent farms being phased in NMA, \(DUM.NMA\), is the product of \(DUM.REGTIME\) and \(DUM.SIZE\).
DUM.NMA = DUM.SIZE × DUM.REGTIME

DUM.NMA would be one only when both DUM.SIZE and DUM.REGTIME equal to one. This can be expressed as:

\[ DUM.NMA_{it} = 0 \text{ if } DUM.SIZE_{it} = 0 \text{ and/or } DUM.REGTIME_{it} = 0 \]
\[ DUM.NMA_{it} = 1 \text{ if } DUM.SIZE_{it} = 1 \text{ and } DUM.REGTIME_{it} = 1 \]

(5.3.3)

In summary, large farms with livestock producing no less than 300 NUs are treated as the regulated group of NMA in the empirical framework. They have to comply with practices suggested by NMA after year 2005. Three dummy variables, including farm size, regulation timing and implementation, are set to represent the issuing of NMA. The dummy variables representing farm size equals to one when farms have NUs no less than 300. The dummy variable represents implementation timing equals to one only if farms operate after 2005, the year when farms with no less than 300 NUs are required to be subject to NMA. Product of these two variables represents the implementation of NMA. This dummy variable equals to one only when farms are being phased in NMA, and equals to zero otherwise.

In additions to these three dummy variables, other factors that are believed to affect farm level profitability are also included in the regression, including farm operator’s characteristics (including farm principal operator’s age and educational level), farm management characteristics (including business type, the adoption of milk record keeping practice, age of the farm, debt to asset ratio, region and breed of herd), technology and time variables.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy profit per cow (π)</td>
<td>$/head</td>
<td>(Direct revenue from cow enterprise-direct expenses from cow enterprise-total allocation expense for cow enterprise-intermediate costs from crops and replacement enterprises)/Number of cows</td>
</tr>
<tr>
<td><strong>Independent variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrient Management Act</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm size (DUM.SIZE)</td>
<td>1/0</td>
<td>1=NU≥300 ; 0=otherwise</td>
</tr>
<tr>
<td>Regulation time (DUM.REGTIME)</td>
<td>1/0</td>
<td>1=YEAR&gt;2005; 0=otherwise</td>
</tr>
<tr>
<td>Implementation of NMA (DUM.NMA = DUM.SIZE × DUM.REGTIME)</td>
<td>1/0</td>
<td>1=Being phased in the Act; 0=otherwise</td>
</tr>
<tr>
<td><strong>Farm operators’ characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principal operator’s age (AGE)</td>
<td>Years</td>
<td>Number of years</td>
</tr>
<tr>
<td>Principal operator’s education (EDU)</td>
<td>1/0</td>
<td>1=Greater than high school education; 0=otherwise</td>
</tr>
<tr>
<td><strong>Farm characteristics</strong></td>
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<td></td>
</tr>
<tr>
<td>Herd size (COWS)</td>
<td>Numbers</td>
<td>Number of milking cows</td>
</tr>
<tr>
<td>Business type (BTYPE)</td>
<td>1/0</td>
<td>1=Sole proprietor; 0=partnership or corporation</td>
</tr>
<tr>
<td>Milk recordkeeping (RECORD)</td>
<td>1/0</td>
<td>1=milk record keeping; 0=otherwise</td>
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<tr>
<td>Age of the farm (FAMAGE)</td>
<td>Years</td>
<td>Number of years</td>
</tr>
<tr>
<td>Debt to asset ratio (DARATIO)</td>
<td>Ratio</td>
<td>Debt to asset ratio</td>
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<tr>
<td>South-western region (DUM.SW)</td>
<td>1/0</td>
<td>1= south-western region; 0=otherwise</td>
</tr>
<tr>
<td>South-eastern region (DUM.SE)</td>
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<td>1=south-eastern region; 0=otherwise</td>
</tr>
<tr>
<td>Breed of Herd (BREED)</td>
<td>1/0</td>
<td>1=Holstein; 0=otherwise</td>
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<tr>
<td><strong>Technology</strong></td>
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<td></td>
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<td>Milking system (DUM.MS)</td>
<td>1/0</td>
<td>1=Parlour; 0=buckets, pipeline or transfer station</td>
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<tr>
<td>Manure system (DUM.MANURES)</td>
<td>1/0</td>
<td>1=Solid system; 0=liquid system</td>
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<tr>
<td>Feeding system (DUM.FS)</td>
<td>1/0</td>
<td>1=Semi/fully automated; 0=manual</td>
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<tr>
<td>Housing system (DUM.HS)</td>
<td>1/0</td>
<td>1=Tie stall; 0=loose housing, free stall or others</td>
</tr>
<tr>
<td>Time trend (T)</td>
<td>Numbers</td>
<td>$T=1$ if Year=2000, $T=2$ if Year=2001, ..., $T=11$ if Year=2010</td>
</tr>
<tr>
<td>Squared-trend ($T^2$)</td>
<td>Numbers</td>
<td>square of time trend $T$</td>
</tr>
</tbody>
</table>
Farm operator’s characteristics: Farm operators’s characteristics include farm principal operator’s age (AGE) and education (EDU). Farm operator’s age may affect the way a farmer manages the dairy operation. It is suggested by previous studies that farm operator’s age should be negatively correlated with profit (Foltz and Chang, 2002; El-Osta et al., 1998). Farm operator’s educational level is believed to have positive effects on profit since people who receive higher education are more likely to embrace new technology and information that are beneficial for production (Huffman, 1977; Lin, 1991).

Farm management characteristics: Farm management characteristics consist of herd size (COWS), farm business type (BTYPE), the adoption of milk record keeping practices (RECORD), age of the farm (FARMAGE), debt to asset ratio (DARATIO), region (DUM.SW and DUM.SE) and breed of herd (BREED). Herd size is the number of milking cows that each farm has. Large farms are usually believed to exploit economies of scale (Foltz, et al., 2002; Postel et al., 2009). Therefore, the coefficient of herd size is hypothesized to be positive.

Farm business types include sole proprietor, partnership and corporation. They have different implications for liability, taxation and succession. There is no consistent conclusion on the effects of business types on profit (Shashini, 2010).

A farm with milk record-keeping practice is able to provide farmers with more information in animal feeding and breeding (Foltz et al., 2002; Gloy, et al., 2002). It is therefore hypothesized that the adoption of milk record keeping practice has positive effect on profit.

Farm age denotes the number of years since a farm starts milk shipping. Farms operate longer are expected to have better managerial experience and thus higher profits (Shashini, 2010). Therefore, farm age and profitability should be positively related.

The debt to asset ratio (D/A) reflects the proportion of assets that are financed
through debt. The effect of debt to asset ratio on profitability is uncertain. It may depend on how effective the borrowed funds has been utilized in generating profits (Haden and Johnson, 1989).

ODFAP samples are collected from Southern Ontario with the grid areas of collection being divided into six regions based on the similar of land capacities, climatic factors and non-dairy opportunities (ODFAP, 2009). These regions are further grouped into: south-central region, south-western region and south-eastern region\textsuperscript{29}. Farms of different areas are subject to different agricultural regulations, weather and soil conditions, \textit{etc}.. Therefore, it is difficult to tell the effect of regions on the production cost and profitability.

In the ODFAP samples, 95\% of cows are Holstein. According to OMAFRA, Holstein are believed to have higher productivities than other breeds (such as Guemsey, Ayrshire, Jersey and other mixed breeds). At the same time, Holstein has a lower non-solid fat to butterfat ratio (SNF:BF) than the other types of breeds. The price of butterfat is lower than other non-fat solids. Therefore, Holstein are expected to have positive effect on profitability with higher productivity and lower fat content.

**Technology:** Variables associated with the dairy production technology include: milking system ($DUM.MS$), manure handling system ($DUM.MANURES$), feeding system ($DUM.FS$) and housing system ($DUM.HS$). Farms with a more advanced milking parlour system is hypothesized to generate higher profitability as compared to the other milking systems, such as buckets, pipeline and transfer station (Schraufnagel, 2007). Therefore, parameter coefficient of milking system is

\textsuperscript{29}The counties in different grid regions are:
Region 1 Elgin, Essex, Kent, Lambton, Middlesex, Norfolk (South-western region).
Region 2 Brant, Huron, Oxford, Perth, Waterloo (South-western region).
Region 3 Bruce, Dufferin, Grey, Simcoe, Wellington (South-central region).
Region 4 Durham, Halimand, Halton, Niagara, Northumberland, Ontario, Peel, Prince Edward, Wentworth, York (South-central region).
Region 5 Frontenac, Hastings, Lanark, Leeds, Lennox & Addington, Peterborough, Victoria (South-eastern region).
Region 6 Carleton, Dundas, Glengarry, Grenville, Prescott, Renfrew, Russell, Stormont (South-eastern region).
hypothesized to be positive.

Manure handling system are divided into solid system\(^{30}\) and liquid system. Stable cleaner, manual and manure pack are categorized as solid handling system in this study. Different types of system require different application practices and may lead the variation in production costs. For instance, a floor is not required to transfer liquid manure, which otherwise is not the case for solid manure (O.Reg 267/03). Different types of manure may also incur different application and storage costs. To give an example, the cost of applying solid manure from heifers is $3 per ton, while the cost of applying liquid manure is $8 per gallon for adult cows (Poon, 2009). The liquid manure can be handled more efficiently when moved relatively short distance, but solid manure is more economical when hauled greater distance (the Ohio State University Bulletin\(^{31}\)). Studies in the United Stated also found that handling systems under different storage capacities result in different production costs (the Ohio State University Bulletin). Therefore, the effect of manure handling system on profitability remains unknown. It may depend on factors such as the hauling distance, manure type and storage capacities.

A semi/fully automated feeding system can increase feeding frequency and labour efficiency (Shashini, 2010). The adoption of automated feeding system can also minimize waste while maximizing nutrition (Delaval, 2009). Therefore, a semi/fully automated system should be more profitable as compared to the manual feeding system.

Bewley et al. (2001) found that a transition from tie-stall barn to free-stall barn in Wisconsin would reduce labour and increase efficiency. This indicates a free-stall barn might be more efficient and cost-saving than tie-stall barn. Since the housing system variable equals to one when a farm has tie-stall barn, the coefficient

\(^{30}\)Solid manure is defined in NMA as either having a dry matter content of 18% or more, or having a slump of 150 mm (6 in.) or less using the Test Method for the Determination of Liquid Waste (slump test) set out in Reg. 347, Sch. 5 of the Environmental Protection Act.

\(^{31}\)http://ohioline.osu.EDU/b604/0012.html
is hypothesized to be negative.

**Time trend variables:** Time trend variables account for any time-variant effects that are not captured in the regression, such as weather and technological change. Some evidence have been found that most of the changes in time trend are captured by technological change (Kim and Chavas, 2005). Squared trend variable is also used to capture the non-linearity of trend. Year dummy variables were not chosen due to the high collinearity between year dummy variables and the dummy variable for regulation timing ($DUM. REGTIME$). Most of the correlation coefficients between $DUM. REGTIME$ and year dummies have significant correlations that are greater than 0.3.

With the descriptions of both dependent and independent variables, profit function (5.1.1) stated at the beginning of this chapter can be written in detail as:

$$
\pi_{it} = \beta_0 + \beta_1 DUM. SIZE_{it} + \beta_2 DUM. REGTIME_{it} + \beta_3 DUM. NMA_{it} \\
+ \beta_4 AGE_{it} + \beta_5 EDU_{it} + \beta_6 FARMAGE_{it} + \beta_7 COWS_{it} + \beta_8 BTYPE_{it} \\
+ \beta_9 RECORD_{it} + \beta_{10} DARATIO_{it} + \beta_{11} DUM. SW_{it} + \beta_{12} DUM. SE_{it} \\
+ \beta_{13} BREED_{it} + \beta_{14} DUM. FS_{it} + \beta_{15} DUM. HS_{it} + \beta_{16} DUM. MS \\
+ \beta_{17} DUM. MANURES_{it} + \beta_{18} T + \beta_{19} T^2 + C_i + u_{it}
$$

(5.3.4)

### 5.4 Summary

The econometric model is specified to empirically estimate the effect of NMA on farm level profitability by assuming that profit per cow is a linear function of a vector of explanatory variables. The definitions of both dependent variable and independent variables are elaborated in this chapter with a focus on the dummy variables that represent the implementation of NMA. Dependent variable is the dairy profit per cow. The other independent variables include farm operator’s
age and education level, herd size, business type, milk record keeping, age of the farm, debt to asset ratio, region, breed of herd, dummy variables for milking system, manure system, feeding system and housing system and time trend variables. Empirical estimates of the regression model will be given in the next chapter to investigate whether and to which extent the regulated farms’ (NU ≥ 300) profitability is affected by NMA.
6.1 Introduction

In this chapter, the null hypothesis in chapter four that NMA does not have significant effect on regulated farms’ profitability is empirically tested by the specified econometrical model. Descriptive statistics of variables, as well as comparisons of production costs, dairy revenue and dairy profit per cow of regulated and unregulated farms are provided to explore if the statistics show consistency with the theoretical framework. The regression model provided in Chapter four is run by following the procedure below: (1) discuss the selection of empirical model (fixed effects, random effects and OLS); (2) test the robustness of the data and (3) give empirical results from the selected regression models. Discussions of the empirical results are developed by explaining the estimate parameter coefficients for independent variables, illustrating the implications of these estimates and investigating reasons that may affect the estimates.

6.2 Descriptive Statistics

Table 6.1 provides descriptive statistics of these variables. The variable that I would like to highlight is the dummy variable DUM.SIZE which represents farm
### Table 6.1: Descriptive statistics of variables (N=723)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Unit</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy profit per cow</td>
<td>CAD $/cow</td>
<td>1619.39</td>
<td>-1048.83</td>
<td>3989.25</td>
<td>739.53</td>
</tr>
<tr>
<td>Farm size</td>
<td>1/0</td>
<td>0.07</td>
<td>0.00</td>
<td>1.00</td>
<td>0.25</td>
</tr>
<tr>
<td>Regulation time</td>
<td>1/0</td>
<td>0.50</td>
<td>0.00</td>
<td>1.00</td>
<td>0.50</td>
</tr>
<tr>
<td>Nutrient Management Act</td>
<td>1/0</td>
<td>0.05</td>
<td>0.00</td>
<td>1.00</td>
<td>0.22</td>
</tr>
<tr>
<td>Principal operator’s age</td>
<td>Numbers</td>
<td>47.08</td>
<td>25.00</td>
<td>79.00</td>
<td>10.13</td>
</tr>
<tr>
<td>Principal operation’s education</td>
<td>1/0</td>
<td>0.58</td>
<td>0.00</td>
<td>1.00</td>
<td>0.49</td>
</tr>
<tr>
<td>Herd size</td>
<td>Numbers</td>
<td>68.07</td>
<td>20.00</td>
<td>390.00</td>
<td>50.75</td>
</tr>
<tr>
<td>Business type</td>
<td>1/0</td>
<td>0.19</td>
<td>0.00</td>
<td>1.00</td>
<td>0.39</td>
</tr>
<tr>
<td>Milk record-keeping</td>
<td>1/0</td>
<td>0.90</td>
<td>0.00</td>
<td>1.00</td>
<td>0.30</td>
</tr>
<tr>
<td>Age of the farm</td>
<td>Numbers</td>
<td>17.95</td>
<td>1.00</td>
<td>62.00</td>
<td>11.58</td>
</tr>
<tr>
<td>Debt to asset ratio</td>
<td>Unit free</td>
<td>0.60</td>
<td>0.00</td>
<td>1.00</td>
<td>0.38</td>
</tr>
<tr>
<td>South-western region</td>
<td>1/0</td>
<td>0.34</td>
<td>0.00</td>
<td>1.00</td>
<td>0.47</td>
</tr>
<tr>
<td>South-eastern region</td>
<td>1/0</td>
<td>0.30</td>
<td>0.00</td>
<td>1.00</td>
<td>0.46</td>
</tr>
<tr>
<td>Breed of Herd</td>
<td>1/0</td>
<td>0.95</td>
<td>0.00</td>
<td>1.00</td>
<td>0.22</td>
</tr>
<tr>
<td>Milking system</td>
<td>1/0</td>
<td>0.27</td>
<td>0.00</td>
<td>1.00</td>
<td>0.44</td>
</tr>
<tr>
<td>Manure system</td>
<td>1/0</td>
<td>0.69</td>
<td>0.00</td>
<td>1.00</td>
<td>0.46</td>
</tr>
<tr>
<td>Feeding system</td>
<td>1/0</td>
<td>0.87</td>
<td>0.00</td>
<td>1.00</td>
<td>0.34</td>
</tr>
<tr>
<td>Housing system</td>
<td>1/0</td>
<td>0.27</td>
<td>0.00</td>
<td>1.00</td>
<td>0.44</td>
</tr>
<tr>
<td>Time trend</td>
<td>Numbers</td>
<td>5.68</td>
<td>1.00</td>
<td>11.00</td>
<td>3.15</td>
</tr>
<tr>
<td>Squared-time trend</td>
<td>Numbers</td>
<td>42.17</td>
<td>1.00</td>
<td>121.00</td>
<td>37.79</td>
</tr>
</tbody>
</table>

Source: Ontario Dairy Farm Accounting Project (2000-2010) and Statistics Canada

size measured by nutrient units. The mean of this dummy variable is 0.07. This indicates that only 7% of farms in the dataset during 2000-2010 are large dairy operations with NU no less than 300. 70% of these large farms are found to operate during the post-implementation period 2006-2010 This results in only 5% of large farms with NU≥300 to be eligible for regulated by NMA. This implies that NMA may appear to be non-binding for the majority of Ontario’s dairy operations. The result is consistent with the annual report of Environmental Commissions of Ontario (hereafter ‘ECO’) (2006), which states that approximately 95-98% of current livestock producers will not be subject to NMA.

To investigate if statistics of sample farms in ODFAP are consistent with the

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32Besides farms with NUs no less than 300, there are also other scenarios of regulated entities, such as farms seeking a building permit or farms that are located within 100 meters of the municipal wells, etc. However, these farms cannot be identified due to the restriction of data availability
theoretical framework that claims the production costs of regulated farms and profitability of unregulated farms should increase due to NMA, I will first provide descriptive statistics of the average dairy profit ($\pi_{it}$), average cost of production and average dairy revenue of regulated farms ($NU \geq 300$) and unregulated farms ($NU < 300$). Figure 6.1 provides the average profits per cow of regulated group and unregulated group (deflated by CPI, index 2002=100) from year 2000 to 2010. The average profits per cow of unregulated farms are relatively flat but show a weak trend of increase over the years. On the contrary, regulated farms’ profits show some fluctuations and a general downward trend. The fluctuations can be a result of the small number of large farms in the dataset, as well as the data’s rotating nature. Only 49 of the 723 farms are found to have NUs no less than 300, and 32 of these farms are “phased-in” farms that operate from 2006 to 2010. Regulated farms’ profits tend to decline during 2001-2004 and 2005-2008, and then show a upward trend from 2008 to 2010. In general, profits of regulated and unregulated farms showed in the figure do not seem to contradict with the statement that unregulated farms’ profitability should increase due to the implementation of NMA. However, profits are captured by various determinants. No conclusion about the economic effect of NMA on profitability can be drawn from the figure.

To have a better understanding of the economic performance of regulated farms and unregulated farms, tables 6.2, 6.3, 6.4 are provided to represent the average profit, dairy production cost and dairy revenue, which are defined in the last chapter. Time periods are divided into two parts: pre-implementation period when NMA did not require farms with no less than 300 NUs to submit NMS/NMP and follow certain practices (2000-2005) and post-implementation period (2006-2010) when large farms with no less than 300 NUs are required to take actions to comply with NMA. Table 6.2 shows that the average profits of regulated farms decline by almost 20% from pre-implementation period to post-implementation period. On
the contrary, profits for unregulated farms have a marked increase of 14.77%.

Table 6.2: Comparisons of dairy profits per cow (CAD $/head) of regulated and unregulated farms.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2000-2005</th>
<th>2006-2010</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulated farms</td>
<td>Mean 2290.83</td>
<td>1846.64</td>
<td>-19.39</td>
</tr>
<tr>
<td></td>
<td>Median 2139.06</td>
<td>1891.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sd 589.87</td>
<td>506.11</td>
<td></td>
</tr>
<tr>
<td>Unregulated farms</td>
<td>Mean 1509.69</td>
<td>1732.70</td>
<td>14.77</td>
</tr>
<tr>
<td></td>
<td>Median 1538.13</td>
<td>1695.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sd 703.18</td>
<td>790.26</td>
<td></td>
</tr>
</tbody>
</table>

Source: Calculated from Ontario Dairy Farm Accounting Project (2000-2010)
Note: 1. Sd refers to standard deviation
2. Data has been deflated by CPI for all items in Ontario, index 2002=100

Elevated milk revenue of unregulated farms may contribute to the increase in their average profits. It can be found from table 6.3 that unregulated farms’ dairy revenue increases by about 12.88%. At the same time, regulated farms experience only a small increase of 0.06% in their dairy revenue. Since all farms are sharing the same milk price, the milk revenue per output of regulated farms and unregulated farms should have similar trends over years if their milk productions are relatively
stable. However, it should be noticed that the milk revenues here are compared on a per cow basis. The differences in productivity may explain why regulated farms and unregulated farms have such a significant difference in change in revenue. The ODFAP data show that the milk production per cow of unregulated farms has an average growth rate of 0.46% over 11 years (2000-2010). On the contrary, though having higher milk production, productivity of regulated farms that have no less than 300 NUs are found to have decreased from year 2000 to 2010 with an average growth rate of -0.32%.

Table 6.3: Comparisons of dairy revenue per cow (CAD $/Head) of regulated and unregulated farms

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2000-2005</th>
<th>2006-2010</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulated farms</td>
<td>Mean 5960.48</td>
<td>5963.79</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>Median 6143.42</td>
<td>6014.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sd 627.74</td>
<td>609.58</td>
<td></td>
</tr>
<tr>
<td>Unregulated farms</td>
<td>Mean 4797.53</td>
<td>5415.46</td>
<td>12.88</td>
</tr>
<tr>
<td></td>
<td>Median 4902.18</td>
<td>5976.29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sd 850.64</td>
<td>604.70</td>
<td></td>
</tr>
</tbody>
</table>

Source: Calculated from Ontario Dairy Farm Accounting Project (2000-2010)
Note: 1. Sd refers to standard deviation
2. Data has been deflated by CPI for all items in Ontario, index 2002=100

Table 6.4 indicates that the dairy production costs of regulated farms increase by 12.19%, which is slightly higher than that (12.01%) of unregulated farms. This is consistent with the theoretical framework which claims that the production costs of regulated farms should increase to a higher degree than that of unregulated farms after the implementation of NMA.

In summary, the descriptive statistics do not contradict with what have been stated in the theoretical framework: the average dairy production costs of regulated farms have a greater rate of increase than that of unregulated farms from pre-implementation period of NMA to post-implementation period. The profits of regulated farms tend to decline from 2000 to 2010, while the profits of unregulated farms show an upward trend. However, the descriptive statistics are unable to
Table 6.4: Comparisons of dairy production costs per cow (CAD $/Head) of regulated and unregulated farms

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2000-2005</th>
<th>2006-2010</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulated farms</td>
<td>Mean 3669.65</td>
<td>4117.15</td>
<td>12.19</td>
</tr>
<tr>
<td></td>
<td>Median 3672.86</td>
<td>4104.36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sd 693.07</td>
<td>649.23</td>
<td></td>
</tr>
<tr>
<td>Unregulated farms</td>
<td>Mean 3287.84</td>
<td>3682.76</td>
<td>12.01</td>
</tr>
<tr>
<td></td>
<td>Median 3263.12</td>
<td>3687.62</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sd 846.91</td>
<td>940.74</td>
<td></td>
</tr>
</tbody>
</table>

Source: Calculated from Ontario Dairy Farm Accounting Project (2000-2010)

Note: 1. Sd refers to standard deviation
2. Data has been deflated by CPI for all items in Ontario, index 2002=100

indicate whether the change in economic performance is caused by NMA since profit, cost and revenue can be affected by numerous factors that are not revealed in the tables listed above. Due to this study’s interest in the effect of NMA on farm level profitability, the econometric model (5.3.4) specified in the last chapter will be run in the following section. The estimation results may help explain whether and to which extent farm level profitability is affected by NMA.

6.3 Model selection

In this section, discussions of the selection of estimation models for panel data regression from fixed effects model, random effects model and pooled OLS is developed. R 2.14.1 is used for data aggregation and STATA 11 is used for estimation in this study. One question addressed in panel data analysis is whether the unobserved time-invariant individual effect is correlated with time-variant dependent variables. Consider the following linear unobserved effects panel data model for $N$ observations and $T$ periods:

$$ Y_{it} = X_{it} \beta + c_i + \mu_{it}, i = 1, ..., N; t = 1, ..., T \tag{6.3.1} $$
where $Y_{it}$ is the dependent variable observed for individual $i$ at period $t$. $X_{it}$ is the $N \times K$ regressor matrix with observable time-variant independent variables, while $\beta$ is a $K \times 1$ vector of coefficients. $c_i$ is the unobserved time-invariant individual effect. $\mu_{it}$ is the error term that is independent and identically normal distributed.

Panel data can be estimated under either fixed effects model or random effects model, depending on the correlation between the time-invariant variable $c_i$ and other observable independent regressors. Fixed effects (FE) model allows $c_i$ to be correlated with $X_{it}$, while random effects (RE) model assumes that $c_i$ is independent of other observed regressors (Wooldridge, 2002). In a RE model,

$$Cov(c_i, X_{it}) = 0; \ t = 1, 2, ..., T \tag{6.3.2}$$

If $Cov(c_i, X_{it})$ does not equal to zero, then the time-constant variable $c_i$ is correlated with the other observable independent regressors. Under this condition, the RE model would be inconsistently estimated and FE is preferable.

Since time-constant variables are unobservable and cannot be directly controlled for in a FE model, they need to be eliminated from the regression by conducting the following within transformation:

$$Y_{it} - \bar{Y}_i = (X_{it} - \bar{X}_i)\beta + (c_i - \bar{c}_i) + (\mu_{it} - \bar{\mu}_i) \Rightarrow \tilde{Y}_{it} = \tilde{X}_{it}\beta + \tilde{\mu}_{it} \tag{6.3.3}$$

in which $\bar{Y}_i$, $\bar{X}_i$, $\bar{c}_i$ and $\bar{\mu}_i$ is the average of $Y_{it}$, $X_{it}$, $c_i$ and $\mu_{it}$ of observation $i$ over period $T$, respectively. Since $c_i$ is constant over time, $c_i = \bar{c}_i$. This transformation cannot be done if the observation appear only once. Therefore, for models of different estimation methods to be comparable, farms with only one observation in the dataset are excluded from the regression. This left 663 farms in the regression with 60 farms being excluded.
When $\text{Cov}(c, X_{it}) = 0$ and the regressors are independent across individuals, strictly exogenous, not auto-correlated and homoscedastic, then pooled OLS is also efficient (Wooldridge, 2002). However, pooled OLS ignores the panel structure of the data and the estimates are not efficient. The standard errors are not valid under pooled OLS but can be corrected through cluster-robust covariance. When there is heteroscedasticity, random effects model estimated under either generalized least square (GLS) or maximum likelihood estimation (MLE) tend to be more efficient than pooled OLS.

### 6.3.1 Fixed effects model, random effects model and pooled OLS

Hausman specification test is a test of whether the FE model or RE model should be used. Hausman specification test consists of seeing how large the difference in estimates is in relation to the variances of estimates (Hausman, 1978). Hausman statistic is computed as:

$$H = (\hat{\beta}^{FE} - \hat{\beta}^{RE})' \times [\text{var}(\hat{\beta}^{FE}) - \text{var}(\hat{\beta}^{RE})]^{-1} \times (\hat{\beta}^{FE} - \hat{\beta}^{RE})$$

Where $\hat{\beta}^{FE}$ and $\hat{\beta}^{RE}$ are the coefficient estimates of FE model and RE model, respectively. The null hypothesis of Hausman specification test is that both estimates are consistent. If test result is statistically significant, one may reject the null hypothesis, indicating that a FE model should be chosen. Otherwise, a RE model would be preferable. The statistic of Hausman’s test computed in the regression is 24.63 with a $p$ value of 0.1355. Thus, I fail to reject the null hypothesis that both estimates are consistent. A RE model is preferable to a FE model in this case.

A Breusch-Pagan Lagrangian multiplier test is suggested to test whether the pooled OLS estimates are efficient. Under the null hypothesis of Breusch-Pagan
LM test, there is no unobserved effect (i.e., $\sigma^2_c = 0$. This means that the variance of time-constant variable is zero. There is no significant difference across units and thus no presence of panel effects). Rejecting the null hypothesis indicates the presence of unobserved effects and pooled OLS would not be efficient. The statistics from Breusch-Pagan LM test has a chi-squared distribution and equals to 279.34 in this study. The $p$ value is less than 0.001. Therefore, null hypothesis is strongly rejected at the 1% significance level. A RE model is also preferable to pooled OLS.

It is possible that sometimes the FE and RE model have significant difference, but one may still fail to reject the null hypothesis of Hausman’s specification test due to high standard errors (Wooldridge, 2002). This will induce the presence of a type II error. The type II error could also occur in the Breusch-Pagan LM test. Thus, the estimates of FE model, RE model and pooled OLS are all reported in the table 6.6 for further investigation, but discussions of the estimates in this study will have an emphasize on the RE model since it is preferable to FE model and OLS under Hausman’s specification test and Breusch-Pagan LM test.

6.4 Diagnostics: Test for Heteroscedasticity, Serial Correlation and Multicollinearity

The robustness of data to heteroscedasticity, serial correlation and multicollinearity are tested in this section. Cluster-robust covariance estimators are reported to correct the potential presence of heteroscedasticity, while Wooldridge test for autocorrelation is used for testing serial correlation. VIFs are measured to indicate the severity of multicollinearity.

**Heteroscedasticity:** Wald test is commonly used to test the presence of heteroscedasticity in a FE model (Greene, 2008). However, no test has been found so far to identify the heteroscedasticity in a RE model. Cluster-robust covariance
estimators are then reported to fix the potential presence of heteroscedasticity in a RE model.

**Serial correlation**: Wooldridge test for autocorrelation in panel data is used to test if there is serial correlation. The statistic of this test follows a F distribution. The null hypothesis under this test is that there is no first-order autocorrelation. The calculated statistics is 3.627 with a \( p \) value of 0.0589. Therefore, I fail to reject the null hypothesis of no serial correlation at the 5% significance level.

**Multicollinearity**: Variance inflation factor (VIF) is an indicator of the severity of multicollinearity. It measures how much the variance of an estimated coefficient will be increased due to collinearity. Multicollinearity is usually considered as a concern if the variance inflection factor (VIF) is large than 10 (White et al., 1995; Kutner, 2004), and a VIF greater than 30 may indicate severe multicollinearity. However, these cut-off values are just informal rules of thumb and there is no irrefutable test to prove whether the multicollinearity is a problem or not. VIFs reported in table 6.5 show that the highest two VIFs (20.58 and 19.8) are for variable \( TREN D \) and its quadratic form. The rest VIFs are all below 10, implying that the collinearity of these variables should not be a concern based on the informal cut-off value of 10 in most literatures. It is common to find a higher degree of collinearity between a variable and its higher order terms (i.e., trend variable and squared-trend in this case). However, this study found that neither the coefficients nor the significance level of estimates of independent variables (except for the time trend variable) change dramatically (i.e., the sign of coefficient changes) by adding the squared-time trend variable to the RE model or subtracting it from the model. Therefore, the collinearity between time trend variable and squared-trend variable does not appear to be a severe concern in this study.
### Table 6.5: Variance Inflation Factors

<table>
<thead>
<tr>
<th>Variable</th>
<th>VIF</th>
<th>1/VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time trend</td>
<td>20.58</td>
<td>0.048599</td>
</tr>
<tr>
<td>squared time trend</td>
<td>19.8</td>
<td>0.050502</td>
</tr>
<tr>
<td>Housing system</td>
<td>9.57</td>
<td>0.104533</td>
</tr>
<tr>
<td>Milking system</td>
<td>7.72</td>
<td>0.129536</td>
</tr>
<tr>
<td>Farm size</td>
<td>4.97</td>
<td>0.201265</td>
</tr>
<tr>
<td>Regulation timing</td>
<td>4.46</td>
<td>0.224014</td>
</tr>
<tr>
<td>Herd size</td>
<td>3.94</td>
<td>0.254096</td>
</tr>
<tr>
<td>Manure System</td>
<td>2.89</td>
<td>0.346198</td>
</tr>
<tr>
<td>Nutrient Management Act</td>
<td>2.71</td>
<td>0.369149</td>
</tr>
<tr>
<td>Farm operator’s age</td>
<td>1.57</td>
<td>0.635351</td>
</tr>
<tr>
<td>Farm age</td>
<td>1.51</td>
<td>0.66246</td>
</tr>
<tr>
<td>South-eastern region</td>
<td>1.48</td>
<td>0.674568</td>
</tr>
<tr>
<td>South-western region</td>
<td>1.41</td>
<td>0.706934</td>
</tr>
<tr>
<td>Debt to asset ratio</td>
<td>1.38</td>
<td>0.723087</td>
</tr>
<tr>
<td>Farm operator’s education</td>
<td>1.21</td>
<td>0.824475</td>
</tr>
<tr>
<td>Feeding system</td>
<td>1.19</td>
<td>0.843228</td>
</tr>
<tr>
<td>Business type</td>
<td>1.13</td>
<td>0.888263</td>
</tr>
<tr>
<td>Milk record keeping</td>
<td>1.09</td>
<td>0.92016</td>
</tr>
<tr>
<td>Breed of herd</td>
<td>1.05</td>
<td>0.948384</td>
</tr>
<tr>
<td>Mean VIF</td>
<td>4.72</td>
<td></td>
</tr>
</tbody>
</table>

Source: Ontario Dairy Farm Accounting Project (2000-2010)

### 6.5 Coefficient Estimates

The summary of parameter estimates of random effects model, fixed effects model and pooled OLS are given in table 6.6. Random effects model is estimated with Generalized Least Square (GLS). The dummy variable $DUM\_SIZE$ representing farms that have no less than 300 NUs is eliminated from the model since it is constant over time for each farm observation. Variables such as farm principal operator’s educational level, business type, region and milk record keeping are usually identified as time-invariant variables (Shashini, 2010). However, there are a few farms have their business type, milk recording keeping practices, farm principle operator’s educational level, and even regions change over time (e.g., farm operations may span more than one municipality) in this study. Therefore, these variables are
not considered as time-invariant and have been kept in the FE model. Results from
the pooled OLS are presented in the last column of table 6.6.

| Table 6.6: Parameter estimates of RE model, FE model and pooled OLS (N=663) |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| Farm size                                      | Random Effects  | Fixed Effects   | pooled OLS      |
| Regulation timing                              | 168.9** (93.0)  | 174.4* (90.8)   | 158 (114.3)     |
| Implementation of NMA                          | -167 (129.6)    | -86.7 (240.7)   | -311.9 (235.8)  |
| Farm operator’s age                            | -3.258 (4.0)    | -6.791 (8.0)    | -2.501 (3.5)    |
| Operator’s education                           | -72.25 (91.0)   | 236.9 (271.2)   | -116.5* (61.1)  |
| Age of farm                                    | -7.828* (4.8)   | 38.20* (22.9)   | -12.51*** (3.0) |
| Herd size                                      | 3.871** (1.6)   | 2.743 (4.5)     | 3.803*** (1.3)  |
| Business type                                  | 74.99 (109.9)   | 389.3 (318.9)   | 104.6 (76.0)    |
| Milk record keeping                            | -186.4 (121.2)  | -559.1** (262.4)| -114.5 (98.2)   |
| Debt to asset ratio                            | -258.1** (115.5)| -23.92 (176.7)  | -434.7*** (84.9)|
| South-western region                           | -215.4* (107.2) | -285.3 (679.8)  | -178.0*** (68.5)|
| South-eastern region                           | -209.5* (107.9) | 7.144 (504.5)   | -204.8*** (69.7)|
| Breed of herd                                  | 659.3*** (142.8)| 565.9** (278.8) | 761.3*** (128.9)|
| Feeding system                                 | 102.6 (121.3)   | -38.37 (308.6)  | 74.21 (86.5)    |
| Housing system                                 | -207.7 (225.0)  | -1235.7 (851.9) | -97.99 (193.5)  |
| Milking system                                 | 134 (133.4)     | -95.77 (512.0)  | 174.5 (163.9)   |
| Manure system                                  | -114.6 (197.0)  | -1176.6*** (415.6)| -5.994 (108.3)|
| Time trend                                     | -90.70** (38.3) | -185.7*** (47.3)| -15.74 (40.6)   |
| Squared time trend                              | 8.638*** (3.1)  | 13.42*** (3.2)  | 3.133 (3.3)     |
| Constant                                       | 1604.9*** (376.5)| 2564.0*** (907.6)| 1340.9*** (272.0)|

| Observations                                  | 663          | 663          | 663          |
| F                                             | 2.764        | 7.430        | 0.1652       |
| $R^2$                                         | 0.0968       | 0.180        |              |

Note: standard error statistics in parentheses
Source: Calculated from Ontario Dairy Farm Accounting Project
* p<0.10, ** p<0.05, *** p<0.01

### 6.6 Results Discussion

The effect of NMA on farm level profitability for Ontario’s dairy sector is empirically
tested in this chapter. Discussions of the estimated parameters will be developed
in this section with a focus on the RE model. The estimated coefficient of main
dummy variable for the implementation of NMA is not statistically significant at the 10% level in all the three models listed in the table 6.6. This indicates that NMA does not have a statistically significant impact at the 10% level on regulated farms’ profitability. The dummy variable for farm size does not have statistically significant effect on profitability in the RE model as well. The RE estimate for the dummy variable of regulation timing $DUM.REGTIME$ has statistically significant and positive effect on profit per cow. This suggests that operating after 2005 may increase the farm level profit per cow by 168.9 dollars.

Other variables that are statistically significant include: farm age, herd size, debt to asset ratio, region, breed of herd, time trend and the quadratic time trend variable. Implication of the parameter estimates in the RE model will be elaborated below.

**Farm age:** Age of the farm appears to have statistically significant and negative effect on profit in the RE model. The estimate for farm age indicates that increasing the farm age by one would decrease the profit per cow by 7.828 CAD dollars. This is consistent with the previous study on U.S. organic farms, in which production costs are found to have positive relation with dairy experience (McBride and Greene, 2002). Explanations could be that older farms are less likely to embrace new technology and are less efficient than newer farms.

**Herd size:** Herd size is found to have a positive and statistically significant impact on farm level profit. Holding other variables constant, profits per cow would be increased by CAD $ 3.871 with one more cow being raised in the milk production. This result is consistent with some other studies on dairy operation (Foltz and Chang, 2002; Gloy et al., 2002) and provides evidence of economies of scale.

**Debt-to-asset ratio:** The RE estimate suggests a negative and statistically significant relationship between the debt-to-asset ratio and farm level profit. This
implies that dairy operations in this study do not experience any increase in profit by using debt to finance their asset. This is consistent with the study of Gloy et al., (2002) which claims that a farm’s return to management should fall under a higher debt-to-asset ratio.

**Region:** Regional dummies for both south-western area and south-eastern area are found to be negatively related with profit. Operating in south-western region and south-eastern region would reduce the profit by 215.4 and 209.5 dollars, respectively. This suggests that holding other variables constant, farms locating in south-central region would be more profitable.

**Breed of herd:** Holstein cows are found to affect profit positively. Raising Holstein as the milking cows instead of other breeds would elevate the profit by 659.3 dollars, which is a relatively large number as compared to the average profit per cow of CAD $ 1619.

**Trend and quadratic trend:** The estimates for both trend and quadratic trend are statistically significant. This suggests a non-linear relationship (U shape curve) between farm level profit and time trend. Farm level profit decreases first, reaches the minimum point and then increases. According to equation (5.3.4), by taking the first derivative of the dependent variable profit \( \pi_{it} \) on variable \( T \), the following equation is obtained:

\[
\frac{d(\pi_{it})}{dT} = \beta_{18} + 2\beta_{19} \times T = -90.70 + 2 \times 8.638 \times T = 0 \quad (6.6.1)
\]

In which \( \beta_{18} \) and \( \beta_{19} \) are coefficients for time trend variable \( T \) and squared trend variable \( T^2 \). Solve equation (6.6.1), \( T = 5.41 \) is obtained. Year 2004 and 2005 corresponds to the time trend variable of 5 and 6 respectively. This indicates that profit decreased since 2000 and reached its minimum point around year 2004/2005.

**Other variables:** Farm principle operator’s characteristics, including farm
principal operator’s age and educational level, do not have statistically significant effect on profit. A possible explanation for this result is: there are more than one decision makers in a farm (Gloy et al., 2002). Farm operations are sometimes jointly decided by stakeholders or family members (e.g., in family-owned business). This makes it difficult to accurately measure effect of quality of the major human capital on profit.

The dummy variable for milk record keeping is not statistically significant. This is partly consistent with the study conducted by Gloy et al.(2002) on New York dairy farms. They found that ledger and computerized record-keeping system do not have statistically significant effect on profitability. Gloy et al., (2002) concluded that this result implies the existence of inefficiency in the allocation of farms’ managerial resource since better performance in profit was found when farms hiring external record-keeping services instead of doing all the milk record-keeping by themselves. However, methods of milk record-keeping are unobservable in this study. It is therefore hard to identify the reason that causes the insignificance in the estimate for milk record keeping.

Parameter estimates for technologies, including milking system, housing system, manure system and feeding system, are all statistically insignificant. An explanation for this is that changes in technologies may have already been captured in the time trend variables.

To investigate whether the explanatory variables have different effects on the profitability of regulated farms (NU≥300) and unregulated farms (NU < 300), parameter estimates were measured separately for regulated and unregulated farms by using RE model. Results are given in table 6.7.

Since the coefficients of dependent variables were estimated separately for regulated and unregulated group, dummy variables associated with NMA, including the dummy variable for farm size (DUM.SIZE) and the dummy variable for imple-
Table 6.7: Parameter estimates of regulated and unregulated farms

<table>
<thead>
<tr>
<th></th>
<th>Regulated farms</th>
<th>Unregulated farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation timing</td>
<td>5897.22 (5791.2)</td>
<td>119.2558 (84.43)</td>
</tr>
<tr>
<td>Farm operator’s age</td>
<td>-35.47* (21.5)</td>
<td>-3.921 (4.046)</td>
</tr>
<tr>
<td>Operator’s education</td>
<td>-26.18 (538.7)</td>
<td>-38.76 (80.81)</td>
</tr>
<tr>
<td>Age of farm</td>
<td>23.87 (20.1)</td>
<td>-8.809** (3.944)</td>
</tr>
<tr>
<td>Herd size</td>
<td>0.577 (3.4)</td>
<td>3.061*** (1.122)</td>
</tr>
<tr>
<td>Business type</td>
<td>- (. )</td>
<td>32.31 (97.03)</td>
</tr>
<tr>
<td>Milk record keeping</td>
<td>-1223.5** (511.7)</td>
<td>-75.72 (116.1)</td>
</tr>
<tr>
<td>Debt to asset ratio</td>
<td>1098.8 (897.2)</td>
<td>-334.0*** (98.73)</td>
</tr>
<tr>
<td>South-western region</td>
<td>-841.8** (361.4)</td>
<td>-191.8** (96.65)</td>
</tr>
<tr>
<td>South-eastern region</td>
<td>-981.8** (437.4)</td>
<td>-171.7* (98.66)</td>
</tr>
<tr>
<td>Breed of herd</td>
<td>5897.2 (5791.2)</td>
<td>529.3*** (143.3)</td>
</tr>
<tr>
<td>Feeding system</td>
<td>- (. )</td>
<td>82.41 (109.2)</td>
</tr>
<tr>
<td>Housing system</td>
<td>- (. )</td>
<td>-51.86 (256.6)</td>
</tr>
<tr>
<td>Milking system</td>
<td>-171.8 (408.4)</td>
<td>29.47 (231.8)</td>
</tr>
<tr>
<td>Manure system</td>
<td>- (. )</td>
<td>-69.77 (131.5)</td>
</tr>
<tr>
<td>Time trend</td>
<td>-565.1 (1178.1)</td>
<td>-74.81** (32.15)</td>
</tr>
<tr>
<td>Squared time trend</td>
<td>39.19 (62.7)</td>
<td>9.272*** (2.651)</td>
</tr>
</tbody>
</table>

Observations 32 691
\[ R^2 \] 0.39 0.16

Standard error statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

mentation of NMA (\textit{DUM.NMA}), can be eliminated from the regressions. Dummy variables for business type, feeding system, housing system and manure system were deleted from the RE model for regulated farms (\textit{NU} \geq 300) since these variables are constant within each farm observation and across farm units. There are no presence of panel effects that came from these variables.

The signs of estimates in these two models in Table 6.7 remain consistent, but the significance levels of some variables vary. This indicates that some of the variables may play different roles in affecting profitability of regulated farms with equal to or more than 300 NUs and unregulated farms with less than 300 NUs. Most of the estimates from the model of unregulated farms are highly consistent with the RE model estimated in table 6.6 (this RE model is considered as the ‘base model’ in this study). One explanation could be that the majority of the observations in
the base model consists of unregulated entities (691 farms), while the number of regulated farms is relatively small. Different from the estimates presented in the base model in table 6.6, farm principal operator’s age are found to have significant and negative effect on the profitability of regulated farms, while age of the farm does not have significant impact on regulated farm’s profitability. Adopting milk record keeping practices are found to significantly reduce regulated farms’ profitability. In addition, estimates for time trends are not statistically significant effect in the regulated farm model.

Although parameter estimates for regulated farms and unregulated farms show some degree of differences, most of them remain consistent with the base RE model presented in table 6.6. The estimation listed in table 6.6 aims at identifying whether NMA has significant effect on farm level profitability and to estimate the degree to which farm level profit is affected. None of the estimates for the variable $DUM.NMA$, which represents the implementation of NMA in RE, FE and pooled OLS models are statistically significant. Thus, I fail reject the null hypothesis came up in Chapter 4 that NMA does not have significant effect on regulated farm’s profitability at the 10% level. In the following section, I will develop discussions that may lead to a type II error, which is caused by failing to reject a false null hypothesis.

### 6.7 Explanations for parameter estimate of NMA

This section will explore reasons that may affect parameter estimates and lead to the failure of rejecting the null hypothesis that NMA has no significant effect on regulated farms’ profitability. The reasons can be briefly summarized as:

1. The regulated group and unregulated group can not be identified with certainty.
2. The regulation timing when NMA became restrictive for regulated farms is vague.

3. Unregulated farms may be subject to other environmental by-laws that affect these farms in similar ways that NMA affects its regulated farms.

4. Milk price is determined not only by production costs of farms in Ontario, but also by COP of farms from other provinces, which cannot be directly controlled for in this study.

5. The negative effect on profitability caused by additional compliance cost may be mitigated if regulated farms are more cost efficient.

6. The additional compliance costs are too small to have significant effect on regulated farms’ profitability.

### 6.7.1 Regulated farms and unregulated farms

As showed in table 2.1 in chapter two, there are more than one scenarios of “phased-in” farms under NMA. Large farm defined by NU is the major scenario and is the only scenario that can be identified. Although farms that apply for building permit, locate within certain setbacks of municipal wells or receive non-agricultural resource materials, are also subject to protocols in NMA, information needed to identify such farms in the dataset is unavailable. The reliability of regression results are contaminated without identifying the regulated group and unregulated group with certainty.

### 6.7.2 Timing of regulation implementation

NMA was passed on June, 2002 and became effective in July, 2003. O.Reg 267/03, the general regulation of NMA, was amended as O.Reg 511/05, which became
effective in December, 2005. Preparing, submitting and following NMS/NMP are major tools to comply with NMA and are most likely to generate compliance costs for regulated farms. The regulated group identified in the empirical framework consists of farms with no less than 300 NUs. Such farms are required by both O. Reg 267/03 and O. Reg 511/05 to submit NMS/NMP only if they operate after July, 2005. Therefore, time period 2006-2010 is set as the “post-implementation” period while 2000-2005 is regarded as the “pre-implementation” period. However, the original regulation must have protocols that have restricted farms regulating before July, 2005. For instance, new operations with NUs between 5 and 300 were required to submit NMS/NMP in O.Reg 267/03. Meanwhile, farms that were previously exempted in O.Reg 267/03 may be required to have a NMS/NMP under the amendment. The original regulation and its amendment may also play different roles in regulating farms that were not studied empirically in this thesis. For example, farms that are seeking a building permit did not need to submit NMS/NMP under O. Reg 267/03 but have to do so after the amendment became effective. Hence, the setting of dummy variable for regulation timings could be a matter for the empirical estimates and can lead to different regression results.

To explore whether different regulation timings have different effects on regulated farms’ profitability, a dummy variable was set to represent the regulation timing of year 2003. The variable equals to one if a farm operates after year 2003 (period 2004-2010 is now the “post-implementation” period), and equals to zero if the farm operates in/before 2003 (“pre-implementation” period is 2000-2003).

\[
DUM.\text{REGTIME}03 = 0 \text{ if } YEAR = 2000, 2001, ..., 2003;
\]

\[
DUM.\text{REGTIME}03 = 1 \text{ if } YEAR = 2004, 2005, ..., 2010;
\]

A new interaction term of this dummy and the dummy variable for farm size was created to represent regulated large farms with no less than 300 NUs that operate after 2003. The dummy variable can be written as:
Table 6.8: RE estimates under different regulation timing (2003 and 2005)

<table>
<thead>
<tr>
<th></th>
<th>Timing: July, 2003</th>
<th>Timing: December, 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm size</td>
<td>71.53 (416.8)</td>
<td>-239.3 (254.3)</td>
</tr>
<tr>
<td>Regulation timing</td>
<td>45.65 (81.5)</td>
<td>168.9** (93.0)</td>
</tr>
<tr>
<td>Implementation of NMA</td>
<td>-508.0* (280.6)</td>
<td>-167 (129.6)</td>
</tr>
<tr>
<td>Farm operator’s age</td>
<td>-3.158 (4.5)</td>
<td>-3.258 (4.0)</td>
</tr>
<tr>
<td>Operator’s education</td>
<td>-78.39 (94.3)</td>
<td>-72.25 (91.0)</td>
</tr>
<tr>
<td>Age of farm</td>
<td>-7.992* (4.5)</td>
<td>-7.828* (4.8)</td>
</tr>
<tr>
<td>Herd size</td>
<td>4.062** (1.9)</td>
<td>3.871** (1.6)</td>
</tr>
<tr>
<td>Business type</td>
<td>78.34 (116.7)</td>
<td>74.99 (109.9)</td>
</tr>
<tr>
<td>Milk record keeping</td>
<td>-183.5 (134.2)</td>
<td>-186.4 (121.2)</td>
</tr>
<tr>
<td>Debt to asset ratio</td>
<td>-260.5** (112.5)</td>
<td>-258.1** (115.5)</td>
</tr>
<tr>
<td>South-western region</td>
<td>-212.2* (112.7)</td>
<td>-215.4* (107.2)</td>
</tr>
<tr>
<td>South-eastern region</td>
<td>-212.9* (113.6)</td>
<td>-209.5* (107.9)</td>
</tr>
<tr>
<td>Breed of herds</td>
<td>653.0*** (166.3)</td>
<td>659.3*** (142.8)</td>
</tr>
<tr>
<td>Feeding system</td>
<td>91.53 (123.6)</td>
<td>102.6 (121.3)</td>
</tr>
<tr>
<td>Housing system</td>
<td>-210.3 (291.4)</td>
<td>-207.7 (225.0)</td>
</tr>
<tr>
<td>Milking system</td>
<td>136.9 (238.8)</td>
<td>134 (133.4)</td>
</tr>
<tr>
<td>Manure system</td>
<td>-111.8 (164.9)</td>
<td>-114.6 (197.0)</td>
</tr>
<tr>
<td>Time trend</td>
<td>-88.29** (43.0)</td>
<td>-90.70** (38.3)</td>
</tr>
<tr>
<td>Squared time trend</td>
<td>9.688*** (3.0)</td>
<td>8.638*** (3.1)</td>
</tr>
<tr>
<td>Constant</td>
<td>1592.5*** (359.3)</td>
<td>1604.9*** (358.5)</td>
</tr>
<tr>
<td>Observations</td>
<td>663</td>
<td>663</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.1668</td>
<td>0.1652</td>
</tr>
</tbody>
</table>

Standard error statistics in parentheses
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

$DUM.NMA03 = DUM.REGTIME03 \times DUM.SIZE$;

Keeping all the other variables the same as presented in table 6.6, a RE model is run by replacing the dummy variable for regulation timing $DUM.REGTIME$ and dummy variable for the implementation of the regulation $DUM.NMA$ with these two new variables $DUM.REGTIME03$ and $DUM.NMA03$. Results are shown in table 6.8.

The estimate for the dummy variable that represents the implementation of NMA is statistically significant at the 10% level and negative when the regulation timing was set to be year 2003. This indicates that NMA implemented in 2003 has statistically significant and negative effect on the profit of regulated farms.
(NU ≥ 00). This fits this study’s alternative hypothesis that profitability of regulated farms with no less than 300 NUs are affected by NMA. Major differences are found for the following variables when comparing the parameter estimates under different regulation timings: (1) the dummy variable for farm size. The coefficients of dummy variable for farm size are insignificant under both regressions in table 6.8, but the signs of the estimates differ; (2) the estimate for regulation timing dummy became insignificant when 2003 is assumed to be the year when NMA was implemented; (3) Most importantly, the estimate for the main dummy variable that represents the implementation of NMA is negative and statistically significant. This is consistent with the alternative hypothesis stated in the theoretical framework. Both the significance level and number of estimates of the other variables in these two regressions have a high consistency.

Possible explanations for the significance in the dummy variable $DUM.NMA03$ are: large farms (NU ≥ 300) suffered a relatively massive change in farm practices when the regulation was first put in place, leading the cost of production to increase. Change in production costs of farms with no less than 300 NUs before the amendment became effective may not be led by practices associated with NMS/NMP but by other requirements listed in O. Reg 267/03. The cost may go down afterwards and the effect of NMA on profit is thus lessened. Another explanation is the time-lagged effect that production costs have on profitability. Every year, the CDC collects production costs data of the previous year, indexes the cost data to the 3rd quarter of the current year, calculates support prices for butterfat and skim milk powder based on the indexed production costs, and finally announces the calculated support prices in February next year. Therefore, the change in production cost will not be reflected in the milk price immediately. Any change in the COP is expected to affect milk price announced the year after. Therefore, it is expected that production costs in 2004 were incorporated in the milk price announced in
2006. If milk price increases due to the elevated COP, then the negative effect of NMA on profitability can be offset to some degree. This may as well explain why the estimate for the dummy variable of NMA is not statistically significant when I consider 2005 as the regulation timing.

6.7.3 Other by-laws

Dairy operations that are not phased in NMA may be subject to other municipal bylaws (ECO, 2006). Based on statistics provided by OMAFRA in February, 2006, the vast majority of approximately 53,000 livestock operations remained subject to municipal laws where they existed. The economic performance of unregulated farms of NMA can thus be affected by these municipal laws in a similar way that NMA affects its regulated farms. Meanwhile, there are also farms that voluntarily adopt the practices suggested by NMA for the purpose of improving their farming performance. The regression results can be biased without taking into consideration these farms affected by NMA.

6.7.4 Production costs data from other provinces

ODFAP data used by the CDC to set support prices is only part of the national COP samples. Milk price is determined by multiple provinces. The production share of Ontario is around 1/3 of the national production. This study does not have production costs data in other provinces. Without controlling for the production costs data in other provinces, the parameter estimates in this study may also be biased. Moreover, the COP is sometimes adjusted by the CDC based on a number of other factors, such as prevailing market conditions and stakeholders’ negotiation. I cannot control for these factors as well.
6.7.5 Cost efficiency

One of the key points developed in the theoretical framework is that large, regulated farms (NU ≥ 300) may bear additional compliance costs under NMA. Without controlling for cost efficiency, every farm was assumed to be 100 percent efficient and produce exactly at the production frontier. If efficiency variation was allowed and regulated farms (NU ≥ 300) are more cost efficient, then the negative effects of increased compliance costs led by NMA might be mitigated. This way the insignificance of the estimate for NMA can be explained. To explore whether cost efficiency has positive effect on profitability, a RE model was run by adding cost efficiency as one of the independent variable to the base model presented in table 6.6. Cost efficiency was estimated using Data Envelopment Analysis (DEA). Table 6.9 shows that cost efficiency has a statistically significant and positive effect on profitability. According to the regression results, increasing the cost efficiency by 1% would increase the profit by around 11.94 dollars.

6.7.6 Additional compliance costs

According to previous literature, compliance cost may only constitute a small proportion of production costs (Dean, 1992; Jongeneel et al., 2007; Jongeneel et al., 2008). The compliance costs can be too small to have significant effect on the economic performance of regulated farms. According to equation (4.3.1) and cost of production formula (4.2.1), any change in milk price led by change in a regulated farm’s production costs can be expressed as:

\[ \Delta p_{milk} = \Delta C_i \times w_i \times w_o \times 0.4 \]  

(6.7.1)

Where \( \Delta p_{milk} \) is the change in milk price received by farmers, \( \Delta C_i \) is the change in the production cost of regulated farm \( i \), \( w_i \) is the production share of a farm \( i \)
Table 6.9: Parameter estimates of regressions with/without cost efficiency

<table>
<thead>
<tr>
<th></th>
<th>RE model without cost efficiency</th>
<th>RE model with cost efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm size</td>
<td>-239.3 (254.3)</td>
<td>-401.9 (251.1)</td>
</tr>
<tr>
<td>Regulation timing</td>
<td>168.9** (93.0)</td>
<td>108.4 (92.87)</td>
</tr>
<tr>
<td>Implementation of NMA</td>
<td>-167 (129.6)</td>
<td>-150.8 (106.7)</td>
</tr>
<tr>
<td>Farm operator’s age</td>
<td>-3.258 (4.0)</td>
<td>-1.613 (4.011)</td>
</tr>
<tr>
<td>Operator’s education</td>
<td>-72.25 (91.0)</td>
<td>-71.78 (87.47)</td>
</tr>
<tr>
<td>Age of farm</td>
<td>-7.828* (4.8)</td>
<td>-7.909* (5.167)</td>
</tr>
<tr>
<td>Herd size</td>
<td>3.871** (1.6)</td>
<td>3.778** (1.666)</td>
</tr>
<tr>
<td>Business type</td>
<td>74.99 (109.9)</td>
<td>54.19 (103.3)</td>
</tr>
<tr>
<td>Milk record keeping</td>
<td>-186.4 (121.2)</td>
<td>-169.2 (119.3)</td>
</tr>
<tr>
<td>Debt to asset ratio</td>
<td>-258.1** (115.5)</td>
<td>-362.6*** (113.9)</td>
</tr>
<tr>
<td>South-western region</td>
<td>-215.4* (107.2)</td>
<td>-222.1** (104.0)</td>
</tr>
<tr>
<td>South-eastern region</td>
<td>-209.5* (107.9)</td>
<td>-249.1** (101.9)</td>
</tr>
<tr>
<td>Breed of herds</td>
<td>659.3*** (142.8)</td>
<td>638.1*** (161.8)</td>
</tr>
<tr>
<td>Feeding system</td>
<td>102.6 (121.3)</td>
<td>168.9 (120.3)</td>
</tr>
<tr>
<td>Housing system</td>
<td>-207.7 (225.0)</td>
<td>-265.8 (194.7)</td>
</tr>
<tr>
<td>Milking system</td>
<td>134 (133.4)</td>
<td>98.95 (109.9)</td>
</tr>
<tr>
<td>Manure system</td>
<td>-114.6 (197.0)</td>
<td>-164.4 (179.5)</td>
</tr>
<tr>
<td>Time trend</td>
<td>-90.70** (38.3)</td>
<td>-52.94 (38.17)</td>
</tr>
<tr>
<td>Squared time trend</td>
<td>8.638*** (3.1)</td>
<td>6.890** (2.939)</td>
</tr>
<tr>
<td>Cost efficiency</td>
<td></td>
<td>1194.3*** (229.4)</td>
</tr>
<tr>
<td>Constant</td>
<td>1604.9*** (376.5)</td>
<td>663.5* (419.1)</td>
</tr>
<tr>
<td>Observations</td>
<td>663</td>
<td>663</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.1652</td>
<td>0.2099</td>
</tr>
</tbody>
</table>

Standard error statistics in parentheses
Source: Calculated from Ontario Dairy Farm Accounting Project
* p<0.10, ** p<0.05, *** p<0.01
Note: the unit of cost efficiency is 100%.
within the province, \( w_o \) denotes Ontario’s production share. According to the COP formula (4.2.1), COP explains 40% of the milk price. Take production data in 2010 as an example: six large farms with NU no less than 300 contribute to only about 36% of total milk production of all sample farms in ODFAP. The average production share of each farm is around 6%. The total production share of Ontario is around 32.73% according to the CDC’s report (CDC, 2011). Therefore, increasing the compliance cost of a regulated farm \( i \) by 1 dollar will lead to an increase of 0.0079 cents in milk price \( (\Delta p_{milk} = 1 \times 6\% \times 32.73\% \times 0.4 \approx 0.0079) \). The extension to which production costs affect milk price depends on the magnitude of change in production cost for each regulated farm.

### 6.7.7 Violations of Regulation

Farms are selected for inspection based on risk, complaints, size and whether a previous inspection was conducted (Niagra Peninsula Conservation Authority, 2011). If regulated farms were not inspected when they violates NMA, then production costs may not incur. This can also lead the parameter estimates in this study to be biased.

### 6.8 Summary

This chapter investigates whether NMA has significant effect on the profitability of regulated farms with no less than 300 NUs. Relied on the econometric model specified in the last chapter, this chapter gave parameter estimates of variables that are believed to capture the determinants of farm level profitability under three different models: RE model, FE model and pooled OLS. RE was chosen for analysis after the Hausman’s specification test and Breusch-Pagan LM test were conducted. The empirical results fail to reject the null hypothesis that NMA has no significant effect
on regulated farms’ profitability. Therefore, the implementation of NMA does not have a statistically significant effect on profitability of farms with no less than 300 NUs. Other variables that are found to have positive and statistically significant effect on profitability include herd size and breed of herd (Holstein). The estimates of dummy variables for south-western region and south-eastern region, as well as debt-to-asset ratio are found to be negative and statistically significant. Time trend variables also have significant effects on farm level profitability. Following the empirical results, this study elaborated factors that may increase the probability of having a type II error by failing to reject a false null hypothesis. The factors include: uncertainty to identify regulated and unregulated farms of NMA, settings of regulation timing, other nutrient regulation by-laws that may affect dairy production, production costs data from other provinces, efficiency variation, extension of additional compliance costs of regulated farms and inspection of non-compliance
Chapter 7  Summary and Conclusions

This chapter summarizes motivation of this study, theoretical framework used for analysis, empirical results, discussions of the empirical estimates, while pinpoints limitations of this study. Suggestions for future researches will also be provided.

The purpose of this study is to examine the economic impact of the Nutrient Management Act (NMA) on farm level profitability. NMA was introduced by OMAFRA and Ministry of the Environment, and provides management for the storage and handling of certain types of nutrients used in agricultural operation. Parts of the dairy operations in Ontario have to be phased in the Act (e.g., farms with no less than 300 NUs). The adoption of farming practices required by NMA is likely to induce additional cost of production in the form of investment cost, administration cost, nutrient export cost, land rental and non-compliance cost, etc. According to the national COP formula set by the CDC, milk price is partly determined by production costs. Therefore, increase in COP may lead to elevated milk price. If milk price increases due to the increase in production costs of regulated farms under NMA, then unregulated farms will be benefited from the Act since they do not have to experience any additional costs associated with NMA, but can share the elevated milk price with regulated farms. Meanwhile, the effect of NMA on economic performance for regulated farms is ambiguous: regulated farms with no less than 300 NUs face increase in both production costs and milk price.

According to this framework stated above, this study came up with the null hypothesis that profitability of regulated farms is not affected with NMA with the
alternative hypothesis that NMA has significant effect on regulated farms’ profitability. Data used in this study to measure the economic effect of NMA came from the Ontario Dairy Farm Accounting Project and the time period of data ranges from year 2000 to 2010. To empirically test the hypothesis, a random-effects (RE) model was run with the basic set up that profit is a linear function of a vector of explanatory variables, including dummy variables that represent the implementation of NMA. The empirical results indicated that NMA has no statistically significant effect on farm level profitability. Of all the other explanatory variables in the regression, farm age was found to have negative and statistically significant effect on profit. Number of cows was found to be positively related with profit, suggesting some evidence of economies of scale. Raising Holstein as the milking cows was found to increase the profit significantly. The estimate for debt to asset ratio was negative and statistically significant. This indicates farms’ asset that was financed through debt may not be well-utilized. Locating in south-western region and south-eastern regions were found to lower profitability. Finally, the coefficients for time trend variable and its quadratic term were found to be statistically significant, indicating a non-linear relationship between the profitability and time trends.

Since I fail to reject the null hypothesis that NMA does not affect the profitability of regulated farms (NU≥300) at the 10% level, discussions were developed to investigate the unaccounted factor that might lead this result. One of the major concerns is that regulated group and unregulated group can not be identified with certainty. Farms were measured by Nutrient Units under NMA. Farms with no less than 300 NUs were treated as the only regulated entities and were used for econometric estimation in the empirical framework. Despite the fact that a majority of regulated farms of NMA consists of these large farms with no less than 300 NUs, there are also farms of other qualifications being phased in NMA (e.g.,
farms that are seeking a building permit). Meanwhile, some dairy operations may voluntarily adopt the farming practices suggested by NMA. They might have been affected in the similar way that NMA affects its regulated farms. There is not enough information to identify all the other farms being affected by the Act.

In addition, timing of the implementation should also matter. NMA was amended in 2005 after its general regulation was put in place in 2003. The amendments and the original regulation are likely to have different impacts on dairy operations. When the regulation timing of NMA was assumed to be year 2003 instead of 2005, coefficient for the implementation of NMA showed a negative and statistically significant effect on the profit. This is consistent with the alternative hypothesis of this study that NMA has a significant effect on regulated farms’ profitability.

Another reason that may help explain the insignificant in parameter estimate for the implementation of NMA is that a vast majority of dairy operations unregulated by NMA are subject to municipal environmental by-laws in Ontario. Therefore, these unregulated farms may be constraint by other nutrient regulations and have their production costs being affected as well.

The relationship between milk price and cost of production is a key factor in the analysis. One of the deficiencies in this study is that the regression has no control over the COP data in other provinces. Milk price and the cost of production should be positively related according to the national COP formula. However, milk price is determined by the pooled nationwide COP data. The cost of production data in Ontario is only part of the national samples.

Efficiency was also discussed in this study. A regression was run by adding the cost efficiency to the base RE model. The parameter estimate indicated that increasing the cost efficiency by 1% would lead to a 11.94 dollars increase in profit. Therefore, an approach to mitigate the effect of additional compliance costs of NMA would be increasing cost efficiency.
Finally, this study discussed the dimension of compliance costs. Since only about 5% of the farms are found to have no less than 300 NUs and regulated under NMA, the Act might be non-binding for the majority of the dairy operations in the sample. Hence, the increase in additional compliance cost may be too small to have significant effect on the profitability.

In summary, this study contributes to the literature by: (1) empirically measuring the economic effect of NMA on the profitability of regulated farms with no less than 300 NUs for Ontario’s dairy production; (2) exploring the pathway through which NMA affects profitability by introducing a key point in this study: the national Cost of Production (COP) formula; (3) identifying the variations in profitability across farms and regions; (4) developing discussions on factors that may have biased the estimated coefficient for the implementation of NMA.

7.1 Policy Implications

The parameter estimate for the implementation of NMA is statistically insignificant, suggesting that the profit of regulated dairy operations with no less than 300 NUs may not be affected by the Act. An explanation for this is that NMA appears to be non-binding for the majority of the farms. The threshold of 300 NUs restricts only a very small proportion of farms, while a majority of the farms in the sample used in this study may not be subject to this regulation. The implementation of this Act is supposed to provide standards that are best management practices for not only regulated farms, but all other dairy operations. To enhance the overall nutrient management performance and be more restrictive for regulated farms, the Act could reconsider types of farms being phased in. Reinforce in compliance and inspection is a way to better ensure that farm practices are conducted following NMA. For those who are not being phased in the Act, education and outreach is
desirable in helping them following the practices under the Act.

Several ways can be suggested to mitigate the potential negative economic effect of the adoption of NMA. First of all, evidence of economies of scale was suggested from the empirical estimates. Therefore, increasing the number of cows may enhance farm level economic performance. However, expansion of dairy operations may be limited under the existing supply management system in Canada. An alternative way to reduce production costs is increasing cost efficiency. If a farm is not 100% efficient, then its production costs can be reduced without any decrease in milk output. The negative effect of additional compliance costs can be mitigated if a farm is more cost efficient than the other farms. In addition, choosing Holstein for milk production over other types of breed is also desirable in increasing profitability. Since around 95% of the farms has raised Holstein, the breed of herds should not be a big concern. Encouraging the older farms to embrace new technology, be more innovative and make changes in their farming practices when necessary may as well increase the profitability. Decreasing the debt-to-asset ratio is also an option to increase profit.

7.2 Limitations and Suggestions for Future Research

This study does not have control for unaccounted factors that may induce a type II error in the empirical estimates by failing to reject a null hypothesis. First of all, this paper is constrained by data. The absence of information used for fully identify regulated farms and unregulated farms of NMA has the potential to bias our results. Meanwhile, the empirical results would have been more reliable if I have control over the cost of production data from other provinces that are used by the CDC to determine milk prices. In addition, provisions of NMA was amended after
it first came into force in 2003. The amendments may affect types and numbers of farms being regulated, and change the extension to which production costs of regulated farms were affected. This leads to the difficulty in accurately measuring the economic effect of the Act.

Another limit of this study is that the economic performance of dairy operations cannot be measured accurately. Dairy revenue and cost of production per cow were measured empirically by using the direct revenue from cow enterprise less direct production cost from cow enterprise and intermediate cost from replacement enterprise and crop enterprises. Part of the production costs and revenues used to calculate dairy profit may derived from livestock operations (e.g., sales of bulls) and crop operations rather than from milk production. Despite a subset has been chosen for empirical estimation based on a farm’s proportion of revenue from milk sales (the farm’s milk revenue should be greater or equal to 80% of the total farm revenue) so that the observations can be compared in a relatively homogeneous group, I am still unable to differentiate the cost of production used for milk production from those used for other farming operations.

Cost efficiency captured in the regression in chapter six was measured by Data Envelopment Analysis (DEA) and by pooling all the data from 2000 to 2010. The estimation results can be contaminated by ignoring the technological change over years. However, cost efficiencies would be incomparable if they were estimated in different years with separate frontiers. Therefore, the reliability of empirical results can be improved by developing a more reliable form of efficiency estimation.

If data containing full information of farms that adopt NMA practices, as well as additional costs that these farms bear under NMA are available, the parameter estimates would be more accurate. Although researches have been conducted in measuring the compliance costs of nutrient management regulation in Ontario using mathematical programming, few studies have been done in econometrically
measuring the compliance costs and targeting specifically NMA. Future research that addresses the identification of regulated farms could also help enhance the reliability of empirical results in this study.
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