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Investment Behavior of Canadian Egg Producers: Analyzing the Impacts of Risk Aversion and Variability of Prices and Costs of Production

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Abstract:

Animal welfare is a major concern for consumers. This concern has not gone unnoticed by sector stakeholders, especially egg producers. One of the fundamental changes likely to affect egg producers regards modes of production, specifically changes in housing systems, ranging from conventional cages to free range. From farmers' perspective, changing their mode of production generates a technological and economic/marketing risk. This study documents the level of risk in the Canadian egg sector (conventional and specialty eggs) using data from 2009 to 2011. Our results indicate multiple uncertainty sources (technological, cost of production, price of eggs) that vary according to the types of eggs. We use a quadratic programming approach applied to expected mean-variance models to analyze the impact of risk on decision to invest when the resources must be allocated to different types of production that have different risk levels. Overall our results show how, given risk aversion parameters, producers minimize their risk levels by devoting their resources to the least risky type of eggs. An important result of our study is that supply management, by reducing the perceived risk level, has favored the development of specialty eggs, for the benefit of consumers.

Keywords: Eggs production, Risk aversion, Uncertainty, Expected mean-variance model, Prices and cost volatility

Résumé:

Des modes de production respectueux de l'environnement et du bien-être animal sont de plus en plus au centre des préoccupations des consommateurs d'œufs. La tendance actuelle dans la filière québécoise de la production d'œufs est donc à l'adoption de production dans des cages offrant plus d'espaces aux poules, d'élevages sans cages (poules en liberté), à la production biologique,... Et, à chaque type de production correspond des risques liés à la biosécurité, à la qualité des œufs, et aux normes de production qui sont différents. Les producteurs feront également face à des risques financiers différents, la variabilité des coûts de production et des prix des œufs n'étant pas la même pour tous les types d'œufs. À l'aide d'une approche de programmation quadratique appliquée au modèle moyenne-variance espérée, nous analysons le comportement d'investissement des producteurs d'œufs en tenant compte de plusieurs sources d'incertitudes. Les résultats révèlent que le comportement optimal des producteurs impliquerait qu'ils consacrent leur ressource à la production d'œufs conventionnels et réduisent celle des œufs de spécialité qui s'avère être plus risquée. Le système de gestion de l'offre contribuerait donc, en réduisant l'aversion au risque des producteurs, à assurer un développement de la production canadienne d'œufs de spécialité.

Mots clés: Production d'œufs, Aversion aux risques, Modèle moyenne-variance espérée, Volatilité des prix et des coûts

Classification JEL: Q12, C61

Investment behavior of Canadian egg producers: analyzing the impacts of changing in risk aversion and in variability of prices and production costs

1. Introduction

In many economic sectors, producers must factor numerous sources of risk and uncertainty into their decision process. The agricultural sector is no exception: risk and uncertainty are key components in decision-making (Huirne et al., 2000). One example is the strong volatility of the prices of raw materials and agricultural products, which has accentuated in recent years (FAO, 2011). Lien et al. (2003) also observe institutional risk, notably related to changes in policies supporting the agricultural sector and trade policies. The empirical question that emerges is how do these multiple sources of risk affect producers' optimal decisions?

Within the Canadian agriculture, the table egg sector is particularly suited to the empirical study of the effect of risk. In the last few decades, Canadian egg production experienced a strong growth and technological innovations have emerged, along with new production systems.[1] One of the fundamental changes that have affected the sector is the production of specialty eggs: organic, Omega 3, free range, etc. Egg producers must therefore decide whether or not to produce several types of eggs that may have different levels of technological and/or financial risk and uncertainty. According to the Fédération des producteurs d'oeufs de consommation du Québec (Quebec federation of table egg producers, FPOCQ),[2] risks related to biosafety, egg quality and production standards are subjects of crucial importance for all table egg producers. Several studies underline that this risk level varies by type of eggs. In organic production, for example, productivity is lower and less constant, and the risk of disease is greater. In addition, specialty eggs are sold in niche markets, where prices are more variable.

One of the first contributions of models integrating uncertainty in producers' choices is that of Sandmo (1971), who analyzed the effects of price uncertainty. A risk-averse producer produces

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[1] See the Egg Producers of Canada (EFC) website: http://lesoeufs.ca/. Site consulted on March 14, 2013.

[2] See address http://www.oeuf.ca/. Site consulted on March 14, 2013.

a smaller quantity in a situation of price uncertainty than in one of certainty. More recently, Dalal and Alghalith (2008) and Bobtcheff and Villeneuvey (2010) examined two sources of uncertainty, namely that of output price and production input price. These authors assert that an increase in price risks (inputs and outputs) should reduce production. Alghalith (2010) also analyzed the impact of multiple sources of uncertainty and the degree of risk aversion on the demand for inputs, and particularly on the optimal ratio of production inputs. In the presence of multiple uncertainties, when a firm has two substitute inputs, demand for each input is less than its certain equivalent. This is explained by the fact that uncertainty affects both the cost of inputs and the price of outputs. However, this decrease is lesser when uncertainty affects only input prices or output prices. Consequently, when risk aversion increases, demand for the two inputs decreases simultaneously. Further, the sources of risk and uncertainty that the firm faces can be correlated such that information on one risk can indirectly provide information on another source of risk. This correlation may decrease the firm's risk-aversion. Eeckhoudt et al. (2011) analyze the behavior of a decision-maker who faces two correlated risks and can obtain information on only one of these risks. Intuition suggests that the existence of a high correlation (in absolute value) between the risks should increase the total value of information because information on one of the risks can indirectly provide information on the other (additive or multiplicative risk). This information can help investors make better decisions. For example, information about good weather conditions can provide direct information on future production (assumed to be good) and indirect information on a decrease in market prices resulting from an increase in the global supply. However, the information can also cause a decrease in the farmer's perception of risk (multiplicative risk) and cause the farmer more losses than a situation without information. Consequently, as Bobtcheff and Villeneuvey (2010) and Algalith (2010) maintain, the optimal investment decision is complex despite optimality conditions that appear intuitive at first glance.

The general objective of this paper is to analyze the optimal choices of Canadian egg producer that must allocate limited resources to production of different categories of eggs. Our results point to varying degrees of risk according to the types of eggs produced. It is then optimal for the producer to orient its resources toward production with the highest gross margin combined with low variance in producer prices, which is that of free range eggs. Production of Omega 3 eggs appears to be the most sensitive to variations in the risk aversion coefficient, along with a decrease in egg prices and an increase in price variance. However, when production costs exhibit high variance, this sector would benefit from greater investments because of a higher gross margin than that of conventional eggs.

The remainder of the paper is structured as follows: Section 2 briefly outlines the main sources of risk in the egg sector, Section 3 describes the methodological approach used, and Section 4 presents the data used in the study. The results of simulations are discussed in Section 5, and Section 6 concludes the paper.

2. Sources of risk in the egg sector

The current trend in egg production is a shift from conventional cage systems to enriched cages and non-cage farming systems (free-range chickens). The European Union banned classic cages in 2012, and the United States has put forth a draft bill that, if adopted by Congress, would oblige egg producers to replace conventional cages with enriched colony systems that would almost double the amount of space provided to each chicken.[3] Depending on the housing system producers adopt, or their choice to favor organic production or not, producers should face differing risks. The sources of these risks are numerous and may directly affect the production chain along with the production decision process.

2.1. Economic/marketing risk and attributes of specialty eggs

Several authors show that in the table egg sector, a growing number of consumers are oriented toward purchasing distinct products in terms of safety, freshness, taste, color, etc. (see for example Jacob and Miles, 2000). This justifies current trends in favor of production of

[3] The new facilities would offer hens an environment containing perches, nests and scratch areas. This bill followed an agreement reached between the Humane Society of the United States (http://www.humanesociety.org) and the United Egg Producers (http://www.unitedegg.org).

specialty eggs to meet this growing demand. However, as Table 1 shows, prices of specialty eggs are more variable than those of conventional eggs, with the former supplying niche markets. Prices of Omega 3 eggs and free-range eggs are notable examples: their coefficients of variation exceed those of conventional eggs.

<< Table 1 about here >>

This retail price variance is transmitted to producers and affects the quantity demanded by consumers. The impact should nonetheless be limited because of the relatively weak price elasticity of eggs: 0.35 in Canada (AAC[4]) and 0.11 in the United States (USDA[5]). However, we can assume that this elasticity is greater for specialty eggs, which are niche products. It is therefore clear that a producer that produces different types of eggs faces different degrees of price risk. In Canada, table eggs are generally protected at the border by high tariffs. Specialty eggs are not, which makes them sensitive to fluctuations in international prices and exchange rates.

New production modes should also be more respectful of the environment and animal welfare. This engenders additional costs that are transmitted almost wholly to customers because of their willingness to pay for these attributes (Norwood, 2011). Lay et al. (2011) show that each livestock system has elements that detract from animal welfare and can consequently reduce the premium that consumers are willing to pay.

2.2. Technology risk and production cost variance

In cage-free systems, laying hens have more (about five times as much) space as in conventional cages and expend more energy. Van Eekeren et al. (2006) demonstrate that free-range chickens consume five more grams of food per day than caged hens do. The excessive energy expense of free-range chickens reduces food efficiency (Elwardany et al., 1998). The

[4] AAFC, Agriculture and Agri-Food Canada, 2011: http://www.agr.gc.ca/index_e.php

[5] USDA United States Department of Agriculture: http://www.usda.gov/

relative share of feed in the production cost is therefore greater, which is translated *de facto* by higher transmission of price variance of primary agricultural goods to costs. The main production inputs whose price variance is transmitted to costs are chicken feed, labor and energy (Farooq et al., 2002). Donohue and Cunningham (2009) show how the rise in prices of the main food inputs influences egg production costs in the United States. In September 2006, these inputs represented about 55% of production costs versus almost 70% in July 2008. In 2006, the food cost represented 33.3% of the breakeven cost, versus 48.75% in 2008. The higher variance in grain prices was therefore transmitted to production costs but to different degrees given that, depending on the type of production, grains made up different proportions of the feeds. Sumner et al. (2010) demonstrate that the contribution of food to the production cost is 10% higher in egg production with caged hens than in cage-free production. Conversely, the housing costs are higher for eggs produced by free-range hens. The cost variance consequently differs by production type.

Patterson et al. (2001) compare two systems of egg production: specialty eggs (alternative systems) and conventional eggs (conventional cages). They find that the technical performance of alternative production systems is inferior to that of conventional cages (see Table 2). De Reu et al (2008) also report that contamination of egg shells by aerobic bacteria (Salmonella enteritidis (Se)) is generally higher for eggs in cage-free systems (free-range farming) compared with eggs in conventional cages. This can incur additional costs associated with decontamination and reduced marketed production.

<< Table 2 about here >>

To summarize, the risk captured by variance of prices and production costs differs depending on the type of egg. All of these dimensions must therefore be considered in an empirical analysis of producers' optimal choices.

3. Methodological approach

Attempts by researchers to integrate risk and uncertainty in mathematical programming models have led to the E-V (expected-mean-variance) model in quadratic programming (Markowitz, 1952).[6] In this type of model, risk and uncertainty are considered by a variance-covariance matrix. The optimal production plan is selected based on the expected gross margin and its variance. Hazell (1971) developed a linear version of the quadratic programming model, MOTAD. This version uses linear approximation of the variance of expected income to represent risk rather than relying on a nonlinear measure, such as the use of the variance-covariance matrix. This method approaches risk by the absolute standard deviation, where all the parameters (prices, costs, return, etc.) of the model are assumed to be random.[7] The disadvantage of this approach is the hypothesis of normality, and approximation of variance is less efficient than with standard quadratic programming models. Similar to the MOTAD model, the Target MOTAD model (Tauer 1983)[8] integrates an additional constraint that sets a target level of total revenues. Risk is measured as the expected sum of negative deviations, based on a pre-defined target level of return. McCarl and Onal (1989) compared linear approximation (MOTAD) with non-linear approximation (E-V) in a series of sectoral models. They conclude that the direct solution of the nonlinear problem is faster and more precise. They also offer a very specific and simple way to capture or consider risk, namely via a variance-covariance matrix (Markowitz, 2012; Komarek and MacAulay, 2013). These findings motivate the choice of the E-V approach in the present study.

Accordingly, we seek an optimal plan for a farm producing several types of eggs. The producer's objective is to maximize its expected profit. Given the available data, we restrict

[6] Komarek and MacAulay (2013) apply this approach to mixed businesses in Australia. Several authors have also used this model in finance to determine the optimal investment given different sources of risk in this field. Recent works include Rubinstein (2012), Yucel and Ozcan (2011), and Han Kim (2012).

[7] Marques and Martins (2007) apply this model to the economic evaluation of soil preparation technologies in a risky environment.

[8] Shahwan and Haddada (2011) use this model in the agricultural sector as part of production optimization given financial risks and a constraint related to water use in a valley in Jordan.

our analysis to production of conventional, Omega 3 and free-range eggs. Let us consider a producer that decided to produce a quantity x_j with j=1-3 of each type of egg. Its objective function is written as:

$$(1) \qquad \text{Max}\,\pi = \sum_{j=1}^{3} E(p_j - c_j)x_j - \alpha x'\Omega(p_j - c_j)x$$

Subject to

$$(2) \qquad \sum_{j=1}^{3} c_{ij}x_j \le b_i \text{ with } i = 1,2,3 \text{ et } x_{j3} \ge 0 \text{ for all } j = 1,2,3$$

where $E(p_j - c_j)$ represents the expected gross margin of each production *j*, *p* is the sale price and *c* the unit production cost. The parameter α represents the producer's coefficient of absolute risk aversion and Ω the variance-covariance matrix. Lastly, the parameter b_i represents the amount of resources available to produce the good *i*. Equation (2) represents the various constraints associated with production of each category of eggs. Specifically, the producer's goal is to produce in under the following constraints:

- the production quota,
- the space allocated per hen, in keeping with the rules for each type of production,
- the number of hens per production system, given that a hen produces a limited quantity of eggs per year.

We consider two main sources of risk: variance of production input prices and of output prices. Technological risk is captured by lower average production for free-range chikens. The matrix $\Omega(p_j - c_j)$ with *j=1 2,3* is a 6x6 matrix because it considers variance and covariance of the prices and costs of each type of production. The parameter α represents the coefficient of absolute risk aversion. It is obtained by dividing the producer's coefficient of relative risk aversion by its expected profit (Skokaï and Moro, 2006; Rude and Gervais, 2008).[9]

4. Data

The data used for the analyses cover the period ranging from January 2009 to December 2011. As mentioned, we are interested in three types of egg production: conventional eggs produced in traditional cages, Omega 3 eggs produced in traditional cages and eggs produced by free-range chickens. The data sources used in the study are summarized in Table A1.

4.1. Technical data

Table 3 summarizes the technical elements that underlie our study. We use the data published by the CRAAQ (2007) on average size of poultry farms in Québec. We hypothesize that three types of eggs are produced: conventional eggs, conventional eggs and free-range eggs. Production is distributed over an area of 36,000 m^2 representing 24 hen houses of 1,500 m^2 each.[10] Three hen houses are dedicated to production of Omega 3 eggs, three to free-range eggs and the remaining hen houses (18) produce conventional eggs.[11]

<< Table 3 about here >>

[9] Estimates of coefficients of relative risk aversion are easier to obtain than coefficients of absolute risk aversion.

[10] For production of conventional eggs, the average capacity of a poultry farm is 34,830 hens, with an average of 1,500 m^2 (CRAAQ, 2007).

[11] EFC (2008) cited by Huang (2013) indicates that aaccording to 2008 Nielsen data regular eggs occupied a 84.5% market share nationwide, followed by omega-3 eggs (12%), and the other specialty eggs compose only a 3.5% market share.

4.2. Producer prices

Producer price represents the price of the egg before it is sent to the grader. The data we had were producer prices for conventional eggs, retail prices of Omega-3 eggs and retail prices of free-range eggs. Several transformations were done to the data to obtain the producer prices for each type of eggs. First, the producer prices for conventional eggs (which were subdivided into several categories) were adjusted by taking into account the relative shares of the three main categories of eggs.[12] These shares are indicated in Table A2. The producer price of a dozen conventional eggs (all categories combined) is equal to the weighted average of the prices of the three categories for the year in question.

The databases consulted did not contain data on producer prices for specialty eggs. These prices were crop approximated according to a two-step approach. The first step consists in determining the total margin in percentage (grader margin and retailer margin) of conventional eggs by hypothesizing that it is identical (in %) for all types of eggs. This margin in percentage of retail prices lets us determine the prices for producers of Omega-3 eggs and of free-range eggs. Prices for Omega-3 egg and free-range egg producers are therefore determined by subtracting the retail price margins of these types of eggs.

4.3. Production costs

Several manipulations were also necessary to determine the production costs of different categories of eggs. The first step consisted of determining the production cost of conventional eggs. As with prices of conventional eggs, we use an average cost calculated based on the cost of the three main categories of eggs. Production costs of conventional eggs are therefore obtained by multiplying the average cost by the adjusted relative shares. The second step consisted of finding the costs of other types of eggs (Omega-3 and free-range eggs) and estimating their variance. To do this we use the results obtained by Sumner et al. (2010) and

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[12] We have considered the relative shares of the main categories of eggs, which represent about 80% of production (See Table A1 in the appendix).

Van Horne and Bondt (2003). Summer et al. (2010) show that the total production cost of Omega-3 eggs is 1.17 times higher than that of conventional eggs and that the cost of free-range eggs is 1.41 times higher. These indices let us convert the monthly costs of conventional eggs into the monthly cost of Omega-3 eggs and free-range eggs and consequently determine the average costs.

Van Horne and Bondt (2003) demonstrate that the average price of feed for hens producing Omega-3 eggs is 1.32 times higher than that of conventional eggs. Sumner et al. (2010) estimate the contribution of the various cost components to the total production cost of eggs. These relative shares are presented in Table 4.

<< *Table 4 about here* >>

Farooq et al (2002) confirm that over half of production costs are linked to feed comprising more than 60% corn (Martin et al 1998). For the estimation of cost variance we consider the three main expense items in egg production, namely prices of grain corn, prices of labor and electricity prices. We capture the varying impact of the variance of each of these elements in production cost variance by assuming that the relative share of each input differs depending on the production mode.

Table A4 present the average prices and costs, and Table A5 shows the variance-covariance matrix of prices and costs considered in the simulation procedure. Table A6 illustrates the correlation coefficients between prices and costs.

5. Main results

5.1. Constant relative risk aversion coefficient (CRRA)

Maximization of the producer profit lets us obtain the first result without considering risk. Under the space constraints allotted to each hen depending on the production system, and the total area, the result of profit maximization shows that the farm would optimally produce 12,830,578 dozen conventional eggs, 2,138,479 dozen Omega-3 eggs and 378,000 dozen free-range eggs representing 83.60%, 13.94% and 2.46% of production respectively.[13] The producer's expected gross margin is $3,701,693, 75.45% of which comes from production of conventional eggs.

Figure 1 shows the changes in profit and quantity produced according to the value of the CRRA.[14] We vary the coefficient from 0 to 8 by increments of 0.5. Although the gross margin of Omega-3 eggs is higher than that of conventional eggs, the first adjustments were made to Omega-3 eggs. This adjustment occurs for a CRRA of 2.69. This result is consistent with the data that indicate higher variance in this production. The last production to be reduced is that of free-range eggs. Even if the price variance of free-range eggs is higher than that of conventional eggs, its greater margin makes it interesting for higher values of CRRA.

<< *Figure 1 about here* >>

Figure 2 shows the impact of this change in quantities produced on relative shares of each category of eggs. The share of Omega-3 eggs decreases as the CRRA increases.

<< *Figure 2 about here* >>

5.2. Simulations

In this section, based on the simulations of the previous section, we set the value of the CRRA at 2.5 and modify a number of price and variance parameters to analyze changes in expected

[13] 83.41% of the production quota is oriented toward production of conventional eggs, 13.90% to Omega-3 eggs and 2.69% to free-range eggs.

[14] The OECD (2004) proposes a relative risk aversion coefficient of 4 for Canada. However, we can assume that it is lower in the egg sector, which is subject to supply management.

gross margin and in the production of different types of eggs. We add the following constraints:

- When the quota allocated to production of free-range eggs is not fully used, the producer may decide to produce Omega-3 eggs. The inverse is not true because we hypothesize that maximum demand for free-range eggs is restricted to the initial value;
- When the quota allocated to production of specialty eggs is not fully used, it may be used for production of conventional eggs. However, the inverse is possible only within a certain limit: we make the assumption that the demand for specialty eggs is restricted. Therefore, the growth of the supply of Omega-3 eggs cannot exceed 25%.

5.2.1. Effect of a decrease in prices

We can assume that an increase in minimum access level and/or a decrease in tariffs would translate into a drop in prices of different categories of eggs on the Canadian market. In this section we analyze the consequences of these scenarios on the producer's allocation of production quotas. Figure 3 presents the effects of a uniform decrease in % of prices of three categories of eggs. Once again, production of Omega-3 eggs would be affected by a decline in prices and therefore in the expected gross margins. Quotas freed by this production would be reallocated to production of conventional eggs. However, the drop in production relative to the initial situation is modest, at under 1%. Based on a decrease in prices of slightly less than 3.25%, production of conventional eggs is below the initial volume.

<< Figure 3 about here >>

5.2.2. Effect of an increase in price variance for egg producers

Egg price variance on the Canadian domestic market depends notably on factors such as exchange rates and border tariffs, which could isolate the domestic market. Stronger volatility in exchange rates and/or a decrease in the level of border protection could consequently contribute to increasing the variance of producer prices for different categories of eggs.

Figure 4 present the effects of an increase in producer price variance for all types of eggs while keeping the other factors constant. It shows that in this context, production of Omega-3 eggs would become more risky, which would lead to a transfer of production quotas from specialty eggs to conventional eggs. Figure 5 shows the larger relative share of conventional eggs.

<< *Figure 4 and Figure 5 about here* >>

Figure 6 shows, however, that the overall supply of eggs is lower than the initial supply following this increase in price variance.

<< *Figure 6 about here* >>

5.2.3. Effect of an increase in variance of egg production costs

As mentioned above, the volatility of principal basic agricultural products has escalated in recent years. Below we analyze the effects of an increase in variance of production costs for different categories of eggs.

Figure 7 presents the effects of an increase in variance of producer prices for all types of eggs while keeping other factors constant. It shows that, given the relatively high gross margin of Omega-3 eggs, it becomes more profitable to increase production of these eggs, to the detriment of production of conventional eggs. Figure 8 shows the larger relative share of specialty eggs. However, as Figure 6 indicates, the total egg supply is lower than in the initial situation.

<< *Figure 7 and Figure 8 about here* >>

6. Conclusions

Similar to other agricultural sectors, the Canadian egg sector faces multiple sources of uncertainty and risk. Specifically, this sector is characterized by a supply management system that can stabilize prices and provide producers with a steady income. However, three major sources of risk and uncertainty have been identified in this sector and examined in this study.

The first source of risk is economics/marketing. Data on egg prices on the Agriculture and Agri-food Canada website confirm the presence of variance in eggs prices that is more pronounced for specialty eggs. Incidentally, current consumer trends favor specialty eggs, because consumers have a positive perception of these eggs in terms of health effect, animal welfare, and the environment. Consumers are therefore willing to pay more for them. If this quality sought by consumers would be lacking, or if an event were to harm consumers' perception of these eggs (for example avian flu), this would represent a risk for producers. The second source of risk is found in the choice of egg production mode; each mode has its inherent technological risks. The third source of risk is found in the variance of prices of the main inputs in egg production. Given that the relative share of each of these components differs depending on the production mode, their costs also exhibit differing variance.

By conducting an empirical study that uses an expected mean-variance quadratic model, we demonstrated the effect of these different sources of risk on production decisions and the producers' expected gross margin. The results of this study let us conclude that in the current context of egg production in Canada, producers perceive a lower level of risk than that generally accepted in the Canadian agricultural sector. Nonetheless, egg producers that must allocate limited resources to production of different categories of eggs will orient their resources toward production with the highest gross margin associated with the lowest producer price variance, which is that of free-range eggs. Production of Omega-3 eggs is most sensitive to variations in the risk aversion coefficient, to the drop in egg prices and the increase in price variance. However, given the high production cost variance, this sector deserves larger investments because of the higher gross margin than that of conventional eggs.

This study adds to our understanding of risk and uncertainty in investments by egg producers and development of production of specialty eggs in Canada. The literature to date has not examined the problem of risk in egg production, having argued for a lack of risk in this sector. This paper explains the effect that risk may have on investment in the sector. Nonetheless, other risks such as those linked to production costs are less controllable and should be studied carefully by producers. The empirical limits of this research are found in the lack of data for the specific case of Canada. However, it allows various actors in the table egg sector to understand the effect of risk on producers' choices and to take the necessary measures to ensure the continuity of the sector.

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List of tables

Table 1: Variance of producer prices for several types of table eggs

	Average producer price ($/dozen)			Price coefficient of variation		
Type of eggs	**2009**	**2010**	**2011**	**2009**	**2010**	**2011**
Conventional, Jumbo category	2.06	2.15	2.08	3.75%	4.07%	3.85%
Conventional Extra-large category	1.79	2.05	1.88	3.88%	3.90%	3.86%
Conventional Large category	1.60	1.67	1.80	1.12%	0.91%	2.86%
Conventional	1.62	1.80	1.80	4.03%	4.15%	2.97%
Omega 3	2.31	2.38	2.23	5.83%	5.50%	12.01%
Free range	2.54	2.60	2.72	4.50%	5.17%	4.99%

Source: Our calculations based on AAFC[15])

Table 2: Characteristics of the measure of egg production in alternative production systems versus conventional cage systems

Elements	Alternative systems	Conventional cages
Mortality rate	7.2%	5.2%
Feed per egg produced	162 g	142 g
Eggs rejected by hen	8.5%	6.3%
Number of eggs per hen and per year	259	284

Source: Patterson et al (2001)

Table 3: Technical elements of production of three types of eggs studied

Elements	Housing systems of laying hens		
	Conventional cages		Free-range eggs
	Conventional eggs	Omega-3 eggs	
Area in m^2	1500	1500	1500
Minimum space per hen/m^2	0.0484	0.0484	0.25
Mortality rate %	5	5	8
Eggs rejected (%)	1.1	2	2
Number of eggs per hen	276	276	252

Source: CRAAQ (2007)

[15] See at http://www.agr.gc.ca/poultry/pri_eng.htm.

Table 4: Comparison of the contribution in % of different items to production costs between cage and non-cage production systems

Items	**Contribution to production cost in cage production system**	**Contribution to production cost in non-cage production system**
Chicks	13.42%	14.76%
Food	48.99%	40.48%
Housing	12.75%	21.90%
Labor	4.70%	12.38%
Additional costs	20.13%	10.48%
Total costs	100.00%	100.00%

Source: Calculations based on Sumner et al (2010)

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Figure 1: Evolution and expected gross margin and quantity of different categories of eggs

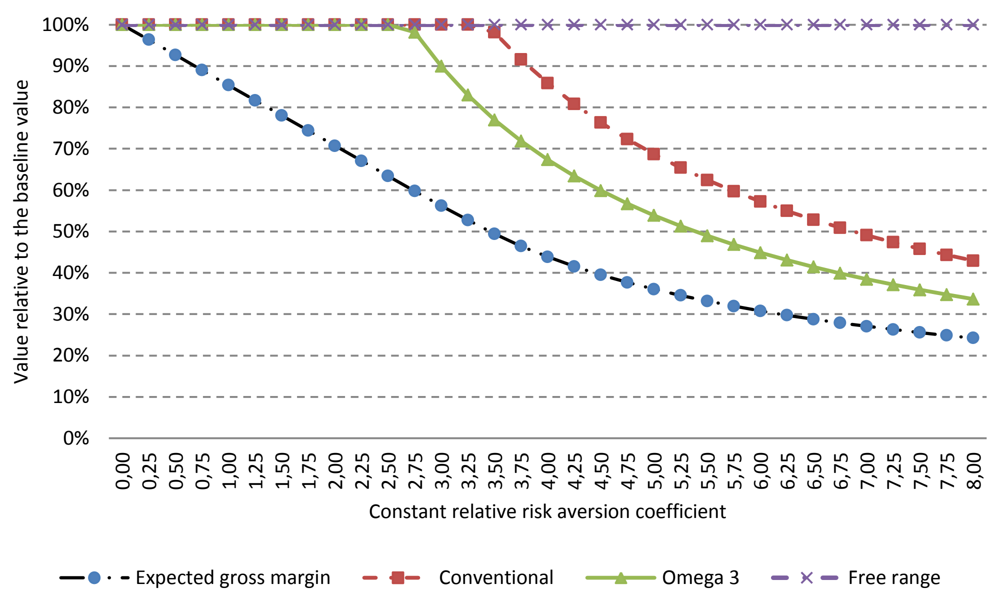


Figure 2: Evolution of relative shares of different categories of eggs

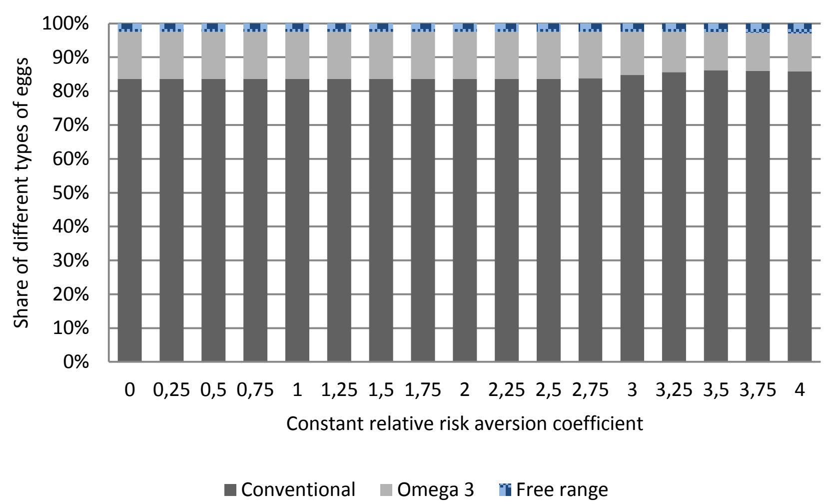


Figure 3: Effect of a uniform decrease (in %) in prices on margin and egg production

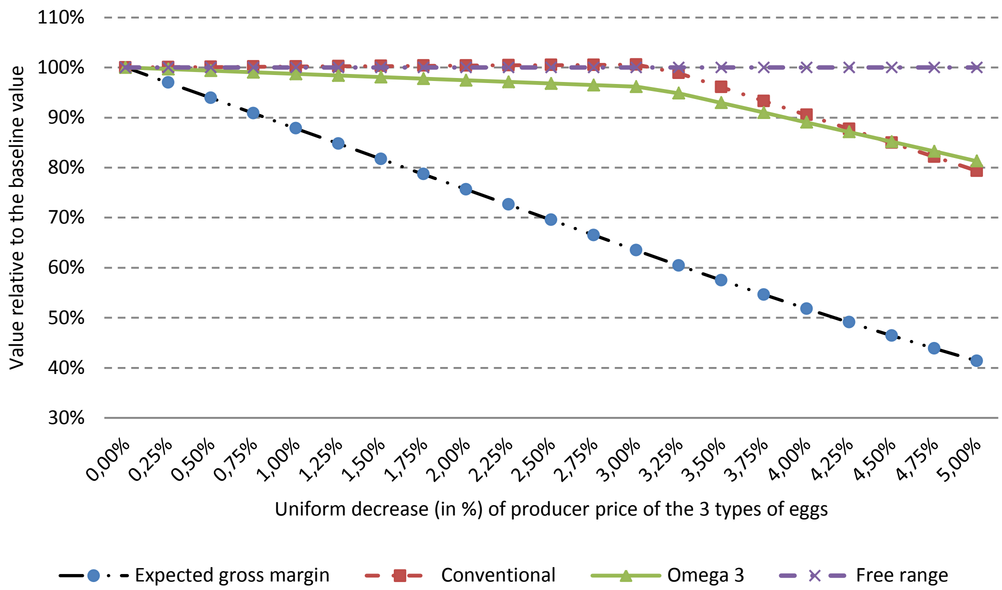


Figure 4: Effects of increases in variance of producer prices for the three categories of eggs

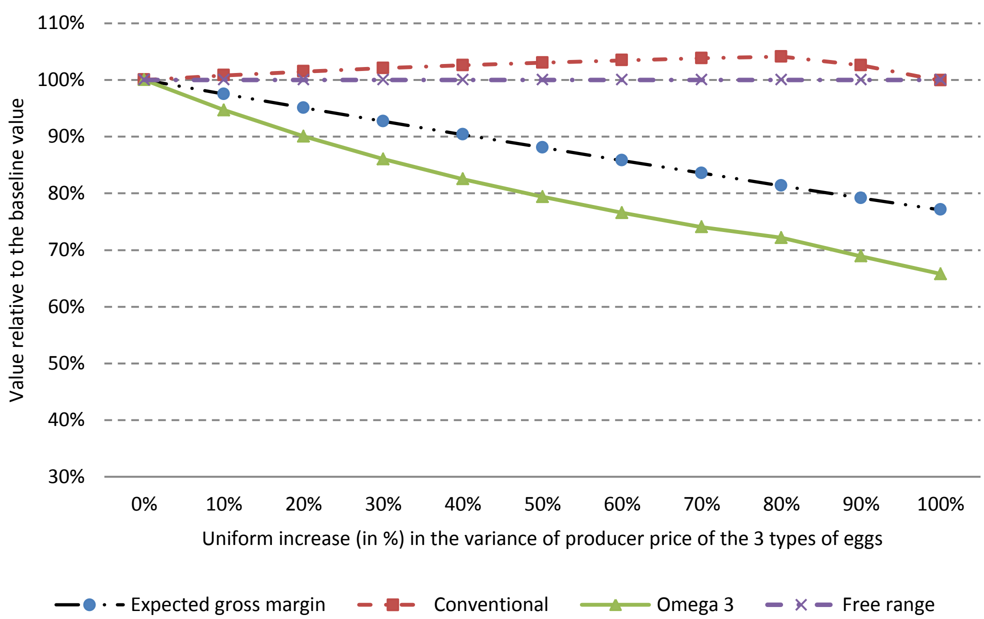


Figure 5: Evolution of relative share of different categories of eggs following an increase in variance of producer prices

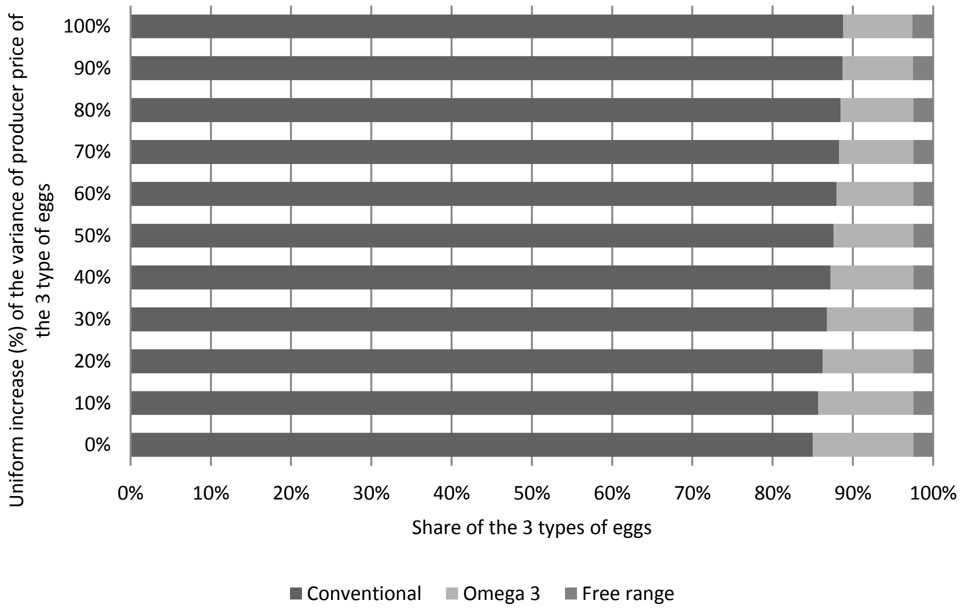


Figure 6: Evolution of total egg supply following an increase in variance of producer prices or production costs

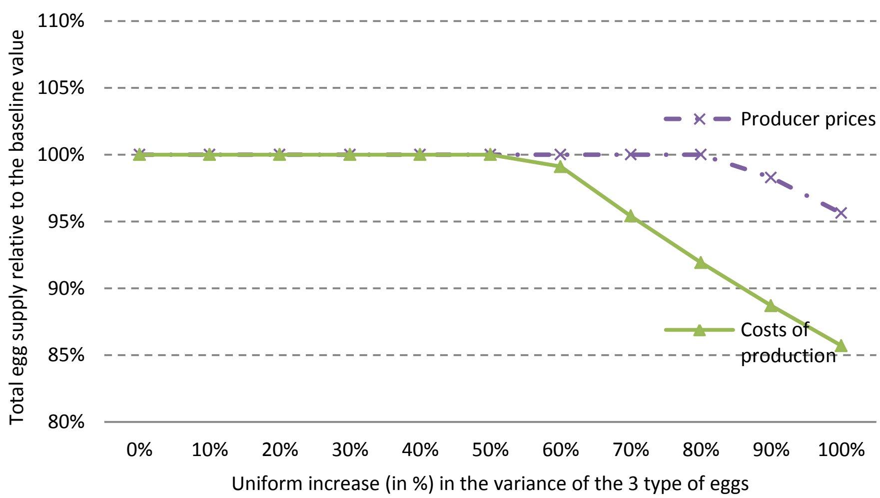


Figure 7: Effects of an increase in producer price variance for the three categories of eggs.

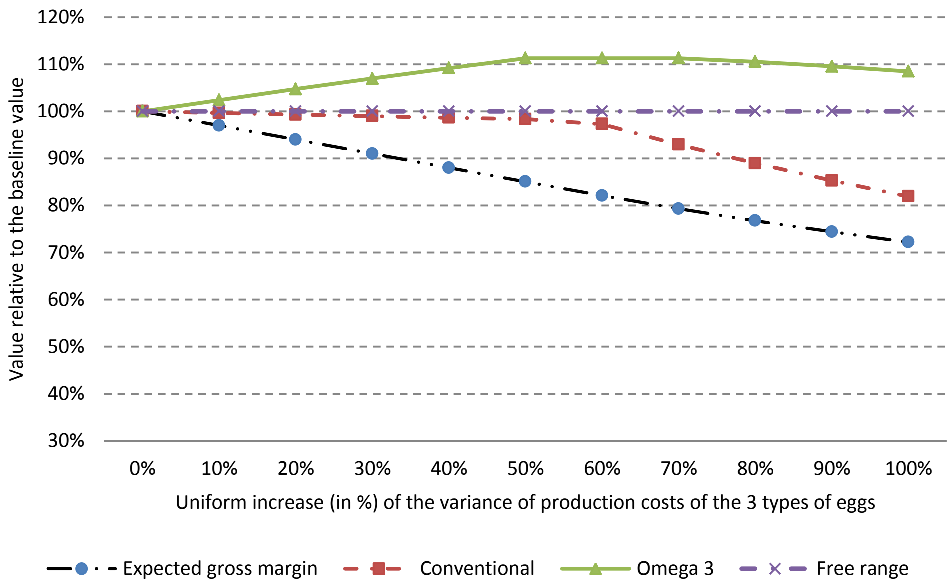
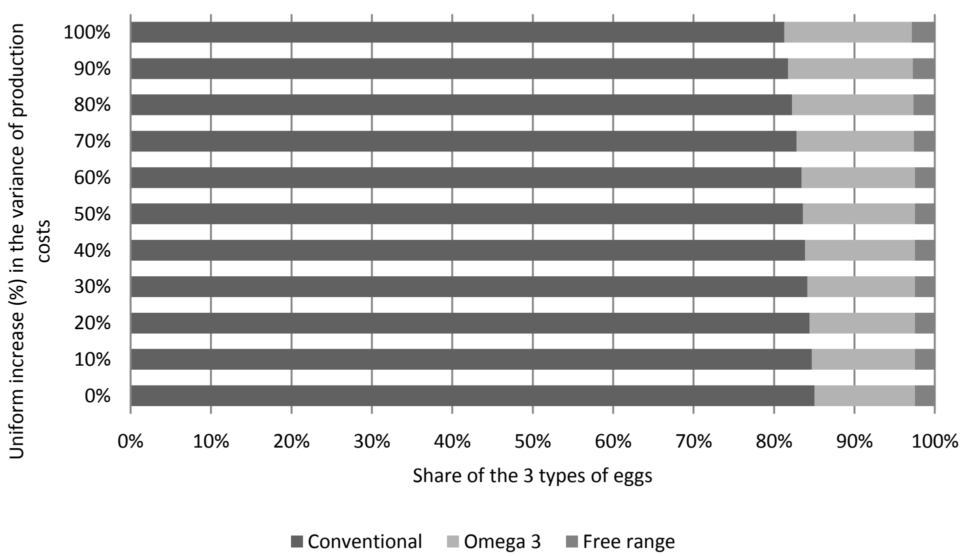


Figure 8: Relative share of the different categories of eggs following an increase in production cost variance



Appendices

Table A1: Sources of data used

Conventional egg producer prices: http://www.agr.gc.ca/poultry/pri_eng.htm
Retail Prices of Omega-3 eggs, free-range eggs and production costs of conventional eggs: http://data.canadaegg.ca/default.asp?CurLang=1
Consumer price indices in the United States: http://www.economagic.com/blscu.htm
Costs of farm wages in the United States: http://www.nass.usda.gov/Statistics_by_State/Kentucky/Publications/Annual_Statistical_Bulletin/B2009/Pg019.pdf and http://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Agri-facts/agri2may.pdf

Table A2: Adjusted relative share of three main categories of eggs

Categories of eggs	**2009**	**2010**	**2011**
Extra-large	26.21%	25.47%	26.53%
Large	54.53%	54.46%	54.28%
Medium	19.26%	20.07%	19.19%

Source**:** http://www.eggs.ca/ consulted on 30/07/2012.

Table A3: Relative share of different categories of eggs in total production

Categories eggs	**2009**	**2010**	**2011**
Jumbo	1.03%	0.85%	0.95%
Extra-large	24.61%	22.13%	22.88%
Large	46.33%	47.32%	46.81%
Medium	16.48%	17.44%	16.55%
Small	2.83%	2.94%	2.80%
Very small	0.49%	0.45%	0.44%
B	0.45%	0.47%	0.45%
C	2.36%	2.33%	2.14%
Other	5.42%	6.07%	6.97%

Table A4: Average price and cost ($CAN) by type of eggs (2009-2011)

	Conventional	**Omega 3**	**Free-range**
Price	1.690	2.304	2.616
Cost	1.485	1.736	2.094

Table A5: Price and cost variance-covariance matrix (2009-2011)

		Prices			Costs		
		Conventional	Omega 3	Free-range	Conventional	Omega 3	Free-range
Prices	Conventional	0.007549					
	Omega 3	-0.001471	0.037593				
	Free-range	0.007283	0.006318	0.020983			
Costs	Conventional	0.014393	-0.008434	0.016352	0.049504		
	Omega 3	0.018998	0.011199	0.008462	0.051736	0.086239	
	Free-range	0.016842	0.009707	0.019110	0.045802	0.060472	0.067601

Table A6: Correlation table of prices and costs (2009-2011)

		Prices			Costs		
		Conventional	Omega 3	Free-range	Conventional	Omega 3	Free-range
Prices	Conventional	1					
	Omega 3	-0.087291	1				
	Free-range	0.572175	0.222449	1			
Costs	Conventional	0.836855	0.219755	0.563895	1		
	Omega 3	0.836590	0.221012	0.221012	0.999994	1	
	Free-range	0.837656	0.216359	0.563749	0.999913	0.999866	1