Comparing Organic and Conventional Dairy Farms in the Netherlands – A Monte Carlo Analysis

Name: Shiyu Gu
Student number: 910926287050
Course code: BEC80436
Supervisor: Xudong Rao
Institute: Business Economics Group

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the Netherlands

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Abstract

The demand of organic milk products increases rapidly in the Netherlands during the past years. The organic milk producing ability is far from reaching consumers' demand. However, the expanding market room and high milk price do not change the fact that organic sector in the Dutch dairy system still contains a small percentage. In order to investigate the low conversion rate in the dairy farms, a family farm income model with Monte Carlo simulation and Multivariable Empirical distribution are used to discuss the viability of organic and conventional dairy farming system. The results present that organic farming seems to be better choice for the dairy farmers because of higher farm income. in spite of the statistic results, more variables like policy change or farming experience also need to be taken into consideration when a dairy farmer is making a farm strategy decision.

Key words: dairy farming, organic farming, risk assessment, Monte Carlo simulation,
decision-analysis, stochastic budgeting

Content

1. Introduction

Organic agriculture is a promising segment of agriculture worldwide. The total organic agricultural land area including in-conversing part is 37.2 million hectares (FiBL and IFOAM, 2013). Organic agriculture promotes soil quality, biodiversity, animal welfare, and crop rotation (John P. Reganold et.al., 2016). According to the 2013 FiBL-IFOAM survey, 0.9 percent of the agricultural land of the countries participating the survey is organic. In the European Union, the figure reaches 5.4 percent. Though organic agriculture has a potential threat to the food security because it relies on more land to produce same amount of food as conventional agriculture, the demand increased rapidly in the past 10 years. Sales of organic products grew almost fivefold between 1999 and 2013, reaching $72 billion (John P. Reganold et.al., 2016).

Agriculture, especially traditional conventional arable farming, is the major contributor to the agrochemical pollution, greenhouse gas emission and soil degradation. Due to the rising serious environmental problems, many people begins to rethink the way of farming. They try to find a way to balance the food yield and environment damage. Sustainable farming is considered to be the best solution. According to the definition given by the IFOAM, organic agriculture is a production system that supports the health of the soil, ecosystem and human beings. Many researches show that organic farming has lower environmental impacts per unit of area than conventional farming (Tuomisto, 2012).

The popularity of organic agriculture promoted the development of organic certification system. The European commission published detailed regulation (EC) No 834/2007 and Commission regulation (EC) No 889/2008 to standardize the organic system which simplifies organic into detailed guidelines. More importantly, organic farming is legally distinguished from conventional farming by a set of principles. Now, there are 283 certification bodies spreaded in more than 170 countries (John P. Reganold et.al., 2016). In the Netherlands, there is only one organic control organization, Skal Biocontrole, assigned by the Ministry of Economic Affairs to certify and supervise the whole organic industry.

In order to promote organic production, the first European Action Plan for Organic Food and Farming was published 10th of June 2004. European organic market grew in line with the trend. With retail sales in 2013 valued at 22.2 billion euros, the European Union is the second largest single market for organic products in the world after the United States (W. Sukkel et al., 2009).

In 2000 the Dutch government set an ambitious target of five percent by 2005 and ten percent by 2010 of the total agricultural area should be organically managed (Acs, et al.,2005). However, the organic farm growth rate is slower than the conventional in the Netherlands (L.A. Raeijmaecke, 2015). The reason why Dutch farmers are reluctant to change their farm management is more or less related to the high risks rising in the transition period and during the production (Berentsen, 2012). By investigating the economic performance of both types of farming systems, we hope to present the key risk sources that will effect the organic production profit and find out how organic farmers try to manage the risks.

This paper uses the Dutch organic dairy industry as an example. In the Netherlands, dairy industry plays a major role in the agriculture sector and occupies the largest percentage of land. In 2014, the total dairy farms number was approximately 18, 000, and 1.6 million dairy cows were kept which produced 12.7 billion kg of milk per year (Zuiveln, 2014). 12.473 billion kg of milk was delivered to factory to make cheese (52.4%), milk powder (13.5%) and other milk products (Zuiveln, 2014). 65% of the milk products were exported (7.2 billion euros) and most of the foreign consumers are European citizens. In the meantime, Dutch government imported 2.6 billion euro dairy products in 2014. Germany was the main Dutch exporting region which provided 44% of the total imported dairy products. Organic milk was imported to satisfy the increasing consumer demand (Bionext, 2012b).

From the life cycle assessment report (M.A. Thomassen et al, 2008), organic dairy farms in the Netherlands performed better in eutrophication potential and energy use per kilogram of milk than conventional dairy farms. Because of its advantages in sustainability, organic dairy industry grew rapidly with consumer demand and dairy farm apply over the past decades. However, the organic dairy farm increasing rate in quantity is lower than the Dutch government expectation and the shortage of organic milk has to be filled by importing from abroad (L.A. Raeijmarcke, 2015). We look deeper into this phenomenon through the farm and market economic data provided by Landbouw Economisch Instituut (LEI), a leading agricultural economics institute in Wageningen University and research center.

The object of this research is to investigate the factors that will hamper the growth of organic dairy industry. In order to achieve this object, economic data from both Dutch conventional and organic dairy farming groups between 2001 to 2014 will be compared to test whether organic dairy farms in the Netherlands really earn more than the conventional dairy farms. All the probability distribution of all uncertain quantities are captured and ran through Monte Carlo simulation. After running the simulation, the results can be used to better explained which variables in the organic dairy sector are the most important uncertainty drivers.

2. Literature review

The limitation of organic farming database usually hampers the assessment. So what the researchers could do largely depend on the data available in the specific region. Generally, there are two widely used methods to complete organic economical assessment (de Bont et al., 2005). One method is to compare the available data from the conventional and organic farm groups in the same period (P.B.M. Berentsen et al., 2012). The second method is to investigate the data showing the farm performance before and after the conversion. But this method is seldom used because it doesn't take market change into consideration.

Dairy sector in the Netherlands is quite capital intensive. If the farmers decide to change the farm management, it requires huge investment. Thus risk management is necessary for the farmer to balance risk and profits (P. B. M. Berenysen et al., 2012). Much of the literature explore the choice between organic and conventional farming (O. Flaten et al., 2005; G. Breustedt et al., 2011; Szvetlana Acs et al., 2009; L.A. Raeijmaecke, 2015; P.B.M. Berentsen et al., 2012; E. Kerselaers et al., 2007) appointed to two major risk sources, one is production risk and the other is price risk. Some also mentioned the importance of governmental policy supports (G. Breustedt et al., 2011; O. Flaten et al., 2005). In the dairy sector, studies comparing the disease risks between organic and conventional dairy farming showed that organic farms usually faced lower disease risks than the conventional dairy farms because they fed the cow in a healthier way.

There are two general techniques of mathematical model in agricultural system, one is simulation and the other is optimization (L. Shalloo et al., 2004). Though simulation models lack the field experimental creditability (McCall, 1993), it provides the chances to discover the complex relationships which can be solved in other methods. A mature stochastic simulation model allows the investigation on effects of varying technical, biological and physical processes on the profitability of farms and the study of the various outcome possibility distribution (Swinton and Black, 2000).

Monte Carlo simulation model is widely used in agricultural risk assessment. It allows the economic feasibility studies for proposed agribusiness to take risks into consideration and show the risks of failure and success (Richardson et al., 2006; Lauwers et al., 2010, Asci et al., 2014). Richardson (2006) and Serhat Asci (2014) used quite similar process which was outlined by Richardson (2008) in his book, Simulation & Econometrics to Analyze Risk. The methods to develop a production-based feasibility simulation model with Excel add-in @Risk is applied in the practical agricultural risk analysis. Ludwig Lauwers introduced Monte Carlo mode in the organic sector to calculated the income risk factors of the organic cropping farms.

However, there are quite limited risk management literatures related to dairy farming sector. Gudbrand Lien (2003) used stochastic budgeting to simulate the business risk and financial performance over a six-year period on a diary farm in Norwegian. The hierarchy of variables approach was applied and treated as a solution to the major difficulty of the whole-farm budgeting, identifying and measuring the relationship among stochastic variables. Shalloo, et al. (2004) developed a budgeting simulation model to investigating the variation of biological, physical and technical processes on a dairy farm profitalibity. Neyhard et al. (2013) investigated the features and options of contracts on milk and feed to determine the influences on the ability of a dairy farm to satisfy the cash flow needs and reduce the variance of farm net income. The research showed that the currently used monthly feed purchase mechanism and monthly cash milk price produced the powerful built-in natural hedge for the dairy farms.

3. Dutch dairy industry overview

Netherlands has a long history in milk production and processing. With its development in technology, modern dairy industry becomes the mainstay industry in the Dutch agriculture sector. Moving from locally-focused on the farm to internationally-oriented business, new technologies offer the possibilities of milk scale growth and international transportation. After the milk quota system abolishment, Dutch diary sector will integrate more into world milk market which opens the new era for the dairy history.

Dutch dairy industry largely depends on importing and exporting, so the milk price is easily affected by the world market. The Netherlands is a densely populated country and the high land price is a heavy financial load for the dairy farmers. From the statistical data in 2015, there are around 18,000 dairy farmers who keep 1.6 million dairy cows in the Netherlands. The annual milk production quantity is 12.5 million tons. The intensive farming created serious pollution risks. Dairy farming threats air and water quality. The manure leaching is a big concern to the environment which contributes to the underground water pollution. EU published the latest phosphate limits in order to control the dairy sector expansion after the milk quota system abolishment. According to the new policy, 60,000 to 100,000 cows have to be cut in the Netherlands to meet the EU environmental request. Thus the growth speed of milk production will be slower in the coming future.

Recently, there has been growing demand for organic milk. More and more consumers care about food safety and animal welfare. They hold the opinion that organic milk production process is closer to the natural laws and it has positive effects on environment. However, the relatively low production capability in the Netherlands cannot meet domestic consumers' demand and the organic milk shortage is fulfilled through importing. Research shows that the annual market demand for organic milk in the Netherlands is around 40 billion liters. There is room for 80 new organic dairy farms.

There are advantages and disadvantage to organic dairy industry. The main aim of organic agriculture is to make agricultural production more sustainable. Organic farms can be less dependable on the external input then the conventional dairy farms. The cow manure, instead of artificial fertilizer is applied into the soil as nutrient supplier of forage production. The composed organic manure is an important source of organic matter which improves the soil quality and increases the soil microbial activities. Organic dairy farms grow at least 60% of the cow forage themselves and accept the traditional grazing-based dairy system. The milky cows graze outside during the grazing seasons. Organic diary farms can build the nutrient cycle which largely improve the nutrient use efficiency. Organic milk is also considered to be healthier than the conventional milk. The Louis Bulk Institute has shown that organic milk contains healthier fatty acids like omega-3 which can produce positive effects in cardiovascular disease and cancer prevention.

Because of the benefits, Dutch government encourages conventional farmers to change their farm management into organic and offer them financial and technical support. But from the LEI statistical result, the proportion of certified organic dairy cows is less than 2% of the total number dairy cow in the Netherlands in 2015. Though organic price is higher then the conventional price and the demand for organic products increases significantly these years in Europe, organic farms still takes a small percentage in the farm group. A reason to explain the low conversion rate might be the high exposure to risk. As the farm net income formula depicts, how much money a farm can make depends on farm outputs and inputs.

Net farm income=Output quantity x Output price – Input quantity x Input price

Organic agriculture encourages farmers to use natural methods to grow food and keep animals which expands the disease risk possibility in the modern society. The decline of artificial intervention asks farmers to be better educated to grasp new farming methods. On the other side, organic dairy farming requires larger farm land input which largely increase the economical load because the land price in the Netherlands in quite expensive. According to the organic regulation, cows must graze outside and should have more indoor activity room. Problem will occur for the dairy farmers to choose from purchasing land and reduction herd size.

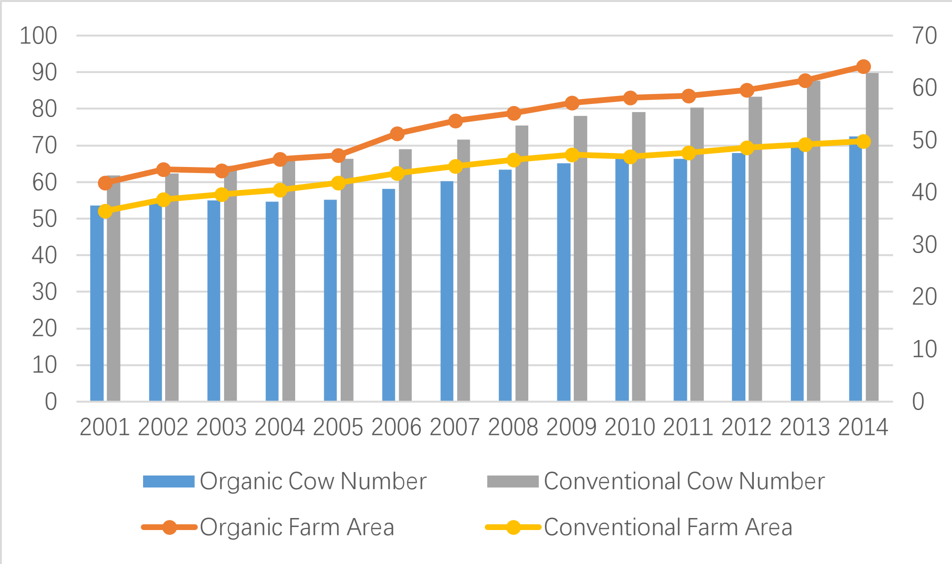
Milk price risks is another big challenge in organic dairy sector. Milk price is the result of supply and demand where the source of price risk lies in. In the traditional grazing system, cows produce little milk during the cold winter season due to light and temperature constrains. Organic dairy sector follows this natural rule. During the winter season, there will occur a shortage of organic milk supply. The fluctuation of seasonal organic milk price is more or less related to the season supply shortage. However, the conventional milk is the result of a highly mechanized industry which can supply milk for the whole year at lower price. Organic market is still niche and young. So the whole supply chain is not mature enough to endure the market changes.

4. Data description

This research is build on the dairy farm database provided by LEI Institute of Wageningen University and Research Center. In this research, there are only two types of farms. One is certified organic dairy farms and the rest all belong to conventional dairy farms. The farms in the research sample are either conventional or organic.

The dairy farm sample contains around 1.6% of randomly chosen dairy farms cross the Netherlands. From Figure 1, both conventional and organic dairy farms showing the similar trend of expanding in dairy herd size and farm land area. It is partly because of farmers' response to the milk quota policy abolishment, but more importantly, the bigger the farm size is, the lower the average production cost will be. In the European regulation, an organic farm ought to provide land for the cows to graze outside and stables that satisfy the request that the minimum activity area per cow inside the stable should be larger then $6m^2$. So the average farm land area of the organic farm sample is always larger than that of the conventional and the difference tends to gradually expand.

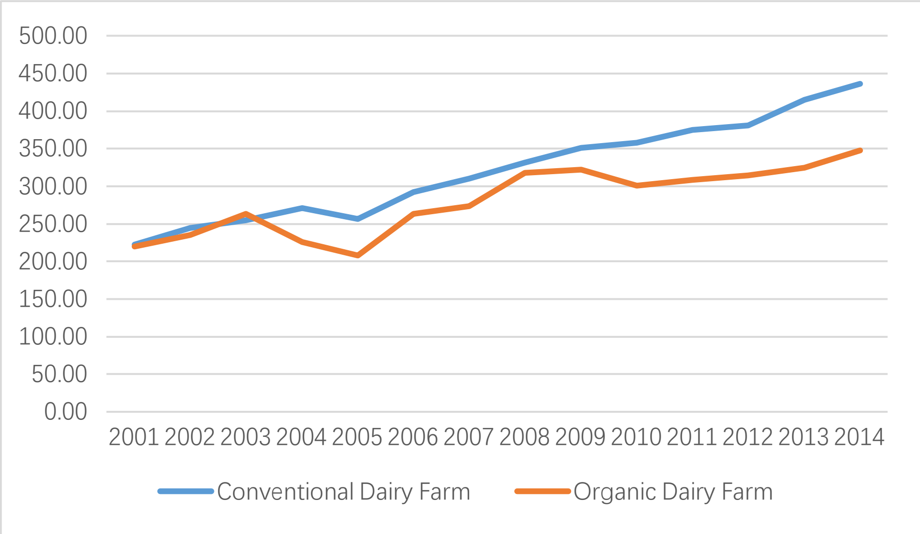
Figure 1. Dutch dairy sector in the period 2010-2014



When looking deeper in to the farm holding results, we can make a full analysis of the dairy farm operation from an economic view. The farm results can be divided into two parts, farm costs and farm output. The main output comes from sold milk which determines the farm annual revenue. Large dairy factories purchase cow milk from dairy farms directly where the milk will be further processed. It is the major sales channel for the dairy farms. In the organic sector, SKAL regulates and supervises the whole chain to ensure the organic milk quality. Organic dairy farms prefer to keep the milk themselves to make milk products such as cheese or ice cream and sold them in the farm or open plaza because many of them cannot accept the low purchased milk price. Organic dairy farms have wider income sources. They broaden the in-farm and off-farm activities to increase their social sustainability and spread the the farming risk.

Dairy farms total costs include specific cost, general cost, labor cost, financial costs, energy cost, contractor cost and assets cost. The total costs and its components generally show an increasing trend from 2001 to 2014. However, the organic dairy farm total costs in this period are more volatile. The total farm costs in the organic sector reached the peak at 2008 which largely because of the significant increase of costs for off-farm manure displacement and the high price of Organic fertilizer and seed material. Expanding farm size and stricter environment constrains can explain the reasons why the costs for off-farm manure displacement were particular higher between 2007 and 2009. The basic raw material price decreased and labor costs had a short decreasing period after the year 2009 and then increased again in 2012.

Figure 2. Dutch dairy farm costs (1000 euros) in the period 2001-2014

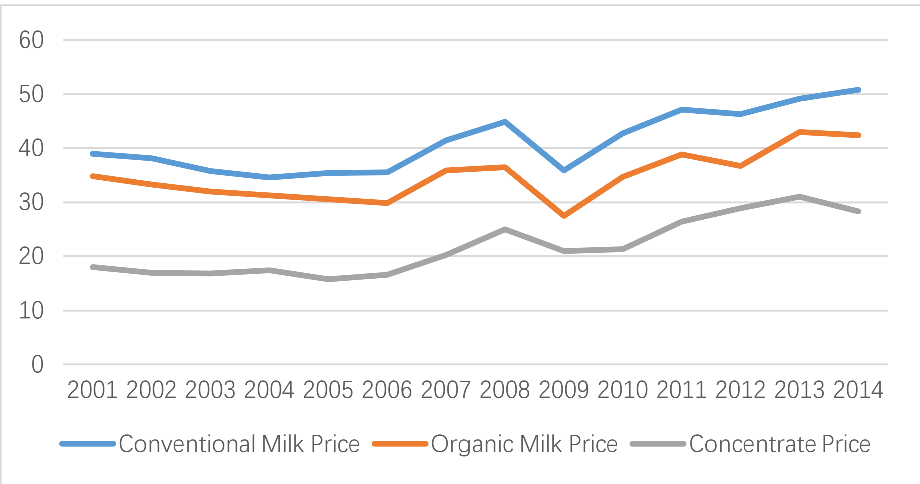


Feed price is a key factor that determine the margin a dairy farm could make. Figure. 1 shows the milk price between 2001 and 2014 when the milk quota system was still applied. It is obvious that milk price and concentrate price fluctuated in a similar trend. Correlation coefficient between milk price and concentrate price is 0.82. It indicates that milk price and concentrate price is positively correlated. From the global cereal and oil seed market data, the price of main feed commodity compound shows a downward trend during the recent years. However, the factory milk price/feed price ratio (the black space between concentrate factory milk price and concentrate price) began to decrease

from 2007. Dutch dairy system is based on grazing and the farms prefer to produce the roughage themselves so that the global feed price has less impact power for the production costs.

Since 2006, the milk price arrived at a high plateau and generally showed an increasing trend. Meanwhile, milk price was much more volatile. The difference between the highest and lowest observed price between 2001 and 2006 was 4.98 euros. However, the difference was 14.92 euros between 2009 to 2014.

Figure 3. Milk and concentrate price fluctuation in the period 2001-2014



The European dairy market is controlled by the Common Market Organization (CMO). European milk quota system began in 1984 and it was introduced to control the dairy sector and stabilize milk price (European Commission, 2009). Since the introduction, milk quota is an important factoe in the European dairy industry. However, with the dairy industry development, European dairy policy continuously changes in order to encouraged the dairy farmers to be more market-oriented and lower the price intervention (European Commission, 2009). On June 26th 2003, the Luxembourg Agreement on the Mid-Term-Review (MTR) announced that the milk quota system will be abolished in 2015. Meantime, the price soft landing policy which announced that the milk quota in the European States would annually increased by 1% from 2009 to 2014 was implemented in order to make preparation for the coming abolishment.

On the 1st April 2015, the milk quota policy introduced 30 years ago was ended and the milk price was expected to decrease because the abolishment will relieve dairy farmers from a financial burden. However, the abolishment of milk quota system has little impact on the milk production in the Europe Union (Roel Jongeneel et.al, 2015). The slow growth rate in dairy sector is a response to the high production cost and little growth in domestic demand. The milk demand at world level will continue to increase in the next decade but the speed will be somewhat slower than the past decade. The milk demand will grow especially in Asia so that the Asia market is the business strategy center for the Dutch dairy companies in the future.

5. Method

From the farm owner's perspective, he is making a farm strategy decision whether to change the farm management into organic or just stay in conventional farming. So he ought to know first whether organic dairy farms in the Netherlands are more profitable than conventional dairy farms. However, in reality, it is quite difficult to answer it simply with yes or no. The farmers have to deal with the uncertainties occurring in the production process which may affect the farm profits. Monte Carlo simulation is widely used in decision-making process.

The objective of most decision-making models is to present the uncertainties around alternatives and calculate the expected value. All possible distributions of uncertain quantities are put into a flexible spreadsheet which will be simulated thousands of times to get the average outcomes and the risk profiles. According to Richardson's report, production-based investment feasibility simulation models ought to follow two steps. Firstly, the possible distribution of all risky variables need to be defined and validated. Secondly, these stochastic variables are linked to the formulas used to calculate receipts, cash flows, productions, costs, and other variables for the project.

With the excel add-on @Risk, the budgets are evaluated for a large number of iterations. The chosen parameters are valued and entered into the model from their probability distributions with Monte Carlo sampling. The probability distributions of the related parameters are combined through the functional equation in the model in order to determine the outcome. The steps will be repeated many times to give the possible distributions of the performances. For the target of stability in simulation results, a large quantity of samples is needed.

The production model to analyze milk production in the Netherlands is built on two different production budgets. The first budget set is for the conventional diary production system in the Netherlands. This budget set is built on better production technology which results in higher yield and costs. The second set is for the Dutch organic milk production system. This set focus more on sustainable production and strengths the inner nutrient use efficiency instead of the depending on external input. Two budgets were updated to 2014 by LEI research institute.

Stochastic variables in this production model are annual milk price, milk yield, and labor costs. Milk price and milk yield affect the cash receipts while the labor costs affect the production costs. Compared to other studies on dairy farm risk management, feed costs are not considered together as a stochastic variable because of the special characteristics of Dutch dairy farming. In the Dutch dairy production system, own roughage production and cow grazing are widely accepted. Thus feed costs are not that important in the farm total production costs as labor or machines purchasing. Historical milk price, labor costs from 2001 to 2014 are directly obtained from LEI institute. Based on the farm results generated from the dairy farm sample provided by LEI, there are only annual sold milk income and milk price data available. Thus milk yield of the two milk production systems are calculated through dividing annual milk output by the annual milk price.

The stochastic variables are simulated by using the multivariate empirical distribution (MVE) approach (Richardson et al., 2000). The advantage of the empirical distribution is that it avoids the limitation of the ability of the model dealing with the heteroscedasticity and correlation. The model in this research has six random variables: milk production, milk price and labor costs for both organic and conventional milk production system. The six variables have ten-year history data (2005-2014) and the prediction period is three years (2016-2018).

Table 1. Historical data for a representative farm group

	Price		Yield		Labor Costs	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Years	euro/kg	euro/kg	Kg/ha	Kg/ha	euro/ha	euro/ha
2006	0.36	0.30	8,010	13,811	112	60
2007	0.41	0.36	7,064	13,483	112	69
2008	0.45	0.36	7,874	13,898	115	87
2009	0.36	0.28	8,214	14,631	150	85
2010	0.43	0.35	7,722	14,905	57	94
2011	0.47	0.29	7,652	14,762	64	102
2012	0.46	0.37	7,767	14,990	56	113
2013	0.49	0.43	7,414	15,386	83	150
2014	0.51	0.42	8,069	15,655	98	124
2015	0.51	0.35	10,459	16,592	98	145
Summary Statistics						
Mean	0.44	0.35	8,024.46	14,811.34	94.55	102.87
Std Dev	0.05	0.05	870.50	888.21	28.45	28.55

Coef Var	0.12	0.14	0.11	0.06	0.30	0.28
Minimum	0.36	0.28	7,064.00	13,483.00	56.00	60.00
Maximum	0.51	0.43	10,458.64	16,592.42	150.00	150.00

The first step to estimate the parameters for a MVE distribution is to separate the non-random and random components for all the stochastic variables. In order to remove the random components of the stochastic variables, regression analysis or mean values can be used. We use the ordinary least squares (OLS) regression to predict the organic milk price, conventional milk yield, organic labor costs and conventional labor costs in 2016, 2017 and 2018. The rest variables including conventional milk price and organic milk yield choose the mean values to the projected means. According the scatter plot charts of these three variables, the organic milk yield use the mean value between 2006 and 2015, and the conventional milk price accepts the mean in the past five years.

Table 2. Projected means for simulation period

	Price (euro/kg)		Production (kg/ha)		Labor Costs (euro/kg)	
Years	Organic	Conventional	Organic	Conventional	Organic	Conventional
2016	0.53	0.37	8,024	16,754	109	167
2017	0.55	0.37	8,024	17,225	119	184
2018	0.56	0.37	8,024	17,726	128	202

The second step is to calculate the random components of all the six stochastic variables. The random component is the residual (ê) of the non-random components or the predicted values.

2.1 $\hat{e}_{it} = A_{it} - \hat{A}_{it}$

The third step is to make the residual (ê) to relatively deviates of their respective deterministic components. Here in Table 2, the organic milk price is used as an example to show how the parameters are estimated with the MVE distribution.

3.1 $D_{it} = \hat{e}_{it} / \hat{A}_{it}$

The fourth step for estimating the parameters is to resort the relative deviations from minimum to maximum and add the pseudo-minimums and pseudo-maximums for all the stochastic variables.

4.1 S_{it} = Sorted D_{it} from min to max,

4.2 P_{min} = Minimum S_{it} * 1.000001,

4.3 P_{max} = Maximum S_{it} * 1.000001

The fifth step is to assign the occurrence probability to each of the sorted deviates (S_{it}). The end points (P_{max} and P_{min}) are defined by 0.00 and 1.00 in order to satisfy the requirements for the probability distribution.

Table 3. Steps for the parameters estimating for the MVE distribution

	Random Variable	Deterministic Component	Stochastic Components	Relative Variability	Sorted Deviates	Probability of Occurrence
	A_{it}	$\hat{A}_{it}$	$\hat{e}_{it}$	D_{it}	S_{it}	$P(S_{it},)$,
P_{min}					-0.1818	0.00
1	0.36	0.44	-0.08	-0.1818	-0.1818	0.05
2	0.41	0.44	-0.03	-0.0682	-0.1818	0.15
3	0.45	0.44	0.01	0.0227	-0.0682	0.25
4	0.36	0.44	-0.08	-0.1818	-0.0227	0.35
5	0.43	0.44	-0.01	-0.0227	0.0227	0.45
6	0.47	0.44	0.03	0.0682	0.0455	0.55
7	0.46	0.44	0.02	0.0455	0.0682	0.65
8	0.49	0.44	0.05	0.1136	0.1136	0.75
9	0.51	0.44	0.07	0.1591	0.1545	0.85
10	0.508	0.44	0.07	0.1545	0.1591	0.95
P_{max}					0.1591	1.00

The sixth step is to account for the M x M intra-temporal correlation matrix for the M random variables (ρ_{ij}). The intra-temporal correlation matrix is calculated by using the stochastic components ($\hat{e}_{it}$).

Table 4. Intra-temporal correlation matrix for the random variables

	Price		Yield	
	Organic	Conventional	Organic	Conventional
Organic Price	1	0.6855	0.3054	0.7264
Conventional Price	0	1	-0.1077	0.3697
Organic Yield	0	0	1	0.6932
Conventional Yield	0	0	0	1

The seventh step is to account for the K x K inter-temporal correlation matrices ($\rho_{i(t,t-1)}$)for each of the stochastic variables. They are calculated by using the stochastic components ($\hat{e}_{it}$) and the related data lagged on year ($\hat{e}_{i(t-1)}$). This is the last step for estimating the parameters and the parameters are summarized in step 8.

8.1 $\hat{A}_{it}$, S_{it}, P_{min}, P_{max}, $P(S_{it},)$, ρ_{ij}, $\rho_{i(t,t-1)}$ for the random variables A_i,

8.2 i = 1, 2, 3, …, M,

8.3 historical years t = 1, 2, 3, …, T,

8.4 simulated years k = 1, 2, 3, …, K

In order to finish the MVE distribution, @Risk or other computer software are needed to generated the independent standard normal deviates (Richardson et al.). Prior to the MVE probability distribution simulation, the square root of all the inter-temporal correlation matrices ($\rho_{i(t,t-1)}$) and the intra-temporal correlation matrix (ρ_{ij}) must be calculated (Clements, Alvin M et al., 1971). The square roots of the matrices are called MSQRT and this procedure can be completed using MATLAB®.

9.1 R_{ij} = MSQRT (ρ_{ij})
9.2 R_i(t, t-1) = MSQRT ($\rho_{i(t,t-1)}$)

The first step to simulate a MVE distribution is to generate a sample of independent standard normal deviates (ISND) with a standard deviation od 1.00 and a mean of 0.00. The best way to generate ISNDs is to use the Excel add-in @Risk and choose the Latin Hypercube option.
10.1 ISND_i = Risknormal (0,1)

The second step is to correlate the 18 ISNDs within the simulation period by multiplying the factored correlation matrix (R_{ij}). The matrix multiplication step can be simplified. Because in the later Monte Carlo simulation, the intra-temporal correlation function need to be typed into the model. Thus, the second step of MVE distribution can be deleted.

The third step for simulating a MVE distribution is to add the inter-temporal correlation of the random variables. It is completed by a second matrix multiplication. Equation 11.1 is repeated for all the six random variables.
11.1 ACSND_i = R_i(t, t-1) * CSND_i

The forth step is to make ACSNDs transformed from matrix to uniform deviates by using the excel formula command = *norm.s.dist* and choose the cumulative normal distribution TRUE.
CUD_i = *norm.s.dist* (ACSND_i)

In the fifth step, the correlated uniform deviates are used to get the random deviates of all the variables for the empirical distribution. The CUD_{ik} can be used along with the sorted deviates (S_{it},) and probability of occurrence ($P(S_{it})$) to account for the fractional deviates (CFD_{ik}) for the random variable A_i. The procedure of interpolation is finished by using a table lookup function in MATLAB.

The last step is to use the correlated fractional deviates and projected mean to calculated the simulated random values in each predicted year for all the variables. Any adjustment can be added if the future variable expansion factors (E_{ik}) are available.
12.1 $\tilde{A}_{ik}$ = $\hat{A}_{it}$ * (1 + CFD_{ik} * E_{ik})

Excel can repeat the step1 to step 5 automatically by using @Risk. The results in table will be used in the farm-level simulation model.

Table 5. Results of simulation price, yield and labor costs for 2016-2018

	Price		Yield		Labor Costs	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Years	euro/kg	euro/kg	Kg/ha	Kg/ha	euro/ha	euro/ha
2016	0.5479	0.3783	7,822	16,776	112.68	173.24
2017	0.5648	0.3756	7,819	17,225	123.14	170.25
2018	0.5929	0.3779	7,800	17,761	132.43	187.19

The aim of this research is to incorporate milk yield, milk price and costs risks into the farm income value calculation. The annual stochastic variable is liked with Pro Forma financial statements to suppose costs and production coefficients for simulating annual net present value and cash flows over a planning horizon. The model is operated with a year-to-year level and produces annually financial statement over a three-year time horizon. The budget sets are added into financial results consist of income statement, cash flow statement and balance sheet.

There are two approaches of calculating the farm results provided by the LEI. The first one is called holding results and the other is called economic results. Here in this research, we accept the farm holding results formula to do the calculation.

13.1 *Total Output/ha = Milk Price * Milk Yield/ha + Other Farm Output/ha*

13.2 *Total Input/ha = Farm Total Costs/ha + Depreciation/ha*

13.3 *Total Family Income = (Total Output/ha – Total Input/ha) * Farm Land Size + Extraordinary Profits/Losses*

The total farm income results calculation of the two production systems uses the figures showing in the Table 6 and the some of the values are fixed. The general costs, intangible costs, tangible costs, contractors, specific costs, farm area and extraordinary profits/losses accept the farm results in the year 2015. The other output, energy costs and financial costs use the mean values of the period 2011 to 2015. Both farm types use the same calculation formula.

Table 6. Family farm income statement

	Organic System	Conventional System
Milk Price (euro/kg)	Random Variable	Random Variable
Milk Production (kg/ha)	Random Variable	Random Variable
Other Farm Output (euro/ha)	706.20	1186.18
Energy Costs (euro/ha)	82.52	126.17
Labor Paid (euro/ha)	Random Variable	Random Variable
General Costs (euro/ha)	286.36	359.86
Specific Costs (euro/ha)	1,251.52	2,631.10
Tangible Assets (euro/ha)	1,516.67	1,864.38
Intangible Assets (euro/ha)	57.58	184.45
Contractors (euro/ha)	336.36	441.23
Finance Costs (euro/ha)	348.00	615.43
Farm Land Size (ha)	66.00	55.30
Extraordinary Profits/Losses (euro)	100.00	500.00

6. Results

Three random variables in the Monte Carlo Simulation use different stochastic distributions. According to the Distribution Fit results, the organic milk price, conventional milk production, conventional labor costs, conventional milk price and organic labor costs follow a Uniform distribution and type in the maximum and minimum values in the period used to calculate the stochastic values. Only the organic milk production fits the Laplace Distribution.

Table 7. Family farm income results

	2016		2017		2018	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
	euro	euro	euro	euro	euro	euro
Minimum	-101,464	-69,012	-91,212	-65,212	-71,885	-66,175
Maximum	207,206	132,500	255,246	136,620	179,674	128,487
Mean	36,847	21,921	34,147	23,604	40,428	25,751
Std Dev	49,417	47,410	49,955	51,767	47,120	49,544

Table 7 presets the Monte Carlo Simulation results of family farm income predictions for the organic and conventional dairy farms in the year 2016, 2017 and 2018. By only analyzing the mean values and stand deviations, organic dairy farming seems to be better choice for the farmers. The average means or organic dairy farms are more than 10,000 euros higher than the conventional system. The stand deviations of both farm types are quite close which indicates that from the net income prediction results, organic dairy farming in the Netherlands seems not riskier then the conventional dairy farming system.

According to the historic figures provided by LEI, we can make a line chart (Figure 4) to depict the changes in the past five years and future three years of family farm income. The family farm incomes of both farming systems fluctuate markedly in this period and it is obviously that, the whole dairy industry follows the similar increase or decrease trend. Though the whole dairy systems suffer a tough period between 2014 to 2017, the dairy farm incomes increase again afterwards and it will enter a new growing period. Before the year 2015, conventional dairy farms in the Netherlands gained more money than the organic, however, this pattern failed after the year 2015, when the average family incomes of organic dairy farming surpassed the values of conventional and the trend will be kept.

Figure 4. Family farm incomes between 2012 and 2018

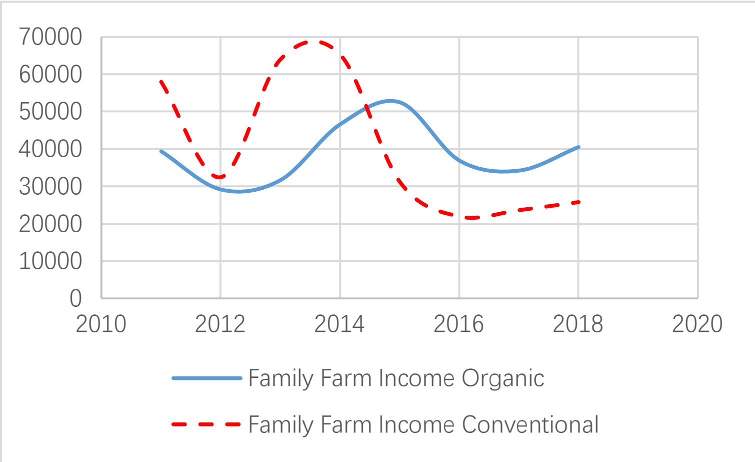
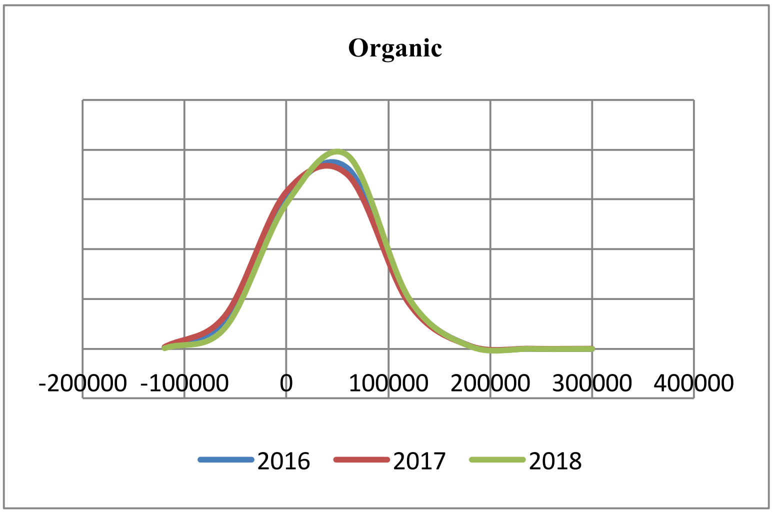
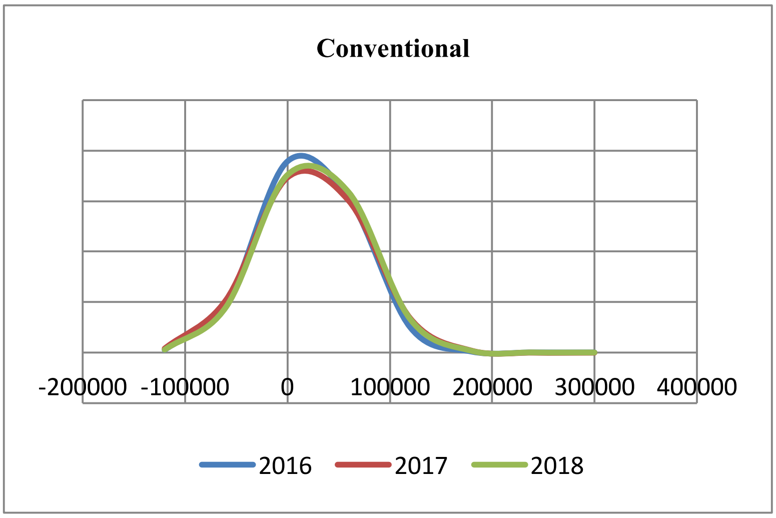


Figure 5 depicts the probability density function charts of dairy family farm income distributions in 2016, 2017 and 2018 for the two farm management system. The deterministic net incomes of the organic diary farm group and conventional dairy farm group are around 4,0000 euros and 2,0000 euros respectively which are approaching to the average of the net income means. The deterministic net incomes of the same farm type are very close and have similar shapes. However, the range between the minimum and the deterministic net incomes of organic dairy farming system are 138,311 euros in 2016, 125,360 euros in 2017 and 112,313 euros in 2018. The corresponding values of the conventional farming system are 90,933 euros in 2016, 88,816 euros in 2017 and 91,926 euros in 2018. The deterministic net incomes of organic farm system are 170,359 euros less than the maximum in 2016, 221,099 euros in 2017 and 139,246 in 2018. The values between the deterministic net incomes of conventional dairy farming system and the maximum are 110,579 euros in 2016, 113,016 euros in 2017 and 102,735 euros in 2018. The net income probability of organic dairy farming has a wider distribution between the maximum and the minimum.

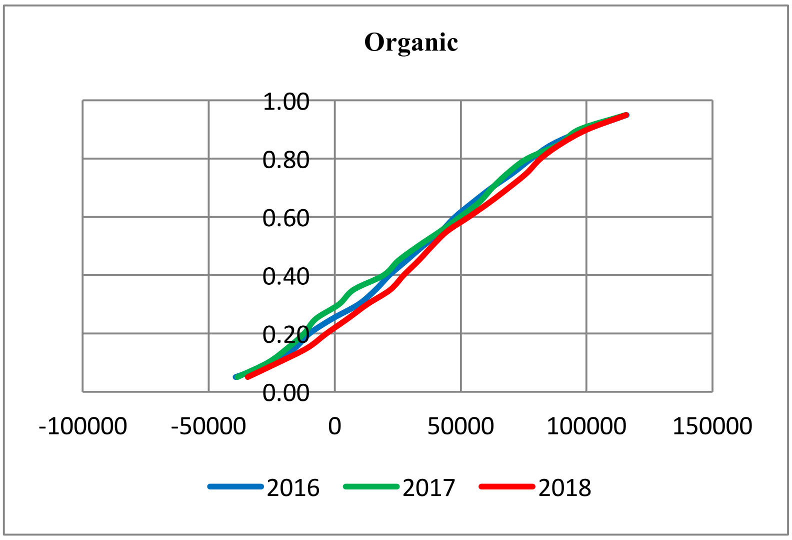
Figure 5. Probability Density Curves of dairy family farm income results

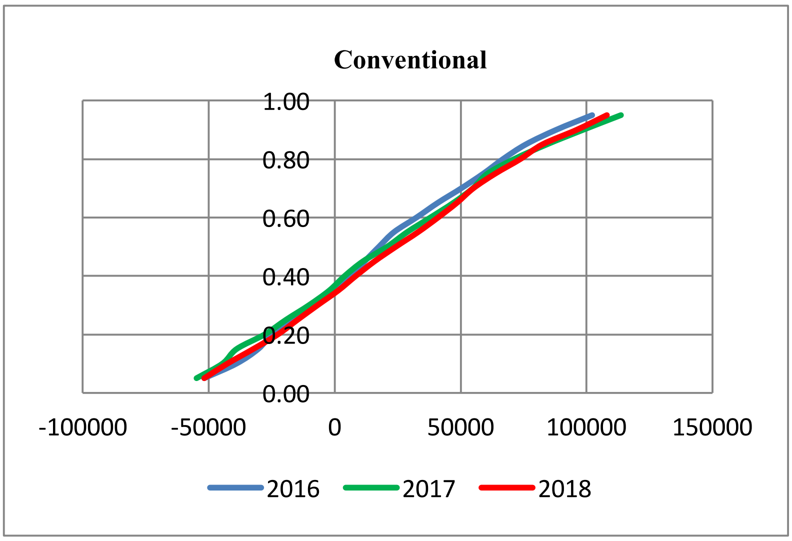




The cumulative distribution function (CFD) of net income values for alternative milk production system are illustrated in Figure 6. During the simulated period, the CFD lines of the same farming type are almost overlapped which indicates that the farm net income will be relatively stable in the coming three years. The probability of a negative net incomes of organic dairy farms is around 25%, whereas the probability of the conventional dairy farms around 35%. The predicted net incomes of the conventional dairy farms at the same probability level is smaller then the organic dairy farms because compared with the distribution of organic lines, conventional lines are centralized on the left side. Organic dairy farming system in the simulated period have lager possibility to gain a positive profit from the dairy farming work.

Figure 6. Cumulative Distribution Curves of dairy family farm income results





7. Discussion

From the farm family income and family income prediction results, organic farms are more profitable than conventional farms and seems not that risky in terms of the standard deviations. But in reality, organic agriculture takes only a small percentage of the total agricultural sector. Are organic dairy farms really not riskier than conventional dairy farms? From pervious research, we can summarize that the risks of the successful organic farming normally come from two directions, one is yield and the other is price. Organic milk factory price shows an obviously increasing trend in the past decade and the average organic milk price per kg is higher (around €0.1) then the conventional. People generally think that organic milk is healthier than the conventional milk and the organic milk market in the Netherlands is gradually expanding. Why the farmers refuse to change their farming management even though there are economic potentials?

7.1 Farm groups in the research

In this research, the average data of both farm types represent typical Dutch organic and conventional farm management results which are closer to the organic or conventional dairy farms operated for years. The results cannot represent the family income of these farms that are in the conversion or in the organic beginning period. Actually, farmers who are in the conversion period or at the beginning stage of organic dairy system are enduring the many difficulties before successfully become a mature organic dairy farm. The conversion and beginning stage will be the future investigating area to better explain the low conversion rate.

7.2 Data option limits

There are also limitations in the data used in the formula calculation. For the farmers of the mature organic or conventional dairy farms, the prediction results can only be treated as a reference. In the MVE distribution, the prediction of projected means has many options. For example, here in this research, we use the linear trend of the historical plots and its R^2 value to be the standards to get the points in the coming three years. If the historical plots show violent fluctuations, we use the historical means in a certain period to be the projected means. However, the future is uncertain and it is difficult to judge which option will offer the accurate prediction. In this research, the whole model consists of calculation formulas and it can be staged. Thus a Robustness analysis is applicable (Rosenhean, 2002) if there are several ways to account the predicted means or other representative values in the family income statement.

7.3 Risk sources beyond the model

Keeping cows in an organic way is different from conventional dairy farming. A series of regulations strictly control the production and labelling of organic dairy products. When converting from conventional to organic diary farms, these restrictions will pose challenges for the farmers. Because all the cows need to graze outside, the farmers have to buy more land to keep same amount of cows and make the land satisfy the requirements of organic grazing land. The farmers also need to expand the stable to reach the organic standard that one cow has at least 6 m2 room inside. The prohibition on the use of artificial preventive and regular antibiotics, medicine and sedatives will force the farmers to learn the knowledge about how to keep the cows healthy by only use natural medicines (Reaijmaecke et al., 2015). The conversion period in the Netherlands is usually longer than three years and a large percentage of farmers give up during the conversion period. The farmers need to invest a lot of money and suffer from the significant yield reduction during the process and the milk products received during the conversion period can only be sold at the conventional price. The farmers have to face the large economical challenge in the conversion periods before they gain profits from the organic dairy farming system (Acs et al., 2007). These risks are not taken into account in own research model because they are more or less happen in the early stages which can not be depicted from the database used in this calculation.

7.4 Non economic factors

In this research, we investigate the phenomenon from an economic view and a mathematical model is used to calculate family income for both farming systems. Every part of the model is related to money. Actually, except the economic factors appear in the farm accounting results, non monetary payoff risks like the farmers' experience, policies or government supports are not taken into account into the model and it is difficult to find relevant database. Policy intervention is always in the most significant factor that farmers care about (Flaten et al., 2005). It is reflected through various ways like subsidiary supports, land use requests, or even tax incentives. Especially after the abolishment of milk quota policy in the Netherlands, government policy intervention will be the major limiting factor to prevent over-expanding and land pollution problems from dairy farms. But these non economic factors are hard to be quantified and inserted into an economic prediction model like the one here.

7.5 The feature of dairy farms

In addition, both farming systems in this research use the same calculation model. But in reality, the conventional and organic farms are different in operation and sales. In the Netherlands, middleman collect the organic milk from the farmers and sell the milk to large milk companies to make further processed milk products. They usually buy the organic milk in a low price which even could not cover the input. So, some organic farmers refuse to sell the milk to the factory. They process the sheep milk, make milk products and sell by themselves. Thus in process of calculating the the organic farm net income, these kind of farms who finally decide not to make contracts with the dairy factories are no longer suitable for the farm output formula, milk price times milk yield, used here. So when the farmers make farming decisions, they ought to think over their own management methods and the most profitable sales channels.

The methodology used in this research can be widely applied to similar studies in various other sectors. The model used here, to investigate the low conversion rate, has its limitations above. There is still room to continue this research and further improve the calculation model in order to the make the risk analysis more accurate.

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