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A comparison of the mid-term economic feasibility of animal welfare systems on pig finishing farms in the Netherlands

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MSc. Thesis

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PREFACE

This master thesis is the final part to complete successfully the Msc. program Management, Economics and Consumer Studies at Wageningen University. To specialise myself more in economics on company-level I choose to do this thesis at the department of Business Economics. At the beginning I had a brainstorm session with my supervisor about my subject interest and thoughts. I got the opportunity to start a challenging research in this actual and hot topic.

I would like to thank several persons who supported me during my research. First of all I want to thank Dr. Helmut Saatkamp and Ir. Eva Gocsik for their guidance, feedback and nice cooperation during the whole period. Beside that I want to thank all personal contacts and companies who provided me with a lot of knowledge and practical inputs.

For me personally it was a very interesting and informative period where I learned a lot about the economy and market of the Dutch pig sector. Besides, I improved my performance in Microsoft Excel and reporting skills.

Gust Voermans

Wageningen, August 2013

Contents

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

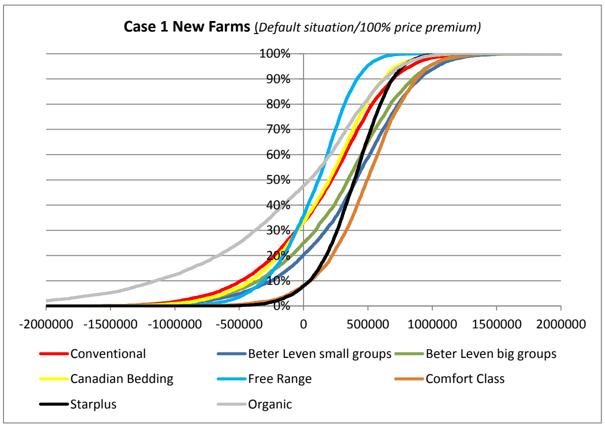
APFP	Average Present Finishing Pig
AW	Animal Welfare
CBS	Centraal Bureau voor de Statistiek (Eng: Central Bureau for Statistics)
CDF	Cumulative Distribution Function
CDRM	Capital Debt Repayment Margin
CDRM-5	Cumulative CDRM after 5 years
CV	Coefficient of Variation
dBA	Decibel
ELI	Ministerie van Economische zaken, Landbouw en Innovatie (Eng: Ministery of Economic Affairs, Agriculture and Innovation)
EU	European Union
FLE	Full Labour Equivalent
GRW	Geometric Random Walk
LEI	Landbouw Economisch Instituut (Eng: Institute of Agricultural Economics)
MDVA	Maatlat Duurzame Veehouderij & Aquacultuur (Eng: Ruler of Sustainable Livestock and Aquaculture)
mm	Millimetre
N.A.	Non Applicable
Nge	Nederlandse Grootte-eenheden
NL	Netherlands
PDF	Probability Density Function
SD	Standard Deviation
SPSS	Statistical Product and Service Solution
VIC	Varkens Innovatie Centrum (Eng: Pig Innovation Centre)
WUR	Wageningen University and Research centre

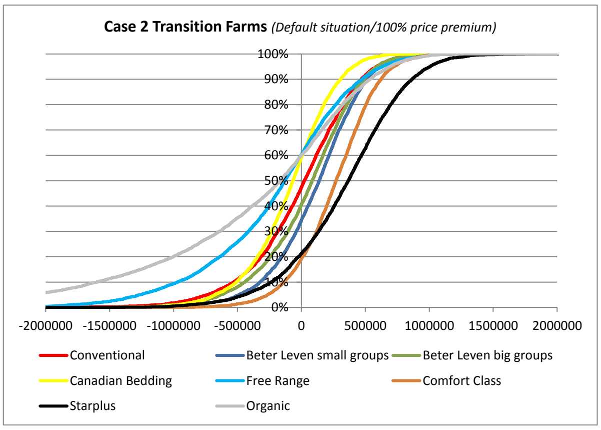
EXECUTIVE SUMMARY

Animal welfare is becoming an important issue facing the pig industry of Western countries. Citizen, animal advocacy groups and political organisations forces farmers to improve the welfare status of the pigs. The problem in this Case is that farmers do not know what financial impact welfare investments have.

This research provides a financial risk and feasibility analysis of finishing pig production systems in the NL with particular attitude to animal welfare. Eight production systems are described in 16 different welfare factors. Except the minimum standard (conventional) and organic, 6 different middle market systems are distinguished. A stochastic simulation model designed in Excel @Risk was the basis of the economic analysis. The cumulative Capital Debt Repayment Margin after 5 years is used as the performance indicator. Five years is judged to be enough for measuring the economic viability of the farm. Most important technical inputs (daily growth, mortality and feed conversion) and price inputs (meat, feed and piglets) are the stochastic determined parameters. Other inputs were assumed to be deterministic. To get insight in different farm situations, two different Cases were assumed: New building farms (1) and Transition farms (2). Besides, a scenario- and sensitivity analysis is used to get a better view of differences in risk.

The highest probability (>90%) for a positive CDRM-5 in the default situation is generated by the Starplus- and Comfort Class system. The second group in this comparison is formed by the Beter Leven 1 star systems (big and small groups). These systems generated a probability between 75%-80%. The Free Range- , Canadian Bedding- and Conventional system form a middle group with 64%-67% probability. The organic system has the lowest economic feasibility (52%). The scenario analysis concludes that all production systems with improved animal welfare needs a certain price premium and volatility to stay economic viable.





Besides a comparison based on default assumptions, also some analyses have been carried out on the factors that can influence the economic feasibility. Main findings are:

- The price premium has a big impact on economic feasibility.
- Above average technical performances changes the ranking between the systems.
- Degree of specialisation can have an impact.
- Tax payments are an important issue in the calculation of the CDRM after 15 years.
- The system of amortising loans has a big effect on the CDRM after 15 years.
- Transition to another production system is not always obvious because market factors have influence.

Depending on the commitment to animal welfare and amount of risk the entrepreneur will make a choice which production system fits best to him and his farm:

- Risk averse farmers can best hold on the conventional system or choose for the Beter Leven small groups system.

- Farmers who are more risk taking entrepreneurs can choose for any other system dependent on personal preferences and specific farm factors.

1. INTRODUCTION

1.1 Background

“Non human animal welfare is arguably the most contentious issue facing the hog industry. Animal advocacy groups influence the regulation of hog farms and induce some consumers to demand more humane pork products” (Seibert and Norwood 2010). Like quoted the societal pressure on animal production to improve animal welfare is increasing in Western countries of the world. This stimulates the pig production chain to develop new husbandry systems with improved animal welfare (Bornett et al. 2002; Franz et al. 2012).

Especially in the Netherlands (NL) the societal pressure is high because animal protection organisations like ‘Varkens in Nood’, ‘Wakker Dier’ and the political organisation ‘Partij voor de Dieren’ create a lot of protest actions and media attention. A recent example is the forced stop in Case of tail docking for piglets (Moesker 2013). The financial uncertainty related to new animal welfare requirements has impact on management choices of the farmer (Hoste 2010[B]).

To improve and guarantee the animal welfare of finishing pigs several above legal concepts have been developed the last ten years in the NL. Examples are: ‘Beter Leven’ and ‘Canadian Bedding’ (Anonymous 2013[B]; Anonymous 2013[I]). These concepts are the so called middle-market segments which are located between the conventional- and organic production system. The increase of added value, customer loyalty and the general image of the total sector are necessary for Dutch pig farmers to remain in existence in the future (van Doorn 2011).

The question is whether conventional farmers will join new product concepts. This choice depends of multiple factors, however the financial impacts are one of the most important. This because farmers do not know what income and risk factors occurs if they change their production system and operate in such uncertain environment (Bornett et al. 2002). Knowledge and insight about this is required to help these farmers with decision making.

1.2 Purpose

The purpose of this research is a financial risk and feasibility analysis of finishing pig production systems in the NL with particular attitude to animal welfare aspects. The research restricts itself to Dutch welfare concepts in the pig sector which are already implemented or are in a further developed stadium.

1.3 Outline of the thesis

The research is constructed according to the following order. First the different animal welfare systems for finishing pigs in the NL are described in Chapter 2. Specific system requirements are inventoried and clear ordered in Tables. A distinction is made between already practical implemented systems and system which are still in development. Chapter 3 is about the used material and methods. To get a good overview and make a right distinction between the different production systems a calculation model is constructed. Explained are the assumptions and inputs. The final results which are generated with the calculation model are analysed, explained and compared in Chapter 4. Finally in Chapter 5 the discussion and conclusions are presented.

2. INVENTORY OF THE DIFFERENT DUTCH ANIMAL WELFARE SYSTEMS FOR FINISHING PIGS

Several different production systems for finishing pigs are developed the last ten years in the NL. These concepts arose mainly from the sector itself instead of required regulations from national or EU governments. A collaboration between market- and societal groups form the basis of this very effective and efficient development (Hopster 2010).

The general target of the innovations is the increase of sustainability in the production process of meat. An important issue in this is the welfare improvement of the animals. This chapter contains an overview and comparison of all different animal welfare systems for finishing pigs that exist at this moment or are in a further developed stadium in the NL (February 2013). The reference in this Case is the conventional system which is the minimum standard for all operating finishing farms.

2.1 Conventional system

The conventional husbandry system for finishing pigs is based on National and European Union legislations. However the Dutch rules go beyond most EU requirements. Two obvious differences are the minimum living surface per animal (EU: 0.65m², NL: 0.8m²) and the application of a full slatted floor (EU: allowed, NL: prohibited). The animal welfare regulations are a minimum, but the legal standards are increasing (Anonymous 2010[E]; Anonymous 2008[B]). The standard animal welfare requirements for a conventional finishing farm in the Netherlands are shown in Table 1.

Table 1: Welfare requirements Conventional system

	Factor	Requirement
1	Min. indoor living space per animal (110 kg)	0.8 m² [(1)]
2	Min. outdoor living space per animal (110 kg)	N.A.
3	Min. solid floor (indoor)	40% [(2)]
4	Max. width opening slatted floor (concrete)	18 mm [(3)]
5	Min. slat width (concrete)	80 mm [(3)]
6	Bedding	Concrete, litter
7	Group size	8-20 (<40)
8	Daylight required	NO
9	Min. artificial light	40 lux, 8 hours a day [(3)]
10	Max. noise level	85 dBA [(3)]
11	Enrichment materials	Metal chain + ball
12	Special scrub opportunity	NO
13	Castration prohibition	NO
14	Tail docking prohibition	NO
15	Stars 'Beter Leven'	N.A.
16	Applied in practice (NL)	YES

[1] Anonymous 2010[E]
[2] Anonymous 1994
[3] Anonymous 2008[B]

2.2 Beter Leven Small Groups system

The ‘Beter Leven kenmerk’ is a three stars system which is developed by the Dutch organisation for animal protection. This system was introduced in 2007 on packaging of Dutch produced meat and eggs. Consumers can distinguish the different products with respect to animal welfare by using a specific logo. The production of one star products is based on conventional farming with the increase of the most important animal welfare aspects (e.g. more living space and more enrichment materials). Figure 1 shows the one star logo and Figure 2 shows a picture of this concept in practice.

Figure 1: Beter Leven kenmerk (www.dierenbescherming.nl)

Figure 2: Finishing pigs 1 star with straw tube (www.boerderij.nl)

After the creation of this label several governmental and advocacy parties signed the ‘Convenant Marktontwikkeling Verduurzaming Dierlijke Producten’ (Tussensegmenten) in 2009. That covenant was the base of collaboration between several companies in the pork chain. A well-known cooperation in this is between the VION Food Group and the Albert Heijn who developed the Good Farming Star concept. Table 2 contains the requirements for the one star Beter Leven concept for husbandry systems with small groups (<40 animals per group).

Table 2: Welfare requirements Beter Leven small groups system

	Factor	Requirement
1	Min. indoor living space per animal (110 kg)	1.0 m^2 [(4)]
2	Min. outdoor living space per animal (110 kg)	N.A.
3	Min. solid floor (indoor)	40% [(2)]
4	Max. width opening slatted floor (concrete)	18 mm [(3)]
5	Min. slat width (concrete)	80 mm [(3)]
6	Bedding	Concrete, litter
7	Group size	8-20 (<40)
8	Daylight required	NO
9	Min. artificial light	40 lux, 8 hours a day [(3)]
10	Max. noise level	85 dBA [(3)]
11	Enrichment materials	Wood, Sturdy rope, Straw [(4)]
12	Special scrub opportunity	YES [(4)]
13	Castration prohibition	YES [(4)]
14	Tail docking prohibition	NO
15	Stars 'Beter Leven'	1 [(4)]
16	Applied in practice (NL)	YES

[2] Anonymous 1994
[3] Anonymous 2008[B]
[4] Anonymous 2013[H]; Anonymous 2010[A]

2.3 Beter Leven Big Groups system

The interest in the big groups system for finishing pigs increased in the NL after the introduction of 'Varkensbesluit 1998' (van den Heuvel et al. 2004). This regulation changed the required minimum living space per animal (85-110 kg) from 0.7m² to 0.8m² (Anonymous 2010[E]). The increase of living space has a negative influence on the production price per animal. The big groups system has several factors that can reduce the cost price and have positive effects on animal welfare:

- Lower investment costs per animal because of savings in internal equipment and more efficient use of space (e.g. less pen separations and less corridors),
- Less required space per animal (10%) if groups are >40 animals,
- New techniques and innovations are better applicable (e.g. cleaning robot, detection/selection opportunities, playing area etc.),
- Relative more movement space per animal. This has a positive effect on the separation between the function areas of the animal (eating, resting-and excretion).
  (Anonymous 1994; van den Heuvel et al. 2004; Baltussen et al. 2010)

Beside these advantages the big group system for finishing pigs is already successful implemented in other countries (e.g. Germany). That fact stimulates Dutch farmers to start with this kind of production system. There are several opportunities in Case of implementation. Group size and the positioning of the living area are flexible. Figure 3 gives a view of a big groups system (300 finishing pigs) which is implemented by several Dutch pig farms (Janssens 2005). Table 3 shows all specific animal welfare factors with respect to the Beter Leven big groups system.

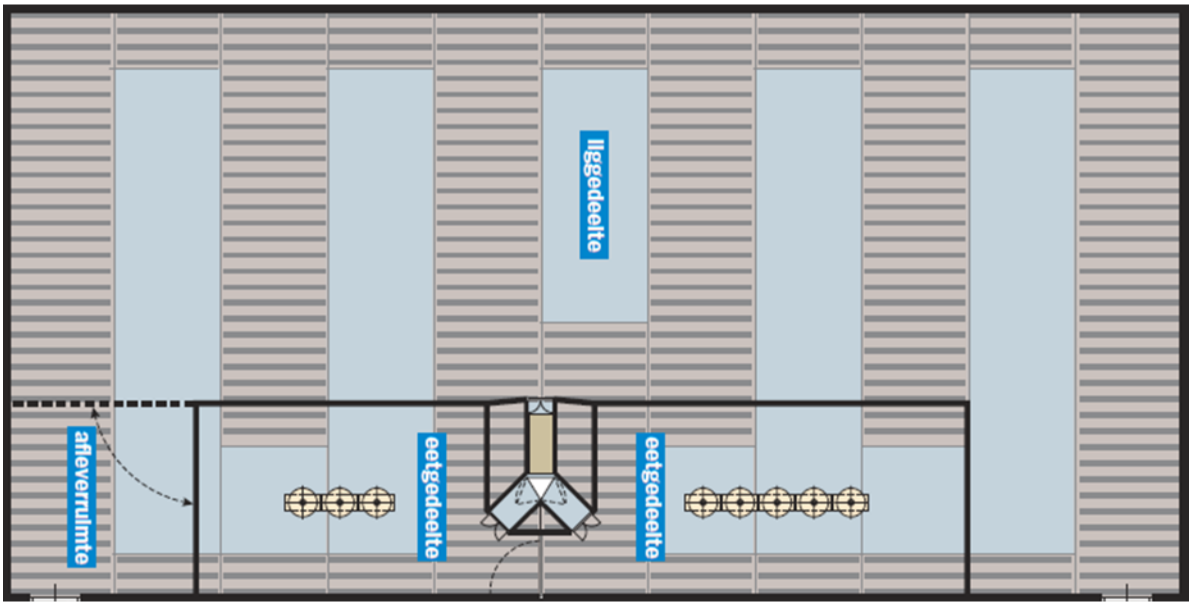


Figure 3: Schematic top view of the big groups system (Agra-Matic Bouw, Milieu, Advies)

Table 3: Welfare requirements Beter Leven big groups system

	Factor	Requirement
1	Min. indoor living space per animal (110 kg)	0.9 m^2 (3)(4)
2	Min. outdoor living space per animal (110 kg)	N.A.
3	Min. solid floor (indoor)	40% (2)
4	Max. width opening slatted floor (concrete)	18 mm (3)
5	Min. slat width (concrete)	80 mm (3)
6	Bedding	Concrete
7	Group size	>40 (3)
8	Daylight required	NO
9	Min. artificial light	40 lux, 8 hours a day (3)
10	Max. noise level	85 dBA (3)
11	Enrichment materials	Wood, Sturdy rope, Straw (4)
12	Special scrub opportunity	YES (4)
13	Castration prohibition	YES (4)
14	Tail docking prohibition	NO
15	Stars 'Beter Leven'	1 (4)
16	Applied in practice (NL)	YES

[2] Anonymous 1994
[3] Anonymous 2008[B]
[4] Anonymous 2013[H]; Anonymous 2010[A]

2.4 Canadian Bedding system

The Canadian Bedding system is also known as the 'Wroetstal' or the 'Krull concept'. This husbandry system is developed in the Vancouver area in western Canada. In that region the lumber industry produces a lot of sawdust what local pig farmers use as a bedding in their pig stables. The sawdust can meet the natural need of the finishing pigs (rooting). Besides, it gives comfort because of the soft bedding. In 2006 JUMBO supermarkets and several Dutch pig farmers introduced the meat from this concept into the market (Elzen et al. 2008). Figure 4 and 5 gives an impression about the practical implication, and Table 4 gives an overview of the animal welfare requirements.

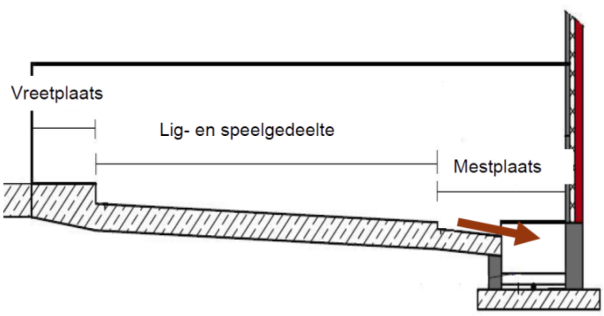


Figure 4: Cross-sectional view Canadian Bedding system (de Buisonjé et al. 2012)

Figure 5: Practical implication Canadian Bedding system (de Buisonjé et al. 2012)

Table 4: Welfare requirements Canadian Bedding system

	Factor	Requirement
1	Min. indoor living space per animal (110 kg)	1.0 m^2 (4)(5)
2	Min. outdoor living space per animal (110 kg)	N.A.
3	Min. solid floor (indoor)	90% (5)
4	Max. width opening slatted floor (concrete)	18 mm (3)
5	Min. slat width (concrete)	80 mm (3)
6	Bedding	Sawdust (5-10 cm) (5)
7	Group size	20-35 (5)
8	Daylight required	YES (5)
9	Min. artificial light	N.A.
10	Max. noise level	85 dBA (3)
11	Enrichment materials	Sawdust (5-10 cm) (5)
12	Special scrub opportunity	YES (4)
13	Castration prohibition	YES (4)
14	Tail docking prohibition	YES (5)
15	Stars 'Beter Leven'	1 (4)(6)
16	Applied in practice (NL)	YES

[3] Anonymous 2008[B]
[4] Anonymous 2013[H]; Anonymous 2010[A]
[5] Anonymous 2013[I]
[6] van Doorn 2011

2.5 Free Range system

The Dutch free range sector for pigs is still very small. For years this production concept was the only system between conventional and organic. However nowadays it is implemented by only 7 farmers in the Netherlands. The system is on many factors comparable with the organic system. Table 5 shows all husbandry requirements with respect to animal welfare.

Table 5: Welfare requirements Free Range system

	Factor	Requirement
1	Min. indoor living space per animal (110 kg)	0.7 m^2 (7)
2	Min. outdoor living space per animal (110 kg)	0.7 m^2 (7)
3	Min. solid floor (indoor)	100% (7)
4	Max. width opening slatted floor (concrete)	18 mm (7)
5	Min. slat width (concrete)	70 mm (7)
6	Bedding	Straw (7)
7	Group size	8-30
8	Daylight required	YES (7)
9	Min. artificial light	N.A.
10	Max. noise level	85 dBA (3)
11	Enrichment materials	Straw (7)
12	Special scrub opportunity	YES (7)
13	Castration prohibition	NO (7)
14	Tail docking prohibition	YES (7)
15	Stars 'Beter Leven'	2 (4)
16	Applied in practice (NL)	YES

[3] Anonymous 2008[B]
[4] Anonymous 2013[H]; Anonymous 2010[A]
[7] Anonymous 2003

2.6 Comfort Class trial

From 2006 until 2009 Wageningen University did research on animal welfare for finishing pigs in the so called Comfort Class trial. The aim of the project was the development of a stable which meets the needs of the animal as much as possible and is still economic viable for the pig farmer. In cooperation with the LEI they carried out an economic analysis which gave insight in extra operational- and investment costs instead of the conventional production system. Important aspects from the comfort class stable that differ from conventional housing are: more living space per animal, daylight entry, natural ventilation, separate micro climate, cooling system (Hoste et al. 2010). Table 6 contains the specific facts that where applied in the Comfort Class stable in Raalte.

Table 6: Welfare requirements Comfort Class stable Raalte

	Factor	Requirement
1	Min. indoor living space per animal (110 kg)	1.2 m^2 [9]
2	Min. outdoor living space per animal (110 kg)	N.A.
3	Min. solid floor (indoor)	75% [9]
4	Max. width opening slatted floor (concrete)	18 mm [3]
5	Min. slat width (concrete)	80 mm [3]
6	Bedding	Concrete, straw [9]
7	Group size	24 [9]
8	Daylight required	YES [9]
9	Min. artificial light	N.A.
10	Max. noise level	85 dBA [3]
11	Enrichment materials	Straw, special rooting device [10]
12	Special scrub opportunity	YES [10]
13	Castration prohibition	YES [10]
14	Tail docking prohibition	YES [10]
15	Stars 'Beter Leven'	N.A.
16	Applied in practice (NL)	NO

[3] Anonymous 2008B
[9] Vermeer et al. 2009
[10] Hoste and Bosma 2009

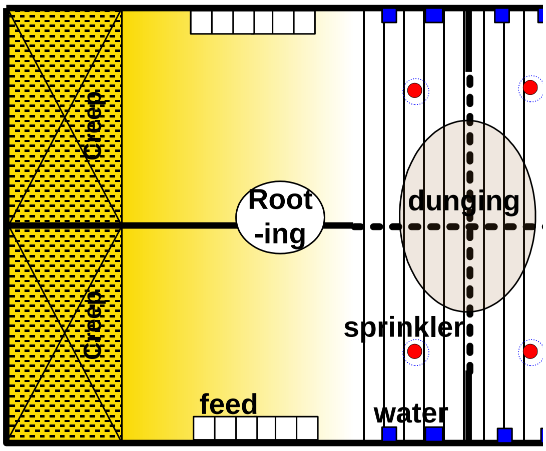


Figure 6: Top view of trial pens Comfort Class Raalte (Vermeer et al. 2009)


Figure 7: Practical implication Comfort Class trial Raalte (Vermeer et al. 2009)

2.7 Starplus trial

Since June 2012 cooperation between several parties started up the Starplus trial at VIC Sterksel. This concept is focussed on the three stars requirements of the Beter Leven kenmerk without the restrictions of the organic husbandry system. Important aspects from the Starplus stable that differ from conventional housing are: extra living space, daylight, natural ventilation, outdoor access and extra enrichment materials (Anonymous 2012[E]). Table 7 shows all animal welfare requirements which are applied in the trial stable at VIC Sterksel. Figure 8 and 9 give a practical impression.

Table 7: Welfare requirements Starplus stable Sterksel

	Factor	Requirement
1	Min. indoor living space per animal (110 kg)	0.9 m^2 (11)
2	Min. outdoor living space per animal (110 kg)	0.3 m^2 (11)
3	Min. solid floor (indoor)	59% (11)
4	Max. width opening slatted floor (concrete)	18 mm (3)
5	Min. slat width (concrete)	80 mm (3)
6	Bedding	Concrete, straw (12)
7	Group size	18 (11)
8	Daylight required	YES (12)
9	Min. artificial light	N.A.
10	Max. noise level	85 dBA
11	Enrichment materials	Straw, roughage (11)
12	Special scrub opportunity	YES (12)
13	Castration prohibition	YES (12)
14	Tail docking prohibition	YES (12)
15	Stars 'Beter Leven'	2 (12)
16	Applied in practice (NL)	NO

[3] Anonymous 2008[B]
[11] Personal contact P. Classens, April 2013
[12] Anonymous 2012[E]


Figure 8: Indoor view Starplus stable (VIC Sterksel)


Figure 9: Outdoor view Starplus stable (VIC Sterksel)

2.8 Organic system

Important issues in organic livestock farming are the mineral cycle, animal welfare and the use of natural raw materials. In Case of animal welfare this system is adapted to all natural needs of the pigs. The animals have more living space, a wide outdoor range and straw for enrichment. All used materials must be produced organic (e.g. feed and roughage) without fertilizers and pesticides. This instead of the free range system (Anonymous 2012[D]).Table 8 shows all welfare requirements for the organic system.

Table 8: Welfare requirements Organic system

	Factor	Requirement
1	Min. indoor living space per animal (110 kg)	1.3 m^2 [(8)]
2	Min. outdoor living space per animal (110 kg)	1.0 m^2 [(8)]
3	Min. solid floor (indoor)	50% [(8]
4	Max. width opening slatted floor (concrete)	18 mm [(3)]
5	Min. slat width (concrete)	80 mm [(3)]
6	Bedding	Straw [(8)]
7	Group size	8-30
8	Daylight required	YES [(8)]
9	Min. artificial light	N.A.
10	Max. noise level	85 dBA [(3)]
11	Enrichment materials	Straw [(8)]
12	Special scrub opportunity	YES [(8)]
13	Castration prohibition	NO [(8)]
14	Tail docking prohibition	YES [(8)]
15	Stars 'Beter Leven'	3 [(4)]
16	Applied in practice (NL)	YES

[3] Anonymous 2008[B]
[4] Anonymous 2013[H]
[8] Anonymous 2012[D]

2.9 Overview

Table 9 presents an overview of all different animal welfare requirements per different production system. The conventional system contains the minimum standards and the organic system meets the highest animal welfare requirements. All other systems belong to the middle-market and have different requirements within this range.

Table 9: Overview of all animal welfare requirements per production system

	Animal welfare factors										Remaining factors	
Name system	Min. indoor living space per animal (110 kg)	Min. outdoor living space per animal (110 kg)	Solid floor (indoor)	Bedding	Group size	Daylight required	Enrichment materials	Special scrub opportunity	Castration prohibition	Tail docking prohibition	Stars 'Beter Leven'	Applied in practice (NL)
1. Conventional	0.8 m^2	N.A.	40%	Concrete, litter	8-20	NO	Metal chain + ball	NO	NO	NO	N.A.	YES
2. BeterLeven small groups	1.0 m^2	N.A.	40%	Concrete, litter	8-20	NO	Wood, sturdy rope, straw	YES	YES	NO	1	YES
3. BeterLeven big groups	0.9 m^2	N.A.	40%	Concrete, litter	>40	NO	Wood, sturdy rope, straw	YES	YES	NO	1	YES
4. Canadian Bedding	1.0 m^2	N.A.	90%	Concrete, sawdust	20-35	YES	Sawdust	YES	YES	YES	1	YES
5. Free Range	0.7 m^2	0.7 m^2	100%	Concrete, straw	8-30	YES	Straw, roughage	YES	NO	YES	2	YES
6. Comfort Class trial	1.2 m^2	N.A.	75%	Concrete, straw	24	YES	Straw, special rooting device	YES	YES	YES	N.A.	NO
7. Starplus trial	0.9 m^2	0.3 m^2	59%	Concrete, straw	18	YES	Straw, roughage	YES	YES	YES	2	NO
8. Organic	1.3 m^2	1.0 m^2	50%	Concrete, straw	8-30	YES	Straw, roughage	YES	NO	YES	3	YES

3. MATERIAL & METHODS

3.1 Measuring mid-term economic feasibility under risk

In this study the term economic feasibility is measured by the cumulative Capital Debt Repayment Margin (in Dutch: financieringsmarge) after 5 years (CDRM-5). This financial indicator measures the amount of money that remains if all operating expenses, taxes, family living costs and debt payments have been paid (Barry and Ellinger 2012). The calculation formula is:

Net farm income (+) Depreciation (+) Non-farm income (-) Family withdrawals (-) Tax expenses (-) Scheduled principal payment

A positive CDRM could be used for new investments or an accelerated repayment. A negative CDRM indicates repayment problems. If repayment problems are not recovered after 5 years the financial situation is bad and we assume the production system is no longer viable. The choice of a 5-year period is judged to be long enough to measure important threats which have a big effect on the continuity of the farm (Gocsik et al. 2013).

The calculation model is repeated 5.000 times using Latin Hypercube sampling in @Risk software environment (Palisade software). With the generated probability density functions (PDF) of the normal distribution (Gaussian/Bell curve) the mean and standard deviation were determined. By generating the cumulative distribution function (CDF) the probability for a positive CDRM-5 was determined.

The possibility for a negative CDRM in a separate period between the 1st en 5thyear is not considered as a problem in a short term. In that Case farmers are assumed to be able to cope with liquidity problems (e.g. by decreasing the level of family withdrawals).

3.2 The stochastic economic simulation model

Stochastic (Monte Carlo) simulation is a technique where a calculation process is repeated several times (iterations) with every time different starting conditions. The result of this collection is a distribution function which reproduces all possible outcomes. Stochastic simulation models do not give exact answers, but provide information on the relative consequences of different options to improve decision making. In this study a stochastic model is used to simulate different input risks with respect to prices and technical performance. Previous research from Gocsik et al. (2013) provided a comparable model which was designed for broilers. This model is adapted and parameterised for finishing pigs.

3.2.1 Technical inputs

In Table 10 the used technical parameters are shown. Most technical inputs are derived from a reliable source. For some parameters it was necessary to do own calculations (e.g. occupation rate and labour intensity).

Production uncertainty, caused by variation in technical results, is processed in the model by defining a probability distribution for the key technical parameters mortality, daily growth and feed conversion ratio. In order to determine the standard deviation (SD) of all production systems the dataset *Bedrijfsvergelijking 2012 from Agrovision BV* is used to estimate the SD for Dutch farmers with a conventional system. With that SD an average coefficient of variation[1] (CV) is calculated and used to calculate the SD of the other production systems.

Table 10: Average technical parameters

Variable	Unit	Conventional	BeterLeven small groups	BeterLeven big groups	Canadian Bedding	Free Range	Comfort Class	Starplus	Organic
Mortality	MEAN (%)	2.4 [1]	2.1 [3]	2.5 [10]	2.1 [3]	3.5 [10]	2.1 [10]	2.3 [8]	4.5 [9]
	SD (%)	0.001 [10]	0.001 [10]	0.001 [10]	0.001 [10]	0.001 [10]	0.001 [10]	0.001 [10]	0.01 [10]
	CV (%)	0.031 [11]	0.031 [11]	0.031 [11]	0.031 [11]	0.031 [11]	0.031 [11]	0.031 [11]	0.031[11]
Daily growth	MEAN (g)	795 [1]	825 [3+5]	750 [4]	825 [3+5]	750 [10]	824 [7]	895 [8]	733 [9]
	SD (g)	5.378 [10]	5.580 [10]	5.073 [10]	5.580 [10]	5.073 [10]	5.574 [10]	6.054 [10]	4.958 [10]
	CV (g)	0.007 [11]	0.007 [11]	0.007 [11]	0.007 [11]	0.007 [11]	0.007 [11]	0.007 [11]	0.007 [11]
Feed conversion ratio	MEAN (kg)	2.58 [1]	2.53 [3]	2.70 [4]	2.53 [3]	2.90 [6]	2.53 [10]	2.60 [8]	3.05 [9]
	SD (kg)	0.034 [10]	0.033 [10]	0.035 [10]	0.033 [10]	0.038 [10]	0.033 [10]	0.034 [10]	0.040 [10]
	CV (kg)	0.013 [11]	0.013 [11]	0.013 [11]	0.013 [11]	0.013 [11]	0.013 [11]	0.013 [11]	0.013 [11]
Feed intake	kg/day	2.05 [10]	2.09 [10]	2.03 [10]	2.09 [10]	2.18 [10]	2.08 [10]	2.33 [10]	2.24 [10]
Occupation rate	%	93.4 [1]	93.6 [10]	90.5 [10]	93.6 [10]	92.8 [10]	93.6 [10]	93.5 [10]	92.3 [10]
Clean/dry period	days	3 [11]	3 [11]	3 [11]	3 [11]	3 [11]	3 [11]	3 [11]	3 [11]
Circulation	#	3.05 [10]	3.16 [10]	2.88 [10]	3.16 [10]	2.88 [10]	3.15 [10]	3.42 [10]	2.81 [10]
Produced manure	ton/APFP	1 [2]	1 [2]	1 [2]	1.15 [11]	1.15 [11]	1.1 [11]	1.15 [11]	1.15 [11]
Used straw/sawdust	gr/animal/day	0 [11]	15 [11]	15 [11]	400 [11]	400 [11]	225 [11]	350 [8]	400 [11]
Needed labour	hrs/1.000 APFP/year	598 [2]	639 [10]	562 [10]	774 [10]	1138 [10]	838 [10]	1112 [10]	1256 [10]
Hours/FLE	#	2349 [2]	2349 [2]	2349 [2]	2349 [2]	2349 [2]	2349 [2]	2349 [2]	2349 [2]
Start weight piglet	kg	25 [2]	25 [2]	25 [2]	25 [2]	25 [2]	25 [2]	25 [2]	25 [2]
Finishing weight	kg	117.9 [2]	117.9 [2]	117.9 [2]	117.9 [2]	117.9 [2]	117.9 [2]	117.9 [2]	117.9 [2]
Carcass weight	kg	92.4 [2]	92.4 [2]	92.4 [2]	92.4 [2]	92.4 [2]	92.4 [2]	92.4 [2]	92.4 [2]

[1] Anonymous 2012[A]
[2] Vermeij et al. 2012
[3] Anonymous 2011[A]
[4] Van den Heuvel et al. 2004; Personal contact Dutch pig farmers
[5] Vermeij et al. 2002
[6] Oenema et al. 2010
[7] Vermeer et al. 2009
[8] Starplus trial VIC Sterksel 2013
[9] Hoste 2009
[10] Own calculation
[11] Own estimation based on Bedrijfsvergelijking 2012 Agrovision BV

The average piglet start weight is equal between the concepts. This is caused by lack of data and because price premium per kg is very difficult to estimate. Finishing live weight and carcass weight are assumed to be the same across production systems due to lack of data. This assumption can be supported by the fact that delivery specifications are the same regardless the production system.

<u>Mortality, daily growth, feed</u>

These inputs are defined as stochastic variables because fluctuations in these variables can considerably affect the financial results of the farm. However these variables do not change independently of each other e.g. a low growth results in a higher feed conversion (Anonymous 2010[D]). Table 11 shows the correlation coefficients generated with SPSS software.

[1] CV = standard deviation/mean

Table 11: Spearman's rank correlation coefficients between tech. parameters (p-values in brackets)

	Spearman's rank correlation coefficient		
Variable	Mortality	Daily growth	Feed conversion
Mortality	1		
Daily growth	-0.577 (0.003)	1	
Feed conversion	0.239 (0.250)	-0.383 (0.059)	1

The correlation coefficients shown above are calculated with data sources input from Bedrijfsvergelijking Agrovision 2008, 2009, 2010, 2011 and 2012. Data were only available for conventional farms. The same correlation parameters are assumed for the other production systems. In Case of the feed consumption and purchase the next assumptions are determined:

- All calculations are based on full concentrates (dry feed). Liquid feed, by products and on farm produced feed are not observed.
- Feed conversion is based on kilograms. In some Cases the relation between kilograms and energy value was needed to get a representative value. In that Case the next energy values are used:
  - Starting feed: 1.17 EW per kg (20%),
  - Grow feed: 1.13 EW per kg (15%),
  - End feed: 1.08 EW per kg (65%),
  - Average: 1.10 EW per kg.
- The feed is delivered weekly. Hence, 52 times a year the feed supplier refills the feed stock.

<u>Genetics</u>
At this moment no indications are found to make a distinction between different genetics use in the different production systems. Topigs the Netherlands has a market share from about 85%. The sold semen in 2012 for this organisation was; Top Pie/Piétrain (50%), Tempo/Large White (37%) and Talent/Duroc (13%) (Anonymous 2013[m]). A normal distribution compared to these Topigs sales is assumed in this research.

<u>Occupation rate</u>
The occupation rate (or stocking density) depends on the mortality rate and the delivery strategy. Because of variation in growth and delivering requirements (weight discounts) a department cannot be totally emptied at once. Assumed is that 25% of the fast growing pigs are delivered first. Two weeks later the remaining 75% of the pigs will be delivered. The big groups system will have a different strategy because the selection possibilities can make the delivering smoother. The assumed delivering scheme is: 10%, 20%, 30%, and 40%.

<u>Produced manure</u>
The amount of produced manure is different per system because of the added straw/enrichment materials.

<u>Labour</u>
Labour activities that have a major impact on labour intensity are: control of outdoor access, extra cleaning activities and the provision of straw/enrichment materials. The total required labour per production system is estimated based on KWIN Veehouderij 2012-2013. The total size of the simulated farms is adapted to 1 full time labour equivalent (2349 hours/year).

3.2.2 Price inputs

The main cost drivers on pig finishing farms are feed costs and the purchase price of 25kg piglets (about 80% of the total costs). Besides, the revenues are mainly determined by the producer/meat/carcass price (Anonymous 2011[E]; Anonymous 2013[G]). A high volatility in the cost drivers and revenues causes high fluctuations in net farm income of pig farms (Zijlstra 2008).

An important assumption is that future price developments between piglets, feed and meat arise not independently from each other. Correlations are based on historical price data and calculated with SPSS software. Principles in this calculation are:

- Used inputs: average annual prices from 1993 to 2011, except the years 1997, 1998, 1999 (Anonymous 2013[E]),
- Used correlation coefficient: Spearman's rank,
- All prices were corrected for inflation by dividing the time series by the annual consumer price index (CBS 2012).

The years of 1997, 1998 and 1999 are excluded because in that period extreme prices fluctuation occurred caused by the epidemic of classical swine fever. The calculation results are shown in Table 12 below.

Table 12: Spearman's rank correlation coefficients between prices (p-values in brackets)

	Spearman's rank correlation coefficient		
Variable	Meat price	Feed price	Piglet price
Meat price	1		
Feed price	0.793 (0.000)	1	
Piglet price	0.079 (0.781)	0.586 (0.022)	1

To estimate representative prices for feed, piglets and meat over the 5-year planning horizon a geometric random walk (GRW) model is used. This model is used because most economic time series follow a stochastic trend. For simulation of the future prices next formula is used (Gocsik et al. 2013).

$$P_t = P_0 \cdot e^{(\mu - 1/2\sigma^2)} \cdot t + \sigma\sqrt{t} - \epsilon_t$$

- P_t = price in year t
- P_0 = average historical price based on year 2007 to 2011 (Anonymous 2013[E])
- $\mu = 0$
- σ = standard deviation based on historical price developments from 1993 to 2011, except 1997, 1998, 1999 (Anonymous 2013[E])
- t = time period depending on the year to calculate (1 to 5)
- ϵ_t = a multivariate normal random variable

Due to lack of data it was only possible to calculate average prices and standard deviations on historical data for the Dutch conventional production system. These averages are used as a basis for the other systems and corrected with a premium dependent on the individual production factors. Table 13 gives an overview of all determined P_0 prices and standard deviations.

Table 13: Parameters for stochastic prices

Variable	Unit	Conventional	BeterLeven small groups	BeterLeven big groups	Canadian Bedding	Free Range	Comfort Class	Starplus	Organic
Meat price (P_0)	€/kg carcass	1.27 [1]	1.35 [2]	1.35 [2]	1.35 [3]	1.51 [4]	1.44 [6]	1.44 [6]	2.54 [6]
Compared to conv.	%	100%	107%	107%	107%	119%	113%	113%	200%
SD	-	0.12 [1]	0.12 [1]	0.12 [1]	0.12 [1]	0.12 [1]	0.12 [1]	0.12 [1]	0.06 [6]
Piglet price (P_0)	€/# (25 kg)	34.4 [1]	35.4 [2]	35.4 [2]	35.4 [2]	41.5 [4]	34.4 [6]	34.4 [6]	86.0 [6]
Compared to conv.	%	100%	103%	103%	103%	121%	100%	100%	250%
SD	-	0.19 [1]	0.19 [1]	0.19 [1]	0.19 [1]	0.19 [1]	0.19 [1]	0.19 [1]	0.26 [6]
Feed price (P_0)	€/100 kg	22.9 [1]	22.9 [1]	22.9 [1]	22.9 [1]	22.9 [1]	22.9 [1]	22.9 [1]	36.7 [5]
Compared to conv.	%	100%	100%	100%	100%	100%	100%	100%	160%
SD	-	0.13 [1]	0.13 [1]	0.13 [1]	0.13 [1]	0.13 [1]	0.13 [1]	0.13 [1]	0.26 [6]

[1] Anonymous 2013[E]
[2] Spreeuwenberg and Quinten 2013
[3] Krekels 2013
[4] Anonymous 2013[J]
[5] Hoste 2010[A]; Krajenbrink 2013
[6] Own estimation

For most systems reliable sources are found to estimate the P0 prices. In Case of the meat price for Comfort Class and Starplus assumptions were necessary because no practical information was available.

<u>Meat/Piglets price</u>
Price premium for the Beter Leven- and the Canadian Bedding systems is estimated at €0.08 per kg carcass weight. Price for the Free Range system is estimated based on the average 'CVS scharrelvarkens' price from the past 5 years. Price premium for the Comfort Class and Starplus systems is estimated at €0.17 per kg carcass weight. This estimation is based on the fact that both systems have a total minimum indoor animal surface of 1.2 m^2 per animal. This surface is located just between the Beter Leven system (1.0 m^2) and the Free Range system (1.4 m^2) in. Because of that we assumed that the price premium is between the premiums of these systems (€1.35 - €1.44 - €1.51) too.

In practice the organic meat price is determined based on cost price. A controlling organisation compares meat and feed prices and protects farmers from big price changes. The meat price is arranged only 2-4 times a year. Because of these reasons the volatility of the meat price is lower in Case of the organic system (Gerbers 2013). The standard deviation of the organic piglets is equal to the SD of organic feed because the cost price is mainly determined by feed costs.

Potential quantity discount/premium with respect to purchase and sale of animals is not taken into account. It is assumed that any increase in piglet price is fully compensated by a higher selling price (due to bigger purchase/sale amounts and stocking density of trucks).

<u>Feed price</u>
The feed prices shown in Table 13 are standard prices. The real purchase price is calculated per production system separately because discounts are taken into account. This is because bigger farms have weekly orders with full loaded trucks and have a higher yearly purchase amounts in relation to the other production systems. Appendix 7.3 contains an overview of the used discount rates.

In Case of organic produced feed the choice of raw materials is more limited than in conventional feed production. Besides, the organic raw material market (especially grain) is smaller (Europe) compared to the global conventional raw material market. All these factors increase the volatility and price level of organic pig feed.

3.2.3 Variable inputs

As determined in the paragraph price inputs, the cost drivers in pig finishing are the stochastically determined purchase costs of feed and piglets. The other variable costs have a minor impact on the total cost price. Therefore the other variable costs are deterministic. Table 14 shows an overview of all deterministic estimated variable costs.

Table 14: Overview of variable costs

Variable costs	Unit	Conventional	BeterLeven small groups	BeterLeven big groups	Canadian Bedding	Free Range	Comfort Class	Starplus	Organic
Quality discount carcass	€/kg carcass weight	0.02 [4]	0.02 [4]	0.01 [4]	0.02 [4]	0.02 [4]	0.02 [4]	0.02 [4]	0.02 [4]
Health care	€/delivered animal	1 [1]	1 [5]	1.05 [5]	1 [5]	1.36 [5]	1 [5]	1.18 [5]	1.72 [5]
Electricity	€/delivered animal	1.1 [1]	1.32 [5]	1.21 [5]	1.32 [5]	0.28 [5]	0.28 [5]	0.28 [5]	0.28 [5]
Heating	€/delivered animal	0.7 [1]	0.84 [5]	0.77 [5]	0.84 [5]	0.35 [5]	0.35 [5]	0.35 [5]	0.35 [5]
Water	€/delivered animal	0.5 [1]	0.55 [5]	0.5 [5]	0.55 [5]	0.55 [5]	0.55 [5]	0.55 [5]	0.55 [5]
Overhead	€/delivered animal	0.5 [1]	0.5 [5]	0.5 [5]	0.5 [5]	1.8 [5]	0.5 [5]	0.5 [5]	3.1 [6]
Manure disposal	€/ton	15 [1]	15 [1]	15 [1]	10 [5]	10 [5]	12.5 [5]	10 [5]	5 [5]
Transport	€/year	7644 [2]	7644 [2]	7644 [2]	7644 [2]	7644 [2]	7644 [2]	7644 [2]	7644 [2]
Labour farmer	€/hour	22.5 [1]	22.5 [1]	22.5 [1]	22.5 [1]	22.5 [1]	22.5 [1]	22.5 [1]	22.5 [1]
Hired labour	€/hour	19.4 [1]	19.4 [1]	19.4 [1]	19.4 [1]	19.4 [1]	19.4 [1]	19.4 [1]	19.4 [1]
Straw/sawdust/roughage	€/kg	0.15 [5]	0.15 [5]	0.15 [5]	0.15 [5]	0.15 [5]	0.15 [5]	0.15 [5]	0.15 [5]
Lease production quota	€/APFP	8 [3]	8 [3]	8 [3]	8 [3]	8 [3]	8 [3]	8 [3]	8 [3]

[1] Vermeij et al. 2012
[2] Anonymous 2013[G]
[3] Anonymous 2013[K]
[4] Own calculation
[5] Own estimation
[6] Hoste 2009

<u>Quality discount carcass</u>

The standard price per kg carcass is corrected with a discount in Case of meat quality (weight, meat percentage, fat/muscle thickness, rejected carcass parts and organs). Assumptions in Case of meat quality are:

- 60% of the delivered carcasses are of high quality and meet all quality requirements. For these pigs the farmer receives the standard price per kg.
- 40% of the delivered carcasses do not meet one or more quality requirements. For this pigs the farmer receives an average quality discount of €0,05.
- The big group system has a lower quality discount because there are more individual selection possibilities in feed supply to the animals and delivery of slaughter pigs (Pijnenburg and Bens 2007).

<u>Health care</u>

With regard to health care cost it was difficult to find reliable data sources. Because of that the KWIN information for the conventional system is used as a basis. Health care costs of the other systems are estimated based on the conventional system. The following assumptions were made:

- Reduction of animal contacts results in fewer lung disorders and a lower use of drugs (van der Peet-Schwering et al. 2008). In the big groups system many animals from different litters are mixed with each other. This will increase the risk of infections and the use of drugs.

- Systems with outdoor access have a less constant climate for the animals. This causes a higher susceptibility for infections (van Dooren et al. 2006).

Electricity
Differences in electricity costs arise because some production systems use a natural ventilation system. A mechanical ventilation system is assumed to use 75% of the total electricity use (Anonymous 2011[D]).

Heating
Heating depends on stocking density. In addition also the provision of straw/enrichment materials in combination with natural ventilation has influence on the way of heating.

Water
Assumptions for the use of water are:
- Used for drinking water: 85%,
- Used for cleaning/overhead: 15%,
- Feed-Water ratio: 1:2 (for every kg feed intake a pig drinks 2 litr water).

Overhead
Examples of overhead costs are: accountant, assurance, telephone, car etc. (Vermeij et al. 2012).

Manure disposal
The price for manure disposal depends on the composition of manure (dry matter, phosphate value), season when it is deposited and the region where it is produced. Because some production systems use much straw/enrichment materials the dry matter content of the manure increases. This has a positive influence on the disposal price (Vermeij et al. 2012).

Transport
Every week mature pigs will be transported to the slaughter. The calculated costs for this are: 52 weeks * 2.5 hours * €58.80 per hour = €7.644 (Anonymous 2013[G])

3.2.4 Investments and fixed costs

Investment prices per m² for new buildings are presented in Table 15. To get the total investments these prices are multiplied with the net stable surface per production system.

Table 15: Overview of investments

Investments	Unit	Conventional	BeterLeven small groups	BeterLeven big groups	Canadian Bedding	Free Range	Comfort Class	Starplus	Organic
Rough construction	€/m²	250 (1)	250 (1)	230 (3)	200 (3)	180 (3)	220 (3)	210 (3)	230 (3)
Inventory	€/m²	120 (1)	123 (1)(2)	123 (1)(2)	140 (3)	110 (3)	135 (3)	110 (3)	110 (3)
Air scrubber	€/m²	20 (1)	20 (1)	20 (1)	20 (1)	-	-	-	-
Total stable	€/m²	390	393	373	360	290	355	320	340
Outdoor access	€/m²	-	-	-	-	100 (3)	-	100 (3)	100 (3)
Land	€/m²	-	-	-	-	4.8 (4)	-	4.8 (4)	4.8 (4)

[1] De Groot 2013
[2] Spreeuwenberg 2013
[3] Own calculation
[4] Anonymous 2012[B]

Differences in investment of the basic construction are affected by:

- Air inlet system. The assumed air inlet system for the conventional and Beter Leven small group system is indirect (inlet through ceiling or ground channels). The other systems use a direct air inlet system with inlet through valves in the wall what gives cost advantages.
- The surface (m²) of the manure cellar. Building a cellar instead of no cellar reduces the use of reinforced concrete and labour.

Differences in investments in inventory are affected by:

- Extra playing materials/scrub opportunities,
- Application of a manure slider,
- Application of mechanical/natural ventilation,
- Use of a micro climate area (creep) inside the stable.

The outdoor access will be constructed by a concrete slatted floor with a full cellar and a rail.

Depreciation, interest- and maintenance are calculated as fixed costs. Table 16 gives an overview of the used cost rates. No differences are assumed between the production systems.

Table 16: Overview of fixed costs

Fixed costs	Unit	Value
Depreciation buildings	%	4
Depreciation inventory	%	8
Depreciation air scrubber	%	10
Calculated interest land	%	2.5
Calculated interest invested capital	%	5
Calculated interest livestock	%	6
Maintenance buildings	%	1
Maintenance inventory	%	2
Maintenance outdoor access	%	1

3.2.5 Interest rates

Interest rates on loans are determined as fixed for the 5-years' time horizon. For estimation of the short-term loan interest rate the average 3-months Euribor 2007-2012 is used as a basis (2.15%). For estimation of the long-term loan interest rate the average of 10-years Dutch government bond yield 2007-2012 is used (3.35%). These rates are both increased by a risk premium of 0.2%.

3.2.6 Remaining income and expenses

A yearly fixed non-farm income of €21.860 is assumed. This is a calculated average from the period 2002-2011. The money can be received by salary of the partner and other premiums/benefits (Anonymous 2013[E]). Annual withdrawals for family living are assumed fixed and estimated at €20.670 per year (Vermeij et al. 2012).

3.2.7 Income tax

The way of tax payment for Dutch companies is dependent of the juridical business form. Almost 90% of the Dutch pig farms are juridical organised as a natural person in a partnership or sole proprietorship (Anonymous 2013[A]). This kind of companies has to pay income tax. For calculating the total tax payments we have to make some assumptions:

- Farm operates as sole proprietorship with a farmer (45-years old) working on the farm (1 FLE)
- Farmer's partner works outside the farm and his/her income is taxed separately.

To get insight in the Dutch tax regulation most important and applicable rules are explained shortly below.

- *Deduction arrangements to reduce the taxable income:*
    - Small scale investments; investments between a value of €2.300 and €306.931 can deduct a percentage of this investment from the net farm income (Vermeij et al. 2012).
    - Self-employed tax allowance; self-employed persons can deduct €7.280 from the net farm income (Vermeij et al. 2012).
    - Loss transfer; a farm can carry over losses/profits to reduce the fiscal profit in any of the three preceding years (Gocsik et al. 2013).

- *Deduction arrangements to reduce tax payments:*
    - Labour tax credit; depends on level of income and age, but cannot exceed €1.611.
    - General tax credit; if the farmer have not exceeded the age of 65 he can deduct €2.033.

If all applicable arrangements are deducted the actual tax payments can be calculated. Depending on the amount of taxable income a tax rate is determined. Appendix 7.2 contains the specific numbers and percentages.

3.2.8 Sustainability tax arrangements

In order to support or promote sustainability in the Dutch agriculture the government has introduced several tax reducing arrangements for investments. Most important available regulations for pig finishing farms are:

- MIA; Milieu Investerings Aftrek (Eng: Environmental Investment Deduction)
- VAMIL; Vervroegde Afschrijving Milieu Investeringen (Eng: Accelerated Depreciation of Environmental Investments)

If farmers want to use an above mentioned arrangement the new investment has to comply with the certification 'Maatlat Duurzame Veehouderij' (MDV). This certification has several requirements depending on farm size. The larger the size of the farm, the stricter the requirements. The requirements are divided into the following sub categories: ammonia emission, animal welfare, animal health, energy, refined dust and landscape (College van deskundigen MDVA).

Applying MIA regulation it is possible to depreciate 27% extra on the investment. In practice this means that the book value on the begin balance is 27% higher than the real invested value. The VAMIL arrangement allows depreciation until 25% of the present business value. Normally the residual value is restricted to 50% of the present business value (bodemwaarde). Besides, it is not required to depreciate according to a predetermined schedule. The VAMIL gives the opportunity to depreciate a flexible amount on an arbitrarily moment (Anonymous 2013[D]; Pijnenburg 2013).

To get insight in the scores of the 8 different production systems Appendix 7.4 contains an example calculation. In this calculation all system principles are observed. However several criteria are in common for a standard pig finishing farm, are not described in the system requirements or are too farm specific. Therefore several general operating devices on a modern pig finishing farm are assumed. Notable differences in scores which could give problems in obtaining an MDV certificate are:

- The animal welfare score of the conventional system. To get enough points on this item it is necessary to invest more in animal welfare than required for this system.
- The ammonia score of the systems with natural ventilation.

If conventional farmers in practice are willing to investment extra in animal welfare almost all pig finishing stables can get an MDV certificate. Examples of valuable extra investments are: daylight access, scrub opportunities, more solid floor and better/more enrichment materials (Pijnenburg 2013).

3.3 Analysis approach

Actual there are two different situations to compare the different production systems on economic feasibility. In Case 1 the focus is on a completely new building system and in Case 2 the focus is on the situation when a farm switches from a conventional to another production system. Besides, three different scenarios are simulated to generate more insight in the differences between the systems. Like mentioned before the main performance indicator in this research is the CDRM-5 which is expressed in a cumulative distribution function. The simulated CDFs are judged on the following factors:

1. The probability of a positive CDRM-5. The lower the CDF-line intersects the vertical probability line the higher the probability of a positive CDRM-5.
2. Ranking of highest CDRM-5 at 50% probability. The CDF which has the highest CDRM-5 at 50% probability is preferred above the others.
3. Progress/risk variation of the whole CDF-line. The bigger the slope of the CDF-line, the lower the risk variation.

Besides, some other output calculations can be used for analysing the performance of the production systems:

- Net return to labour and management: Revenues (-) Variable costs (-) Fixed costs.
- Net farm income: Net return to labour and management (+) Own labour (+) Reward on equity (calculated interest – paid interest).

3.3.1 Case 1: New building farms

This Case contains a baseline for a farm with 1 FLE available labour. This means a conventional farm with 4,200 pig finishing places (Vermeij et al. 2012). The number of animal places for the other production systems is adapted dependent on labour intensity. In Case of the capital situation, the debt-to-equity ratio at the beginning of the first year is assumed to be 70%-30%. Long term debt is financed by a mortgage. The principal loan payments are calculated assuming an annuity loan over a 20-year period.

3.3.2 Case 2: Transition farms

The starting situation in this Case is a conventional pig finishing farm with 4,200 animal places. The intention is to continue with conventional production or to switch to another system with higher animal welfare criteria. The farm was built 15 years ago and was started with 70% debt and 30% equity capital. The debt-to-equity ratio at the beginning of the 16th year is changed to 60%-40%. Renovation and rebuild of the inventory is needed to comply with other animal welfare requirements of the production system. It is assumed that there will be no expansion of stable surface. All changes will occur inside the stable, except potential outdoor access. Required investments were financed by an annuity loan with an interest rate of 3.55%. The repayment period is adapted on the size of the loan:

- 5 years in Case of Investments between €15.000 and €50.000,
- 10 years in Case of Investments between €50.000 and €150.000,
- 20 years in Case of investments above €150.000.

3.3.3 Scenario analysis

Research by Gocsik et al. (2013) shows that the meat price has the biggest influence on the CDRM in conventional broiler production. At various points broiler production is comparable with the production of finishing pigs. Income in both sectors mainly depends on technical results, producer- and feed prices (Zijlstra 2008; Anonymous 2013[L]). Because of that we considered 4 different scenarios with different price premiums and risk for the meat price:

1. Default situation (100% price premium),
2. No price premium, default volatility,
3. 50% price premium, default volatility,
4. 50% price premium, high volatility.

With this overview it is easier to compare the different production systems in Case of price premium dependency and meat price risk.

3.3.4 Sensitivity analysis

In Case of the stochastic determined prices and technical inputs it is interesting to know how each variable influences the CDRM. Because of that a sensitivity analysis is conducted to assess the revenue/cost key drivers and differences between the different production systems. For this calculation the @Risk multivariate stepwise regression is used. Table 17 represents the results. The beta coefficients refer to the number of standard deviations the CDRM-1 will change, given a one SD change in the input while all other variables held constant (e.g. if the SD of the meat price increases with 1 the SD of CDRM-1 of the conventional system increases with 1.02).

Table 17: Sensitivity analysis on CDRM-1

	Beta coefficients							
Stochastic variables	Conventional	BeterLeven small groups	BeterLeven big groups	Canadian Bedding	Free Range	Comfort Class	Starplus	Organic
Case 1 new building farms								
Meat price	1.02	1.05	1.01	1.04	1.02	1.07	1.09	0.34
Feed price	-0.52	-0.49	-0.50	-0.49	-0.50	-0.46	-0.49	-0.66
Piglet price	-0.49	-0.49	-0.48	-0.48	-0.49	-0.46	-0.47	-0.55
Feed conversion ratio	-0.04	-0.05	-0.04	-0.05	-0.05	-0.05	-0.04	-0.04
Grow/animal/day	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.00
Mortality rate	-0.01	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.00
Case 2 transition farms								
Meat price	1.02	1.04	1.03	1.05	0.99	1.09	1.08	0.31
Feed price	-0.52	-0.49	-0.50	-0.50	-0.47	-0.48	-0.49	-0.63
Piglet price	-0.50	-0.48	-0.49	-0.48	-0.51	-0.45	-0.45	-0.56
Feed conversion ratio	-0.05	-0.05	-0.04	-0.05	-0.05	-0.05	-0.04	-0.04
Grow/animal/day	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.00
Mortality rate	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00

The sensitivity analysis confirms that the meat price has the biggest influence on the CDRM. This holds for all production systems except the organic system. Here the feed price is the variable with the highest influence on the CDRM. This finding seems reasonable, since the organic feed price is much higher than conventional feed price. The sensitivity of feed- and piglet price is on a similar level in Case of the conventional and most middle-market systems. In Case of the technical inputs the feed conversion has the highest sensitivity. In both Cases the prices have much more influence on the CDRM in relation to the technical parameters. This all implies that the economic feasibility is rather affected by external factors than factors that are under farmer's control.

4. RESULTS

4.1 Default situation

The assumption in the default situation is that a farmer receives a higher price if the applied production system guarantees more animal welfare. The higher price is a certain price premium above the conventional determined price.

4.1.1 Case 1: New building farms

Most important results from the 1st production year for all different production systems are shown in Table 18 on the next page.

Validation of the calculated outputs is important to guarantee actual and representative results. An important and widely used financial indicator in the Dutch pig sector is *feed profit* (also presented in Table 18). This calculation measures the operational performance. In Case of finishing pigs the calculation formula for feed profit is: revenues (-) purchase costs piglets (-) feed costs. The generated feed profit per APFP from the conventional production system in the 1st year is €87. Regression results from ABN AMRO estimates an average feed profit in 2013 from €87 as well (Hilkens 2008). The graph in Appendix 7.5 confirms this.

The CDRM-5 per production system is presented in Figure 10. The vertical axis shows the probability range and the horizontal axis represents the value of the cumulative CDRM-5 in euro.

The production systems Starplus and Comfort Class generate the highest economic feasibility with a probability of more than 90%. The second group with the highest feasibilities are the Beter Leven small groups- and Beter Leven big groups system with a probability of 75%-80%. Thirdly the Free Range-, Canadian Bedding- and Conventional system form a middle group with 64%-67% probability. The Organic system has the lowest chance (52%) to generate a positive cumulative CDRM-5. This indicates still a need of a financial buffer at the end of the 5th year. The variation in probability between the different systems is affected by several factors:

- The Starplus and Comfort Class systems are not introduced in practice. Therefore some assumptions had to be made in Case of meat price. Besides, it is assumed that these concepts are only applied into the finishing part of the production stage. Because of that the supplying sow farms will not be charged with extra costs caused by animal welfare requirements. So these farms use conventional piglets.
- The low economic feasibility in the organic system is strongly affected by a more volatile and higher price level of feed compared to the other systems.

At 50% probability Comfort Class exceeds the other systems with a cumulative CDRM-5 of €400.000. Starplus is equalized to the Beter Leven small groups system. The risk variation is lowest for the Free Range and Starplus system. The other systems have all a higher risk variation because the slope of the CDF-lines is smoother.

Table 18: Summary of outputs 1st year Case 1

	Conventional		BeterLeven small groups		BeterLeven big groups		Canadian Bedding		Free Range		Comfort Class trial		Starplus trial		Organic system	
RESULTS 1ST YEAR	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Animal places #	4200		3925		4620		3240		2220		2995		2255		2025	
Average present fattening pigs #	3924		3674		4183		3033		2061		2803		2108		1869	
Delivered animals per year #	11951	83	11599	80	12035	84	9575	66	5930	41	8840	61	7205	47	5259	37
Labour per production unit (hours/animal)	0.197		0.203		0.195		0.245		0.396		0.266		0.326		0.447	
Revenue per delivered fattening pig	€ 115	€ 14	€ 122	€ 15	€ 123	€ 15	€ 122	€ 15	€ 138	€ 17	€ 131	€ 16	€ 131	€ 16	€ 232	€ 14
Total revenues	€ 1,375,285	€ 172,696	€ 1,420,482	€ 178,020	€ 1,484,989	€ 184,812	€ 1,172,599	€ 147,093	€ 818,467	€ 102,518	€ 1,155,857	€ 145,007	€ 942,055	€ 118,046	€ 1,220,094	€ 76,189
Variable costs per delivered fattening pig (without feed)	€ 49	€ 7	€ 50	€ 7	€ 51	€ 7	€ 56	€ 7	€ 66	€ 8	€ 51	€ 7	€ 52	€ 7	€ 116	€ 24
Total variable costs (without feed)	€ 586,543	€ 81,661	€ 583,355	€ 81,034	€ 616,375	€ 84,874	€ 535,788	€ 66,878	€ 389,447	€ 49,497	€ 452,221	€ 60,033	€ 375,265	€ 48,979	€ 608,140	€ 127,855
Feed costs per delivered fattening pig	€ 52	€ 7	€ 51	€ 7	€ 54	€ 7	€ 51	€ 7	€ 59	€ 8	€ 51	€ 7	€ 53	€ 7	€ 101	€ 27
Total feed costs	€ 621,239	€ 84,478	€ 591,250	€ 80,427	€ 653,667	€ 89,176	€ 489,192	€ 66,437	€ 349,335	€ 47,137	€ 451,677	€ 61,328	€ 379,189	€ 51,357	€ 531,743	€ 141,887
Feed profit per APFP	*€ 87*	*€ 40*	*€ 114*	*€ 44*	*€ 97*	*€ 40*	*€ 114*	*€ 44*	*€ 108*	*€ 46*	*€ 143*	*€ 46*	*€ 149*	*€ 50*	*€ 126*	*€ 108*
Fixed costs per delivered fattening pig	€ 21		€ 25		€ 22		€ 25		€ 25		€ 26		€ 22		€ 40	
Total fixed costs	€ 252,548		€ 286,141		€ 264,885		€ 237,089		€ 149,037		€ 229,511		€ 161,356		€ 212,170	
Net return to labour and management	*€ -85,045*	*€ 160,884*	*€ -40,265*	*€ 165,095*	*€ -49,937*	*€ 170,941*	*€ -89,469*	*€ 136,517*	*€ -69,352*	*€ 96,698*	*€ 22,447*	*€ 131,575*	*€ 26,245*	*€ 106,172*	*€ -131,958*	*€ 212,538*
Net farm income	*€ 20,505*	*€ 160,133*	*€ 71,823*	*€ 164,425*	*€ 58,903*	*€ 170,132*	*€ 9,627*	*€ 135,965*	*€ 9,680*	*€ 96,234*	*€ 119,915*	*€ 131,134*	*€ 107,407*	*€ 105,837*	*€ -34,542*	*€ 210,092*
Depreciation	€ 93,795		€ 109,713		€ 100,388		€ 88,794		€ 46,984		€ 81,977		€ 51,707		€ 75,905	
Tax expense	€ 2,137		€ 23,426		€ 17,456		€ -		€ -		€ 47,881		€ 41,390		€ -	
Principal payments	€ 41,686		€ 48,596		€ 43,808		€ 37,115		€ 19,233		€ 36,549		€ 22,202		€ 32,745	
CDRM at the end of the 1st year	*€ 42,573*	*€ 122,922*	*€ 87,427*	*€ 115,286*	*€ 72,966*	*€ 122,221*	*€ 38,871*	*€ 105,829*	*€ 22,854*	*€ 76,239*	*€ 109,305*	*€ 80,506*	*€ 89,624*	*€ 64,556*	*€ -17,202*	*€ 180,769*
Cumulative CDRM at the end of the 5th year	*€ 151,337*	*€ 469,861*	*€ 358,900*	*€ 465,706*	*€ 287,780*	*€ 476,799*	*€ 141,733*	*€ 413,498*	*€ 78,171*	*€ 289,305*	*€ 477,196*	*€ 330,865*	*€ 379,703*	*€ 258,779*	*€ -130,079*	*€ 736,285*
Probability of positive CDRM at the end of the 5th year	66.8%		79.7%		74.9%		66.6%		64.3%		91.9%		92.1%		52.4%	

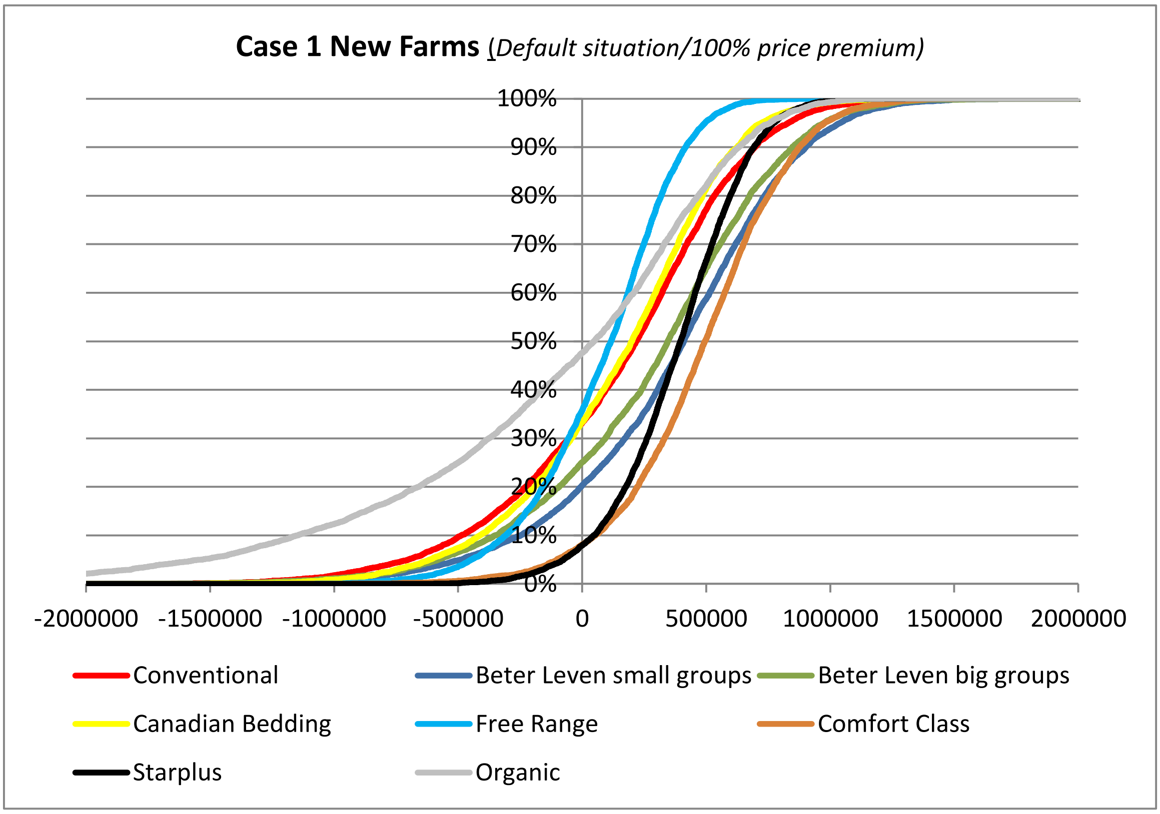


Figure 10: Simulated distribution functions of CDRM-5 Case 1 in the default situation

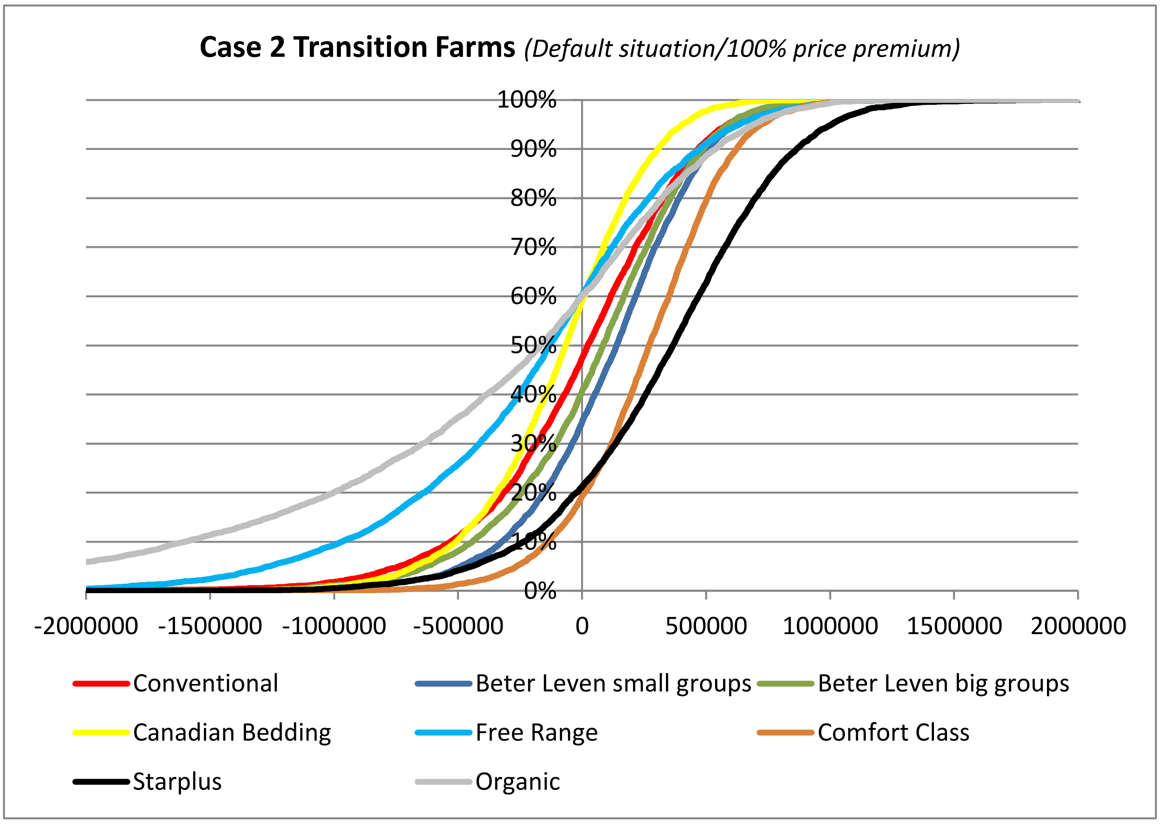


Figure 11: Simulated distribution functions of CDRM-5 Case 2 in the default situation

4.1.2 Case 2: Transition farms

After 15 year operational activities we consider a farm situation with different financial and production assumptions than in Case of new farms. After 1 year production (16th year) in the new situation the results shown in Table 19 are simulated.

If the farm converts to a new production system most systems (excluding the Free Range system) can keep fewer animals than before due to lower stocking density requirements. This has direct influence on the total farm revenues. The ranking of economic feasibility between the different production systems does not explicitly change. The Comfort Class and Starplus system are still on top of the list with respectively 81% and 79% probability of a positive cumulative CDRM-20. The organic system has still the lowest economic feasibility with 40% probability. At 50% probability Starplus exceeds Comfort Class. That is exactly the opposite of the situation in Case 1.

Some remarkable differences if we compare the 16th and 1st year results are;

- Net return to labour/management and net farm income is increased because the level of fixed costs decreases. The building is partly and the starting inventory is totally economic depreciated. Depreciation on new invested inventory and outdoor access occur but do not exceed the depreciation value of the starting investments.
- Tax expenses increase a lot because net farm income is increased. Besides, the taxable depreciation on the building is zero in the 16th production year because of the 'bodemwaarde' (Eng: bottom value) regulation. Only the new investments in inventory can be taxable depreciated.
- The CDRM after the 16th year is lower than after the 1st year in Case of all production systems. This is mainly caused by lower depreciations, higher tax expenses and higher principal payments.
- The cumulative CDRM after the 20th year is lower than after the 5th year in Case of all production systems. This is mainly caused by lower depreciations, higher tax expenses and higher principal payments. Figure 11 confirms this because all CDF's shift to the left in Case 2 compared to Case 1.

The decreasing CDRM-1 and CDRM-5 in Case 2 compared to Case 1 indicates a reduction in payment capacity. However this does not necessarily directly lead to problems. As described the debt-to-equity ratio is decreased in Case 2. This means that retained earnings in previous years were added to the own equity. If the own equity had grown slower (less than 10%) more retained earnings could be used for the repayment of creditors.

Table 19: Summary of outputs 16th year Case 2

	Conventional		BeterLeven small groups		BeterLeven big groups		Canadian Bedding		Free Range		Comfort Class trial		Starplus trial		Organic system	
RESULTS 16TH YEAR	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Animal places #	4200		3296		3969		2987		4629		3074		4023		2693	
Average present fattening pigs #	3924		3085		3593		2796		4298		2877		3762		2486	
Delivered animals per year #	11951	83	9739	68	10338	72	8826	61	12366	86	9073	63	12856	85	6994	49
Revenue per delivered fattening pig	€ 115	€ 14	€ 122	€ 15	€ 123	€ 15	€ 122	€ 15	€ 138	€ 17	€ 131	€ 16	€ 131	€ 16	€ 232	€ 14
Total revenues	€ 1,375,265	€ 172,510	€ 1,192,696	€ 149,661	€ 1,275,600	€ 158,836	€ 1,080,915	€ 135,463	€ 1,706,720	€ 214,218	€ 1,186,263	€ 148,662	€ 1,680,831	€ 210,666	€ 1,622,501	€ 101,218
Var. costs per delivered fattening pig (without feed)	€ 49	€ 7	€ 50	€ 7	€ 51	€ 7	€ 56	€ 7	€ 69	€ 8	€ 51	€ 7	€ 54	€ 7	€ 117	€ 24
Total variable costs (without feed)	€ 586,540	€ 81,604	€ 491,051	€ 68,023	€ 530,541	€ 72,862	€ 494,496	€ 61,645	€ 852,366	€ 103,210	€ 465,119	€ 61,644	€ 699,040	€ 87,377	€ 820,908	€ 170,139
Feed costs per delivered fattening pig	€ 52	€ 7	€ 51	€ 7	€ 54	€ 7	€ 51	€ 7	€ 58	€ 8	€ 51	€ 7	€ 52	€ 7	€ 101	€ 27
Total feed costs	€ 621,242	€ 84,506	€ 497,586	€ 67,608	€ 562,396	€ 76,628	€ 450,956	€ 61,262	€ 720,871	€ 98,411	€ 463,558	€ 62,935	€ 671,903	€ 91,670	€ 704,235	€ 188,768
Feed profit per APFP	*€ 87*	*€ 41*	*€ 114*	*€ 44*	*€ 97*	*€ 40*	*€ 114*	*€ 45*	*€ 110*	*€ 46*	*€ 143*	*€ 46*	*€ 151*	*€ 50*	*€ 127*	*€ 108*
Fixed costs per delivered fattening pig	€ 12		€ 15		€ 17		€ 18		€ 16		€ 17		€ 14		€ 25	
Total fixed costs	€ 139,206		€ 141,485		€ 171,771		€ 158,745		€ 191,678		€ 152,232		€ 180,991		€ 175,576	
Net return to labour and management	*€ 28,277*	*€ 162,790*	*€ 62,574*	*€ 138,752*	*€ 10,892*	*€ 146,265*	*€ -23,282*	*€ 126,113*	*€ -58,194*	*€ 202,768*	*€ 105,354*	*€ 134,295*	*€ 128,897*	*€ 190,584*	*€ -78,218*	*€ 282,907*
Net farm income	*€ 103,513*	*€ 161,984*	*€ 136,388*	*€ 138,162*	*€ 91,868*	*€ 145,539*	*€ 53,112*	*€ 125,574*	*€ 33,896*	*€ 201,742*	*€ 180,297*	*€ 133,821*	*€ 214,114*	*€ 189,946*	*€ 13,466*	*€ 279,456*
Depreciation	€ 43,420		€ 44,636		€ 60,788		€ 53,841		€ 66,858		€ 50,367		€ 62,613		€ 64,612	
Tax expense	€ 62,814		€ 79,447		€ 56,529		€ 36,089		€ 26,747		€ 101,863		€ 119,633		€ 36,099	
Principal payments	€ 60,318		€ 62,017		€ 64,901		€ 66,965		€ 70,266		€ 64,749		€ 67,919		€ 69,025	
CDRM at the end of the 16th year	*€ 14,823*	*€ 99,547*	*€ 36,492*	*€ 77,714*	*€ 23,273*	*€ 89,518*	*€ -6,012*	*€ 80,942*	*€ -23,670*	*€ 142,530*	*€ 63,301*	*€ 69,728*	*€ 85,738*	*€ 103,222*	*€ -55,217*	*€ 218,892*
Cumulative CDRM at the end of the 20th year	*€ -8,621*	*€ 413,570*	*€ 109,105*	*€ 335,597*	*€ 47,636*	*€ 371,808*	*€ -91,560*	*€ 331,918*	*€ -195,760*	*€ 555,400*	*€ 256,787*	*€ 313,333*	*€ 332,890*	*€ 443,858*	*€ -384,774*	*€ 921,252*
Probability of positive CDRM at the end of the 20th year	52.3%		66.0%		58.7%		41.9%		39.1%		81.4%		79.2%		39.7%	

4.2 Scenario analysis

In this chapter we compare the different production systems related to the meat price. Meat price and SD for the conventional system were assumed to be the same in all situations. This means that also the probability of a positive CDRM-5/CDRM-20 for the conventional system (67%-52%) remains the same in all scenarios.

4.2.1 Scenario 1: No price premium, default volatility

In this scenario a situation without extra price premium for animal welfare is simulated. This means that all systems earn the same meat price as the conventional system. Figure 12 shows that the CDFs of all alternative production systems in Case 1 shift to the left. Compared to the default situation the ranking is totally changed. In this situation the conventional system is most economic feasible in both Cases followed by the Beter Leven small groups system. Thirdly the group Comfort Class, Beter Leven big groups and Starplus have similar results. The Canadian Bedding system has just as in the default situation the thirdly last position. The Free Range- and Organic system has the lowest chance with a zero or close to zero probability of a positive CDRM-5. Hence, compensation for producing under high animal welfare standards is very important in Case of alternative production systems. The more the systems deviate from the conventional system, the more they have a need for price compensation. The Starplus CDF-line has the strongest slope. This indicates a lower risk variation. The other systems have a comparable slope relative to each other.

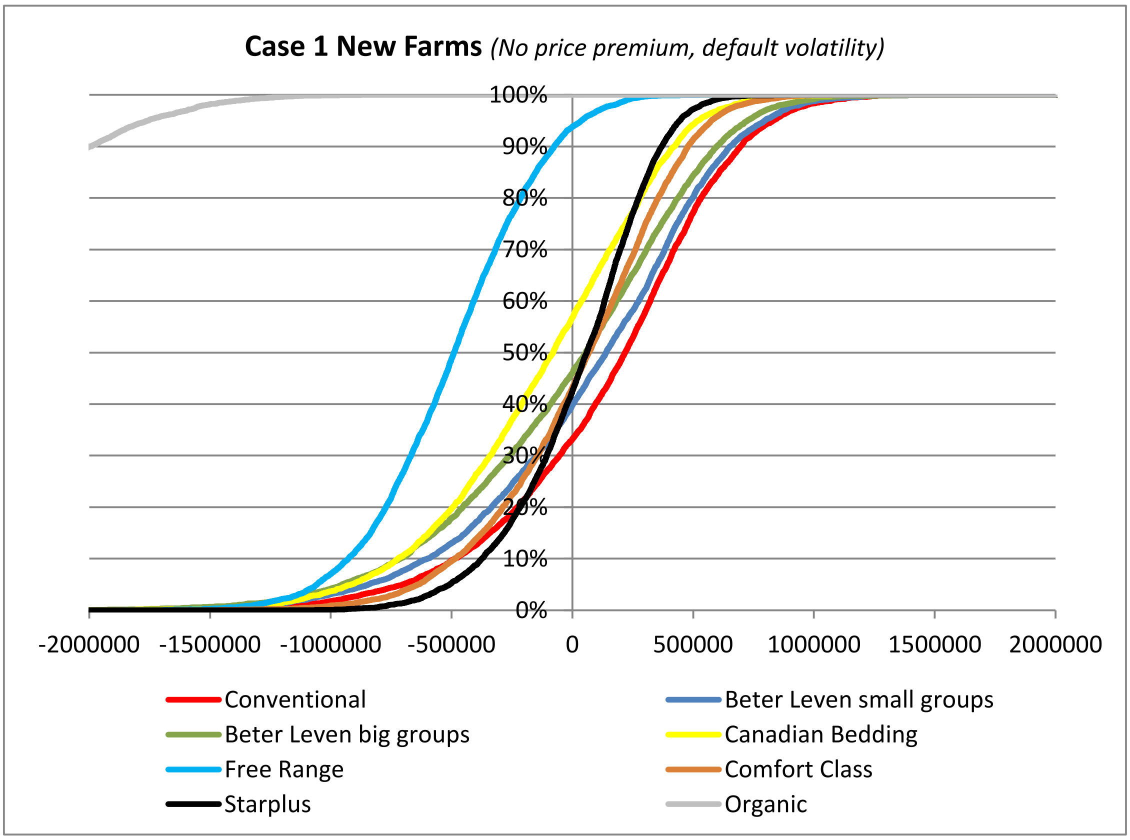


Figure 12: Simulated distribution functions of CDRM-5 Case 1 in scenario 1

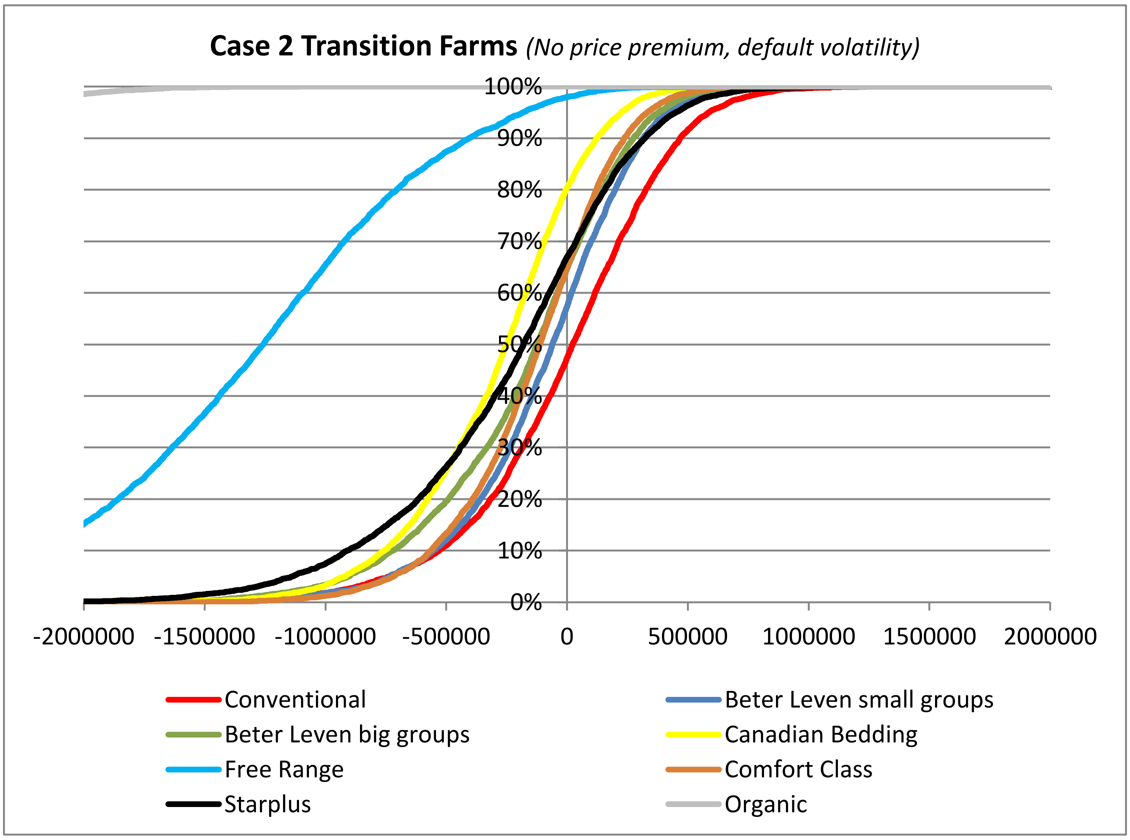


Figure 13: Simulated distribution functions of CDRM-5 Case 2 in scenario 1

Figure 13 presents the scenario 1 simulation from the transition farms. Remarkable is that all lines shift to the left side of the conventional system. Conventional has the highest probability on a positive CDRM-5 and the only positive CDRM-5 at 50% probability.

4.2.2 Scenario 2: 50% price premium, default volatility

In this research price premiums were estimated. There is uncertainty around these estimated premiums. Therefore, we simulated also a scenario assuming less price premium. In Figure 14 the CDFs seems to be very similar to the default situation. Starplus and the Comfort Class system are leading in Case of the highest CDRM-5. These are followed in succession by Beter Leven small groups-, Conventional-, Beter Leven big groups-, Canadian Bedding-, Free Range- and the Organic system. The slope of the Starplus CDF is still the biggest.

In Figure 15 the ranking stays almost the same compared to the default situation. The differences between the systems become smaller and the CDFs come closer to each other. Free Range and Organic still have the lowest economic feasibility.

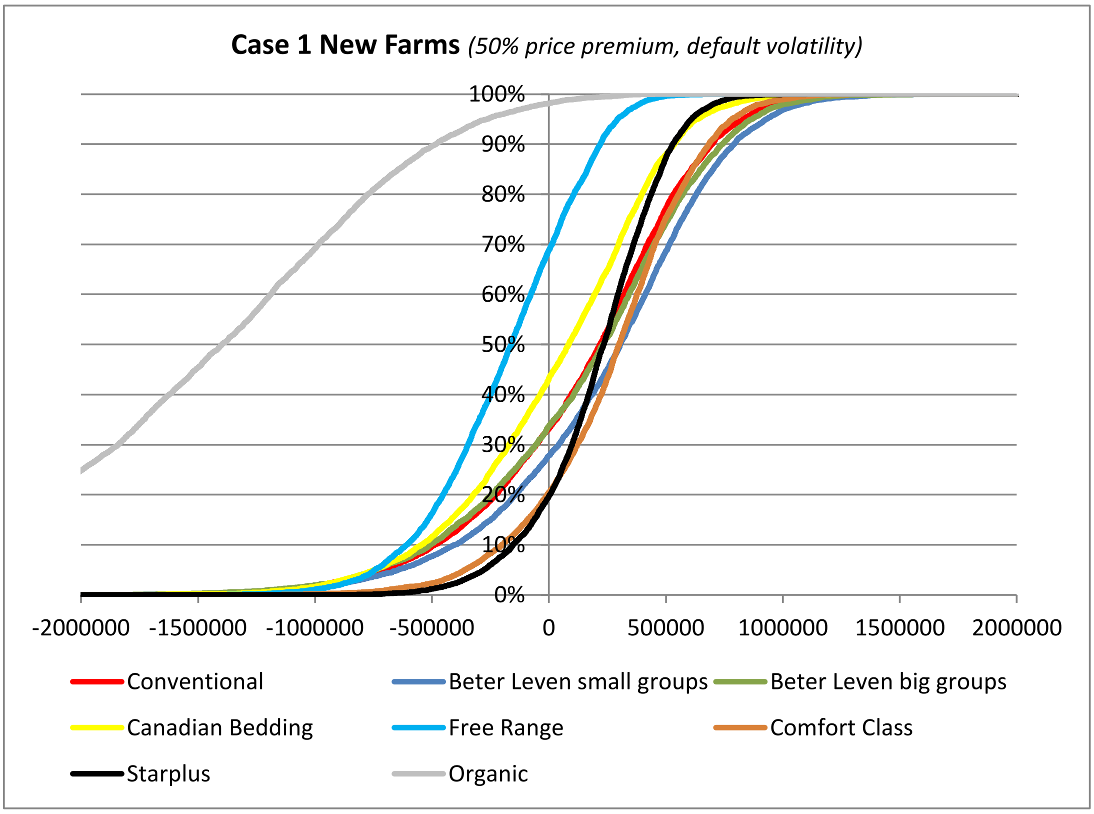


Figure 14: Simulated distribution functions of CDRM-5 Case 1 in scenario 2

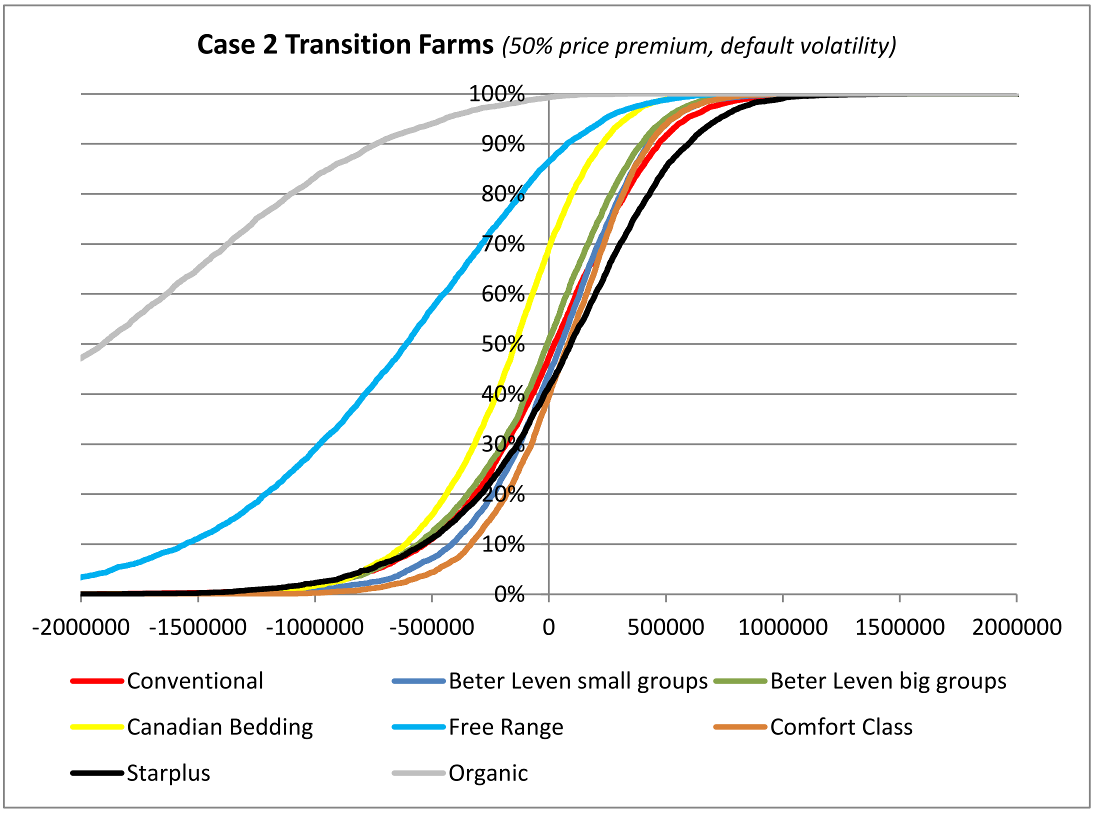


Figure 15: Simulated distribution functions of CDRM-5 Case 2 in scenario 2

4.2.3 Scenario 3: 50% price premium, high volatility

Scenario 3 is constructed to illustrate the impact of higher volatility. The standard deviation from the meat price is twice as much the SD in the default situation. For the conventional system the SD stays the same as in the default situation because there is no risk of a lower price premium. In Figure 16 the conventional system generates the highest probability for a positive cumulative CDRM-5. In Case 1 the Conventional-, Free Range- and Starplus system have the lowest risk variation. In Figure 17 all CDF-lines become very smooth which indicates an increase of the risk variation in Case 2. The Conventional system has with excellence the highest economic feasibility.

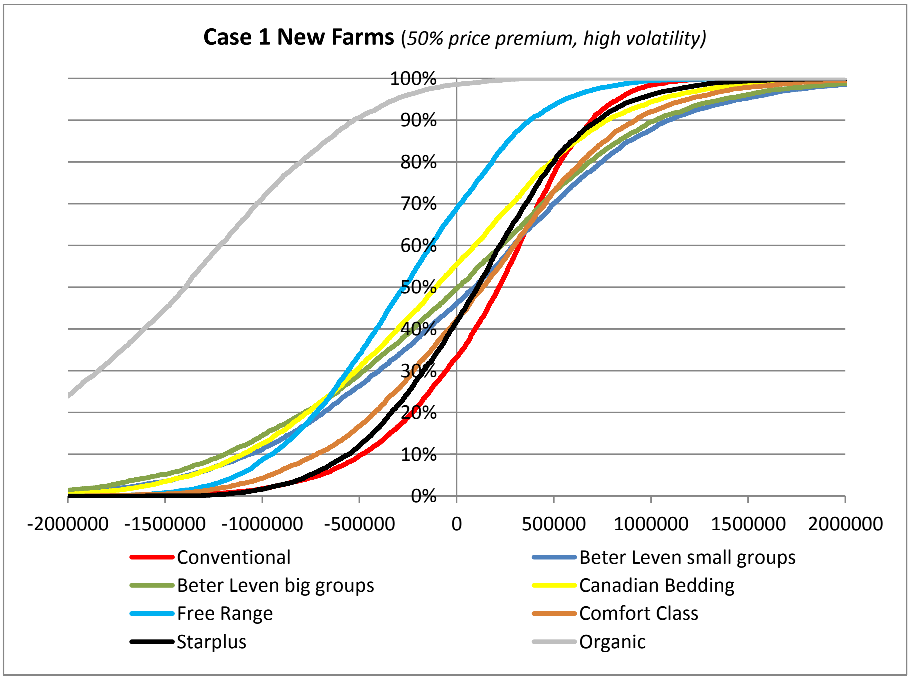


Figure 16: Simulated distribution functions of CDRM-5 Case 1 in scenario 3

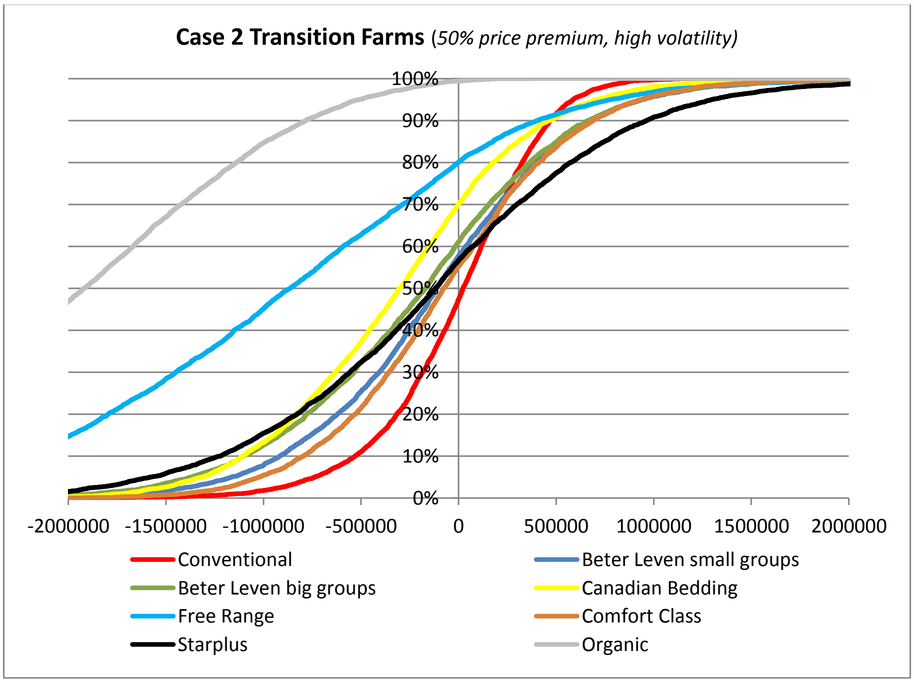


Figure 17: Simulated distribution functions of CDRM-5 Case 2 in scenario 3

5. DISCUSSION AND CONCLUSIONS

5.1 Discussion

The aim of this research was a financial risk and feasibility analysis of finishing pig production systems in the NL with particular attitude to animal welfare aspects. By using Microsoft Excel @Risk a stochastic simulation model is developed and applied for different production systems. Two different farm situations were considered: new building farms (Case 1) and farms with the opportunity to change the conventional production system into a new system with increased animal welfare aspects (Case 2). Assumed was that farmers received a certain price premium dependent on the level of animal welfare. To assess risk a scenario- and a feasibility analysis were simulated. The key performance indicator in the model was the cumulative Capital Debt Repayment Margin after 5 years. Compared to other research this is pretty unique because most agricultural economic studies focus itself on farm income (e.g. Baltussen et al. 2010) or cost price (e.g. Hoste 2010[B]).

5.1.1 Feasibility of production systems

The general picture with respect to economic feasibility that emerged was:

1. **Conventional system**
   This system contains the minimum standards with respect to animal welfare and is used as baseline. Most important parameter in this system is meat price. Output from the CDRM-5/20 in default situation is €151,337 (Case 1) and €-8,621 (Case 2) with a positive outcome probability of respectively 67% and 52%.

2. **Middle-market systems implemented**
   - <u>Beter Leven small groups:</u>
     Most important parameter is the price premium. Output from the CDRM-5/20 in default situation is €358,900 (Case 1) and 109,105 (Case 2) with a positive outcome probability of respectively 80% and 66%.
   - <u>Beter Leven big groups:</u>
     Most important parameter is the price premium. Output from the CDRM-5/20 in default situation is €287,780 (Case 1) and €47,636 (Case 2) with a positive outcome probability of respectively 75% and 59%.
   - <u>Canadian Bedding:</u>
     Most important parameter is the price premium. Output from the CDRM-5/20 in default situation is €141,733 (Case 1) and €47,636 (Case 2) with a positive outcome probability of respectively 67% and 42%.
   - <u>Free Range:</u>
     Most important parameter is the price premium. Output from the CDRM-5/20 in default situation is €78,171 (Case 1) and €-195,760 (Case 2) with a positive outcome probability of respectively 64% and 39%.

3. **Middle-market systems in development**
   - <u>Comfort Class trial:</u>
     Most important parameter is the price premium. Output from the CDRM-5/20 in default situation is €477,196 (Case 1) and €256,787 (Case 2) with a positive outcome probability of respectively 92% and 81%.
   - <u>Starplus trial:</u>
     Most important parameter is the price premium. Output from the CDRM-5/20 in default situation is €379,703 (Case 1) and €332,890 (Case 2) with a positive outcome probability of respectively 92% and 79%.

4. **Organic system:**
   The organic system meets the highest animal welfare aspects. Most important parameter (in contrast with the other systems) is the feed price. Output from the CDRM-5/20 in default situation is €-130,079 (Case 1) and €-384,774 (Case 2) with a positive outcome probability of respectively 52% and 40%.

The Starplus- and Comfort Class system simulates the highest probability for a positive cumulative CDRM-5 in the default situation for both Cases. These systems succeed to combine a lower stocking density with efficient technical results. However, high meat price dependency makes these systems vulnerable for fluctuations. Besides, the fact that these systems are not introduced in practice represents a barrier for potential farmers who want to start with such farm system. The Beter Leven small groups system has the highest economic feasibility in Case of already implemented systems and is less dependent of meat price compared to Starplus and Comfort Class. Good technical results in combination with an appropriate meat price premium give a full compensation to higher fixed costs per unit. The scenario analysis shows that this system is a good alternative system. Even if the price premium will decrease to 50%, the Beter Leven small groups system creates more financial buffer than the conventional system. The Beter Leven big groups system generates the fourth highest probability for a positive cumulative CDRM-5. The bottleneck in this system seems to be the technical results. Especially daily growth and feed conversion are difficult to optimise. The CDRM-5 of the Canadian Bedding system is comparable with the conventional system. The price premium and good technical results are exceeded by high required bedding- and fixed costs. The Free Range and Organic production system generate the lowest economic feasibility in both Cases. Decreasing technical results and increased fixed costs are not compensated by the price premium.

5.1.2 Feasibility determining factors

Besides a comparison based on default assumptions, also some analyses have been carried out on the factors that can influence the economic feasibility. The main findings in this respect are described below:

- As discussed already in 5.1.1., the *price premium* has a big impact on the feasibility. Some differences were assumed regarding the relation between animal welfare and price premium. The Canadian Bedding system has higher animal welfare aspects in relation to the Beter Leven systems, but receives the same price premium. In Case of Starplus and Comfort Class it is assumed that price premium increases linear when stocking density decreases. This direct relation is not proven in practice. It is difficult to determine the price premium of animal welfare that customers want to pay. Research from Burrell and

Vrieze (2003) shows that there exist no significant relation between consumer's price importance and the importance attached to animal welfare.

- *Technical performance*. The baseline for all production systems are average technical results. When a farmer is capable to operate above average the comparison, ranking and analysis will change.
- *Degree of specialisation* can have an impact. This study only referred to fully specialised finishing farms. However, in some production systems the chain is less dispersed which means that the farrowing, growing and finishing part of the production consist in a closed unit. Especially in the organic farm system the production of 25kg piglets is extremely expensive which pushes the piglet price to a higher level.
- *Tax payments* are an important issue in the calculation of the CDRM after 15 years. Sustainability tax arrangements (e.g. Mia/Vamill) can reduce the taxable income and indirectly create a positive influence on the CDRM.
- *The system of amortising loans* has a big effect on the CDRM after 15 years. Using an annuity loan creates an upward trend in the amount of principal payments. This gives a negative influence on the CDRM after 15 years.
- Transition to another production system is not always obvious because *other factors* have influence. An important issue is market accessibility. Supply and demand from niche markets are limited and not all farms are appropriate to switch their production system.

5.1.3 Choice making aspects

As can be seen there is quite some variance with regard to the returns, and hence economic feasibility. Therefore, risk and risk behaviour is important when it comes to decision making. Besides, the rather objective aspects described above, also more subjective (farmer related) aspects play a role in the actual decision making. For instance, research from Meuwissen et al. (2000) presents that Dutch pig farmers rank especially *production risks* as very important.

The choice of a farmer to start or switch to another production system with more animal welfare is dependent of different factors. First of all a farmer must have the purpose to improve the welfare status of the pigs. Job satisfaction and the moral of the farmer are important issues in this. Secondly the farm operations must generate enough financial income and risks must be minimised. Depending on the commitment to animal welfare and amount of risk the entrepreneur will make a choice which production system fits best to him and his farm:

- Risk averse farmers can best hold on the conventional system or choose for the Beter Leven small groups system. The conventional system is not dependent of any extra price premium. The Beter Leven small groups system is similar to the conventional system. It is pretty easy to switch back to the conventional system by increasing the stocking density. In case of all other systems it is difficult and expensive to convert back to the conventional system.

- Farmers who are more risk taking entrepreneurs can choose for any other system dependent on personal preferences and specific farm factors:
    - Starplus and Comfort Class combine high animal welfare improvements with the ability to produce efficient. However, these systems are not introduced in practice which gives much uncertainty about customer market and price setting.
    - The Beter Leven big groups system is a capital efficient system with high improved animal welfare. However, the technical results give a negative pressure on efficient production and economic results.

    - The Canadian Bedding system contains too much animal welfare in relation to the price premium and the other middle market systems.
    - Capital intensive specialised pig finishing farms are not economic viable in case of the Free Range- and Organic production system. These systems only can remain economic alive without repayment problems when: the average piglet price/fluctuation is reduced (e.g. by produce own piglets) and/or feed price/fluctuation is reduced (e.g. by producing own feed) and/or fixed costs are reduced (e.g. by using high depreciated buildings).

5.2 Conclusions

- Mid-term economic feasibility of Dutch animal welfare systems for finishing pigs is particularly determined by the price premium.
- Other factors that have influence are:
    - Technical performance,
    - Degree of specialisation,
    - Payable tax amount,
    - System of amortizing loans,
- This study suggests that risk averse farmers might prefer the conventional and Beter Leven small groups system whereas less risk averse farmers prefer another system dependent on personal preferences.

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7. APPENDIX

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7.2 Overview taxable income and tax rates

Schijf	Belastbaar inkomen	Percentage
1	t/m €18.945	33.1
2	Vanaf €18.946 t/m €33.863	41.95
3	Vanaf €33.864 t/m €56.491	42
4	Vanaf €56.492 en hoger	52

7.3 Overview feed price discounts

Cluster/truck loading discount (source: Agrifirm Feed 2013)

Weight (ton)	Discount/premium (€/100 kg)	
2+3	€	1.60
4+5	€	0.60
6+7	€	0.20
8-11	€	-
12-15	€	-0.20
16-23	€	-0.30
24-31	€	-0.40
32	€	-0.50

Yearly purchase discount (source: Agrifirm Feed 2013)

Yearly purchase (ton)	Discount (€/100 kg)
until 50	€ 0.00
75	€ -0.10
100	€ -0.20
125	€ -0.25
150	€ -0.30
200	€ -0.35
300	€ -0.40
500	€ -0.45
750	€ -0.50
1000	€ -0.55
1500	€ -0.60
2000	€ -0.65
2500	€ -0.70
3000	€ -0.75
4000	€ -0.80
5000	€ -0.85

7.4 Overview Maatlat Duurzame Veehouderij

Minimum points certification MDV dependent on farm size

Fattening pigs	Minimum points per farm size		
Categories	<= 350 Nge	>350<=700 Nge	>700 Nge
Min. ammonia points	14	14	14
Min. animal welfare points	22	26	29
Min. animal health points	17	20	21
Min. energy points	10	10	10
Min. refined dust points	10	10	10
Min. landscape points	29	29	29
Free area points	9	9	9
Total	**111**	**118**	**122**

Certification score MDV per production system.

	Conventional	BeterLeven small groups	BeterLeven big groups	Canadian Bedding	Free Range	Comfort Class trial	Starplus trial	Organic system
Animal places	4200	3925	4620	3240	2220	2995	2250	2025
NGE per animal place	0.0437							
Total NGE	184							
Ammonia	**73**	**62**	**62**	**62**	**0**	**0**	**0**	**0**
Air scrubber	73	62	62	62	0	0	0	0
Animal welfare	**13**	**25**	**21**	**39**	**46**	**46**	**42**	**53**
Netto pen surface per animal	0	6	3	6	13	10	10	17
Group size	0	0	3	1	0	1	1	0
Outdoor access	0	0	0	0	0	0	0	3
Solid floor surface per animal	0	4	0	13	12	12	12	10
Lying area	2	2	2	5	5	5	5	5
Enrichment materials	2	2	2	4	4	4	4	4
Drinking water registration	2	2	2	2	2	2	2	2
Feeding system	0	0	0	0	0	0	0	0
Type of slatted floor	5	5	5	1	3	5	1	5
Stable volume	2	2	2	2	2	2	2	2
Day light access	0	0	0	3	3	3	3	3
Scrub opportunities	0	2	2	2	2	2	2	2
Animal health	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**
Cleaning place vehicles	3	3	3	3	3	3	3	3
Courtyard hardening	2	2	2	2	2	2	2	2
Hygiene room	9	9	9	9	9	9	9	9
Pest control plan	2	2	2	2	2	2	2	2
Fire extinguishers in the stable	1	1	1	1	1	1	1	1
Energy	**11**	**11**	**11**	**11**	**17**	**17**	**17**	**17**
Average insulation value	2	2	2	2	2	2	2	2
Heat circulation	6	6	6	6	6	6	6	6
Economical HR boiler	3	3	3	3	0	0	0	0
Natural ventilation system	0	0	0	0	9	9	9	9
Refined dust	10	10	10	10	10	10	10	10
Dry feed with covering the pen stock	10	10	10	10	10	10	10	10
Landscape	**50**	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Collective landscaping and architectural design	50	50	50	50	50	50	50	50
TOTAL score	**174**	**175**	**171**	**189**	**140**	**140**	**136**	**147**

7.5 Long term average feed profit