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Department of Economics

Business Interruption

- estimating losses in Swedish dairy production

Sandra Alm & Alexandra Söderström

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Sandra Alm & Alexandra Söderström

Supervisor: Hans Andersson, Swedish University of Agricultural Sciences, Department of Economics

Examiner: Karin Hakelius, Swedish University of Agricultural Sciences, Department of Economics

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Sandra Alm & Alexandra Söderström

Summary

Dairy production is a complex biological production that involves large investments, both in buildings and in equipments. The investments are supposed to generate cash flows during the economic lifetime, which for a dairy barn generally is comprised by 25 years. If a fire destroys a dairy barn it would not only involve losses of the assets themselves but losses of the cash flows as well. A business interruption insurance is included in the Swedish agricultural insurances and is supposed to cover these losses. However, there has been limited previous research regarding the calculation of such losses. Furthermore, it is essential for a dairy producer to regain the production as soon as possible since each day out of production involves a loss for the business. A model for insurance companies to use when estimating these losses may speed up this process.

The aim of this thesis is to develop a model for estimating losses due to business interruption and utilize the model to assess the production losses arising in a Swedish dairy production subject to a fire. Factors affecting business interruption losses are in previous studies argued to be; length of business interruption, annual lost sales, future changes in performance, seasonality and business characteristics. A common way to measure the losses is by comparing the business financial setting before a business interruption with the situation after. Theory regarding business interruption calculations, investments and production economy are relevant in order to understand what factors to include in such calculations. The calculations can be conducted using a production function of the business before an interruption compared with a production function of the business after the interruption.

This thesis is of quantitative character and bases on two quantitative case studies along with interviews with experts. Eight simulations are made with various key characteristics features in a dairy production in order to estimate the losses in different situations. Since a dairy production is complex there is a need for assumptions in the simulations in order to make them comparable. The simulations are compared in order to see how the differences within the variating dairy farms are affecting the results. The case studies and the interviews are used to validate the figures in the model in order to enhance the reliability.

The results in all simulations show that it takes at least two years in the new barn to regain a production similar to the one prior the business interruption. During the two start-up years, the production is still suffering from the business interruption resulting in lower contribution margin in the business. Larger herds may require even longer time since it can be difficult to get enough animals in the beginning. Furthermore, it may take longer time before the milk yield has recovered to an even distribution, which is preferable in a dairy production. The results also indicate that the profit margin of the investments are 1,8 - 2,8 percentage points lower, across a 25 year economic lifespan, after a business interruption, which affect productions with lower original profit margin more extensively since these farms are more sensitive to such changes.

The conclusions in the study states that the economic losses are highly dependant on factors such as milk price, milk yield, number of dairy cows, operational cost for feed production as well as the length of business interruption and start-up process. Additional factors that are recognized to impact the losses are the production disturbances. Thus, the economic losses due to a business interruption in a Swedish dairy farm need individual calculations for the indemnities in order to be properly estimated.

Sammanfattning

En mjölkproduktion är en komplex biologisk produktion som innefattar stora investeringar, både i byggnader och i utrustning. Investeringarna är avsedda att generera kassaflöde under dess ekonomiska livslängd, vilket för en mjölkladugård generellt antas vara 25 år. Om en brand förstör mjölkladugården innebär det en förlust av både tillgångarna och kassaflödet från produktionen. En avbrottsförsäkring inkluderas i svenska lantbruksförsäkringar för att täcka sådana förluster. Forskning angående beräkningen av dessa förluster är begränsad. Vidare är det viktigt för en mjölkproducent att återuppta produktionen så fort som möjligt eftersom varje dag utan produktion innebär en förlust för företaget. En modell för försäkringsbolag att använda vid estimeringen av avbrottsförlusterna kan effektivisera denna process.

Syftet med denna uppsats är att utveckla en model för estimering av förluster som uppkommer vid driftsavbrott samt att använda modellen för att bedöma produktionsförlusterna som uppkommer i en svensk mjölkproduktion som utsatts för brand. Faktorer som påverkar avbrottsförluster är enligt tidigare studier; längden på avbrottet, årlig förlorad försäljning, framtida ändringar i prestanda, säsong och företagets karaktärsdrag. En vanlig metod att mäta förlusterna är att jämföra företagets ekonomiska situation före ett driftsavbrott med situationen efter. Teori angående driftsavbrottsberäkningar, investeringar och produktionsekonomi är relevant för förståelsen om vad som ska inkluderas i dessa jämförelser. Beräkningar kan göras genom att använda en produktionsfunktion för produktionen innan ett avbrott och jämföra med en produktionsfunktion över produktionen efter avbrottet.

Denna uppsats är av kvantitativ karaktär och grundar sig på två kvantitativa fallstudier tillsammans med intervjuer med experter inom området. Åtta simuleringar avseende varierande karaktärsdrag i en mjölkproduktion görs för att estimera förlusterna vid olika förutsättningar. Eftersom mjölkproduktion är en komplex produktionsgren finns ett behov av att göra antaganden i simuleringarna för att göra dem jämförbara. Simuleringarna jämförs för att studera hur olikheterna i mjölkföretag påverkar resultatet. Fallstudierna och intervjuerna används för att validera de värden som använts i modellen, vilket bidrar till att öka reliabiliteten i studien.

Resultaten i samtliga simuleringar visar att det tar minst två år från det att byggnaden är färdigställd till dess att produktionen är tillbaka till normalt. Under denna tid påverkas fortfarande produktionen av driftsavbrottet och medför ett lägre täckningsbidrag. I större besättningar kan detta ta ännu längre tid eftersom det kan vara svårt till en början att få tag på tillräckligt många djur. Vidare kan det ta ännu längre tid innan mjölkavkastningen är tillbaka på en jämn nivå över året, vilket många mjölkföretag föredrar. Resultaten visar även att vinstmarginalen i företaget är mellan 1,8–2,8 procentenheter lägre efter ett driftsavbrott, beräknat över en 25-årig ekonomisk livslängd. Denna skillnad påverkar främst gårdar med en lägre ursprunglig vinstmarginal.

Studiens slutsatser är att de ekonomiska förlusterna är beroende av faktorer så som mjölkpris, mjölkavkasning, antal mjölkkor, operationell kostnad för foderproduktion och även längden på driftsavbrott samt uppstartsprocess. Ytterligare faktorer som påverkar förlusterna är produktionsstörningar. Därmd kräver varje enskilt driftsavbrott i en svensk mjölkproduktion individuella beräkningar för att säkerställa en korrekt försäkringsersättning.

Abbreviations and terminology

BasU = Business as Usual
BI = Business Interruption
CM = Contribution Margin
DM = Dry Matter
ECM = Energy Corrected Milk
NPV = Net Present Value
PV = Present Value
SLB = Swedish Holstein
S-U = Start-Up
VMS = Voluntary Milking System

Batch milking system = Milking system used in Parallel or Herringbone stalls
Multiparous cows = Cows in second lactation or higher
Primiparous cows = Cows in first lactation
Stanchion barn = A barn where the cows are tied

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1 Introduction

This masters' thesis starts with a presentation of the general background of the problem area, which is followed by a problem background and the identified problem. Further, the aim is stated, along with the research questions and delimitations. The chapter concludes with an outline over the following paper.

The presence of risk when running a business in the agricultural sector is well known. Hardaker *et al.* (2007) categorize the agricultural risk into six groups: *production risk, price* or *market risk, institutional risk, human* or *personal risk, business risk* and *financial risk*. Extreme weather, fire, production failure and uncertainty about the performance of crops and livestock relates to *production risk*. *Price* and *market risks* include uncertainties about how prices and exchange rates can change. *Institutional risk* involves risk for unfavorable changes in politics and rules. Farmers' carelessness, illness or other life crises represent *human* or *personal risks*. The aggregate uncertainty that influence the profitability of the firm is associated to *business risk* and the *financial risk* is connected to the way the business is financed and includes changes in interest rates and availability of external borrowing.

Since farmers are exposed to many risks and since they in general are risk-averse, a common method to manage risks is to sign an insurance policy with a proper protection (Meuwissen, 2000). The basic condition of insurance is shared financial risks in a large group of people, where each person pays a smaller insurance premium in order to receive a larger amount of money in case of an accident (Randquist, 2015). Thereby, farmers may get financial security through signing an insurance policy.

The different agricultural risks have created a large range of agricultural insurance products. The market contains several different insurances that cover one or several risks. The risks associated with growing and marketing crops were early stated as central to the farmer and the need to develop crop insurance was identified (Hoffman, 1932). Thus, crop insurance has received large attention within the literature of agricultural insurance (Boyd *et al.,* 2013). The crop yield is particularly dependent on the weather and the observed climate change has urged the development of weather index insurances as well. Moreover, a farmer with both crop and livestock production may contract a whole farm income insurance in order to receive protection against the covariate risk (Turvey, 2012).

Moreover, the offered agricultural insurances vary between countries. In Sweden, there is for instance no comprehensive crop insurance; it only involves insurance against hail and reseeding (Pers. comm., Regnér & Jansson 2, 2016). Nevertheless, there is a special insurance providing farmers with a basic protection that covers many of the agricultural risks. The insurance covers property and livestock as well as losses due to business interruptions (**BI**) (Sveriges Föreningsbank, 1992). Länsförsäkringar is a Swedish insurance company that offers this kind of insurance (www, Länsförsäkringar 1, 2016). In general, Länsförsäkringars agricultural insurance includes property insurance that involves buildings, machinery, inventories, products *etc*. Moreover, it includes indemnity for income losses due to property damage, in other words a BI. In addition, it covers crises, legal protection, liability protection and insurance during business travels.

1.1 Problem background

Agricultural insurances act as an important prerequisite in order to attract investments within the agricultural sector and to stabilize the farmers' revenues (Clipici & Frant, 2013). The agricultural business has experienced an increased industrialization, which has enhanced the requirement for agricultural investments (Meuwissen, 2000). New investments within the sector normally involve large values and are assessed through investment appraisal of expected future income (Bergknut *et al*., 1993). Moreover, a general focus within the sector has been to increase productivity. Dairy cattle breeding has focused on enhanced productivity since the increase in cost of land and labor is higher than the increase in price of milk (Rauw, 2009). This development leads towards more efficient and rational farming systems that can be operated with less labor and cost per unit (www, SCB, 2012). In Sweden, this structural change within the agricultural sector has occurred during the recent decades and has caused the number of farms to decrease, at the same time as the farm size has increased (www, Jordbruksverket 1, 2015).

The severity of financial consequences from the production risks increase due to the larger values within agricultural businesses (www, Land Lantbruk, 2015). Fire is a common production risk causing damages on the farm properties as well as risking the continuity of the production and causing BI (Sveriges Föreningsbank, 1992). Among Länsförsäkringars policyholders, fire causes roughly 50 % of all BIs (Pers. comm., Regnér & Jansson 1, 2016). Every year there are about 2000 fire accidents in Swedish agriculture, which represent 10 percent of all fires in the country (www, Land Lantbruk, 2015). This represents a cost of almost 400 million SEK. Diagram 1 illustrates how the costs may be attributable to the location where the fire started. As reveled by Figure 1, the largest costs from fires are attributable to the livestock building, barn/storehouse and residence housing (www, Brandskyddsföreningen, 2014).

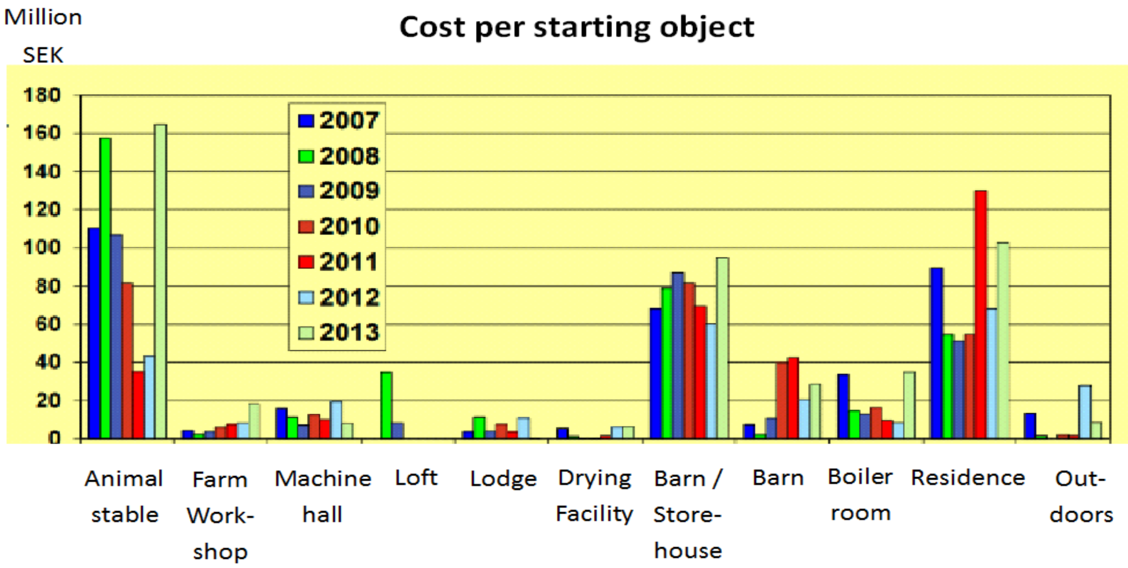

Figure 1. The costs of fire damages associated with different objects (Brandskyddsföreningen, 2014).

To a farmer, the financial consequences of fire damage depend on the enterprise structure at the farm. The consequences involve costs of destroyed buildings, destroyed inventory and hurt or dead livestock, but also lost revenues from production, which may be difficult to evaluate (Pers. comm., Regnér & Jansson 1, 2016). It also implies the need for new investments in order to get the production restarted. Moreover, it takes time to complete the new investment project and to get the production operating at full capacity, which also implies a cost to the farmer. In a biological production such as milk production, it might be possible to evacuate the cows and find a temporary barn for production. However, this may create decreased production since the cows need time to adjust to a new environment (Phillips, 2010; Bruckmaier, 2005; Bruckmaier & Blum, 1998). These kinds of risks and costs are covered by an agricultural insurance (www, Svensk försäkring, 2007).

As a farmer signs an insurance contract, the risk is transferred to the insurance company (Randquist, 2015). Moreover, when a claim is reported, the insurance company carries out a claim adjustment, in order to value the indemnity that should be paid to the policyholder (Dahlénius & Lund, 2011). The insured interest is defined in the insurance's terms and conditions by specifying the exposure unit and the insured sum (Renmar, 2008). The insurance terms of Länsförsäkringar's BI insurance states:

> *"Interruption insurance normally applies to consequential damages due to property damage according to A.11[1]. The interruptions insurance covers economic losses caused by that the entire or parts of, the production is down or through subsequent production disturbances. The policyholder has to be active and no later than within 6 months act to resume the production." (Länsförsäkringar 2, 2016, p. 3)*

Moreover, there are different insurance types that provide different coverage such as full insurance and first risk insurance (Sveriges Föreningsbank, 1992). First risk insurance normally involves a partial insurance of the property's value and the indemnity is limited to a predetermined amount. The damage is valued accordingly to the value assessment regulations. However, the indemnity cannot exceed what has been predetermined. Full insurance covers the entire value of the property and the claims payment is determined by the existing value assessment regulations (*ibid*). This implies that there is no predetermined insurance sum. Since many farmers are known to be risk-averse, the rational choice often is to have full insurance coverage (Lee, 2012).

1.2 Problem

BI is generally unexpected and may originate from different occurrences, leading to a suspension of operation (Slee, 2011). A BI causes a disruption in the company's cash flow and creates losses of the future earnings (Roberts, 2011). An insurance against BI is supposed to replace the income loss during the time needed to repair the damages (Sveriges Föreningsbank, 1992). Thereby, the insurance company needs to understand the value associated with an agricultural production system and also how it functions in order to calculate what has been lost and thereby value a proper indemnity. As mentioned, a dairy enterprise involves large values and a BI may cause substantial economic losses. It forces the farmer to make a new investment in order to return to the production. Furthermore, liquidity problems would quickly arise, which cause problems for the farmer with the bills that need to be paid. Hence, the insurance company is supposed to estimate the costs rapidly in order to settle the indemnity so that the farm's production system can be resumed. A fast and systematic settlement of the indemnity is also motivated by other factors. It reduces the insurance company's costs and thereby enhances competitiveness and productivity (Mayers & Smith, 1981). In addition, the fact that money is worth more today than tomorrow can inspire an efficient claim assessment (Olsson, 2011).

[1] A11 is a section in the terms and conditions of property insurance at Länsförsäkringar.

As previously stated, fires are a major risk that causes several BI a year. However, it may neither be an insurance claim for the same insurance company nor in the same area. In addition, no agricultural insurance claim is the other one alike. It may pass a long time between severe insurance cases that cause BI but when the accident occurs it is crucial to resume the production as fast as possible (Bourdreaux *et al*., 2011). Therefore, it would be helpful to develop a model that enables a systematic assessment of the damages.

Moreover, there have been studies of BI insurances, but few have focused on biological production systems such as the dairy production. The complexity and unique nature of each dairy enterprice makes it difficult to assess the values in each individual production system that may be lost during a BI. In previous literature, features such as the length of the BI, annual lost sales, future changes in performance, seasonality, changes in market condition and consumer demand have been emphasized to affect the losses (Rose & Huyck, 2016; Jain & Guin, 2009). Although, an additional factor to consider in a biological production system is that it takes time for the farmer to regain the production after rebuilding a barn (Hansson & Olsson, 1996). This is due to the fact that production disturbances often occur in a newly built barn. In addition, younger dairy cows do not produce as well as older cows, which lower production in a start-up (**S-U**) phase (*ibid*). These issues have not been addressed in previous literature about BI even though these losses can be extensive. Rose & Hyuck (2016) enlightens that BI losses may exceed the property losses, especially in cases where the losses accumulate even after the production is restarted. Due to the lack of research in this area and the importance of making proper estimations of the economic losses in a dairy production subject to a BI, there is a need for BI modeling in an agricultural setting.

1.3 Aim and delimitations

The aim of this thesis is to develop a model for estimating losses due to BI and utilize the model to assess the production losses arising in a Swedish dairy production subject to a fire. The following research questions will be answered in order to achieve the aim:

- How large are the losses in a dairy production during the time the production is subject to a business interruption?
- How does a business interruption affect the present value of the investment and the profit margin in a dairy production?

The agricultural business is be complex and individually oriented in many ways. Hence, to be able to carry out this thesis delimitations are made. At first, this thesis is conducted in cooperation with Länsförsäkringar. Therefore, data as well as information is not collected from any other insurance company in Sweden. If other insurance companies also would have been contacted it would have provided additional perspectives.

Moreover, a dairy production can be either conventional or organic, which implicates different production techniques and methods. In turn, there are different needs regarding input and output in the production system which include different prices. Two different calculations would therefore be required in order to estimate the losses due to a BI in each production line. The organic production is also strictly regulated by policy regimes, which may complicate the analysis. Thus, the organic production is not considered in this study. By not considering the organic dairy production, this study is not reflecting the economic consequences in such a production setting. In addition, other policy regimes are not taken into consideration when developing the model.

Furthermore, this study is conducted with a partial analysis of a dairy farm, which implies that it delimits to include all possible components in the production at a farm. This study focuses on incomes and costs directly applicable to dairy production. This in order to study what may be related to the dairy production losses in case of a fire. Consequently, the study delimits from aspects that may have considerable impact on the economic losses in a business that is subject to a BI.

In addition, this study is delimited from risks regarding the future milk price and milk yield. Thus, the risk of fluctuating figures due to changes in market conditions is not considered. Such changes may have major impact on the estimated losses during the long period of time that an investment in a dairy production extends over. However, these kinds of changes are hard to forecast and an attempt to try to predict them may make the calculations unreliable and misleading.

1.4 Outline

In figure 2, the outline of this paper is presented to provide the reader with an overview of the following structure.

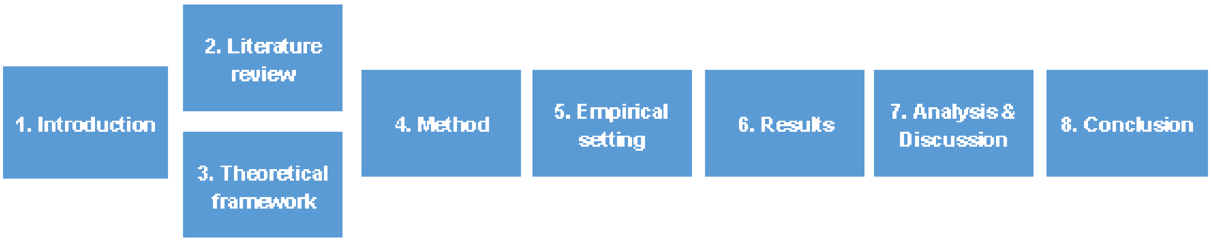

Figure 2. Illustration of the outline of this paper. Source: Own processing.

Chapter 1, the introduction, presents the background to the recognized problem and concludes with a problem formulation, the aim and research questions of the study. Chapter 2, the literature review, presents previously conducted researches in the field. This follows up by chapter 3, the theoretical framework, where theories relevant for the present study are presented. The fourth chapter, method, describes the method used to conduct this study, followed by a presentation of the mathematical model developed for the calculations. The empirical setting is described in chapter 5 to provide the reader with an understanding of the environment for the empirical study. The results of the empirical study are presented in chapter 6 and these are analyzed and discussed in chapter 7. In the last chapter, the conclusions of the study are presented along with suggestions to future research.

2 Literature review

Chapter 2 presents a literature review of previous research related to the subject of this thesis. The literature review is conducted in order to generate an understanding of what has been researched previously within BI insurance and the production economics in dairy farms. The search for relevant literature is extensive and indicates that there have been few previously performed studies within the field.

2.1 Business interruption insurance

The BI is along with extreme weather and uncertainty about the performance of crops and livestock related to the production risk (Hardaker *et al*., 2007). The definition of a BI is by Rose & Huyck (2016) stated as the loss of revenues due to destruction of the capital stock in a firm. Furthermore, the hazard causing the most BIs is fire (Zajdenweber, 1996). In previous research, BI insurance is regarded as an insurance of its own (Rose & Huyck, 2016; Jain & Guin, 2009; Zajdenweber, 1996). However, there are resembling features to income insurance because it compensates for loss of income, but only for the time of BI due to a specific event (just low margins are not insured) (Meuwissen, 2000). The agricultural insurance in Sweden includes BI and therefore, there is no need to sign a specific BI insurance for a Swedish farmer.

The coverage of BI is usually wider for farmers than for other businesses. It covers the sales value of a product less the cost that has not incurred *e.g.* feed to animals that will not be needed after the BI. An important factor to consider when farmers' BI coverage is arranged is that the loss of income depends on the length of the period with losses (Gaughan, 2009). Therefore, it is important to settle an adequate maximum period of indemnity. Roberts (2011) argues that for livestock farmers it may take two or three years to recover the business.

In table 1, an overview of the literature review is presented, where important features for this study are emphasized.

Table 1. Overview of the studied articles, highlighting features important for the study. Source: Own processing

Previous studies	Factors affecting BI losses	Calculating losses during BI	Production economy in dairy farms
Hardaker *et. al.*, 2007	BI as a production risk		
Stephenson *et al*., 2012	Price, Quantity, Variable costs, Fixed cost and Extraordinary expenses	Compare expected profits wih actual profits. -Before and After method -Yardstick method	
Rose & Huyck, 2016	Length of the BI, Annual lost sales, Future changes in performance, Seasonality, Changes in market condition and Consumer demand	Historical performance and projected sales	
Jain & Guin, 2009	Building characteristics, Business characteristics, Additional insurances	Estimate daily business income loss * number of days estimated to be out of production	
Gaughan, 2009	Length of the BI		
Roberts, 2011	Length of the BI. Dairy production needs two-three years to regain the production		
Barry et al. 2001	Farm size, Relative prices and yield, Farm type, Life cycle, Financial structure and Location		
Zajdenweber, 1996	Business characteristics		
Newman, 2012		Business trading history	
Amato *et al*., 2011		Expected annual income * expected inaccessibility because of a BI	
Meuwissen, 2000		Partial budgeting. Estimate Daily business income loss * number of days estimated to be out of production	
Bourdreaux *et al*., 2011		Compare firm booking between the year before the BI and the year after the BI. Calculate CFfO	
Palsander & Wiman, 1996			Factors to consider: Size, revenues and costs
Olsson, 1995			Profitability depends on: milk yield, number of dairy cows, number of shares, working hours, age of the farmer, replacement cost of buildings, present value of buildings, salvage value of machinery and equipment, share of milk income, grassland and barley yield, subsidy per cow and support area
Ekman, 1995			Optimal planning of the production in Swedish dairy farming
Gunnarsson, 2002			Economic consequences of installing the VMS technology at a farm level was presented
Olsson, 2004			The dairy price effect on investments

2.2 Factors affecting business interruption losses

Stephenson *et al*. (2012), emphasize that profits are affected by variations in price, quantity, variable costs, fixed costs and extraordinary expenses. Thus, these are key factors to consider when assessing the losses during a BI. Rose and Huyck (2016) stress factors such as the length of the BI, annual lost sales, future changes in performance, seasonality, changes in market condition and consumer demand that determine the damages of a BI. Jain & Guin (2009) also emphasize the length of the BI as an often-disputed key figure in claims settlements that need to be accounted for. It can for example be viewed as the time it takes for the business to regain full performance or as the time until a building is fully restored.

Jain & Guin (2009) simulate hurricane events and use historical loss and insurance data in order to plot figures to estimate the downtime for different businesses. The figures show that when a hotel building is destroyed to 100 percent it takes approximately 800 days before the building and business is operating again. For offices, the number is approximately 150 days. The authors describe key factors that affect BI losses:

- *Building characteristics*, large buildings take more time to restore and some buildings are more advanced than others and are therefore more difficult to replace.
- *Business characteristics*, businesses are different in size and complexity. Businesses in office buildings can be easier relocated than for example an agricultural business. Businesses can also differ in the level of resiliency against BI.
- *Other factors,* such as if the business has insurance also against contingent BI that would increase the total BI losses in the eyes of the insurance company.

Barry *et al*. (2001) study the variability in net farm income and if it is influenced by the size of the farm and other structural characteristics in the business. The included factors are farm size and type, relative prices and yields, life cycle, financial structure and location. Their study supports the idea of a strong relationship between the farm size and the relative variation in real net farm income. The study also suggests that other structural factors influence the variation in net farm income.

The damages of a BI may be argued to be rather insignificant compared to the damages in for example buildings, equipment and machinery caused by fire (Zajdenweber, 1996). However, the author conducted a study of extreme values within the BI insurance since the damages also may be many times larger than the capital damage, depending on the business characteristics. Even though these extreme insurance cases are unusual, the insurance company needs to be reinsured in case of a catastrophe.

2.3 Calculating losses due to a business interruption

Newman (2012) stresses the importance of knowing how to calculate the BI payments. Previous literature share the opinion that the method to assess how the damages vary depends on the features of the BI. The following section examines several methods, which differ by various parameters. To begin, Newman (2012) suggests to keep good records about the previous business trading history and to seek advice from the accountant of the business in case of a BI. Moreover, Stephenson *et al*. (2012) argue that one approach to assess the lost profits due to a BI is to compare the expected profits with the actual profits. Two frequently applied methods are the before and after method and the yardstick method (*ibid*). The first approach implies that the lost profits are calculated as the difference between profits before and profits after a BI and the second approach examines the profits in other similarly organized companies. These methods may also be combined into a third hybrid approach.

Another method is to multiply the expected annual income with the expected inaccessibility because of a BI in order to estimate the economic losses caused by the BI (Amato *et al*., 2011). Moreover, an additional approach is to estimate the daily business income loss and then to multiply it with the number of days that the business is deemed to be out of production (Jain & Guin, 2009; Meuwissen, 2000). Business income is by Jain & Guin (2009) defined as 1) the net profit or loss without regard to the income taxes that is lost due to the damage and 2) the continued costs that are unaffected by the disruption, pay rolls and taxes, for example.

Furthermore, losses can also be calculated using a technique denoted partial budgeting, which generally is based on four cathegories: *additional returns*, *reduced costs*, *returns forgone* and *extra costs* (Meuwissen, 2000). The *additional return* refers to governmental compensation, the *reduced costs* represent variable costs, the *foregone returns* are missed production and *extra costs* are costs that occur due to BI. Meuwissen (2000) focused her study on BI due to epidemic diseases in pig production and includes the supply chain in her analysis. The losses for the farmers regard the time that the buildings are empty at the farms and are derived through a comparison between a situation without livestock epidemic and a situation with epidemic. The author emphasizes the losses related to the cost of restarting a production with a new herd, such as the gradual repopulation and fit into the farmer's production system. The study regards all farmers as one group, thus no individual farm based calculations are made.

The perception of the business needs to be clear for the insurance company to be able to estimate the losses due to BI. Rose & Huyck (2016) stress the importance to conduct a thorough data collection on individual facilities in order to improve the estimation of losses from a BI. To do so, the accountant of the business is an important actor that can provide solid information about the previous financial situation in the business. The calculations can be based on historical performance and projected sales (*ibid*).

Moreover, Bourdreaux *et al.* (2011) argue for a different method where BI calculations are based on comparisons of the firms' records the year before the property destruction and the year after the BI. They argue that, when using the records as a base, depreciation and other non-cash charges also need to be considered. Other non-cash charges are *e.g.* expansion funds, periodization and other appropriations. This is argued as a more precise reflection of firms' profitability since these non-cash appropriations reduce profits in order to reduce tax payment. Bourdreaux *et al.* (2011) present a model in which the first step is to calculate the Cash Flow from Operations (CFfO) where depreciation and other non-cash charges are added back to the net profit after taxes. The next step is to calculate the CFfO after the BI and subtract this from the former. From this the change or decline in CFfO can be derived. However, this calculation of BI losses is complicated because it is based on the businesses historical financial performance but it is the future damages that need to be predicted. In the future, production and price risks are uncertain but they will most likely change due to competitive market forces in a more globalized market for agricultural products (Meuwissen *et al*., 2003). Stephenson *et al*. (2012) also emphasize that the variation in the key factors (price, quantity, variable costs, fixed costs and extraordinary expenses) need to be accounted for. This in turn affects the estimation of lost revenues and reduced costs.

Furthermore, Stephenson *et al*. (2012) highlight four challenges when calculating lost profits from a BI. Firstly, the fact that there are multiple causal factors that occur simultaneously. Secondly, it can be difficult to determine the extent of avoided variable costs. Thirdly, to forecast future revenues might not be a simple linear regression from previous revenue trends. Fourthly, there is usually a small sample size in number of cases with lost profits.

2.4 Production economy in a dairy farm

Since dairy production is a complex and many times unique production, it can be difficult to know what factors to include regarding calculations of the production. Palsander & Wiman (1996) study the conversion costs when shifting the dairy herd from conventional to organic. To do this, the authors calculate the economic contribution margin (**CM**) in both organic and conventional dairy production using a Net Present Value (**NPV**) approach. To collect the data required for the study the authors use case study methodology involving seven farms. Factors that need to be taken under consideration for the profitability in dairy production are by the authors grouped into three parts; size, revenues and costs. The size factors include number of cows, number of heifers and hectares of land for feed production and grazing. The revenues and costs regards cows, heifers, own feed production and grazing. Each of these include different variables such as amount of feed per cow and heifer, milk yield per cow, amount of produced manure, number of produced calves and amount of produced feed, along with working hours and prices for all the variables.

Shifting from a conventional to an organic production involves a large strategic decision. Another substantial consideration is when the farmer is facing an intergenerational transfer. Olsson (2004) studies how major investments after an intergenerational transfer affect the economic situation in the business. By conducting case studies among different farming systems, the author shows that the investments are highly affected by changes in the received product price. The study includes three dairy farms with the sizes; 40, 50 and 80 dairy cows. A change of 0,1 SEK/kg in the milk price affects the investments in a dairy enterprice with between 57 000 and 76 000 SEK, where the larger number refers to the larger herd and the smaller impact is related to the smaller herd.

Furthermore, Olsson (1995) examines factors that affect the profitability in dairy production, by analyzing previous literature and theory with a regression analysis together with quartile grouping. The author's conclusion states that the factors impacting the profitability per dairy cow are; milk yield, number of dairy cows, working hours, age of the farmer, replacement cost of buildings, present value of buildings, salvage value of machinery and equipment, share of milk income, grassland and barley yield, subsidy per cow and support area.

Some of the variables presented by Olsson (1995) are also included in Ekman's study (1995) regarding optimal planning of the production in Swedish dairy farming. The study was conducted in connection to when Sweden joined the European Union, in order to analyze how the production system would have to adjust to the new conditions. Ekman (1995) develops a mathematical programming model to maximize the single farms economic result when adapting to the new conditions. The author includes the milk yield, feed ration and utilization of the building as important factors in the calculations. The author argues that the milk yield is affected by the feeding ration, lactation number and calving distribution. Later on, Gunnarsson (2002) further developed the model by Ekman (1995) when he examined the economic consequences of installing Voluntary Milking System (**VMS**) in a dairy farm. The study includes many of the elements used by Ekman (1995) in the developed model.

2.5 Summary of the literature review

A BI insurance is supposed to cover losses of revenues due to destruction of the capital stock in a firm. The factors that affect the losses are *e.g.* the length of the BI, annual lost sales, future changes in performance, seasonality and business characteristics. The literature review has indicated that the BI losses usually are estimated by comparing the financial situation before a BI with the situation afterwards. When estimating the losses, it is important to know what production factors to include in the calculations. As presented, there are multiple ways of determining the losses due to a BI. However, it is clear that regardless of what method to use it is important to know what factors to include in the calculations. These are dependent on the business and market characteristics. In the case with dairy production, important factors are; number of cows and heifer, hectares of land for feed production, produced manure and milk yield.

3 Theoretical framework

The previous chapter develops a fundamental understanding about the problem area and reveals important aspects. This chapter presents relevant theoretical elements to enhance the understanding and provide tools required for estimating BI losses in a dairy production.

3.1 Business Interruption Theory

There are two basic approaches to calculate the lost earnings due to a BI because of different insurance markets in the United Kingdom and the United States (Roberts, 2011). The basis in the UK is called "loss of turnover" and the basis in the US is called "loss of business income". Both of them also have two major sub forms as illustrated in figure 3.

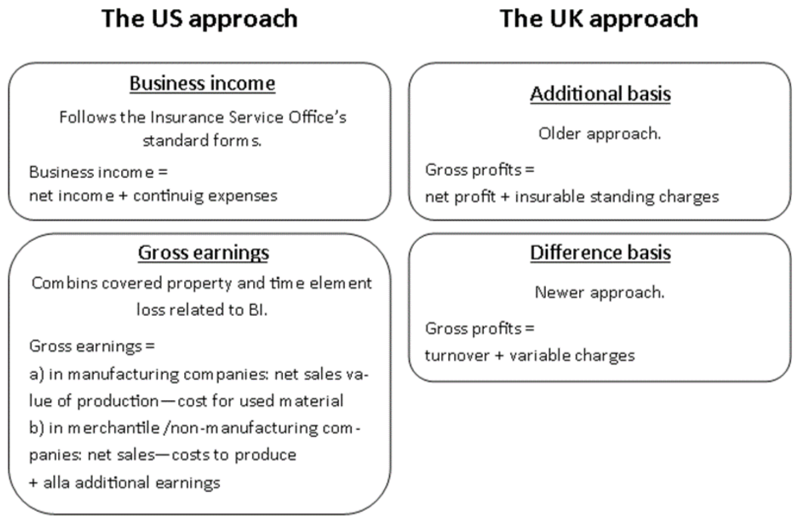

Figure 3. An overview of the different forms to calculate lost earnings due to BI. Source: Own processing.

As figure 3 shows, there are similarities between the US "business income" and the UK "additional basis" as well as for the US "gross earnings" and the UK "difference basis". However, there are two main differences between the approaches (*ibid*):

1. The starting point for the UK forms is the reduced turnover, unlike the US forms that starts with the interruption of business activities. The US forms starts by an evaluation of how the output has been affected by the BI and then loss of turnover can be measured.

2. The UK forms have formulas to calculate the loss, as opposed to the US forms. Instead, the US forms provide a guidance of the factors that should be regarded during the loss determination.

The BI is only covered if the suspension of operation occurs in a physically damaged property that has insurance coverage for the cause of BI (Slee, 2011). The insurance covers the loss of sustained income and incurred costs induced by resuming a normal operation (*ibid*). Alternatively, the BI claim may be valued according to the amount of lost profits or business value, if it is possible to be reasonable certain about that (*ibid*). The indemnity from a BI insurance is often based upon the hypothetical loss of future earnings (Roberts, 2011; Slee, 2011). Moreover, the extent of the hypothetical loss of future earnings depends on the investments in the business.

3.2 Investment theory

An investment refers to the purchase of long-lasting resources that imply consequences over several years for a company (Olsson, 2011). Investments represent changes in the capital stock and are essential for companies to be able to produce goods and services (Ross *et al.*, 2008). Investments can be made in *e.g.* buildings, equipment and people, which all require an initial cost. According to the Swedish tax agencys legal guidance (RSV S 1996:6), an investment in a building such as a dairy barn has an economic life cycle of 25 years. The inventory such as milking equipment, feeding equipment and manure handling system can be expected to have an economic life cycle of 10-15 years. Thus, the inventory is supposed to create cash flows during 10-15 years and the building in approximaley 25 years. After this time, reinvestments are necessary in order to generate new cash flows. However, theory does not always represent the real depreciation of an asset; the technical life cycle is often longer than the economic (Thomasson, 2013).

Moreover, the dairy production requires an individually adjusted business solution in order to have a well-fitted production and the right equipment (www, DeLaval 1, 2011). There is a broad automatization in today's farms, where feeding systems, cow separating systems and milking robots play important parts (Douphrate *et al.*, 2013). The dairy cows are milked with a milking machine that can be operated either manually or automatically. The latter refers to VMS, which is common in today's larger herds (www, DeLaval 2, 2011). The barn is normally designed for two types of housing; stanchion barn or free-stall barn. However, it is no longer legal in Sweden to build stanchion barns and thus only free-stall solutions are built today (www, Jordbruksverket 2, 2014). The herd size and the number of milking units are aspects that affect the choice of system (Wagner *et al.*, 2001). The milking center is the most expensive investment in the production and is therefore an important decision (*ibid*.). As a result, the investment cost for a dairy farm varies depending on the choices the farmer makes to find a relevant solution. However, regardless of the choices the farmer makes the investments need to function in order for the farmer to keep an efficient production (Hansson & Olsson, 1996).

To finance and repay the investment, it is supposed to create an income stream (Olsson, 2011). The income stream can be calculated with an investment calculation (*ibid*). An investment calculation precedes the actual investment and act as an important foundation when deciding whether or not to invest. It works as a resource allocation, along with estimation of future cash flows, profitability, risk and uncertainty during the investment's lifetime (Bergknut *et al.*, 1993). Figure 4 illustrates the future payments of an investment, where a positive sign represents cash inflow and a negative sign stands for cash outflow.

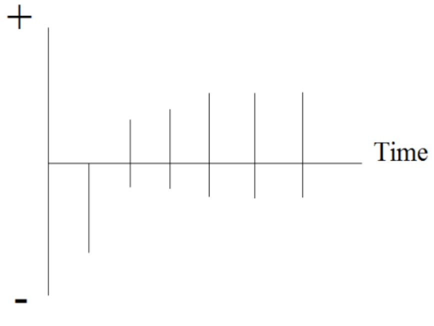

Figure 4. Illustration of the future payments of an investment. Source: Olsson, 2011; Own processing.

An investment calculation is commonly conducted using either a NPV analysis or a Real Option model (Ross *et al*., 2008). The Real Option model includes adjustments that can be made during the life cycle of the investment. Thus, it is regarded as a more advanced calculation than the NPV analysis (*ibid*). However, a Real Option model is best justified for calculations in uncertain and risky environments, in other circumstances the NPV analysis is more appropriate (Sapienza, 2003).

Furthermore, not only new investments generate cash flows in businesses. A cash flow can origin also from a business's operation and financial activities (Ross *et al*., 2008). The operating activities represent sales of products and services and the financial activities involve equity and debt changes. However, the cash flows are connected to the capital in the firm, which originate from an investment (*ibid*).

Since investments usually extend over many years, the future cash flows are calculated to the Present Value (**PV**) by discounting with the cost of capital interest rate (Olsson, 2011). The applied discount rate is established by the required return and the risk free bank rate (*ibid*). It reflects the interest rate required to cover debt and to compensate for the forgone return on equity asset (Lagerkvist & Andersson, 1996). The interest rate can be expressed in either nominal or real terms. The nominal interest rate includes compensation for time and investment risk along with inflation that makes money lose its value over time (Lagerkvist, 1999). The time factor is included due to that the possibility to consume is postponed into the future. The real interest rate includes the compensation of time and risk but is adjusted for inflation (Bergström & Södersten, 1982).

There are two general formulas to discount a future cash flow, depending on if the cash flow is continuous or discrete (Chiang & Wainwright, 2005). The continuous formula is preferably used when the interest rate is compounded continuously, *i.e.* compounding every miniscule instant. The discrete formula, on the other hand, is best used when the interest rate is compounded at a finite time period, *e.g*. daily, monthly or yearly (*ibid*). Equation 1 denotes the PV of cash flow, using the discrete formula and yearly compounding:

$$PV = \frac{C}{(1+i)^t} \tag{1}$$

Where C represents the cash flow of year t and i represents the annual discount rate. Generally, the interest rate is given as an annual rate. Hence, when calculating for other time span payments the annual discount rate needs to be adjusted (*ibid*). This is done by changing the yearly time variable into fractions of the year as presented in table 2.

Table 2. Commonly used fractions of one year. Source: Own processing

Compounding period	Fraction of one year
1 day	1/365
1 month	1/12
3 months	1/4
6 months	1/2
1 year	1

The fractions are denoted *m* resulting in the discrete PV formula presented in equation 2.

$$PV = \frac{C}{(1+i)^m} \tag{2}$$

If there are several cash flows in the future, the PVs may be discounted and summed. When the cash flows are constant and with no end, a perpetuity method is used (Ross *et al*., 2008). Unending cash flows are not very common. However, the British bonds labelled *consoles* are of this specific character (*ibid*). It is more common that the cash flows stream from regular payments over a fixed time period. In these cases, an annuity method is used (*ibid*). The annuity formula using yearly compounding is shown in equation 3:

$$PV = \frac{C_1}{(1+i)^1} + \frac{C_2}{(1+i)^2} + \cdots + \frac{C_T}{(1+i)^T} = \sum_{t=1}^{T} \frac{C_t}{(1+i)^t} \tag{3}$$

T represents the total number of years over which the capital asset is generating an income stream. For more frequently compounded periods, the variables T and t are replaced with the fractions presented earlier, resulting in formula 4:

$$PV = \frac{C_1}{(1+i)^m} + \frac{C_2}{(1+i)^m} + \cdots + \frac{C_M}{(1+i)^M} = \sum_{m=1}^{M} \frac{C_m}{(1+i)^m} \tag{4}$$

Where *M* stands for the total fractions of a year. If the cash flows are evenly distributed over the time periods, these formulas may be simplified. However, this is not common in agricultural production systems due to seasonality and complexity of several in- and outputs.

3.3 Production theory

Agricultural production involves several highly complex processes that need to co-operate. Several inputs are required in order to produce an output. Thus, managing an agricultural production involves numerous choices *e.g.* deciding how much of a variable input to use per livestock unit or hectare (Hazel & Norton, 1986). Another choice is how to combine factors like labor and machinery. These choices can be referred to as different techniques. Some technical factors to take into account in the dairy production activities are; the calving date, level of produced grassland, the cow's genetic potential, level of concentrate, and length of grazing season (Valencia & Anderson, 2000). Thus, the overall dairy production is comprised by technical relationships among in- and outputs in the different sub-processes.

Figure 5 is an illustration of the complexity in a dairy production that shows how different components are linked in the sub-processes. The fire in a dairy production destroys the barn building and causes a BI where there is no output from the production.

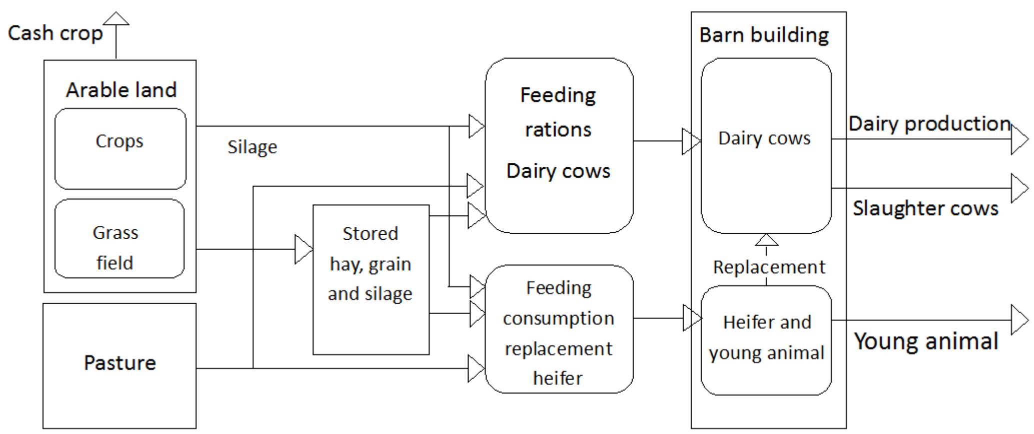

Figure 5. Illustration of components in a dairy production. Source: Ekman, 1995; Own processing.

Theory of production classifies inputs into fixed, variable and random inputs (Doll & Orazem, 1984). Buildings, machinery and land are often referred to as fixed inputs in farming. The number of dairy cows and amount of feed are typical variable inputs in a dairy production. Moreover, nature or economic forces in the surrounding world represent the random inputs. In a dairy herd, the inputs result in output of milk, calves, manure and culled animals. Whether an input is variable or fixed depends on how easily they can be controlled and thereby changed (Debertin, 2012). This entails that the time perspective is an important aspect to consider (*ibid*). In the near future it is easy to distinguish wheather or not the inputs that can be controlled. However, with a long time perspective all inputs can be regarded as variable since there is time to change the fixed inputs of today.

A production function explains the transformation of input into output of different commodities (Debertin, 2012). It demonstrates the combination of inputs that maximizes the output. Moreover, it is the in- and outputs that generate a cash flow in the business, where the inputs carry the costs and the outputs bring the revenues. The total revenues minus the total costs equals the profit (Allen *et al*., 2009). With the production function, it is possible to estimate the value that the production is expected to generate.

During a BI there are disturbances in the production function due to the lack of fixed or/and variable inputs that prevent output from being produced. In a dairy production, this is apparent by the partial or completely lack of output of milk, slaughtered cows, young livestock and manure. Furthermore, this causes an economic loss in the business since no revenues are generated. However, also the variable cost for input, such as feed and work, are reduced. This in turn reduces the losses in the lost production. Since each dairy production is unique the exact circumstances for each BI is hard to predict. However, the extent of the losses depends on if other inputs can be introduced to the production.

Assumptions are usually made in the production functions while studying how a production system responds to different events and inputs in order to eliminate effects from other variables (Doll & Orazem, 1984; Liljegren *et al*., 1983). A production function with several inputs is more representative for a real production (Debertin, 2012). Equation 5 shows the production function, where x represents the input and y stands for output.

$$y = f(x_1, x_2, x_3, x_4, x_5) \tag{5}$$

The prerequisite for the function to be usable is that x should be equal to or above zero. A BI due to a fire that destroyes the barn, implies that no inputs can be used in the production. Thus, the inputs equal to zero as equation 6 denotes.

$$x_1, x_2, x_3, x_4, x_5 = 0 \tag{6}$$

When the farmer is restarting the production, there have been new investments in the new building and dairy cows. Moreover, the other variables are gradually adjusted with regard to the production level that can be reached with the new herd.

The production function is founded on the law of diminishing returns (Debertain, 2012). However, the law is more properly named as the law of diminishing marginal return since it concerns how extra inputs affects the marginal product (*ibid*). The word *additional* is essential in the law and the law states that after a certain amount of inputs, each additional variable input creates less additional output, when all other inputs are held constant. The change in output due to an incremental change of an input is called marginal physical product (**MPP**).

3.3.1 Dairy production

In production economics theory, actors are often assumed to seek profit maximization. However, studies have shown that dairy farmers, along with other agricultural farmers, are not always motivated merely by profit maximization but also by other, non-numerical, factors (Edward-Jones, 2006; Lin *et al.,* 1974). Such factors may include social norms, cultural beliefs and personal values for example (Edward-Jones, 2006). However, since dairy producers today are faced with low milk prices, which for a single farmer are hard to affect, it may be essential for them to seek to minimize the costs which is necessary in order to maximize profits. A firm is maximizing the profits when the marginal revenue *i.e.* the change in revenue due to one extra unit of output, is equal to the marginal costs, which represents the additional cost for the firm to produce one extra unit of output (Pindyck & Rubinfeld, 2009). Profit maximization can also be expressed with the regard to maximize output from the used inputs (Debertin, 2012). A financial ratio often used in order to measure the performance in the business is the profit margin. The profit margin is calculated as the result divided with the turnover (Ax, 2009).

With a long-term perspective, the output in a profit-maximizing firm on a competitive market is where the long-run marginal cost is equal to the product price (Pindyck & Rubinfeld, 2009). However, in order to run a profitable production over time, it is of importance to make sure that the profit exceeds the average total costs (Flaten, 2001). This can be expressed as $P_y * f(x_1, x_2, x_3, x_4, x_5) > \sum_{i=1}^{4}(P_{xi}X_i) + FC$ or according to equation 7, where FC represents the fixed costs since x_5 may be considered as 1.

$$P_y > \frac{\sum_{i=1}^{4}(P_{xi}X_i)+FC}{f(x_1,x_2,x_3,x_4,x_5)} \tag{7}$$

The price of milk and feed are volatile and affect the profitability in a dairy farm (Wolf, 2012). In the short run, a firm may experience periods with no profit due to a higher cost of production than the price of products produced (Pindyck & Rubinfeld, 2009). Today, this is the general situation for dairy farmers in Sweden. The farmers that remain in business believes in a reduction of production costs and an increase in product price and thus, expect profits in the future. Although, the firm still needs the product price to exceed the average variable costs $P_y > \frac{\sum_{i=1}^{4}(P_{xi}X_i)}{f(x_1,x_2,x_3,x_4,x_5)}$ (*ibid*). Otherwise, the firm is loosing money with every additional unit produced.

In equation 8, the revenues and cost that are normal in a dairy farm are expressed and the equation denotes the profit maximizing function. Assuming that $f(x_1, x_2, x_3, x_4, x_5)$ is homogeneous of degree 1. In addition, $VC_D = \sum_{i=1} P_{x_l x_i x_a}(NX_a + NX_l + NX_i)$.

$$\max_{N, X_g, X_k, X_a, X_l, X_i, A_k} \pi = P_y f\big(X_k, X_g, X_a, X_l, X_i, X_b\big)N - \sum_{i=1} P_{x_l x_i x_a}(NX_a + NX_l + NX_i) + P_g\big(A_g Y_g - NX_g\big) - C_g A_g\ C_k A_k - P_a NX_a - FC \tag{8}$$

$$\text{s.t. } A_k + A_g \leq \bar{A}$$

$$NX_k = A_k Y_k$$

VC_D =Variable costs in dairy production

N	=Number of cows in production
$f(.)$	=Production function for milk production
P_y	=Milk price
P_g	=Price of feed grain per kg DM
P_a	=Price of feed by-products per kg DM
A_k	=Area for silage or forage production
A_g	=Area for grain production
Y_g	= Yield of grain production in kg per ha
Y_k	= Yield of silage or forage production in kg per ha
X_k	= Kg silage of forage per cow
X_g	= Kg feed grain per cow
X_a	= Kg feed by-products per cow
X_l	= Hours of labor per cow
X_i	= Other variable inputs per cow
X_b	= Buildings
C_k	= Variable costs per hectare of silage or forage
C_g	= Variable costs per hectare of grain
FC	= Total fixed costs
$\bar{A}$	= Total land

The main product in a dairy farm is the milk yield, which can be read in equation 13 (Debertin, 2012). The milk yield from each dairy cow is individual and varies during the cow's lactation cycle (Phillips, 2010). In addition, the number of lactation periods affects the yield and figure 6 illustrates the variation in yield between primiparous and multiparous cows.

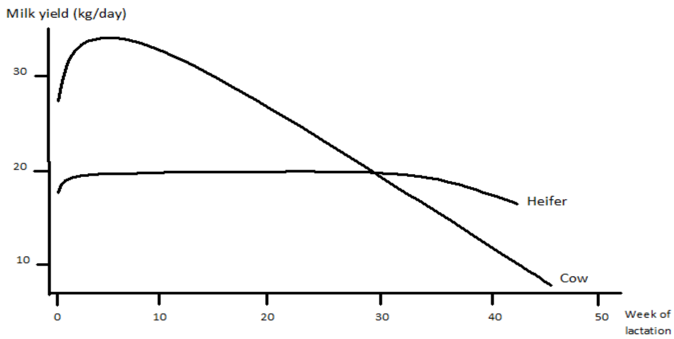

Figure 6. Level of milk yield during the lactation for multiparous and primiparous cows. Source: Phillips, 2010; Own processing.

Moreover, figure 6 illustrates that the yield declines closer to the dry period. The flatter lactation curve represents a primiparous cow and the peaking lactation curve relates to a multiparous cow. The total milk yield on the farm is often regularly produced and sold that in turn creates a relatively steady cash flow in the firm. However, other values in the production are manure and calves. The manure produced is spread on the fields, decreasing the need for other fertilizers. The calves are either used as recruitment heifers, decreasing the need to buy heifers outside the farm, or sold as live calves or sent for slaughter, which bring revenues to the business.

Furthermore, the milk yield depends on the feed ration, which can be composed by different ingredients with various proportions. For example, the ration can contain mostly roughage with high quality, roughage with medium quality *etc.* (Ekman, 1995). The feeding system is important since feed represents a large share of the cost (Phillips, 2010). The feed can either be produced on the farm or bought. In either case, it is a cost since producing the feed requires time and buying the feed requires capital. The feed can be valued to its operational cost which is the cost of using a specific resource in the production (Nilsson *et al*., 1983). The operational cost can be derived based on maximizing program in equation 8 and forming the Lagrangian function. The Lagrangian function enables the maximization or minimization of a function that is subject to one or several constraints (Pindyck & Rubinfeld, 2009). The Lagrangian function includes of the objective function, the constraint function and a Lagrangian multiplier (Debertin, 2012). The Lagrangian multiplier is usually referred to as shadow price and measure of the marginal cost of the fixed inputs at a certain level of production (*ibid*). Equation 8 formulated as a Lagrangian function is expressed in equation 9. However, A_k needs to be substituted with the condition $\frac{N*X_k}{Y_k}$ that expresses the cost for growing silage at the farm and not grain. The land constraint λ is added as a measure of the maximum available land.

$$\max_{N, X_g, X_k, X_a, X_l, X_i, A_g, \lambda} L = P_y f(X_k, X_g, X_a, X_l, X_i)N - \sum P_{X_l, X_i} N(X_l, X_i) + P_g(A_g Y_g - NX_g) - C_g A_g - C_k \frac{N*X_k}{Y_k} - P_a N X_a + \lambda\,(\bar{A} - \frac{N*X_k}{Y_k} - A_g) - FC \quad (9)$$

The first order necessary conditions are the first derivatives of the objective function with respect to the inputs as well as the Lagrangian multiplier, which are held equal to zero (Debertain, 2012).

$$\frac{\delta L}{\delta N} = P_y f(.) - \sum P_{X_l X_i}(X_i) - P_g X_g - \frac{C_k X_k}{Y_k} - P_a X_a - \frac{\lambda X_k}{Y_k} = 0 \quad (10)$$

$$\frac{\delta L}{\delta X_g} = P_y f'_{X_g}(.)N - P_g N = 0 \quad (11)$$

$$\frac{\delta L}{\delta X_k} = P_y f'_{X_k}(.)N - \frac{C_k N}{Y_k} - \frac{\lambda N}{Y_k} = 0 \quad (12)$$

$$\frac{\delta L}{\delta X_a} = P_y f'_{X_a}(.)N - P_a N = 0 \quad (13)$$

$$\frac{\delta L}{\delta X_l} = P_y f'_{X_l}(.)N - P_l N = 0 \quad (14)$$

$$\frac{\delta L}{\delta X_i} = P_y f'_{X_i}(.)N - P_i N = 0 \quad (15)$$

$$\frac{\delta L}{\delta A_g} = P_g Y_g - \lambda = 0 \quad (16)$$

$$\frac{\delta L}{\delta \lambda} = \bar{A} - \frac{N*X_k}{Y_k} - A_g = 0 \quad (17)$$

Equation 11 and 12 can be rewritten to equation 18:

$$P_y f'_{X_k}(.) - \frac{C_k}{Y_k} - \frac{\lambda}{Y_k} = P_y f'_{X_g}(.) - P_g \quad (18)$$

Equation 18 can be simplified to equation 19:

$$\frac{P_y MPP_{X_k}}{P_y MPP_{X_g}} = \frac{\frac{C_k + \lambda}{Y_k}}{P_g} \quad (19)$$

Note: equation 19: $P_y MPP_x = P_x$

Equation 19 expresses the cost for silage production with the current circumstances. The operational cost of silage production is expressed as $\frac{C_k+\lambda}{Y_k}$, where $\lambda = P_g Y_g$. Thus, λ is the shadow price for the land.

3.3.2 Dairy production disturbance

As mentioned, BI caused by fire forces the farmer to build a new barn in order to return to the production. However, a newly established dairy farm usually implies disturbances in the production, which in turn lowers production (Hansson & Olsson, 1996). This restrains production capacity and the farmer may not profit maximize. Factors connected to production disturbances are presented in figure 7.

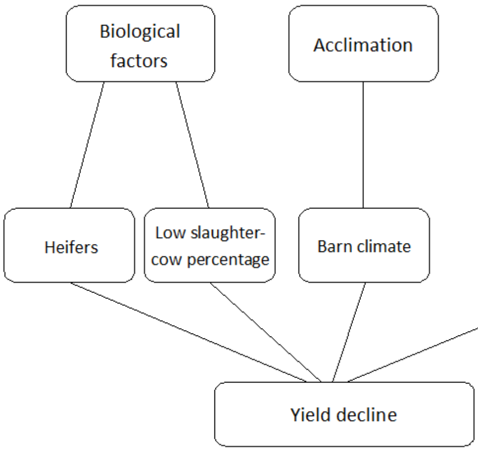

Figure 7. Factors which may lower the yield after rebuilding a barn. Source: Hansson & Olsson (1996); Own processing.

As observed in figure 7, reasons for production disturbances are partly biological since there may be a high percentage of primiparous cows that generally produce less milk than older cows. A high percentage of primiparous cows also lead to a lower number of slaughtered low-yielding cows, which also decrease the performance (*ibid*). Furthermore, the barn needs to be filled with the intended number of cows in order for it to be efficient (*ibid*). When the barn is not completely filled incomes from the milk yield is lost. The barn can either be filled by own recruitment heifers or with off-farm purchased cows. However, the barn is filled quicklier when the animals are bought off-farm resulting in both high milk yield and a higher number of culled cows (*ibid*). Further, the climate and design of the barn is important for animal welfare, which is important in order to obtain high producing cows (Phillips, 2010). If the cows are stressed in some way by the housing or by other cows, that will lower their milk yield (Phillips, 2010; Bruckmaier, 2005; Bruckmaier & Blum, 1998). Moreover, the dairy farmers need to learn their new barn before they are able to operate as effectively as in the previous one. These disturbances affect the business during a long period; it can take 1-2 years before the milk yield is back to normal (Hansson & Olsson, 1996).

3.4 Summary of the theoretical framework

BI theory is relevant for the present study when calculating the losses from a BI. In order to calculate the losses caused by a BI, it is common to compare the firm's financial records before and after the damage. A dairy production system involves large investments that are supposed to generate cash flows during many years. However, an investment subject to a BI is affected in a way that causes these expected cash flows to be disrupted. Investments can regard buildings, machinery, land *etc*. To calculate the PV of an investment there are different methods available depending on for how long and to what extent the investment is expected to bring a cash flow. A dairy barn is assumed to have an economic lifetime of 25 years.

Different assets that together create a cash flow can be explained by a production function, which consists of the combination of input variables that create the maximal output. This implies that the production function can be used in order to estimate the expected value in the production. Accordingly, it can be used to calculate the lost revenues in a production system when there is a fire destroying the dairy barn, implicating that no output can be produced. The main output in a dairy production is milk, the milk yield in turn depends on e.g. the size of herd, the proportion of first lactation heifers, barn climate, and the livestock's feed. Furthermore there are numerous other inputs in dairy production, which implies a complex environment. This creates a need for extensive assumptions when expressing a production function.

4 Method

The following chapter presents how this study is conducted. The chosen research approach and design is stated. Afterwards, the model for the calculations is presented, followed by reflections regarding the trustworthiness and ethical aspects of this study.

4.1 The research approach

In general, there are two broad research approaches that researchers use in order to carry out a study; the quantitative and the qualitative approach. The quantitative approach emphasizes numerical data while the qualitative approach typically implies collecting non-numerical data (Robson, 2011). The qualitative approach enables the researcher to understand connections and correlations in a situation (Bryman & Bell, 2013). The fundamental argument in favor of that approach is that research involves human interaction and therefore the researcher also needs to consider other factors than numbers and statistics in order to reach an understanding. The quantitative approach implicates a use of many observations, formal measurements and statistical analyses in order to make generalizations (Robson, 2011).

The findings and results of this study are not sought to be generalized and standardized, but a quantitative approach is suitable given that the study is developing a model to assess BI losses. The study is developed based on theory and existing concepts *i.e.* has a deductive logic, in order to obtain a solid understanding of the studied area, which is characterizing the quantitative approach (Bryman & Bell, 2013).

4.2 The research design

Apart from deciding what research approach to use, the researcher also needs to determine the design of the study. This is worth careful consideration so that the study will run smoothly and without confusing the researcher along the way (Robson, 2011). The research design may be either fixed or flexible, depending on how the study is performed. As previously stated, this study focuses on developing a model in order to reach the aim. The suitable research design is thereby of a fixed character (*ibid*). The fixed design is also suitable for quantitative studies that are theory driven, which this study is (Bryman & Bell, 2013).

According to Robson (2011), the research design is composed by the purpose, conceptual framework, research questions, method and sampling strategy. The first three components have been presented above but not the sampling strategy or the method. The sampling strategy implies from who, where and when the data is collected. Moreover, the method refers to the chosen techniques with which the data collection, analyses and the trustworthiness is established. The method to perform the study is fixed and predetermined before the data collection due to the fixed design. The data collection consists of both secondary and primary data, where the secondary data is extracted from previous research and literature, and the primary data is collected through quantitative case studies and telephone interviews with experts on the subject.

A mathematical model is developed to act as the foundation for the subsequently developed simulation model, in order to answer the research questions and reach the aim. Microsoft Excel is used to construct the simulation model, with consideration to the theoretical framework along with the literature review. This is necessary in order to be able to decide the variables that should be considered in the model. Different BI are simulated with regard to both primary and secondary data in order to estimate the losses due to BI. The simulations are implemented for a reference farm, which is used to validate the simulation model. The reference farm is a fictional farm that is constructed by the authors based on secondary data. The reference farm is presented in section 5.3.

4.2.1 Literature review

A literature review is conducted in order to identify what is already known within the specific research area (Robson, 2011). This study focuses on BIs in dairy production, which impacts the literature review. Databases such as Primo, Google Scholar and Web of Science were browsed, using different key terms like business interruption, insurance, agriculture, dairy farm, indemnity etc. Literature in both international and Swedish context is reviewed, although the setting for this thesis is in a Swedish context. Despite this, studies concerning BI in dairy production in particular were not found. However, one study regarding BI conducted in pig production is reviewed. Since there throughout were few articles in the agricultural sector addressing BI, studies regarding BI in non-agricultural settings have also been reviewed. Information and experiences concerning real BI in Swedish dairy productions are obtained through the case studies and the Delphi- method (Linstone & Turoff, 2002).

4.2.2 Quantitative case study

A traditional case study involves a detailed and close investigation of a phenomenon that is of particular interest for a study (Robson, 2011). A case study can be conducted as the single method in a research or together with other methods such as a quantitative modeling (Yin, 2012). In this study, two case studies are combined with the development of the quantitative simulation model as stated earlier. A quantitative case study can be suitable when no statistics is present in order to produce quantitative data for the studied setting (Yin, 2012).

The case study is suitable in studies with explanatory research questions (Yin, 2012). That refers to *how* and *why* questions, and the present study is addressing two *how* questions. The present study involves quantitative case studies among two dairy producers that have been exposed to a BI due to a fire and who have an agricultural insurance at Länsförsäkringar. These farmers are selected by Länsförsäkringar based on three preconditions, so that they are relevant for the study: they own an agricultural insurance covering BI, their BI occurred during the past seven years and the insurance loss adjustment is settled. Since data collection from real events is carried out, the case study is a beneficial method. However, it is important to be aware of the consequences due to having Länsförsäkringar selecting our case farms. One aspect is that the selected case farms may represent relatively uncomplicated insurance cases, thus there is a risk that problems arising from the BI might be overlooked.

The data collection in case study research can be both qualitative and quantitative (Yin, 2012). It can also be collected from several sources *e.g.* surveys, interviews, direct observations or archive records (*ibid*). The primary data in this study is collected through telephone interviews. In quantitative case studies it is especially important that the respondents are asked the same questions to ensure consistency (Yin, 2012). Hence, the questions are mainly structured and of quantitative character to produce quantitative data (Appendix 1). Although, some open questions are included in the questionnaire. The open questions contribute with qualitative data providing a deeper understanding of the studied setting (Bryman & Bell, 2013). However these are not the main focus in this case study since the foremost purpose is to produce quantitative data. Hence the in-depth analysis that case studies traditionally involve is constrained.

By conducting the interviews, the study recieves important information of BI and the problems arising from them. As previously stated, this information is subsequently used to develop BI simulations in the reference farm. The relevant information and data concerns how the farmers perceive that their businesses were affected, both during the BI and afterwards when the production was restarted. The aspects regarding time and production disturbances are of particular interest since there seems to be a shortage of information about that in previous research.

4.2.3 Delphi method

In those aspects where the outcome still is unclear and where there appears to be many different alternatives, there is a need for further investigation. Thus, the Delphi-method can be applied. The Delphi-method includes interviews and/or questionnaires with experts to obtain their opinions in a subject and to create a common standpoint (Linstone & Turoff, 2002). The interviews and questionnaires can be conducted several times to obtain a focused result. Although, the process stops when a result is definable (*ibid*).

In this thesis, a part of the Delphi-method is used to collect assessments from experts regarding installation problems, time needed to build a barn and the livestock's adjustment to the new barn. Telephone-based interviews were conducted with four experts. Two of them work at Växa Sverige, which is a Swedish organization that, for example, offers advisory services to dairy producers (www, Växa Sverige, 2016). The other two are claim adjustors at Länsförsäkringar. Thus, the experts in this thesis have knowledge about real events regarding fires in dairy operations. This primary data is as earlier mentioned used in the development of the BI simulations. The experts provide general data that can be applied in several settings. The process stoppes after the first round of interviews since a result is defined.

4.2.4 Simulation model

A simulation model is developed in order to estimate the economic losses due to a BI in a dairy production. A simulation implies that the examined situation and environment is constructed by the researcher with the intention to study the effect and outcome of a manipulation of this setting (Bryman & Bell, 2013). It is a well-known method to apply when the object is to learn about a real situation by using a representative model for this situation (Andersson *et al*., 2000). The environment in this study consists of the reference farm, where the BI is simulated.

A simulation model may involve controllable inputs, selected by the researcher, which produces an output (Andersson *et al*., 2000). This is illustrated in figure 8.

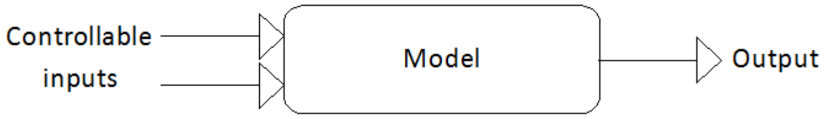

Figure 8. The general characteristics of a simulation model. Source: Andersson et al. (2000); Own processing.

The input parameters that are considered to be adjustable in this study are: number of cows, milk yield per cow, milk price, labor, feed production and the investment in the production. These inputs are extracted from equation 8 in the theoretical framework and literature review since they are recognized to be important for the output in dairy production. Moreover, the output is represented by the total milk production, manure, silage and calves.

Since a dairy production is highly individual, it is of interest to simulate a BI in different settings to be able to observe how the economic losses are affected. Therefore, the milk price, milk yield and herd size are changed in the reference farm in order to identify how these different variations affect the output and to what extent (*ibid*). The variations are based on factors extracted from the theoretical framework to be important for the profitability in the business. Costs are also shown to be highly influencing the profitability in dairy productions. However, only the costs themselfs are not changed. The changes in cost that occur are due to the changes made in the above mentioned variables. This may distort the results of production losses due to a BI. Table 3 provides a summary of the key characteristics that are implemented in the different simulations.

Table 3. Presentation of the key characteristics in the simulations. Source: Own processing

Simulation	Key characteristics
1	80 dairy cows, Low milk yield, 3,223 Milk price
2	80 dairy cows, Low milk yield, 2,537 Milk price
3	80 dairy cows, High milk yield, 3,223 Milk price
4	80 dairy cows, High milk yield, 2,537 Milk price
5	180 dairy cows, Low milk yield, 3,223 Milk price
6	180 dairy cows, Low milk yield, 2,537 Milk price
7	180 dairy cows, High milk yield, 3,223 Milk price
8	180 dairy cows, High milk yield, 2,537 Milk price

The low milk yield implies that the highest lactating dairy cows in that herd yield 10 000 kg energy corrected milk (**ECM**)/year and the high milk yield implies that the highest lactating dairy cows in that herd yield 12 000 ECM/year. The measurement ECM is a synonym to milk with 4% fat (Spörndly, 2003). In addition, the variations between the dairy cows in the herd are divided according to the index in table 5, presented later on in section 5.3.1.1. The received milk price is initially at 3,223 SEK/kg ECM, based on an average of future expectations in the European market presented in FAPRI World Agricultural Outlook Database (2011). The price is adjusted for inflation. In addition, the lower milk price of 2,537 SEK/kg ECM is representing the price in March from the Swedish dairy coopertative Arla (www, Jordbruksaktuellt, 2016).

4.3 Loss calculation of a business interruption

The losses due to a BI depend on how long the interruption lasts as well as how long time it takes for the producer to be back in full production (Gaughan, 2009). Losses are usually measured until the business' profits of sales have recovered (Slee, 2011). The loss period can be closed, open or infinite (Gaughan, 2009). The closed loss period refers to BI cases where the loss period ends and figures about the sales are available both before and after the BI. Moreover, with an open loss period, the losses are continuing into the future *i.e.* the business does not recover to the growth path before the BI. Finally, the infinite period of loss address BI situations where the operation is shut down. In the present study the loss period is regarded as closed and the figures before and after the BI are available through the simulations.

Moreover, the losses from a BI can be analyzed with different methods (Slee, 2011). The method should be selected based on aspects such as profitability historically, the business nature as well as future probabilities (*ibid*). Furthermore, the intention with the business is an important consideration because if the company was about to carry out an investment there could be reason to assume an increase in the company's profitability (*ibid*).

A logic way to proceed is to compare the turnover in a pre-interruption period with a corresponding period post interruption (Gaughan, 2009; Roberts, 2011). This is the UK approach mentioned earlier in the theoretical chapter and it is usually implemented in Sweden (Roberts, 2011). The turnovers are compared with the intention to assess the effects of a BI on the business' earning capacity (*ibid*). This creates the possibility to measure the effects and shortage in turnover without waiting until the business' financial year has ended. Another option could be to compare annual profits, but if the damage extends between the financial years it will impact the profit during the next year as well (Gaughan, 2009). Thus, in this study the loss in turnover during the period when the farmer is subject to BI is regarded. This is then compared with the turnover of a pre-interruption period.

The UK approach can also be argued for since the loss of turnover has been proven to be an adequate yardstick to measure the net effect on the business' earnings due to a BI (Roberts, 2011). The variable expenses such as wages, energy and other inputs in the process are likely to vary proportionately during changes in turnover, whereas the standing charges are less likely to do so. However, the standing charges remain stable and they will not fall proportionately. Thus, the incidence from standing charges will increase and reduce the net profit. The net profit is also reduced since the volume of turnover is smaller (Cloughton, 1991). Exceptions from this are likely to refer to the wages since they are subject to legal issues.

4.3.1 Legal aspects of employment

According to LAS (SFS 1982:80), termination of an employee due to redundancy requires evidence that there is a shortage of work. The employee also has a period of notice in which he/she has the right to continued salary and other benefits, along with a right to reasonable permission to look for new employments (LAS, SFS 1982:80). The period of notice is at least one month, although it increases with the length of the employment. A person who has been employed for 2-4 years has the right to two month period of notice and at 4-6 years of employment the lenght is three months (LAS, SFS 1982:80). The maximum period of notice is six months which regards those who has been employed for ten or more years. However, the employer has according to the same law the right to deduct possible new earnings that the employee receives from a new employment. Also earnings that the employee obviously could have earned during the period of notice can be deducted (LAS, SFS 1982:80).

4.4 Mathematical model

The mathematical model is based on the theoretical framework presented in chapter 3. In addition, the previous section concerning the loss calculation if a BI influences the model with a comparative feature, implying that different time periods need to be identified. Thus, the underlying technique is to compare a situation of business as usual (**BasU**) with a situation of BI. The important time periods are evident in figure 9, which shows an illustration of the theoretical implication due to a BI in an investment. The first time period involves the BasU, which is the time when the production is functioning as normal before a BI. The second period is comprised of the BI, which is limited to the time where the building is under reconstruction. This is followed by the third period of S-U, which considers the fact that it takes time to regain the same production level as before the BI. The fourth period includes the remaining time of the investment's economic lifetime.

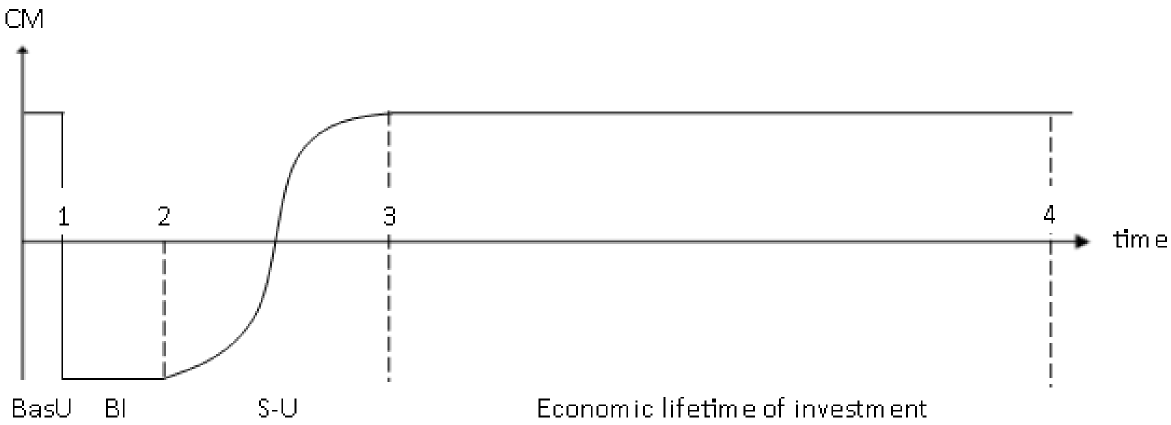

Figure 9. Illustration of a BI. Source: Own processing.

The mathematical model is denoted in equation 20. The equation shows a calculation of the PV of the investment in a dairy production, where the values are discounted with a discount rate of 5% (Lagerkvist, 1999). The first three years are calculated on a monthly basis and discounted accordingly. The following years until the economic lifetime is reached are calculated annually and discounted accordingly. The economic loss due to the BI is derived as the difference in PV between an investment with BasU and an investment subject to a BI. Thus, two PV are calculated for each simulation and are then compared with each other. Both PV with BasU and PV with BI are calculated accordingly to equation 20.

$$PV = \sum_{m=1}^{36} \frac{\left(\left(\sum_{l=1}^{3}(I-C)_{l,c,f,m} * M_{l,c,f,m}\right) + (I-C)_{h,f,m} * H_{f,m} - P_{l,c,f,m} * M_{l,c,f,m} - FC_m\right)}{(1+i)^m} + \sum_{t=4}^{25} \frac{\left(\left(\sum_{l=1}^{3}(I-C)_{l,c,f,t} * M_{l,c,f,t}\right) + (I-C)_{h,f,t} * H_{f,t} - R_t - FC_t\right)}{(1+i)^t} \quad (20)$$

$I_{l,c,f,m}$	= Income from a cow in lactation l, calving time c, feed amount f in month m
$C_{l,c,f,m}$	= Cost for a cow in lactation l, calving time c, feed amount f in month m
$M_{l,c,f,m}$	= Number of cows in lactation l, calving time c, feed amount f in month m
$I_{h,f,m}$	= Income from a heifer that recieves feed amount f in month m
$C_{h,f,m}$	= Cost for a heifer that recieves feed amount f in month m
$H_{f,m}$	= Number of heifers that recieves feed amount f in month m
$P_{l,c,f,m}$	= Price for a cow in lactation l, calving time c, feed amount f in month m
FC_m	= Fixed costs month m
$I_{l,c,f,t}$	= Income from a cow in lactation l, calving time c, feed amount f in year t
$C_{l,c,f,t}$	= Cost for a cow in lactation l, calving time c, feed amount f in year t
$M_{l,c,f,t}$	= Number of cows in lactation l, calving time c, feed amount f in year t
$I_{h,f,t}$	= Income from a heifer that recieves feed amount f in year t
$C_{h,f,t}$	= Cost for a heifer that recieves feed amount f in year t
$H_{f,t}$	= Number of heifers that recieves feed amount f in year t
R_t	= Reinvestments in year t
FC_t	= Fixed costs in year t

4.5 General assumptions in the mathematical model

The mathematical calculations in this study is developed by using data from Agriwise if nothing else is stated. Agriwise is a database that consists of information adjusted for economic planning and analysis in agricultural business (www, Agriwise, 2015). The figures in the database regarding prices *etc*. are updated regularly. Some general assumptions for the mathematical model are presented subsequently, with regard to the different time periods that are identified.

4.5.1 Business as Usual

The starting point in the model is that the reference farm is operating as usual with the characteristics presented later on in section 5.3. The farmer is assumed to strive at profit maximization in terms of choosing grain, silage and other inputs in an optimal manner according to equation 9. An investment at year 0 composes the basis of the dairy production, which is expected to generate a CM during the economic lifetime of 25 years. The CM is assumed to be constant during the economic lifetime. The CM is based on income and costs. The dairy cows and heifers produce milk, meat and manure which compose the dairy production incomes. Dairy costs involve feed, feed production, labor and other incremental costs.

4.5.2 Business Interruption

In December, a fire is assumed to ruin the dairy barn. The rebuilding is assumed to take twelve months, thereby the BI last for twelve months. The farmer intends to resume dairy production as prior to the accident. Thus, the new barn has the same characteristics and inventory as the previous building. Moreover, feed production is carried out as normal. The surplus of feed from the previous harvest is sold to the operational cost according to equation 19.

A fundamental assumption is that no dairy cows survive the fire. This implies that the study does not consider if the farmer would have an alternative building to lodge and milk the dairy cows in or if the entire herd can be sold. According to the interviewed experts, it is common that any surviving cows are slaughtered if the livestock barn is destroyed along with the milking equipment, since the cows need to be milked daily. Hence, the case with no surviving dairy cows is realistic. As a result, no milk is produced. However, the recruitment heifers are assumed to be unaffected by the fire since they are assumed to be kept in a separate building.

4.5.3 Start-Up

The S-U process is assumed to begin in January, twelve months after the fire, when the new barn is completed. The farmer purchases new dairy cows as a herd from another farm and their lactations are assumed to be evenly distributed over the year, as during BasU. However, this procedure does not fill all places in the new barn. The remaining places are filled monthly by the own recruitment heifers that survived the fire. This implies more primiparous cows in the production. However, the losses would be even higher if the heifers are affected by the fire since that implies that an entirely new herd must be purchased in order to resume the production.

4.5.4 The remaining time of the investments economic lifetime

After the S-U, the CM is assumed to be on the same level as during BasU. Furthermore, the investment after a BI appears one year later than the initial investment which needs to be adjusted for in order to make the scenarios comparable. In addition, a reinvestment in building equipment is required regardless if there is a BI or not. These are regarded in the calculations as a lump sum in year 12 during the buildings economic lifetime.

4.6 Trustworthiness

The concept regarding trustworthiness in quantitative research involves fundamental issues regarding validity, reliability and generalizability (Robson, 2011). Validity refers to if the researcher is measuring what was intended to be measured. Reliability is connected to the chosen measurement tools and how accurate it is to use them in the studied setting (Bryman & Bell, 2013). If the reliability is low, the results cannot be valid (Robson, 2011).

The intention with the mathematical model is for it to be especially applicable to dairy production. To validate that the mathematical model is measuring what was intended, the model is reviewed by persons with knowledge of the subject. This ensures that the mathematical model is valid to apply in the studied environment. The reliability of the results is established by comparing the results with previous literature and studies. Also, a thorough work on the method chapter enhances the reliability by using methods suitable for the subject. Furthermore, experts on BI, production disturbances and animal nutrition are contacted to further ensure the reliability of the figures used in the model.

To further enhance the trustworthiness a sensitivity analysis is conducted. A sensitivity analysis involves testing how much the inputs in a mathematical model contribute to the output (Robson, 2011). This is done by changing one input variable while keeping the others constant. This enhances the understanding of the model and helps to find input variables that may be redundant or wrongfully adapted (*ibid*). The sensitivity analysis includes a change in the milk price and a change in the milk yield in the simulations.

4.7 Ethical aspects

Ethical aspects need to be taken into consideration in most research and during the whole process. In research involving human beings this is especially important (Oliver, 2010), which is the case in the present study. The researcher has responsibilities towards participants so that they are not harmed in any way, not physically nor psychologically (*ibid*). Furthermore, the researcher also has responsibilities towards fellow researchers, the public and the academic community. Thus, it is of utmost importance that the researcher is honest and present reliable and understandable information (*ibid*).

When working with interviews there is a need to work through some ethical steps. First the researcher needs to fully inform the participants about the study, how it will be conducted and their contribution to it (Oliver, 2010). Second, there is a need for consent from the participants to present their answers in the study, at this way it is important to offer anonymity to the participants (*ibid*). If tape recorders are used the participants should be informed about this. The case farms in this study are in the initial step contacted by Länsförsäkringar who afterwards gave consent to contact them. Then, the participants were sent an e-mail in which the purpose of the interviews was presented along with information about the questions (Appendix 1). All interviews are conducted through telephone and the interviewed people are treated with confidentiality and presented anonymously in the thesis.

One great concern in this thesis is not to harm the relationship between Länsförsäkringar and their customers. It is possible that the loss estimations in this thesis reveal a deviating amount relative to the indemnity that was payed to the farmers. This could lead to conflict. However, all participants are informed about that the values in thesis are estimates. Hence, no exact indemnities are calculated. Also, they are informed that the calculations origin from the reference farm and are therefore not a reflection of each case farm.

5 The empirical setting

This chapter provides information about the empirical setting for the study. The quantitative case studies and the interviews with the experts are pronounced, which act as a foundation to the different simulations that are developed. Afterwards, the reference farm is presented, where the simulations are made.

5.1 The case farms

By doing the quantitative case studies, the study gains information of BI characteristics that is used in the simulations. Table 4 presents the main features from the case farms, where the outline is inspired by the questionnaire (Appendix A) that is applied in the interviews.

Table 4. Characteristics of the case farms. Source: Own processing

Business before the fire	**Case farm 1**	**Case farm 2**
Milking system	Stanchion barn	Stanchion barn
Number of dairy cows	20	50
Age distribution in years	0-10	0-5
Milk yield, kg ECM	8000	<8000
Recruitment heifers	Own breeding	Own breeding
Recruitment percentage	37,5%	40-45 %
Feed, roughage	Own production	Own production
Feed, concentrate	Purchased	Purchased
Employee/ Intern	0	1 Intern
Business interruption		
Month when fire occured	April	May/June
Surviving animals	Only a few calves	All
Months required to rebuild barn	11	31
Feed production during BI	A small amount sold	Kept
Work for farmer	On new building	On new building
Work for employee/ Intern	---	On new building
Start-up		
Number of cows positions	30	132
Milking system	Milking stations	Batch
Filled cow units in barn the first week	83%	67%
Months until 100 % filled positions	10	12
New herd	50 % primpiarous, 50 % older	50 % primpiarous, 50 % older
Milk yield, kg ECM	9500	>8000
Production disturbances	Learning process, higher stress on the legs	Have not been able to cull cows yet

The most relevant features in this study are the once regarding the BI and the S-U. In addition, the recruitment percentage, feeding system and age distribution is of importance for the simulations. As the table illustrates, after the BI both farms changes milking system since it is not leagal to build stanchion barns today (www, Jordbruksverket 2, 2014). They also expand the number of cows in production, yet such characteristics are not changed in the simulations. However, they are interesting for the discussion of the business before and after the BI.

5.2 The expert interviews

The interviews with the experts reveal several possible production disturbances when re-starting dairy production. The disturbances are regarded as similar to the disturbances related to starting a new dairy production. However, they depend on the possibility to buy the herd from the same place instead of mixing herds. The problem with mixing livestock from different herds is partly health related due to entries of various diseases and contaminations. In addition, stress increases when the cows need to develop a new hierarchical structure, which decreases the milk yield.

The experts argue that it is easier today to get hold of a complete dairy herd since many dairy producers are exiting their business. However, the possibility depends on the size of the herd. They argue that it may be possible to find a herd of up to 60 cows, but it is probably harder to find a complete herd consisting of 70 cows or more. Moreover, planning is essential when a barn has burnt down. The farmer should start planning how to get hold of new livestock as soon as possible. The situation one year after the production has restarted is something that is often overlooked. Since a heifer needs two years of breeding before producing the first calf there will be a gap of heifers the second year after S-U, unless new heifers are bought the second year. The first heifers calve the first year and then it will take two years before the new born calves are ready to breed their own calves. The gap creates a lack of recruitment heifers and thus, no new cows will enter production, decreasing the possibility to cull low producing cows.

Furthermore, in a newly established barn there are often disturbances with the different systems and both the cows and the farmer need to get acquainted with the new barn. This is highly individual and depending on the former systems in the farm. The experts argue that it normally takes 12-14 months before the production is operating like prior to the fire. However, seasonality and location may affect this time period since it is harder to build new barns during winter due to the cold.

5.3 The reference farm

The reference farm is a conventional dairy farm located in the forest districts of Götaland since this is the district with the most dairy productions in Sweden (www, jordbruksverket 3, 2014). The farmer has 53 hectare arable land for silage production and 27,5 hectare of pasture, which is assumed to cover the roughage requirements of the 80 Swedish Holstein (**SLB**) dairy cows and 30 heifers that the herd size is comprised of. The size of the reference farm is due to the average herd among Swedish dairy producers, which is 81 cows (www, Jordbruksverket 4, 2015). The most cows in Sweden are SLB cows (www, Växa Sverige, 2016). The cows are held in a non-isolated free-stall barn and are milked with one VMS robot (www, Agriwise, 2015). The dairy cows lactate in between 8000- 10 000 kg ECM/year, with regard to the index in table 6. The highest milk yield 10 000 is determined by the average milk yield for dairy cows in Sweden included in the milk recoding year 2014 (www, Växa Sverige, 2016).

The work requirements are linked to the characteristics and mechanization in the dairy barn. The main factors affecting the work requirements are the milking system, manure removal system and feeding system (Gustafsson, 2009). A conventional dairy farm may require about 31,7 hours per dairy cow and year while with a VMS technology the need may be decreased to 22,3 hours per cow and year (*ibid*). Moreover, Gustafsson (2009) argues that the number of dairy cows may affect the work amount needed per cow. A higher number of cows reduce the required amount of work per cow. The total working hours in the reference farm are divided on the number of dairy cows, heifers and hectares of cultivated land. The annual working hours per dairy cow and heifers are determined to 22 h and 8 h respectively. Moreover, the feed production requires 4,8 h/hectare round-bale silage and 2,2 h/hectare pasture. Hence, this farm require 2314 hours of work per year which represents 1,25 persons working full time, where one full time job implies eight hours per day for 227 days. Thus, the farmer works full time and has an employee working 25% with 220 SEK/ hour. The employee is assumed to have been employed for three years, which implies a two month period of notice (LAS, SFS 1982:80). Table 5 provides a summary of the characteristics of the reference farm.

Characteristics	**Reference farm**
Milking system	1 VMS
Number of dairy cows	80
Number of heifers	30
Milk yield, kg ECM	8000-10000
Milk price/ kg ECM	3,223
Hectares silage production	53
Hectares pasture	27,5
Working hours	
Per cow/ year	22
Per heifer/ year	8
Per hectare silage	4,8
Per hectare pasture	2,2
Total hours of work	2314
Employee 1	25%

*Table 5. Summary of the characteristics in the reference farm***.** *Source: Own processing*

5.3.1 Business as Usual

The following section addresses the BasU with regard to the dairy production incomes and costs in the reference farm.

5.3.1.1 Dairy production incomes

The main income in dairy production flow from the milk revenues, which depend on the milk price and milk yield. The milk price is known to be rather volatile and the milk yield depends on calving time for dairy cows and their number of lactations (Ekman, 1995; Gunnarsson, 2002). Dairy cows have a yearly cycle that involves calving, lactation and dry period before the next calf is born. The annual lactation cycle is assumed to be twelve months, with ten months (305 days) lactation and two months (60 days) dry period if the cow is kept in production (Ekman, 1995; Steeneveld *et al*., 2014).

Both Ekman (1995) and Gunnarsson (2002) present an index that shows the variation in the milk yield depending on when the lactation begins and the lactation number of the cow. Gunnarsson's (2002) index is presented in Table 6 and is applied to the reference farm.

Table 6. Indexes over milk yield with regard to a dairy cow lactating for the first time in Jan-Feb and milking two times a day. Source: Gunnarsson, 2002; Own processing

Period / Lactation	Lactation 1	Lactation 2	Lactation 3
Jan-Feb	1,000	1,128	1,194
Mar-Apr	0,982	1,133	1,191
May-Jun	0,980	1,091	1,175
Jul-Aug	0,997	1,086	1,130
Sep-Oct	1,001	1,119	1,183
Nov-Dec	1,007	1,127	1,208

The dairy cows are assumed to calve with an even distribution during the year. They are distributed over lactations one, two and three. Cows who enter lactation three or higher are expected to follow the features of a third lactating cow. According to table 6, cows calving for the third time and in late autumn show the highest milk yield, while cows calving for the first time and in the beginning of the summer represent the lowest milk yield.

Dairy cows are continuously culled after lactation when they do not meet the production goal, in order to be replaced by recruitment heifers (Ekman, 1995). The number of culled dairy cows is therefore equal to the number of recruited heifers. Thus, the distribution over different lactations depends on how the dairy cows are culled. Culling is necessary in order to maintain a high average milk yield at the farm. Other reasons for culling can be age, disease, difficult calving and other genetic factors (Phillips, 2010). The price for a culled cow is obtained from current market prices and represent an income to the farm. The weight of the dairy cows increases with the number of lactations, where the figures are extracted from Koenen (2001). The study assumes that a primiparous dairy cow weighs 560 kg at 24 months age, a second lactating dairy cow weighs 595 kg at 36 months, a third lactation dairy cow weighs 625 kg at 48 months and dairy cows older than 60 months weighs 635 kg.

The calves are a bi-product from dairy production and it is assumed that half of the calves born are males and the other half are females. The calves kept on the farm are the females that will be recruited into the dairy production after 24 months of breeding time. These animals are held in another building than the dairy cows. The age distribution is evenly distributed since the dairy cows calve regularly. The female calves that are not meant to be recruited into production is together with the male calves sold as life calves to the current market price. Another bi-product in dairy production is the manure produced that can be spread on the fields. This is valuable for the farmer since it lowers the need to buy other fertilizers. The amount of manure depends on number of cows and heifers.

5.3.1.2 Dairy production costs

The largest incremental costs distributable to dairy production are related to feed consumption, which is influenced by feed requirements among the livestock. During the lactation cycle, the dairy cows have different nutritional needs in order to produce the desired milk yield and thereby the rations are varied in order to be efficient (Phillips, 2010). Spörndly (2003) presents an equation to calculate the standardized dry matter (**DM**) intake required at different lactation levels, which is presented in equation 21.

$$0{,}43 * \text{kg ECM/day} + 5{,}7 = \text{DM intake/day.} \tag{21}$$

Equation 21 illustrates that a cow with a high milk yield requires more DM per day than a cow with lower milk yield. The equation is used for the lactation period but not during the dry period. During the dry period, the dairy cows are given 12 kg DM/ day (Pers. comm., Spörndly, 2016).

The applied proportion between roughage and concentrate is influenced by the study of Spörndly & Kumm (2010) who argue in favor for a proportion of 60% roughage and 40% concentrate. The roughage is comprised by silage or pasture, the concentrate is divided on 50% grains (wheat and barley) and 50% complementary feeding stuffs (Pers. comm., Spörndly, 2016). The concentrate is purchased off farm at a price recommended by Spörndly (Pers. comm., 2016). The dairy cows are held on pasture during the grazing period June-September. During the dairy cow's dry period a feed ration with the proportion of 80% roughage and 20% concentrate is implemented (Pers. comm., Spörndly, 2016).

The recruitment heifers also require feed during the breeding. The heifers get a feeding ration composed by 1483 kg DM roughage in terms of silage, 315 kg grain and 44,5 kg complementary feeding stuff during 12 months. The heifers have a yard connected to their barn where they can be outside during the summer months and are thereby not held on pasture.

In a conventional dairy system, the calves consume liquid at a minimum of 15% of their body weight, representing 5-7 liters, of colostrum the first couple of days (www, Jordbruksverket 5, 2007). After that time, the calves continue to drink milk for at least six weeks, along with calf starter and hay (www, DeLaval 3, 2011). For this, the farmer can choose to either continue to feed the calves with whole-milk or to use milk formula (*ibid*). In the reference farm, the calves are given whole-milk, which lowers the milk yield from the dairy cows during those weeks.

Moreover, other incremental costs in dairy production include litter, medicine, labor, electricity, insurance and maintenance. All of these costs and amounts are general figures that one dairy cow or heifer is assumed to carry regardless of herd size, except for the labor.

5.3.2 Business Interruption

Because of the even age distribution among the heifers, some of them are already inseminated when the fire occurs and some are soon to be calving. These heifers are sold regularly during the year, resulting in extra income. Only the heifers that are not yet inseminated are kept on the farm in order to be recruited into the new herd when the BI is over. These heifers are assumed to graze the pasture since there are no dairy cows to do this.

During the BI, the farmer works with the remaining business such as the care of heifers and the feed production. This is not enough for a full time job and except from that, the farmer also works on rebuilding the barn and has no side income from another work. Since the work requirements at the farm are reduced during the BI, there is no room for employees. Thereby, they are assumed to have to quit but the farmer still needs to pay their salary during the period of notice. The farmer also needs to pay the continuing incremental costs that regard the heifers and the feed storage. The destroyed barn also carries a fixed cost due to the resource consumption in the building and feeding system, which regards the size of the investment as well as the technical life cycle. Thus, it involves the amount of resources that is consumed and assignable to one year of the technical life cycle.

5.3.3 Start-Up

The farmer is assumed to be able to employ a person at 25 % in order to meet the work requirements again. The first week the building is filled by 75% of the cows where half of them are primiparous cows, one quarter are second lactation cows and the last quarter are cows in third lactation or more. The older cows are purchased from another farm and can therefore be assumed to be evenly distributed across lactations.

5.3.4 Changes in the setting due to the simulation of a larger herd

The reference farm is slightly changed during the simulations with a herd of 180 dairy cows. The bigger production requires two VMS robots and two employees, where one works 100% and the other works 58%. The farmer has 119 hectares arable land for silage production as well as 62 hectares of pasture. The silage is stored in a silo, which requires 5 h work/ ha. Moreover, when the new barn is rebuilt after the BI, it is only filled to 50 %. The reason is that it is usually diffucilt to get hold of such a large number of livestock at once. However, the proportions of dairy cows in different lactations remain the same.

6 Results

In this chapter, the essential results from the simulation model, with regard to the research questions, is presented. They act as a foundation to the following analysis and discussion.

6.1 Business Interruption's effect on the milk yield

The total milk yield is recognized to be the main output in a dairy production. Figure 10 illustrates the milk yield in *simulation 1* of the reference farm during BasU, the BI as well as when the production has restarted.

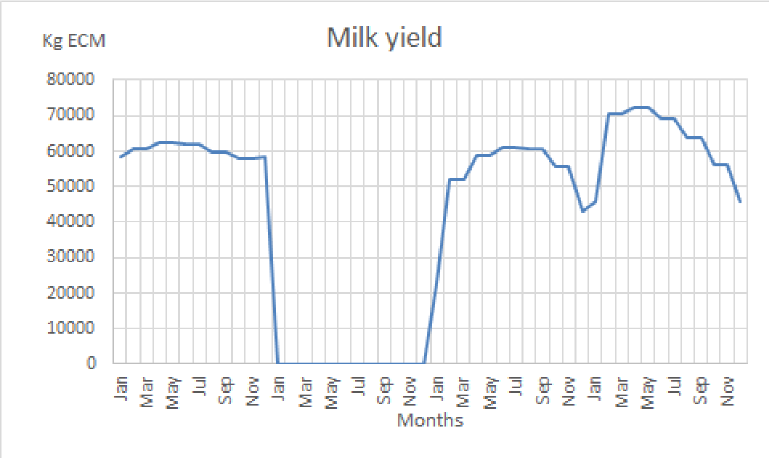

Figure 10. Illustration of the milk yield during four years in simulation 1. Source: Own processing.

The first year represents the BasU and reveals a relatively even distribution of milk production across the year. The second year represents the BI and it can be noticed from Figure 10 that no milk is produced during this time. In January after the BI, the production is restarted and the first milk yield is noticed in February. During the first year of S-U, the lactation curve is both lower and more uneven than it was before the fire. The second year of S-U shows a higher peak in milk yield than the previous years, however the milk yield remains uneven. In the other simulations, this is also visible, although the curve during the S-U years is shaped differently.

6.2 Business Interruption's effect on the contribution margin

This section illustrates and describes the results from the different simulations regarding the CM. Table 3 from the method chapter is presented again to provide a reminder of the different key characteristics in the simulations.

Table 3. Presentation of the key characteristics in the simulations. Source: Own processing

Simulation	Key characteristics
1	80 dairy cows, Low milk yield, 3,223 Milk price
2	80 dairy cows, Low milk yield, 2,537 Milk price
3	80 dairy cows, High milk yield, 3,223 Milk price
4	80 dairy cows, High milk yield, 2,537 Milk price
5	180 dairy cows, Low milk yield, 3,223 Milk price
6	180 dairy cows, Low milk yield, 2,537 Milk price
7	180 dairy cows, High milk yield, 3,223 Milk price
8	180 dairy cows, High milk yield, 2,537 Milk price

At first, the simulations for a larger herd, which implies that silage is stored in a silo, show an operational cost of 1,30 SEK/ kg DM for silage. This is a lower operational cost than the farmer in a smaller herd is assumed to operate, which is 1,56 SEK/kg DM. Figure 11 displays the CM between BasU and the CM during and after the BI. They contain the first four years of an investment with BasU and an investment subject to BI.

Simulation 1. In figure 11, the CM during four years are illustrated, where the first year refers to BasU, the second when the farm is subject to a BI and the third and fourth portray the S-U years after the BI.

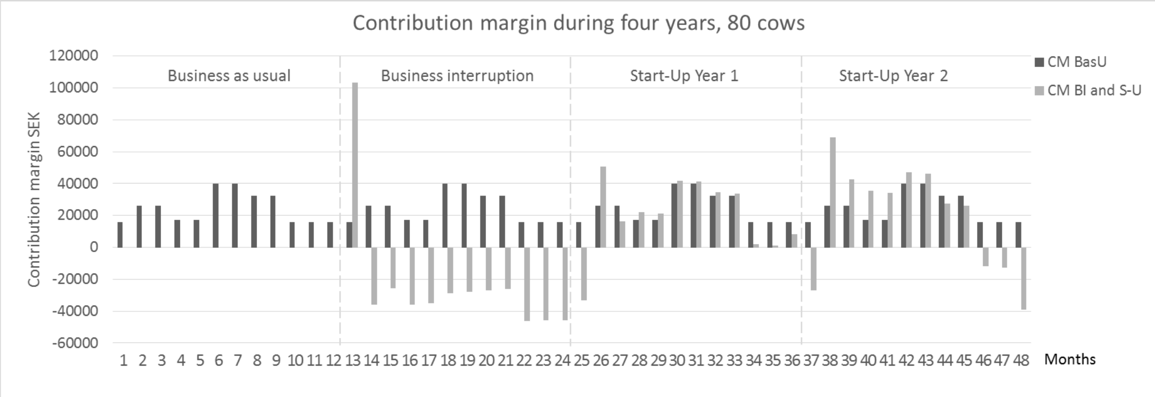

Figure 11. Illustration of the CM during four year in simulation 1. Source: Own processing.

BasU yields an annual CM of 294 677 SEK, which is the sum of the bars in figure 11 that refer to the original CM during one year. During the BI, the CM is -276 692 SEK, which is the sum of the bars referring to the CM BI and S-U between month 13-24. The CM during the first S-U year equals -282 481 SEK, as the bars referring to CM BI and S-U between months 25-36 illustrate, except for one adjustment: the CM during S-U year 1 is adjusted in figure 11 by adding back the cost to purchase the new livestock in month 26. The cost implies a large non-recurring cost of 275 000 SEK and impacts the bar month 26 in a manner that makes it difficult to read the values and variations between the other bars. The cost of purchased livestock is however included in the CM. The second year of S-U equals a CM of 237 347 SEK, as the bars 37-48 show.

Simulation 2. In figure 12, the CM during four years are illustrated accordingly to figure 11. There is a major difference compared with *simulation 1* due to the lower milk price.

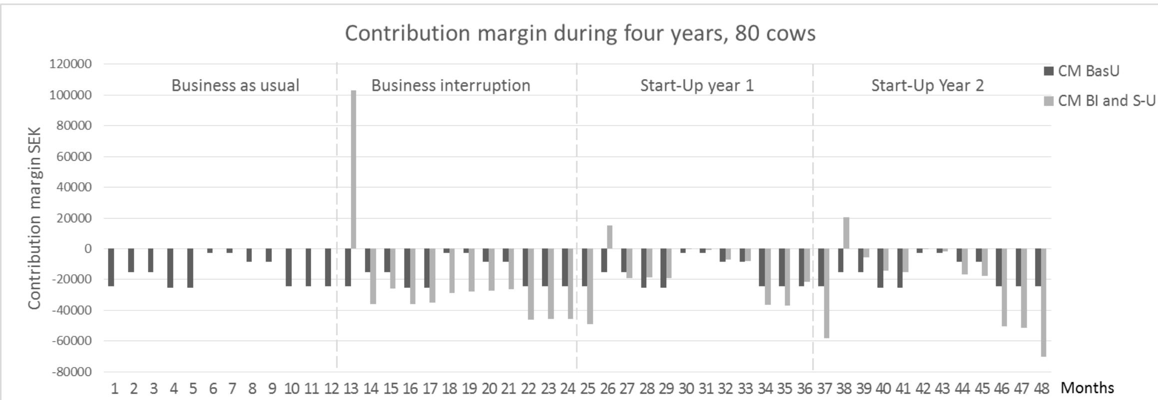

Figure 12. Illustration of the CM during four year in simulation 2. Source: Own processing.

BasU yields an annual CM of -201 587 SEK and during the BI, the CM is -276 692 SEK. The CM during the first S-U year equals -476 155 SEK, except for the adjustment that is mentioned in association to figure 11. The cost to purchase a new herd is added back in month 26. The second year of S-U equals a CM of -281 611 SEK.

Simulation 3. In figure 13, the CM during four years are illustrated.

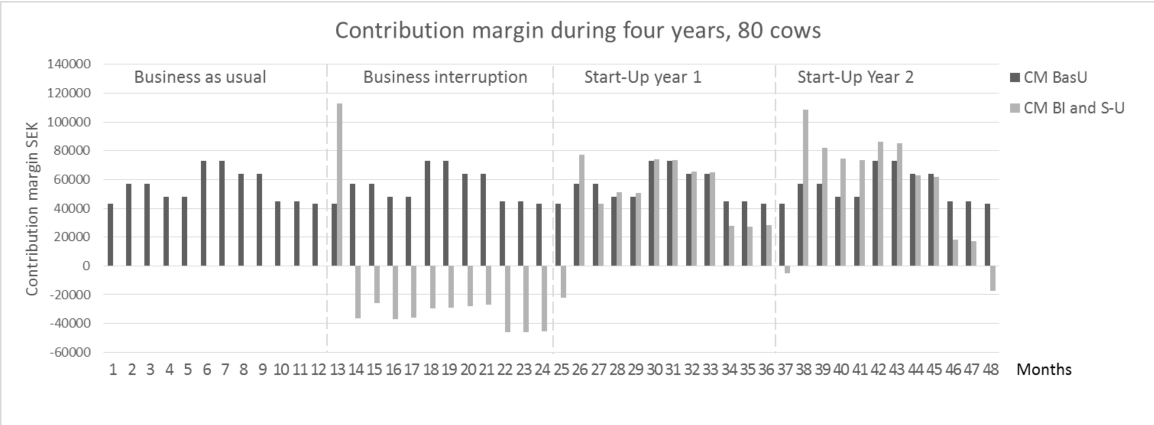

Figure 13. Illustration of the CM during four year in simulation 3. Source: Own processing.

BasU yields an annual CM of 658 566 SEK and during the BI, the CM is -273 086 SEK. The CM during the first S-U year equals 286 625 SEK, except for the adjustment that is mentioned in association to figure 11. The cost to purchase a new herd is added back in month 26. The second year of S-U equals a CM of 648 107 SEK.

Simulation 4. In figure 14, the CM during four years are illustrated. There is a major difference compared with *simulation 3* due to the lower milk price.

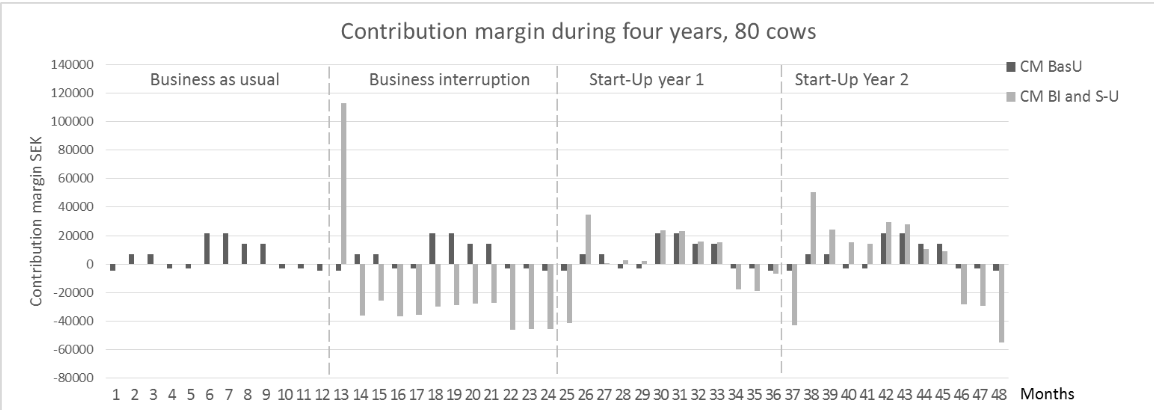

Figure 14. Illustration of the CM during four year in simulation 4. Source: Own processing.

BasU yields an annual CM of 63 050 SEK and during the BI, the CM is -273 086 SEK. The CM during the first S-U year equals -242 784 SEK, except for the adjustment that is mentioned in association to figure 11. The cost to purchase the herd is added back in month 26. The second year of S-U equals a CM of 25 357 SEK.

Simulation 5. In figure 15, the CM during four years are illustrated.

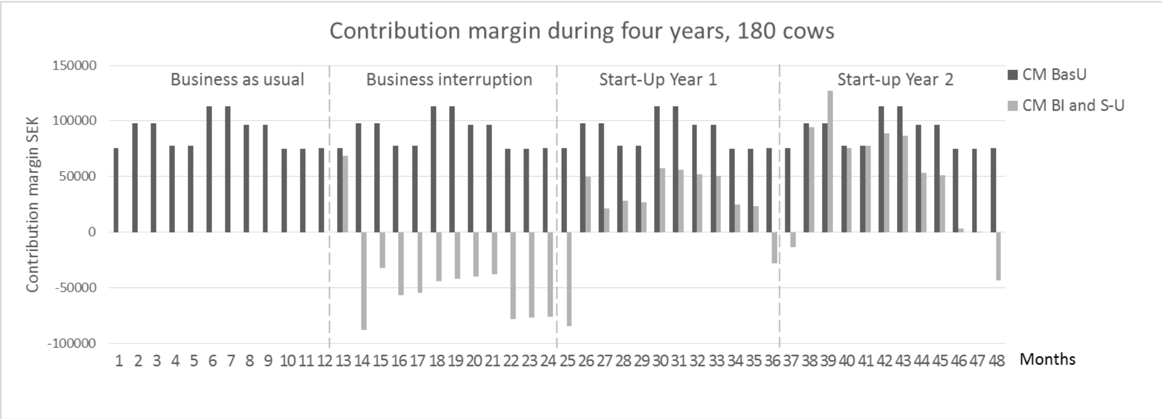

Figure 15. Illustration of the CM during four year in simulation 5. Source: Own processing.

BasU yields an annual CM of 1 070 427 SEK and during the BI, the CM is -557 133 SEK. The CM during the first S-U year equals -322 238 SEK, except for the adjustment that is mentioned in association to figure 11. The cost to purchase a new herd is added back in month 26. Due to the larger herd size this cost is 680 000 SEK. The second year of S-U equals a CM of 600 945 SEK.

Simulation 6. In figure 16, the CM during four years are illustrated. There is a major difference compared with *simulation 5* due to the lower milk price.

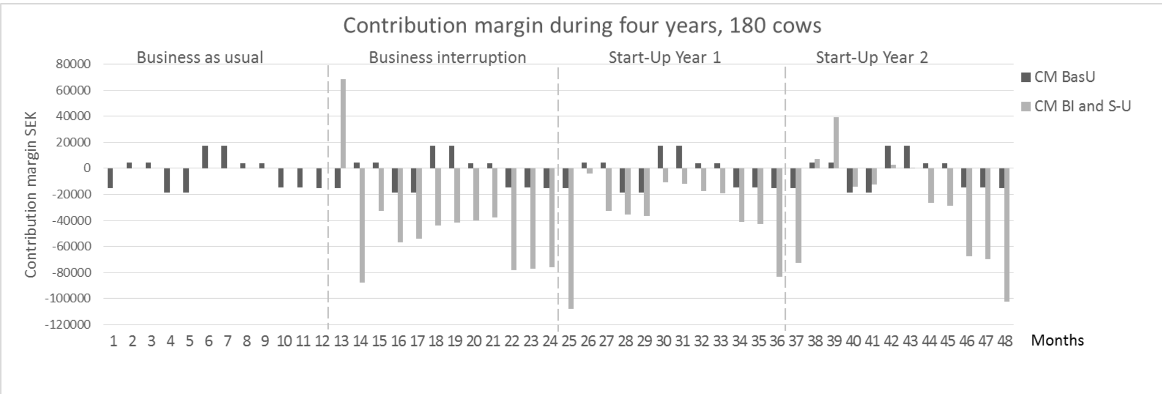

Figure 16. Illustration of the CM during four year in simulation 6. Source: Own processing.

BasU yields an annual CM of -47 079 SEK and during the BI, the CM is -557 133 SEK. The CM during the first S-U year equals -1 040 495 SEK, except for the adjustment that is mentioned in association to figure 11. The cost to purchase the a herd is added back in month 26. The second year of S-U equals to a CM of -343 807 SEK.

Simulation 7. In figure 17, the CM during four years are illustrated.

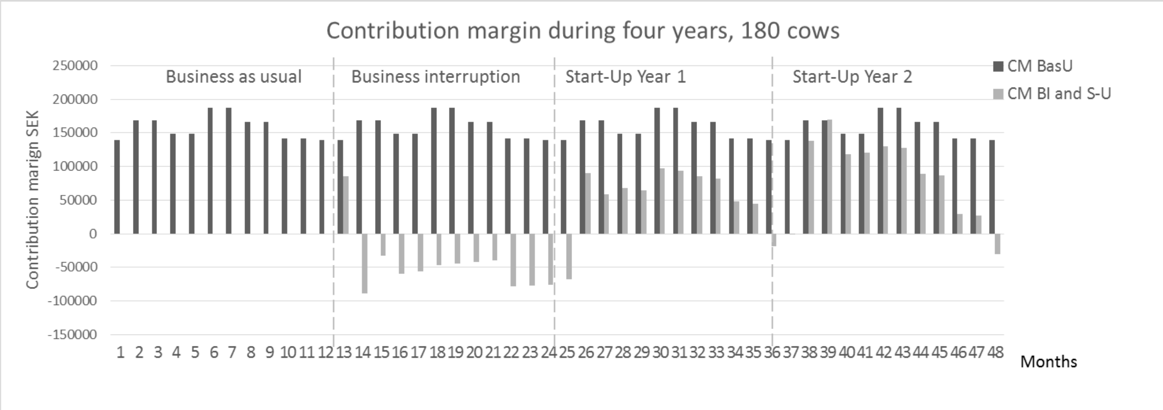

Figure 17. Illustration of the CM during four year in simulation 7. Source: Own processing.

BasU yields an annual CM of 1 902 516 SEK and during the BI, the CM is -554 287 SEK. The CM during the first S-U year equals 49 196 SEK, except for the adjustment that is mentioned in association to figure 11. The cost to purchase a new herd is added back in month 26. The second year of S-U equals to a CM of 1005 638 SEK.

Simulation 8. In figure 18, the CM during four years are illustrated. There is a major difference compared with *simulation 7* due to the lower milk price.

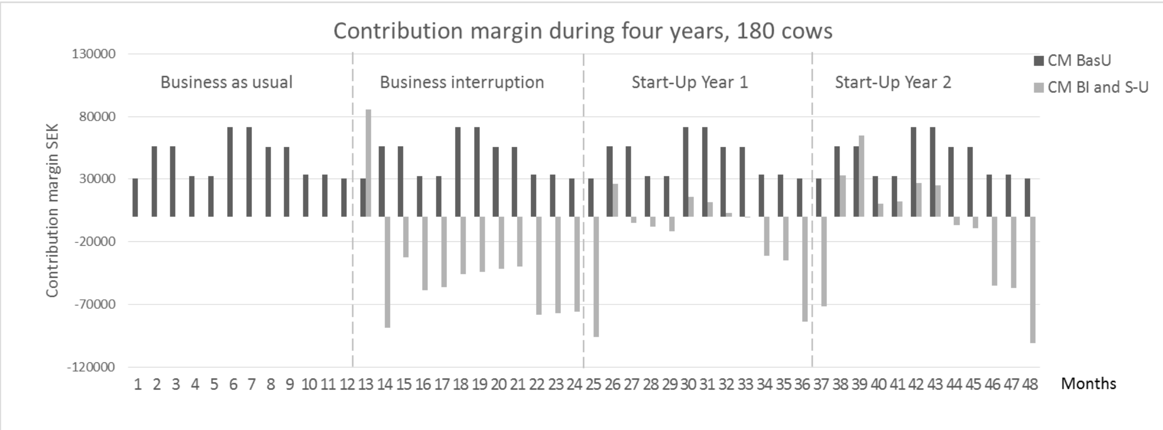

Figure 18. Illustration of the CM during four year in simulation 8. Source: Own processing.

BasU yields an annual CM of 561 509 SEK and during the BI, the CM is -554 287 SEK. The CM during the first S-U year equals -812 768 SEK, except for the adjustment that is mentioned in association to figure 11. The cost to purchase a new herd is added back in month 26. The second year of S-U equals to a CM of -128 119 SEK.

In table 7, a summary of the CM in all simulations is presented during the previously mentioned years. All figures are in SEK and note that the values are not discounted.

Table 7. Summary of the CM during four years. Source: Own processing

Simulation		CM BasU	CM BI	CM S-U 1	CM S-U 2
1	80 cows, Low yield, High price	294 677	-276 692	-282 481	237 347
2	80 cows, Low yield, Low price	-201 587	-276 692	-476 155	-281 611
3	80 cows, High yield, High price	658 566	-273 086	286 625	648 107
4	80 cows, High yield, Low price	63 050	-273 086	-242 784	25 357
5	180 cows, Low yield, High price	1 070 427	-557 133	-322 238	600 945
6	180 cows, Low yield, Low price	-47 079	-557 133	-1 040 495	-343 807
7	180 cows, High yield, High price	1 902 516	-554 287	49 196	1 005 638
8	180 cows, High yield, Low price	561 509	-554 287	-812 768	-128 119

6.3 The Present Value of the investment

The PV of the investment during BasU and the PV of an investment subject to a BI are presented in table 8, which includes all eight simulations accordly to equation 2. The PVs are compared and the table also reveals the difference in PV. All figures are in SEK.

Table 8. The PV of the investments referring to the different simulations. Source: Own processing

Simulation	Key characteristics	PV BasU Initial building	PV BI New building	Difference	Per cow
1	80 cows, Low yield, High price	3 809 692	2 761 983	-1 047 709	-13 096
2	80 cows, Low yield, Low price	-3 215 544	-3 888 154	-672 609	-8407
3	80 cows, High yield, High price	8 960 961	7 667 036	-1 293 925	-16 174
4	80 cows, High yield, Low price	530 678	-313 127	-843 805	-10 547
5	180 cows, Low yield, High price	14 597 144	11 546 956	-3 050 188	-16 945
6	180 cows, Low yield, Low price	-1 222 566	-2 974 585	-1 752 018	-9 733
7	180 cows, High yield, High price	26 376 396	21 948 939	-4 427 457	-24 596
8	180 cows, High yield, Low price	7 392 743	4 522 988	-2 869 755	-15 943

All simulations show a negative impact on the PV of the investment. Hence, dairy production is not a profitable enterprise given that it does not satisfy the required return of 5% attributable to the discount rate. However, there are differences in how large this impact is. For example, the table shows that simulation 2 and 6, with low milk yield and low milk price, have a negative PV also before the simulated BI. These two simulations show the lowest difference per cow in each herd size of 80 vs 180 cows.

6.3.1 Effects on profit margin

The effects of a BI in terms of the profit margin during the investment's economic lifetime are presented in figure 19. All simulations are represented and the profit margins during BasU as well as in case of a BI are included.

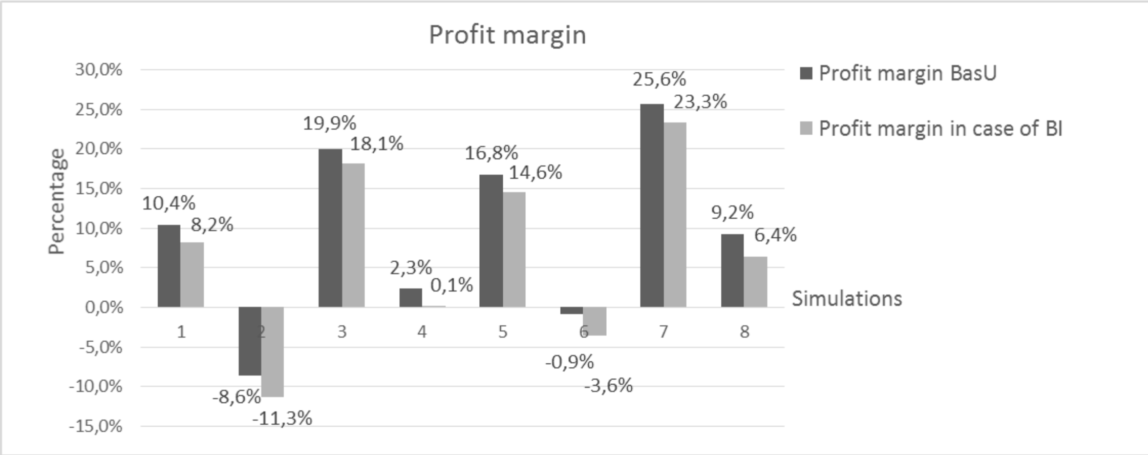

Figure 19. The effects in the profit margin concerning the different simulations. Source: Own processing.

The results reveal that the BI, not unexpectedly, has a negative impact on the profit margin over the dairy barns 25 years economic lifecycle. The impact varies among the different simulations between 1,8-2,8 percentage points. Moreover, it is noticeable that the profit margin in simulation 1-4, which represents the simulations with 80 dairy cows, is lower than the corresponding simulations 5-8 with 180 dairy cows. Hence, a dairy herd of 180 cows represents a more economically viable unit.

7 Analysis and discussion

This chapter contains the analysis of the presented results from the empirical study with respect to the theoretical framework. Also, a sensitivity analysis is performed regarning milk price and milk yield. The results are later on discussed in relation to previous research as a method to validate the results in this study. The intention is to be able to answer the research questions presented in the introduction. The research questions are repeated in the two first headings of this chapter.

7.1 How large are the losses in a dairy production during the time a dairy production is subject to business interruption?

This section is developed with regard to three of the time periods that are identified in section 4.6; BasU, BI and S-U. It is important to analyze the CM during BasU to understand the value that is created when the business operates as usual, which represents the comparative figures in order to estimate the extent of the losses due to a BI. The period a dairy production is subject to a BI varies between different situations since each farm is a unique business. In this study, it involves the length of the BI as well as the time required to restart the production. The reason to include the S-U is because it is regarded as a concequence of the BI. Hansson & Olsson (1996) argue that production disturbances may appear 1-2 years after the S-U, until the milk yield has recovered to the level it was before the BI.

7.1.1 Business as Usual

In accordance to Debertin (2012), the results show that the output depends on the inputs used. The revenues and CM are affected by the milk yield, since the milk yield is the main output in the production. It is noticeable in *simulation 2* and *simulation 6* that a lower milk price has negative impact on the CM, which is below zero at a low milk price. This is not an unusual situation for dairy farmers in Sweden today. The situation occurs when the milk price is lower than the costs of production as equation 7 shows (Pindyck & Rubin, 2009). However, in these two simulations, the average variable costs are covered by the product price. Therefore, the production is assumed to continue in the hope of reduced production costs or a higher milk price in the future (*ibid*). Also Flaten (2001) emphasizes that the profits need to exceed the average total costs. There is a possibility for this since the price of milk and feed are shown to be volatile (Wolf, 2012). Alternatively, as *simulation 4* and *simulation 8* reveal, the farmer can have a positive CM during BasU with a lower milk price if the milk yield is higher. With a high milk yield along with a high milk price as in *simulation 3* and *simulation 7* the CM increases even more.

7.1.2 Business Interruption

The results from the empirical study demonstrate that the business does not produce any milk during the BI since no inputs can be used in dairy production (Debertin, 2012). Hence, the business does not receive any revenues from milk production. However, in the beginning of the BI year, a positive CM is shown in all the diagrams. This is referred to that the farmer sells redundant feed and the inseminated heifers that are to calve during the time of BI, which create an extra income. The price of the feed is set by the operational cost according to Nilsson et al. (1983) and equation 19. It differs between the simulations with a smaller respectively larger herd due to the different feed administration systems. Moreover, some costs are shown to continue in the results. These costs are attributable to the heifers and feed production that still needs care and maintenance. This results in a negative CM during the BI period, which is shown to be rather stable between the simulations with the same number of cows. The reason for this is that the situation of a BI eliminates the effects of a different milk price and/or milk yield. Thus, the remaining cash flows are similar. This could be argued to represent a reasonable certainty concerning the lost CM during the time period of the BI, which is a desirable basis for the valuation (Slee, 2011). Although, there are several factors that may cause differences in the length of the BI that should be considered. These differences may be due to seasonality and location in the country, which the interviewed experts emphasize. However, such factors have not been regarded in the present study.

7.1.3 Start-Up

In the S-U years, the dairy production is restarted, but the milk yield is shown to be fluctuating on a lower level than during BasU. The lower level of milk yield in the beginning of S-U year 1 can be derived to the fact that only 75% of the 80 positions in the barn are filled in *simulations 1-4* and 50% of the 180 spots in *simulations 5-8*. This along with a higher proportion of primiparous cows, who produce less milk than multiparous cows (Phillips, 2010). The fluctuations in the milk yield are related to that the dairy is composed by the recruitment heifers who survived the fire. In addition, the fluctuations depend on how many dairy cows that are calving at the same time in the beginning of the S-U and thereby their dry period occurs at a similar time period (*ibid*). However, the own recruitment heifers and the purchased herd are assumed to calve evenly during the year and thus some milk yield is received also in November-December. The problem with a fluctuating milk yield is that the costs do not fluctuate as much and thus, during some periods, the revenues cannot cover the costs. Hence, the non-adapted herd can be regarded as a production disturbance following the BI (Hansson & Olsson, 1996). This is in accordance to the fact that a newly started dairy production is often followed by production disturbances (Phillips, 2010; Bruckmaier, 2005; Bruckmaier & Blum; Hansson & Olsson, 1996). Other disturbances mentioned earlier are the learning process and stressed cows. These disturbances are not shown in the calculations, since these losses are difficult to quantify. However, both the case studies and the expert interviews reveal that these disturbances are not uncommon in newly started dairy productions.

A feature identified is S-U year 2 is that *simulations 1-4* show a CM closer to the CM in BasU than *simulations 5-8*. The reason for this is related to the different proportion of the amount of dairy cows in the new herd. As mentioned, the barn is filled with 75% and 50% in *simulation 1-4* and *simulation 5-8* respectively. Thus, *simulations 5-8* have a lower proportion of inputs in the beginning than during BasU and thereby a lower proportion of output (Debertin, 2012). This lower proportion of livestock decreases the revenues and variable costs proportionately. Yet, the fixed costs refer to 180 cows, which in turn imply a lower CM due to the empty positions that do not create any value but still carry costs. In *simulations 1-4*, the proportion of cows in the new herd is higher, resulting in a lower effect from the fixed costs that can be refered to the empty positions. Furthermore, it is shown that it requires longer time before the barn is filled to 100% since recruiting own heifers is a lengthy process. This is also accordingly to the literature, which reveals that the barn would be filled faster if buying a larger proportion of the animals instead of recruiting own animals (Hansson & Olsson, 1996). This in turn would bring revenues to a certain extent. However, it also implies a large cost in the beginning of the restarted production when the cash flow probably is on a low level.

According to Douprate *et al*. (2013), modern dairy farms seek to maximize the efficiency of resources into finished products. Profit maximization deals with to maximize output with regards to the inputs applied (Debertin, 2012). However, it may be argued that the farmer is unable to profit maximize in the S-U. The reason to assume this is that the farmer seems to be unable to use the full potential in the new barn due to the production disturbances of the non-adapted herd. Thereby, the milk yield does not reach a desirable level that maximizes the profits, which is reflected by the lower CM.

Furthermore, the losses are concentrated to the time of BI and the time of S-U since the business is assumed to recover the CM during the following years the production is operating. However, the results reveal that the CM does not totally recover during the S-U phase. This is due to the time it takes to regain a similar production level as before the BI, but also due to a noticed gap of recruitment heifers in the production. The experts are also emphasizing that this gap may appear during the second year. When the gap is present, the farmer is unable to cull low producing dairy cows in the same extent as before the BI since no recruitment heifer are available to fill the positions. This may be recognized as another production disturbance, resulting in a lower milk yield and lower slaughter revenues (Hansson & Olsson, 1996). The disturbance is shown to extend over more than the two years included in the S-U phase, which also is argued in the theory chapter (*ibid*). Consequently, the situation with an unevenly distributed herd regarding the time of calving, lactation and age will presumably follow the farmer during a long time period.

Another interesting matter, which is revealed by the case stydies, is that the milk yield may increase after the BI. In the simulations, a potential increase in milk yield is not assumed. The reason to this is that the investment that is assumed to be damaged by a fire is newly established. Thus, to build a new barn is not a major improvement in the equipment or other fixed inputs. However, in a real scenario, the barn could be of older character and perhaps in need of reinvestments, which are essential in order to maintain the production capacity (Ross *et al.*, 2008). If the technical lifetime in the building and/or equipments is close to the end, it is time to reinvest (Thomasson, 2013). In turn, the fire and BI could provide the farmer with the opportunity to build a new barn and postpone the reinvestments for a while. Furthermore, the farmer has the possibility to change dairy production system regarding the herd size and/or the milking center in example (Wagner *et al.*, 2001). However, it implies a cost for the farmer since the indemnity naturally does not compensate for expansion the business. In addition, if the fire occurs in a stanchion barn it is not legal to rebuild such a building. Thus, the free stall solution would be implied (www, Jordbruksverket 2, 2014). Thereby, the new investment implies new fixed inputs in the production that may increase the output level *i.e.* the milk yield (Debertin, 2012).

7.2 How does a business interruption affect the present value and the profit margin of the investment in a dairy production?

There is a negative difference between the PV of the initial investment and the new, which represents the loss due to a BI. The reason for this may be related to the decrease in CM during the first couple of years during the BI and the S-U. Table 8 illustrates that the extent of the decrease follows the lowered CM, implying that *simulations 1-4* demonstrate a lower PV decrease than *simulations 5-8* due to the different herd sizes. The table also shows that the milk price has substantial effect on the difference in PV. A higher milk price results in a higher decrease in PV because the expected revenues that are lost would have been higher (Allen *et al.*, 2009; Roberts, 2011). A higher milk yield is also causing a higher decrease in the PV since the farmer could have expected higher revenues due to that.

The business needs a positive CM in order to repay the initial investment cost (Olsson, 2011). A positive PV of the 25 year investment is noticed in all simulations both before and after the fire, except from *simulation 2* and *simulation 6*. These two simulations reveal a negative PV both before and after the fire, however, the PV is even lower after the fire in these two simulations. For *simulation 2* the decrease is -672 609 SEK and for *simulation 6* the decrease is -1 752 018 SEK, which is revealed in table 8 and may be argued to represent the potential indemnity. This is discussed in section 7.1.1 to not be an unusual situation for Swedish dairy farmers today. Accordingly, these businesses need a higher milk price or a substantial decrease in input prices in the future, in order to maintain production in the long run (Pindyck & Rubin, 2009). Otherwise, the investments are not profitable.

Furthermore, as a consequence to the decrease in PV when the investment is subject to BI, the profit margins are affected negatively. The reason is related to that no production occurs during the BI. In addition, it may be due to that the farmer is unable to profit maximize in the first years of S-U. The decrease in the profit margin is between 1,8 - 2,8 percentage points for the expected profit margin during the investment's economic lifetime. An interpretation of these results is that a BI implies that the farmer will operate his/her dairy production with a lower profit margin in the new investment during its whole economic lifetime. However, this loss is avoided with an agricultural insurance that covers the BI losses.

Moreover, the implications for each business are different depending on the original profit margin. To the simulations with a profit margin closer to 0 % it may be argued that the effects are more severe since the original margin is already limited and thus, the slightest difference has a high impact on the business profitability. A business with a higher original profit margin may be argued to be more tolerable towards these changes over time.

7.3 Sensitivity analysis

The sensitivity analysis conducted of the results is presented below in order to stress the economic implications due to changes in the milk price and the milk yield.

7.3.1 Change in milk price

A change in milk price is shown to substantially influence the PV in the simulations. An increase affects the PV positively and a decrease affects the PV negatively. However, the effect depends on the characteristics of the dairy system. As seen in table 8, where the difference between the PV of each simulation is presented, there are variations in the differences. Table 9 presents the change in PV between the simulations with the same milk yield characteristics but with different milk prices. The change in PV reveals information regarding how the PV would be affected by a change in milk price of 0,1 SEK/kg ECM.

Table 9. The change in PV due to a 0,1 SEK change in milk price. Source: Own processing

Simulation	Change in PV due to different milk price	Change in PV due to a change in milk price of 0,1 SEK/ kg	Per cow
Simulation 1 and 2	375100	55162	690
Simulation 3 and 4	450120	66194	827
Simulation 5 and 6	1298170	190907	1061
Simulation 7 and 8	1557702	229074	1273

In table 9, it may be read that the milk yield seems to influence the impact of a change in the milk price. It is noticed by the higher change per cow when comparing the dairy farms with low milk yield in *simulation 1 and 2* with the dairy farms with a high milk yield in *simulation 3 and 4*. The relative difference per cow between *simulation 1 and 2* and *simulation 3 and 4* is approximately 20 % larger due to the higher milk yield in *simulation 3 and 4*.

Moreover, the herd size appears to influence the effects of a price change. This is revealed by comparing *simulation 1 and 2* with *simulation 5 and 6* and *simulation 3 and 4* with *simulation 7 and 8*, where the simulations in a larger herd appear to face a larger effect due to a price change. The reason for the difference between the small and large herd may be attributable to the fundaments of profit maximization in dairy farms. A dairy farm maximizing more resources and inputs may be able to produce a larger output more efficiently (Debertin, 2012). Thus, a larger farm has the opportunity to develop a larger profit on changes in the milk price. Then, a price change of 0,1 SEK as illustrated influences the PV with an additional 50 % per cow for a larger farm compared to the smaller. However, the sensitivity analysis shows that the relative difference per cow when comparing *simulation 5 and 6* and *simulation 7 and 8* is also approximately 20 % larger due to the higher milk yield in *simulation 7 and 8*, as stated in relation to the smaller herds. This could be expected if all other variabels stay unchanged (*ibid*). This may be argued to increase the trustmorthiness in the mathematical model.

7.3.2 Change in milk yield

A change in the milk yield is recognized to substaintially affect the PV in the simulations, where a higher yield is positive for the PV and a lower yield is negative for the PV. Table 10 presents the change in PV due to a change in the milk yield between the simulations with the same characteristics, except from the milk yield. The milk yield differs between 10 000 and 12 000 kg ECM/year between the highest yielding dairy cows in each herd. Regardless of this, the differences between dairy cows with different calving time and number of lactation are according to the index in table 5. The change in PV provides information concering the impact due to difference in the milk yield among the dairy cows.

Table 10. The change in PV due to a change in the milk yield with 2000 ECM/ year among the highest yielding dairy cows. Source: Own processing

Simulation	Change in PV due to different milk yield	Per cow
Simulation 1 and 3	246216	3078
Simulation 2 and 4	171196	2140
Simulation 5 and 7	1377269	7651
Simulation 6 and 8	1117737	6210

In table 10, it may be noted that the milk price appears to influence the effect of a change in the milk yield. This is observed when comparing the effect per cow in *simulation 1 and 3* (high milk price) with the effect in *simulations 2 and 4* (low milk price). The relative difference per cow between *simulation 1 and 3* and *simulation 2 and* 4 reveals that the higher milk price has a positive impact of approximately 40 %.

The herd size appears to influence the effects from a change in milk yield since the effects per cow appear to be larger for the larger herds compared to the smaller herds. As stated in connection to the change in milk price, this difference between a small and large herd may be a consequence related to profit maximization (Debertin, 2012). The farmer with the larger farm has the opportunity to produce in a more efficient way.

Moreover, the relative difference per cow, when comparing *simulation 5 and 7* (high price) and *simulations 6* and *8* (low price), reveals an impact of approximately 20 %. This is a lower impact than compared to the relative difference among the smaller farms. The reason for this may be due to the fact that the costs doesn't change as much as the milk yield and there are lower costs per cow in larger herds.

7.4 Discussion

The results in this study are difficult to compare with previous literature on the subject since there is a lack of previous research with comparable figures. Earlier studies focus on how the losses due to a BI may be estimated, BI due to major catastrophes such as hurricanes (Jain & Guin, 2009) or other BI causing extreme values (Zajdenweber, 1996). Meuwissen's (2000) study involves the situation of a BI due to a national livestock epidemic affecting farrowing farms. This can also be regarded as a major catastrophe for a whole sector. Meuwissen calculates losses per sow in a farrowing farm that is completely empty during one year of BI, where the included values pertain to additional returns, reduced variable costs, returns foregone and extra costs. The additional returns and extra costs are equal to zero. However, this study shows that the farmer receives additional returns by selling the redundant feed as well as recruitment heifers and extra costs with the employees during the BI. This may be due to the differences between the production lines of farrowing farms and dairy farms. Moreover, no findings may be noted concerning the S-U process, which is recognized to be affecting the losses in an extensive way, in accordance to the analysis. In addition, Meuwissen refers to farmers as a group and therefore, no figures or differences may be observed concerning individual farms. Thus, the findings in this study may be regarded as quite novel and unique in terms of shedding light upon the situation for an individual farmer subject to a BI in his/her dairy production.

In order to obtain the results in this study, several assumptions have been made regarding the production. One assumption is that the farmer is profit maximizing while previous studies have shown that farmers not always strive for profit maximization (Lin *et al.,* 1974) but are driven also by other factors such as social norms, cultural beliefs and personal values (Edward-Jones, 2006). By assuming profit maximization the results may be affected. One example of this is that a dairy farmer who does not profit maximize may not terminate the employee during a BI. The farmer may value the employee higher since it may be hard get hold of good labor when the production is restarted. However, the presented results appear to be reasonable. The sensitivity analysis of the milk price reveals that the effects in the larger herd are more substantial than in the smaller herd. The figures regarding the herd of 80 dairy cows can be compared with the results in the study by Olsson (2004). One of the author's conclusions are the investment in a dairy production is affected in between 57 000 and 76 000 SEK by a change of 0,1 SEK/ kg in the milk price. This study show an impact between 55 000 SEK and 66 000 SEK in the herds with 80 dairy cows and between 191 000 and 229 000 SEK in the herds with 180 dairy cows. Thus, the results in this study show similar figures in the 80 dairy cow herd size. Moreover, the herd size appears to be influencing the effect from a price change since the change per cow is larger in the larger farms than in the smaller farms. The reason to this can be that larger farms have the ability to produce more milk in a more efficient way than smaller farms since they operate more resources. Thus, they may experience a larger impact from differences in the milk price.

The sensitivity analysis reveals that both the milk yield and the milk price affect the losses to a large extent. Thus, if a new herd does not produce as well as the previous herd it will cause a decrease in the PV. However, it might as well cause an increase in the PV if the cows produce better than the previous herd, if it extends over a longer time period. In the present study, the cows are assumed to produce as well as the previous herd.

There is a need for the insurance company to be able to understand the values and the processes in an agricultural business in order to replace the losses in a business subject to a BI by a proper indemnity. The findings in this study show that the individualities in dairy productions cause differences in PV between an investment with BasU and an investment with a BI. The differences are due to the variations in the simulations, with regard to the milk price, milk yield and number of dairy cows in the production. This is in accordance to the factors to be affecting the profits emphasized by Stephenson *et al*. (2012). Moreover, Barry *et al*. (2001) supports that the size of the farm and other structural characteristics influence the variations in net farm income. In this study, the variation in farm size implies slightly different structural characteristics for the production, which in turn impact the cost in the production. The major effects from this is a lower fixed cost per dairy cow connected to the larger farm size as well as a lower operational cost for the feed production with silage in silo.

The length of the BI is in previous studies stressed to be crucial for the losses of a BI (Rose and Hyuck, 2016; Gaughan, 2009; Jain & Guin, 2009; Meuwissen, 2000). The results in this study state that the business needs at least two years until the production has recovered in CM, which Roberts (2011) also argues for. This lenght is also argued in favor for in other settings than the agricultural one, such as in hotel businesses (Jain & Guin, 2009).

Another factor that is influencing the PV of the investment is the change in market conditions (Rose & Huyck, 2016). This study regard this aspect by changing the milk price, however the costs of input are not changed in these settings, which may be expected when the output price increase. The implications due to this would decrease the profit margin in the simulations with a high milk price.

7.4.1 Methodology discussion

The comparative method used in the present study is argued to be an accurate method for estimating losses caused by BI (Stephensson *et al*., 2012; Rose & Huyck, 2016; Newman, 2012; Bourdreaux *et al.,* 2011). In the present study, the focus has been on estimating the losses without any financial records over the BI period available. The study includes many assumptions, which imply that the results would be different in other studied settings. Thereby, the figures are hypothetical future expectations that are based on the historical financial situation in the firm and the market. Thus, no exact figures regarding the size of the losses are received. However, the mathematical model present an understanding of what needs to be involved in the estimations and therefore, the model may be applied during other circumstances.

The mathematical model can be used when estimating the losses by putting in relevant data in the model. However, it requires large knowledge of each dairy production, since each BI in a dairy production are of a unique character. To estimate the losses prematurely it is important to know the milk price, milk yield and continued costs. The milk yield is affected by number of cows in each lactation, the feed ration, and the calving distribution. Furthermore, also the time perspective needs to be recognized.

8 Conclusions

This final chapter contains the conclusions in the study with regard to the aim. The aim of this thesis is to develop a model for estimating losses due to BI and to utilize the model in order to assess the production losses arising in a Swedish dairy production subject to a fire.

In this thesis, the economic implications due to a BI in a dairy production are investigated. The study contributes with a new mathematical model that aids the estimation of economic losses due to a BI emerging from a fire. Through the development of the mathematical model, the empirical results are derived and the research questions can be answered. The study involves eight different BI simulations in a reference farm and the results show that a BI causes economic losses in the production. The extent of the economic losses lowers the PV of the investments and the profit margin in the business.

The study reveals that the economic losses differ substantially due to the general differences regarded in the simulations. Factors that impact the economic losses in this study are; milk price, milk yield, number of dairy cows, operational cost for feed production as well as the length of BI and S-U process. Additional factors that are recognized to impact the losses are the production disturbances concerning fluctuating milk yield due to various characteristics among the dairy cows in the new herd, the replenishment of the new herd into the new barn and the gap of own recruitment heifers. The results regarding the decrease in PV of the investment subject to a BI show large variations, in between 672 000 - 1 294 000 SEK referring to the 80 dairy cow farm and in between 1 752 000 - 4 427 000 SEK referring to the 180 dairy cow farm. In addition, the negative effect on the profit margin differ between 1,8 - 2,8 percentage points.

The conducted sensitivity analysis states the impact on PV due to a change in milk price and a change in the milk yield, which appears to be varying between the simluations. The figures concerning the changed milk price are validated and found reasonable in the discussion, with regard to the findings by Olsson (2004). The change in PV is further expressed by a measurement per cow in order to give the reader further understanding of the implications due to a price change, which shows a difference between 690-1273 SEK/ cow.

Consequently, the economic losses due to a BI in a Swedish dairy farm need individual calculations for the indemnities in order to be properly estimated. However, the comparing method between BasU and the business subject to a BI can be considered as a valid method to perform the estimations.

8.1 Future research

As stated in the problem in the beginning of this thesis, there is a lack of research in the area of BI in agricultural settings. Future studies within organic settings offer the possibility to make an interesting comparison with the findings in this study. Moreover, an element of risk could provide insights of how fluctuating market conditions would affect the economic losses. Also, a study conducted with a different methodology such as survey among several farmers that have experienced a BI would be of interest since it could enable generalizations to some extent. In addition, it is possible to do a case study of businesses that focuses on their financial records before and after a BI. Accordingly, there are many possibilities to future research in this area. Although, it is necessary to keep in mind that it is a sensitive topic, which demands great ethical considerations.

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Personal messages

1. Sigurd Regnér & Gustaf Edhe Jansson, Länsförsäkringar AB. 2016-01-22.
2. Sigurd Regnér & Gustaf Edhe Jansson, Länsförsäkringar AB. 2016-02-29.
3. Rolf Spörndly, Research Group Leader at the Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences. 2016-03-21.

Appendix 1: Questionnaire to case farms

Before fire

1. For how long have you been a farmer?

2. How was the production conducted?
- o Conventional
- o Ecological

3. What housing system was implemented?
- o Stanchion barn
- o Free-stall barn

4. How was the dairy cows milked?
- o Stanchion milking
- o Robot
- o Carousel
- o Milk-pit
- o Other ____

5. How many milking dairy cows was part of the production?
___ dairy cows

6. How much did the dairy cows lactate the year before the fire?
___ litres

7. How was the old herd proportioned between the lactations?
___ number of cows in first lactation
___ number of cows in second lactation
___ number of cows in third lactation
___ number of cows in fourth lactation
___ number of cows in fifth lactation or more

8. How large was the recruitment percentage?
___%

10. How was the production supplied with heifers?
- o Own recruitment
- o Bought

11. How was the production provided with concentrate?
- o Self-sufficient with concentrate
- o Solely bought concentrate
- o ___ % bought och ___ % farm produced concentrate

12. How was the production provided with forage?
- o Self-sufficient with forage
- o Bought approximatley___ %

13. What feeding system was used?

- Complete ration feed
- Free acess of forage, complemented with individually adjusted concentrate
- Individual feed

14. Did any employees work at the farm?

- Yes, ____ persons
- No

15. What form of employment was implemented?

- Hourly employment
- Part time
- Full time

Business Interruption

16. What year did the fire occur?

Year ________

17. In what month did the fire occur?

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

18. How long time did the rebuilding of the barn take?

___ months

19. What happened with the herd after the fire?

- The herd died in the fire
- The herd were sold
- The herd were held in another building
- The herd were slaughtered
- Other – brief explanation

____
____
____

20. If the farm produced own feed before the interruption, what happend with the feed production during the business interruption?

- The feed was produced and sold
- No feed was produced during the business interruption
- Other – brief explanation

____
____
____

21. What were your occupation during the business interruption?

- Worked with rebuilding the new barn
- Worked on other location

Other – brief explanation

____

22. If there were employees at the farm, how were they managed?

- Worked with rebuilding the new barn
- Worked on other location
- Other – brief explanation

  ____

New building

23. Does the new barn differ from the old one?

- yes, ___ more cattle places
- yes, ___ fewer cattle places
- No, the same amount of cattle places

24. What milking system was introduced in the new barn?

- Robot
- Carousel
- Milk-pit
- Other____

25. If new animals were bought, from how many farms were they bougth?

- From few farms (<3 st)
- From a couple of farms (3-6 st)
- From many farms (>6 st)

26. How large part of the dairy cow units where filled during the first months after rebuilding?

___ % of the cow units

27. How long time did it take until all dairy cow units where filled? (Disregard single empty units)

___ months

28. How was the proportion of cows among in respective lactation when the new building was entered?

___ animals in first lactation
___ animals in second lactation
___ animals in third lactation
___ animals in fourth lactation
___ animals in fifth lactation or more

29. Has the average milk yield restored to the same level as before the fire?

- Yes
- No

30. If yes, how long time did it take before the average milk yield restored to the same level as before the fire?

___ months

31. If no, at what level is the milk yield today compared to before the fire?

___ % of milk yield before the fire

32. What feeding system was installed in the new production?

- Full-feed
- Free asset of roughage, completed with individually adjusted concentrate

33. Did you experience anu production disturbances before the production was restored to normal?

- Yes
- No
- If so was the case – describe breifly

34. If yes, what factors disturbed the production? (Choose one ore more alternative)

- The dairy cows acclimation to the new building
- A large part of primiparous cows
- Learning process in the new building
- Techninchal difficulties
- Other

35. Other additions

Once again, thank you for your participation!

Sandra & Alexandra

Appendix 2: Questionnaire to experts

How long time does it take to build a dairy barn?

How long time does it usually take to resume the production after the barn is rebuilt?

During how long time can the farmer expect production disturbances?

Can you give examples of installation problems that may occur in a newly build dairy barn?

What is most common today – buying animals from multiple different farms or buying entire herds from single farms?

Can you give examples of what problems that may occur when buying animals from multiple different farms?

When buying entire herds: How large part of the livestock are commonly primiparous, second lactating versus third lactating cows?

Is it common that a farmer buys more new heifers a year after restarting the production due to that the new calves require two years before they are ready to enter the production? (i.e. a gap in heifers)