THE FINANCIAL IMPACT OF REARING STRATEGIES ON DUTCH DAIRY FARMS UNDER THE IMPLEMENTED RESTRICTION OF PHOSPHATE RIGHTS

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Abstract

After the abolishment of the milk quota in 2014, the number of dairy cows in the Netherlands increased. As a result, the Dutch dairy sector exceeded the amount of phosphate excretion as agreed with the European Union. To limit the increase in dairy cows and, hence, the increase in environmental impact, the Dutch government introduced a system of phosphate rights in 2018. This meant that farmers were allocated rights for the amount of phosphate that could be excreted in the manure, and this also included the phosphate excretion of calves. This created a trade-off between the number of dairy cows and young stock that could be kept on the farm.

There are several rearing strategies that can allow for the possibility of more dairy cows on the farm. In addition to the standard on farm rearing, it is possible to outsource the young stock calves to a rearing farm or to completely have no young stock and purchase every heifer from the market. There are also opportunities to improve farm management so that the first calving age or replacement rate can be reduced, which can also have a positive effect on the number of calves on the farm.

In this study, a comparison was made at the farm level to determine which rearing strategy appears to be the most economically beneficial. Using the enterprise budgeting program JONKOS, the rearing costs for both the dairy farm and the rearing farm were calculated. Then, at the dairy farm level, the farm results were compared by taking into account milk revenue, feeding costs for the dairy cattle, and other related costs for the dairy cattle, along with the calculated rearing costs. The rearing costs of the own rearing strategy were around 2,500 euros per heifer and for the outsourced rearing strategy, the rearing costs were around 2,400 euros per heifer (depending on time present on the rearing farm). These costs included the costs for own labour and building, when these costs were not considered, both rearing strategies had a cost of around 1,400 euros per heifer, which corresponded to the value in the case heifers were purchased from the market.

Based on the evaluated rearing costs, the gross margins of the different strategies were compared at farm level. To this end a representative Dutch dairy farm was defined based on a dairy herd size of 100 cows. The gross margin consisted of the milk revenue minus the rearing costs, feeding costs (dairy) and other animal-related costs (dairy). With the outsourcing strategy, a farm was able to have more dairy cows within the limited phosphate excretion space, and the rearing costs were not substantially different. Therefore, the gross margin with the outsourced rearing strategy was higher compared to the own rearing strategy. When excluding own labour and building costs, the difference was about 30,000 euros per year. The strategy based on the purchase of heifers resulted in a comparable as the outsources strategy. The outsourced strategy had the advantage over the without rearing strategy in that the farmer still has control over the genetic quality and health status of his animals.

The impact of management strategies resulting in a lower age of first calving, or a lower replacement rate were assessed in relation to the own on farm rearing strategy. Lowering age of first calving (from 26 to 22 months) or replacement rates (from 26% to 20) resulted in an increase of the gross margin of a maximum of 30,000 euros. Thus, lowering the replacement rate and age of first calving were good measurements when a farmer wants to lower his rearing costs, considering an own rearing strategy. Thereby, also increasing milk revenue, as there more phosphate limitation space becomes available for dairy cows.

The introduction of phosphate rights has created an increased dependency between the number of dairy cows and the number of young stock on the farm. From this study, it can be concluded that an outsourced rearing strategy can be a measure to improve farm economic performance while accounting for the phosphate excretion restriction. With an outsourced rearing strategy, a farmer can milk more dairy cows within the farm's phosphate excretion capacity, without a substantial increase in the rearing costs, resulting in a higher overall farm result.

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1. Introduction

After the abolishment of the milk quota in 2014, the number of dairy cows in the Netherlands increased. As a result, the Dutch dairy sector exceeded the amount of phosphate excretion as agreed with the European Union. To limit the increase in dairy cows and, hence, the increase in environmental impact, the Dutch government introduced a system of phosphate rights in 2018. To this end, all farmers received phosphate excretion rights based on the number of total animals (dairy cows + youngstock) present on the farm on the reference data of 02/07/2015 (RVO, 2020). Upon the introduction of the phosphate system, many dairy farmers had to decrease their number of livestock. On average, the number of dairy cows decreased by 10%, while the number of young stocks decreased by 30%. (Agrimatie, 2021a). This difference shows that farmers reduced their young stock relatively more than their dairy cows to maximise the production on the farm within the given phosphate quota. This is also demonstrated by the relative number of young stock per dairy cow, which decreased from 5.5 to 4.7 calves per 10 cows from 2017 to 2020 (Kringloop, 2021).

The rearing of heifers is a costly business, with high costs for feed, labour, and housing (Mohd Nor et al., 2015). In 2012, the cost of rearing a heifer was estimated between €1400 to €1700 (Mohd Nor et al., 2012). Since then, input prices (for example, feed prices) have risen sharply, while the market price of heifers has become very volatile due to a decreased supply and a higher demand (Agrimatie, 2022).
A good indicator of the required number of full-grown heifers needed per year is the replacement rate. This rate was around 25-30% before the introduction of phosphate rights (Mohd Nor et al., 2014) and decreased after 2015 to about 21% in 2020 (Agrimatie, 2021). A 21% replacement rate would mean that a dairy farmer of hundred cows needs approx. twenty-one heifers per year to replace their dairy cows.

There are different strategies for a farmer to obtain these required numbers of heifers. One strategy is to rear own young stock, which is very common in the Netherlands. In this way, a farmer has control over the health and genetic quality of the heifers on the farm (Verbruggen, 2014). The downside of having own young stock is that they occupy part of the phosphate quota. Therefore, young stock on the farm will mean less phosphate space left for milk production on farm level. Another strategy is to outsource the rearing of own heifers, with the benefit to keep more dairy cows for milk production, while still having the control over the genetic quality of the future replacement animals. On the other hand, this will come at an actual expense for housing and labour for rearing the young stock (otherwise, it would have been own input). Furthermore, a farm can choose to buy his/her heifers on the market, which also allows the farmer to keep more dairy cows on the farm by using the phosphate excretion capacity normally used by the young stock unit. The downside of this strategy is the potential disease threat by introducing animals form outside the farms, the lack of having control over the genetic quality, and the farmer's dependence on the availability of high-quality heifers as well as the market prices of heifers.

The introduction of phosphate rights has created an increased dependency between the number of dairy cows and the number of young stock on the farm. With this research, I want to study the financial impact of the different rearing strategies under the implemented restriction of phosphate emission rights, accounting for this emerged dependency. Furthermore, different scenarios will be taken into account to make a distinction between intensive farmers and extensive farmers, as consequences might differ substantially between these two types of farm production systems.

To reach the objective of this study, there are three research questions formulated:

1. What are the costs determinants of rearing replacement heifers in the Netherlands?
2. What are the financial consequences of the different rearing strategies on Dutch dairy farms under the implemented restriction of phosphate rights?
3. How sensitive are these financial consequences to changes in milk production and milk prices or altered dairy replacement management?

The first chapter provides a review on the literature on heifer rearing costs to answer research question 1. This chapter provides insights into the relative cost components of heifer rearing and management

aspects an impact on rearing costs at herd level. These insights are used as background knowledge for answering research question 2 & 3. After this chapter, the chapter on material and methods explains how to answer the second and third research questions. In chapter four the results of research questions two and three will be shown, which then discussed in chapter 5. The report concludes with the main conclusions of this study.

2. Determinants of replacement heifer rearing costs

This chapter reviews the known literature on heifer rearing costs. This review covers not only information on the rearing of the heifers in the Netherlands, but also other commercial dairy production countries to give an indication of which of costs are most important. The first part of this chapter provides insights in the total costs and relative costs components of heifer rearing. In the second part, the main management-related determinants with an impact on total rearing costs at herd level are considered.

2.1 Costs of rearing heifers

A few studies about the costs of rearing heifers have been performed in the past. Mohd Nor et al. (2012) did a study with a stochastic model that accounts for uncertainty in diseases and variation in fertility and growth to calculate the total costs of raising a heifer in a Dutch dairy herd. The estimated cost was €1,567 per successfully raised heifer, with relatively most of the cost attributed to feed and labour. In this same study, they found that the rearing costs were about 13% of the total production cost of milk. Verbruggen (2014) and Derkman (2013) estimated that the costs of rearing heifers in the Netherlands were around €1,967 and €1,559, respectively. A significant difference between these two studies was the inclusion of costs of own labour, which were present in Verbruggen (2014) and lacking in Derkman (2013).

In comparison to commercial dairy systems in other countries, the average cost of raising a heifer in the US, including labour costs, was reported as $1,124 (€1,050)(Gabler et al., 2000) and $1,808 (€1,690)(Heinrichs et al., 2013). Also, the estimated costs in the UK were around £1,794.55 (€2,016), including labour and capital interest. Without these costs, the average estimate was around £1,391 (€1,612) (Boulton et al., 2017). When comparing the referenced studies, one should be aware of the many differences between these studies. Not only due to the differences between countries and years in which the studies were done. Also, due to differences in actual calculations. Some studies only consider the purchased feed costs and neglect roughage costs, hence underestimating the actual feed costs, (like Verbruggen (2014) and Derkman (2013)). Other do not consider labour costs or costs components like depreciation (like Mohd nor et al (2012)). Therefore, it is difficult to compare all these studies, but based on these studies it is clear that most relevant costs components are associated with feed, labour, and housing.

2.2 The costs components of rearing heifers

Feeding costs

Feeding costs are one of the most significant costs associated with the rearing heifers and depend on the nutritional requirements that need to be met, given the available feed. These costs vary between farms and depend on the rearing management system used. Boulton et al. (2017) found that the feeding costs contributed to 36.8% of the total costs of rearing heifers in the UK. In this study, three distinct rearing phases were distinguished: birth to weaning, weaning to conception, and conception to calving. Between birth and weaning, the feed costs contributed up to 46.4% of the total costs related to this phase. This percentage decreased in the phase between weaning and conception to 35.6% and to 32.7 percent between conception and calving.

Verbruggen (2014) and Derkman (2013) found that the percentage of the feeding cost was 14% and 10.5 % of the total cost. This is not in line with Modh Nor et al. (2012); this study found that the relative feeding costs were around 44%. This difference between the studies was a result of the fact that the costs of feed in the studies of Verbruggen (2014) and Derkman (2013), only accounted for concentrates and milk replacer, hence reflecting the purchased feed costs. The costs of roughages were not included in these calculations, as this is a complex factor to calculate, as they contain the costs of crops, contract work, rent of land, use of equipment and lease of land.

The feeding costs of rearing heifers can vary between farms and will depend on which management strategy is used. Within the three different phases of the life of a dairy heifer, the requirement, and thus,

management strategies will differ. Therefore, the feed cost per phase will also differ. Between birth and weaning, the cost will consist mainly of milk replacement and a small amount of roughage. There are different strategies by which calves are fed during this period, differing in the type of milk replacer used and the way it is fed, which will have an influence on the labour costs. Farmers either use milk replacer (milk powder) or whole milk (Boulton et al., 2015; Hawkins et al., 2019). The difference in costs between a powder fed or whole milk fed calve is not significant. As the amount of feed that is used is the biggest contributor to the costs, relevant differences can occur given the implemented feeding regimen. Whereas some farmers feed their calves only four litres per day, other farmers will give up to eight litres of milk replacement daily. However, the farmer with the higher amount of milk replacer will have the higher total costs. The costs per kg daily gain per day can be lower than for a farmer with a lower amount of milk replacer (Hawkins et al., 2019). The higher amount of milk replacer has a positive effect on the growth of the calve, which can cause a decrease in the age of calving and hence lowering the total costs (see 2.3).

In the second phase of life, the time between weaning and conception, the costs consist of roughages and concentrates. Also, these costs will differ depending on which management strategy is used. For the farmer, it is most important to meet the nutritional requirements of their animals. In the first weeks after weaning, the farmer often feeds his calves roughages (grass and maize silage) and concentrates. Depending on the calves' growth and availability of silage, the farmer can choose to lower the concentrates and increase the maize in the diet, which can decrease the costs of the diet. Furthermore, feeding costs can differ depending on the housing system used (Hawkins et al., 2020). When a farmer is able to graze its calves, this will decrease the costs of roughage. However, other costs, such as fences and pasture losses, will occur. It is also possible that the animals on the pasture do not meet the nutritional requirement, which will cause a decline in growth and ultimately cost the farmer. In general, the farmers' relative feeding costs will be around 40 to 50 % of the total costs (Hawkins et al., 2020) For all farmers, it is important to meet the nutritional requirements to avoid fattening the calves, as this will decrease growth and increase the (health) costs of the farm.

During the time between conception and calving, the feed will consist mainly of roughages. With the exception that after six weeks before calving, during the period it is common to feed these animals the same feed as the dry cows (Mourits et al., 2013).

Labour costs

Another significant cost of the rearing of heifers is the labour costs. Mohd Nor et al. (2012) found that the labour cost of rearing a heifer was around 499 euros per reared heifer in the Netherlands, which is 31% of the total costs. In a study in the UK, the relative labour costs were 22.3% of the total costs (Boulton et al., 2017. Verbruggen (2014) found a similar relative cost with 25% of the total costs. As most farms are family-owned businesses, the level of opportunity costs due to additional labour differs between farms (Mohd Nor et al., 2012). Most farmers will perceive the opportunity costs of their labour as zero. Therefore, labour costs are often underestimated, and when studies are compared, it is essential that these costs are considered.

Like the feeding costs, the relative labour costs of rearing vary with the different stages of the heifer's life (Boulton et al., 2017). In the time between birth and calving, the farmer will need labour to feed the milk replacement to the calve. Depending on which management system is used, there will be differences. Farms with automated systems will have lower labour costs than farms where the calves are in individual or group houses (Hawkins et al., 2019). Also, the labour costs are correlated to the feeding costs, as when more milk is fed, more labour is needed to feed the calves ((Boulton et al., 2015). The labour costs after weaning are lower, and these costs are mainly contributed to feeding these animals. Although, the housing system that is used can influence labour costs. The labour costs when the animals are pasturing are lower than when the calves are all-year inside (Hawkins et al., 2020). On the other hand, the costs of pasture management will be higher, the same as explained with the feed costs.

Housing/buildings costs

Furthermore, a farmer will have costs for the buildings and housing of their animal. Mohd Nor et al. (2012) found that the housing costs of rearing heifers were estimated at around €180 per calve, around 12% of the total costs. Boulton et al. (2017) found that the cost of bedding and housing were 8.7% and 4.3%, respectively. Verbruggen (2014) found that the building costs accounted for 11% of the total costs. All studies found a relative cost of around 12% but considered different criteria to calculate these costs. The studies do not clearly define the underlying components of the building/housing costs. Some include depreciation and/or bedding costs, while others exclude them. Therefore, comparing these studies on building/housing costs is difficult. In practice, farmers tend to forget the stables' deprecation (exclude building costs in their cost estimations), after all, “the barn is already there” (Mohd Nor et al., 2015). Also, farmers tend to overlook the bedding costs, as often the bedding in the young stock barn is the same as what is used in the dairy cow barn. This means the farmer perceives these costs as costs for the dairy cows and does not include these in the estimation of the young stock costs (Mohd Nor et al. 2015)

Other costs (Healthcare, reproduction etc.)

Some smaller cost components will consist of health and fertility costs. Boulton et al. (2017) found a relative contribution due to healthcare costs of 4.1% of the total costs. The cost during the period between calving and weaning was the highest, with an average of 9.6% of the total costs. Verbruggen (2014) and Mohd Nor et al. (2012) found similar relative percentages of 2.13% and 3.06% of the total costs. Also, the relative costs of fertility were similar between the studies, which were 4.4% (Boulton et al., 2017), 2.55% (Mohd Nor et al., 2012) and 2.13% (Verbruggen, 2014).

The veterinary cost consists of routine check-ups, vaccines, and treatment for diseases. The costs are especially high in the first couple of months, as in this period, the calves have the highest risk of becoming sick. The two most significant health risks are diarrhoea and respiratory diseases, which viruses or bacteria can cause. Therefore, it is essential for a healthy and clean environment for these animals. These diseases will have an economic effect, affecting growth and, therefore, calve later than their healthier counterparts. The reproduction costs will consist of the expenses of insemination, and with good management, the average amount of insemination is around 1.8 times per heifer (KWIN, 2021-2021). Calves will be inseminated when they are heavy enough and have enough size. On average, this is around 15 months (calving age at 26 months (KWIN, 2020-2021)), and it is possible to inseminate earlier with good management strategies.

2.3 How to value rearing costs?

It can be challenging to differentiate the cost of raising young stock from the overall expenses of running a dairy herd. For example, heifers are fed the same type of feed as dairy cows. Another example is the use of crops, equipment, and contract work for the roughages, as it can be challenging to determine how much of the costs are attributed to the young stock (Verbruggen, 2014). Due to the difficulty in determining the cost of raising young stock, farmers will likely underestimate these costs and need to prioritise raising young stock (Mohd Nor et al., 2015).

Moreover, when evaluating rearing costs there is always the problem of how to account for farmer’s own input (like labour and capital) hence, unpaid costs for the contribution of production resources when determining the costs of dairy farm. There are two approaches to valuing these costs: the replacement cost approach and the direct revenue approach (Mourits et al., 2013). With the replacement cost approach, costs are based on the value of a replacement production resource, which focuses on the continuity of the business and allows for an assessment of the farm’s profitability. For example, labour costs are calculated even if the farmer performs all the labour on their dairy farm and does not need to pay any wages. In this case, the costs are based on what a replacement worker would cost, because the value of the "work done by the entrepreneur" is equivalent to what a replacement would cost. With the direct revenue approach, it is assumed that the use of a production resource incurs costs only when there is an alternative application for that resource. In other words, every production resource entails costs equivalent to the revenue of the best alternative use, commonly referred to as the 'marginal utility

principle. In this research, the replacement costs approach was used for the valuation of the labour and the capital.

2.4 Herd management determinants influencing rearing costs at herd level.

The first calving age and the replacement rate have a significant influence on the costs of rearing heifers at herd level. The calving age is the age when the heifer is calving for the first time; in the Netherlands this age is around 26 months (KWIN, 2020-2021). The replacement rate is the number of heifers needed to replace the dairy cow and is, at the moment, around 26% (KWIN, 2021). Higher growth rates can lower age at puberty and subsequently lower age at first calving. The potential benefits of accelerated rearing in terms of reduced total feed and labour costs must be weighed against possible disadvantages such as decreased productivity due to fat accumulation or poor condition caused by low calving weight (Mourits et al., 2013).

If the total rearing costs on farm level are considered, the costs on a farm are determined not only by the individual animal's rearing costs but also by the young stock occupancy rate. The number of youngstock on a dairy farm should be the same as the need for replacement heifers. Thus, when the replacement rate can be lowered, the number of calves can be lowered, and therefore, the total rearing costs at herd level will be lower. The optimal young stock occupancy rate depends on the replacement rate, age at first calving, and young stock mortality during the rearing period (Table 1) (Mourits et al., 2013). Based on a first calving age of 26 months and a replacement rate of 26%, a dairy farm with 100 dairy cows should at least have 60 heads of youngstock. This number of youngstock is including a 6% mortality rate. Reducing the first calving age to 24 months would reduce this required number to 55 heads. The same reduction can be obtained by lowering the replacement to 24%.

Table 1: Optimal young stock occupancy according replacement rate and age of calving on the farm (Mourits et al. 2013).

Replacement rate	Age of calving						
	22	**23**	**24**	**25**	**26**	**27**	**28**
20%	39	41	42	44	46	48	49
22%	43	45	47	49	51	52	54
24%	47	49	51	53	55	57	59
26%	51	53	55	57	60	62	94
28%	64	57	59	62	64	67	69
30%	58	61	64	66	69	72	74
32%	62	65	68	71	73	76	79
34%	66	69	72	75	78	81	84
36%	70	73	76	80	83	86	89
38%	74	77	81	84	87	91	94
40%	78	81	85	88	92	95	99

3. Material & Methods

To compare different rearing strategies under the established phosphate restrictions, a simulation study was performed to evaluate the consequences on a standardised dairy farm, representative of an average Dutch dairy farm. The model study consisted of two steps. In the first step, the rearing costs per strategy were studied by the use of the enterprise budgeting JONKOS model, representing the costs of the rearing unit on a farm. In the second step consequences on farm level were estimated based on a newly developed partial budgeting model that accounted for the trade-offs between the rearing and dairy units within the phosphate restriction.

In section 3.1 the assumptions behind the defined characteristics of the standard farm are described, as well as the different modelled rearing scenarios. Subsequently, the youngstock enterprise budgeting program JONKOS is explained in more detail. This model was used for calculating the rearing costs for the different rearing strategies. In the next subsection, the modelling design is explained by which the rearing scenarios are compared to obtain insight into the consequences at herd level. For this comparison, an Excel model was developed, to mimic the rearing costs at the rearing unit level, trade-offs within the overall herd phosphate restriction, and feed and animal health-related costs at the dairy herd level. The required phosphate excretion calculations are separately explained in section 3.1.4, Finally, in section 3.2 the sensitivity analyses as performed are to answer research question three are presented.

3.1 Comparing different rearing strategies.

3.1.1 Farm characteristics of the standardized farm

To define a standard farm using the sector information of Binternet (BIN, 2023), a representative year had to be chosen on which the average farm characteristics are based. In this research is chosen for the year 2019 as the standard year, with the following reasoning. The reference year of 2015 did not provide a reasonable estimate of the current number of livestock on the average farm, as dairy farm sizes have grown and altered in composition since the milk quota was abandoned. The following considered year was 2017 when the first reduction regulations on phosphate were announced. These regulations included the reduction of phosphate in feed, a 4% generic reduction in the livestock of non-grassland-bound farms, and a buy-out regulation. Due to these measures, the average number of cows decreased then and was not representative of the current number of farm animals. These phosphate regulations were also the reason for a non-representative year in 2018, where all non-grassland-bound farms had to decrease an additional 8% of their animals. This resulted in a slight decrease in the average number of cows in 2017 and 2018 but a significant reduction in young stock. Unlike previous years, 2019 was much calmer regarding rules and market fluctuations. However, this changed again in 2020 and 2021, with the COVID-19 outbreak causing market prices to fluctuate wildly. Although this did not affect herd size, the fluctuating market prices will have an influence on rearing strategies in which the farmer is dependent on the market. Thus, the more recent years 2020 and 2021 were not chosen as the year to determine the standard number of dairy and young stock but 2019.

In 2019, the average farm consisted of 102 cows, 32 calves younger than a year and 28 calves above a year (BIN, 2023). In this research, the standard farm is adjusted to 100 cows, with the associated young stock of 30.7 calves under a year and 26.7 calves above a year (BIN, 2023). Other rearing-related characteristics of the standard farm are the replacement rate and the first calving age. In this research, the replacement rate for the standard was based on the number of heifers available per year, which was equal to 26%. The average first-calving age in the Netherlands is 26 months (BIN, 2023). This means that a heifer will calf on average when the animal is two years and two months.

Another important characteristic of the farm was the milk production of the cows. The milk production was the most important source of revenue on the farm, and the milk production would determine which amount of phosphate right was needed on the farm. The average milk production per dairy cow in 2019 was used as the standard for milk production. The average milk production in 2019 was 8900 kg per cow, with a protein content of 3.57% and a fat content of 4.42% (BIN, 2023). On farm level, this meant

that the farm had a production of 890,000 kg of milk per year. Furthermore, the standardised farm also had some land in ownership. In the case of the year 2019, the average number of hectares of a dairy farm was 57.1 ha, consisting of 47.4 ha of grassland and 9.7 ha of arable land (BIN, 2023). The arable land is mainly used for the growth of maize.

Based on the official fixed phosphate emission rate per animal type (Table 12, Appendix A), the phosphate rights for the standardised farm had been determined. With an average milk production of 8900 kg, the phosphate excretion rate is 43.5 kg per dairy cow annually. For calves younger than one year, the rate was equal to 9.6 kg per phosphate per year, and for calves older than one year was equal to 21.9 kg per year. Given these phosphate emission rates and the standardised herd composition of 100 dairy cows, 26.7 calves younger than a year and 30.7 calves above a year (Table 2), the total phosphate excretion for the standard farm summed to 5278 kg. For the remainder of the study, this estimated phosphate excretion level was set equal to the available phosphate rights on the farm.

An overview of all the standardised farm characteristics can be seen in Table 2

Table 2: Overview of characteristics of the standard farm.

# Milk cows	100
# Calves <1 year	26.7
# Calves >1 year	30.7
# Total young stock	54.4
Replacement rate (%)	26
Calving age (months)	26
Annual milk production per cow in kg	8,900
Annual Milk production on farm level in kg	890,000
Protein content milk (%)	3.57
Fat content milk (%)	4.42
# Hectares of land in ownership	57.1
Grassland (hectares)	47.4
Arable land (hectares)	9.7
Phosphate excretion / restriction (kg)	5278

3.1.2 Rearing scenarios

As explained in the introduction, a dairy farmer needs replacement heifers for when dairy cows need to be replaced. There are several options to obtain these replacement heifers. In this section, three of these options are explained, along with an explanation of how the corresponding rearing costs were calculated. These three different rearing strategies were then used to compare which option is economically most beneficial.

The first rearing strategy is most common in the Netherlands, viz., rearing all replacement heifers on the dairy farm itself. The rearing costs for this option were calculated with the Excel program JONKOS_dairyfarm, which will be further explained in section 3.3.1.

The second strategy was the so-called outsourced rearing option. This means that the calves are partly reared at another farm. The period of outsourced rearing could differ, indicating alternative scenarios within this option. Calves could be moved to the rearing farm at the age of fourteen days to the age of twelve months. The calves were all moved back to the dairy farm two months before calving. This means

that the calves moved at a younger age were longer present on the rearing farm. The different scenarios can be found outlined in Table 3. The rearing costs in these scenarios consisted of the costs that occurred on the dairy farm before and after moving to the rearing farm and the costs that occurred on the rearing farm.

Table 3: Different outsourced rearing scenario, with the age of moving to the rearing farm and the time the calves are present at the rearing farm given an average rearing period of 26 months.

	Moved from dairy farm	**Present on rearing farm**
Scenario 1	14 days	23.5 months
Scenario 2	Two months	22 months
Scenario 3	Four months	20 months
Scenario 4	Six months	18 months
Scenario 5	One year	12 months

The rearing costs of a heifer that was outsourced consisted of two parts: costs that occurred during the rearing at the dairy farm and at the rearing farm. The rearing costs on the dairy farm were calculated with the help of the Excel program JONKOS_dairyfarm, with some modifications which are explained in section 3.1.3. For the calculation of the rearing costs on the rearing farm, there are two options.

The first option was to calculate the costs with the Excel program JONKOS_rearingfarm to estimate the actual enterprise costs as faced by the rearing farmer. The other option was to calculate the rearing costs with a fixed price per day, representing the payment as agreed upon in the rearing contract between the dairy farmer and the rearing farmer. This second option is more how it is done in practice. Actual rearing prices ranged between 2.50 and 2.90/rearing day.

In the third scenario, the strategy was to have no rearing and buy all the required heifers on the market. Under this scenario, it was assumed that all calves born at the dairy farm were sold at fourteen days of age and that the required number of replacement heifers could be obtained from the market when needed. Costs related to this scenario were represented by the average market price of 2022.

3.1.3 JONKOS

In this research, the costs of rearing heifers were calculated with the Excel enterprise budgeting program JONKOS. Livestock Research, DLV, WUR Chair Group Business Economics, and the Faculty of Veterinary Medicine of Utrecht University jointly developed JONKOS (Evers & de Haan, 2014)). This program gives insight into the costs of heifer rearing, with separate versions for dairy farmers and youngstock rearing farmers.

The JONKOS modules were developed in 2013, and the dairy sector has undergone many changes since then. The main changes were abolishing the milk quota in 2015 and introducing phosphate rights in 2018. Also, input prices, such as feed and energy, have increased considerably since then. In this study, the required input of JONKOS has been updated using KWIN 2021-2022 An overview of these updates can be found in Table 4.

In the subsequent section, the structure of the JONKOS_dairy farm module is explained, followed by an explanation of the JONKOS_rearing farm module. In Appendix B, all sheets of JONKOS_dairyfarm can be found.

Model structure JONKOS_dairy farm

JONKOS consisted of one main sheet and several sub-sheets. The main sheet did give an overview of the cost categories, calculated with the standard price in the sub-sheets. These costs could be changed as needed for the purpose it is used. The sub-sheets were divided into the following topics:

- General information and number of animals
- Diet composition
- Roughages
- Animal related costs
- Land and buildings
- Manure
- Labour and installations
- Water and energy

On the main sheet in JONKOS, it was possible to give inputs about the farm characteristics. These characteristics were the amount of produced milk, the number of dairy cows, the needed number of heifers, the average calving age and the number of young stock present on the farm. The replacement rate was based on the number of heifers needed. In the standard farm, 26 heifers are required on 100 cows, representing a replacement rate of 26%. Also, the average calving age could be adjusted. The standard is 2.02 years (26 months), which could be changed from 1.10 years up to 2.06 years.

The diet composition was calculated based on the average days the animals were grazed and, consequently, the average days the animals were housed indoors. The standard for animals under a year was 90 days, and the standard for animals above a year was 180 days of grazing. The average standard diet consisted of 10% maize and 90% grass silage, supplemented with an average amount of concentrates the calves are fed at their age. Furthermore, it was possible to fill in the losses associated with the concentrates, roughages, and grazing; these losses were equal to:

- Feed losses concentrate 2%
- Field losses roughage 6%
- Preservation losses roughage 3%
- Feed losses roughage 5%
- Grazing losses with unlimited grazing of 20% (this leads to a grazing efficiency of 80%)

Based on the number of concentrates given, days grazing, standard roughage diet and the associated losses, JONKOS could calculate the requirement of fresh grass, grass silage and maize silage in kg Dry Matter (DM) for all calves present on the farm.

In JONKOS, there were two options for obtaining the roughages: the farm can grow itself or can only purchase their roughages. In the option of own growing, the assumption was made that enough land was available for the calves. In the option of only purchased roughages, the assumption was made that all feed is purchased. There was no option for a combination of own growing and purchasing. For the option of own growing, there were different options for the type of ground and, therefore, different amounts of yields. There were the following options:

- Dry sandy soil, 9,500 kg DM grass/ha/year and 12,500 kg DM maize/ha/year.
- Moderate sandy soil, 11,000 kg DM grass/ha/year and 14,500 kg DM maize/ha/year.
- Good sandy soil, 12,500 kg DM grass /ha/year and 15,500 kg dm maize/ha/year.
- Peat soil, 11,000 kg DM grass/ha/year and 14,500 kg DM maize/ha/year.
- Wet clay soil, 10,000 kg DM grass/ha/year and 13,500 kg DM maize /ha/year.
- Good clay soil 14,000 kg DM matter grass/ha/year and 16,500 DM dry matter maize/ha/year.

In this research was chosen for the own growing option on moderate sandy soil.

With the requirement of roughages calculated in the sub-sheet diet composition, the number of hectares needed to produce the required roughage was calculated. In this calculation, the average amount of DM per cut is 2500 kg DM, based on the amount of DM yield achieved with the chosen option moderate sandy soil. Then JONKOS calculated the cost of land and contract work based on these hectares. For the hectares of grassland, the land costs consisted of the fences, crop protection, and seed and fertiliser costs. For the hectares of grassland, the contract work costs consisted of reseeding, mowing, tedding, raking, silage making, manuring and other contract work costs.

In the main sheet of JONKOS the health care costs of the calves under and above a year were defined. The sub-sheet allowed for adjustments to the assumptions regarding insemination, shearing, and bedding costs. The bedding costs were calculated assuming that the calf pens were bedded with straw (100 kg per calf per year), and the heifer stalls were bedded with sawdust (65 kg per heifer per year). The quantities were adapted from KWIN 2021-2022. In addition to calculated interest for the present animals (percentage and replacement value from KWIN 2021-2022), the model included disposal costs for fallen animals (mortality is calculated in the "General and Animal Numbers" sub-sheet). Given the low mortality rate, the assumption was that a separate visit was required for each fallen animal. The total costs per stop were charged, in addition to the individual pickup costs per.

With the land use calculated in the “Roughages” sub-sheet JONKOS could calculate the rent costs, with the use of the given rent price. The building costs were calculated based on the replacement value and the number of places in the barn. The costs of the buildings consisted of depreciation, interest and maintenance. The manure costs were based on the number of animals present and the standard of excretion that are given. The number of hectares determined the amount of manure that could be placed within the farm. If there was too much manure, the manure needed to be disposed of. When there was less, the manure would be divided over the arable land and grassland. After the manure, the fertiliser would be added until the standard norm is achieved. The cost of fertiliser is used in the calculation of the roughage costs.

JONKOS was able to calculate the costs of installations and machinery, for example, an automatic feeding system. In this research, there was chosen to exclude such installations. Therefore, the installations part of JONKOS was not used. The labour costs were calculated based on the need for labour. When, for example, an automatic feeding system was used, the need for labour did go down. In the case of this research, there were no such installations, and the model assumed a number of minutes per animal group. In the group under a year, the number of minutes was assumed to be 73/day. In the group above a year, this number was assumed to be 33/day. With this information, JONKOS was able to calculate the hours worked per year. Further, JONKOS calculated the number of hours needed for the land work, based on the number of land and the amount of work done (this was the same for all scenarios). Then JONKOS added both hours and determined with the given cost per hour what the total labour costs of the farm were.

Water was calculated based on the number of animals present and the standard norm of the amount of water these animals needed. The energy use calculated was based on the heating of the milk replacement and the lighting in the barn.

Output JONKOS_dairyfarm

In the main sheet of JONKOS, the model output was presented. The output consisted of the total rearing costs and a breakdown of all cost categories.. JONKOS_dairyfarm calculated the total rearing costs including labour and building costs. Also, the rearing costs without labour, without buildings and without labour and buildings were included in the JONKOS_dairyfarm model. Furthermore, the total rearing costs on the farm level were calculated, as well as the rearing costs per 100 kg of milk and per animal per day (See Appendix B).

Model structure JONKOS_rearingfarm

The model structure of the JONKOS_rearingfarm was almost the same as that in JONKOS_dairyfarm, but there were some differences. The first difference was the number of animals in a rearing farm; there were no milking cows, and only young stock was present on the rearing farm. As these calves were not born at the farm, the age of arrival was needed. When the heifer had to give birth, the heifer was moved back to the original farm. Also, an age of disposal was required. With this information, the costs of a rearing farm can be calculated.

Also, it was necessary to assume the amount of land available on the farm. In the case of JONKOS_dairyfarm, this number was calculated. In the case of the JONKOS_rearingfarm, this number was an input variable. To make a fair comparison, it was assumed that in JONKOS_rearingfarm the same calculation was used as in JONKOS_dairyfarm. This meant that in this research, the number of land available in JONKOS_rearingfarm depended on the nutritional requirements of the calves present and the given concentrates and losses (same as in JONKOS-dairy farm). Therefore, the assumptions were made that the farmer had, in all cases, the needed number of hectares. The soil type characteristics were the same as in the JONKOS_dairyfarm.

Outsourced rearing strategy and JONKOS

Furthermore, there were some additional calculations added in the JONKOS_dairyfarm compared to the original model. This was regarding the outsourcing strategy to make the possibility of a combination of the JONKOS_dairyfarm and the JONKOS_rearingfarm. As explained, the rearing costs of the outsourcing strategy consisted of a dairy farm part and a rearing farm part. This meant that in JONKOS_dairyfarm, the number of days present on the farm needed to be adopted. In this case, the number of calves under a year was calculated in the following way:

*(# of days before moving away/365) * # of calves needed.*

And the number of calves above a year:

# of days after moving back/365 # of heifers needed*

With these numbers, it was possible to calculate the total costs of the outsourcing strategy.

Table 4: Overview of all the costs in JONKOS from 2013 till 2021

Prices in JONKOS-model		**2013**	**2018**	**2021**
Growth, harvest, purchased roughages, concentrates and other feed				
Purchased grass silage	Euro/ton	50	78	78
Purchased maize silage	Euro/ton	40	42	72
Concentrates	Euro/100 kg	20	22.5	28,5
Milk replacer	Euro/kg	1.5	2	2
Animal related costs				
Health costs <1 year	Euro/animal	36	38	38
Health costs >1jaar	Euro/animal	15	16	16
Price per insemination	Euro	11.75	13.1	14.01
Sperm price	Euro	10.5	15	20
Shearing	Euro/animal	5.4	6.95	7.05
Bedding	Euro/ton	100	120	120
Tariff collecting dead animal	Euro/stop	35.82	18.97	18.97
Tariff dead animal <1 year	Euro/animal	1.31	3.2	3.2
Tariff dead animal >1 year	Euro/animal	9.35	28.26	28.26
Land and buildings				
Replacement value barn per animal >1 year	Euro/animal	1800	2400	2610
Replacement value barn per animal >1 year	Euro/animal	2000	2600	2900
Lease per ha	Euro/ha	600	627	723

Manure production and manure dispospal				
Price manure dispospal	Euro/ton	12	15	18
Fertilizer	Euro/kg	0.85	0.93	0.9
Labour				
Price per labour hour	Euro/hour	22	27	29
Water and energy				
Price water	Euro/m3	1.07	0.73	0.78
Price energy	Euro/kWh	0.2	0.21	0.16
Young stock market prices				
Calve < 1 year	Euro/animal	335	315	530
Calve > 1 year	Euro/animal	825	925	1075
Replacement heifers	Euro/animal	1100	1250	1315
Newborn heifer calf	Euro/animal	65	30	15
Costs grassland				
Fences	Euro/ha	50	90	120
Crop protection	Euro/ha	17	16	20.5
Seed	Euro/ha	155	190	198
Contract work				
Reseeding	Euro/ha	240	258	420
Mowing	Euro/ha	28	25	25
Tedding	Euro/ha	21	19	19
Raking	Euro/ha	21	19	19
Harvesting	Euro/ha	100	125	147
Manure	Euro/ha	2.5	3.15	4.54
Other	Euro/ha	25	26	26

Costs maize land				
Crop protection	Euro/ha	90	75	76
Seed	Euro/ha	192	220	225
Contract work				
Plowing	Euro/ha	168	185	197
Seeding	Euro/ha	70	78	80
Crop proctection	Euro/ha	35	38	40
Harvesting	Euro/ha	350	380	491
Manure	Euro/m3	2.5	2.95	3.71
Other	Euro/ha	25	26	26

3.1.4 Phosphate calculations

To evaluate the consequences of the various rearing strategies at herd level within the imposed phosphate restriction and, hence, the potential trade-offs between the rearing and milking unit, the amount of phosphate excretion per strategy had been estimated. As mentioned earlier, the average phosphate excretion per cow was 43.5 kg (milk production = 8900 kg, see appendix A), per calve above a year 21.9 kg and per calve under a year 9.6 kg.

Own rearing

The phosphate excretion under the own rearing strategy was considered the base strategy, as explained in section 3.1. For the own rearing scenario, the phosphate excretion was estimated at:

Milk production = 8900 kg / cow per year
Number of cows (initial) = 100

*Annual amount of phosphate milk cows = 100 cows * 43.5 kg = 4350 kg*
*Annual amount of phosphate calves >1 year = 30.7 * 21.9 kg = 672 kg*
*Annual mount of phosphate calves <1 year = 26.7 * 9.6 kg = 256 kg*
Annual amount of phosphate calves youngstock = 672 kg + 256 kg = 928 kg
Total annual amount of phosphate farm = 5278 kg

This total amount of excretion is assumed to be equal to the phosphate rights present on the farm. Of the total excretion, 82% originates from the milking unit and only 18% from the rearing unit, indicating the maximum potential of trade-offs in phosphate excretion.

Outsourced rearing

In the outsourced rearing scenario, the amount of phosphate that could be excreted (restriction) was the same as that of the scenario of own rearing. Since calves that moved to the rearing farm did not contribute any more to the phosphate excretion of the dairy farm, there would be extra phosphate excretion capacity available for the milking unit. See, for example, the calculation in the case the young stock was moved to the rearing farm after fourteen days of age.

Phosphate excretion capacity = 5278 kg per year
Milk production = 8900 kg /cow per year
Number of cows (initial) = 100

Number of young stock moved to raiser = 26 calves under a year
Number of young stock moved back to the dairy farm = 26 calves above a year

*Phosphate young stock <1 year old = (14 days /365 days) * 26 * 9.6 kg = 9.5 kg*
*Phosphate young stock >1 year old = (60 days/365 days) * 26 * 21.9 kg = 93.6 kg*
Phosphate excretion young stock on dairy farm = 103.1 kg per year

Additional phosphate excretion capacity for dairy cows = 5278 kg - 103 kg = 5174 kg per year
Maximum number of cows given the increased phosphate excretion capacity = 5174 kg / 43.5 kg per cow = 119 cows

This example shows that outsourcing the rearing of heifer calves at the age of two weeks makes it possible to keep nineteen more cows under the same phosphate restriction. However, a larger dairy herd required a larger number of heifers to be raised for replacement. Hence, the actual phosphate excretion by youngstock at the dairy farm was higher. By accounting for this change in youngstock size, the actual maximum amount of increase in dairy cows was eighteen cows. Furthermore, in this example, the calculation was chosen for the age of fourteen days before being moved to the rearing farm. If this

age of moving were higher, the amount of phosphate restriction space available would be less, the amount of phosphate restriction space for milk production can be found in Table 5.

Table 5: Amount of phosphate excretion capacity available for milk production given the standard farm with a phosphate restriction of 5278 kg/year.

	Phosphate excretion capacity available for milk production	**Number of dairy cows**
Home-reared	4350 kg	100
Age of calves when outsourced to a rearing farm		
Fourteen days	5157 kg	118
Two months	5120kg	117
Four months	5074 kg	116
Six months	5035 kg	115
One year	4893 kg	112

Without rearing

In this scenario, it was assumed that there was no phosphate excretion capacity needed for the rearing of the replacement heifers. All calves were moved and sold at fourteen days, meaning the remaining phosphate restriction capacity could be completely used for the dairy cows in this scenario. An example calculation is as follows:

Phosphate excretion capacity = 5278 kg per year
Milk production = 8900 kg / cow per year
Number of cows = 5278 kg per year / 43.5 per cow per year = 121 cows

In this example, it would mean that this farm of 100 cows can grow to 121 cows. However, there is a restriction on the maximum number of cows that can be kept on the farm because there is not infinite space for the cows in the barn. The maximum number of cows in this study was set at 120 cows, assuming that this was the potential housing available on an average farm.

3.1.5 Farm level comparison

To evaluate the economic consequences of the various rearing strategies at farm level a separate Excel model has been developed. The economic consequences of a rearing strategy are reflected by the rearing costs as explained in 3.2 and the gross margin related to the milk production by the dairy herd of which the size varies by the youngstock rearing corrected excretion capacity. The evaluated dairy-related gross margin consists of the milk earnings, the dairy feeding costs and other variable dairy cow-related costs. The farm model then calculated a "total herd gross margin", by subtracting all costs of the milk earnings. These gross margins at herd level of the different strategies were then compared in the results. An example of this Excel model can be found in Appendix C.

All the rearing strategy scenarios were compared to the own rearing strategy to see what the effect is of the different rearing strategies and to obtain an indication of which is more financially beneficial for the dairy farmer. JONKOS can calculate the rearing costs with and without the own labour and building costs. For the final comparison to conclude, the rearing costs without own labour and building costs were used to align with the variable costs approach that was used in the gross margin calculation of the dairy herd.

Calculation gross margin at farm level

Gross margin dairy unit

In the dairy part of the model, the milk earnings were determined by the number of dairy cows and the milk production on the farm, which was multiplied by the milk price. In the standard scenario, this milk price was 0.38 euros per kg of milk. For the feeding costs and animal-related variable costs, there had to be made some assumptions. The feeding costs and the animal-related costs, consisting of animal health, crop costs, contract work and fuel costs, were estimated with the help of Binternet (BIN, 2023). However, in both, the feeding and animal-related variable costs of Binternet young stock costs are included as Binternet expresses total costs – including rearing costs - per kg milk or per dairy cow. These values needed to be corrected for these rearing-related costs because these rearing costs are already included in the rearing strategy specific part of the model.

The performed correction was based on the young stock costs per 100 kg milk, which were calculated in JONKOS_dairyfarm with the characteristics of the standard farm. The feeding costs of dairy cows were, according to BIN in 2021, equal to 12.18 cents per kg of milk, and the young stock costs were 0.70 cents per kg of milk. This meant that the dairy feeding costs used in this research were set at 11.48 cents per kg of milk. The other variable dairy costs are calculated in the same way. According to BIN, in 2021, the animal health costs were 2.23 cents per kg, the other animal-related costs and crop costs were 3.77 cents per kg of milk, contract work was 2.84 cents per kg, and the fuel cost was 1.93 cents per kg milk. The total other costs were 10.77 cents per kg of milk. The young stock costs based on the similar posts of JONKOS were 2.88 cents per kg of milk. This meant that the total other costs for the dairy cows were set at 7.89 cents per kg of milk.

Calculating "Total herd Gross Margin"

The model calculated the overall herd gross margin almost in the same manner for all three earning strategies. The model starts with the basic information of the farm, such as the number of cows, the number of young stock above and under a year, the milk production, and the milk earnings. The number of cows is based on the for youngstock rearing corrected excretion capacity (Table 5). Depending on the rearing strategy, this number varies between 100 and 120.

With the number of cows, the number of heifer calves needed is determined based on the replacement rate of 26% (Table 1). With this replacement rate and the % mortality losses of the calves, the number of calves above and under a year was calculated. With this information, the rearing costs per heifer could be calculated. In the case of the strategy without rearing, these rearing costs were represented by the purchase prices of a new heifer, as explained in the section about the different strategies.

With the total rearing cost, it was possible to calculate the costs per 100 kg of milk when these total costs were divided by the total milk production on the farm. After the rearing costs, the dairy feeding and other dairy variable costs were added to the model. The feeding and other animal-related costs were given as the amount per kg of milk, and when this is multiplied by the milk production, the costs can be calculated. After all the costs are calculated based on the total number of milk produced, the overall gross margin on the farm was calculated:

Gross margin = Milk earnings – Total costs (rearing costs + dairy feeding costs + dairy-related variable costs), with

*Milk earnings = 8900 Kg / cow per year * €38.00/ 100 kg milk * (herd size | phosphate excretion capacity)*

*Feeding costs = 8900 Kg / cow per year * €11.48/ 100 kg milk * (herd size | phosphate excretion capacity)*

*Dairy related variable costs = 8900 Kg / cow per year * €7.89/ 100 kg milk * (herd size | phosphate excretion capacity)*

*Rearing costs = (number of youngstock | dairy herd size) * costs per heifer per strategy (see 3.1)*

3.2 Sensitivity analysis on milk production, milk prices and replacement management strategies.

To explore the impact of changes in production level and milk price, as well as specific changes in management strategies by varying replacement rate and age at first calving, a sensitivity analysis was performed using scenario analysis. All sensitivity analyses were performed within the own rearing strategy and using the standardised farm. The JONKOS_dairyfarm was used to calculate the rearing costs, as explained in section 3.1.3.

3.2.1 Scenarios

The first scenario evaluated the impact of the level of milk production. Due to the higher phosphate excretion at higher production levels, fewer cows can be milked (see Appendix A). This difference in the number of dairy cows then influences the number of rearing heifers on the farm which were needed. In this scenario, the milk production of 7500 kg per cow, 9000, kg per cow, 10500 kg per cow, and 12000 kg per cow were compared. The second scenario was about changes in milk price, and what the effect of the milk price was on the financial result. The milk prices in this scenario ranged from 20 cents to 50 cents. The third scenario was about improving the replacement management on the farm. With improved management, it was possible to decrease the replacement rate and age of the first calving on the farm. Both aspects should reduce the number of calves needed to be reared, hence reducing rearing costs while releasing phosphate excretion capacity.

3.2.2 Phosphate calculations

As can be seen in Appendix A, the phosphate excretion per cow decreased when the milk production level decreased. This meant when the milk production level was lower, more cows could be milked within the same phosphate restriction. An example can be found in the following calculation:

Milk production level decreases from 8900 to 8000 kg per cow per year
Phosphate excretion decreases from 43.5 to 40.6 kg per year.

*Phosphate excretion dairy herd = 100 cows * 40.6 kg per cow per year= 4060 kg per year*
Phosphate excretion young stock = 928 kg
Phosphate deficit = 5278 -928 + 4060 = 290 kg
Extra cows compared to the standard herd size of 100 cows = 290 kg /40.6 kg per cow = 7 cows

In this example, the farmer could milk approx. seven cows more when the milk production level is decreased by 900 kg. However, the same condition applies as explained in section 3.1.4. in the sense that this number needed to be corrected for the larger amount of youngstock that is needed. This correction had been taken into account in the model calculations.

Also, different management strategies of decreasing replacement rate and decreasing the age of first calving influenced the phosphate restriction space available for dairy cows. With a decreasing replacement rate, the farmer needed to rear fewer animals as the farmer needed less. In the case of decreasing the age of first calving, the farmer needed fewer calves as the calves were earlier available to replace a dairy cow. Both management strategies caused fewer calves on the farm, and this extra phosphate restriction space could be used to own additional dairy cows. These calculations worked the same as the outsourced rearing strategy, see 3.1.4.

3.2.3 Farm level comparison

In this research question, the same model was used as for the second research question. With the altered milk production, some changes were made in the feeding costs. The feeding costs were based on the

nutritional requirement of the animals and the assumption that higher milking-producing cows are fed more maize and concentrates in the diet. The nutritional requirement was given in VEMs. VEM is a Dutch measurement system to determine how much energy a cow needs for milk production (Corporaal, 1990). And was calculated in the following way:

$$VEM = 5323 + 440 \times FPCM + 0.73 \times FPCM^2$$

Where FPCM stands for fat and protein corrected milk yield measured in kg, which is calculated in this way:

$$FPCM = (0.337 + 0.116 \times \%F + 0.06 \times \%P) \times M$$

Where %F stands for the fat percentage in the milk, %P stands for the protein percentage in the milk and M stand for milk yield in kg.

In this research question, the milk and protein percentages were used of the standard farm, which were set at 4.42% fat and 3.57% protein. With this information, it was possible to calculate the VEM needed per cow dependent on the production level (Table 6). In this table, the assumptions were made about the amount of grass silage, maize silage and concentrate in the diet. These assumptions are based on the idea that by increasing concentrates and maize in the diet, milk production also increases (Abrahamse et al., 2007). This ratio of grass silage, maize silage and concentrates was an indication per milk production level, and in practice, can be different depending on management strategies. The price per kVEM in 2022 was for the grass silage 0.10 euros (Cowdashboard, 2023), for the maize silage 0.16 euros (Cowdashboard, 2023), and for the concentrates 0.21 euros (BIN, 2023). For an average production of 9000 kg, the feed cost price per 100 kg was 0,12 euros. Compared to the feed costs price in 2022, according to Binternet (2023), these prices were the same for an average milk production. Based on the assumptions explained, the feeding costs per 100 kg of milk for the different milking levels are calculated, which can be found in Table 6.

Table 6: Feeding costs prices of research question 3.

Milkproduction per year	Kg VEM needed	% Grass Silage	% Maize Silage	% Concen-trates	Price kVEM	Price per 100 kg milk in euro euros
7500	17333	80	10	10	0.12	**0.098**
8000	18170	60	20	20	0.13	**0.11**
8500	19010	55	20	25	0.14	**0.11**
9000	19856	40	35	25	0.15	**0.12**
9500	20705	40	30	30	0.15	**0.12**
10000	21559	35	35	30	0.15	**0.12**
10500	22418	30	40	30	0.16	**0.12**
11000	23280	30	35	35	0.16	**0.12**
11500	24148	20	40	40	0.17	**0.13**
12000	25020	20	35	45	0.17	**0.13**

The other animal-related variable costs remained the same the scenarios were compared in the same way as explained in section 3.1.5, hence, by excluding own labour and building costs related to the rearing unit

4. Results

In this chapter, first the calculated rearing costs for the three different rearing strategies - own rearing, outsourced rearing and without rearing – are presented. After this, the impact of the different rearing strategies on farm level is shown. Lastly, the results of different milk production levels, milk price age of first calving and replacement rate are discussed.

4.1 Rearing costs per heifer under different rearing strategies

Own rearing strategy

Table 7 shows the output of JONKOS_dairyfare costs related to own heifer rearing. The highest costs were the labour costs and building costs. They were followed by the lease costs, contract work, animal-related costs and feeding costs. Farmers often perceived labour and buildings as zero costs, making a substantial difference of €1123 in the total rearing costs estimation.

Table 7: Overview of all costs of the own rearing of heifers on the standard farm

	Per heifer:
Total rearing costs	€ 2,586
Excluding labour	*€ 1,883*
Excluding buildings	*€ 2,159*
Excluding labour & buildings	*€ 1,472*
Breakdown rearing costs:	
Feeding costs (Concentrates & milk replacer)	€ 234
Animal - related costs	€ 245
of which health costs	*€ 59*
of which insemination costs	*€ 72*
of which calculated interest	*€ , 63*
of which other animal related costs	*€ 50*
Crop costs	€ 175
Contract work	€ 328
Buildings	€ 411
Lease	€ 427
Water and energy	€ 25
Labour	€ 702
Mortality loss	€ 36

Table 8 shows the difference in the last decade in the rearing cost of an average farm of 100 cows, with an average replacement rate and the average age of calving. The results of 2013 were calculated in the research "Jongveeopfok in bedrijfsverband - Faalkosten en winstkansen" (Mourits et al., 2013) The results of 2018 refer to the results after an update of JONKOS input by its developers (VerantwoordelijkeVeehouderij, 2019) the results of 2021 represent the estimated rearing costs based on the updated prices as presented in Table 4 and discussed in the Materials and Methods section. Table 8 shows that the labour and building costs are the most contributing to the total rearing costs, followed by the lease costs (costs of land), contract work costs, animal health-related costs, and purchased feed costs. The difference between 2013 and 2018 is 383 euros, between 2018 and 2021 is 220 euros, and the total difference in rearing costs between 2013 and 2021 is 603 euros per heifer when accounting for all costs. This is mainly due to a 42% increase in the value of labour. When excluding the costs of own labour and buildings, the difference in rearing costs over time was equal to 308 euros, mainly resulting from increases in lease and feed prices.

Table 8: Average rearing costs of dairy heifers from 2013 until 2021.

Total rearing costs per heifer:	**2013**	**2018**	**2021**
Including labour & buildings	€ 1,974	€ 2,357	€ 2,577
Excluding labour	€ 1,481	€ 1,737	€ 1,844
Excluding buildings	€ 1,658	€ 1,984	€ 2,166
Excluding labour & buildings	€ 1,165	€ 1,364	€ 1,473
Breakdown of rearing costs per heifer:			
Labour	€ 493	€ 620	€ 703
Buildings	€ 316	€ 373	€ 411
Lease land	€ 313	€ 370	€ 427
Contract work	€ 283	€ 327	€ 328
Animal related costs	€ 211	€ 217	€ 246
Purchased feeding costs	€ 165	€ 196	€ 234
Crop costs	€ 134	€ 200	€ 176
Water and energy	€ 33	€ 24	€ 26
Risk of loss	€ 26	€ 28	€ 36

Outsourced rearing strategy

When the rearing of heifers was outsourced, the rearing costs consisted of the costs incurred on the rearing farm and the dairy farm. The distribution of the costs among the two farms depended on the outsourced rearing time. Table 9 shows the distribution of the costs among the two farms when the calves were outsourced after fourteen days of age. The difference in the distribution of the costs between the farms reduces with the time of outsourcing (Table 10), e.g., when moving at twelve months of age, the costs incurring on the dairy farm are around 900 euros, and on the rearing farm, about 1200 euros. As expected, the rearing farm costs had the same built-up as the dairy farm rearing costs, with the labour and building costs contributing the most. When labour and buildings were included, the range of the costs - depending on the time of outsourcing - was between 2463 euros and 2207 euros; excluding the labour & buildings costs resulted in a range between 1496 euros and 1405 euros.

Table 9: Rearing costs when calves at the age of fourteen days are outsourced from the dairy farm a rearing farm. The costs consist of incurring at the dairy farm and the rearing farm.

Total rearing costs	**Rearing farm**	**Dairy farm**	**Total costs per heifer**
Including labour & buildings	€ 2,148	€ 370	**€ 2,518**
Excluding labour	€ 1,592	€ 326	**€ 1,918**
Excluding buildings	€ 1,779	€ 326	**€ 2,105**
Excluding labour & buildings	€ 1,225	€ 281	**€ 1,506**
Breakdown rearing costs per heifer:			
Feeding costs	€ 194	€ 92	**€ 286**
Animal related costs	€ 217	€ 31	**€ 249**
of which health	€ 54	€ 4.	**€ 59**
of which insemination	€ 61	€ 11	**€ 73**
of which calculated interest	€ 56	€ 8	**€ 64**
of which other animal-related costs	€ 45	€ 7	**€ 52**
Crop costs	€ 143	€ 28	**€ 171**
Contract work	€ 293	€ 50	**€ 343**
Buildings	€ 368	€ 45	**€ 413**
Lease	€ 318	€ 49	**€ 367**

Water and energy	€ 19	€ 2	**€ 21**
Labour	€ 553	€ 45	**€ 598**
Risk of loss	€ 37	€ 28	**€ 65**

Table 10: The costs of the strategy of rearing a farm at the age of moving of two, four, six and twelve months.

	Including labour & buildings			Excluding labour & buildings		
	Rearing part	Dairy part	Total rearing costs	Rearing part	Dairy part	Total rearing costs
22 months oursourcing	€ 1,962	€ 444	**€ 2,405**	€ 1,107	€ 328	**€ 1,435**
20 months outsourcing	€ 1,817	€ 512	**€ 2,329**	€ 1,049	€ 372	**€ 1,408**
18 months oursourcing	€ 1,661	€ 640	**€ 2,301**	€ 983	€ 457	**€ 1,423**
12 months outsourcing	€ 1,234	€ 973	**€ 2,207**	€ 817	€ 669	**€ 1,486**

Without rearing; purchasing replacement heifers strategy.

With this strategy, the costs per heifer depended on the market prices. The following graph shows the market prices from 2018 to 2022 for the various categories of dairy cattle. This graph shows an increase in all categories, where the heifers (1-2 years, non-pregnant) increased by 450 euros, and the dairy cows increased by almost 800 euros in five years. The average value of a replacement heifer was equal to around 1350 euros, with the assumption that replacement heifers have the same market value as first-class dairy cows. 1350 euros was also the price for a replacement heifer, as indicated in KWIN-2020-2021.

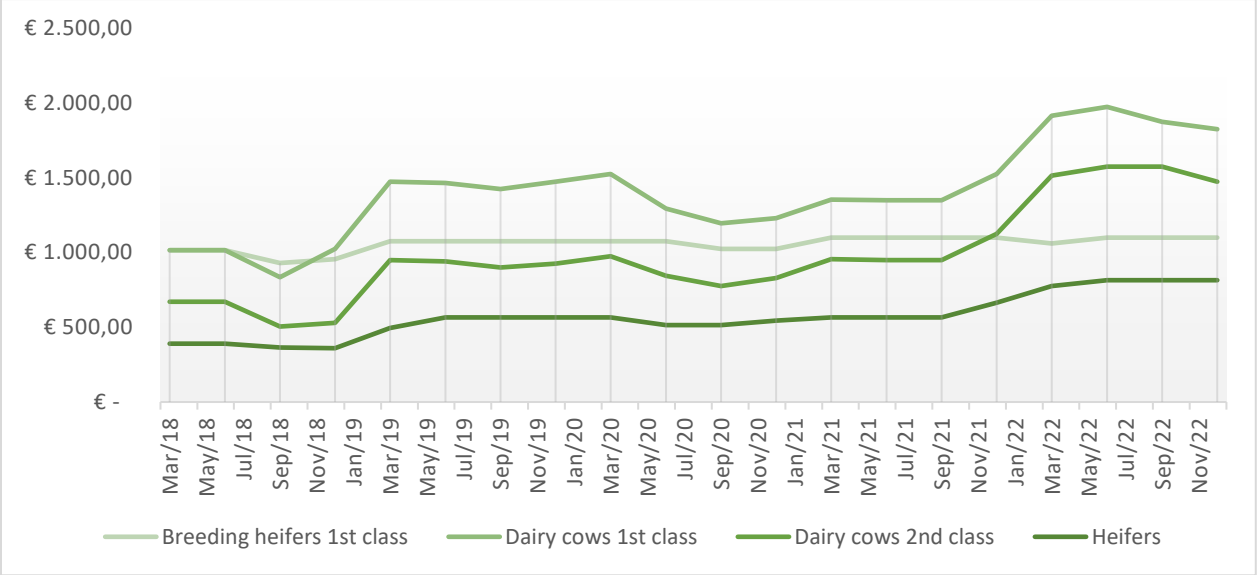

Figure 1: Market prices of dairy cattle in the Netherlands from 2018 to 2022. Source: Agrimatie

4.2 Financial consequence of rearing strategies on farm level

The financial consequences of a rearing strategy at herd level depend on the rearing costs as presented in 4.1 and the estimated gross margin related to the milk production by the dairy herd, of which the size varies by the for youngstock rearing corrected excretion capacity (Table 4).

Own rearing strategy

Table 11 shows all revenues and costs of the standard farm, under an own rearing strategy. The total milk revenue was 340,000 euros. The dairy costs consisted of the feeding and the animal-related costs

and were around 170,000 euros. The total rearing costs on farm level were equal to 69,200 euros, including the labour and building costs, and 40,000 euros when excluding them. The gross margin of the complete dairy farm was equal to 98,600 euros, including all rearing costs. Excluding the rearing labour and building costs, this gross margin was equal to 128,400 euros.

Table 11: Revenue and cost on farm level of the standard farm

Total milk revenue	€	338,222
Total rearing costs including labour & buildings	€	69,239
Total rearing costs excluding labour	€	50,431
Total rearing costs excluding buildings	€	57,804
Total rearing cots excluding labour & buildings	€	39,421
Total feed costs dairy unit	€	102,356
Total other costs dairy unit	€	68,000
Total costs farm level including labour & buildings	€	239,596
Total costs farm level excluding labour	€	220,788
Total costs farm level excluding buildings	€	228,162
Total costs farm level excluding labour & buildings	€	209,778
Gross margin including labour & buildings	€	98,625
Gross margin excluding labour	€	117,434
Gross margin excluding buildings	€	110,060
Gross margin excluding labour & buildings	€	128,443

Outsourced rearing strategy

When a farmer outsourced the youngstock rearing, there were different strategies for when the calves leave the dairy farm. Between these strategies, there were differences in the gross margins due to differences in dairy herd size due to released phosphate excretion capacity. Including the labour and building costs, the range in gross margin was between 123,000 euros and 114,000 euros. Excluding the labour and building costs resulted in a range between 163,000 euros and 145,000 euros (Figure 2). All calculations of the gross margin, including income and total costs, can be found in Appendix C.

Within the own rearing strategy, there was also an option to use a fixed price per day instead of the calculations of JONKOS. The prices per day were fixed at the amount of 2,70 euros, which meant the total rearing costs per day, including all costs, were lower compared to the JONKOS calculations. Excluding the labour and building costs, the rearing costs when using a fixed price were higher. Therefore, the gross margin, including all costs, was higher and excluding the labour and building costs, the gross margin was lower. Also, with a fixed price, there was a difference in gross margin of the age of leaving, The gross margin of the age of leaving of twelve months was the highest, and the age of leaving of fourteen days was the lowest, which is the other way around than the calculations of the JONKOS. The gross margin of the dairy farm with a fixed price of 2,70 euros can be found in Figure 2. Including labour and building costs, this ranged between 128,000 euros and 137,000 euros. Excluding these costs, the gross margin ranged between 130,000 euros and 140,000 euros.

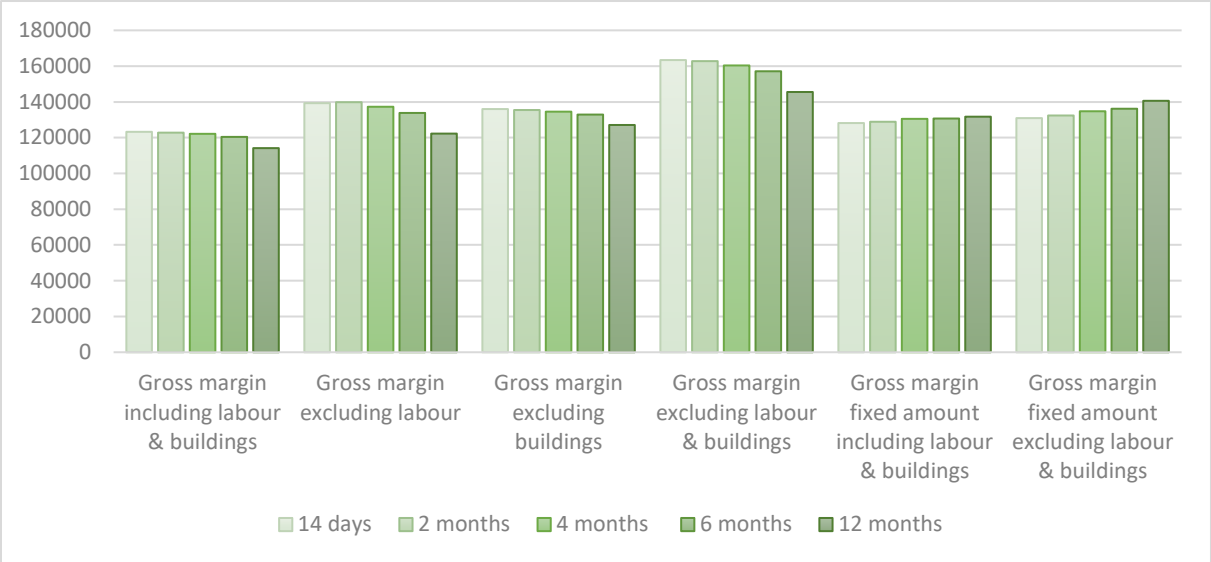

Figure 2: Gross margin including/excluding the labour and buildings costs at different age of leaving the dairy farm. The first four results are calculated with JONKOS, the last two results are calculated with a fixed price of 2,70 euros.

Figure 3 shows the influence of the different fixed prices per day, where can be seen that the lower the fixed prices, the larger the gross margin of the dairy farm was. The gross margin ranged between 143,500 euros and 115,700 euros including labour & buildings costs and between 147,700 euros and 119,900 euros when excluding these costs.

Figure 3: Gross margin with rearing with a fixed price including and excluding at age of moving of two and four months. In this figure the fixed price is changed.

Without rearing; purchasing replacement heifer strategy.

The gross margin of the standard farm without rearing was equal to 159,300 euros (Table 11). As shown in Figure 1, the heifer cost on the market is very volatile. Therefore, in Figure 4 are all gross margins calculated from 1,000 euros to 2,150 euros. Due to this strategy, it was possible to increase the milk revenues on the farm with 67,000 euros in the same phosphate excretion limitation space compared to the standard farm.

Table 11: Overview of earnings, costs, and gross margin of a farm without rearing, with the market price of the heifers' of 1350 euros. Between brackets is the increase in milk revenue due to the extra cows milked within the same phosphate excretion limitation space.

Milk earnings	€	405,840.00
Prices heifers	€	1,350.00
Total costs heifers	€	42,120.00
Total feed cost	€	122,820.00
Total other cost	€	81,595.20
Total cost	€	246,535.20
Gross margin	€	159,304.80

Figure 4: Gross margin on a dairy farm without rearing with different market prices for heifers.

4.2 Comparison of financial result between the different rearing strategies

When all rearing strategies were compared by their farm result, including the labour and building costs, the strategy in which all replacement heifers are purchased resulted in the highest gross margin. The highest gross margin excluding the labour and building costs for rearing was achieved with the outsourced strategy, calculated with JONKOS. In these results, the importance of including or excluding the labour and building costs can be seen, as these on farm level resulted in a difference of almost 30,000 euros. Also, when labour and building costs are excluded, the gross margin is closer or even better than the without rearing strategy. Excluding these costs, the rearing costs of all strategies were closer together. This showed that the heifers on the market were sold under their actual cost price.

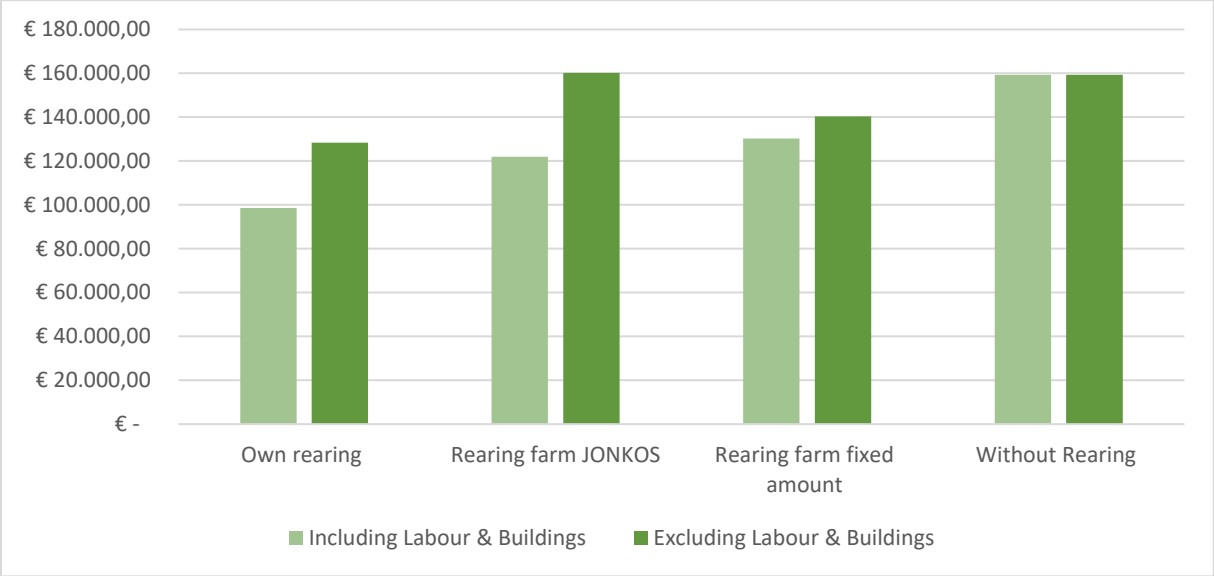

Figure 5: Gross margin including and excluding the labour and buildings costs for the own rearing strategy, outsourced rearing strategy calculated with JONKOS, outsourced rearing strategy calculated with fixed amount and the farm without rearing.

In Figure 6, the differences between the standard farm and all other strategies can be found. Including the labour and building costs, the largest difference between the own rearing strategy is achieved with the strategy without rearing; this difference was 60,000 euros. Excluding the labour and building costs the largest difference was compared with the rearing farm calculated with JONKOS; this difference was 31,500 euros. These results show the increase in gross margin due to the extra revenue that could be generated due to the additional cows in the same phosphate excretion limitation space. Although there were some differences in the total costs on farm level, the rearing costs did not substantially change. This was especially the case when the labour and building costs were excluded. Therefore, it was possible to have a higher milk production on farm level, with almost the same costs in the rearing of the heifers, which resulted in a higher gross margin on farm level.

Figure 6: Difference of gross margin between the standard farm and the four other strategies. Including and excluding the labour and buildings costs.

4.3 Scenario analysis accounting for variance in milk production and price

In this section, the effect of the variance in milk production level and milk prices on the gross margin of the standard farm with own heifer rearing is shown. With the introduction of the phosphate right, milk production affected the phosphate excretion per cow and, thus, the number of cows on the farm. If the milk production per cow was increased, it was possible to have a higher milk production per cow, but due to the fewer number of animals could decrease the total milk production on farm level. Another important factor for the milk revenue is the milk price, and this price can be very volatile and can have a substantial impact on the farm result.

Milk production level

Higher milk production levels resulted in a higher gross margin on farm level. Although with a higher milk production level, the number of dairy cows that could be kept within the phosphate restriction was decreased, the gross margin did increase. Due to the higher milk production level, the milk revenue slightly increased, even with fewer cows on the farm. Furthermore, with fewer cows, the number of replacement heifers also decreased, which resulted in lower rearing costs. The feeding costs per cow did increase, but total feeding costs did not increase substantially. The difference between the 7,000 kg milk production level and the 12,000 milk production level is around 25,000 euros.

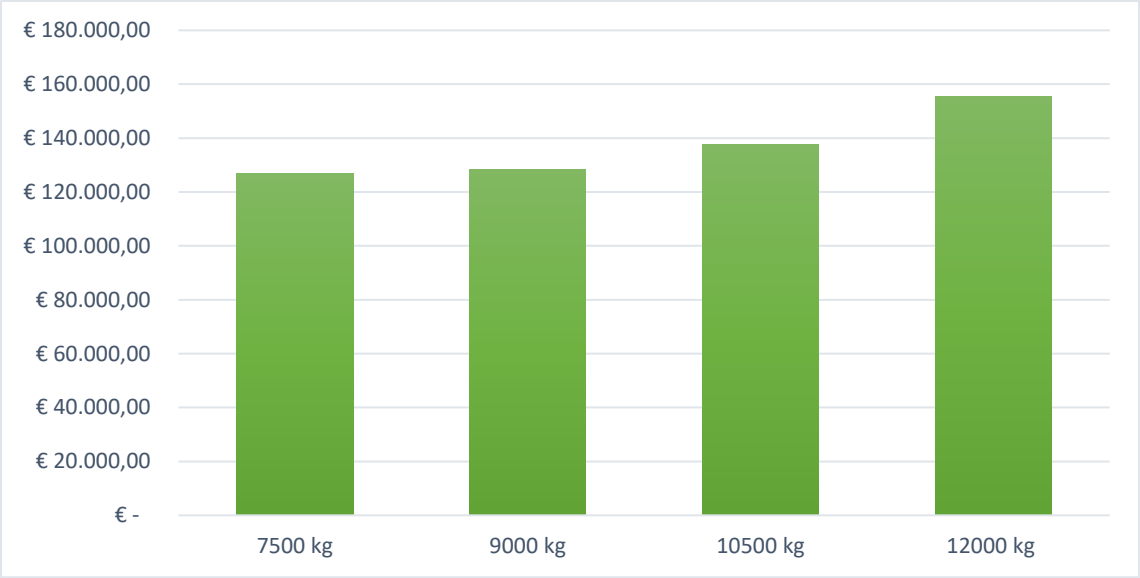

Figure 7: Gross margin excluding the labour and buildings of the own rearing at four different levels of milk production.

Milk price

Higher milk prices had a positive effect on the farm result (Figure 8). With a milk price of 0.20 euros, the gross margin on the standard farm is negative. The highest gross margin was achieved milking price of 0.50 euros. If the milk price were around 0.25 euros, the gross margin would be around zero. The difference in gross margin between the lowest milk price and the higher milk price was around 260,000 euros.

Figure 8: Gross margin of the standard farm, farm with phosphate excretion, with outsourced rearing calculated with JONKOS, outsourced rearing calculated with fixed price per day and a farm without own rearing, at different milk prices.

Scenario analysis in variance in replacement rate & age of calving

Decreasing the replacement rate and age of first calving showed a positive effect on the standard farm result. If the replacement rate is decreased from 25% to 20% the gross margin increased approx. with 15,000 euros. If the age of first calving is decreased from 26 months to 23 months, the gross margin on farm level increased with around 17,000 euros. The difference between the highest and the lowest replacement rate and age of first calving was around 50,000 euros (Figure 9). Decreasing the

replacement rate and decreasing the age of first calving resulted in a positive effect, mainly due to the lower need for a replacement heifer by which more phosphate excretion capacity became available, and the milk revenue on the farm increased.

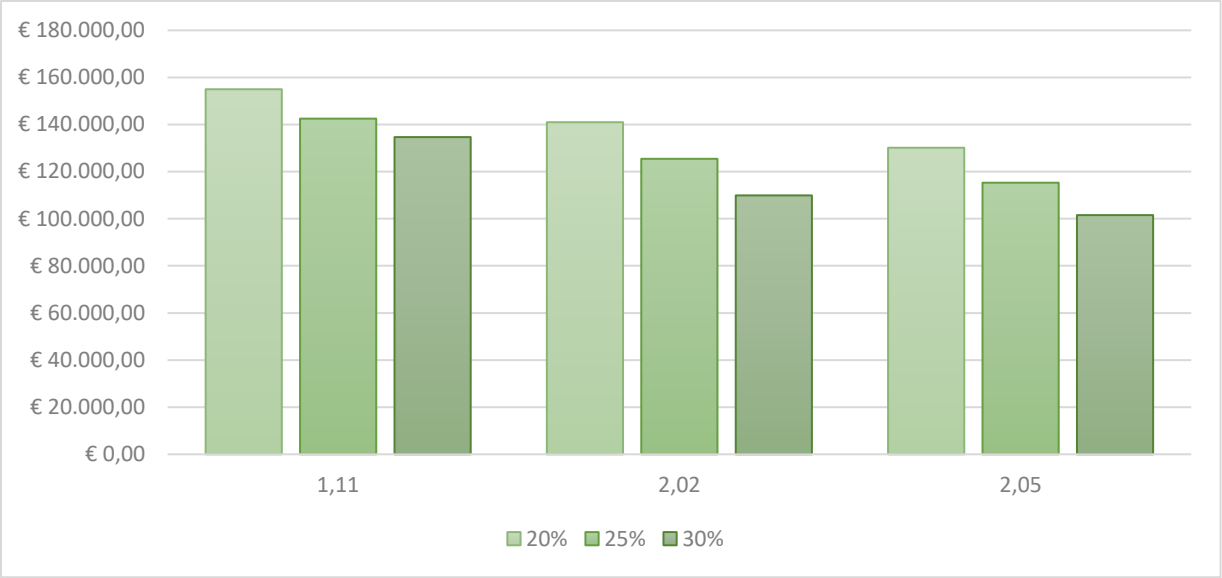

Figure 9: Gross margin on the standard dairy farm with the age of calving of 1.11, 2.02 and 2.05 months and with the replacement rate of 20%, 25% and 30%.

5. Discussion

This study started with an overview of the cost determinants related to the rearing of replacement heifers. These costs consisted of several components, but the most important were labour, buildings, and feed costs. In the studies of Mohd Nor et al. (2015) and Boulton et al. (2018), the feeding costs accounted for between 36% and 44% of the total rearing costs while in the studies of Verbruggen (2014) and Derkman (2013) this proportion was 14% and 10.5%, respectively. In this research, the feeding costs representing the value of purchased feed (milk replacer & concentrates) equalled to 9% of the total costs, including labour and building costs, for the standard farm. This result aligns with the results of Verbruggen (2014) and Derkman (2013); in their studies they also only accounted for the purchased feed costs. When all costs related to the roughages (lease, crop, contract work) are added, total feeding costs represented 44% of the total rearing costs, corresponding to the findings of Boult et al. (2018) and Mohd Nor et al. (2015). This comparison demonstrates the importance of the components considered in the feed cost calculation, as they relate to almost half of the total rearing costs.

In all the earlier referenced studies above, t labour costs ranged from 22% to 31% of the total rearing costs. Comparable results were found in this study: the labour cost was 27% of the total cost at a standard farm with own rearing. The remaining costs were more difficult to compare with the literature. For example, the calculations of the animal-related costs as health, reproduction and bedding costs differed between the studies. In some studies, these costs were more specified, and bedding costs were sometimes calculated within the total housing costs. Whereas in this study, only the costs of replacement of the barn were considered as building costs.

The resulting relative contribution of the various cost categories in this research was quite similar compared to the findings in known literature. However, the total rearing costs per heifer did increase through time as shown in Table 8. In an economic approach, all costs are considered, but often, the labour and building costs are perceived to be zero by the farmer. Therefore, in this research, the rearing costs were calculated by including and excluding these costs. The total rearing cost of the own rearing strategy, including the labour and building costs, resulted in 2586 euros per heifer. Compared to the study of Verbruggen (2014), which also included labour and building costs, the costs appeared to have increased by 600 euros. When the costs are compared without the labour costs (Derkman, 2013), the total rearing costs appeared to have increased by 285 euros. This increase per heifer also meant an increase on farm level. On an average farm, the increase was equal to 15,000 euros, including all costs, excluding the labour and building costs, this increase was equal to 7500 euros.

In this research, only the average information found in the literature was used for the calculations of the rearing costs. In practice, there can be many differences between dairy farms with respect to management strategies. Consider for example an altered feeding strategy than assumed at the standard farm by the use of an automatic feeding system for the feeding of the milk replacer. With the use of an automatic feeding system, labour costs decreased, and the costs of machinery and installations increased. In the case of the JONKOS budgeting program, this meant that the average costs of the rearing of heifers decreased by 25 euros per heifer. The labour costs per heifer decreased by 50 euros, and the installation costs increased by 25 euros. Another important driver for differences in rearing costs between farms is the soil type of a farm. The type of soil type affects the amount of roughages that can be produced of one hectare of grass or maize. In this research was chosen for an average good sandy soil type, but in reality, peat and clay soil types will yield in a higher DM of roughages per hectare. This means that for these soil types, less land is needed, and that the total feeding costs per heifer could decrease.

In JONKOS_rearingfarm, the total amount of land needed for the feed was optimised to make a fair comparison between the different strategies. In practice, this amount is not optimised, and often, a farmer needs to purchase feed or sell his feed. Also, in JONKOS_dairyfarm, this was the case, but JONKOS assumed there were enough roughages on the farm. There was no possibility of having their own roughages and purchasing roughages, which is much more common in practice.

When comparing the own rearing strategy and the outsourced rearing strategy, it was found that there was no substantial difference between the rearing costs. When all the costs were included, the differences were at most €300 per heifer, depending on how long the calves were present at the rearing farm. Excluding the labour and building costs, the differences between the own rearing strategy and the outsourced rearing strategy are much closer. Depending on the time present on the rearing farm, sometimes the outsourced strategies seemed better, and sometimes the own rearing strategy seemed better. The differences between the two strategies were not larger than 100 euros per heifer. These differences were mainly due to the different ways of calculating the labour between JONKOS_dairyfarm and JONKOS_rearingfarm farm. In JONKOS_dairyfarm, the amount of labour per calve is valued differently than in JONKOS_rearingfarm. The same applied to how the number of animals was calculated and how the building costs were calculated in JONKOS_dairyfarm if the outsourcing strategy is considered. JONKOS_dairyfarm and JONKOS_rearingfarm were not developed to compare the dairy farm level when outsourcing strategy is considered. Still, it was possible to indicate the rearing costs of the outsourced strategy.

After the rearing costs calculation, the rearing strategies were compared at farm level. These comparisons consisted of four components to calculate the gross margin of the different strategies: i) milk revenue, ii) rearing costs, iii) dairy feed costs and iv) dairy other variable costs. In this study, the only income was the milk revenue. The selling of the animals was not taken into account. With the JONKOS calculations, there were only as many heifers as needed, which meant no selling of animals. Thereby, it was forgotten that animals that are replaced will be sold to a slaughterhouse and will have a revenue. With a replacement rate of 26% on 100 cows, it meant that around 26 cows were replaced. These cows could either be sold to another farmer, sold to the slaughterhouse or died on the farm. When the cows are sold to another farm or slaughterhouse, there should be revenue. If the cow died on the farm, there should be a cost. The average revenue could be assumed to be around 1,000 euros per replaced heifer. This means the total gross revenue on the standard farm-on-farm level should be increased by 26,000 euros.

Further, no selling of young stock was considered. In the JONKOS calculations, this should be a fairer comparison between the different rearing strategies. For the reason that between the strategies, the number of calves could be different, if not the most optimal scenario was considered. In practice, there will be young animals sold. This will mean that for a farm with a lower replacement rate and more young stock at the farm, a higher gross income is generated than at a farm with a low high rate and very few youngstock. On the other hand, the rearing costs will increase on this farm. Therefore, this should be considered in assessing the gross margins found in this research. In practice, these gross margins will be higher. The effect of these extra sold animals depends on the age at which the animals are sold and the rearing costs that were already made before they were sold. For example, if the ten animals are sold after fourteen days on the farm for around 200 euros, the extra revenue should be 2000 euros. Another example: if the ten animals are sold just before calving for around 1,800 euros, there should be an increase in revenue of 18,000 euros. In both examples, it should be considered that the rearing costs also increase with these extra animals. With the average calculations used in JONKOS, these rearing costs should be around the same or even higher. Thus, the gross margin on the dairy farm will likely not change with this inclusion of the sold young stock.

The other three components within the estimated gross margin were cost components (rearing costs, dairy feed costs and dairy other animal-related costs). In comparing the three rearing strategies, the dairy feed and other animals-related costs per 100 kg of milk were the same for every scenario. In the comparison between different management strategies, this changed with the introduction of different milk production levels, where the production determined the feeding costs of this farm. The assumption was made that with higher production, the cost per kg of milk would increase, and vice versa. In practice, this is not always the case. As feeding costs depend on various factors in this research, only the kVEM prices were used according to the nutritional requirements of these animals. In practice, these costs depend on how much land is available, the soil type of the land, the quality of the roughages and even regional variation in weather. Thus, in practice, it is not always the case that the feeding price per kg of milk is lower with a lower production and vice versa. The same conditions applied to the animals-

related costs on the farm. These costs were very dependent on the management strategies used on the farm. In this research was chosen to have the same costs for all the farms. In practice, a highly productive farm can have more efficient management than a low productive farm, which means lower costs. On the other hand, highly productive cows are more on the edge of their capabilities, which can increase health problems (Fleischer et al., 2001). Therefore, an increase in these other animal–related costs on the farm. The rearing costs in this research question on farm level were also changing. Because with higher milk production, fewer dairy cows could be held under these phosphate excretion limitation space. With the same replacement rate, fewer calves are needed, and therefore, the total costs on farm level will be lower. In this research, the assumption was made that the replacement rate does not differ when milk production increases or decreases. It is likely that with higher milk production, this replacement rate will increase. Although, this strongly depends on the management capabilities of the farmer.

To summarise the last paragraphs, the feeding costs and animal-related costs on the farm are dependent on the management strategies used on the farm, which will mean when a farm can decrease the costs per 100 kg, hence increasing the gross margin on this farm. In this research, the assumption was made that all management strategies are the same for the different milk production levels, and in this case, the higher milk production seemed most beneficial. If a high-producing farm cannot have good management measures and therefore the feeding costs on the farm increase, the gross margin will decrease. If a low-producing farm can decrease the feeding costs more with good management measurement, the gross margin on this farm will increase. In this case, the gross margin of the low-producing and producing farms will be closer to each other, and therefore, the farm result of the two farms will be closer. This research will only depict the average management strategies used, and it should be considered that, in practice, management strategies will influence the farm result. If in this research, also, a stochastic simulation was used, it might be that there was more variation between the rearing strategies. And that with the use of this stochastic simulation, there would be a better depiction of differences between farms, as it is in practice.

The own rearing strategy and the without rearing strategy had only one outcome. Within the outsourced rearing strategy, there were multiple outcomes as different ages were considered at which the calves were leaving the dairy farm to the rearing farm. Within the outsourced rearing strategy, it appeared that the gross margin was the highest when the calves were leaving at early, at an age of fourteen days. The earlier a calf leaves the farm, the more phosphate space becomes available for a dairy cow, and that will increase the total revenue of the farm. In practice, most farms will move their calves at later ages, with the most important reason being the health risk and the control on the first months of feeding (McGuirk, 2007). Therefore, in this study was chosen to compare the age of leaving of four months to make a more average comparison.

When the three different rearing strategies were compared, it showed that when fewer calves are present on the dairy farm, more cows could be milked within the same phosphate restriction. In the case of the outsourced rearing strategy, this increase was around seventeen cows and in the case of the without rearing strategy, this increase was around twenty cows. This increase in dairy cows increased the milk revenue on the farm. Further, the rearing costs between the three rearing costs were quite similar if the labour costs and building costs were not considered. When these costs are considered, the difference between the without rearing strategy and the own rearing strategy can be around 1,000 euros per heifer, depending on the market prices.

When all costs are considered the most economic optimal strategy was the strategy without rearing. The difference between the own rearing strategy and the without rearing strategy was around 60,000 euros (labour and building costs included). The downfall of the strategy without rearing is that in this strategy, there is no control over the genetic quality and health status of the purchased heifers. The model used in this research assumed the purchased animals have the same milk production as the own reared animals. When cows were purchased on the market, the farmer only had the choice of the animals on the market. However, due to the lack of control of the genetic quality these animals could have lower milk production. Often, the health status of these animals is unknown, with the risk of diseases which could be dragged into the herd, resulting in an increase in health costs on the farm. Although it is possible to

purchase higher-quality of heifers, but this will mean that the price of the animals also will be higher. Therefore, the evaluated rearing strategy difference in gross margin will in practice be lower. Also, the without strategy is highly dependent on the market prices. In this research, the price of KWIN-2020-2021 was used, but the price has increased in the last two years due to a reduced supply on the market, which will mean a lower gross margin than this study suggests, as can be seen in Figure 4.

When excluding the labour and building costs, the most favourable option appears to be the strategy of outsourcing the rearing, with a difference of around 30,000 euros. However, the strategy without rearing did have almost the same result as the outsourced rearing strategy. The outsourced strategy had the advantage over the without rearing strategy in that the farmer still has control over the genetic quality and health status of his animals.

Both the outsourced and the without rearing strategies seemed to be more economically beneficial compared to the own rearing strategy. This is mainly due to the trade-off between the phosphate rights and the number of dairy cows that could be held. When the animals are outsourced, it does not mean that the cost price per heifer increases; the cost price could even decrease. However, the calculations of the JONKOS_rearingfarm did not account for extra costs of the phosphate rights of the rearing farm, as the assumption was made that the rearing farm received these phosphate rights and did not have to buy them. This means that it was assumed that the rearing farm would not calculate these costs in the rearing costs. If this were the case, the rearing costs on the rearing farm would increase, and the outsourced strategy would become less financially beneficial or not even beneficial at all. Because given a current market price of 150 euros per kg phosphate (Fosfaatrecht.nu, 2023) depreciated over 5 years (WEcR, 2023), phosphate costs equal 30 euros per kg a year. Which means a calve under a year cost 9,6*30= 288 euros additional per year and a calve above a year cost 21,9* 30= 657 euros per year,

In research question three, the influence of improving management strategies was explored, by simulating a change in milk production level, milk price, age of first calving and replacement rate. A higher milk production resulted in a higher gross margin on farm level. Although, under the current phosphate restriction, the number of cows decreased, the total milk production on the farm increased. The costs of feeding per cow did increase, but compared on farm level, this increase was not proportional to the increase in milk production. Also, the rearing costs on farm level were lower, as with fewer cows, fewer replacement heifers are needed. These assumptions were all made with perfect management; thus, in practice, this growth in gross margin will be lower than found in this research. This difference was most substantial when the production surpassed 11,000 kg, as after the level of milk production of 10,600 kg, the amount of phosphate excretion per cow does not increase further – according to the fixed rates as defined by the phosphate right system - if the milk production increases. Also, under different milking prices, it is not always economically profitable to have a higher milk production.

If the replacement was decreased from 25% to 20% and the age of calving decreased from 26 months to 23 months, the gross margin on the farm increased to around 25,000 euros. This number is only an average depiction of the influence of these two management strategies, and in practice, the increase in gross margin is expected to be lower. As with a lower age of calving, the milk yield per first-calved cow can be lower (Mohr Nod et al., 2013). Also, with a replacement rate of 20%, the health costs on the farm can be higher since a lower replacement rate often means more older cows and, thus, more veterinary costs (Wouters & Hemmen, 2001). In practice, it is often not possible to achieve the maximum decrease in the replacement rate and age of calving. However, when a farmer pays more attention to these management factors, it appears to be more profitable for the farmer.

6. Conclusion

The introduction of the phosphate rights system in the Netherlands, increased the dependency between the number of dairy cows and young stock on the dairy farm by sharing a restricted phosphate excretion capacity. Due to this dependency, outsourcing of the youngstock appeared to be a more economically beneficial rearing strategy compared to own rearing. With an outsourced rearing strategy, a farmer could milk more cows within the restricted phosphate excretion space, while the difference between the rearing costs of own rearing and outsourced rearing were not substantial. Hence, outsourcing heifer rearing resulted in a higher gross margin at farm level than own rearing. However, in a dairy system based on own heifer rearing farm economic results can be improved to a comparable extent by lowering the replacement rate and the age of first calving.

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Appendix A Phosphate Excretion Table

Tabel 12: Phosphate excretion per different milk level

Minimum	Maximum	Phospphate excretion (KG)
	<5625	32.4
5625	**5874**	34
5875	**6124**	34.8
6125	**6374**	35.5
6375	**6624**	36.2
6625	**6874**	36.9
6875	**7124**	37.7
7125	**7374**	38.4
7375	**7624**	39.1
7625	**7874**	39.8
7875	**8124**	40.6
8125	**8374**	41.3
8375	**8624**	42
8625	**8874**	42.7
8875	**9124**	43.5
9125	**9374**	44.2
9375	**9624**	44.9
9625	**9874**	45.6
9875	**10124**	46.4
10125	**10374**	47.1
10375	**10624**	47.8
10624>		49.3

Appendix B JONKOS excel sheets.

Main Sheet JONKOS

Invoer — Alleen gele cellen invullen! — Bedragen excl. BTW

(door op kopje te klikken zijn extra uitgangspunten in hulpwerkblad in te vullen)

Bij invullen suggestie (bijna) geen aan- en verkoop van vaarzen

Algemeen en dieraantallen		Suggestie	
Geleverde melk	890059		kg
Aantal melkkoeien	100		stuks
Aantal benodigde kalfvaarzen per jaar	26		stuks
Leeftijd vaarzen bij afkalveren (mpr)	2.02		jaar.maand
Aantal aanwezig stuks jongvee	57.4	57.4	kalveren en pinken

Bij deze uitgangspunten worden 0.0 drachtige vaarzen verkocht

Vervangingspercentage	26%	30	%
Rente op leningen (%)	3.5	3.5	%

Rantsoen			
Aantal dagen weiden 0-1 jaar	90	90	dagen
Aantal dagen weiden > 1 jaar	180	180	dagen
% maiskuil ruwvoer stal 0-1 jaar	10	10	%
% maiskuil ruwvoer stal > 1 jaar	10	10	%
Kg krachtvoer 0-1 jaar STAL[1]	1	1.02	kg/dier/staldag
Kg krachtvoer > 1 jaar STAL[1]	1	0.93	kg/dier/staldag
Kg krachtvoer 0-1 jaar WEI[1]	0	0	kg/dier/weidedag
Kg krachtvoer > 1 jaar WEI[1]	0	0	kg/dier/weidedag

[1] hier alleen krachtvoer invullen, voor extra krachtvoervervanger klik op kopje **Rantsoen**!

Teelt, oogst en aankoop ruwvoer			
Ruwvoer zelf telen of aankopen?	zelf telen		
Grondsoort en ds tot. opbrengst grasland	matige zandgrond, 11000 kg ds/ha/jr		
Prijs aangekochte graskuil (45% ds)	78	78	euro/ton incl oogst + transport
Prijs aangekochte maïskuil (33% ds)	72	42	euro/ton incl oogst + transport

Veekosten			
Gezondheidskosten 0-1 jaar	39	38	euro/dier
Gezondheidskosten > 1 jaar	16.5	16	euro/dier
Strooiselkosten		848	euro per jaar (aanpassen strooi

Grond en gebouwen				
Vervangingswaarde stal per dier 0-1 jaar	2600	2280 tot 2530	euro/dier	(in ligboxenstal goedkoper dan bij aparte jongveestal)
Vervangingswaarde stal per dier > 1 jaar	2900	2530 tot 2660	euro/dier	(in ligboxenstal goedkoper dan bij aparte jongveestal)
Pachtprijs per ha	723	627	euro/ha	

Mestproductie en mestafvoer			
Prijs mestafvoer	18	15	euro/ton

Arbeid en installaties				
Prijs per gewerkt uur	29	27	euro/uur	(waardering totaal uren: eigen en vreemde arbeid)
				Uren besteed aan jongvee: 576 uur/jaar
				Kosten arbeid: 18278 euro

Water en energie			
Prijs water	0.78	0.73	euro/m³

Uitvoer — Resultaten exclusief BTW

	Per opgefokte vaars	Per 100 kg melk	Per dier/dag
Totale opfokkosten	**2587**	**7.56**	**3.27**
Exclusief arbeid	1884	5.50	2.38
Exclusief gebouwen	2175	6.35	2.75
Exclusief gebouwen + arbeid	1473	4.30	1.86

Uitsplitsing opfokkosten per vaars:	
Voerkosten	234
w.v. krachtvoer en melkpoeder	*234*
w.v. ruwvoer	*0*
Veekosten	246
w.v. gezondheid	*60*
w.v. inseminatie	*72*
w.v. berekende rente	*63*
w.v. overige veekosten	*50*
Gewaskosten	176
Loonwerk	328
Werktuigen en installaties	0
Gebouwen	411
Pacht	427
Water en energie	25
Mestafvoer	0
Arbeid	703
Uitvalrisico	36
Rente + afschrijving fosfaatrechten	0

Resultaten op bedrijfsniveau:		
Opfokkosten	67287	(+)
Gemiste opbrengst nuka's	410	(+)
Kosten aankoop vaarzen	0	(+)
Totaal	**67696**	
AF: opbrengsten verkoop vaarzen	0	(-)
Totale kosten jongveeopfok	**67696**	

General information sheet

Algemeen: berekening benodigde dieren bij opgegeven vervanging

	Invoer	Suggestie	
Afkalfvaarzen per jaar	26.00173		stuks
Leeftijd bij afkalveren	26		maanden
Leeftijd spenen	67	67	dagen
Uitval 0 - 1 jaar	2	2	%
Uitval > 1 jaar	2	2	%
Aantal aanwezige dieren 0-1 jaar	**26.8**		stuks
Aantal uitgevallen dieren 0 - 1 jaar	0.54		stuks
Waarde dier 0-1 jaar (ivm uitvalrisico)	530	315	euro/dier
Aantal aanwezige dieren > 1 jaar	**30.7**		stuks
Aantal uitgevallen dieren > jaar	0.61		stuks
Waarde dier > 1 jaar (ivm uitvalrisico)	1075	925	euro/dier
Benodigde afkalfvaarzen voor vervanging	26.0		stuks
Werkelijk aantal afkalfvaarzen/jaar obv jongveebezetting	26.0		stuks
Overschot af te kalveren vaarzen	0.0		stuks
Prijs verkochte afkalfvaarzen	1315	1250	euro/dier
Prijs nuchter vaarskalf	15	30	euro/dier

Uitvalrisico	**943**	euro
Opbrengsten vrijwillige afvoer	**0**	euro
Kosten aankoop drachtige vaarzen	**0**	euro

met aantal dieren wat in rood is aangegeven wordt gerekend

Diet sheet

Krachtvoer	0-1 jaar	norm	> 1 jaar	norm						
Gemiddeld aantal aanwezige dieren	26.8		30.7		stuks					
Aantal dagen op stal	275		246		dagen					
Krachtvoergift op stal	1		1		kg/dag					
Krachtvoervervangers (kvv) op stal	0		0		kg ds/dag					
Aantal dagen in de wei	90		180		dagen					
Krachtvoergift in de wei	0		0		kg/dag					
Vervoederingsverliezen	2	2	2	2	%	prijs	norm		bedrag	
Totale bruto behoefte krachtvoer	7509		7687		kg	28.5	22.5	euro/100 kg	4331	euro krachtvoerkosten
Totale bruto behoefte kvv	0		0		kg ds/dag	17	17	euro/100 kg ds	0	euro kosten krachtvoervervanger

Ruwvoer	0-1 jaar	norm	> 1 jaar	norm				
Totale ruwvoeropname per staldag	2.9	2.9	8.8	8.8	kg ds/dag			
Aandeel graskuil	90	90	90	90	%			
Aandeel maïskuil	10		10		%			
Aandeel overig ruwvoer (aanvoer)	0		0		%			
Opname graskuil totaal	19214		59688		kg ds graskuil			
Opname maïskuil totaal	2135		6632		kg ds maïskuil			
Opname overig ruwvoer totaal	0		0		kg ds overig ruwvoer			
Vervoederingsverlies	5	5	5	5	%			
Conserveringsverlies	3	3	3	3	%			
Veldverlies	6	6	6	6	%			
Bruto behoefte graskuil	22181		68908		kg ds	Totale bruto behoefte graskuil:	91089	kg ds
Bruto behoefte maïskuil	2465		7656		kg ds	Totale bruto behoefte maïskuil:	10121	kg ds
Bruto Behoefte overig ruwvoer	0		0		kg ds	Totale bruto behoefte overig ruwvoer:	0	kg ds
Totale opname vers gras per weidedag	2.5	2.5	9.1	9.1	kg ds/dag			
Opname vers gras totaal	6023		50215		kg ds			
Beweidingsrendement	80	80	80	80	%			
Bruto behoefte vers gras	7529		62769		kg ds	Totale bruto behoefte vers gras:	70298	kg ds

Roughages sheet

Benodigde bruto hoeveelheid ds:		
Vers gras	70298	kg ds
Graskuil	91089	kg ds
Maïskuil	10121	kg ds
Overig ruwvoer	0	kg ds

Aanvoer ruwvoer			Prijs (opgave)	Norm		Bedrag	
Graskuil	0	kg ds	0.17	0.17	euro per kg ds	0	euro
Maïskuil	0	kg ds	0.22	0.13	euro per kg ds	0	euro
Overig ruwvoer	0	kg ds	0.00	0.10	euro per kg ds	0	euro
Totaal kosten aangevoerd ruwvoer						0	euro

Gewasopbrengst		norm	
Grasland	11000	11000	kg ds bruto/ha
Maïsland	14500	14500	kg ds bruto/ha

Benodigde hectares voor jongvee:			
Voor vers gras	6.39	6.39	ha
Voor maïsteelt	0.70	0.70	ha
Voor graskuil	8.28	8.28	ha
Snedezwaarte bij maaien	2500	2500	kg ds per snede
Gemaaide hectares	36.44	36.44	ha
Oppervlakte land jongvee totaal	15.37		ha

Teelt- en oogstkosten grasland voor jongvee	opgave	norm	
Afrastering	120	90	euro per ha
Gewasbeschermingsmiddelen	20.5	16	euro per ha
Herinzaaipercentage	10	10	%
Zaaizaad	198	190	euro per ha herinzaai
Kunstmest +overige bemesting[1]	133		euro per ha
Gewaskosten grasland totaal	4306		euro

Teelt en oogstkosten maïsland voor jongvee	opgave	norm	
Gewasbeschermingsmiddelen	76	75	euro per ha
Zaaizaad	225	220	euro per ha
Kunstmest[1]	85		euro per ha
Gewaskosten maïsland totaal	269		euro

Loonwerk (bij eigen beheer "**0**" invoeren):			
Herinzaai	420	258	euro per ha herinzaai
Maaien	0	25	euro per gemaaide ha
Schudden	0	19	euro per gemaaide ha
Harken	0	19	euro per gemaaide ha
Inkuilen + aanrijden kuil	147	125	euro per gemaaide ha
Bemesten[1]	4.54	3.15	euro per m³
	340		m³ mest op grasland
Overige loonwerkkosten	26	26	euro per ha
Loonwerkkosten grasland totaal	7898		euro

Loonwerk:			
Ploegen + zaaiklaar maken	197	185	euro per ha
Zaaien	96	78	euro per ha
Onkruid bestrijden	40	38	euro per ha
Oogst + aanrijden kuil	491	380	euro per ha
Bemesten[1]	3.71	2.95	euro per ha
	12		m³ mest op maïsland
Overige loonwerkkosten	26	26	euro per ha
Loonwerkkosten maïsland totaal	636		euro

Animal related sheet

Gezondheidszorg	**0-1 jaar**	**norm**	**> 1 jaar**	**norm**					
Gemiddeld aantal aanwezige dieren	26.8		30.7		stuks				
Gezondheidszorg	39		16.5		euro per dier			Totale kosten gezondheidszorg	1550 euro
Inseminatie			**> 1 jaar**	**norm**					
Inseminaties per drachtigheid			1.8	1.8	keer				
Prijs per inseminatie			14.03	13.1	euro				
Spermaprijs per dosis			20	15	euro	Kosten per pink	€ 61	Totale kosten inseminaties	1878 euro
Scheren	**0-1 jaar**	**norm**	**> 1 jaar**	**norm**					
Kosten per dier	7.05	6.95	7.05	6.95	euro/dier			Totale kosten scheren	405 euro
Strooisel	**0-1 jaar**	**norm**	**> 1 jaar**	**norm**					
Type strooisel	Stro		Zaagsel						
Hoeveelheid strooisel per dier	140	140	65	65	kg/jaar	Kosten per kalf	€ 17		
Prijs per ton	120	120	200	200	euro per ton	kosten per pink	€ 13	Totale kosten strooisel	848 euro
Berekende rente	**0-1 jaar**	**norm**	**> 1 jaar**	**norm**					
Vervangingswaarde	530	315	1075	925	euro per dier	Rente per kalf	€ 19		
Rente	3.5		3.5		%	Rente per pink	€ 38	Totale berekende rente	1650 euro
Destructie									
zie voor uitval pagina Algemeen	**0-1 jaar**	**norm**	**> 1 jaar**	**norm**					
Uitval dieren		0.5		0.6	stuks				
Tarief ophalen dieren per stop	19.26	18.97	19.26	18.97	euro per stop	Destructie kalveren	€ 21		
Aanvullend tarief per dier	6.04	3.2	38.77	28.26	euro per dier	Destructie pinken	€ 36	Totale destructiekosten	57 euro

Land and buildings sheets

Pacht

zie voor oppervlakte grond tabblad Ruwvoer

	opgave		
Oppervlakte grond voor jongvee	15.37		ha
Pachtprijs	723		euro per ha

Totale kosten pacht **11112** euro

Gebouwen	opgave	norm				
Aantal dierplaatsen 0-1 jaar	26.8	26.8	plaatsen in de stal			
Vervangingswaarde per dierplaats 0-1 jaar	2600		euro per dierplaats			
Aantal dierplaatsen > 1 jaar	30.7	30.7	plaatsen in de stal			
Prijs per dierplaats > 1 jaar	2900		euro per dierplaats			
Vervangingswaarde mestplaat	0		euro			
Vervangingswaarde overige bouwwerken	0		euro			
Totale vervangingswaarde bouwwerken	158504		euro			
Rente	3.5		%	rentekosten	2774	euro
Afschrijving	3	3	%	kosten afschrijving	4755	euro
Onderhoud	2	2	%	kosten onderhoud	3170	euro

Kosten gebouwen totaal **10699** euro

Manure sheet

Totale mestproductie	352		m³						
N-gehalte in de mest	4.4	4.4	kg N/m³						
Berekening mestplaatsingsruimte jongvee									
Beschikbaar grasland	14.67		ha						
Beschikbaar maïsland	0.50		ha						
Provincie (ivm derogatie)	Overijssel/Gelderland/Utrecht								
Mestplaatsingsruimte per ha	230	230	kg N/ha						
Forfaitair geproduceerde N in mest	2984	2916	kg N uit dierlijke mest (norm is forfaitair, bij gebruik BEX kan aangepaste productie worden ingevuld)						
Maximaal plaatsbare N	3489		kg N uit dierlijke mest						
Verplichte afvoer	0		m³	prijs mestafvoer	18	euro per m³	Kosten mestafvoer	0	euro
Beschikbaar voor aanwenden	352		m³						
Toediening drijfmest jongvee									
Drijfmestgift op grasland	23	23	m³/ha						
Drijfmestgift op maïsland	23	23	m³/ha						
Aanvoer stikstofkunstmest									
Gebruiksnorm N grasland	170	250	kg N/ha						
Werking N drijfmest op grasland	45	45	%	norm is wettelijke werking ivm kunstmestruimte (werkelijke werking ligt rond 55%)					
Ingeschatte kunstmestgift	124		kg N/ha						
Gebruiksnorm N maïsland	140	140	kg N/ha						
Werking N drijfmest op maïsland	45	45	%	norm is wettelijke werking ivm kunstmestruimte (werkelijke werking ligt rond 60%)					
Ingeschatte kunstmestgift	94		kg N/ha	prijs kunstmest	0.9	euro per kg	Kosten N-kunstmest	1681	euro
							Overige bemesting bij herinzaai	315	euro
							Totale bemestingskosten	1996	euro
Fosfaatrechten									
Productie fosfaat jongvee (forfaitair)	928	928	kg P2O5						
Toegekende fosfaatrechten jongvee	928	928	kg P2O6	maak inschatting op basis van beschikking hoeveel rechten voor jongvee per 1/1/2018 aanwezig zijn					
Waarde aangekocht fosfaatrecht	150	150	euro/kg P2O5 recht	(alleen kosten voor extra aangekochte fosfaatrechten na 1/1/2018)					
Waarde aangekochte fosfaatrechten jongvee	0		euro				Rente- en afschrijving fosfaatrechten	0	euro

Installations and machinery sheet

Installaties en werktuigen

	opgave	norm						
Vervangingswaarde mestschuif	0	7500	euro					
Vervangingswaarde drinkautomaat	0	5500	euro					
Vervangingswaarde krachtvoercomputer en toebehoren	0	7000	euro					
Vervangingswaarde overige installaties, werktuigen	0		euro					
Totale vervangingswaarde installaties en werktuigen	0		euro					
Rente	3.5		%	rentekosten	0	euro		
Afschrijving	10	10	%	kosten afschrijving	0	euro		
Onderhoud mestschuif	10	10	%	kosten onderhoud	0	euro		
Onderhoud overige installaties en werktuigen	2	2	%	kosten onderhoud	0	euro	Totale kosten installaties	0 euro

Arbeid dieren	**0-1 jaar**	**norm**	**> 1 jaar**	**norm**			
Aantal dieren	26.8		30.7		stuks		
Vaste arbeidsbehoefte per diergroep	65	65	30	30	minuten per diergroep per dag		
Arbeidsbesparing per dier door mestschuif	0	0	0	0	minuten per diergroep per dag		
Arbeidsbesparing per dier door drinkautomaat	0	0			minuten per diergroep per dag		
Arbeidsbesparing per dier door krachtvoercomputer	0	0	0	0	minuten per diergroep per dag		
Arbeidsbesparing per dier door overige installaties	0	0	0	0	minuten per diergroep per dag		
Variabele arbeidsbehoefte na arbeidsbesparing	65		30		minuten per diergroep per dag		
Gewerkte uren per diergroep	393		183		uren per diergroep	gewerkte uren per jaar	576 uur

Arbeid veldwerkzaamheden grasland (bij geen loonwerk)	Loonwerk ?*	opgave	norm		
Gemaaide hectares		36.44		ha	
Maaien	Nee	0.5	0.5	uur eigen arbeid per gemaaide ha	
Schudden	Nee	0.6	0.6	uur eigen arbeid per gemaaide ha (inschatting 2 keer schudden)	
Harken	Nee	0.4	0.4	uur eigen arbeid per gemaaide ha	
Inkuilen + aanrijden kuil	Ja	0	1	uur eigen arbeid per gemaaide ha	
Bemesten	Ja	0	1	uur eigen arbeid per ha grasland	
Totaal eigen arbeid veldwerkzaamheden		55		uur	
kosten arbeid per uur	29			euro per uur	Totale arbeidskosten 18278 euro

* antwoord hangt af van invoer op pagina "Ruwvoer"

Water and energy sheet

Water en energie

	0-1 jaar	norm	> 1 jaar	norm	
Aantal dieren	26.8		30.7		stuks

Water	0-1 jaar	norm	> 1 jaar	norm		
Drinkwater	15	15	45	45	liter per dag	
Water voor kunstmelk	5	5			liter per dag tot spenen	
Totaal waterverbruik	129		587		m³	
Prijs water per m³	0.78		0.78		euro per m³	Totale kosten water 559 euro

Energie

Energieverbruik water voor kunstmelk:			
Temperatuur koud water	8	8	°C
Temperatuur kalvermelk	40	40	°C
Energieverbruik warm water*	333		kWh/jaar
Energieverbruik mestschuif	0	0	kWh/jaar
Energieverbruik kalverdrinkautomaat	0	0	kWh/jaar
Energieverbruik krachtvoercomputer	0	0	kWh/jaar
Energieverbruik ov. Installaties	0	0	kWh/jaar
Energieverbruik verlichting	150	150	kWh/jaar
Totaal energieverbruik	483		kWh/jaar
Prijs energie	0.21	0.21	euro/kWh

Totale kosten energie 101 euro

* om 1 m³ water met 1°C te verhogen is ongeveer 1,16 kWh nodig

Appendix C Rearing strategies calculations on farm level

Own rearing calculations

Calculation without phosphate excretion					
Number of cows	100	**KG milk**			**8900**
Number of young stock above a year	30.66	**KG phosphate**			**43.5**
Number of young strock belowe a year	26.77	**Replacement rate**			**26.00%**
KG melk per cow	8900				
Total milk	890059				
Total earnings milk	€ 338,222.45				
Rearing costs per heifer inc labour & buildings	€ 2,586.54				
Rearing costs per heifer exc labour	€ 1,883.92				
Rearing costs per heifer exc buildings	€ 2,175.27				
Rearing cots per heifer exc labour & buildings	€ 1,472.65				
Total rearing costs inc labour & buildings	€ 69,239.65				
Total rearing costs exc labour	€ 50,431.10				
Total rearing costs exc buildings	€ 58,230.14				
Total rearing cots exc labour & buildings	€ 39,421.59				
Total costs per 100 kg milk inc labour & buildings	€ 7.78	€	0.08		
Total costs per 100 kg milk exc labour	€ 5.67	€	0.06		
Total costs per 100 kg milk exc buildings	€ 6.54	€	0.07		
Total costs per 100 kg milk exc labour & buildings	€ 4.43	€	0.04		
Feed costs milking cows per 100 kg milk	**0.115**	*Total feed costs*		€	102,356.80
Other costs milking coww per 100 kg milk	**0.0764**	*Total other costs*		€	68,000.51
Gross margin per 100 kg milk inc labour & buildings	€ 11.08	*Total costs farm level inc labour & buildings*		€	239,596.96
Balance per 100 kg milk exc labour	€ 13.19	*Total costs farm level exc labour*		€	220,788.41
Balance per 100 kg milk exc buildings	€ 12.32	*Total costs farm level exc buildings*		€	228,587.45
Balance per 100 kg milk exc labour & buildings	€ 14.43	*total costs farm level exc labour & buildings*		€	209,778.90
Gross margin inc. labour & buildings	€ 98,625.49				
Gross margin exc. labour	€ 117,434.05				
Gross margin exc. buildings	€ 109,635.00				
Gross margin exc. labour & buildings	€ 128,443.56				
Phosphate milk cows	4350.29				
Phosphate young stock < 1 year	256.98				
Phospahte young stock > 1 year	671.38				
Total phosphate space in KG	5278.65				

Outsourced rearing calculations

				KG milk	8900		Milk price	0.38
Rearing farm				KG Phosphate price	43.5		Feeding costs per kg milk	0.115
Phosphate space	5278.65			Replacement rate	26.00%		Other costs per kg milk	0.0764
	Phosphate space young stock	**Phosphate space dairy cows**	**Maximum number of dairy cow**	**KG milk per dairy cows**	**Total milk**	**Milk earnings**	**Feed cost**	**Other costs**
Jongvee 14 dagen	122.46	5156.19	118.5	8900	1054945	€ 400,879.02	€ 121,318.65	€ 80,597.78
Jongvee 2 maanden	158.47	5120.18	117.7	8900	1047578	€ 398,079.52	€ 120,471.43	€ 80,034.94
Jongvee 4 maanden	204.89	5073.76	116.6	8900	1038080	€ 394,470.49	€ 119,379.23	€ 79,309.33
Jongvee 6 maanden	245.26	5033.39	115.7	8900	1029820	€ 391,331.64	€ 118,429.31	€ 78,678.26
Jongvee 12 maanden	386.01	4892.64	112.5	8900	1001022	€ 380,388.53	€ 115,117.58	€ 76,478.11

	Cost rearing farm inc labour & buildings	**Cost dairy farm inc labour & buildings**	**Total rearing cost per heifer inc labour & buildings**	**Total rearing costs inc labour & buildings**	**Total rearing cost per 100 kg milk**	**Saldo per 100 kg milk**	**Total costs**	**Balance inc. labour & buildings**
14 dagen	€ 2,146.70	€ 370.92	€ 2,517.62	€ 77,589.46	€ 0.074	€ 11.51	€ 279,505.89	€ 121,373.13
Jongvee 2 maanden	€ 1,961.85	€ 443.52	€ 2,405.36	€ 73,612.31	€ 0.070	€ 11.83	€ 275,528.74	€ 122,550.78
Jongvee 4 maanden	€ 1,816.86	€ 512.13	€ 2,328.98	€ 70,628.58	€ 0.068	€ 12.06	€ 272,545.01	€ 121,925.48
Jongvee 6 maanden	€ 1,661.42	€ 640.07	€ 2,301.50	€ 69,239.65	€ 0.067	€ 12.14	€ 271,156.09	€ 120,175.55
Jongvee 12 maanden	€ 1,233.98	€ 973.02	€ 2,207.00	€ 64,540.03	€ 0.064	€ 12.41	€ 266,456.47	€ 113,932.06

	Cost rearing farm exc labour	**Cost dairy farm exc labour**	**Total rearing cost per heifer exc labour**	**Total rearing costs exc labour**	**Total rearing cost per 100 kg milk exc labour**	**Saldo per 100 kg milk exc labour**	**Total costs**	**Balance exc. labour**
14 dagen	€ 1,592.74	€ 326.12	€ 1,918.86	€ 59,136.54	€ 0.056	€ 13.25	€ 261,052.97	€ 139,826.05
Jongvee 2 maanden	€ 1,452.57	€ 395.79	€ 1,848.36	€ 56,566.13	€ 0.054	€ 13.46	€ 258,482.56	€ 139,596.96
Jongvee 4 maanden	€ 1,365.67	€ 464.28	€ 1,829.94	€ 55,494.80	€ 0.053	€ 13.51	€ 257,411.23	€ 137,059.26
Jongvee 6 maanden	€ 1,269.77	€ 585.66	€ 1,855.43	€ 55,819.80	€ 0.054	€ 13.44	€ 257,736.23	€ 133,595.41
Jongvee 12 maanden	€ 1,015.20	€ 914.15	€ 1,929.35	€ 56,420.75	€ 0.056	€ 13.22	€ 258,337.18	€ 122,051.35

	Cost rearing farm exc buildings	**Cost dairy farm exc buildings**	**Total rearing cost per heifer exc buildings**	**Total rearing costs exc buildings**	**Total rearing cost per 100 kg milk exc buildings**	**Saldo per 100 kg milk exc buildings**	**Total costs**	**Balance exc. buildings**
14 dagen	€ 1,778.49	€ 326.07	€ 2,104.57	€ 64,859.90	€ 0.061	€ 12.71	€ 266,776.33	€ 134,102.69
Jongvee 2 maanden	€ 1,615.99	€ 375.91	€ 1,991.90	€ 60,958.84	€ 0.058	€ 13.04	€ 262,875.27	€ 135,204.25
Jongvee 4 maanden	€ 1,500.14	€ 420.16	€ 1,920.30	€ 58,234.96	€ 0.055	€ 13.25	€ 260,151.39	€ 134,319.10
Jongvee 6 maanden	€ 1,374.82	€ 511.86	€ 1,886.67	€ 56,759.84	€ 0.054	€ 13.35	€ 258,676.27	€ 132,655.37
Jongvee 12 maanden	€ 1,036.25	€ 728.28	€ 1,764.53	€ 51,600.85	€ 0.049	€ 13.71	€ 253,517.28	€ 126,871.24

	Cost rearing farm exc labour & buildings	**Cost dairy farm exc labour & buildings**	**Total rearing cost per heifer exc labour & buildings**	**Total rearing costs exc labour & buildings**	**Total rearing cost per 100 kg milk exc labour & buildings**	**Saldo per 100 kg milk exc labour & buildings**	**Total costs**	**Balance exc labour & buildings**
14 dagen	€ 1,224.54	€ 281.27	€ 1,496.16	€ 46,109.47	€ 0.044	€ 14.49	€ 237,705.16	€ 163,173.86
Jongvee 2 maanden	€ 1,106.71	€ 328.19	€ 1,434.67	€ 43,905.89	€ 0.042	€ 14.67	€ 235,501.58	€ 162,577.94
Jongvee 4 maanden	€ 1,048.95	€ 372.32	€ 1,408.25	€ 42,706.47	€ 0.040	€ 14.75	€ 234,302.16	€ 160,168.33
Jongvee 6 maanden	€ 983.16	€ 457.44	€ 1,423.25	€ 42,818.07	€ 0.041	€ 14.70	€ 234,413.77	€ 156,917.87
Jongvee 12 maanden	€ 817.47	€ 669.41	€ 1,486.34	€ 43,465.51	€ 0.041	€ 14.52	€ 235,061.21	€ 145,327.32

Price fixed amount per day

2.7

	Rearing cost fixed amount	**Cost dairy farm inc labour & buildings**	**Total rearing cost per heifer inc labour & buildings**	**Total rearing costs inc labour & buildings**	**Total rearing cost per 100 kg milk**	**Saldo per 100 kg milk**	**Total costs**	**Balance inc. labour & buildings**
Jongvee 14 dagen	€ 1,933.20	€ 370.92	€ 2,304.12	€ 71,009.83	€ 0.067	€ 12.13	€ 272,926.26	€ 127,952.76
Jongvee 2 maanden	€ 1,809.00	€ 443.52	€ 2,252.52	€ 68,934.67	€ 0.066	€ 12.28	€ 269,441.04	€ 128,638.48
Jongvee 4 maanden	€ 1,647.00	€ 512.13	€ 2,159.13	€ 65,477.53	€ 0.063	€ 12.55	€ 264,166.09	€ 130,304.40
Jongvee 6 maanden	€ 1,479.60	€ 640.07	€ 2,119.67	€ 63,769.56	€ 0.062	€ 12.67	€ 260,877.12	€ 130,454.52
Jongvee 12 maanden	€ 985.50	€ 973.02	€ 1,958.52	€ 57,273.67	€ 0.057	€ 13.14	€ 248,869.36	€ 131,519.16

	Rearing cost fixed amount	**Cost dairy farm inc labour & buildings**	**Total rearing cost per heifer inc labour & buildings**	**Total rearing costs inc labour & buildings**	**Total rearing cost per 100 kg milk**	**Saldo per 100 kg milk**	**Total costs**	**Balance exc. Labour & buildings**
Jongvee 14 dagen	€ 1,933.20	€ 281.27	€ 2,214.47	€ 68,246.95	€ 0.06	€ 12.39	€ 270,163.38	€ 130,715.64
Jongvee 2 maanden	€ 1,809.00	€ 328.19	€ 2,137.19	€ 65,405.19	€ 0.06	€ 12.62	€ 265,911.56	€ 132,167.96
Jongvee 4 maanden	€ 1,647.00	€ 372.32	€ 2,019.32	€ 61,237.70	€ 0.06	€ 12.96	€ 259,926.26	€ 134,544.23
Jongvee 6 maanden	€ 1,479.60	€ 457.44	€ 1,937.04	€ 58,275.16	€ 0.06	€ 13.20	€ 255,382.72	€ 135,948.92
Jongvee 12 maanden	€ 985.50	€ 669.41	€ 1,654.91	€ 48,395.24	€ 0.05	€ 14.03	€ 239,990.93	€ 140,397.60

Without rearing calculations

Without rearing					
Phosphate space	5234.34			*KG milk*	8900
Number of Cows	120.3297079			*KG phosphate*	43.5
Kg Milk	8900			*Replacement rate*	26.00%
Total Kg of milk	1070934.4				
Milk earnings	€ 406,955.07				
Needed number of heifers	31.3				
Prices heifers	€ 1,350.00	according to KWIN			
Total costs heifers	€ 42,235.73				
Cost per 100 kg milk	€ 3.94	*per kg melk*	€ 0.039		
Feeding kost per kg milk	0.115	*Total feed cost*	€ 123,157.46		
Other costs dairy cows per kg milk	0.0764	*Total other cost*	€ 81,819.39		
Saldo per 100 kg milk	€ 14.92				
Total cost	€ 247,212.57				
Gross margin	€ 159,742.50				