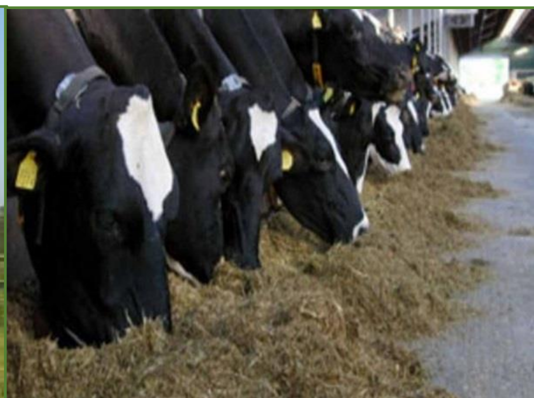
Wageningen University - Department of Social Sciences

Business economics

The relation of farmland yields, mineral efficiency and economic performance on Dutch dairy farms

Stefan Regelink
June 2015





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Acknowledgement

This report is written to conclude my master thesis in Business Economics. This thesis is part of my education Animal Sciences at the Wageningen University. The relation between the 'KringloopWijzer' and economic performance was a very topical subject, this because most farmers have to use the 'KringloopWijzer'. Because it is a current subject, little research was done to this subject. This all made it a very interesting thesis subject. The process of this thesis was a very educational period. I have learned a lot about the calculation rules of the 'KringloopWijzer' and how to influence the utilizations with the 'KringloopWijzer'.

The research question of this thesis came from Dirksen Management Support (DMS). Also the data for this thesis was collected by DMS. I would like to thank DMS for the opportunity to do my thesis in this subject with their data. Also I would like to thank Hans Dirksen, John Baars and Lisette van Zuijlen for their supervision from DMS during this thesis. Also the opportunity to be present on meetings with farmers to discuss about their 'KringloopWijzer' results and economic performance was very interesting and educational. I would also like to thank Henk Hogeveen for his supervision of Wageningen University.

Wageningen, June 2015

Abstract

Dairy farm income can largely differ between farms. In the Netherlands the income of dairy farms in 2014 was between 7,000 and 60,000 euro, with an average of 39,000 euro. The biggest part of the revenues are milk revenues. The biggest part of the costs is for feed purchasing and feed producing. The total feed related costs in 2013 were 58 percent of the total costs. This means that milk revenues and feed related costs have the biggest influences on the farm income. In the Netherlands, farms can use the calculation tool 'KringloopWijzer' to calculate how efficient they are with the minerals nitrogen and phosphor on their farm. The 'KringloopWijzer' calculates the utilization of nitrogen and phosphor for the total farm, and for the animal, manure, soil and crops separately. Also the dry matter yield produced on the farmland is calculated. The utilizations and dry matter yields are calculated with the outputs of milk and meat and with the inputs of purchased feeds and fertilizers. This leads to the expectation that farms with higher utilization or higher dry matter yield in the 'KringloopWijzer' should have higher farm revenues or lower costs for purchased feeds. To test these relations, of 232 farms, results of the economic performance and results of the 'KringloopWijzer' were collected. The farms were all clients of Dirksen Management Support. Outliers for extreme intensities and phosphor utilizations were removed. Of each farm, the technical efficiency was calculated with Data Envelopment Analysis, where milk supply was used as output, and number of hectares, feed costs, fertilizer costs, seeds costs, pesticide costs, labor costs (calculated own and hired), contract worker costs, and machinery costs the input variables. To analyze the farm characteristics, 'KringloopWijzer' results and the economic performance, SPSS was used with descriptive analyses. For the relation between economic performance and 'KringloopWijzer' SPSS was used with the GLM univariate analysis. Dependent variables were the technical efficiency of the Data Envelopment Analysis, feed costs per 100 kg FPCM, gross margin per 100 kg FPCM, total feed costs, and total gross margin. The models were corrected for farm influences which affect the dependent variables, without it were effects from the 'KringloopWijzer', like intensity of livestock per hectare and soil type. The soil utilization of nitrogen and the animal utilization of phosphate were both positive related to the technical efficiency, what indicates that efficient farms in the 'KringloopWijzer' produce the same output of milk, with less inputs of land, land related costs, or feed costs. Each 1,000 kg dry matter yield more per hectare resulted in 0.23 euros lower feed costs per 100 kg FPCM. Due to the higher dry matter yield, the soil utilization of nitrogen was increased, what increased the feed costs per 100 kg FPCM. However the increased feed costs per 100 kg FPCM by soil utilization of nitrogen was less than the decreased of the feed costs per 100 kg FPCM with more DM yield. Each 1,000 kg dry matter yield on total farm resulted in 37 euros lower total feed costs. The soil utilization of nitrogen was positively related to the total gross margin with 508 euros per percent utilization. Total gross margin was also increased with 206 euro per 1,000 kg dry matter pasture grass. Pasture grass is related to grazing, while grazing decrease soil utilization. This indicates that increase pasture grass could be only economic profitable when per 2,500 kg dry matter, the soil utilization of nitrogen was less than 1 percent decreased. The animal utilization of nitrogen was positive related to feed cost per 100 kg FPCM, total feed costs and total gross margin. Because animal utilization is associated with maize and concentrate diets, and high producing cows. The farms with a high animal utilization of nitrogen should probably buy more maize of concentrates, which increase the feed costs. However due to higher milk revenues, the total gross margin was still increased.

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1. Introduction

In 2014 the average income for dairy farmers in the Netherlands was 39,000 euro. The highest income was found to be more than 60,000 euro, whereas the lowest income was found below 7000 euro (Van Der Meulen et al. 2014). This large gap between incomes shows that farms can improve their income a lot. In 2013 the revenues on a Dutch dairy farm existed for 79% of milk, making it an important factor for the farms net profit (de Jong 2013). Milk revenues are influenced by the milk yield, but milk revenues alone are no guarantee to a good net profit, because in the net profit costs also have to be included (Buza et al. 2014). Feed costs are the biggest costs of a dairy farm and thereby influence the gross margin (Buza et al. 2014). In 2013, for the Netherlands, 42% of the costs exist of variable costs and 25% of the costs exist of land processing costs (de Jong 2013). The variable costs existed for 60% of concentrates, 8% of roughage and 10% of crop related costs (de Jong 2013). This makes a total of 58% of the total costs related to feed. Between the 25% best farms and 25% least best farms, a difference of feed costs for purchased concentrates and roughage can be 4 euro per 100 kg of milk (Gielen 2015).

Grassland and feeding management have a big effect on feed costs and thus it is expected that it has a big influence on the net profit. Therefore, optimizing grassland and feeding management could positively influence economic results (Rougoor et al. 1999). The feed costs depend on the farm situation and is difficult to compare from farm to farm. For example, an intensive farm needs to buy more feed than an extensive farm. In some studies the home-raised feeds are valued for market price because the true costs are unknown. In the Netherlands, feed costs are calculated as purchased feed however on dairy farms the biggest part of the forage is produced on the farm. The costs of total feed is between 40% and 60% of the total costs for producing milk (Bailey et al. 2009).

In the Netherlands farmers are restricted to a fixed amount of manure they can use on their own land (RVO 2015). For the Dutch dairy farmers, 59% produces more manure than they can use on their own farms (CBS 2014). The surplus of manure has to transport to farms who can use the manure. Because a lot of farmers have too much manure, they have to pay to remove their manure, making it a cost. With the Dutch tool “kringloopwijzer” (KLW), farmers can prove that they are more mineral efficient and the KLW gives them the ability to remove less manure of their farms. The KLW uses milk production, milk composition, number of livestock, feed composition and the ratio of available feed product to calculate the mineral efficiencies and dry matter (DM) yield of the land. The KLW corrects for purchases and sales of feed and fertilizers (Schroder et al. 2014). Results of the KLW are varying between different farms, with farm nitrogen (N) efficiencies between 33 and 45% and farm phosphor (P) efficiencies between 67 and 303% in 2012 (Hilhorst 2013). Efficient mineral use could also have an influence on the feed costs. This because more self-produced feed means that less feed has to be purchased or less land is needed. In 2014 average agricultural land has a market price of 53,000 euro (NVM 2015). Thereby it is expected that farmers who are more efficient and have a higher land yield have lower feed costs. This could indicate a higher farm income. However this is not as evident, since high producing land could have more costs.

1.1. Research problem

With the KLW, farmers can evaluate how efficient they are with the minerals on their farm. The KLW calculates DM yield from grass and maize land, the utilization in total farm and the utilization separately for animal, manure, soil and crop. No information is available of the efficiencies and DM yields calculated with the KLW in relation with the farm economic performance. Because of the great differences in the KLW efficiencies between farms, there is improvement possible. To investigate in the relation between KLW and economic performance, farmers can see the economic effects of improving their efficiency. They can use the KLW as a tool to evaluate their technical performance and improve their economic performance. Because of the great differences in income between farms, improving the economic performance could be a great benefit for farms.

1.2. Research questions

Main question:

- What is the relationship between the results of the KLW and the economic performance of Dutch dairy farms?

Sub questions:

- What are the characteristics of the farms in the DMS database?
- What are the results of the technical efficiencies from the KLW in 2014 of the farms in the DMS database?
- What is the economic performance in 2014 of the farms in the DMS database?
- How are the KLW parameters related with farm economic performance?

Hypothesis: More efficient use of the KLW (higher DM yields/hectare and lower mineral surplus) results in a better gross margin.

2. Literature review

This chapter describes the roll of N and P in dairy farms and how to improve animal and soil utilization with management. How the KLW calculates the mineral utilizations and the dry matter yield per hectare will be described. In order to be able to analyse the economic performance, the financial statement of the gross margin will be described, and the relation between the technical efficiency and the farm economic performance from earlier research will be investigated. Because less scientific literature about these subjects is available, research reports from applied research will also be used.

2.1. Mineral efficiency

N and P are the most important minerals with losses to the environment. These losses can be harmful for the ground water or could have a contribution to the greenhouse effect. Originally these losses where compensated by bounding of N by legumes and with weathering of rocks for P delivery. Nowadays farmers compensate these losses with fertilizing, which affects the natural cycle of N and P (Schroder et al. 2014).

2.1.1. Nitrogen

N is an important element for all biological molecules in animals and crops. N is present in amino acids, proteins and sugars. Animals and crops need N to be able to live and for their growth. For plant cells, N is essential for cell division and breeding. A shortage of N is negative for the growth and thereby decreases the yield of cropland. Unfortunately, N is easy leachable and evaporable to the environment, and thereby losses can easy exist. This will be negative for the N utilization. Figure 2.1 shows a cycle of N in a dairy farm. N excreted from cows in manure is used for fertilizing the soil. N available in the soil is used by crops, these crops are used for feeding the cows. N input in the farm exists of feed purchases, fertilizer purchases, mineralization, deposition and N bound by clover. N outputs exist in milk and meat, and losses to the environment like gas production by cows, evaporation from manure, soil and crops and leaching to ground water. When the utilization of N will increase, the losses of N to the environment will be reduced. Animal and soil utilization are the most influenced by management and will be descripted further.

Animal utilization

The cow is responsible for a big loss of N. Improving animal utilization has a big effect on N losses. For the cow N input exists of feed. The important outputs are milk and meat. Unutilized N will be excreted by gasses and manure, whereby urine is responsible for the biggest part of excreted N (Kristensen et al. 2005). Management is an important factor to improve N utilization. A lot of diets for dairy cows contain more N than is needed for the milk production and maintenance of the cow. All overfed N is not used by the cow, and thereby feeding more N than the standards for milk production requirements, results in a lower feed N utilization (Jonker et al. 2002). Increasing dietary N with one gram, decreases the percentage of feed N utilization with 0.05 units. With this relation 71% of the variation in feed N

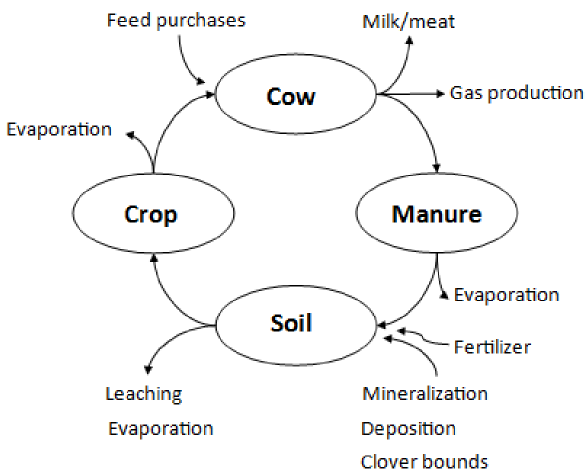


Figure 2.1: N cycle in dairy farms

utilization is explained (Jonker et al. 2002). Kristensen et al. (2005) found that a decrease in dietary crude protein content from 17.1 to 10.9% resulted in a 1.5 kg lower milk production, but the N efficiency increased from 27 to 31%. However this is in counteract with the positive correlation of milk production with feed N utilization (Jonker et al. 2002). Each kg increase in fat corrected milk will results in a 0.45 higher percentage unit of utilization. Thereby 25% of the variation in feed N utilization could be explained by the variation in milk production per cow (Jonker et al. 2002). This indicates that a higher milk production increases N utilization, if the N requirements are not exceeded. The N excretion of dairy cows is higher with grazing than with barn housed cows (Kristensen et al. 2005; 'T Mannetje 2003). Because of the great amount of fresh grass in the diet, grazing herds are mostly overfed with dietary N. This overfed N results in a lower N utilization for grazing cows.

Soil utilization

N utilization in soils is calculated with the N input by fertilizing, mineralization, deposition and N bound by clover. The N output exists of yields of grass or maize. Because it is difficult to determine the mineralization, deposition and N bound by clover, most studies in literature don't take those inputs into account. Losses of N are from leaching and evaporation during fertilizing and forage production. The use of fertilizer is for about 17% responsible of the total nitrous oxide emission (Velthof & Oenema 1997). Lowering the N input with fertilizer has the biggest effect on improving the farm N efficiency (Groot et al. 2006). Decrease of N fertilizer from 192 to 108 kg per hectare results in 55 kg less N losses to the environment per hectare (Van Calker et al. 2004). The N uptake in grass is linear related with the N application. However, old grass fields had a higher N uptake than new grass fields. This is probably due to the higher mineralization on the old fields (Reijs et al. 2007). Total DM yield and DM yield per kg N uptake was higher on new grassland fields than on old grassland fields. This resulted in a lower mineral efficiency for old grassland fields (Reijs et al. 2007). Dry matter yield of grassland in the Netherlands between 1998 and 2006, were on average 10.2 tons per hectare with 306 kg N (Aarts et al. 2008). More intensive farms with more milk production per hectare had a higher dry matter yield all years. Possible explanations could be the use of more fertilizer and better utilization of grass in autumn (Aarts et al. 2008). The dry matter yield for maize between 1998 and 2006 was 14.8 tons per hectare, with 177 kg N (Aarts et al. 2008). This means that with maize the yield of N is far lower than with grassland.

The N concentration in groundwater is generally higher in sandy soil than in clay soils (Schröder et al. 2005). Schröder et al. (2005) found that an N surplus which leached to groundwater, was 11% for grassland and 31% for arable land on clay soils. For grassland on sandy soils and peat soils it was respectively 39% and 4% (Schröder et al. 2005). This means that soil type and crop type have a big influence on the leaching of N and thereby on the utilization of N. With specific fertilizing per parcel, N will be utilized better (Verloop & Oenema 2011). Due to policy restrictions to reduce N losses, N fertilizer has to be decreased, resulting in lower grassland yields. This leads to more feed purchases or to more land which has to be used for producing feed (Van Calker et al. 2004). This would increase the feed costs for farmers. Leaching and grazing are both responsible for around 25% of the total nitrous oxide emission on Dutch sandy soils (Velthof & Oenema 1997). With grazing of cows, the N utilization will be decreased by less distribution of manure, less growth of grass and more losses of grass (Van den Pol-van Dasselaar et al. 2013). Farms with 100% mowing of grass have a 15% higher dry matter yield and a 10% more N and P yield than farms with grazing of cows (Aarts et al. 2008).

2.1.2. Phosphor

P is important for the growth, energy supply and the reproduction of animals and crops. P is an element of DNA-molecules and animal protein. In crops P is needed for photosynthesis and for the utilization of N and other nutrients. Figure 2.2 shows the P cycle in dairy farms. P excreted from cows in manure is used for fertilizing the soil. P available in the soil is used by crops, these crops are used for feed for the cows. P input in the farm exists of feed purchases, fertilizer purchases and P release from soil storages. Outputs are milk and meat, and losses to the environment as accumulation in the soil and leaching of P to ground water. When the utilization of P will increase, the losses of P to the environment will be reduced. Animal and soil utilization are the most influenced by management and will be described further.

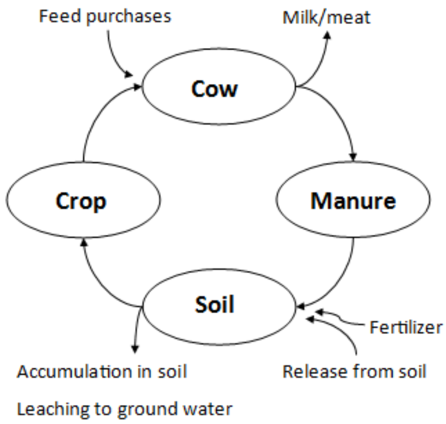


Figure 2.2: P cycle in dairy farms

Animal utilization

The cow utilization of P, is the output of P by milk and meat as a fraction of the dietary input of P. Unutilized P will be excreted in the faeces. The best strategy to improve animal P utilization is to reduce P overfeeding (R^2=0.78). This because animal related P inputs (feed or supplements) are negatively related with the animal P utilization (Spears et al. 2003). Wu et al. (2001) found that with an increase in dietary P content there is also an increase in fecal P content (R^2=0.84). When P is fed to the requirements, the apparent digestibility of P will be in the range of 45 to 50% (Wu et al. 2000). An increase of each gram of dietary P will result in 0.64 gram of P more excreted in the feces (Wu et al. 2000). A second strategy to improve P utilization is to increase milk production (R^2=0.35) (Arriaga et al. 2009). Because the milk production is not related to the dietary P content, the milk production could be increased without increasing the dietary P intake. A higher output of P in milk results in a lower excretion of fecal P (Arriaga et al. 2009). The P content in milk seems to be related to the milk protein content (R^2=0.37), which indicates that the output of P in milk can also be increased with a higher milk protein content (Wu et al. 2000). Higher P utilization has no negative effect on bone strength. Feeding 0.31% dietary P compared to 0.39% did not influence milk production or bone strength, only the bone P content was slightly lower (Wu et al. 2001). Comparing 0.38% dietary P with 0.48% dietary P made no difference in milk production over two lactations. In early lactation bone calcium will be mobilized for the high milk production, thereby also P will be available for the cow. In later lactation when calcium will be bound in the bone, also P will be bound. This means that dietary P intake could be constant over the whole lactation (Wu et al. 2000).

Soil utilization

P cannot evaporate, thereby farm losses of P will be leachable to ground water or accumulate in the soil (Oenema et al. 2012). The average P yield of grass and maize land was respectively 39.1 kg and 30.2 kg in the period 1998-2006 in the Netherlands (Aarts et al. 2008; Oenema et al. 2012). On average, farms with a high milk production per hectare also had a high P yield. This could probably be due to higher use of fertilizer (Aarts et al. 2008; Oenema et al. 2012). N fertilizer positively affects the grass yield and thereby the P yield. P fertilizer has only effect on soils with a low P content, this because on most Dutch dairy farms the amount of P in the soil is not limited for grass yield (Oenema et al. 2012). Because of enough available P in the soil, farms that did not use P fertilizer had a better

P efficiency (Gourley et al. 2012; Spears et al. 2003). The ratio grass and maize silage influences the excretion of P by cows, because maize silage contains less P. Expected is that farms with a higher grass yield, and more grass in the diet, have a higher P excretion. However farms with a high P yield are on average more intensive with more milk per hectare, and thereby they also purchase more feed (Oenema et al. 2012). Oenema et al (2012) found that farmers with feed purchases mostly focus on the energy and protein content, and focus less on P content. While this P content is most responsible for the P excretion.

2.2. 'KringloopWijzer'

With the Dutch tool KringloopWijzer (KLW), farmers can prove that they are more mineral efficient than the forfeit standards of the government. The KLW uses number of livestock, milk production, housing system, soil type and crops, grazing system and feed and fertilizer purchases as input variables. Feed storage and fertilizers will be taken into account. The KLW calculates the dry matter (DM) yield per hectare for grass and maize land separately. The mineral utilization will be calculated for farm, animal, manure, soil and crop. This means that all mineral flows of figure 2.1 and 2.2 will be calculated. The rules for these calculations are described in the report 'Rekenregels van de KringloopWijzer' by Schroder et al. (2014) and will be summarized in this paragraph.

2.2.1. Dry matter yield calculation

Weighing of the real DM yield would be practically impossible on all dairy farms because it would be very expensive, labor intensive and unreliable. The DM yield can be assumed by measuring the size of the feed storages times the feed density. The density is determined with fixed values per type of storage and the method of covering it. However these results differ too much from reality. Thereby the KLW calculates the DM yield of grassland and maize land by the amount of feed that the livestock needs.

First the VEM (Energy value for milk production) need for farm livestock is calculated. The Fat and Protein Corrected Milk (FPCM) production of the cows determines the VEM need for production. For maintenance VEM is needed depending on the body weight of the cow. The body weight is an assumed value dependent on the breed. VEM needed for maintenance is calculated differently for lactation and for dry period. Assumed is, that cows have 307 days of lactation and 58 days of dry period per year. There will be an addition of VEM needed for pasturing, pregnancy and growth in the first lactations. For pasturing distinguish is made between limited and unlimited pasturing. For pregnancy and growth distinguish is made between breed. These values together are the total VEM need for the dairy cows. For young livestock the VEM need is calculated with forfeit values dependent on the breed. Dairy cows and young livestock together are the total VEM need of livestock on the farm.

Second, the VEM intake is calculated. In the KLW it is assumed that livestock has a VEM intake of 102% of their VEM need. Third, the VEM of purchased feed, corrected for storages, is subtracted from the VEM need. The remaining VEM need should be produced on the farm. Fourth, of all farm produced feeds, VEM, P and N are analyzed per kg DM. From this the total DM yield of the farm is determined. For fresh grass of the pasture always 960 VEM/kg DM is assumed. Fifth, of all farm produced feeds the DM is estimated by size and density of the storage. This was not reliable enough for total DM yield, but it is used for the ratio of maize and grass, and to make distinguish between DM produced in the previous year and this year. The grazing system and the hours of grazing determine the ratio of fresh grass from the total grass intake. Thereby the total DM of grass and total

DM of maize in that year produced on the farm is determined. Sixth, the produced DM is divided by the amount of hectares used. This gives the DM per hectare.

2.2.2. Utilization of N and P

In order to calculate the utilization of N and P, it is important to calculate the flows of N and P on the farm. Controlled outputs of milk and meat and controlled inputs of feeds and fertilizers are measured for the amount of N and P. Next to this, the uncontrolled outputs and inputs are calculated. To calculate the N and P flows, the utilization of animal, manure, soil and crop have to calculated separately.

Animal utilization

The animal utilization is calculated as the milk and meat that is produced as a fraction of consumed feed. Gas production and manure production are unutilized N and P. First the input of N and P for consumed feed has to be calculated. For this, all feed has to be analyzed on VEM, N and P per kg DM. This determines the ratios N/VEM and P/VEM. With the VEM intake of farm livestock and N/VEM and P/VEM, the N and P intake can be calculated. Second, the fixation of N and P in the cow is calculated with fixed values. Third, the outputs of all N and P from the cow have to determine, for the outputs N and P by milk and meat, measured values of delivered milk and meat are used. Outputs of gases are fixed values. The remaining output of manure is input minus fixation and the output of milk, meat and gasses.

Manure utilization

The manure utilization is calculated as manure and feed refusals available for the soil as a fraction of manure and feed refusals produced. Unutilized N and P are losses during storage and fertilizing. The manure and feed refusals produced are calculated in the animal utilization. The losses of storage are determined by forfeit values depending on barn and storage type. Losses during fertilization are determined with forfeit values depending on used type of injector and depending on grass or arable land. For losses of N and P of manure during grazing are also determined with forfeit values. N and P available for soil are produced N and P by the cow, minus the losses during storage and fertilizing.

Soil utilization

The soil utilization is calculated as yield of N and P as a fraction of available N and P from manure, fertilizer, N bound by clover, deposition and mineralization. Unutilized is leached N and P in the soil and evaporation of N in the air. The available N and P of manure is calculated in manure utilization. The amount of fertilizer is known because it is purchased. For the N binding of clover, the amount of clover yield is calculated by the share of clover in grassland and the total DM yield of grassland as calculated in paragraph 2.2.1. Assumed is that 4.5 kg N is bound by each ton DM of clover. The deposition of N is calculated with forfeit values depending on region. The mineralization is calculated as 235 kg N per hectare of peat soils. Yield of the land is the amount of N and P consumed, as calculated in animal utilization, minus a fixed percentage for field losses, like evaporation, and for conservation losses during storage. Input of N and P minus the output from yield are the losses of N and P in soil. Depending on the soil type a leaching fraction is assumed and the other losses will evaporate in the air.

Crop utilization

The crop utilization is calculated as feed that is fed as a fraction of total feed produced or purchased. Unutilized in the crop are losses for producing and conservation/storage of feed. N and P which is fed, is calculated in animal utilization. Losses of evaporation during field and during conservation in storage are calculated with fixed percentages.

Farm utilization
The utilization of the total farm is calculated as milk and meat produced as a fraction of all extern supplied minerals (purchases of feed, fertilizer and livestock, the deposition, mineralization and the N binding by clover). Unutilization of the total farm are all N or P which leaves the farm unintentionally, like the evaporation of stored feed and manure, evaporation during fertilizing, evaporation during forage production and leaching of N and P in the soil.

2.3. Economic performance

The economic performance will first be described by the financial statement. Then, what is known about the relation of mineral surplus and farm economic results will be described. Also the economic results of grassland and silage management will be described because these management actions have a big influence on the mineral surplus.

2.3.1. Financial statement

The financial statement in this study used the returns minus the allocated costs to calculate the gross margin, and the gross margin minus the unallocated costs to calculate the net farm income. Returns can be split up in milk revenues, gains/losses from livestock sales and other revenues. The allocated costs can be split up in feed costs, health costs, livestock related costs and crop related costs. The unallocated costs are labor (calculated own and hired), contract worker costs, costs for buildings, machinery (deprecation, maintenances, tax, fuel), costs for ground (rent, water authority costs), manure removal costs, and other costs (deprecation milk quota, interest expenses of livestock, other costs). This study focusses on the gross margin in order to evaluate the economic performance. Differences in amount of land will be corrected in the model by the intensity of milk per hectare. Depreciations and interest are not used, because buildings and machinery do not directly influence the mineral efficiency and DM yield of grass and maize land. The interest costs are not always supplied by farmers and with depreciation, differences could be made between book depreciation and tax depreciation. Labor costs are not used, because the amount of own labor is discussable.

The economic results can be expressed in total amount, in euro per 100 kg of milk or in euro per cow. Because of the milk quota system, most studies concerning optimizing economic result in the Netherlands, use gross margin expressed in 100 kg of milk to compare farms (Rougoor et al. 1999). This because the total amount of milk production is limited on a farm and thereby not influenced with management decisions. The management decisions should mainly influence the result per 100 kg of milk.

2.3.2. Income Over Feed Costs

The gross margin for milk income minus the feed costs is also called Income Over Feed Costs (IOFC). However it is not sure that lower feed costs increase the IOFC. Feed costs are determined by the diet. The diet itself has an influence on the milk yield and is therefore an influence on the milk income. Buza et al (2014) found that minimizing feed costs per day did not maximize IOFC. On the contrary, higher forage cost and total feed costs could increase milk yield and thereby IOFC. This suggests that a good diet and quality of feed influences the milk yield and IOFC more than the reduction of feed costs influences the IOFC. Rougoor et al. (1999) found that feed costs are explained (R^2=0.60) with feeding, feed purchasing, silage making, grazing, management goals, management decisions and farm plan.

2.3.3. Mineral surplus

The main characteristics that influence the mineral balance are farm intensity in milk per hectare and milk production per cow. An increasing intensity increases the mineral surplus. Intensive farms bought more feed, however they had lower feed costs per 100 kg of milk in the study of Rougoor et al. (1999). This was explained by the fact that those farms had more milk, and per kg of milk they need less feed. This means that intensity has impact on the economic results. Milk per hectare has a direct influence on purchases of silage and concentrates, the number of cows per hectare and the gross margin per 100 kg of milk (Rougoor et al. 1997).

Increasing milk production per cow results in less cows for the same total farm production which decreases the mineral surplus (Ondersteijn et al. 2003). Higher milk yields per cow decreases the number of cows per hectare, which is positive for the gross margin per 100 kg of milk (Rougoor et al. 1997). Cows with a higher milk production need a smaller part of their nutrients for maintenance. Milk production per cow influences the returns per cow, but also the costs by the amount of concentrate used per cow and the price of concentrates (Rougoor et al. 1997). However the cost of feed are spread out over more kg of milk (Maulfair et al. 2011). This makes high producing cows more mineral efficient and results in a higher IOFC per cow.

Farmers with higher yields, and thereby higher N efficiency, have higher gross margins. However N efficiency was not related with gross margin. Lowering the N input with fertilizer for increasing N efficiency, did not influence gross margin, because fertilizer costs are only a small part of the total costs (Groot et al. 2006). Due to a lower yield by a lower N level on grassland, costs of contract workers were lower according to a study which had three situations, high, medium and low levels of N input (Van Calker et al. 2004).

2.3.4. Grazing

Rougoor et al. (1999) found that the amount of grassland that cannot be grazed by cows has an increasing effect on feed costs. Farms with a lot of grassland which cannot be grazed by cows, spent more money on purchasing silage (Rougoor et al. 1999). However there was no explanation for this, because the quality of the silages of these farms was the same as on other farms, and the intensity in kg milk per hectare was not higher. When there are more than 10 milk cows per hectare of land which can be grazed, it should be economically more efficient to house cows in the barn (Van den Pol-van Dasselaar et al. 2013). Grazing will be economically attractive when the grass intake is at least 500 kg DM per cow per year (Van den Pol-van Dasselaar et al. 2013). Farms with a higher percentage of grazing are less feed self-sufficient. This because of higher losses of minerals during grazing and a lower growth of grass. With the feeding of more silage, the mowing percentage will be increased and thereby the self-sufficiency of the farm. This should decrease feed purchases, however this increases costs on contract workers (Van den Pol-van Dasselaar et al. 2013). On average, grazing results in 21,628 euro more income from operation. When grazing is combined with an automatic milking system, the average income from operation will be 16,151 higher than non-grazing farms. The income differences will be smaller when the farm increases (Van den Pol-van Dasselaar et al. 2013).

2.3.5. Silage quality

Farmers with a high milk production are afraid that there silage has a to low quality and will cut there grass to early. Thereby these farmers have a higher VEM and DVE content per kg DM in the silage, however the quantity of silage was lower. Farmers who cut grass at 28 growing days have a lower milk production than farmers who cut earlier but have a higher gross margin. Farmers who cut at 39 growing days, have the highest quantity of silage, but the lowest silage quality, lowest milk production and lowest gross margin (Rougoor et al. 1999). A high mowing percentage is related to buying less feed, however these farmers could buy more fertilizer which affects the N-surplus (Rougoor et al. 1997). Farmers who had a better grazing management had also better results in silage management. This results in lower feed costs per 100 kg of milk for both roughage and for concentrates (Rougoor et al. 1999). Marston et al (2011) found that corn silage diets resulted in a higher feed cost than grass silage diets.

2.4. Framework for this research

Figure 2.3 shows the relations between management, KLW performance and Economic performance. A distinguish is made between causality relations, relations by calculations of the KLW and the hypostatized relations. Causality relations are based on research, literature and on experiences of DMS. The available land is negatively related to diet concentrate and maize ratio and positively related to the diet grass ratio, which is based on experience. This because on most Dutch dairy farms 80% of the land is grassland. This due to the requirements of derogation. With a self-sufficient farm a lot of grass will be available for the diet. With a decreasing availability of land, most farmers will buy concentrates or maize instead of grass. Concentrates and maize have lower concentrations of N and P and mostly higher VEM than grass. Thereby maize and concentrates are negatively related to N/VEM and P/VEM, while grass is assumed to be positively related with N/VEM and P/VEM (Aarts et al. 2008).

Relations of the KLW are relations between variables which are used to calculate the other variable. Thereby milk production and young stock are positively related to DM yield, because they increase the VEM need. Feed purchased is negatively related to DM yield because it is subtracted of the VEM need. Also VEM/kg DM is negatively related, because with more VEM/kg DM and the same total VEM need, the DM yield is lower. N/VEM and P/VEM are negatively related to animal utilization because with the same VEM intake cows have a higher N and P intake which decreases the utilization. Milk yield increases the animal output which increases the utilization. Soil utilization is positively related with DM yield and negatively related with fertilizing. DM yield increase soil output and fertilizing increase soil input, and both influence the soil utilization. Animal and soil utilization are both positively related to farm utilization. However animal P utilization should not directly influence the farm utilization. This because of P excretion by the animal exists only in manure and thereby does not leave the KLW cycle.

Hypostatized relations are the farm utilization, with feed costs and gross margin, and the DM yield with feed costs. This because when a farm produces more own feed, less feed purchases should be needed. Higher DM yields are assumed to have a higher utilization, thereby also farm utilization should be negatively related to feed costs and positively to gross margin. The farm utilization is also influenced by milk output. A higher milk output should increase gross margin and this should also lead to a positive relation between farm utilization and gross margin.

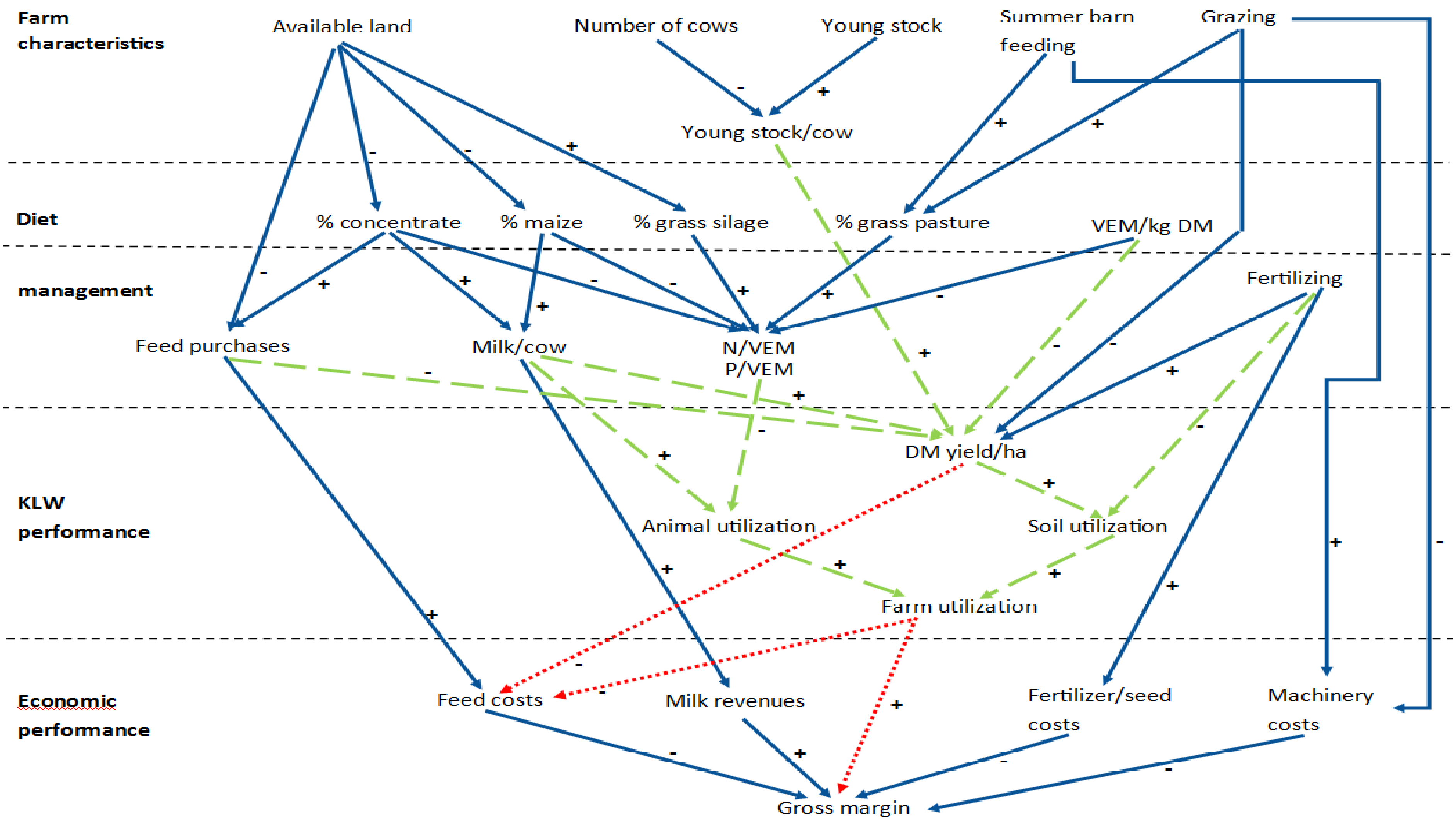
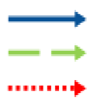


Figure 2.3: Relations between management, "KringloopWijzer" (KLW) and economic performance



= assumed to be a causality relation

= calculated relation by KLW

= hypostatized relation

3. Material and method

This chapter describes the selection of the data in paragraph 3.1. In paragraph 3.2 the analyses, the used models, and the selection of the parameters of the data are describes.

3.1. Data selection

3.1.1. Data collection

For this study data was collected by 'Dirksen Management Support' (DMS). DMS is an advice agency which supports farmers with KLW management and economic performance. DMS collects data of KLW results and economic performance of their clients. The economic data was provided by accountanty agencies to the farmers. Those farmers provide their data to DMS by completing an online form. Economic data consist of the variables described as in paragraph 2.1.1 Economic performance. The KLW tool was completed by farmers or by their consultant and sent to DMS. The KLW was calculated as described in paragraph 2.2 'KringloopWijzer'. DMS controlled the data if values were correct. All data was merged in a database. The total database included 232 dairy farmers who were distributed in the Netherlands.

3.1.2. Selection of outliers

Ten farms were removed from the dataset. Data of intensity in FPCM production per hectare were plotted in scatter plots and boxplots. Outliers were visual selected. One farm had a very low intensity of 5,834 kg FPCM per hectare. Five farms had very high intensities between 39,310 and 41,720 kg FPCM per hectare. While the other farms have intensities between 8,976 and 32,898 kg FPCM per hectare. Because those farms were not in line with the other farms in the database, they could influence the linear regression. Also data of farm balance surplus of P_2O_5 per hectare were plotted in scatter plots and boxplots. Outliers were visual selected. Two farms were excluded because they had an extreme low farm balance surplus of P_2O_5 per hectare of -92 and -97 kg. These are unrealistic numbers and they were very different from the other farms in the database. Two farms were excluded because they had a different farm balance surplus of P_2O_5 and soil balance surplus of P_2O_5. On dairy farms this should be the same, because the KLW assumed that losses of P_2O_5 could only exist in the soil.

3.2. Data analysis

Data was analyzed in different steps. First, the farm characteristics, KLW results, and the economic performance were described. Second, the DEA technical efficiency is calculated and described. As firth, models were fitted to the data, to investigate the relations of the KLW results, with DEA technical efficiency and the economic performance.

3.2.1. Descriptive analyses

For an overview of the farms in the database, data of the farm characteristics, the KLW results and the economic performance were described. This was analyzed with the program SPSS with descriptive analyses for the mean, standard deviation, and minimum and maximum.

3.2.2. Data Envelopment Analysis

To analyze the technical efficiency of the farms Data Envelopment Analysis (DEA) was used (Ji & Lee 2010). DEA is a method to analyze the technical efficiency. DEA calculated the most technical efficient production frontier with all inputs and outputs. The farms on this frontier are the most efficient farms. For the other farms the distance to the production frontier was calculated, with this distance the efficiency of those farms was calculated. DEA can calculate output efficiency and input efficiency. In both cases the most efficient farm get a score of 1. The output efficiency calculates what the maximum output with the same input could be. A farm with a score of 1.2 means that it produces 80% of what it could produce with the same input. The input efficiency calculates what could be the minimum input with the same output. A farm with a score of 0.8 could produce the same output with 80% of the input, compared with the most efficient farm. In 2014 Dutch dairy farmers were restricted in the amount of milk supply by a quota system, and thereby the output cannot be changed. Because of that, in this situation, the input efficiency was calculated with DEA. Advantage of DEA is that it can use input and output variables without an estimated value. DEA can calculate with number of hectare and kg of milk. This prevents an discussion about the value of land.

The output variable used in DEA was kg milk produced. Input variables were number of hectares, feed costs, fertilizer costs, seeds costs, pesticide costs, labor costs (calculated own and hired), contract worker costs, and machinery costs. The costs were expressed in euros for the total farm. For seed costs and pesticide costs some farms had 0 euro. DEA cannot calculate with 0 input, thereby for these farms 0.01 euro was used for pesticide cost. For seed costs also 0.01 euro was used when a farm had no maize land. Some farms had maize land without seed costs, assumed was that this could not be right. For those farms the average of the database was used. The technical efficiency was plotted in a histogram to describe the deviation.

3.2.3. Single statistical effect models

For five dependent variables, single statistical effect models were fitted to the data. These variables were the technical efficiency of DEA, feed costs per 100 kg FPCM, gross margin per 100 kg FPCM, total feed costs, and total gross margin. The technical efficiency was calculated as a dependent variable for the multiple statistical effect model, because of including the amount of hectares without giving them a value. The other variables were selected due to the hypostatized relations, described in figure 2.3. The independent variables were selected as the most important management and KLW results described in figure 2.3. These were the DM yield, diet composition, hours of grazing, balance surplus of N and P_2O_5, and utilization of N and P_2O_5. For DM yield the weighted average yield for grass and maize was used. This because when maize was used separately, only farms with maize land were used in the analyses. These were only 158 farms of the 222. All independent variables were separately test in the single statistical effect models for each dependent variable. The models were corrected for farm characteristics which could influence the analyses. These corrections were, GVE per hectare corrected for intensity, because more intensive farms have higher feed costs. GVE was preferred because it includes also the amount of young stock of the farm, were young stock below 1 year was 0.4 GVE and above 1 year was 0.7 GVE. In the total feed costs and total gross margin, total GVE and total numbers of hectares were used. Kg FPCM per cow per year was used, because the milk production has also influence on the feed costs, the revenues, and the animal utilization. Percentage grassland was use to correct for the higher DM yields for maize land. Soil type was selected because there were differences in soil utilization between soil types. Peat soils have, due to a high mineralization, a low soil N utilization. The analysis was done with SPSS, GLM univariate. Soil type grassland was included in the model as fixed factor, the other correction variables and prediction variables were covariates. For the five dependent variables the single statistical effect models in equations 3.1 to 3.5 were used.

$$\textit{Technical efficiency}_i = \alpha + \beta(KLW)_i + \textit{FPCM per cow per year + percentage grassland + soil type grassland} \quad \textbf{equation 3.1.}$$

$$\textit{Feed costs per 100 kg FPCM}_i = \alpha + \beta(KLW)_i + \textit{GVE per hectare + FPCM per cow per year + percentage grassland + soil type grassland} \quad \textbf{equation 3.2.}$$

$$\textit{Gross margin per 100 kg FPCM}_i = \alpha + \beta(KLW)_i + \textit{GVE per hectare + FPCM per cow per year + percentage grassland + soil type grassland} \quad \textbf{equation 3.3.}$$

$$\textit{Total feed costs}_i = \alpha + \beta(KLW)_i + \textit{numbers of GVE + FPCM per cow per year + numbers of hectares + percentage grassland + soil type grassland} \quad \textbf{equation 3.4.}$$

$$\textit{Total gross margin}_i = \alpha + \beta(KLW)_i + \textit{numbers of GVE + FPCM per cow per year + numbers of hectares + percentage grassland + soil type grassland} \quad \textbf{equation 3.5.}$$

Where α is the constant, β is the slope, KLW is the prediction variable, $_i$ is specific farm, and the models were corrected with correction variables.

3.2.4. Multiple statistical effect models

For all five dependent variables of the single statistical effect models (paragraph 3.2.3), multiple statistical effect models were made. These models were similarly corrected as the single statistical effect models. All independent variables tested in the single statistical effect models with a significance below 0.250 where selected as prediction variable for the multiple statistical effect models. These variable were test in a correlation matrix for correlations higher than 0.8, when that was the case, only one of the variables were chosen. The models were analyzed with SPSS, GLM univariate. Soil type grassland was included in the model as fixed factor, the other correction variables and prediction variables were covariates. The models were run as a backward procedure, whereby from each model the least significant prediction variable was excluded. This until all prediction variables were significant (p<0.05). The correction variables were not excluded, even when they were not significant. For the five dependent variables the multiple statistical effect models in equations 3.6 to 3.10 were used.

$$\textit{Technical efficiency}_i = \alpha + \beta_1(KLW)_{i1} + \beta_2(KLW)_{i2} + ... + \beta_{in}(KLW)_{in} + \textit{FPCM per cow per year + percentage grassland + soil type grassland} \quad \textbf{equation 3.6.}$$

$$\textit{Feed costs per 100 kg FPCM}_i = \alpha + \beta_1(KLW)_{i1} + \beta_2(KLW)_{i2} + ... + \beta_{in}(KLW)_{in} + \textit{GVE per hectare + FPCM per cow per year + percentage grassland + soil type grassland} \quad \textbf{equation 3.7.}$$

Gross margin per 100 kg $FPCM_i = \alpha + \beta_1(KLW)_{i1} + \beta_2(KLW)_{i2} + ... + \beta_{in}(KLW)_{in}$ *+ GVE per hectare + FPCM per cow per year + percentage grassland + soil type grassland* ***equation 3.8.***

Total feed costs$_i = \alpha + \beta_1(KLW)_{i1} + \beta_2(KLW)_{i2} + ... + \beta_{in}(KLW)_{in}$ *+ numbers of GVE + FPCM per cow per year + numbers of hectares + percentage grassland + soil type grassland* ***equation 3.9.***

Total gross margin$_i = \alpha + \beta_1(KLW)_{i1} + \beta_2(KLW)_{i2} + ... + \beta_{in}(KLW)_{in}$ *+ numbers of GVE + FPCM per cow per year + numbers of hectares + percentage grassland + soil type grassland* ***equation 3.10.***

Where α is the constant, β_1 is the slope for the first prediction variable and KLW_{i1} is the first prediction variable, β_2 is the slope for the second prediction variable and KLW_{i2} is the second prediction variable, and β_n is the slope for the last prediction variable and KLW_{in} is the last prediction variable. $_i$ indicates the specific farm. To control the models, the standardized residuals were plot and visual controlled on normal distribution.

4. Results

This chapter first provides the descriptive statistics of the studied farms, divided in farm characteristics in paragraph 4.1, KLW results in paragraph 4.2, economic performance in paragraph 4.3, and technical efficiency in paragraph 4.4. Secondly the results of the single and multiple statistical effect models will be present in paragraph 4.5.

4.1. Farm characteristics

Table 4.1: Characteristics of the farms in the DMS database of 2014 expressed in mean, standard deviation, minimum and maximum(N= 222 farms)

	Mean	S.D.	Min	Max
Kg milk supply *1,000	924	355	295	2,183
Kg FPCM[a]/cow	8,861	918	5,296	11,563
Fat %	4.31	0.16	3.91	4.77
Protein %	3.50	0.08	3.30	3.72
Number of cows	110	42	43	295
Young stock/10 cows	6.7	2.1	0.4	11.8
Kg concentrate/kg milk	25	4	14	42
Kg milk/hectare *1,000	18.4	4.9	9.0	32.9
Kg milk/unit labor *1,000	590	167	161	1,090
GVE[b]/hectare	2.84	0.69	1.72	6.54
Hectare total	54.8	23.2	19.0	161.1
Grass	47.3	20.6	16.9	161.1
Maize	6.9	6.2	0	32.3
Available for grazing	32.6	16.4	0	111
Soil type grassland				
% Clay	50.5	n/a	n/a	n/a
% Sand	31.1	n/a	n/a	n/a
% Peat	17.6	n/a	n/a	n/a
% Other	0.9	n/a	n/a	n/a
Soil type maize land				
% Clay	36.5	n/a	n/a	n/a
% Sand	31.1	n/a	n/a	n/a
% Peat	3.6	n/a	n/a	n/a
% no maize land	28.9	n/a	n/a	n/a
Grazing				
% of farms with grazing	77.0	n/a	n/a	n/a
Days grazing[c]	152	42	4	250
Hours/day[c]	7.6	3.0	1.0	20.0
Hours/year[d]	1,188	680	60	3,840

[a] *Fat and Protein Corrected Milk*
[b] *Livestock including young stock (< 1 year: 0.4 GVE and >1 year: 0.7 GVE)*
[c] *Only farms with grazing included (N=171)*

Table 4.1 shows the characteristics of the farms from the database for the year 2014. There is a lot of deviation between farms. The farm with the lowest milk supply had 295,000 kg milk and the highest had 2,183,000 kg milk per year. Number of young stock per 10 cows was very low for the minimum with 0.4. This farm probably did buy heifers for livestock replacement, or young stock was raised by another farmer, what is also noticed in this database as sold calves and purchased heifers. Most land was used as grassland, this is probably caused by the participation of derogation, wherefore a minimum of 80% grassland is required (Dutch farmers with derogation may increase their N application of manure from 170 kg to 230 or 250 kg). 64 farmers had no maize land. Soil type was mainly clay for both grassland and maize land. Peat soil was the lowest proportion in this data base. The other soil type of grassland was not known. 77 percent of the farms had grazing, the mean days of grazing on those farms were 152 days with 7.6 hours per day.

4.2. 'KringloopWijzer' results

Table 4.2 shows the results of the KLW of the farms in the database for 2014. Excretion of livestock of N and P_2O_5 is expressed as forfeit and as farm specific calculation by the KLW. This shows that the average farms were, respectively for N and for P_2O_5, 7 and 11 percent more efficient than was assumed with forfeit values. However, the differences are large and it is shown that there were also farms who were less efficient when their excretion was specifically calculated with the KLW compared with the forfeit values. Differences in crude protein and P in the diet, and thereby also the ratio of those nutrients with VEM were large. While these are important ratios to manage the efficiency of N and P. The VEM intake as percentage of the VEM need was calculated by the amount of measured feed in storage. This is a control for the measured feed in storage. Because KLW assumed a VEM intake of 102 percent of the VEM need. When farms deviate a lot with the VEM intake expected from the feed storage, probably the measurement of the feed storage was not exact. For the utilization of N and P, the biggest deviation was in farm and soil utilization.

Table 4.2: Results of the KLW of the farms of the DMS database of 2014 (N=222 farms)

	Mean	S.D.	Min	Max
N excretion livestock				
Excretion KLW	15,770	6,216	6,558	41,077
Excretion forfeit	16,987	6,598	6,709	43,029
% KLW advantage	7.02	6.72	-20.91	21.01
P_2O_5 excretion livestock				
Excretion KLW	5,414	2,152	2,116	13,772
Excretion forfeit	6,134	2,385	2,210	15,222
% KLW advantage	11.33	9.59	-18.50	34.65
Diet				
VEM diet	959	17	906	1001
Crude protein diet	161	9	135	198
P diet	3.82	0.27	3.06	4.62
CP[a]/VEM	0.169	0.010	0.142	0.204
P/VEM	0.0040	0.0003	.0033	0.0049
% VEM intake of the need[b]	103	8	74	125
% VEM pasture grass	9	8	0	43
% VEM grass silage	37	8	20	56
% VEM maize silage	23	11	0	52
% VEM by-products	5	5	0	23
% VEM other	1	2	-3	15
% VEM concentrate	26	5	9	46

Table 4.2: Continued

	Mean	S.D.	Min	Max
Feed efficiency	1.08	0.08	0.84	1.32
Yield grassland				
Dry matter (1000 kg)	12.03	1.98	7.92	18.47
N (kg)	330.49	54.79	203.00	497.00
P_2O_5 (kg)	110.38	18.44	64.00	172.00
Yield maizeland				
Dry matter (1000 kg)	18.92	3.46	9.22	27.60
N (kg)	202.49	42.21	93.00	317.00
P_2O_5 (kg)	88.35	20.27	45.00	154.00
Utilization N				
Farm	34.1	10.1	14.4	70.0
Animal	24.2	2.0	18.0	29.0
Manure	79.1	3.6	65.0	88.0
Soil	70.1	11.9	39.6	106.0
Crop	87.6	1.7	79.0	93.7
Farm surplus / ha	223	83	51	501
Soil surplus / ha	145	77	-29	411
Utilization P_2O_5				
Farm	237.6	868.8	0.0	10,635.9
Animal	31.5	2.6	23.0	39.0
Manure	100.0	0	100.0	100.0
Soil	120.9	20.7	75.0	196.4
Crop	89.6	1.7	79.8	94.4
Farm Surplus / ha	-8	7	-33	10

[a] *Crude Protein*
[b] *Controle VEM intake, calculated with the amount of VEM present measured by density, high and width of the feed storage*

4.3. Economic performance

Table 4.3 shows the economic performance of the farms of the database for the year 2014. The numbers are shown in euros per 100 kg FPCM. There was a great differences between the minimum and maximum total revenues, however the standard deviation was not very big. Differences could exist in milk revenues, determined by different factories or milk composition. A few farms had a negative income for sales/growth of livestock, probably on those farms, young stock was raised by another farmer. The costs for that were subtracted from the income sales/growth of livestock in this database. A big variation was visible in the other revenues, these revenues could exist of sales of feed, but also of revenues from leased milk quota. Income from leased milk quota influence the total revenues, gross margin and net farm income, however it is not a result of farm management. Variation in feed costs was influenced by the costs for concentrates, roughage and by-products. Costs for roughage had a big difference between highest and lowest, probably dependent on the intensity of milk or cows per hectare. Mean gross margin was 32 euro per 100 kg FPCM with differences between 10 and 58 euros. In the unallocated costs, the depreciation of buildings, machinery, and milk quota were included. Interest was not included in the unallocated costs and thereby also not in the net farm income. Total unallocated costs had a big variety, great differences were shown in labor, machinery, building and in the general costs. The big variation in revenues and costs between farms, results in a big difference in net farm income. The average net farm income in 2014 was for these farms positive, but the lowest net farm income was -33 euro per 100 kg FPCM, while the highest has a positive net farm income of 15 euro per 100 kg FPCM.

Table 4.3: Economic performance of the farms in the DMS database of 2014 in euros per 100 kg Fat and Protein Corrected Milk (N=222 farms)

	Mean	S.D.	Min	Max
Total revenues	**49.28**	**4.14**	**39.43**	**73.17**
Milk revenues	41.39	1.94	35.62	51.88
Livestock sales and growth	3.05	1.64	-2.35	11.05
Other revenues	4.84	2.80	0.00	17.07
Total allocated costs	**17.14**	**2.30**	**10.76**	**24.75**
Feed costs	10.78	2.06	5.62	17.83
Concentrate	7.28	1.23	4.34	13.04
Roughage	1.72	1.46	-0.68	10.27
By-products	0.94	1.05	0.00	6.15
Milk replacer	0.42	0.21	0.00	1.24
Other feed costs	0.43	0.49	0.00	3.84
Product related costs *(health, breeding, etc.)*	2.32	0.68	1.01	5.13
Fertilizing costs	1.38	0.46	0.08	2.92
Seeds costs	0.34	0.26	0.00	1.31
Pesticides	0.23	0.18	0.00	0.85
Energy	0.88	0.32	0.05	1.79
Other producing costs	1.21	0.59	0.04	3.63
Gross margin	**32.13**	**4.48**	**20.23**	**58.27**
Total unallocated costs	**29.06**	**5.63**	**17.64**	**62.44**
Contract worker grassland	3.43	1.49	0.34	8.13
Labor *(calculated for own labor, and for hired labor)*	7.74	2.90	3.33	29.07
Manure remove	0.33	0.49	0.00	3.14
Machinery costs *(deprecation, fuel, service)*	3.94	1.62	0.35	11.70
Costs of buildings *(deprecation, tax, etc.)*	5.35	2.63	0.40	13.43
Ground *(rent, water authority costs, etc.)*	1.61	1.21	0.19	6.19
General costs *(calculated interest for livestock, lease/depreciation costs milk quota, other costs)*	6.66	3.99	0.61	41.60
Net farm income	**3.07**	**6.12**	**-32.55**	**15.19**

4.4. Technical efficiency

Figure 4.1 shows the results of the DEA analysis. The figure shows that a lot of the farms had the score of 1. What means that they are the most efficient farms in the database.

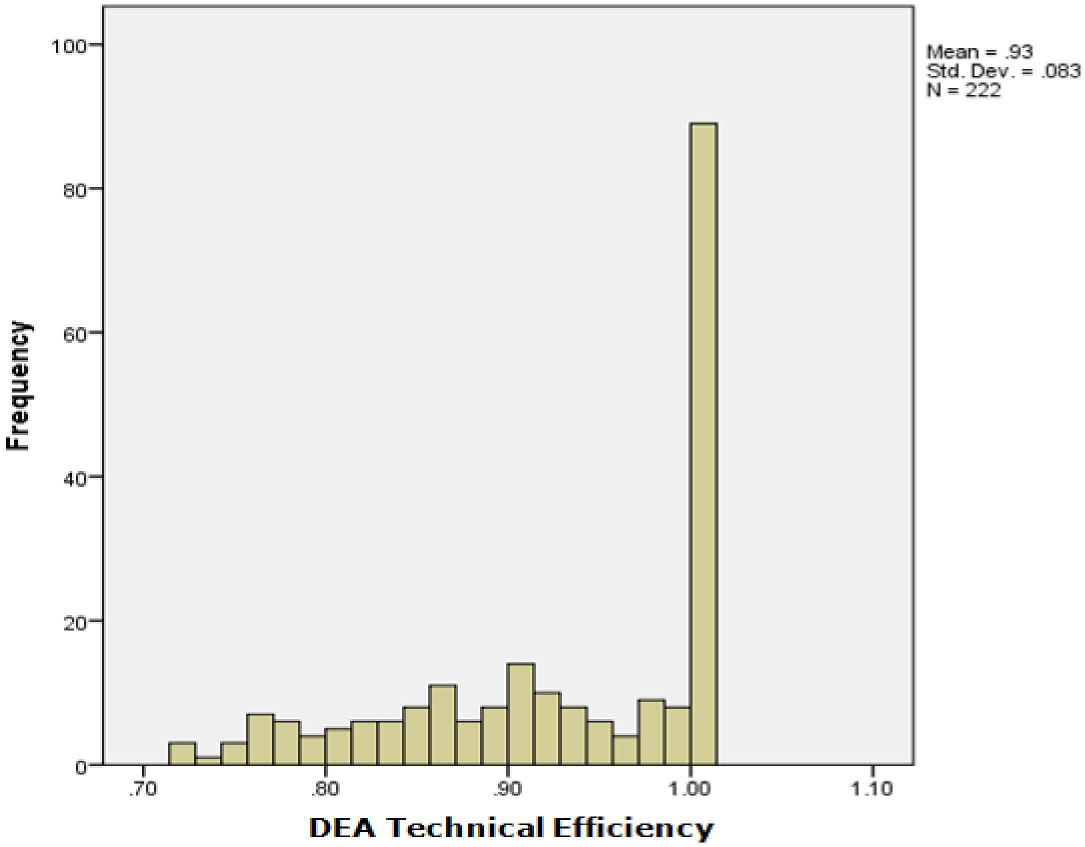


Figure 4.1: frequency of scores in the DEA technical efficiency.

4.5. Relation KLW parameters with economic performance

For five dependent variables, single and multiple statistical effect models were fitted to the data. This to investigate the relation between the KLW and the economic performance. Paragraph 4.5.1 presents the dependent variable of technical efficiency, paragraph 4.5.2 presents the dependent variable feed costs per 100 kg FPCM, paragraph 4.5.3 presents the dependent variable gross margin per 100 kg FPCM, paragraph 4.5.4 presents the dependent variable total feed costs, and paragraph 4.5.5 presents the dependent variable total gross margin.

4.5.1. Data Envelopment Analysis

Table 4.4 shows the results of the single statistical effect models with dependent variable technical efficiency from the DEA analysis. The model was corrected for kg FPCM per cow per year, percentage grassland, and soil of type grassland. All independent parameters were separately tested in the single statistical effect model.

Table 4.4: results of the single statistical effect models with dependent variable technical efficiency, and prediction variable the independent parameter. The model is corrected for kg FPCM per cow per year, percentage grassland, and soil type grassland (N=222)

Independent parameter	β	R^2	Sig.
DM yield grass- and maize land			
Average DM yield (1,000 kg/ha)	0.011	0.158	0.000
Diet VEM ratio in percentage			
Grass pasture	0.000	0.104	0.858
Grass silage	0.000	0.105	0.545
Grass total	0.000	0.106	0.507
Maize silage	0.001	0.120	0.045
Concentrate and by-products	-0.002	0.115	0.093
Hours grazing (100 hours/year)	-0.001	0.118	0.063
Farm surplus of N /ha	$-6.955*10^{-005}$	0.106	0.468
Soil surplus of N/ha	0.000	0.118	0.063
Farm surplus of P_2O_5 /ha	-0.001	0.137	0.004
Utilization N			
Farm	0.003	0.169	0.000
Animal	0.008	0.127	0.017
Soil	0.002	0.141	0.003
Utilization P_2O_5			
Farm	$-4.399*10^{-006}$	0.106	0.477
Animal	0.007	0.134	0.006
Soil	0.001	0.135	0.005

Table 4.5: results of the multiple statistical effect model with dependent variable technical efficiency (R^2 =0.219, N=222)

	β	Std. Error	Sig.
(Constant)	0.471	0.104	0.000
Correction variables			
FPCM[a]/cow/year (kg)	$-8.757*10^{-6}$	$6.667*10^{-6}$	0.190
Percentage grassland	0.003	0.001	0.000
Soil type grassland : Clay [b]	0.030	0.012	0.017
: Peat [b]	0.068	0.019	0.000
: Sand	0		
Prediction variables			
VEM diet ratio of concentrate and by-products	-0.002	0.001	0.055
Soil utilization of N	0.001	0.001	0.003
Animal utilization of P_2O_5	0.007	0.002	0.003

[a] *Fat and Protein Corrected Milk*
[b] *based on soil type grassland: sand*

Table 4.5 shows the results of the multiple statistical effect model with dependent variable technical efficiency from the DEA analysis. The independent variables of the single statistical effect models with a significance below 0.250 were used as prediction variables. However, soil surplus of N, and farm utilization of N were excluded by their high correlation (r>0.8) with soil utilization of N. Also farm surplus of P_2O_5 was excluded by its high correlation with soil utilization of P_2O_5. The model shows that farms with peat soils had the highest technical efficiency and farms on sandy soils the lowest. Percentage grassland increased the technical efficiency. Farms with more concentrates and by-products had a lower technical efficiency. Farms with a higher soil utilization of N or with a higher animal utilization of P_2O_5 had a better technical efficiency.

4.5.2. Feed costs per 100 kg FPCM

Table 4.6 shows the results of the single statistical effect models with dependent variable feed costs in euros per 100 kg FPCM. The model was corrected for GVE per hectare, kg FPCM per cow per year, percentage grassland, and soil type grassland. All independent parameters were separately tested in the single statistical effect model.

Table 4.6: results of the single statistical effect models with dependent variable feed costs in euros per 100 kg FPCM, and prediction variable the independent parameter. The model is corrected for GVE per hectare, kg FPCM per cow per year, percentage grassland, and soil type grassland (N=222)

Independent parameter	β	R^2	Sig.
DM yield grass- and maize land			
Average DM yield (1,000 kg/ha)	-0.155	0.357	0.021
Diet VEM ratio in percentage			
Grass pasture	-0.090	0.415	0.000
Grass silage	-0.022	0.346	0.201
Grass total	-0.110	0.457	0.000
Maize silage	-0.008	0.342	0.644
Concentrate and by-products	0.141	0.490	0.000
Hours grazing (100 hours/year)	-0.064	0.381	0.000
Farm surplus of N /ha	0.000	0.341	0.832
Soil surplus of N/ha	$-8.657*10^{-5}$	0.341	0.967
Farm surplus of P_2O_5 /ha	0.003	0.342	0.655
Utilization N			
Farm	0.002	0.341	0.888
Animal	0.073	0.344	0.357
Soil	-0.014	0.346	0.214
Utilization P_2O_5			
Farm	0.000	0.345	0.242
Animal	0.011	0.341	0.849
Soil	0.000	0.341	0.944

Table 4.7 shows the multiple statistical effect model for dependent variable feed costs in euro per 100 kg FPCM. Only the independent parameters with a significance below 0.250 in the single statistical effect model were used as prediction variable in the multiple statistical effect model. The model shows that GVE/ha had a big influence on the feed costs. Increasing 1 GVE per hectare increased the feed costs with 1 euro per 100 kg FPCM. FPCM per cow had no significance influences on the feed costs. Percentage grassland was positive related to feed costs. On peat soils the feed costs were the highest. Of the prediction variables, average DM yield per hectare, diet ratio pasture

grass and diet ratio grass silage were negatively related to feed costs. Each 1,000 kg DM more per hectare, decreased feed costs with 0.23 euro per 100 kg milk. Percentage pasture grass was highly correlated with hours grazing per year, thereby hours grazing per year was excluded in the model. This make is not sure if the feed costs were effected by pasture grass or by grazing. Concentrates and by-products increased the feed costs per 100 kg FPCM, this was also the case with soil utilization of N.

Table 4.7: results of the multiple statistical effect model with dependent variable feed costs in euros per 100 kg FPCM (R^2 =0.578, N=222)

	β	Std. Error	Sig.
(Constant)	5.396	1.680	0.002
Correction variables			
GVE/ha[a]	0.952	0.208	0.000
FPCM[b]/cow/year (kg)	$-6.229*10^{-5}$	0.000	0.592
Percentage grassland	0.041	0.015	0.006
Soil type grassland : Clay [c]	0.358	0.251	0.156
: Peat [c]	0.885	0.416	0.035
: Sand	0	.	.
Prediction variables			
Average DM yield (1,000 kg/ha)	-0.233	0.083	0.005
VEM diet ratio of grass pasture	-0.106	0.018	0.000
VEM diet ratio of grass silage	-0.056	0.018	0.002
VEM diet ratio of concentrate and by-products	0.113	0.017	0.000
Soil utilization of N	0.027	0.013	0.049

[a] *Livestock including young stock (< 1 year: 0.4 GVE and >1 year: 0.7 GVE)*
[b] *Fat and Protein Corrected Milk*
[c] *based on soil type grassland: sand*

4.5.3. Gross margin per 100 kg FPCM

Table 4.8 shows the results of the single statistical effect models with dependent variable gross margin in euros per 100 kg FPCM. The model was corrected for GVE per hectare, kg milk per cow per year, percentage grassland, and soil type grassland. All independent parameters were separately tested in the single statistical effect model.

Table 4.8: results of the single statistical effect models with dependent variable gross margin in euros per 100 kg FPCM, and prediction variable the independent parameter. The model is corrected for GVE per hectare, kg FPCM per cow per year, percentage grassland, and soil type grassland (N=222)

Independent parameter	β	R^2	Sig.
DM yield grass- and maize land			
Average DM yield (1,000 kg/ha)	-0.036	0.152	0.829
Diet VEM ratio in percentage			
Grass pasture	0.160	0.201	0.000
Grass silage	-0.001	0.152	0.988
Grass total	0.153	0.199	0.000
Maize silage	-0.030	0.153	0.487
Concentrate and by-products	-0.156	0.191	0.002
Hours grazing (100 hours/year)	0.127	0.185	0.004

Table 4.8: Continued

Independent parameter	β	R^2	Sig.
Farm surplus of N /ha	-0.002	0.152	0.699
Soil surplus of N/ha	-0.001	0.152	0.907
Farm surplus of P_2O_5 /ha	-0.004	0.152	0.803
Utilization N			
Farm	-0.002	0.152	0.953
Animal	-0.342	0.164	0.081
Soil	0.008	0.152	0.760
Utilization P_2O_5			
Farm	0.000	0.153	0.543
Animal	-0.215	0.160	0.136
Soil	0.004	0.152	0.794

Table 4.9 shows the results of the multiple statistical effect model with dependent variable gross margin in euro per 100 kg FPCM. The dependent variables of the single statistical effect models with a significance below 0.250 were used as prediction variables. The model shows that intensity of the farm in GVE per hectare, was negatively related to the gross margin per 100 kg milk. FPCM per cow and percentage grassland had no significant effect on the gross margin. With the soil type sand, the gross margin was the lowest, however soil type was not significant is this model. Only two prediction variables were significant in this model. Both were diet ratio variables, where pasture grass increase the gross margin and concentrates and by-products decrease the gross margin. Percentage pasture grass is highly correlated with hours grazing per year, thereby hours grazing per year was excluded in the model. This make it not sure if the gross margin was effected by pasture grass or by grazing.

Table 4.9: results of the multiple statistical effect model with dependent variable gross margin in euros per 100 kg FPCM (R^2 =0.225, N=222)

	β	Std. Error	Sig.
(Constant)	41.989	4.230	0.000
Correction variables			
GVE[a]/ha	-1.448	0.449	0.001
FPCM[b]/cow/year (kg)	0.000	0.000	0.305
Percentage grassland	-0.005	0.034	0.880
Soil type grassland : Clay [c]	0.421	0.649	0.517
: Peat [c]	0.449	0.945	0.635
: Sand	0	.	.
Prediction variables			
VEM diet ratio of grass pasture	0.136	0.044	0.002
VEM diet ratio of concentrate and by-products	-0.125	0.049	0.011

[a] Livestock including young stock (< 1 year: 0.4 GVE and >1 year: 0.7 GVE)
[b] Fat and Protein Corrected Milk
[c] based on soil type grassland: sand

4.5.4. Total feed costs

Table 4.10 shows the results of the single statistical effect models with dependent variable total feed costs in euros. The model was corrected for numbers of GVE, kg FPCM per cow per year, number of hectares, percentage grassland, and soil of type grassland. All independent parameters were separately tested in the single statistical effect model. Instead of DM yield per hectare, total farm DM yield was used. Also percentage of the diet was replaced by 1,000 kg DM fed. This because total feed costs is an absolute value, and thereby it is better that this is also the case for the DM yield and diet composition.

Table 4.10: results of the single statistical effect models with dependent variable total feed costs in euros, and prediction variable the independent parameter. The model is corrected for numbers of GVE, kg FPCM per cow per year, numbers of hectares, percentage grassland, and soil type grassland (N=222)

Independent parameter	β	R^2	Sig.
DM yield grass- and maize land			
Farm total DM yield (1,000 kg)	-34.69	0.823	0.011
Diet (1000 kg DM)			
Grass pasture	-88.35	0.827	0.000
Grass silage	-26.48	0.818	0.205
Grass total	-87.98	0.832	0.000
Maize silage	-24.23	0.818	0.270
Concentrate and by-products	41.45	0.830	0.000
Hours grazing (100 hours/year)	-452.55	0.820	0.044
Farm surplus of N /ha	0.632	0.817	0.980
Soil surplus of N/ha	3.850	0.817	0.881
Farm surplus of P_2O_5 /ha	0.995	0.817	0.991
Utilization N			
Farm	139.38	0.817	0.487
Animal	2,537.78	0.823	0.009
Soil	-166.47	0.818	0.230
Utilization P_2O_5			
Farm	2.095	0.818	0.200
Animal	506.01	0.817	0.481
Soil	18.16	0.817	0.805

Table 4.11 shows the results of the multiple statistical effect model with dependent variable total feed costs in euros. The dependent variables of the single statistical effect models with a significance below 0.250 were used as prediction variables. Except the total grass in the diet, this was excluded by its high correlation (r>0.8) with grass silage. The model shows that number of GVE and kg FPCM per cow increased the feed costs, each kg FPCM production per cow, increased the total feed costs with 8 euros. With 1,000 kg more pasture grass on yearly basis, the feed costs were 88 euros lower. Concentrates and by-products are positive related with the total feed costs. Each 1,000 kg DM yield decreased the total feed costs with 37 euros. A better animal utilization of N increased the total feed costs.

Table 4.11: results of the multiple statistical effect model with dependent variable total feed costs in euros (R^2 =0.852, N=222)

	β	Std. Error	Sig.
(Constant)	-189,026.35	27,675.72	0.000
Correction variables			
Numbers of GVE[a]	857.24	53.79	0.000
FPCM[b]/cow/year (kg)	8.47	1.79	0.000
Numbers of Hectares	-157.76	171.09	0.358
Percentage grassland	649.49	160.35	0.000
Soil type grassland : Clay[c]	3,330.03	3,223.39	0.303
: Peat[c]	9,969.78	4,501.54	0.028
: Sand	0		
Prediction variables			
Diet grass pasture (1,000 kg DM)	-87.69	23.68	0.000
Diet concentrate and by-products (1,000 kg DM)	39.02	9.88	0.000
Farm total DM yield (1,000 kg)	-36.94	12.62	0.004
Animal utilization of N	2,322.63	901.36	0.011

[a] Livestock including young stock (< 1 year: 0.4 GVE and >1 year: 0.7 GVE)
[b] Fat and Protein Corrected Milk
[c] based on soil type grassland: sand

4.5.5. Total gross margin

Table 4.12: results of the single statistical effect models with dependent variable total gross margin in euros, and prediction variable the independent parameter. The model is corrected for numbers of GVE, kg FPCM per cow per year, numbers of hectares, percentage grassland, and soil type grassland (N=222)

Independent parameter	β	R^2	Sig.
DM yield grass- and maize land			
Farm total DM yield (1,000 kg)	12.77	0.888	0.629
Diet (1000 kg DM)			
Grass pasture	196.05	0.896	0.000
Grass silage	-24.13	0.888	0.551
Grass total	109.99	0.891	0.007
Maize silage	-43.91	0.888	0.302
Concentrate and by-products	4.16	0.887	0.842
Hours grazing (100 hours/year)	865.00	0.889	0.054
Farm surplus of N /ha	-70.97	0.888	0.153
Soil surplus of N/ha	-69.42	0.888	0.161
Farm surplus of P_2O_5 /ha	-354.34	0.890	0.041
Utilization N			
Farm	1,021.41	0.891	0.008
Animal	4,804.70	0.891	0.011
Soil	485.24	0.889	0.070
Utilization P_2O_5			
Farm	-1.164	0.887	0.713
Animal	763.38	0.888	0.583
Soil	239.76	0.889	0.091

Table 4.12 shows the results of the single statistical effect models with dependent variable total gross margin in euros. The model was corrected for numbers of GVE, kg FPCM per cow per year, numbers of hectare, percentage grassland, and soil of type grassland. All independent parameters were separately tested in the single statistical effect model. Instead of DM yield per hectare, is chosen for total farm DM yield. Also percentage of the diet was replaced by 1,000 kg DM fed. This because total gross margin is an absolute value, and thereby it is better that this is also the case for the DM yield and diet composition.

Table 4.13 shows the results of the multiple statistical effect model with dependent variable total gross margin in euros. The independent variables of the single statistical effect models with a significance below 0.250 were used as prediction variables. Farm and soil surplus of N were excluded by their high correlations with soil utilization of N. Farm surplus of P was excluded by its high correlation (r>0.8) with soil utilization of P_2O_5. The model shows that numbers of GVE, kg FPCM per cow per year, numbers of hectares and percentage grassland increased the total gross margin. Of the prediction variables, only positive related variables were significant related. Increasing each 1,000 kg of grass pasture in the diet resulted in 206 euros higher gross margin. The animal and soil utilization of N were both positive related to the gross margin.

Table 4.13: results of the multiple statistical effect model with dependent variable total gross margin in euros (R^2 =0.901, N=222)

	β	Std. Error	Sig.
(Constant)	-362,760.28	58,459.99	0.000
Correction variables			
Numbers of GVE[a]	1,468.14	89.80	0.000
FPCM[b]/cow/year (kg)	17.95	3.47	0.000
Numbers of Hectares	1,140.16	248.60	0.000
Percentage grassland	165.71	312.31	0.596
Soil type grassland : Clay[c]	13,054.25	6,251.71	0.038
: Peat[c]	28,617.48	9,799.16	0.004
: Sand	0	.	.
Prediction variables			
Diet grass pasture (1,000 kg DM)	205.67	46.53	0.000
Animal utilization of N	5,758.11	1,792.27	0.002
Soil utilization of N	507.91	252.60	0.046

[a] *Livestock including young stock (< 1 year: 0.4 GVE and >1 year: 0.7 GVE)*
[b] *Fat and Protein Corrected Milk*
[c] *based on soil type grassland: sand*

5. Discussion

In this chapter the results will be discussed. Contradictions within models will be explained. Also relations and contradictions between the models will be explained. This to conclude on the relation of the KLW and economic performance and what this means in practice. The relation of this study are associations and not causal relationships. Thereby it is not sure, that with changing one variable, the other variable will changed also. Not all variables were perfectly normal distributed.

5.1. Used Data

All farmers in the database are clients of DMS and thereby not randomly selected. This because they pay for advice, what could mean that those farmers are more conscious about KLW management and economic performance than the average Dutch dairy farmer. The average farm in this study had 7 percent less N excretion and 11 percent less P_2O_5 excretion from livestock calculated with the KLW than forfeit values (table 4.2). However there were also farms which had a higher excretion with the KLW. The average results of the KLW of all farmers in the Netherlands are not known, thereby the results of the DMS farmers cannot be compared. The average farm in this database had 200,000 kg milk more produced compared with a publication of Alfa Accountants en Adviseurs (2015). Farms in de DMS database had also more cows (110 versus 92) and had more milk per hectare (18,400 versus 16,000). Young stock per 10 cow was with 6.7 the same. The feed costs per 100 kg FPCM was 10.78 for the DMS database and 9.69 for Alfa accountants, however the gross margin was for the DMS database 32.13 and for Alfa Accountants en Adviseurs database it was 27.72. Because the DMS farms were bigger and more intensive in milk per hectare, it is not sure, if the results of this study can be applied for the average farm in the Netherlands.

5.2. Correction variables

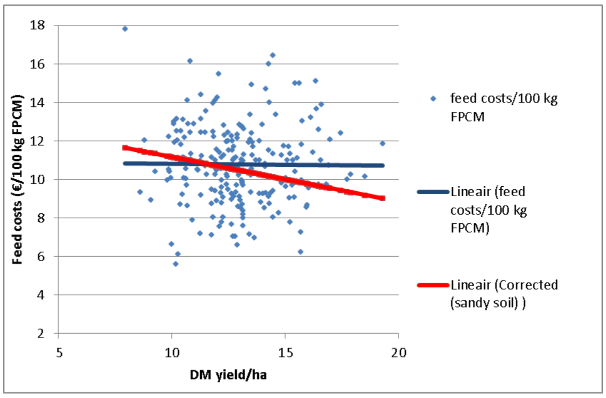


Figure 5.1: linear relation between DM yield/ha and feed costs/100 kg FPCM, uncorrected and corrected for GVE/ha, FPCM/cow/year, percentage grassland, and soil type grassland

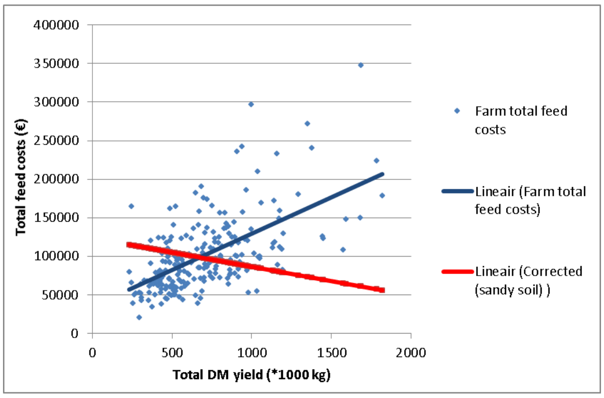


Figure 5.2: linear relation between total DM yield and total feed costs, uncorrected and corrected for number of GVE, FPCM/cow/year, number of hectares, percentage grassland, and soil type grassland

The models were corrected for farm characteristics who have influence on the analyses. Figure 5.1 shows that the relation between DM yield/ha and feed costs per 100 kg FPCM. Uncorrected there is no slope visible, while corrected for GVE/ha, kg FPCM/cow/year, percentage grassland, and soil type grassland, the slope is negative. What means that corrected for these variables, and thereby comparable farms, the DM yield/ha has influences on the feed costs per 100 kg FPCM. Figure 5.2

shows the relation between total DM yield and total feed costs, the slope is positive. This because the slope shows the farms size, bigger farms have more total DM yield and higher feed costs. However corrected for number of GVE, kg FPCM/cow/year, number of hectare, percentage grassland, and soil type grassland, the slope is negative. What means that within the same farm size of number GVE and number of hectare, a higher DM yield results in lower feed costs.

5.3. Data Envelopment Analysis

With DEA, the efficiency of milk production of the inputs for feed and feed producing was analysed. The model of table 4.5 shows that soil utilization of N and animal utilization of P_2O_5 were both positively related to the technical efficiency, what means that those farms had the same output of milk with less inputs of land, land related costs and feed costs. In DEA, land has no value, but this conclude that a better utilization in the KLW was correlated with the efficiency of a farm.

5.4. Dry matter yield

The dry matter yield had a significant negative relationship to the feed costs per 100 kg FPCM (table 4.7) and to the total feed costs (table 4.11). This effect was not visible for gross margin, probably there are too much other influences whereby the effect of dry matter yield will no longer be significant. For feed costs the results mean that for each 1,000 kg per hectare, the feed costs were 0.23 euros lower per 100 kg FPCM. On the total farm, each 1,000 kg DM more produced, resulted in 37 euros lower total feed costs. A reduction of 37 euros is not very much when 1,000 kg less had to be purchased. It could be that the extra yield had not the same quality as the rest of the yield, for example it could be an extra cutting in the autumn. Thereby it cannot replace the same amount of concentrates.

5.5. Soil utilization

The model shows that with feed costs per 100 kg FPCM (table 4.7), the soil utilization of N has a positively relation. For each percentage of higher soil utilization, the feed costs should increase 0.03 euros per 100 kg FPCM. This was not expected because a higher DM yield decreased the feed costs per 100 kg FPCM. DM yield per hectare and soil utilization of N were positively related (R^2=0.44, slope=3.98/1000 kg DM)(data not shown). This means that a higher soil N utilization increased the feed costs, but indirectly with a higher DM yield decreased the feed costs. For each extra 1,000 kg DM, the soil utilization increase 3.98 percent units. Thereby decrease of feed costs per 100 kg FPCM by a higher DM yield is more than the increase of feed costs with the higher soil utilization. This also agree with Groot et al. (2006), who found that farmers with higher yields, have higher gross margins. However they found that the N efficiency was not related with the gross margin.

In this study, N soil utilization was not related to gross margin per 100 kg FPCM, but it was related to the total gross margin. Each percentage of increased soil utilization was related to 508 euros more gross margin for the average farm size in the database (table 4.13). This is in contrast to the positively related soil utilization of N with feed costs per 100 kg FPCM. However due to the higher soil utilization, the DM yield per hectare increased also and thereby the feed costs decreased. This indicates that with a better soil utilization the DM yield increases sufficient to decrease the feed costs per 100 kg FPCM. Thereby the soil utilization gave a positive relation with total gross margin.

5.6. Animal utilization

The animal N utilization was positively related to the total feed costs (table 4.11) and positively related to the total gross margin (table 4.13). This suggests that the income was also increased with an higher animal N utilization. With a single statistical effect model with dependent variable total milk revenues, and the same corrections used as for the total feed cost model, a percent animal utilization of N increased the total milk revenues with 9,500 euros (data not shown). Due to the higher milk revenues, there was no effect of animal N utilization visible with the feed costs per 100 kg FPCM and gross margin per 100 kg FPCM. When the total milk revenues and total feed costs both increase, the feed costs per 100 kg FPCM are not affected. The same could with the gross margin, it was not affected per 100 kg FPCM but with a higher milk supply, the total gross margin was increased. The higher animal N utilization is mostly reached by a higher percentage of maize or concentrates. This because with the same VEM intake, the intake of N and P is lower. Most farms have only 20 percent of maize land, thereby with a maize rich diet, maize should be purchased. This explains the higher feed costs for a better animal utilization. Due to a more energy rich diet by maize silage, cows can produce more milk. High producing cows have also a higher N utilization (Jonker et al. 2002). This because per 100 kg FPCM, they need less feed for maintenance. The higher milk production explains the higher gross margin. Animal P_2O_5 utilization was positively related with the DEA technical efficiency. This is explains also that farms with a better animal P_2O_5 utilization had more milk production with the same input of land, land related costs, or feed costs. The animal utilization of N and P_2O_5 were positively correlated (R^2=0.53)(data not shown). Thereby the relations found for animal N and P_2O_5 utilization, can also implemented as animal utilization in general.

5.7. Diet composition

The diet composition was important in all five models. With a higher percentage of pasture grass in the diet, the feed costs per 100 kg FPCM were 0.11 euro lower and the gross margin per 100 kg FPCM increased 0.14 euro. The total feed costs, a decreased with 88 euros when 1,000 kg DM of pasture grass more was fed. The total gross margin increased with 206 euros for each additional 1,000 kg DM pasture grass. The lower feed costs could be due to lower losses of feed during storage. Lower feed costs have a positive effect on the gross margin. The amount of pasture grass in the diet is highly correlated to the hours of grazing per year. Since most dairy factories give a tax for grazing, also the revenues should be higher. Grazing normally decrease the soil utilization (Van den Pol-van Dasselaar et al. 2013). Thereby pasture grass was negatively related to feed costs per 100 kg FPCM and soil utilization positive. However, both variables were positively related with total gross margin. Thereby with pasture grass the total gross margin was increased, but when the soil utilization decreases, the gross margin will decrease. This indicates that an increase of 2,500 kg DM of pasture grass, increase the gross margin with 500 euro. This is the same as with one percent of soil utilization of N. This means that there is a balance, and pasture grass is only economic profitable, when 2,500 kg DM pasture grass results in less than one percent decrease in soil utilization of N. Because with feeding pasture grass in the barn, the soil utilization is not negative affected, it could be profitable for the total gross margin. However feeding pasture grass on the barn should increase machinery costs, and those costs are not included in the gross margin.

Concentrates and by-products are negatively related to the technical efficiency, what probably indicates that the higher costs for those products as input in DEA were not compensated for less land or more milk production. More concentrates and by-products increased the feed costs per 100 kg

FPCM and total feed costs, the gross margin per 100 kg FPCM is negatively related with 0.12 euro per 100 kg milk. The total gross margin is not affected by concentrate and feed costs, probably due to a higher milk production the total gross margin will be the same.

5.8. Soil type

The soil type has big influences in all models. Peat soils had significant higher feed costs per 100 kg FPCM (table 4.7) and total feed costs (table 4.11) compared with sandy soils. The total gross margin was also significant higher on peat soils compared with sandy soils (table 4.13). Only for the gross margin per 100 kg FPCM the differences were not significant. With a single statistical effect model, corrected with the same variables used as for total feed costs and total gross margin, peat soil had 21,600 euro more milk revenues with total milk revenues as dependent variable (data not shown). The same model with dependent variable total seeds- and herbicides costs, peat soils had 1,500 euros lower costs for seeds and herbicides (data not shown). The higher milk revenues and lower costs for seeds and herbicides explains how the total feed costs could increase and also the gross margin increase for peat soils. Peat soils are mostly not appropriate for maize land. Thereby the costs for seeds and herbicides are also lower. A lower ratio of maize land means a lower DM yield what can increase the feed costs. However the model should correct for that with percentage of grassland. The higher milk revenues on peat soil cannot be explained.

5.9. Intensity

Rougoor et al.(1999) found that intensive farms (more milk production per hectare) have more feed purchases, however due to the higher milk production, the feed costs per 100 kg FPCM were lower. This was not visible in this study. In this study the feed costs per 100 kg FPCM were higher on more intensive farms and the gross margin per 100 kg FPCM was lower. Differences with Rougoor et al. (1999) was, that in this study the intensity GVE per hectare was used. However for this study GVE per hectare was highly correlated with FPCM per hectare (R^2=0.79).

6. Conclusion

Farms with a better soil utilization of N and a better animal utilization of P_2O_5 had a better technical efficiency. This concludes that they need less inputs of feed costs, land, or land related costs for the same milk output.

The soil utilization of N increased the total gross margin with 508 euros for the average farm size of 924,000 kg milk. Each 1,000 kg DM more produced on the farm decreased the total feed costs with 37 euros. A better soil utilization of N increased the feed costs per 100 kg FPCM, but with a better soil utilization, the DM yield per hectare increased, what results in net lower feed costs per 100 kg FCPM. This results also in a positive relation of soil utilization of N with total gross margin.

Animal utilization of N is associated with maize or concentrates rich diets and high producing cows. Animal utilization of N increased the total feed costs. Due to higher total milk revenues, the total gross margin was increased with a higher animal utilization of N.

Pasture grass in the diet increased the total gross margin. However due to grazing the soil utilization can decrease what decreased the total gross margin. Thereby increasing pasture grass is only economic profitable when per 2500 kg DM the soil utilization of N decreases less than one percent.

Concentrates and by-products decreased the technical efficiency and gross margin per 100 kg FPCM, and increased the feed costs per 100 kg FPCM, total feed costs. The total gross margin was not negative affected by concentrates and by-products, probably due to more kg milk supply.

Due to higher total milk revenues, peat soil had the best technical efficiency, and the best total gross margin. This despite the higher feed costs per 100 kg FPCM and the higher total feed costs for peat soils.

7. References

'T Mannetje, L., 2003. Advances in grassland science. *NJAS - Wageningen Journal of Life Sciences*, 50(2), pp.195–221.

Aarts, H.F.M., Daatselaar, C.H.G. & Holshof, G., 2008. *Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmaïs op melkveebedrijven*,

Alfa Accountants en Adviseurs, 2015. *Cijfers die spreken*, Available at: http://www.alfa.nl/InternetDocumenten/Cijfers die Spreken Melkveehouderij 2015.pdf.

Arriaga, H. et al., 2009. Nutritional and management strategies on nitrogen and phosphorus use efficiency of lactating dairy cattle on commercial farms: an environmental perspective. *Journal of dairy science*, 92(1), pp.204–215. Available at: http://dx.doi.org/10.3168/jds.2008-1304.

Bailey, K. et al., 2009. Managing income over feed cost. Available at: http://extension.psu.edu/animals/dairy/business-management/financial-tools/income-overfeed-cost/publications [Accessed March 4, 2015].

Buza, M.H. et al., 2014. Evaluating the effect of ration composition on income over feed cost and milk yield. *Journal of dairy science*, 97(5), pp.3073–3080.

Van Calker, K.J. et al., 2004. An LP-model to analyse economic and ecological sustainability on Dutch dairy farms: Model presentation and application for experimental farm "de Marke." *Agricultural Systems*, 82, pp.139–160.

CBS, 2014. Dierlijke mest; mest en mineralen per bedrijfstype, 1990-2013. Available at: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=80885NED&D1=0-2,11,20,29-36&D2=0-2,5-7,9&D3=0&D4=7-19&HDR=T&STB=G1,G2,G3&VW=T [Accessed March 25, 2015].

Gielen, J., 2015. "Melkveehouders met hoogste ruwvoerproductie draaien financieel het beste." Available at: http://countus.nl/kennisbank/105/melkveehouders-met-hoogste-ruwvoerproductie-draaien-financieel-het-beste [Accessed March 25, 2015].

Gourley, C.J.P. et al., 2012. Farm-scale nitrogen, phosphorus, potassium and sulfur balances and use efficiencies on Australian dairy farms. *Animal Production Science*, 52(929), p.944.

Groot, J.C.J., Rossing, W. a H. & Lantinga, E. a., 2006. Evolution of farm management, nitrogen efficiency and economic performance on Dutch dairy farms reducing external inputs. *Livestock Science*, 100, pp.99–110.

Hilhorst, G., 2013. KringloopWijzer onmisbaar voor betere mineralenbenutting. *Koeien & Kansen Nieuwsbrief 2013 38* , p.3. Available at: https://www.wageningenur.nl/nl/Publicatie-details.htm?publicationId=publication-way-343433363233 [Accessed March 25, 2015].

Ji, Y.-B. & Lee, C., 2010. Data envelopment analysis. *The Stata Journal*, 10(2), pp.267–280.

De Jong, K., 2013. Resultaten Melkveehouderij Bedrijfsanalyse 2013. Available at: http://ppp-agro.nl/Portals/8/documenten/Resultaten melkveehouderij 2013-def.pdf [Accessed March 25, 2015].

Jonker, J.S., Kohn, R. a & High, J., 2002. Dairy herd management practices that impact nitrogen utilization efficiency. *Journal of dairy science*, 85(5), pp.1218–1226. Available at: http://dx.doi.org/10.3168/jds.S0022-0302(02)74185-4.

Kristensen, T., Søegaard, K. & Kristensen, I.S., 2005. Management of grasslands in intensive dairy livestock farming. *Livestock Production Science*, 96, pp.61–73.

Maulfair, D., Heinrichs, J. & Ishler, V., 2011. Feed Efficiency for Lactating Dairy Cows and Its Relationship to Income Over Feed Costs. *College of Agricultural Sciences*, DAS 11-183, pp.1–6.

Van Der Meulen, H. et al., 2014. *Actuele ontwikkeling land-en tuinbouw in 2014*, Available at: https://www.wageningenur.nl/upload_mm/2/5/7/fee08b01-b83a-4afd-a02a-7b7e124eccf4_2014-040 vdMeulen_web.pdf.

NVM, 2015. Grondprijzen A&LV. Available at: https://www.nvm.nl/landelijk/marktinformatie/grondprijzen.aspx [Accessed March 2, 2015].

Oenema, J. et al., 2012. *Variatie in fosfaatopbrengst van grasland op praktijkbedrijven en mogelijke implicaties voor fosfaatgebruiksnormen*, Available at: https://www.wageningenur.nl/upload_mm/4/3/7/fa29c0f4-da49-4380-9332-3269cdf9e926_WOTwerkdocument_287.pdf.

Ondersteijn, C.J.M. et al., 2003. Farm structure or farm management: Effective ways to reduce nutrient surpluses on dairy farms and their financial impacts. *Livestock Production Science*, 84, pp.171–181.

Van den Pol-van Dasselaar, A., Philipsen, A.P. & De Haan, M.H.A., 2013. *Economisch weiden*,

Reijs, J.W. et al., 2007. Effects of different diets on utilization of nitrogen from cattle slurry applied to grassland on a sandy soil in The Netherlands. *Agriculture, Ecosystems and Environment*, 118, pp.65–79.

Rougoor, C.W. et al., 1999. Influence of grassland and feeding management on technical and economic results of dairy farms. *Netherlands Journal of Agricultural Science*, 47, pp.135–151.

Rougoor, C.W. et al., 1997. Relationships between technical, economic and environmental results on dairy farms: an explanatory study. *Livestock Production Science*, 47, pp.235–244.

RVO, 2015. Dierlijke mest gebruiksnorm en gebruiksruimte. Available at: https://mijn.rvo.nl/dierlijke-mest-gebruiksnorm-en-gebruiksruimte [Accessed March 25, 2015].

Schröder, J. et al., 2005. *Limits to the use of manure and mineral fertilizer in grass and silage maize production in The Netherlands, with special reference to the EU Nitrates Directive*,

Schroder, J.J. et al., 2014. Rekenregels van de KringloopWijzer : achtergronden van BEX, BEA, BEP en BEC.

Spears, R. a, Young, a J. & Kohn, R. a, 2003. Whole-farm phosphorus balance on western dairy farms. *Journal of dairy science*, 86(2), pp.688–695. Available at: http://dx.doi.org/10.3168/jds.S0022-0302(03)73648-0.

Velthof, G.L. & Oenema, O., 1997. Nitrous oxide emission from dairy farming systems in the Netherlands.pdf. *Netherlands Journal of Agricultural Science*, 45, pp.347–360.

Verloop, K. & Oenema, J., 2011. *Opties voor beter mest-en gewasmanagement; Verkenning op vijf Koeien & Kansenmelkveebedrijven*, Available at: www.koeienenkansen.nl.

Wu, Z. et al., 2001. Milk production, estimated phosphorus excretion, and bone characteristics of dairy cows fed different amounts of phosphorus for two or three years. *Journal of dairy science*, 84(7), pp.1738–1748. Available at: http://dx.doi.org/10.3168/jds.S0022-0302(01)74609-7.

Wu, Z., Satter, L.D. & Sojo, R., 2000. Milk production, reproductive performance, and fecal excretion of phosphorus by dairy cows fed three amounts of phosphorus. *Journal of dairy science*, 83, pp.1028–1041.