MACHINERY COSTS ON DANISH FARMS

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ABSTRACT

Detailed analyses of machinery costs carried out on 500 full-time farms in Denmark from 1990 to 1996 show that the average machinery costs are 2,845 DKK per hectare before labour costs and 4,125 DKK per hectare after labour costs. The farms analysed have an average acreage of 136 hectares and consist of arable-, pig- and dairy farms. Arable farms have the lowest costs and dairy farms the highest and the costs are falling with increased acreage. The paper finishes with recommendations on how farmers can make a quick estimate of their own machinery costs and improve their investment planning.

INTRODUCTION

After the attention for many years has been on how to reduce variable costs, the focus today is on how to reduce fixed costs on farms. The term "fixed costs" is here slightly misleading as it gives the impression that this cost category can not be changed. But it is possible to change the capacity and reduce the cost related to that capacity, although it takes longer than for variable costs. The investment decision especially is important as many of the costs follow from that and it is often difficult to change your mind once the investment decision is made.

A previous analysis has shown potential reductions of up to 20% in capacity costs on Danish Dairy farms (Lund et al., 1993). Here reduced machinery costs were pointed out as one area where savings could be made.

The total machinery costs in Danish agriculture amount to approximately 10 billion DKK yearly and they constitute a major proportion of the total fixed costs on Danish farms. However, many farmers do not have a clear picture of the total machinery costs on their farm. Surveys carried out in Denmark seem to suggest that farmers underestimate machinery costs and future machinery investments by approximately 30%

(Jacobsen, 1994a and Jacobsen, 1994b). Danish farmers do not often contact their advisor before making a machinery investment, therefore it is very important that the farmer is able to calculate his costs in order to make the right decision.

Unlike the control of variable costs, not many management tools deal with how well a given capacity is being used. However, the machinery cost analysis is an example of how it is possible to focus on the cost of a given capacity. The advisory tool, which is used in a machinery cost analysis, was developed in 1990 at the Section for Buildings and Machinery at The Danish Advisory Centre. The purpose was to develop a tool, which could help the local machinery advisors in Denmark to make a detailed and standardised calculation of the machinery costs on a farm. The tool has since been used in almost all machinery costs analyses carried out in Denmark. The tool named "The Machine Module" is now an integrated part of a larger economic control system.

A machinery cost analysis is carried out by the local machinery advisor in co-operation with the farmer. The first step in the analysis is when the advisor visits the farm and makes an assessment of the value of each machine and its usage. The advisor then makes the calculations which show the total cost and compares it with contractors' charges. On the basis of this, a report is sent to the farmer stating the costs and indicating where savings can be made. The analysis is offered from eight advisory centres in Denmark and it costs 3-5,000 DKK.

The purpose here is to gather the detailed analyses carried out at the farm level in order to provide a better estimation of the actual costs on Danish farms. Based on literature analysis, such a survey is fairly unique. Most other analyses involve either fairly few farms or only a few pieces of machinery and few have therefore been able to estimate the total machinery costs based on detailed farm analyses.

This paper starts with a discussion of how to calculate the machinery costs and the correspondence between theoretical assumptions, empirical results and the practice adopted by the local machinery advisors. The collection of the data is described in the subsequent section and the results of the analysis are presented in the section which follows. The machinery costs are analysed in relation to factors such as acreage and enterprise. Furthermore, estimates are made as to whether machinery tasks carried out by the farmer are cheaper than contractors' charges. Finally, suggestions are given as to how to improve future planning and control of machinery costs on farms.

Considerations concerning tax and inflation are left out as they are often not part of a machinery cost analysis. This does not imply that tax considerations have no impact on the investment decisions, but merely that the calculations carried out in the analysis are before tax calculations.

MACHINERY COSTS

The total machinery costs consist of a calculation of depreciation, interest, maintenance, fuel, contractors' charges and labour costs. Some of these are clearly fixed costs related to establishing a capacity (interest), while others are variable costs which vary with use (fuel). Some costs can be looked upon both as fixed and variable as they vary, to some extent with the activity carried out. How the local machinery advisors calculate the different costs using "The Machinery Module" is presented in the following.

Calculation of the costs

The value of the machine is based on the sales value (replacement value) and not the machines production value on the farm. The production value is often very difficult to establish and it will not typically fall as quickly as the sales value. The value of each machine is estimated by the machinery advisor, together with the farmer and perhaps a local machine dealer if necessary.

The interest used in the calculation is determined either by what interest is currently achieved or the interest on borrowed capital. In most cases the interest is in-between these two as machinery is financed with both sources of capital.

The level of depreciation is determined according to type of machinery and age based on results from previous Danish investigations. A decreasing balance method is normally used with an average level of 15%. Empirical results suggest a higher rate of depreciation in the first years and the program allows for this (Cunningham, 1988). The advisors say that they use the table as a starting point, after which they adjust for individual differences as there can be large differences between farms and farmers.

Maintenance costs consist of both repairs and maintenance or in other words the costs needed to keep the machine running. Maintenance is very difficult to estimate on the machine level as the cost of wear and tear can be delayed from one period to the next. Some years will have high maintenance costs, others very low costs. Empirical

findings (Yule, 1995) seem to suggest that maintenance costs do increase over the lifetime of the machine, but they increase at a decreasing rate. The problem is that maintenance varies greatly between brands, type of machine and managers, which makes it difficult to find the correct level. The advisors therefore support their estimate by looking at the existing level of maintenance costs in the farm accounts.

Many farmers buy contractor charges, which replace fixed costs that the farmer would otherwise have. Quite a few farmers co-own machines with their neighbour, which can be accounted for in the analysis. It is assumed that the non-cash agreements equal each other.

It is difficult to estimate the correct level of labour costs. It is uncertain how much time is spent on things other than driving the machinery, such as time used to repair the machine and machinery management. It is also difficult to determine the correct level of payment as it is based on what the farmer would otherwise get. In the case of an employed tractor driver, it is much easier to calculate the cost, as he is paid a salary. The payment used is around 100 DKK per hour. The advisors set the levels based on a discussion with the farmer, which seems to work well.

There is, in general, a good correspondence between theoretical assumptions, empirical results and the practice adopted by the local machinery advisors. The largest difference is in relation to maintenance costs, where the theory assumes a strong increase over the lifetime, but the empirical findings suggest an increase at a decreasing rate. This means that that the empirical marginal cost curve has an L-shape, where the theoretical total cost curve is a U-curve, during the period which is normally investigated. This suggests that farmers should keep their machinery for a long period.

Type of cost calculation

The Machine Module allow for both an average cost and a marginal cost calculation. The marginal cost is the estimated cost for the following period, whereas the average cost is the annual cost from when the machine was bought until it is sold. However, the average cost calculation carried out in the analysis, is based on the value at the time of the analysis and not at the time when it is bought. This means that the average cost is underestimated by approximately 500 DKK per hectare.

The purpose of the analysis should determine which one of the two methods should be used. The marginal costs analysis is good when looking at the current state,

whereas the average gives a better picture of the long term costs This is especially true regarding the individual machine. If the average age of the machinery on a farm is fairly constant then the difference between the marginal and the average costs regarding the whole farm should be minimal. Most advisors use the marginal cost analysis as it is easier to explain to farmers. The calculations in this report are therefore based on the marginal cost principal.

DATA

The machinery advisory centres in Denmark have carried out some 1,000 detailed analyses of machinery costs since 1990. However, many of these are no longer available on computer, but only in paper-form. Other analyses have only dealt with a few machines and has therefore also been left out. What has remained aree 500 analyses from 500 farms carried out from 1990 to 1996 (see Poulsen, B. and Jacobsen, B., 1997).

In order to make the machinery analyses comparable, extensive tests were made to ensure that e.g. labour costs were included in all of them. It was also ensured that the machinery covered only field machinery and not machinery used for feeding animals. Finally all the costs were indexed to fixed 1995 DKK. It should be mentioned that in only 417 of the 500 analyses was a calculation of the alternative cost using contractor charges made.

In order to be able to carry out the analysis we wanted, additional registrations were made when the data was collected at the local machinery advisor. These registrations consisted of data such as type of farm, the year the analysis was carried out and the actual cultivated area. Surprisingly, none of theses are included when carrying out a machinery analysis.

The 500 farms constitute less than 2% of all Danish full-time farms and less than 3% of the total cultivated area in Denmark The farms have an average acreage of 137 hectares, which is twice the size of an ordinary full-time farm in Denmark. The material consists of slightly more pig farms and farms from the eastern part of Denmark than the population of full-time farms in general. It is assumed that the farmers who have had an analysis made are more interested and keen to control their machinery costs than the average farmer.

RESULTS

The results show that the average machinery costs including depreciation, interest, maintenance, contractors charges and fuel, are ***2,845 DKK*** pr. hectare and ***4,125 DKK*** per hectare including labour costs. (se table 1) Despite the difference in ways of calculation these results are similar to previous Danish findings regarding machinery costs based on accounts (Poulsen and Jacobsen, 1997).

TABLE 1.The average machinery costs per hectare including the results for the 10% of farms with the highest and lowest machinery cost per hectare.

	Lowest 10%	**Average**	Highest 10%
No. of farms	50	**500**	50
Area (ha)	210	**137**	57
Working hours (hours/ha)	8	**13**	22
Wages (DKK/time)	98	**104**	105
Machine value (DKK/ha)	5011	**6791**	9179
Costs (DDK/ha)			
Depreciation	627	**875**	1192
Interest	526	**743**	1068
Maintenance	458	**648**	1108
Fuel	152	**200**	323
Miscellaneous	70	**80**	111
Result 1	1833	**2546**	3802
Contractor costs	-376	**299**	1208
Result 2	1457	**2845**	5010
Labour costs	773	**1280**	2276
Result 3	2230	**4125**	7286

The average value of machinery comes to just under 6,800 DKK pr. hectare and the average number of working hours is 13 hours per hectare. Of the total costs, depreciation and interest account for 39%, maintenance 16%, labour costs 31%, contractors' charges 7% and fuel and other items account for the rest.

There is a large variation in costs, from 2,230 DKK per hectare for the 10% of farms with the lowest costs, to 7,286 DKK for the 10% of farms with the highest costs. The large variation is due to differences in all cost categories and not one single category. The differences could be due to factors like the cropping pattern, area and region, which we will look closer at in the following. It is noticeable that the group of farms with the lowest costs have an income from contracting. So, although their machinery value per hectare is the lowest they still have enough capacity to do contract work.

Profit from owning machinery

In order to see whether having one's own machinery is profitable, the costs are compared with the alternative cost. The alternative cost equals what it would cost for a contractor to carry out the same operations as the farmer is currently doing. The alternative cost is looked upon as an income and if the actual costs are higher than this income, the farmer would profit by letting contractors do the job.

The results from 417 farms show an average surplus of 285 DKK pr. hectare if the farmers have the machinery themselves, compared to the contractors' charges. The average wages setting the profit equal to zero is 138 DKK per hour where the standard is 100 DKK per hour.

When looking at the profit from owning machinery, there are still large differences between the best and the worst results. These differences are, as opposed to previous results, no longer due to differences in cropping patterns, which should have been accounted for in the alternative cost calculation. Also the economics of size should, to some extent, have been accounted for.

TABEL 2. The average machinery costs and the profit from owning machinery, including the groups with the 10 percent highest and lowest profit from owning machinery.

	Lowest 10%	**Average**	Highest 10%
No. of farms	42	**417**	42
Area	70	**134**	181
Working hours (hrs./ha)	16	**12**	13
Wages (DKK/time)	108	**105**	111
Machine value (DKK/ha)	9293	**6718**	6722
Costs (DDK/ha)			
Depreciation	1295	**876**	844
Interest	1064	**732**	700
Maintenance	738	**598**	654
Fuel	253	**189**	175
Miscellaneous	127	**90**	100
Result 1	3477	**2485**	2473
Contractor costs	756	**311**	-257
Result 2	4233	**2796**	2216
Labour costs	1660	**1222**	1436
Result 3	5893	**4018**	3652
Opportunity cost (DKK/ha)	4294	**4303**	5608
Profit from owning machinery (DKK/ha)	-1599	**285**	1956
Calculated earnings (DKK/hr.)	2	**138**	273

One out of three farmers would have had lower costs if the machine operations had been done by contractors. However, there is some uncertainty concerning this, as the number of hours that the farmer uses is probably underestimated and the contractor's charges are, in some cases, overestimated. Therefore it is possible that up to half of all Danish farms could lower their machinery costs by leaving the work to contractors.

Machinery costs per hectare fall with increasing acreage. The main reason is that the larger farms have much lower numbers of working hours per hectare, as well as lower machinery assets per hectare. The average machinery costs fall from 5,618 DKK per hectare for small farms, to 3,322 DKK for large farms.

TABLE 3. The average machinery costs per hectare according to area.

Area (ha)	20-49	50-74	75-99	100-149	150-249	250-	All
No of farm	67	89	88	106	98	52	500
Area	39	61	85	121	184	422	137
Working hours (hrs./ha)	18	15	13	11	10	8	13
Wages (DKK/time)	101	103	103	101	109	115	104
Machine value (DKK/ha)	7513	6995	7410	6747	5993	6055	6791
Costs (DDK/ha)							
Depreciation	882	843	953	899	811	865	875
Interest	865	786	797	719	642	659	743
Maintenance	846	730	680	607	526	517	648
Fuel	239	222	208	188	177	163	200
Miscellaneous	94	92	100	73	68	43	80
Result 1	2926	2673	2738	2486	2224	2247	2546
Contractor costs	952	606	52	74	116	155	299
Result 2	3878	3279	2790	2560	2340	2402	2845
Labour costs	1740	1522	1332	1122	1061	920	1280
Result 3	**5618**	**4801**	**4122**	**3682**	**3401**	**3322**	**4125**

There is a much larger use of contractors on small farms than on large ones, which is not surprising, but the small farms also have the highest machine values per hectare, which result in a high cost per hectare. There is a smaller variation on larger farms between the best and the worst, which seem to suggest that the control with machinery here is better.

Regarding the different enterprises, it is clear that dairy farms have the highest machinery costs and arable farms the lowest, with pig farms in between. Small dairy

farms, especially, have very high machinery costs, namely 6,500 DKK per hectare, even though most machinery used for feeding animals indoors has been excluded. One of the reasons is the high maintenance costs and the high number of working hours per hectare, at the same time as the contractors' charges are the highest. This could imply that the total cost of producing beet or grass is higher than expected, meaning that the total cost of producing one's own feed is very high on some farms. There is hardly any difference between the costs on arable and pig farms of more than 50 hectares.

The results of the analysis also shows that farms with special crops like carrots and sugar beet, and farms that use irrigation, have higher costs than those which do not. It has also been found that the machinery costs are higher in the eastern part of Denmark (clay soil) than in the western part (sandy soil). Finally, there seems to be a tendency towards lower costs per hectare over time, but as it is not the same farms that are analysed each year, it could be due to other factors.

TABLE 4. The average machinery costs per hectare according to type of enterprise.

Type of enterprise	Cereal	Dairy	Pig	All
No. of farm	116	178	206	500
Area	219	91	130	137
Working hours (hrs/ha)	10	16	11	13
Wages (DKK/time)	110	104	102	104
Machine value (DKK/ha)	6243	7070	6857	6791
Costs (DDK/ha)				
Depreciation	871	881	873	875
Interest	675	781	748	743
Maintenance	550	797	575	648
Fuel	174	233	186	200
Miscellaneous	71	82	82	80
Result 1	2341	2774	2464	2546
Contractor costs	97	575	175	299
Result 2	2438	3349	2639	2845
Labour costs	1057	1618	1114	1280
Result 3	**3495**	**4967**	**3753**	**4125**

DISCUSSION OF RESULTS

There is a large difference between farmers' machinery cost and the further investigation has shown that area, type of enterprise, region and use of irrigation explain approximately 50% of the variation in the machinery costs. The remaining difference is due to factors like earnings, tax-level and future strategy for the farm. There is also a large variation between farmers concerning risk and the effect of timeliness. Furthermore many farmers want to have their own machinery in order to have a variation in their daily work. All in all, this leads to large differences between the total machinery costs on similar farms.

There is nothing wrong with high machinery costs if it is in line with the farmer's objectives. However, many farmers seem to underestimate their machinery costs. A high level of machinery costs might not therefore be in line with their objectives, but surprisingly few farmers have had an analysis of their machinery costs made.

With few farmers having carried out a machinery analysis and many underestimating their actual cost, it is obvious to ask why more of these analyses have not been carried out. From interviews with 25 farmers concerning their investment planing, it was found that some were interested, but they had not made an attempt to contact the advisor and others did not think it would make any difference to their situation (Jacobsen, 1996). A third group of farmers were satisfied with their present level of machinery costs, although they did not know the exact level, and they were a little afraid of what a machinery cost analysis would show.

The results suggest, that if all farmers were able to do as well as the best 10% of farmers, they could save, on average, close to 2,000 DKK pr. hectare per year. However, it is more likely that many would be able to reduce the average costs by approximately 1,000 DKK per hectare per year. For the average full-time farm, the potential reduction is therefore around 65,000 DKK per year.

IDEAS FOR IMPROVED PLANNING

In order to reduce future machinery costs, farmers need to know their present level of machinery costs per hectare. Here the farmer can start with the following quick estimate, based on machinery analyses carried out :

$$\text{Machinery cost} = \frac{(\text{Machinery value} * 0.36) + \text{Contractor charges (net)}}{\text{Cultivated area}}$$

The idea is that the value of the machinery is multiplied by a factor of 0.36 which accounts for interest, depreciation and maintenance. To this figure net contractors charges are added and income from contracting deducted. The sum is then divided by the farmer's cultivated area and the result is an estimate of the cost per hectare before labour costs. Previously a factor of 0.3 has been used as a "rule of thumb", but the results here show that a figure of 0.36 is the best. The rule gives a reasonable estimate in 3 out of 4 cases if a range of +/- 500 DKK per hectare is allowed. The farmer can then decide, based on the result, whether he wants a detailed machinery analysis made.

One of the reasons behind too high machinery costs is that specialised equipment is very capital intensive. This means that the farmer needs to crop a larger area to justify the investment. Smaller farms can achieve this either through co-ownership or by doing contract work for neighbours. Looking at where the potential savings are, it seems like better control of investments, maintenance and working hours is required.

The advisory service offered to the farmers can also be improved. The machine advisors have to improve their marketing of themselves and their products. Many Danish farmers have no clear idea of what the advisor can offer. Convincing the farmers that they have the expertise which enable them to find solutions which could save costs if the farmer is interested.

Improving the management tools and having more co-operation between financial advisors and the machinery advisor which would enable the machinery advisor to reach more farmers who need a more efficient planning of the machine operations.

There is a large potential for reductions in machinery costs on many Danish farms. Further research could provide more information about why there are such large differences in machinery costs and how the potential savings can be achieved. Suggestions for improvements can be made both by researchers and advisors, but the primary initiative has to come from the farmer if the result is going to be successful.

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