Full Product Costs on Base of Farm Accountancy Data
by Means of Maximum Entropy

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Abstract

The paper presents an approach to allocate joint costs to production branches based on maximum entropy. Using bookkeeping data from the Farm Accountancy Data Network (FADN) we derive full product costs. Accordingly, the suggested approach offers the opportunity of full product costs based on actual costing rather than normal costing.

The approach is applied for arable crop in Switzerland providing full product costs on a hectare base. The resulting total costs are up to 20 percent higher than in literature. An important reason is labour, which shows for all analysed production branches higher costs than in the actual costing based literature.

Key Words: Full Product Costs, Maximum Entropy, FADN, Arable Crops
JEL Codes: M41, Q12

1. Introduction

Production costs are critical to farming decisions. The full product costs of a produced unit are of interest for three reasons. First, the difference between output price and full product costs is equal to profit or loss or rather profitability. Second, full product costs provide the opportunity to calculate cost shares of all inputs and give insight to the cost structure. Finally, full product costs are also a suitable tool to compare different farms. Since farms are usually price takers full product costs provide insight in differences between farms regarding their efficiency and productivity. Furthermore, full product costs allow comparisons on an international level. For example, the International Farm Comparison Network (IFCN) reports annually the full product costs of a litre of milk for dairy farms all over the world (Hemme 2008).

Full product costs usually refer to normal costing or budgeted costing, which is useful for a planning process. In order to analyse the current profitability of production branches data from accountancy

would be more appropriate. Especially for labour bookkeeping data allows using actual costs instead of fixed hourly rate or labour costs.

When analysing full product costs it is necessary to distinguish between direct costs and joint costs. Most countries of the Farm Accountancy Data Network (FADN) including Switzerland provide information about direct costs on a production branch level. Contrary, joint costs are only available for the whole farm, which normally includes several production branches. In order to estimate full product costs joint costs need to be allocated to all production branches. Therefore, so called distribution keys are applied, which require a substantial effort in terms of labour[1]. This paper suggests an alternative approach based on maximum entropy method. Maximum entropy allows overcoming data gaps like the true allocation of joint costs by using available information. This method provides the best possible estimate of the missing data.

Maximum entropy is widely applied to derive input output coefficients in agriculture: Léon et al. (1999) as well as Peeters and Surry (2005) use FADN-data from farms in Brittany (France). Based on regional economic accounts for agriculture (EAA) Hansen and Surry (2007) derive input quantities for different production branches for Germany. Garvey and Britz (2002) estimate input allocation from EU farm accounting data.

The suggested approach organises the allocation of joint costs using two sets of given data: i) a mean value of costs per units (e.g. machinery costs per hectare wheat) and ii) a reasonable range (e.g. minimal and maximal value for machinery costs per hectare wheat).

The paper is organized as follows. Section two presents the maximum entropy approach for the distribution of joint costs. Section three describes the used data. The results are presented in section four. In the last section, we draw conclusions.

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[1] In Germany the DLG (2004) provides a distribution key.

2. Maximum Entropy

Assume a farm, which produces j arable crops. An arable crop is considered as a production branch (e.g. an area of wheat in hectares). From the FADN data we know joint costs T for k items (e.g. machinery), denoted as T_k for the whole farm. The amount of cost item k for production branch j (e.g. machinery costs for a hectare of wheat) is defined as $C_{k,j}$. $C_{k,j}$ can be divided into two parts, a mean value or fixed component $F_{k,j}$ and an additional component $A_{k,j}$:

$$C_{k,j} = F_{k,j} + A_{k,j} \tag{1}$$

Both components are based on either literature or expertise, which is elaborated in more details in the next section. $A_{k,j}$ refers to a reasonable range and varies between a lower ($L_{k,j,lower}$) and an upper limit ($L_{k,j,upper}$). $A_{k,j}$ can be computed by using the two limits and the corresponding probabilities $p_{k,j,i}$, whereas i takes the values "lower" und "upper".

$$A_{k,j} = p_{k,j,lower}L_{k,j,lower} + p_{k,j,upper}L_{k,j,upper} \tag{2}$$

The probabilities have to sum up to 1:

$$\sum_{i=1}^{2} p_{k,j,i} = 1 \tag{3}$$

Maximum entropy allows determining the probabilities. According to Golan et al. (1996) the following logarithmic function needs to be maximized:

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$$\max\left[-\sum_{}^{k}\sum_{}^{j}\sum_{i=1}^{2}p_{k,j,i}\ln p_{k,j,i}\right] \qquad (4)$$

A constraint is necessary to ensure that the costs of item k of all production branches j ($C_{k,j}$) sum up to the total costs of the whole farm for item k (T_k):

$$\sum_{}^{j}S_j C_{k,j} = T_k \qquad (5)$$

Since the costs are measured per area in hectares, we multiply $C_{k,j}$ with the area of hectares of production branch j (S_j).

Expressions 1 to 5 build together the core model. In addition, the maximum entropy approach allows the introduction of other available information. For instance, we know that barley has a lower intensity in the production process and hence lower costs than wheat. They peak of maximal 98 percent of the costs of wheat (Lips und Ammann 2006). Accordingly, the model is extended by an inequation:

$$C_{k,barley} \leq 0.98 * C_{k,wheat} \qquad (6)$$

The model is solved by maximizing equation (4) with the constraints given in equations 3 and 5 as well as the inequation 6. Based on a maximum entropy application for input output tables by Robinson et al. (1997) the model is written in the General Algebraic Modeling System (GAMS; Brooke et al. 1998). The model is formulated for a single farm. In the following a group of farms will be analyzed. Consequently, the model needs to be solved for every farm separately.

3. Data Base

The analysis concentrates on farm with arable corps for two reasons:

i) For six arable crops (wheat, barley, rapeseed, sun flower, potatoes and sugar beet) full product costs are available for Switzerland (Lips and Ammann 2006). Based on the years 2001 to 2003 they use actual costing as well as normal costing for their cost calculation. The following cost items are based on bookkeeping data (actual costing): seeds, plant protection, cleaning and drying, hail insurance, other direct costs, land rents and "other joint costs". Four cost items refers to normal costing: fertilizer (based on nutrient requirements), labour (based on work budget systems), machinery (based on standard mechanisation) and interest rates of own capital.

ii) Reduction of complexity by excluding farms with annual husbandry

The FADN system of Switzerland consists of approximately 3500 farms. For the bookkeeping year 2004 only twelve farms are available, which concentrate on arable corps and accordingly do not have animal husbandry (Agroscope FAT 2005). They dispose of 13 different crops with a total of 71 products branches: Wheat (11), barley (6), rapeseed (6), sun flower (1), potatoes (3), sugar beet (9), grain maize (6), silage maize (4), protein peas (2), soy bean (1), temporary ley (4), natural grassland (12) and forest (6).

Unfortunately, all farms have substantial activities outside the core agricultural business, which include among others, renting buildings out, working on other farms with own machinery and direct sale. The mean return related to these activities is substantial and amounts to approximately CHF 50'000.-. Accordingly, the above mentioned activities affect costs on labour, machinery and "other joint costs".

As a consequence, we exclude these activities from accountancy data assuming that returns are equal to costs[2].

Out of the accountancy data five cost items per hectare and production branch are considered:

- Direct costs summarize the following items: Seed, fertilizer, plant protection, cleaning and drying and hail insurance. Since direct costs are recorded on a production branch level no further measurements are necessary.

- For rented land two specifications are available: The number of hectares and the total amount, which was paid in order to rent land. Hence, the average rental rate can be calculated. All but two farms hold own land. We assume that there is a homogenous quality of land. As a consequence, the average rent per hectare can be used for the total surface of the farm[3].

- Three cost items are only available for the farm as a whole: labour, machinery and "other joint costs". In line with section 2 they are allocated to production branches by means of maximum entropy.

  The cost item labour includes both the salaries of farm employees as well as reimbursement of family labour[4]. Machinery costs contain costs of farm-owned machines (interest, depreciation, carburant, services) and costs of machinery services of other farmers or companies (e.g. combine harvesters for cereal harvest). Finally, "other joint costs" include depreciations of farm buildings and land improvements, insurance premium, energy, water, telephone, a share of the farmer's car, overheads as well as interest rates of own capital.

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[2] Correcting accountancy data is organized as follows. 50 percent of the return of renting out buildings are deducted from total labour cost. The remaining 50 percent are reduced from "other joint costs". In the case of working on other farms with own machinery half of return is reduced from labour and machinery, respectively. To correct the other activities we deduct 50 percent of the referring return from labour.

[3] Since the interest rate of own land is included in the interest rates of own capital, a correction of the "other joint costs" is necessary.

[4] The latter is calculated as follows. Starting with the agricultural income we deduct the interest on owner's capital. Therefore, we take the interest rate of Swiss Federal Term Bonds as a basis.

The mean value or fixed component ($F_{k,j}$) for all 13 crops are calculated for the year 2004 based on the procedure, which is outlined by Lips and Ammann (2006). For the additional component ($A_{k,j}$) we assume an asymmetric range respecting the fact that costs may exceed substantially the fix component. For instance, the fixed component for machinery costs for wheat is CHF 1684.- The upper and lower limits are CHF +2000.- and CHF -500.-, respectively. These limits are applied for most of production branches and cost items. Due to higher labour and machinery costs in the production of potatoes and sugar beet the referring limits are larger (up to CHF +5000.- and CHF -2000.-).

4. Results

In the results section we concentrate on six arable crops (wheat, barley, rapeseed, sun flower, potatoes and sugar beet). For all of them we compare the results of two methods, the outlined maximum entropy approach (ME) and the cost calculation (Calc) by Lips and Ammann (2006) from literature. The results of the remaining seven production branches are in the appendix. The results for the maximum entropy results refer to the average of the involved farms. For example the results of wheat are based on 11 farms (Table 1).

Maximum entropy shows higher full product costs for all production branches. Cereals and oil seeds (rapeseed and sun flower) are about 15% lower in the calculation approach. Total costs for cereals and oilseeds are rather consistent[5]. For potatoes and sugar beet the differences between the two methods are minor.

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[5] For the comparison between wheat and barley note that inequation 6 implicates slightly smaller costs for labour, machinery and other joint costs.

The three cost items labour, machinery and "other joint costs" show considerable differences. The maximum entropy approach leads to higher results for labour costs for all production branches. An explanation are the underlying types of calculation. While maximum entropy is based on actual costing, the calculation by Lips and Ammann (2006) use normal costing (work budget systems). Looking at machinery costs the picture is different. For cereals the results of both methods are similar. Rapeseed and sun flower show around 15 percent higher machinery costs with the maximum entropy approach. Substantially lower results can be observed for potatoes and sugar beet. Concerning sugar beet the result can be explained by a very low under limit for machinery cost (CHF –2000.-). The results for "other joint costs" are higher for all production branches. The differences are around CHF 400.- per hectare. Since the calculation for this cost item is also based on actual costing in Lips and Ammann (2006) it seems to be a specific effect of the twelve farms.

Table 1: Full Product Costs in CHF per Hectare for six Arable Crops

Production Branch	Wheat		Barley		Rapeseed		Sun Flower		Potatoes		Sugar Beet	
Method	ME	Calc	ME	Calc	ME	Calc	ME	Calc	ME	Calc	ME	Calc
Number of farms	11		6		6		1		3		9	
Direct Costs	1096	1182	1001	1029	1245	1462	976	1299	4330	4322	1597	1898
Labour	1502	825	1499	810	1324	696	1290	684	4459	3543	3033	1602
Machinery	1629	1591	1486	1506	1561	1366	1732	1506	3885	4553	1549	2839
Other joint costs	1167	791	1122	779	1260	784	1276	783	1386	982	1282	879
Land	673	718	628	718	745	718	528	718	845	718	721	718
Total	6056	5107	5729	4842	6129	5026	5803	4990	14901	14118	8181	7936
in %	100	84	100	85	100	82	100	86	100	95	100	97

Method: ME = maximum entropy approach, Calc = cost calculation by Lips and Ammann (2006)

Besides the differences of absolute values, the size of cost shares is of interest. Table 2 shows them, again for both methods. For cereals as well as oil seeds the differences between the two approaches reach at most nine percent. Labour and "other joint costs" show higher cost shares under the maximum entropy approach. Cost shares of machinery and land are lower.

For potatoes and sugar beet main differences are located in the cost items labour and machinery. It has to be noted that the cost share for the sum of them is equal for both methods.

Table 2: Cost Shares in % for six Arable Crops

Production Branch	Wheat		Barley		Rapeseed		Sun Flower		Potatoes		Sugar Beet	
Method	ME	Calc	ME	Calc	ME	Calc	ME	Calc	ME	Calc	ME	Calc
Direct Costs	18	23	17	21	20	29	17	26	29	31	20	24
Labour	25	16	26	17	22	14	22	14	30	25	37	20
Machinery	27	31	26	31	25	27	30	30	26	32	19	36
Other joint costs	19	15	20	16	21	16	22	16	9	7	16	11
Land	11	14	11	15	12	14	9	14	6	5	9	9
Total	100	100	100	100	100	100	100	100	100	100	100	100

Method: ME = maximum entropy approach, Calc = cost calculation by Lips and Ammann (2006)

5. Conclusions

The paper focus on maximum entropy method in order to derive full product costs based on farm accountancy data (FADN-data).

The application for arable crop farms shows that the approach provides reasonable results. Nevertheless, the results should be carefully examined since activities beyond agricultures needed to be excluded in the data. In addition, the sample is rather small. If we compare the results of the maximum entropy methods to literature labour costs are higher. While the latter is based on normal costing the maximum entropy uses FADN data, which belongs to the actual costing type. Therefore, results suggest focusing more on differences between normal und actual costing of the input labour for farms with arable corps in Switzerland.

Limited on arable crops the maximum entropy approach is not ready yet for a broad application. Further steps are necessary to expand the analysis on farms with animal husbandry. As a consequence,

the treatment of farms with both arable corps and animal husbandry, the typical Swiss farm, will be possible.

Compared with other methods to allocate joint costs (e.g. distribution keys) maximum entropy reduces the necessary effort strongly. Accordingly, the approach offers manifold opportunities, like the analysis of profitability, productivity or economies of scale. Furthermore, to provide full product costs of all production branches would be a useful tool for farmers to take management decisions. Finally, the potential option to provide farmers full product costs could stimulates more farmers to take part of the FADN.

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Appendix

Table 3: Full Product Costs in CHF per Hectare for Maize, Protein Peas, Soy Bean, Grassland and Forest

	Grain Maize	Silage Maize	Protein Peas	Soy Bean	Temporary Ley	Natural Grassland	Forest
Number of farms	6	4	2	1	4	12	6
Direct Costs	1278	643	1065	1114	215	173	1
Labour	1535	2007	1495	1477	1009	954	893
Machinery	1503	2366	1909	1324	616	508	634
Other joint costs	1276	1405	1444	1292	840	852	821
Land	703	597	718	1011	537	677	0
Total	6295	7019	6631	6218	3217	3164	2349

Abbreviations

i lower or upper limit of range of additional costs

j Production branch (for example wheat or potatoes)

k Cost item (for example machinery)

$A_{k,j}$ Additional component of cost item k for production branch j

$L_{k,j,i}$ Limit i of cost item k of production branch j

$C_{k,j}$ Cost item k for production branch j

$F_{k,j}$ Mean value or fix component of cost item k for production branch j

$p_{k,j,i}$ Probability that limit i of cost item k of production branch j is applied

S_j Surface of production branch j (measured in hectares)

T_k Total costs for the whole farm of cost items k (for example machinery)