Labour-use pattern on Swiss dairy farms

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Abstract: Analysing the labour-use pattern on Swiss dairy farms, we apply a typology scheme with two criteria: on-farm wage labour and off-farm family labour. The resultant four farm types are analysed based on the data from the Swiss Farm Accountancy Data Network (FADN) as well as the spatial data on available jobs. Only 17% of dairy farms have neither on-farm wage labour nor off-farm family labour. 60 % have family members involved in off-farm activities. On average, 0.3 annual work units (AWU) are employed in off-farm activities, earning double the on-farm income per AWU. In line with the literature, we found that the likelihood of on-farm wage labour increases with the farm size and the degree of diversification. Involvement in off-farm activities is more likely if the farm manager is young and has a spouse with a non-agricultural education. Furthermore, private consumption per consumer unit has a positive marginal effect on the likelihood of off-farm work. Finally, no evidence was found of available jobs within a range of 10 kilometres acting as a proxy for the local labour demand for off-farm activities, leading us to the conclusion that involvement in off-farm work is an option for most of the analysed dairy farms.

Key words: dairy farm, FADN, farm household, off-farm work, on-farm wage labour, Switzerland

Despite the complete liberalisation of the cheese market between the European Union and Switzerland, several agricultural policy instruments are still in place for the dairy sector, such as tariffs for all other dairy products and cheese-production subsidies. As a result, the farm-gate milk price in Switzerland is substantially higher than in the neighbouring regions such as Southern Germany or Austria. In 2010, the average price for a kilogram of raw milk was 0.62 Swiss Francs (CHF; Bundesamt für Landwirtschaft 2011a), while prices in Bavaria and Austria were CHF 0.43 (Agrarmarkt Austria 2011).

A second difference between dairy farms in Switzerland and the neighbouring German-speaking regions is that the percentage of the part-time or sideline dairy farms is lower in Switzerland[1]. In 2009, only 8% of Swiss dairy farms were part-time farms (Bundesamt für Statistik 2012). In Baden-Württemberg, the share in 2005 was 28% (Arndt 2006). In 2008, the percentage of part-time farms in the administrative districts of Ravensburg and Breisgau-Hochschwarzwald, both of which are in Baden-Württemberg and relatively close to the Swiss border, were 15% and 30%, respectively (Rothfuß et al. 2009). For Bavaria and Austria, the percentage of the part-time forage-growing farms, which are closely connected to dairy farms, was 50% (2009; StMELF 2010) and 46% (2007; Statistik Austria 2008), respectively. Despite this, there was no uniform difference in the farm size measured in dairy cows between Switzerland and its neighbours. In 2009, the average Swiss dairy farm had 20 dairy cows (Mouron and Schmid 2011), while the relevant numbers for forage-growing farms in Baden-Württemberg, Bavaria and Austria were 32, 28 and 12 cows, respectively (LEL and LfL 2011, p. 194; BMLFUW 2011, p. 234).

Though negotiations of both the Doha Round of the World Trade Organization and the free-trade agreement for agricultural commodities between Switzerland and the European Union came to a standstill (Bundesamt für Landwirtschaft 2011b, p. 185), a further liberalisation of trade would almost certainly lead to a lower producer price. Comparing dairy farms in Austria and Switzerland, Kirner and Gazzarin (2007) point out that the milk price in Austria decreased substantially after that country joined the European Union in 1995. As a consequence of any sort of stronger economic integration, dairy farms would be faced *ceteris paribus* with a drop in the income. To offset this, increasing

[1]It is important to note that the definition of part-time farms differs among the three countries in question. In Switzerland, the criterion is that the farm manager devotes less than 50% of his total working hours to farm work (Bundesamt für Statistik 2012). In Germany, there is a case differentiation in terms of volume of work: farms with a work volume of less than 0.75 of an annual work unit (AWU) are classified as part-time, while a work volume of more than 1.5 AWU is defined as full-time. Farms with a work volume of between 0.75 and 1.5 of an AWU are classified as part-time if less than half of the total income originates from agriculture (Arndt 2006). In Austria, a part-time farm is one to which the managing couple devote less than half of their working hours (Statistik Austria 2012).

the quantities of milk produced would enable farmers to take advantage of the economies of scale. Owing to the scarcity of agricultural land (Gazzarin et al. 2008), however, this would be difficult to accomplish. Alternatively, starting a cooperative with other dairy farmers would be another way to benefit from the scale effects, and thereby to cut costs and increase income. However, the results of a survey analysing how farm managers perceive farming collectives clearly show their fear of the potential interpersonal conflicts (Pulfer 2007). Another option available to farm managers for offsetting a reduction in agricultural income is to increase their off-farm income by undertaking or expanding the off-farm activities. The resultant rise in the percentage of part-time dairy farms would lead to a convergence of Swiss dairy-farm structure with that of the neighbouring regions.

In view of this possible adjustment process, it is important to improve our understanding of the on- and off-farm activities of farm families. At the same time, the use of hired or wage labour must also be taken into account, which leads to an analysis of the dairy farm's labour-use pattern. Specifically, there are three questions to be answered. Firstly, how many dairy farms are involved in the off-farm activities even on a limited level, and what is the proportion of the on-farm to off-farm income for family members? Secondly, what features of a farm are important for the off-farm and on-farm wage labour? Finally, does local labour demand play a role in the decision of a farmer or of his/her family to engage in the off-farm activities?

The aim of this paper is to help farm consultants to identify opportunities for dairy farmers. Moreover, it is the aim of the analysis to assist agricultural policy-makers in evaluating the attendant measures of the potential adjustment process.

To analyse the labour-use pattern, we apply a farm typology scheme with four farm types, which is in line with an approach frequently used in the literature (e.g. OECD 2001; Findeis 2002; Benjamin and Kimhi 2006; Blanc et al. 2008). The analysis relies on data made available by the Swiss Farm Accountancy Data Network (FADN) (Roesch and Hausheer Schnider 2009). Moreover, the number of jobs at a local level is used as a proxy for the local labour demand (Bundesamt für Statistik 2009).

METHODOLOGY

Farm type classification

To analyse the labour-use pattern, we apply the classification scheme proposed by Blanc et al. (2008), which is based on two criteria: (i) the existence of on-farm wage labour (Does the farm use hired labour?) and (ii) the existence of off-farm family labour (Do members of the farm manager's family work off-farm?). The resultant typology consisting of four farm types is illustrated in Table 1. Type 1 neither hires in labour nor has family members working off-farm. For these farms, the family labour supply and the farm labour correspond exactly. The farm-type 2 has family members who work off-farm, while the on-farm wage labour is non-existent. By contrast, the farm-type 3 hires in labour, but it has no family members working outside of the farm. With the farm-type 4, wage labour is both hired in and family members are employed in the off-farm activities.

Table 1. Four farm types

		Off-farm family labour	
		no	yes
On-farm wage labour	no	type 1	type 2
	yes	type 3	type 4

The typology used here is similar to that of the OECD (2001, p. 16) and Findeis (2002). Farm-types 1 and 3 correspond to types II and I, respectively. The farm-type III covers the farm-type 3 (Findeis 2002) and the types 3 and 4 (OECD 2001). Benjamin and Kimhi (2006) apply a more detailed classification, differentiating between the off-farm work performed by males or females. They also distinguish between whether or not the farmer's spouse works on the farm, yielding a classification composed of 16 farm types.

In accordance with the literature, we apply a threshold value of zero for both criteria. Accordingly, minor activities in terms of time commitment, such as serving as a local councillor (off-farm activity) or a hired worker for only a few weeks, lead to assignment to types 2 and 3, respectively.

Descriptive statistics

After dairy farms are assigned to farm types, the main characteristics of the observations for each farm type are analysed descriptively. To determine whether there are significant differences between the farm types in terms of the characteristics considered, we first test the hypothesis of a normal distribution for each continuous variable considered (with the exception of the categorical variables) by means of the Shapiro-Wilk test. If the hypothesis is rejected, we then apply the nonparametric Kruskal-Wallis test to analyse the significance of the differences between types, otherwise an analysis of variance would be carried out. For

$$\frac{\partial Prob_k(m=j)}{\partial x_{ki}} = \frac{\beta_{ij} e^{\sum_{i=1}^{n}\beta_{ij}x_{ki}} \sum_{m=1}^{4} e^{\sum_{i=1}^{n}\beta_{im}x_{ki}} - e^{\sum_{i=1}^{n}\beta_{ij}x_{ki}}\left[\sum_{m=1}^{4}\beta_{im} e^{\sum_{i=1}^{n}\beta_{im}x_{ki}}\right]}{\left[\sum_{m=1}^{4} e^{\sum_{i=1}^{n}\beta_{im}x_{ki}}\right]^2} \quad (3)$$

categorical variables, the significance of the differences is investigated by the means of the Chi-square test.

Multinomial logit model and marginal effects

In the further step, the farm-type affiliation is explained by means of a multinomial logit model, taking advantage of the fact that the dependent variable (farm type) is unordered. Each farm belongs to one particular farm-type m (= 1, 2, 3, 4). Given a sample with k farms and i (= 1, ..., n) independent variables (x_{ki}), and assuming farm-type-specific coefficients β_{im}, the probability *Prob* of farm k belonging to type j can be formulated as follows (Greene 2008, p. 843):

$$Prob_k(m=j) = \frac{e^{\sum_{i=1}^{n}\beta_{ij}x_{ki}}}{\sum_{m=1}^{4} e^{\sum_{i=1}^{n}\beta_{im}x_{ki}}} \quad (1)$$

Defining farm-type 1 as the base outcome, we define $\beta_{i1} = 0$. The probability $Prob_k$ becomes:

$$Prob_k(m=1) = \frac{1}{1+\sum_{m=2}^{4} e^{\sum_{i=1}^{n}\beta_{im}x_{ki}}} \quad \text{and}$$

$$Prob_k(m=j\neq 1) = \frac{e^{\sum_{i=1}^{n}\beta_{ij}x_{ki}}}{1+\sum_{m=2}^{4} e^{\sum_{i=1}^{n}\beta_{im}x_{ki}}} \quad (2)$$

Equation 2 is estimated by means of the maximum likelihood method, yielding all the coefficients β_{im}.

The multinomial logit model is based on the assumption of independence of irrelevant alternatives (IIA; Greene 2008, p. 847). For instance, regardless of whether farm-type 4 is in the model, the estimated coefficients of the other farm types should not be affected. We apply Hausman tests to analyse whether the IIA holds. Given that four farm types are under consideration, three Hausman tests must be applied, skipping the farm-type 2, 3 and 4, respectively on the first, second and third tests. If the Hausman test is not well defined, we apply the SUEST ('seemingly unrelated estimation') procedure provided by the Stata software, which uses an alternative estimator guaranteed to be positive (semi-)definite (StataCorp 2007a, p. 549). As pointed out by Long and Freese (2006, p. 275), the assumption of IIA cannot be avoided by using a probit specification in the Stata software (mprobit), since mprobit also assumes IIA.

The estimation is carried out using a two-stage procedure. Based on theoretical considerations, we select independent variables from the database. In the first step, we test whether the specific variables can be excluded from the model by means of the log likelihood ratio test. In the second step, we test whether the remaining variables agree with the assumption of IIA by applying the Hausman test, which again leads to the exclusion of variables.

Unlike the OLS estimation, the coefficients of the logit model are not meaningful for the interpretation of marginal effects. Thus, marginal effects $\partial Prob_k(m=j)/\partial x_{ki}$ must be calculated separately. Applying the quotient rule for equation 1 yields equation 3.

Moreover, abbreviating $Prob_k = (m = j)$ with P_{kj} and inserting Equation 1 in Equation 3 yields the following (Blanc et al. 2008, p. 501):

$$\frac{\partial P_{kj}}{\partial x_{ki}} = P_{kj}\left[\beta_{ij} - \sum_{m=1}^{4}\beta_{im}p_{km}\right] \quad (4)$$

The marginal effects are estimated by holding all other variables constant (*ceteris paribus*). Hence, the mean values of the independent variables are used. The Stata software package (version 10) provides the marginal effect as described by equation 4. For dummy variables, the difference of the prediction function at one minus its value at zero is computed (StataCorp 2007b, p. 269f).

APPLIED DATA

Dairy farms represent the most important farm type in Switzerland. More than 75% of a farm's livestock units (LU) must be bovine in order for the farm to be classified as a dairy farm in the Swiss Farm Accountancy Data Network (FADN; Roesch and Hausheer Schnider 2009). In addition, at least 25% of the bovine LU must be dairy cattle[2]. In 2008, there were 1285 dairy farms present in the FADN sample

[2]For the sake of a comprehensive description, there are three additional conditions (Roesch and Hausheer Schnider 2009). Firstly, dairy farms must use no more than 25% of the utilised agricultural area (UAA) for arable farming. Secondly, no more than 10% of the utilised agricultural area must be used for vegetables, fruits or vines. Lastly, no more than 25% of the cattle must be suckler cattle.

(Roesch and Hausheer Schnider 2009), which is based on a non-random sampling procedure.

The Swiss FADN data provide a detailed information on annual work units (AWU) for the two criteria of the on-farm wage labour and the off-farm family labour, which enables us to apply the classification scheme described above. Information about on-farm family labour is also available. In addition to the agricultural income of the farm and the work income per family AWU (full-time, 100%), the FADN also includes a detailed information on off-farm income, as well as on "other income" such as social transfers (e.g. retirement or child benefit) or the rental revenue from buildings. All are reported in Swiss Francs (CHF). Although farmers are requested to declare all their off-farm income, in the FADN survey some respondents refuse to do so, which is indicated by a separate binary variable representing the existence of other incomes not assessed in the FADN survey.

In order to explain the affiliation of the dairy farms with one of the farm types, we are interested in variables that may affect the labour-use pattern.

The dairy farm's volume of work or labour demand is of central interest. We therefore consider both the farm size and the degree of diversification[3], factors which are also addressed in the literature (e.g. Benjamin 1994; Benjamin and Kimhi 2006; Blanc et al. 2008). The size of specialised dairy farms is measured by the number of livestock units (LU; one cow = one LU). The number of animals per hectare is used as an indicator of production intensity. As an important indicator of diversification, the number of agricultural production branches includes all animal-husbandry and crop-farming activities. Organic farming is considered to be another type of diversification. Furthermore, to measure agriculture-related activities such as agritourism or direct sales, we use the share of sales of agriculture-related activities. Finally, as a typical indicator of specialisation – the contrary of diversification – the percentage of cattle out of the total number of LU is considered.

Following Blanc et al. (2008), who use agricultural wage as an explanatory variable, we use the above-mentioned on-farm work income per family AWU as an overall indicator of the farm performance. In addition, the quantity of milk produced (in 1000's of kg) per AWU is employed as a (partial) labour-productivity indicator. As a further performance indicator, the milk yield per cow and year is applied. Also related to the performance, a dummy variable concerning leasehold farms as well as the share of the turnover of direct payments are applied, the latter indicating the extent to which the dairy farm is dependent on direct payments.

The composition of the farm manager's family household is directly related to the supply of own-family workforce. A dummy variable indicates whether the farm manager has a spouse. The number of family household members under the age of 19 on the one hand and equal to or above the age of 19 on the other are considered to be independent variables. In addition, a dummy indicates whether retired or disabled people live in the farm household[4]. The annual private consumption per consumer unit in CHF is applied as an indicator of the standard of living of the farm manager's family. Since a (full) consumer unit refers to an adult person, a conversion must be made for children.

The farm manager's age as well as the squared age in order to account for the non-linearity (Blanc et al. 2008) is also considered a potential determinant of the farm-type affiliation.

In order to record the influence of education on the labour-use pattern, we may take advantage of the detailed data provided in the Swiss FADN for three areas of education: agricultural, non-agricultural and housekeeping. For both the farm manager and the farm manager's spouse, we assign the value of one to the relevant dummy variables if, at a minimum, the enrolment in a training programme (e.g. apprenticeship) is given. As regards the farm manager's agricultural education, we make a further distinction and indicate the highest level of education with two dummy variables, viz. the start or completion of an apprenticeship (basic agricultural education), and the completion of a master craftsman's diploma or a higher education (higher agricultural education, college or university), respectively.

Harsche (2007) shows the regional importance of the off-farm activities for the German Federal State of Hessen. Accordingly, we use several variables describing the dairy farm's location. The FADN gives the region where the dairy farm is situated (plains, hill or mountain area) leading to two dummy variables. The altitude above sea level is available as another indicator. Both region and altitude are indicators of the natural production conditions in terms of the topography as well as of the length of the vegetation

[3]Although dairy farms have an obvious focus on milk production, they might have other branches of production such as arable farming, fruit production or pig fattening.

[4]The dummy is 1 if the amount of the old-age pension or disability pension received is greater than 0, i.e. if a retired person or a person with a disability lives in the farm household.

period, both of which strongly affect the organisation of the on-farm labour.

As a proxy for the local labour demand, we use spatial data on the number of full-time jobs at the community level (Bundesamt für Statistik 2009). Based on the geographic information system (GIS) database which includes the distance between communities, we aggregate the full-time jobs within a range of 10 kilometres. In addition, for the mountain area we only consider jobs in the communities located in the same watershed area. Using the community number, the spatial data are assigned to the FADN data, which also includes this number for each farm. Since the spatial data are only available for 2008, we concentrate on that particular year for the analysis in order to guarantee the data consistency.

RESULTS

Allocation of on-farm wage labour and off-farm family labour

With respect to the 1285 dairy farms for which the data for the year 2008 is available, we are first interested in the extent to which they make use of the off-farm family labour and the on-farm wage labour. Table 2 gives the allocation to categories. Whereas 512 dairy farms or 40% have no involvement in the off-farm family-labour activities, 211 farms or 16% report a minor involvement of family members in the off-farm work (greater than 0 and not exceeding 0.1 AWU). Only four farms show an involvement of more than one AWU.

Table 2. Allocation of off-farm family labour and on-farm wage labour for 2008

Range of AWU	Off-farm family labour	On-farm wage labour
= 0	512	536
> 0 and ≤ 0.1	211	112
> 0.1 and ≤ 0.2	160	101
> 0.2 and ≤ 0.5	266	192
> 0.5 and ≤ 1.0	132	245
> 1.0 and ≤ 1.5	2	72
> 1.5 and ≤ 2.0	1	21
> 2	1	6
All dairy farms	1285	1285

AWU = annual work unit(s)

As regards the on-farm wage labour, 536 farms employ no wage labour at all. Wage labour is employed within a limited range of 0–0.1 and 0.1–0.2 AWU on 112 and 101 farms, respectively. 99 dairy farms or 8% employ more than one AWU.

Descriptive statistics of four farm types

Applying the farm typology (Table 1), we discover that 214 (17%) of the 1285 dairy farms belong to the farm type 1 (Table 3), 322 (25%) and 298 (23%) to the farm types 2 and 3, respectively, and 451 (35%) both hire in labour and have family members who work off-farm (type 4).

Table 3 reports the average descriptive statistics for all dairy farms considered, as well as for the four individual farm types. In average, the dairy farms of the sample investigated have 27.9 livestock units and the total AWU of 1.66, of which 1.34 are family AWU. Significant differences between the types can be reported for all these key figures[5]. As regards farm types, we can recognise two major groups according to the farm size, reflected in LU and the total AWU. Farm types 1 and 2 are smaller than farm types 3 and 4. Whereas farm types 1 and 2 use no wage labour, types 3 and 4 employ slightly more than one half AWU, which accounts for nearly one third of the total on-farm workforce.

For the farm types 2 and 4, 0.30 and 0.27 family AWU respectively work off-farm. For both types, less than 20% of the family AWU are employed off-farm. For all farms, the total family AWU – i.e. the sum of the on-farm and off-farm family AWU – amounts to 1.51 in average.

Agricultural income includes the remuneration of family members working on-farm as well as the farmer's own capital, and comes to about CHF 63 000 in average for all dairy farms. The income from off-farm activities amounts to around CHF 12 900. Although the farm types 1 and 3 do not engage in the off-farm activities, their accounts show minor off-farm labour incomes. Both agricultural and off-farm income vary significantly among the different farm types, which is hardly surprising given the differences in the farm size and the off-farm employment. In average, other income such as social transfers accounts for CHF 6301, leading to the total household income of CHF 82 077, including the agricultural income, off-farm income and other income.

The relative income per full-time, year-round family workforce unit (AWU) is a meaningful indicator. Table 3 presents these values for the on-farm[6], off-

[5]For all continuous variables, the hypothesis of a normal distribution is rejected (Shapiro-Wilk test).

Table 3. Workforce units and income of all farm types for 2008

Variable	Unit	Dairy farms					Chi-squared	*P*-value
		all	type 1	type 2	type 3	type 4		
Dairy farms	number	1 285	214	322	298	451		
Livestock units	LU	27.9	25.6	21.3	33.7	30.0	198	< 0.001
Total on-farm workforce	AWU	1.66	1.46	1.37	1.90	1.79	240	< 0.001
On-farm hired workforce	AWU	0.32	0	0	0.56	0.54	937	< 0.001
On-farm family workforce	AWU	1.34	1.46	1.37	1.34	1.26	50	< 0.001
Off-farm activity of family members	AWU	0.17	0	0.30	0	0.27	925	< 0.001
Total family workforce	AWU	1.51	1.46	1.67	1.34	1.53	141	< 0.001
Agricultural income	CHF	62 881	64 134	49 248	73 014	65 324	83	< 0.001
Off-farm labour income	CHF	12 894	613	22 214	154	20 486	878	< 0.001
Other income	CHF	6 301	5 944	6 175	6 835	6 209	3.6	0.30
Household income	CHF	82 077	70 691	77 637	80 003	92 019	53	< 0.001
On-farm income per family AWU	CHF	39 371	38 213	29 209	45 639	43 033	84	< 0.001
Off-farm income per family AWU	CHF	45 041	0	72 712	0	76 419	924	< 0.001
Combined income per family AWU (on- and off-farm)	CHF	43 674	38 213	37 474	45 639	49 392	56	< 0.001
Existence of other income not considered in the FADN survey	dummy	0.24	0.27	0.20	0.28	0.23	5.8	0.12
Consumption per consumer unit	CHF	22 410	21 735	20 081	23 757	23 502	20	< 0.001

AWU = annual work unit(s); CHF = Swiss Francs; LU = livestock unit(s)

farm and the resultant combined income. The latter is a weighted average. Taking the average for all dairy farms, a family AWU earns CHF 39 371 on-farm. There are statistically significant differences among the farm types, however. While type 1 is close to the average, the performance of type 2 is fairly poor, amounting to only around 74% of the average, or CHF 29 209. Farm types 3 and 4 considerably exceed the average, by 16% and 9%, respectively. The variation within farm types is illustrated by the means of the coefficient of variation, which is 0.8 for all farms. The reference values for farm types 1, 2, 3 and 4 are 0.5, 0.7, 0.7 and 1.0, respectively.

Both farm types involved in the off-farm activities (2 and 4) boast of fairly high off-farm incomes per family AWU of CHF 72 712 and CHF 76 419, respectively. For the farm types 2 and 4, the off-farm income per AWU exceeds the on-farm income per AWU by 87% and 76%, respectively. The all-farm average of the combined income per family AWU is CHF 43 674. Focusing on the two major groups in the terms of farm size (groups 1 and 2; 3 and 4), we observe that the group comprising farm types 1 and 2 has a significantly lower combined income per family AWU than the group consisting of the types 3 and 4. For the farm type 2, the off-farm income almost compensates for the limited on-farm income compared to the farm type 1. Similarly, the off-farm income allows the farm type 4 to outstrip the farm type 3.

24% of dairy farms state that they have additional incomes not declared in the FADN survey (Table 3, second-last row). The applied Chi-square test demonstrates that there are no significant differences among the four farm types in the terms of the percentage of farms with other incomes not declared in the FADN survey. Accordingly, we can assume that the existence of the undeclared income is similar for all types, which is an important precondition for the analysis.

Finally, the consumption per (adult) consumer unit has a mean value of CHF 22 410, and it differs significantly among the farm types.

[6]In order to calculate the on-farm income per family AWU, we must deduct the remuneration of own capital from the agricultural income and then divide the result by the number of family AWU. The procedure described refers to the official calculation of the Swiss FADN. The interest rate for a 10-year Swiss government bond is applied as the interest rate for the remuneration of own capital (Roesch and Hausheer Schnider 2009).

Results of the multinomial logit model

Starting with the variables presented in the Section Applied data, the following variables are excluded in the first estimation step according to the results of the log-likelihood ratio test: organic farming, leasehold farm, turnover share of direct payments, farm manager's age squared, spouse's agricultural education, farm manager's non-agricultural education, farm manager's housekeeping education, and altitude above sea level. At the second stage, another four variables – number of animals per hectare, presence of a spouse, farm manager's basic agricultural education, and hill region are excluded due to the Hausman test in order to respect the assumption of IIA.

Table 4 includes the variables of the resultant multinomial logit model, including the estimated coefficients, *p*-values, and the marginal effects presented on a *ceteris paribus* basis. Two variables – the percentage of cattle out of the total livestock and jobs within 10 km – are not significant at least at the 10% level for any of the farm types, although their impact was significant at the first stage. The multinomial logit model explains 16% of the variance (pseudo-R^2), and clearly outperforms a model without any explanatory variable (likelihood ratio test $p < 0.001$).

Table 4. Results of the Multinomial Logit Model

Variable	Unit	Farm type 2			Farm type 3			Farm type 4		
		coef.	*p*-value	marginal effects	coef.	*p*-value	marginal effects	coef.	*p*-value	marginal effects
Constant		3.568	0.052	–	–5.098	0.006	–	–3.754	0.034	–
Livestock units (total)	LU	–0.087	< 0.001	–0.023	0.103	< 0.001	0.016	0.065	< 0.001	0.012
Turnover share of agriculture-related activities	%	0.008	0.41	–0.002	0.015	0.145	–0.001	0.030	0.001	0.005
Agricultural production branches	number	0.038	0.499	–0.013	0.127	0.018	0.005	0.170	0.001	0.025
Percentage share of cattle out of total livestock	%	–0.024	0.128	–0.006	0.027	0.103	0.004	0.017	0.257	0.003
On-farm income per family member	kCHF/ year	–0.013	0.003	–0.002	0.003	0.473	0.001	–0.001	0.729	0.0004
Labour productivity	1000 kg milk/AWU	0.008	0.051	0.004	–0.024	< 0.001	–0.003	–0.020	< 0.001	–0.003
Milk yield per cow and year	1000 kg	–0.084	0.374	–0.055	0.362	< 0.001	0.036	0.342	< 0.001	0.053
Household members under 19	number	0.211	0.009	0.039	–0.163	0.054	–0.040	0.008	0.916	0.002
Household members 19 or over	number	0.357	0.005	0.060	–0.210	0.114	–0.059	0.046	0.714	0.005
Retired & disabled individuals	Dummy	–0.528	0.253	–0.133	1.197	0.002	0.196	0.610	0.137	0.010
Private consumption per consumer unit	kCHF	0.032	0.01	0.003	0.002	0.856	–0.003	0.023	0.037	0.003
Age of farm manager	years	–0.029	0.015	–0.0001	–0.018	0.122	0.003	–0.046	< 0.001	–0.007
Higher agricultural education of farm manager	dummy	1.239	< 0.001	0.009	0.784	0.008	–0.087	1.690	< 0.001	0.226
Non-agricultural education of spouse	dummy	0.377	0.051	0.009	–0.049	0.804	–0.092	0.667	< 0.001	0.136
Housekeeping education of spouse	dummy	0.769	< 0.001	0.071	0.251	0.234	–0.032	0.443	0.025	0.024
Mountain area	dummy	0.474	0.048	0.060	–0.049	0.843	–0.050	0.197	0.393	0.015
Jobs within 10 km	in 1000	–0.003	0.284	–0.0003	0.000	0.925	0.001	–0.003	0.233	–0.001

AWU = annual work unit(s); kCHF = 1000's of Swiss Francs; LU = livestock unit(s)

1285 observations; Base outcome: farm-type 1; Log likelihood = –1454; Pseudo R^2 = 0.163

The number of livestock units as an indicator of the farm size has a significant effect on all three farm types. Compared to the base outcome (farm-type 1), the marginal effect is negative, meaning that an additional livestock unit decreases the probability of belonging to the farm type 2 by 2.3%. For farm types 3 and 4, the marginal effects of an additional livestock unit are positive: 1.6% and 1.2%, respectively. Both variables describing diversification (turnover share of agriculture-related activities and number of branches of agricultural production) have a significant effect on the farm type 4. The number of production branches is also of importance for the farm type 3.

The on-farm income per family member only influences the probability of belonging to the farm type 2, with a high income decreasing this probability. Labour productivity is a significant determinant of the farm type affiliation for all three farm types. An additional 1000 kg of milk per AWU increases the probability of belonging to the farm type 2 by 0.4%. For the farm types 3 and 4, the effects are negative, with 0.3 % in each case. Conversely, milk yield per cow and year has a significant positive impact on the types 3 and 4. An additional 1000 kg of milk yield per cow and year boosts the probability of belonging to farm types 3 and 4 by 3.6% and 5.3%, respectively.

The number of household members under 19 years of age on the one hand and 19 years of age or older on the other only plays a significant role for affiliation to the farm type 2. If there are retired or disabled household members, the probability of belonging to the farm type 3 rises by around 20%. Although the individuals from both of these groups may well work on-farm, they may also need care, which absorbs a portion of the work capacity of the farm manager's family. Furthermore, retired people are unlikely to work off-farm. Private consumption is of importance for both farm types involved in the off-farm activities (2 and 4). An additional CHF 1000 per consumer unit increases the probability of belonging to the farm types 2 and 4 by 0.3% in each case.

The farm manager's age has a negative impact on the probability of belonging to farm types 2 and 4. Accordingly, the existence of an off-farm activity is more likely if the farm manager is young.

A higher agricultural education such as the possession of a master craftsman's diploma affects the probability of belonging to all three farm types (2, 3 and 4) compared to the base case (1). While the marginal effects are positive for the farm types 2 and 4, it is negative for the farm type 3. The spouse's non-agricultural education has a significant effect on farm types 2 and 4, increasing the probability of belonging to these groups by 0.9% and almost 14%, respectively. Similarly, the housekeeping education of the spouse increases the probability of belonging to the farm types 2 and 4. To be located in the mountain area only plays a significant role for the affiliation to the farm type 2.

DISCUSSION

As pointed out in the Section Descriptive statistics of four farm types, around 80% of farming households whose family members engage in the off-farm activities earn a higher income per AWU off-farm. This is in line with the results of the annual comparison of the on-farm income of the entire Swiss FADN with the salaries earned in the Swiss industry and service sectors. For the period 2008–2010, the median on-farm income per AWU in the plains, hill and mountain regions of Switzerland came respectively to 65%, 53% and 39% of the median salary in the industry or service sectors (Schmid and Roesch 2011).

The results of the multinomial logit model in terms of the number of available jobs within 10 km were unexpected. Accordingly, by the way of a sensitivity analysis, the correlation between the absolute number of the off-farm AWU and the available jobs is analysed for different distance ranges. For distances of 5, 10 and 15 km, the correlations are –0.04, –0.05 and –0.03, respectively. The correlations at the regional level (plains, hill and mountain areas) for the three distance ranges are not stronger than –0.08.

For the comparison of our results with the literature, we first focus on the off-farm labour. Blanc et al. (2008) report for French farms for the year 2000 a negative impact of the large size on their "regime 2", whose definition corresponds to that of our farm type 2. This finding is therefore in keeping with the negative effect of livestock units on the farm type 2 observed in our multinomial logit model. The positive effect of the number of adults on regime 2 found by Blanc et al. (2008) corresponds to our results concerning the effect of the household members of 19 years of age or over. Conversely, in contrast to our results, Blanc et al. (2008) reported a significant positive effect of the agricultural wage on the probability of belonging to the regime 2. As an explanation for this, they used an econometric model based on the French FADN for agricultural wage, rather than the real wage of the analysed farms. As regards the age of the farm manager, Blanc et al. (2008) report a significant positive linear effect on the regime 2, as well as a significant negative effect of the squared age, which is also reported by Kimhi and Rapaport (2004) analysing the off-farm work of Israeli farm households. The basic

conclusion that the probability of the off-farm work is high for younger and low for older farm managers is in line with our finding of a negative linear effect for the farm types 2 and 4.

As regards the on-farm wage labour in the literature, our finding of a positive impact of the farm size (number of livestock units) on the probability of belonging to farm types 3 and 4 is in conformity with the results of similar studies. Benjamin (1994) reports a positive effect of size on the probability of hired-in labour for French farms. Blanc et al. (2008) mention the positive impact of size for their regimes 3 and 4 (whose definition corresponds to that of our farm types 3 and 4), applying dummy variables for different farm-size categories (farm size being measured in terms of the standard gross margin). Reporting marginal effects on the likelihood of hired labour in the case of French farms, Benjamin and Kimhi (2006) also show positive impacts for larger farm-size classes. Benjamin (1994), Benjamin and Kimhi (2006) and Blanc et al. (2008) report the positive effect of diversification on the likelihood of the presence of hired labour. Our results for the variables "turnover share of agriculture-related activities" (farm type 4) and the "number of agricultural production branches" (farm types 3 and 4) also indicate that diversification increases the likelihood of the on-farm wage labour. Benjamin and Kimhi (2006) show a positive marginal effect of a higher-level agricultural education of the farmer on the likelihood of hired labour. This is in keeping with our findings regarding the impact of the higher agricultural education of the farm manager on the likelihood of belonging to the farm type 4, while contradicting the marginal effect we found for the farm type 3. Finally, Benjamin and Kimhi (2006) also report a positive impact of a higher general level of education of the spouse on the likelihood of hired labour, corresponding to our findings regarding the non-agricultural education of the spouse for the farm type 4.

CONCLUSIONS

In order to analyse the labour-use pattern on Swiss dairy farms, we apply a typology scheme with two criteria: on-farm wage labour and off-farm family labour. Since the analysis is based on 1285 dairy farms from the Swiss Farm Accountancy Data Network (FADN), which relies on a non-random sampling procedure, the results cannot be generalised to dairy production in Switzerland as a whole. Nevertheless, the resultant four farm types reveal significant differences with respect to several variables such as the on-farm income per family AWU and private consumption.

Although the average involvement in the off-farm activities for farm types 2 and 4 is at a fairly low level of around 0.3 annual work units (AWU), the average earnings for an AWU from the off-farm labour are around double those from the on-farm labour. We are therefore able to conclude that – at least from the economic point of view and based on the analysed sample – the off-farm labour is a successful activity.

The number of available jobs within 10 km has no significant impact on any of the farm types. Moreover, even at the regional level (plain, hill and mountain areas); the correlations between the number of jobs and the off-farm family AWU are almost non-existent. This leads us to the conclusion that the spatial location of a dairy farm in our sample has no or minor impact on the off-farm activities. Furthermore, most places in Switzerland seem to have an adequate local labour demand. Accordingly, most of the dairy-farming households analysed have the choice of engaging their members in the off-farm work.

Both farm types with family members involved in the off-farm work (types 2 and 4) show a significant influence of private consumption per consumer unit in the multinomial logit model. The higher the living standard of a household, the greater the likelihood of it engaging in off-farm activities. This is in line with the findings of Rathmann et al. (2010), who identify the income increase as a primary motive for farm households in Schleswig-Holstein (Northern Germany) to engage in the outside paid work.

Confronted by the lower producer prices for milk due to the further trade liberalisation, dairy farmers will need to adjust their businesses. Substantially increasing production is difficult owing to the scarcity of agricultural land, the most frequent limiting factor to the farm growth indicated by dairy farmers in Eastern Switzerland (Gazzarin et al. 2008). In addition, production growth is associated with high costs in terms of additional facilities, livestock, and production rights (previously quota), as shown by Gazzarin and Lips (2007). Furthermore, a discrete-choice experiment carried out in Eastern Switzerland concerning dairy farmers' preferences with respect to their work revealed strong preferences for remaining in dairy production (Lips and Gazzarin 2008). Conversely, due to the aforementioned discrepancy between the on-farm and off-farm work in the terms of remuneration, a greater involvement in the off-farm labour is an effective option for offsetting the household income losses. In addition, since the living standard has a positive impact on the likelihood of members of a farm household engaging in the off-farm work, a drop in income from agriculture is less likely to be accompanied by a fall in the living standard if family

members enhance the off-farm employment. On an aggregate level, the percentage of part-time dairy farms in Switzerland would increase and converge to the levels observed in dairy farming in Southern Germany and Austria, which are already confronted with a lower milk price than Switzerland. Given the demonstrated ability of the members of dairy-farming households to find an appropriate off-farm work and the absence of significant differences among regions in terms of local demand for labour, the adjustment of the dairy-farm labour-use patterns in the event of trade liberalisation could well be quite a smooth process. Alternatively, a specific employment service in Switzerland could support dairy farms during an adjustment process. These conclusions are of a particular interest for policymakers and farm consultants. Members of dairy-farming households interested in starting or expanding their off-farm activities could be offered part-time jobs with a degree of daily and seasonal flexibility (e.g. the daily milking process, or the forage harvest in summer). A potential for a further employment exists, since 512 out of 1285 farms (40%) have no involvement whatsoever in off-farm activities, and a further 371 farms (29%) are only involved to a limited degree (between 0 and 0.2 AWU). Of course, this is subject to the condition that the members of the household labour force are not overburdened with the work on the family farm, and hence have enough free time for the outside work. Alternatively, a substitution of more off-farm activities and less on-farm work and hence a reduction of the dairy production could be an option.

The present analysis enables us to identify the variables that are important to the labour-use pattern. The involvement in off-farm activities is more likely if the farm manager is young and has a spouse with a non-agricultural education. In line with the literature, we found that hiring in wage labour is associated with larger farm sizes and a high degree of diversification. Moreover, according to the multinomial logit model, a high milk yield per cow and a relatively low labour productivity are typical characteristics for employing the on-farm wage labour, which is done by 58% of the farms.

The results for the farm type 2 are especially revealing. Based on the descriptive statistics, we know that the on-farm income for this group is modest, which is also confirmed by the multinomial logit model (a high on-farm income per family AWU reduces the likelihood of belonging to the farm type 2). Labour productivity can be excluded as a reason for this, since a high labour productivity increases the probability of belonging to the farm type 2. We therefore conclude that either the size of the farm or geographical conditions (i.e. the farm's location in the mountain area) are responsible for the poor performance in terms of the on-farm income.

The present analysis focuses on the aggregate labour force of the farm manager's household. There is no differentiation at the personal level. The impact of the spouse's non-agricultural education on the off-farm activities (farm types 2 and 4) points to the differences between farm managers and their spouses in the labour-use patterns of off-farm activities. Accordingly, in a future analysis it would be important to distinguish between farm managers and their spouses, as already done by Benjamin and Kimhi (2006) and Bjørnsen and Biørn (2010). Furthermore, the personal workload and its trends over time are of interest for a more in-depth understanding of the labour-use patterns on Swiss dairy farms.

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