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Full Research Article

Labour constraints on choosing profitable products for part-time farmers in Swiss agriculture

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Abstract. In this paper we suggest that low labour availability on part-time farms may limit part-time farmers' choice of production enterprises, and as a consequence those farmers may be forced to engage in less profitable enterprises. This proposition is illustrated by a conceptual framework based on the assumption that products with high returns to labour are labour intensive. An empirical analysis for the period 1996-2004 based on aggregated yearly data from the Swiss Farm Accountancy Data Network (FADN) did not fully confirm the proposition. This may suggest the existence of a joint determination of the choice of production enterprise and of the choice to work off the farm. In addition, our assumption that highly profitable enterprises are labour intensive may not hold for specific products or contexts.

Keywords. Part-time farms, enterprise choice, labour, returns to labour, Switzerland.

JEL Codes. Q12

1. Introduction

Several papers have investigated the reasons underlying the choice of specific production enterprises in agriculture. Moran and Anderson (1988) analysed the determinants of changing from dairying to beef farming in New Zealand in 1975-1983. More recently, Gillespie and Mishra (2011) examined the selection of agricultural production enterprises among five of them (beef, dairy, crops, hogs, broilers) in the United States (US). Some articles have also investigated the issue in developing countries, such as Okon *et al.* (2012) and Ojo *et al.* (2013) in Nigeria or Tamirat (2013) in Ethiopia. Most of the articles relied on the use of a multinomial probit to evaluate the determinants of the probability of choosing a specific production enterprise. By contrast, Gillespie and Mishra (2011) evaluated the extent of engagement in a specific enterprise, by using tobit equations (one for each of the five enterprises considered) where the dependent variable was the share of

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value produced by the specific enterprise within the total farm production value. These studies reported significant effects of sociological characteristics (age, education, household size) and structural characteristics (farm size, location) of the holding on enterprise selection.

Only Gillespie and Mishra (2011) studied the role of off-farm work on the choice of enterprises. The authors considered the number of off-farm hours spent by the farmer as a proxy for off-farm commitment. A broader definition of off-farm commitment is gainful activities carried out off the farm, not only by the farm head, but also by other members of the farm family (Lund, 1991). In addition, as noted early by Salter (1936), the extent of off-farm occupation may be measured either in terms of labour quantity supplied off the farm or in terms of income stemming from off-farm work. This author provided the first definition of part-time farming as "the combination of a small amount of farming with an occupation not connected with the farming".

Using farm-level data in 2003, Gillespie and Mishra (2011) showed that in the US a greater time spent off farm by the farmer induced a higher probability to choose beef production over crop or dairy production. The authors explained this results by the low capital and labour requirements in beef production enterprise (most beef farmers being low-input cow-calf or stocker farmers), as "farmers choose a production enterprise based on labour availability and requirements (and other farm resources)". In this paper we also follow the idea that labour requirements may limit part-time farmers' choice of production enterprises, but we go a little further. We suggest that, as a result, part-time farmers may be forced to engage in less profitable enterprises. This idea is based on the assumption that products with high returns to labour are labour intensive. This suggestion is supported by Kingwell's (2011) proposition that "profitable farming systems are complex and time-consuming to manage" when considering farmer's annual labour, land use or enterprise diversity, and revenue and expenditure diversity for a sample of Australian farms.

We demonstrate our idea with a simplified conceptual framework in Section 2, and we provide an empirical application for Swiss farms, for which the methodology and data are described in Section 3. Section 4 presents the results and Section 5 concludes.

2. Conceptual framework

The conceptual framework presented below demonstrates the idea that in some situations part-time farmers may not produce highly profitable products, but instead may be constrained to produce on their land mainly products with low returns to labour. The underlying assumption, as explained above, is that products with high returns to labour are labour intensive: this means that they require that a substantial level of labour input is used, a requirement that part-time farms may not be able to meet due to constrained own labour supply.

The notion of a substantial amount of labour input that needs to be allocated to a specific production activity deals with the technical nature of agricultural production processes. There is a proportion of factor requirements that are fixed, which may occur, firstly, when entering a new production activity, and secondly, during the production process of specific activities. Firstly, as shown by Mann *et al.* (2003), entering a production activity requires investment decisions in at least two respects. In order to start a new produc-

tion activity, not only capital investments become necessary, but human capital has also to be invested, so that technologies and the organisation of labour are known to the farmer. Labour investments and other fixed factor requirements often contribute to the persisting phenomenon of economies of scale (Hallam, 1991; Shah, 1992; Langlois, 1997). Mann *et al.* (2003) additionally showed by internationally comparing exit rates from production enterprises, that conservative farmers like Swiss farmers tend to consider entering a new production process more as an investment compared with more flexible farmers as, for example, Dutch farmers. Secondly, labour requirements differ across agricultural products. For example, pig breeding is a labour intensive activity and requires a substantial labour time in order to become acquainted with the numerous complicated cycles and processes of piglet production (Knap *et al.*, 2001). Once the business is running, a substantial number of hours have, at several stages of the breeding process, to be spent in order to keep animals healthy and to result in the desired number of piglets, independent of holding size. By contrast, an example with a relatively low level of labour requirements is the production of spelt. Producers who are familiar with grain production generally have little additional investments to do to enter the production of spelt.

Our conceptual framework is mainly graphical, but is based on a theoretical objective program of farmers who may work or not off farm, and who have the possibility to produce two products with different returns to labour and different labour use requirements. We assume that product 1 has higher returns to labour than product 2, but necessitates a level of labour input that is above a specific threshold contrary to product 2.

Using a simplified framework, the objective program for farmers is as follows:

$$\text{Max} \quad \Pi = p_1 f_1(X_1,L_1) + p_2 f_2(X_2,L_2) + p_X(X_1 + X_2) + \omega L_O \tag{1}$$

on X_1, X_2, L_1, L_2, L_O
subject to

$$f_1\left(X_1, L_1\right) = 0 \quad \text{for } L_1 > \overline{L}_1 \tag{2}$$

$$p_1 \frac{\partial f_1\left(X_1, L_1\right)}{\partial L_1} > p_2 \frac{\partial f_2\left(X_2, L_2\right)}{\partial L_2} \tag{3}$$

$$T = L_1 + L_2 + L_O \tag{4}$$

$$L_1 \geq 0 \tag{5}$$

$$L_2 \geq 0 \tag{6}$$

$$L_O \geq 0 \tag{7}$$

where
Π is the total (on-farm and off-farm) profit;
f_1, f_2 are the production functions of respectively product 1 and product 2;

L_1, L_2 are labour hours devoted to the production of respectively product 1 and product 2;
X_1, X_2 are other factors devoted to the production of respectively product 1 and product 2;
p_1, p_2, p_X are the prices of product 1, product 2 and the other inputs, respectively.
$\bar{L}_1$ is the labour input that needs to be allocated to the production of product 1; it is a specific threshold below which product 1 cannot be produced.
T is the total time endowment;
L_O is the time allocated to off-farm employment;
ω is the off-farm wage.

Constraint (2) represents the requirement of a substantial level of labour input (i.e. above the threshold $\bar{L}_1$) for the production of product 1, while constraint (3) shows that the marginal returns to labour for product 1 is greater than the one for product 2, therefore representing the larger returns to labour for product 1. Constraint (4) is the time constraint.

The case of a farmer producing both products is depicted on Figure 1. The horizontal axis shows the labour allocation to both products; the length of the axis representing the total time available to the farmer (T). The left, respectively right, vertical axis represents the profit generated from the production of product 1, respectively of product 2. Both production technologies p_1f_1 and p_2f_2 are depicted, with the production technology of product 2 starting at L_2= 0 and the production technology of product 1 starting at $L_1 = \bar{L}_1$ The larger returns to labour for product 1 than for product 2 (formalised by constraint (3)) are represented by a greater slope of the production technology of product 1 than the slope of the production technology of product 2. The farmer's objective is to maximise his/her total profit; the latter is maximised at point A, that is to say where the marginal labour productivities of both products are equal. From the farmer's objective program above, the optimal point A is represented by the following Kuhn and Tucker condition:

$$p_1 \frac{\partial f_1\left(L_1^*\right)}{\partial L_1} = p_2 \frac{\partial f_2\left(L_2^*\right)}{\partial L_2} = \omega - \mu_0 \tag{8}$$

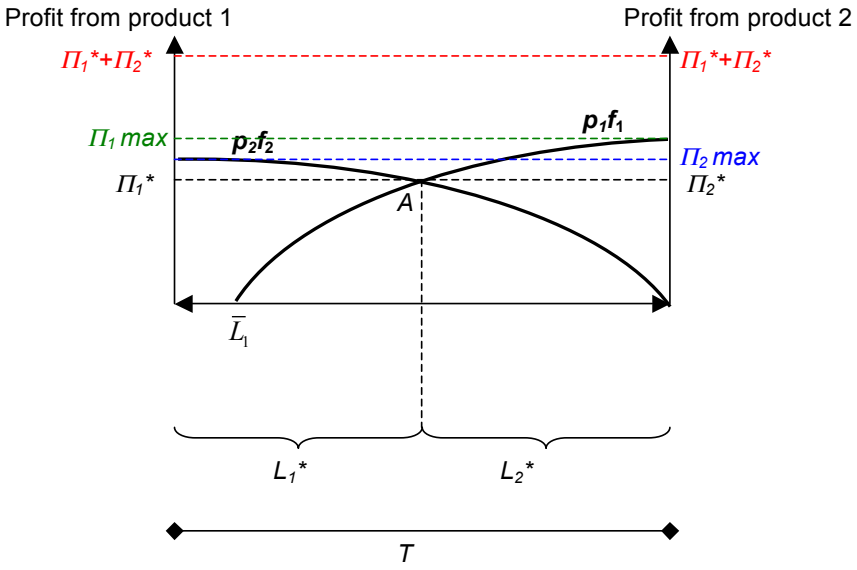
μ_0 being the Lagrange multiplier of constraint (7).

At point A the total profit generated is $\Pi_1^* + \Pi_2^*$ which is greater than the maximum profit that could be generated if the farmer was producing product 1 only (Π_1 max) or product 2 only (Π_2 max). For this reason the farmer produces both products.

This is the case of a full-time farmer, that is to say all time is allocated to production: $T = L_1^* + L_2^*$. However, a farmer may be part-time farmer that is to say may also work off farm, as represented by Figure 2. Here the farmer's off-farm labour allocation is L_O^* and both products are still produced: $T = L_1^* + L_2^* + L_O^*$. In this case the Kuhn and Tucker condition is:

$$p_1 \frac{\partial f_1\left(L_1^*\right)}{\partial L_1} = p_2 \frac{\partial f_2\left(L_2^*\right)}{\partial L_2} = \omega \tag{9}$$

Figure 1. Graphical representation of labour allocation for a full-time farmer.



Source: the authors

However, when a farmer allocates a large part of his/her time off farm, only product 2 may be produced, as depicted by Figure 3. In this case, the farmer is constrained in his/her time left for production. The profit from producing product 2 only (Π_2 max) is greater than any other combination (production of product 1 only, or production of both products). Thus, in this case, the farmer is better off not producing product 1 at all, even though this product is more profitable than product 2. The Kuhn and Tucker conditions for product 1, respectively product 2, are:

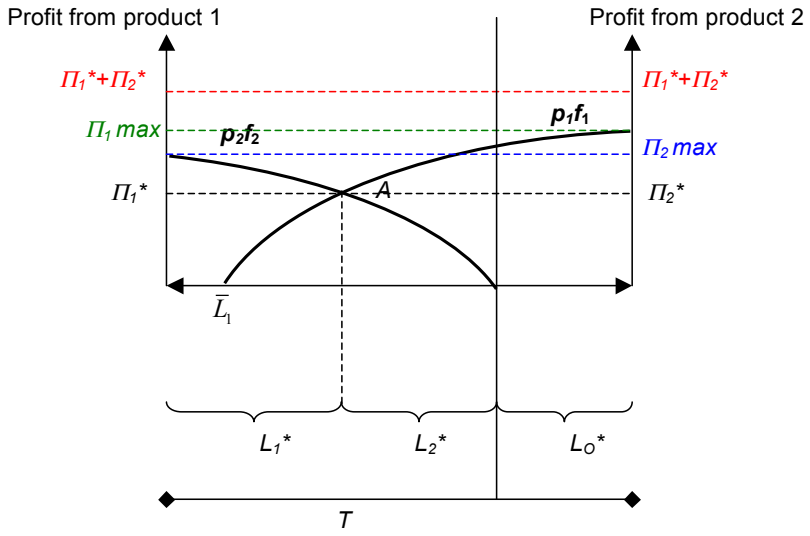
$$\left(p_1 - \lambda\right)\frac{\partial f_1\left(L_1^*\right)}{\partial L_1} = \omega \tag{10}$$

$$p_2\frac{\partial f_2\left(L_2^*\right)}{\partial L_2} = \omega \tag{11}$$

λ being the Lagrange multiplier of constraint (2).

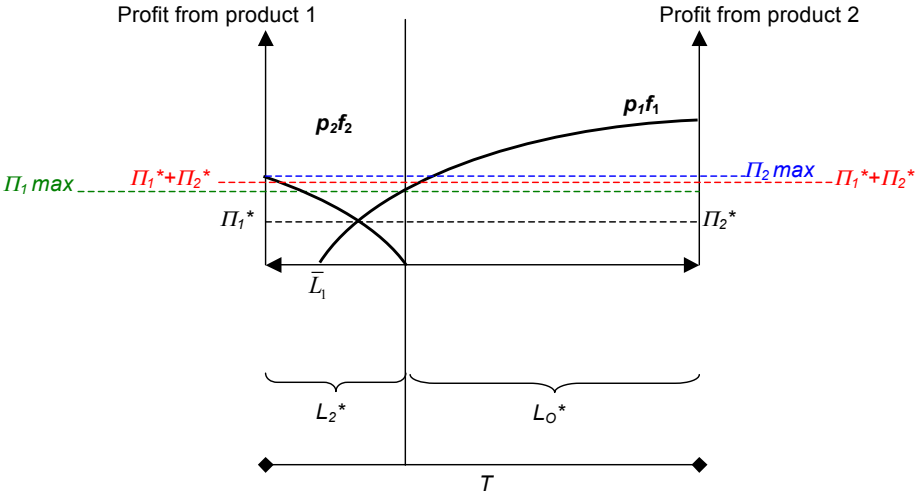
We acknowledge that this is a simplified framework. Firstly, in this framework only production aspects (technologies and prices) are considered since it is a farm profit maximisation framework. By contrast, several studies have shown that there exist other determinants of labour demand, such as farmer's or farm household's age, education and com-

Figure 2. Graphical representation of labour allocation for a part-time farmer allocating little time off farm.



Source: the authors

Figure 3. Graphical representation of labour allocation for a part-time farmer allocating much time off farm.



Source: the authors

position, as well as macroeconomic conditions (Baum *et al.*, 2006; Benjamin and Kimhi, 2006; Dupraz and Latruffe, 2015). To account for household's characteristics, the household's utility could be maximised instead of the farm profit, and total time endowment (T)

would be augmented by the time endowment of family members. Also, members of the farmer's household may engage in off-farm activities, thereby providing additional income but constraining the availability of on-farm labour. In addition, leisure and consumption are not considered in our framework. In a utility maximisation framework, they would be additional decision variables of the household's programme. Leisure would enter the time constraint (4), and an additional constraint would be needed, namely the budget constraint including consumption and profit (Benjamin and Kimhi, 2006). Farmer's and household's preferences for leisure and consumption could be integrated in the specification of the utility function. Secondly, in our framework farm labour does not include hired labour nor contract labour. The latter could nevertheless be used by part-time farmers to fulfil the demand for labour particularly in peak periods (Errington, 1998). This would extend the time endowment on the farm, or allow the farmer to spend additional time off farm. Distinguishing between the different types of labour implies considering that they are not substitutable. Thirdly, risk neutrality is assumed here while some authors have reported that farmers may be risk averse. In this case, off-farm income could act as insurance, reducing the variability of the farmer's income as noted by Barlett (1991) and Mishra and Goodwin (1997). In addition, the choice of the production enterprise may be guided by the variability of the income generated by each enterprise. The choice of producing only one product or two products may also be explained by risk considerations: diversifying the production portfolio may reduce production risk, while in the absence of risk, specialisation may be more profitable.

Similarly to Gillespie and Mishra's (2011) indication as regard their framework, ours also "simplifies a complex issue". Our framework notably assumes that farmers are risk neutral and that there is perfect substitutability across all types of labour. However, it shows that in certain situations profitable enterprises may not be operated by part-time farmers due to labour constraints.

3. Methodology and data

The above conceptual framework shows that farmers who allocate a large part of labour off farm may not be able to produce highly profitable products, in other words part-time farmers may concentrate on products with low returns to labour. We now provide an empirical application based on data from the Swiss Farm Accountancy Data Network (FADN) dataset for the 9-year period 1996-2004. As explained by Roesch (2012), the FADN provides bookkeeping information for a rotating non-random sample of about 3,500 farms and "weighted extrapolation can be used to apply the results to the Swiss agricultural sector with its approximately 50,000 farms".

Despite FADN data being farm level data, we carry out our empirical analysis with data aggregated at the production enterprise level. We consider 16 different production enterprises with a sufficient number of observations: pig fattening, pig breeding, suckler cows, milk, proteinseeds, sunflower, rapeseed, wheat, sugar beet, spelt, maize, triticale, barley, oats, rye, and potatoes. As we consider a 9-year period, our sample should include 144 observations (16 observations per year). However, there are in total 141 observations in the sample used for the empirical analysis, as no data were available for sunflower in three years (1996-1998).

Our objective is to test whether the engagement of part-time farms in production enterprises depends on the profitability of these enterprises, based on the assumption that products with high returns to labour are labour intensive. For this, we carry out a regression where the dependent variable is the share of the country's agricultural production for a specific enterprise j (j=1,...,16) that is produced by part-time farms, while the explanatory variable is the average financial returns to labour for the production enterprise j. If the sign of the explanatory variable's coefficient is (significantly) negative, this would indicate that the more profitable the enterprise, the less it is produced by part-time farms, and would give support to our proposition.

In order to calculate the explanatory variable, which is the average financial returns to labour for the production enterprise j, one issue is to obtain the labour input allocated per enterprise. The latter is not available in the FADN data and needs to be calculated. For this, we use the standard labour requirements (SLR) calculated for each product, under typical Swiss conditions, by the "Labour Economics" Research Group from the Swiss Federal Research Station ART (Schick and Stark, 2007). However, it is expected that these "theoretical" figures may diverge from "real" figures that is to say from the farm's actual labour use per enterprise. In fact, standard labour requirements were also calculated by ART for the total farm (FLR), and comparing them with the observed figures of total labour used per farm available in the FADN data (L) shows some discrepancy. The comparison can be made with the following ratio:

$$l = \frac{L}{FLR} \tag{12}$$

which takes the value of 1 when what is observed on a farm (as recorded in FADN) exactly matches ART theoretical calculations, and is strictly larger than 1 when ART calculations underestimate farms' labour use. In the present case, the observed (FADN) labour use on Swiss farms (L) tends to be higher than that estimated by ART (FLR) since the average of the ratio l for our sample is 2.33.

We account for this discrepancy in the calculation of labour use for single enterprises. More precisely, we apply the discrepancy coefficient l to the measure of standard labour requirements for each enterprise on each farm provided by ART (SLR), in order to obtain the "real" labour use for single enterprises (R):

$$R = l \times SLR \tag{13}$$

Then for each farm i in the FADN sample, financial returns to labour (P) for each production enterprise j are calculated as the returns from the production (Π) divided by R:

$$P_{ji} = \frac{\Pi_{ji}}{R_{ji}} \tag{14}$$

Finally, average financial returns to labour in the sample were calculated for each enterprise *j* by:

$$P_j = \frac{\sum_i \left(P_{ji} W_{ji} A_{ji} \right)}{N_j \sum_i W_{ji} \sum_i A_{ji}} \tag{15}$$

where
W_{ji} is the FADN extrapolation weight of each farm *i* involved in the production activity *j*;
A_{ji} is the amount produced by each farm *i* in the production activity *j*;
N_j is the number of farms involved in the production activity *j*.

The use of aggregated data is motivated by the issue we wish to test. An investigation of the choice of enterprises by farms would simply rely on using of a multinomial model (or on tobit models as in Gillespie and Mishra, 2011) applied to farm level data, and for example on comparing the model results for part-time farms to the model results for full-time farms. However, our question goes further than the choice of enterprise, since we wish to investigate whether the choice is related to the profitability of enterprises. Using such multinomial methodology for our question would therefore imply defining a priori categorising enterprises based on their profitability. Another possibility with farm level data would be to use the financial returns to labour as a dependent variable and the part-time status as an explanatory variable. However, this would imply estimating as many equations as there are enterprises. The advantage of using the methodology described above is that it can give a straight answer to our question and enables to consider the average profitability of each enterprise within the sample, that is to say the average profitability that could be expected when engaging in this enterprise.

In order to test the sensitivity of our proposition to the definition of profitability, two regressions are performed, differing by the proxy of financial returns to labour ($P_{j)}$ used as the explanatory variable. In a first regression, we use the revenue produced per unit of labour, and in a second regression we use the gross margin (that is to say the revenue reduced by the variable costs for crops and livestock) per unit of labour. Another explanatory variable included in the regression is a livestock enterprise dummy, which represents the categorisation of the 16 enterprises into livestock and crop activities, since there could be any systematic bias for part-time farms to either of them. Two additional variables are included in order to account for the fact that part-time farmers may invest more intensively in substitutes for their own time (namely capital and hired labour): the sample's average capital to labour ratio for each production enterprise *j*, and the sample's average share of hired labour for each production enterprise *j*. Finally, time dummies are included. Due to the panel characteristics of our data (16 observations per year) we use a panel data model with random effects, the Breusch-Pagan test indicating that this specification is preferred over the pooled Ordinary Least Squares (OLS) specification (Wooldridge, 2002).

As explained above, part-time farming may be measured in terms of hours spent off farm or in terms of income generated by off-farm activities. While our conceptual framework is based on the notion of time and not on the notion of income, there is no information regarding off-farm hours in the Swiss FADN. For this reason, our categorisation

is based on the share of household income stemming from off-farm activities: full-time farms are those where less than 50 per cent of income stem from off-farm activities, and part-time farms are those where more than 50 per cent of income stem from off-farm activities. This definition of part-time farms is standard in analyses about Swiss farms, as for example in Roesch (2012).

Table 1 presents descriptive statistics of the variables used in the regressions. During the period 1996-2004 and for the 16 enterprises outlined above, on average 10 percent of the country's agricultural production was produced by part-time farms, with a minimum of 6 percent and a maximum of 41 percent for specific enterprises. On average the revenue per labour unit for the 16 enterprises considered was 216,270 Swiss Franks, while the respective figure for the gross margin per labour unit was 37,095. The average capital to labour ratio was 443,279 Swiss Franks and on average 22.5 percent of the labour used was hired. Table 2 presents averages (over the period 1996-2004) of the variables of interest per enterprise. Figures show that the enterprise for which the average share of production provided by part-time farms is highest is suckler cows (22.4 percent of the country's production). This can be explained by lower labour requirements in grazing systems, in line with Gillespie and Mishra's (2011) observation in the US in 2003. By contrast, the lowest average share of production provided by part-time farms is for pig breeding (5.2% of the country's production), confirming our suggestion above that this is a labour intensive activity. The high average revenue per labour unit and gross margin per labour unit for this production seems to support our idea that labour intensive enterprises may be highly profitable. However, Table 2 shows that a high share of production produced by part-time farms is not always associated with a high revenue or gross margin to labour, which does not support our proposition. It should however be kept in mind that Table 2 presents average figures for the whole period 1996-2004 and not yearly figures. In addition, we do not expect an exact relationship but we want to test with econometrics the strength of the relationship.

Table 1. Descriptive statistics of the aggregated data used: 16 enterprises in 1996-2004.

Variable	Mean	Standard deviation	Minimum	Maximum
Share of the country's agricultural production produced by part-time farms	0.100	0.059	0.006	0.413
Revenue per labour unit (P_j) (Swiss Franks)	216,270	234,673	4,339	1,161,250
Gross margin per labour unit (P_j) (Swiss Franks)	37,095	53,756	1,375	282,226
Livestock enterprise (dummy)	0.255	0.438	0	1
Capital to labour ratio (Swiss Franks)	443,279	71,907	45,942	610,288
Share of hired labour	0.225	0.029	0.146	0.282

Number of observations: 141.
Source: authors' calculations based on Swiss FADN data for 1996-2004.

Table 2. Descriptive statistics of the aggregated data used: yearly averages per enterprise.

Enterprise	Share of the country's agricultural production produced by part-time farms	Revenue per labour unit (Swiss Franks)	Gross margin per labour unit (Swiss Franks)
Pig fattening	0.078	290,501	95,933
Pig breeding	0.052	335,129	175,042
Suckler cows	0.224	134,832	121,697
Milk	0.073	56,813	43,203
Proteinseeds	0.107	145,308	2,854
Sunflower	0.104	121,663	2,128
Rapeseed	0.086	135,521	1,880
Wheat	0.076	78,457	4,664
Sugar beet	0.074	1,004,197	71,130
Spelt	0.140	95,753	3,450
Maize	0.109	242,275	7,652
Triticale	0.076	162,993	5,287
Barley	0.082	160,881	5,136
Oats	0.113	128,326	4,453
Rye	0.100	153,908	5,283
Potatoes	0.101	182,231	32,078

Number of observations: 141.
Source: authors' calculations based on Swiss FADN data for 1996-2004.

4. Results

Table 3 and Table 4 present the regression results of the share of the country's agricultural production that is produced by part-time farms, for 16 specific enterprises in 1996-2004. Results in Table 3 are for the regression including in the explanatory variables the revenue per labour unit as the proxy for the financial returns to labour in each production enterprise. Results in Table 4 are when the proxy for the financial returns to labour is the gross margin per labour unit. The Wald tests show that both models are highly significant. The Breusch-Pagan tests conclude to a random effect panel specification. In both models the dummy for livestock enterprise, the capital to labour ratio and the share of hired labour have no significant effect.

As regard the main variable of interest, results in Table 3 show that the coefficient for the revenue per labour unit is significant (at 5 percent) and negative. This indicates that the share of part-time farms in a specific production is influenced by the returns to labour in this specific production. The more revenue per labour unit is generated by a product, the less part-time farms engage in its production, giving support to our proposition. By contrast, Table 4 shows that this effect is not confirmed when returns are proxied by gross margin, as the coefficient of the gross margin per labour unit is not significant. We have investigated whether the effect of the returns to labour on the dependent variable differed depending on the type of activity, namely livestock or crop, by including in the regression

the returns to labour interacted with the livestock enterprise dummy. However, the coefficient for this cross term was not significant.

Table 3. Explaining the share of part-time farms in the country's agricultural production, using the revenue as the proxy for financial returns.

Explanatory variable	Coefficient	p-value	Significance
Revenue per labour unit (P_j)	-4.88 E-08	0.041	**
Animal enterprise (dummy)	-8.52 E-03	0.757	
Capital to labour ratio	3.36 E-09	0.965	
Share of hired labour	-5.28 E-01	0.114	
Constant	0.240	0.006	***
Wald test (Chi^2)	114.6	0.000	***
Breusch-Pagan test (Chi^2)	26.9	0.000	***
R^2	0.224		
Number of observations	141		

Dependent variable: share of agricultural production produced by part-time farms in 16 different production enterprises. Results for time dummies not shown. Estimated using random effects since the Breusch-Pagan test rejects the null hypothesis of a pooled OLS model in favour of a random effect specification. *, **, *** indicate significance levels at 10, 5 and 1 percent respectively.
Source: authors' calculations based on Swiss FADN data for 1996-2004.

Table 4. Explaining the share of part-time farms in the country's agricultural production, using the gross margin as the proxy for financial returns.

Explanatory variable	Coefficient	p-value	Significance
Gross margin per labour unit (P_j)	-8.86 E-08	0.669	
Animal enterprise (dummy)	1.11 E-03	0.972	
Capital to labour ratio	-6.10 E-09	0.934	
Share of hired labour	-5.17 E-01	0.120	
Constant	0.230	0.005	***
Wald test (Chi^2)	118.5	0.000	***
Breusch-Pagan test (Chi^2)	29.7	0.000	***
R^2	0.199		
Number of observations	141		

Dependent variable: share of agricultural production produced by part-time farms in 16 different production enterprises. Results for time dummies not shown. Estimated using random effects since the Breusch-Pagan test rejects the null hypothesis of a pooled OLS model in favour of a random effect specification. *, **, *** indicate significance levels at 10, 5 and 1 percent respectively.
Source: authors' calculations based on Swiss FADN data for 1996-2004.

5. Conclusion

The literature has little investigated part-time farmers' choices of production enterprises on their farm. Such choices may be more constrained than those made by full-time farmers due to limited time availability, as suggested by Gillespie and Mishra (2011) for US farms. A further idea, that we developed in this paper, is that part-time farmers, due to their constraint on farm labour supply, may not engage in highly profitable enterprises. This may be the case for example, as shown by our conceptual framework, when such enterprises are labour intensive. This conceptual framework, as well as the empirical application for Swiss farms using FADN data for 1996-2004 and revenue per labour unit as the proxy for financial returns, illustrate this idea that there may be difficulties to enter attractive activities within agriculture if off-farm employment constitutes an important part of the household income. This may help explain the low profitability of part-time farming, as shown for example by Roesch (2012). Using FADN data for 2005-2010 the author showed that the probability of being a profitable farm is lower for part-time farms.

Our proposition, that part-time farmers tend to engage in products with low financial returns to labour, has been confirmed with our empirical results when revenue per labour was used as the proxy of financial returns to labour. However, the relationship was not strongly significant (at 5 percent only) and the coefficient was found to be very close to zero, indicating that the effect is negligible. In addition, the proposition was not confirmed when gross margin per labour was used instead. This suggests that our proposition, which was illustrated by our conceptual framework, is not supported by our data. One reason may be that this proposition of constraint posed by part-time jobs on profitable enterprises, may hold only in specific contexts. Another reason may be that our assumption that highly profitable enterprises are labour intensive could be questioned, in particular for specific products.

Hence, further research may be necessary. For example, although part-time farms may be constrained in their choice of enterprise as we suggest, the consequence in terms of residual profit may not be negative. This may depend on the proxy used for profitability and further analysis is therefore required. The role of government support could also be investigated, as it may influence the choice of production by part-time farmers.

In addition, one could question whether the causality is unique. While we assumed here that the part-time status determines the choice of enterprise, the reverse may also hold. Indeed, farmers may be forced to engage in a low profitable enterprise for structural reasons, such as difficult soil and climatic conditions in the farm location, or low land availability and high land prices (this is the case in Switzerland, see Giuliani, 2002). Based on our assumption that high profitable enterprises are labour intensive and inversely, those farmers forced to choose low profitable enterprises would have an excess of labour, an excess that they would supply off the farm. There may thus be a mismatch between the availability of "excess supply of labour in agriculture" (Schultz, 1945) and the availability of other factors, a mismatch which is balanced by offering labour outside of the farm. This suggests that there is a possibility of joint determination of the choice of production enterprise and off farm status, which would require specific econometric modelling in future research.

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References

Baum, S., Cook, P., Stange, H. and Weingarten, P. (2006). Agricultural employment trends in an enlarged European Union: does the CAP reform / introduction matter? Paper presented in the IAAE Conference, Gold Coast, Australia, 12-18 August.

Barlett, P.F. (1991). Motivations of part-time farmers. In: Hallberg, M.C., Findeis, J.L., and Lass, D.A. (eds), Multiple Job-holding among Farm Families. Iowa State University Press: 45-70.

Benjamin, C. and Kimhi, A. (2006). Farm work, off-farm work, and hired farm labour: estimating a discrete-choice model of French farm couples' labour decisions. *European Review of Agricultural Economics* 33(2): 149-171.

Dupraz, P. and Latruffe, L. (2015). Trends in family labour, hired labour and contract work on French fieldcrop farms: the role of agricultural policies. *Food Policy* 51: 104-118.

Errington, A. (1998). The increasing flexibility of machinery and labour inputs to UK farming. *Etudes et Recherches sur les Sytèmes Agraires et le Développement* 31: 371-385.

Gillespie, J. and Mishra, A. (2011). Off-farm employment and reasons for entering farming as determinants of production enterprise selection in US agriculture. *The Australian Journal of Agricultural and Resource Economics* 55: 411-428.

Giuliani, G. (2002). Landwirtschaftlicher Bodenmarkt und landwirtschaftliche Bodenpolitik in der Schweiz. ETH, Zurich, Switzerland.

Hallam, A. (1991). Economies of size and scale in agriculture: An interpretative review of empirical measurement. *Review of Agricultural Economics* 13(1): 155-172.

Kingwell, R. (2011). Managing complexity in modern farming. *Australian Journal of Agricultural and Resource Economics* 55(1): 12-34.

Knap, P.W., van der Steen, H.A.M. and Plastow, G.S. (2001). Developments in pig breeding and the role of research. *Livestock Production Science* 72(1): 43-48.

Langlois, R.N. (1997). Scale, scope and the reuse of knowledge. Paper prepared for the conference in honor of Brian J. Loasby, Stirling, Scotland, 26-28 August.

Lund, P. (1991). Part-time farming: a note on definitions. *Journal of Agricultural Economics* 42(2): 196-199.

Mann, S., Mack, G. and Ferjani, A. (2003). Können Produktionsentscheidungen als Investitionsentscheidungen modelliert werden? *Agrarwirtschaft* 52(7): 333-341.

Mishra, A.K. and Goodwin, B.K. (1997). Farm income variability and the supply of off-farm labor. *American Journal of Agricultural Economics* 79: 880-887.

Moran, W. and Anderson, A.G. (1988). Predicting enterprise choice: exit from dairying in New Zealand. *Journal of Rural Studies* 4(3): 203-214.

Ojo, M.A., Nmadu, J.N., Tanko, L. and Olaleye, R.S. (2013). Multinomial logit analysis of factors affecting the choice of enterprise among small-holder yam and cassava farmers in Niger State, Nigeria. *Journal of Agricultural Sciences* 4(1): 7-12.

Okon, U.E., Enete, A.A. and Amusa, T.A. (2012). Enterprise choice decisions in urban food production in Nigeria - Empirical evidence from Akwa Ibom state. *Outlook on Agriculture* 41(1): 51-56.

Roesch, A. (2012). Factors affecting the situation of economically weak farms in Switzerland. *Agricultural Economics Review* 13(1): 23-38.

Salter, L.A. (1936). What is part-time farming? *Journal of Farm Economics* 18(1): 191-197.

Schick, M. and Stark, R. (2007). Der Arbeitsvoranschlag unter Berücksichtigung von Arbeitsorganisation und Zeitplanung, Presentation at the AKAL-Seminar, Vienna, Austria, 5 March.

Schultz, T.W. (1945). Agriculture in an unstable economy. New York: McGrawHill.

Shah, A. (1992). Dynamics of public infrastructure, industrial productivity and profitability. *The Review of Economics and Statistics* 74(1): 28-36.

Tamirat, M. (2013). Financial constraints and entrepreneurial activity choice among clients of micro finance institutions in Jimma area. *Journal of Development and Agricultural Economics* 5(12): 510-518.

Wooldridge, J. (2002). Econometric Analysis of Cross Section and Panel Data. Massachusetts Institute of Technology.