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WHY FAMILY FARMS ARE INCREASINGLY USING WAGE LABOUR ?

In many developed countries, the share of wage employment out of the total agricultural labour force has been increasing for the last ten years. Using data from French agricultural censuses, we present an analysis of the factors that influence households' decisions about whether to work on the family farm or to work outside, and about the use of wage labour. Studying how the effects of these factors have varied between 1988 and 2000 enables us to highlight the different mechanisms that have led to an increase in permanent wage employment during that period. In particular, we show that family labour and permanent wage labour have become nearly equivalent in 2000, whereas that was not the case in 1988.

Key words : Agricultural employees, farms, family labour.
Classification JEL : C34, C35, J22, J43.

1 Introduction

In many developed countries, the decline of agricultural wage employment has slowed down significantly and in some cases has been replaced by a stabilisation or an increase. At the same time, the decline of family employment continues. In total, the share of wage labour in the agricultural labour force has been increasing in most developed countries. This phenomenon results both from the fact that family farms use wage-workers more frequently and that the number of capitalist agricultural enterprises has increased. In the latter the objective function to maximise is profit, whereas in the former it is the household utility function that must be maximised, a function that is traditionally dependent on leisure and consumption, the latter being dependent on the financial resources of the family which consist of the income derived from farming but also, in some cases, the income derived from activities outside the farm.

The economic and sociological specificities of family farming have been described in detail by Gasson et al (1988). The economic model that best accounts for these specificities is the "farm-household" model which originates in the works of Chayanov (1925)[1]. Tanaka (1951) and later Nakajima (1986) formalised Chayanov's theory. A great number of works have used this theoretical framework to analyse the choice of farming households to work on the farm or outside (Lass and Gempesaw (1992), Kimhi,(1994), (1996), Kimhi and Lee, (1996)). The studies concerning the demand for wage labour are scarcer and often consider the farm as an ordinary capitalist enterprise (Vandeman, Sadoulet and De Janvry,(1991)). However, several authors have simultaneously analysed farms' demand for wage labour and the supply of labour by agricultural households on the farm and outside : Lopez (1984), Huffman (1991), Benjamin (1996), Benjamin Corsi and Guyomard (1996), and Benjamin and Kimhi (2003). However these works take into account all wage workers without making any distinction between permanent wage labour and seasonal wage labour, that is by implicitly assuming that both types of salaried employment are substitutable.

Our contribution is original inasmuch as it tests this hypothesis and shows that it is unfounded ; secondly it examines the relations of substitutability and/or complementarity between permanent wage labour and the recourse to agricultural contractors or CUMAs (Agricultural machinery co-operative associations) ; last but not least, it provides a framework for analysing the interweaving factors that influence the evolution in time of permanent wage labour on family farms.

Our article is structured as follows : Section 2 provides a few stylised facts concerning the evolution of wage labour on farms. Section 3 presents the foundations of the farm-household model. Section 4 describes the econometric model we have chosen and the data we have used. In section 5, we discuss the empirical results obtained. Section 6 concludes.

2 Stylised facts about the demand for wage labour

Findeis (2002) has studied the recent evolution of agricultural employment in developed countries. She shows that there has been a decline in agricultural employment as a whole,

[1]Translated into English by R.Smith in 1966 (Thorner, Kerblay, Smith (1966)).

but also an increase, in most countries, in the share of wage employment out of the total agricultural employment.

Since the beginning of the 1970s agricultural employment in France had declined by approximately 3% every year. During the 1990s the decline of family employment accelerated and was accompanied by an increase in seasonal wage employment. Furthermore the number of permanent employees increased from 161 300 in 1988 to 164 200 in 2000, whereas it had been dropping by just over 5% per year between 1970 and 1988. In total, the share of permanent and seasonal wage labour out of the total agricultural employment has significantly increased in the last decade (from 15.5% in 1988 to 24.2% in 2000).

Rattin (2003) has shown that this overall stabilisation of the number of permanent employees conceals evolutions that differ according to the characteristics of the farms. Thus, permanent wage employment has increased significantly in off-land types of farming and in farms specialised in quality wine-making, but it has decreased in other wine-making farms and those specialised in arboriculture. Furthermore, the number of permanent employees has increased in "capitalist" agricultural enterprises that employ between 5 and 20 workers ; however it has been decreasing in large-scale fruit and vegetable farms and arboriculture enterprises with a staff of 30 employees and more. Similarly the number of family farms employing only one employee has slightly dropped. Moreover, an increasing number of farms using permanent wage labour tend to adopt the legal status of partnership[2]. Furthermore, the stabilisation of the number of permanent employees is accompanied by a slight decline in the volume of labour supplied, which dropped from 142 700 annual work units (AWU) in 1988 to 137 600 in 2000. This reflects an increase in part-time permanent employment that results in particularly from the development of employer associations enabling several farmers to share the services of one employee. Finally, during this period, there has been a slight increase in the externalisation of labour : the number of labour hours supplied by agricultural contractors and CUMAs has increased by 23%, but still represents a very small part of the quantity of labour employed in the agricultural sector : less than 1% in 2000.

Various reasons have been proposed to explain these evolutions (Blanc and Perrier-Cornet 1999). The long-term decline in agricultural employment is mainly due to the fact that the increase in the demand for agricultural products is weaker than the growth of labour productivity. The strong and steady increase of the latter is partly due to the development of mechanisation leading to a substitution of labour by capital that was initially detrimental to salaried employment. In the 1990s, the decline in family labour accelerated partly because an increasing number of farmers' wives work outside their husbands' farms. This tendency can be partly explained by a rise in their general education level, which has enabled them to earn higher income than in the past when they work outside. Furthermore, less and less farmers' children succeed to their parents, which contributes to the decline in the number of farms and to the increase in the size of the those that remain. This phenomenon was also reinforced by the measures accompanying the reform of the Common Agricultural Policy and in particular by the implementation of pre-retirement programmes. The decrease in the number of on-farm active family members per farm combined with the increase in the economic size of agricultural holdings has contributed to stabilising, if not increasing, the volume of permanent wage employment. This tendency has probably been reinforced by the demand for more leisure

[2] 70% of all permanent employees were employed in farms of this type in 2000, against less than 50% 12 years previously.

time by farmers, and in particular by the younger ones. Similarly, because of the increasing quantity of cognitive tasks that farm managers need to perform, the latter have less time available to carry out operational tasks, which has led to an increased demand for wage labour.

Cross section analyses make it possible to determine the factors that affect, at a given time, the recourse to wage labour, the labour supplied by the family members on or outside the farm ; they also allow to assess the corresponding functions of labour demand and supply. Basing themselves on French data for the year 1988, Benjamin, Corsi, Guyomard (1996) have carried out estimates of this type. First of all they have distinguished eight "labour regimes" depending on whether the man and/or woman worked or not outside the farm and according to whether wage employees were employed on the farm. With a multinomial logit, they have estimated each household's probabilities of corresponding to one of these configurations taking into account variables characterising the men and the women (age, human capital), the household (size of the family, number of children) and the farm (size, standard gross margin (SGM), type of farming, presence or not of diversification activities (tourist hosting, transformation of agricultural products, etc). This enabled them to identify the factors that affect the probability for the woman and/or man to work outside the farm and the probability for wage-workers to be employed on the farm. They showed that in 1988 the recourse to wage labour obviously depended positively on the economic size of the farm, but also on the number of children, on the farm operator's level of agricultural education (but not on his general education level) and was higher in vegetable and flower production and in arboriculture than in other types of farming. They then estimated functions of off-farm labour supply, for the man and for the woman, and a function of demand for wage labour in the different labour regimes where the functions could be identified[3]. The demand for wage labour then increases with the farmer's general education level, with the diversification of activities on the farm, the presence of computer equipment, specialisation in horticulture and arboriculture, and of course the economic size of the farm. The agricultural wage rate has the expected negative effect, but it is not always significant. We shall see below why it is so. In this research strategy, the relations of substitution or complementarity between wage labour and family labour are not easy to identify. However, a substitution effect may be suggested when the signs of the variables in the function of demand for wage labour are different from the signs of the same variables in the function of supply of off-labour by the woman or the man. This led the authors to conclude that the woman's labour could be substitued by wage labour and that the latter was complementary to the man's labour. Benjamin and Kimhi (2003) adopt a similar approach basing themselves on data for the year 2000, but they take into account the fact that the man or the woman might not work on the farm, which leads to 16 possible regimes. They find that the man and the woman's level of general education increases the probability that wage workers are employed on the farm and that wage labour complements the man and the woman's on-farm labour.

The econometric model we propose in section 4 enables us to better determine the effects of substitution and complementarity between the different categories of labour, while taking into account the simultaneity of the family members' supply of labour on and outside the farm.

[3]That is four configurations for each. For example, the demand for wage labour is estimated in the regime where wage labour is combined with both the man and the woman's off-farm labour, or where it is combined with only the man or the woman's off-farm labour or in the case where neither the husband nor wife works outside.

3 The farm-household model

The fundamental characteristics of the family holding is that all or part of the labour is supplied by family members and therefore has no explicit monetary cost since it is not exchanged on a market. As a consumer, the household must choose between privileging its level of leisure or its level of consumption. But the latter is limited by the family's income, which depends on the decisions the family makes as a producer. It is this interdependency between the decisions related to production and those related to the household's consumption that the farm-household models aim to take into account. Simple versions of these models rest on the following hypotheses :

- The production technology of the farm is described by a classical production function[4]. Output Y is a function of the overall quantity of labour L, of another variable input X and of fixed production factors Z. The output is sold at price p and the input is bought at price ν.
- The wage labour L_h and family labour L_f are substitutes but not necessarily equivalent. Therefore we have $L_h = L - kL_f$.
- The household has a classical utility function[5] dependent on two variables : income and leisure time. We therefore suppose that all the members of the household have the same preferences.
- The total time available (T) to the household is allocated to three main activities : leisure (L_{ei}), labour on the farm (L_f) and labour outside the farm (L_o) remunerated at rate w_{off}. Both types of labour are perfect substitutes in the utility function : they have the same disutility. This is a limiting hypothesis. Lopez (1984) and Fall and Magnac (2003) have shown that it is generally not verified.

The question is then that of the maximisation of the household utility function in relation to the time of leisure and to income (I), which is composed of the profit obtained for a given quantity of family labour on the farm, and in relevant cases, of the income derived from an activity conducted outside the farm.

Figure 1 provides a graphic illustration of the resolution of the model under the simplifying hypothesis of perfect equivalence between on-farm family labour and hired labour : $L = L_h + L_f$.

As a producer, the household maximises its profit. With w_a, the exogeneous wage of hired labour, the optimal quantity of labour be will be L^* such that its marginal productivity will be equal to w_a. If the amount of labour provided by the family is inferior to this optimum, wage labour will be used to reach the optimum. In this case, the implicit price of on-farm family labour is equal to w_a since an increase of one unit of family labour will lead to a reduction of one unit of wage labour, therefore in an increase of the family income equal to w_a. However, if the quantity of labour supplied by the family is superior to the optimum (L^*), the implicit price of family labour will then equal its marginal productivity (which is then inferior to the agricultural wage since we are beyond the optimum). The relation between the quantity of labour supplied by the household and its implicit price determines the function of the demand for family labour of the farm. It is represented on figure 1 by the curve D_{farm}. When the

[4] Continuous, twice differentiable, increasing in its arguments and quasi concave.
[5] Continuous, twice differentiable, increasing in its arguments and quasi concave.

quantity of family labour decreases from the infinite to the optimum (Ob), its implicit price increases from 0 to w_a and remains equal to w_a when the amount of labour supplied by the family becomes inferior to Ob.

As a consumer, the household trades off income against leisure. Its utility function defines the marginal rate of substitution of income for leisure. This rate decreases with the quantity of leisure and therefore increases with the total quantity of labour the household supplies on or outside the farm. This relation between the total quantity of labour supplied by the household and its marginal rate of substitution of the income for leisure determines the function of the household's supply of labour.

With this data, the household can solve the programme of maximisation of the utility of the time of labour it supplies on the farm or outside, under the constraint of not negativity of these variables. The utility function makes it possible to define the marginal rate of substitution of consumption (and therefore the income since, by hypothesis, the household does not save) for leisure. This rate decreases with the quantity of leisure and therefore increases with the total quantity of labour the household supplies on or outside the farm. This relation between the total quantity of labour supplied by the household and its marginal rate of substitution of the income for leisure determines the function of the household's supply of labour.

Furthermore, the household must decide between the demand for labour from outside, and the farm's demand for labour. The family will prefer to supply the labour needed by the family enterprise as long as the implicit price of the labour it supplies on the farm remains superior to the income that could be derived from working outside. If the implicit price of the family labour becomes inferior to the outside income, then they will choose to work outside the farm. The intersection of the functions of demand and supply of labour allows to determine the quantity of family labour supplied on and off the farm, and the quantity of wage labour employed, as illustrated in figure 1.

Six solutions are possible depending on the respective values of the off-farm wage and of the on-farm wage and on how the household trades off leisure against income, that is the position of its labour supply curve. There is one interior solution and five corner solutions.

1. When the labour supply curve is S_4, the reservation wage of the household (that is its marginal rate of substitution of income for leisure when no labour is provided) is superior to the wage that it would derive from an off-farm occupation (w_{off3}) and superior to the implicit price of its labour on the farm. The family works neither on the farm nor outside and the quantity of wage labour employed will be equal to the optimum, that is Ob.
2. When the supply curve is S_3 and the off-farm wage (w_{off3}) is superior to the agricultural wage, the household does not work on the farm and provides the amount of off-farm labour (Oe) for which its marginal rate of substitution of income for leisure is equal to w_{off3}. As in the previous case, the wage labour will be equal to Ob.
3. When the supply curve is S3 and the off-farm wage (w_{off1}) is inferior to the agricultural wage, the household works only on the farm. It provides a quantity of labour (Oa) such that its marginal rate of substitution of income for leisure is equal to the implicit price of its labour (w_a). As the family labour (Oa) is inferior to the optimum (Ob) a quantity of wage labour equal to ab will be employed in order to reach the optimum.

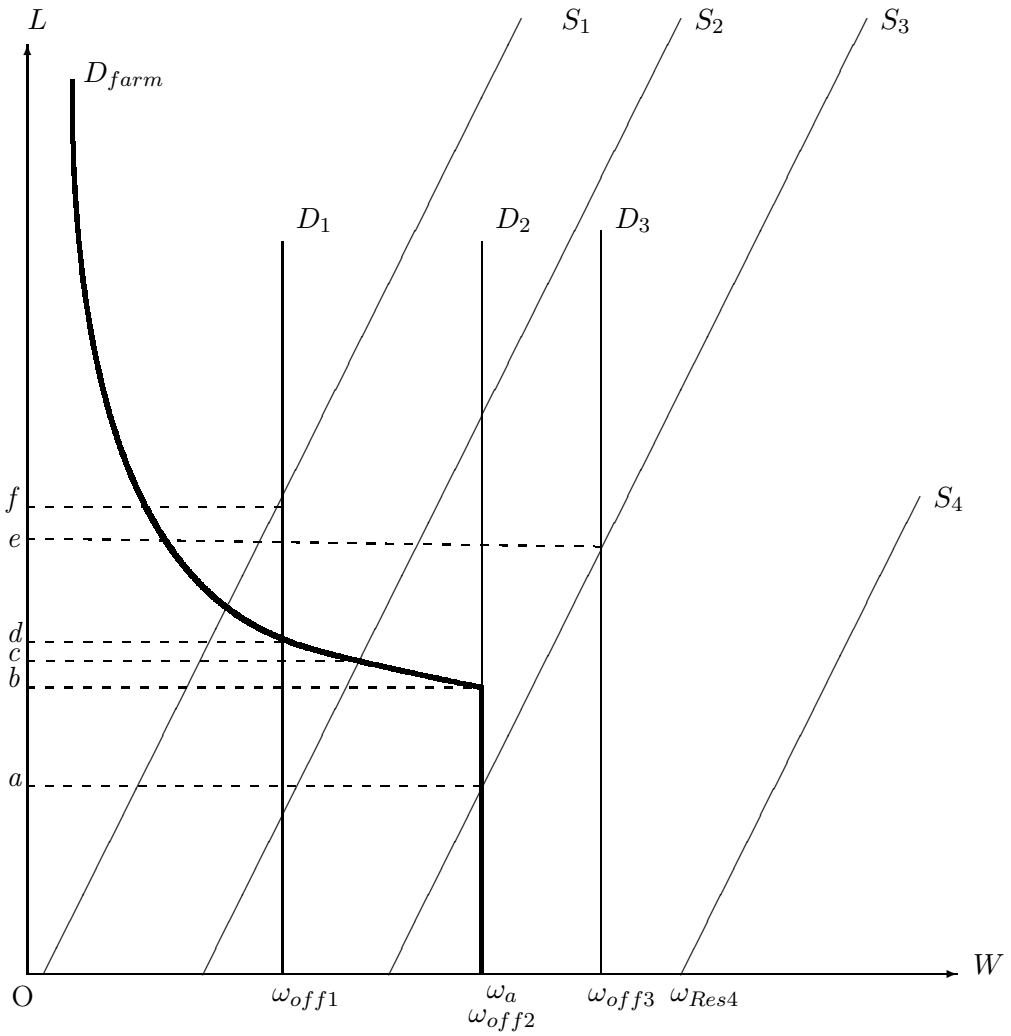

FIG. 1 – On-farm and off-farm family labour and wage labour determination

4. When the supply curve is S_2 and the off-farm wage (w_{off1}) is inferior to the agricultural wage, the household works also only on the farm. It provides a quantity of labour (Oc) such that its marginal rate of substitution of income for leisure is equal to the implicit price of its on-farm labour, which this time is inferior to w_a since the quantity of family labour is superior to the optimum. Then, no wage labour can be employed. Here, contrary to the previous cases and the following ones, a slight move of the supply curve will translate into a change in the total quantity of labour used on the farm and therefore in a change in the output. Decisions concerning consumption have an impact on the decisions concerning production. The model is no longer recursive.
5. When the supply curve is S_1 and the off-farm wage (w_{off1}) is inferior to the agricultural wage, the household supplies a total quantity of labour equal to Of, Od on the farm and df outside, since beyond ordinate point d of the curve of the farm's demand for family labour, working outside becomes more remunerative than working on the farm. In this case, the marginal rate of substitution of income for leisure, the implicit price of the on-farm family labour and the off-farm wage (w_{off1}) are all equal.
6. An internal solution occurs when the agricultural wage and the off-farm wage are equal. Such is the case when the off-farm labour demand is D_2 (the off-farm wage being w_{off2}). If, for instance, the supply curve is S_3, the total quantity of labour supplied by the family will always be Oa, but the quantities of labour supplied on the farm and supplied outside the farm are undetermined, which implies that the quantity of wage labour employed - comprised between Ob (if all the family only works outside) and ab (if the family only works on the farm) - cannot be precisely determined. That is the only case which makes possible to have wage and family labour on the farm and family labour outside the farm simultaneously. However, this equality between off-farm and on-farm wages is a very specific configuration. A more realistic way of accounting for the simultaneity of the three types of labour (which is frequently the case) is to suppose that the members of the family do not have the same human capital and that therefore they do not obtain the same remuneration when they work outside. This hypothesis is in keeping with what has been observed in France where farmers' wives often have a higher level of general education than their husbands do. This hypothesis can be illustrated in figure 1 by supposing that both spouses in the couple have the same utility function and therefore the same labour supply curve[6] S_3, but that the woman's off-farm wage is w_{off3} and the husband's is w_{off1}. In this case, the labour supplied by the woman outside the farm will be equal to Oe ; the labour supplied on the farm by the man will be equal to Oa and the wage labour will be equal ac.

In this economic model, the quantity of wage labour employed on the farm is always determined as the balance (if it is positive) between the optimum and the volume of labour supplied by the family on the farm. The level of the latter depends on how the household choose to use the time available to them : leisure, labour outside the farm, labour on the farm. The econometric model of the quantity of wage labour employed, of family labour on or off the farm must take into account this logic of the economic model. It must therefore consist of a system of simultaneous equations leading to the determination of the amount of family labour supplied on and off the farm, combined with an equation of wage labour into which the estimation of the amount of on-farm family labour derived from the resolution of the first system is introduced as an argument. Furthermore, as we are dealing with family farms, we are not concerned by the first two solutions of the economic model (with no labour supplied by the

[6]This hypothesis is not critical. It makes it possible to facilitate the graphic illustration. The only condition for a woman to work outside the farm is that the wage she will derive from an outside job must be superior to its reservation wage or to the agricultural wage.

household on the farm). We have to consider two corner solutions only : for wage labour and off-farm family labour. Modeling them implies to resort to functional forms taking explicitly into account those corner solutions (probit or tobit).

4 The econometric model and the data used

4.1 The equations of permanent wage labour on the farm and of the labour supplied by the family on and outside the farm

The volume of labour supplied by the household on the farm (L_f) depends on : i) the characteristics of the farm (F) and on the household members agricultural education (K_{ha}) which both affect the demand for labour of the holding ; ii) the characteristics of the household (H) which determine its utility function and therefore its supply of labour ; and iii) the volume of labour supplied outside the farm (L_o). In turn, this quantity of off-farm labour depends on the wage (w_{off}) which the members of the family can expect to derive from an off-farm job, on the characteristics of the household which affects its utility function and on the quantity of labour it supplies on the farm. The system of simultaneous equations determining the quantity of labour supplied by the family on and off the farm will therefore be :

$$\begin{aligned} L_f &= L_f(F, K_{ha}, H, L_o) \\ L_o &= L_o(H, w_{off}, L_f) \end{aligned}$$

In this model the impact of the off-farm wage on the on-farm family labour is captured through the amount of off-farm labour. Similarly, the impact of both the farm's characteristics and the agricultural education of the family on the off-farm labour is captured through the amount of on-farm family labour.

The quantity of permanent wage labour employed (L_h) will depend on the agricultural wage (w_a), on the characteristics of the farm, on the labour-management skills of the farmer (LMS), on the estimated quantity of family labour ($\hat{L}_f$) calculated from the previous equation system and on the other sources of labour (O_{lab}) : seasonal employees and agricultural contractors and CUMAs. We will therefore have :

$$L_h = L_h(F, w_a, LMS, \hat{L}_f, O_{lab})$$

4.2 The data used

The data used come from a one tenth sample of French agricultural censuses carried out in 1988 and 2000. As we have chosen to only consider family farms, we have eliminated capitalist agricultural enterprises. This has led us to discard the 1000 French farms with the highest Standard Gross Margin (SGM), the farms with the status of commercial or Joint Stock Company. We have also eliminated the small farms that only generate a small part of the household's income. We have therefore only retained what French agricultural Statistics consider as "professional" holdings, that is the farms whose SGMs are at least equal to 8 European Size Units (ESU, that is the equivalent of 12 hectares of wheat) and which use at least 0,75 Annual Work Units (AWU)[7]. In total the samples used for our study contain 48 693

[7]That is in equivalent full time.

farms in 1988 and 37 069 in 2000.

Agricultural censuses indicate the quantities of labour, measured in AWU supplied on the farm by the different members of the family, the permanent and seasonal wage employees, the agricultural contractors and the CUMAs. However, they do not give information on the quantity of labour supplied outside the farm by the different family members. They only indicate whether or not the latter are employed outside the farm and if the off-farm occupation is the main or secondary activity. Because, as a result, we cannot measure L_o in full-time equivalent units, we have considered this off-farm occupation as a binary variable equal to 1 if at least one of the family members has its main activity outside the farm (or has a secondary job outside combined with a less-than-half-time job on the farm) and equal to 0 otherwise.

The variables retained to characterise a farm (E) are :

- its economic size measured by the SGM ;
- its type of farming (F_{type}) : "cereals and field crops", "horticulture", "quality wine-making", "other wine-making and fruit", "granivore", "dairying", "beef cattle and other grazing livestock", "field crops and grazing livestock", "mixed cropping" (which is the reference category in the estimations) ;
- the labour-substituting machinery (EL) is described by two variables : the number of tractors and the number of other machines ;
- the volume of cognitive tasks (C) is approached by two dummy variables : the use or not of a computer to help run the farm and whether or not the farmer keeps detailed accounting records ;
- the legal status of the farm (SJ) takes three forms : an independent farm (which is the reference in the estimations), a GAEC (group of farmers that pool land and machinery), an EARL(limited liability agricultural holding).

The specific agricultural human capital (K_{ha}) is estimated by 6 variables. The first three are related to the farmer's level of initial agricultural training, to the spouse's, and to the highest level among the other family members. Three levels are distinguished for the farmer and his spouse : below short secondary education, equal to short secondary education, equal or above long secondary education. In order to simplify the estimates, only two levels have been taken into account for the other members (below and equal or above long secondary education). The three other variables indicate whether the farmer, his spouse and other members of the family have, at any time, received agricultural continuing education.

The variables characterising the household (H) are :

- its size H_s,
- the number of children under 10 (C10)
- the age of the farmer and his age squared (to take life cycle effects into account).

Our data do not give any information on the wage earned by the members of the family who work outside. The wage (w_{off}) which they can expect to derive from an off-farm job is approached by to types of variables :

- The general human capital of the members of the household (K_{hg}) indicates the position on the wage scale of the jobs they can occupy outside the farm. It is estimated by three variables : the farmer's general education level, his spouse's, and the highest education level among the other members. Each level is either equal to 1 if it corresponds to at least long secondary education, or 0 otherwise.

- The rate of regional unemployment(RU) serves as a proxy of the impact on the wage level of the tension on the local labour market.

Furthermore, as it is often the farmer's spouse who has an off-farm job, we have introduced in the equation of the off-farm family labour a dummy variable indicating whether or not the farmer has a spouse (F_{sp}).

In the permanent wage labour equation, the farmer's labour-management skills (LMS) are represented by two dummy variables indicating whether or not the farmer has a level of agricultural and general education equal or above long secondary schooling. The agricultural censuses do not give any indication as to the wages of the agricultural employees. We have tried, with the accountancy data from the FADN (Farm Accountancy Data Network) to estimate the cost of wage labour with variables common to the FADN and to agricultural censuses and to use this estimation in the permanent wage labour equation. This does not generate very significant results. We have seen that Benjamin, Corsi and Guyomard (1996) had met similar difficulties. This is probably due to the fact that the differences in pay reflect differences in qualifications between workers rather than differences in pay between workers with similar qualifications. Therefore the wage has not been explicitly introduced in the wage labour function. However, the rate of regional unemployment (RU) has been introduced in order to take into account the impact on the farm wage level of the tension on the local labour market.

4.3 The estimation of the model

The economic model imposes a two step method. First, we must estimate a system of two simultaneous equations which have not the same form : because of the nature of our data the equation related to the labour supplied outside has a probit form ; whereas the equation related to the family labour supplied on the farm has a linear form. Second, we have then to estimate the wage labour with a Tobit model (because a certain number of farms do not employ permanent workers) into which the estimate of the family labour supplied on the farm calculated above is introduced as an argument.

The simultaneous equations are of the type :

$$y_1 = \alpha_1 y_2 + \beta_1' X_1 + e_1 \quad (1)$$

$$y_2 = \alpha_2 y_1 + \beta_2' X_2 + e_2 \quad (2)$$

where $y_2 = 1$ if $y_2^* > 0$ and $y_2 = 0$ otherwise.

Estimation follows the typical two stage estimation process. In the first stage, the following models are fitted using all of the exogeneous variables :

$$y_1 = \gamma_1'(X_1 + X_2) + \nu_1 \quad (3)$$

$$y_2 = \gamma_2'(X_1 + X_2) + \nu_2 \quad (4)$$

where γ_1' and γ_2' are vectors of parameters to be estimated and ν_1 and ν_2 are error terms.

Equation (3) is estimated via OLS and (4) via probit. From these reduced-form estimates, the predicted value from each equation are obtained for use in the second stage.

$$\widehat{y}_1 = \widehat{\gamma}_1'(X_1 + X_2) \quad (5)$$
$$\widehat{y}_2 = \widehat{\gamma}_2'(X_1 + X_2) \quad (6)$$

In the second stage, the original endogeneous variables in (1) and (2) are replaced by their respective fitted values in (5) and (6). Thus in the second stage the following two equations are fitted.

$$y_1 = \delta_1 \widehat{y}_2 + \lambda_1' X_1 + \varepsilon_1 \quad (7)$$
$$y_2 = \delta_2 \widehat{y}_1 + \lambda_2' X_2 + \varepsilon_2 \quad (8)$$

Again, (7) is estimated via OLS and (8) via probit.

The final step in the procedure is the correction of the standard errors. This is necessary because the outputted standard errors in (7) and (8) will be based on $\widehat{y}_1$ and $\widehat{y}_2$ and not on the appropriate y_1 and y_2.Thus the estimated standard errors in (7) and (8) will be incorrect. The correction to be implemented follows the procedure proposed by Maddala (1983). Finally, the model we estimate consists of three equations :

$$\begin{aligned} y_1 &= \delta_1 \widehat{y}_2 + \lambda_1' X_1 + \varepsilon_1 \\ y_2 &= \delta_2 \widehat{y}_1 + \lambda_2' X_2 + \varepsilon_2 \\ y_3 &= \delta_3 \widehat{\widehat{y}}_1 + \lambda_3' X_3 + \varepsilon_3 \end{aligned}$$

where

$$\begin{aligned} \widehat{\widehat{y}}_1 &= \delta_1 \widehat{y}_2 + \lambda_1' X_1 \\ y_1 &= L_f \\ y_2 &= L_o \\ y_3 &= L_h \\ X_1 &= (SGM, F_{type}, K_{ha}, EL, C, SJ, H_s, C10, age, age^2) \\ X_2 &= (H_s, C10, age, F_{sp}, K_{hg}, RU) \\ X_3 &= (SGM, F_{type}, LMS, EL, age, C, SJ, O_{lab}, R_u) \end{aligned}$$

$\delta_1, \delta_2, \delta_3$ are parameters and $\lambda_1, \lambda_2, \lambda_3$ vectors of parameters to be estimated.

5 The results

5.1 Off-farm family labour

Most of the household characteristics variables have the expected effect. The proportion of farms with at least one household's member working outside is of course an increasing function of the number of people living on the farm. The farm operator's age has a negative impact on the frequency of off-farm work. Pluriactivity of farmers is perhaps more common at the early stages of their career which is often the time when they need additional sources of income to invest. Furthermore, the age of the farm operator reflects the age of his spouse

as both are very strongly correlated[8] , and young wives are more likely to work outside the farm than older wives do. This is probably more the result of a generation effect than of a life cycle effect. Indeed, off-farm work is often provided by wives. When the size of the household is controlled for, the fact that the farmer is married has a strong and positive impact on the frequency of off-farm work. Likewise, this frequency decreases with the number of children under 10 in 1988. However, this effect is no more significant in 2000. This is in keeping with the general tendency observed in French society : it is increasingly common for women with children to work.

The variables used to approximate off-farm wage have the expected impact. The frequency of off-farm work declines when regional unemployment increases. Working outside is all the more frequent as the general education levels of the spouse is high, since she can be better remunerated. It is the same for the other members of the family, but only in 2000. The effect of the farmer's general education is never significant. Most of the farm operators work full-time on the farm whatever be their general education.

Finally, the probability that at least one household members works outside declines when the quantity of on-farm family labour increases. As explained earlier, this negative impact reflects also the effect of the characteristics of the farm and of the agricultural specific human capital of the household members.

5.2 On-farm family labour

The quantity of family labour employed on the farm depends on the characteristics of the household. It is an increasing function of the number of people living on the farm (that is of the size of the family labour "reserve") and a non-linear function of the farm operator's age. The operator's age initially has an increasing effect, and then a decreasing effect. It is maximal when the farmer is in his early fifties, that is when two adult generations are the most likely to live on the farm. The amount of domestic tasks (here roughly approximated by the number of children under 10) increases slightly the amount of labour supplied on the farm, in particular by women as it easier for them to combine domestic works with an on-farm activity than with an off-farm occupation.

The agricultural education received by the spouse and the other members of the family has a very positive impact on the quantity of family labour. Indeed, working on the family farm gives them the opportunity to exploit their knowledge assets. However, the farmer's agricultural education level has a low impact, because whether or not he is trained, he always works on the farm.

Among the variables describing the characteristics of the farm, those related to the production systems have a significant impact. Systems involving tasks that must be completed daily, or tasks that must be performed simultaneously (horticulture, dairying) cannot be carried out by a single individual and require a larger family labour force. Conversely, field and permanent crop systems can be managed by a single individual. Indeed, resorting to agricultural contractors in the first case and to seasonal labour in the second, enables the farmer to cope with work peaks at harvest time. The economic size of the holding has the expected positive effect, but it is quite low. Mechanical equipment appear to be complementary to family labour

[8] R^2 is equal to 0.8 in 1988 and 0.71 in 2000.

rather than to be a substitute for it. The variables used to approximate the impact of the amount of cognitive tasks on the volume of family labour have either a low impact or are not significant. Finally, GAECs have, all things being equal, a bigger family labour force as they contain at least two associates. The effect of the status of limited liability agricultural holding is less marked and decreased significantly between 1988 and 2000. This is due to the fact that this status can be adopted by a farm whose operator is the only family worker, a configuration that has become increasingly common for this type of legal status.

Of course, the labour that the family members supply outside the farm reduces the amount of labour that they can supply on the farm, but to a limited extent probably because it reduces also the leisure time. However, this effect was significantly more marked in the year 2000 than in 1988. It may be that some of the members of the family who had a job outside were used to working also on the farm, but that this behaviour is becoming less and less frequent.

5.3 Permanent wage labour

The volume of permanent wage labour depends to a large extent on the characteristics of the farm. It is an increasing function of the farm's economic size. "All things being equal", land intensive farming (horticulture, quality wine-making, other permanent crops) requires a greater number of permanent employees than the more land extensive production systems (field crops, mixed systems of livestock and field crops, dairying). In the latter case, the development of wage employment is hindered by the necessity to increase significantly the area of the farm in order to be able to hire an additional worker. The indicators which, in both agricultural censuses, enable us to approximate the amount of cognitive tasks that the owner must perform, have a strong positive effect on the volume of wage labour used on the farm. Both the frequency of those indicators and their impact on wage employment have increased between 1988 and 2000. When the load of cognitive tasks performed by the farm manager becomes heavier, he has less time to devote to operational tasks, and as a result has to hire employees to complete part of these tasks. We observe a relation of complementarity between the number of tractors and wage employment. The effect of the other categories of equipment is minimal. It was slightly negative in 1988 and had become slightly positive in 2000. Finally, the legal status of the farm has an effect on permanent wage employment. All things being equal, the managers of EARL and GAEC employ more permanent wage-workers than the operators of individual farms. Using wage labour reinforces the integration of the farm in commercial exchanges and therefore makes it more vulnerable to the fluctuations affecting the input and output markets and to the random variations of its production. This explains why employers adopt, more often than others do, a legal status that enables them to better protect their family patrimony if the farm undergoes serious economic difficulties.

A higher general education level (at least equal to long secondary education) has a very positive impact on the volume of wage employment, whereas the same level of agricultural education has a much less positive effect. The management of wage labour probably requires specific skills that are acquired more through general education than through specialised agricultural education.

Seasonal employment appears to be complementary rather than substitutable to permanent employment : seasonal workers and permanent workers are not employed to perform the same tasks. The impact of the recourse to agricultural contractors or CUMAs, which was

not significant in 1988, had become significant, strong and negative in 2000[9]. It appears that nowadays, in order to compensate for the lack of family labour, the externalisation of certain tasks partly replaces the employment of wage labour. As expected, we observe that family labour and wage labour are substitutable. But, according to our estimations one unit of family labour was the equivalent of 1.29 unit of wage labour in 1988, and of only 1.1 unit in 2000 . Two reasons can explain this evolution. First, the level of agricultural and general education of the wage workers has increased significantly over the 1988-2000 period, which has narrowed the skill and productivity gap between wage and family workforces. Second, the share of full-time employees in permanent wage employment has declined in particular because of the development of groups of employers. As permanent wage labour becomes more easily divisible, its volume can be adjusted more accurately to meet the farm's needs. Finally, farmers tend to resort more to permanent wage employment as they grow older and see their strengths decline.

The regional unemployment rate has a positive effect on the volume of wage labour. That probably reflects the negative impact of unemployment on agricultural wages.

6 Conclusion

Our study has enabled us to identify the variables which has a direct or indirect impact on permanent wage labour and to measure their effects. That sheds a light on the mechanisms of evolution of permanent wage employment in so far as they translate into changes in either the mean value of those variables or in their average effects. In French family agricultural enterprises, permanent wage employment increased slightly between 1988 and 2000 (from 0.15 AWU per farm to 0.19). This evolution results from a number of factors with opposite effects.

Firstly, the percentage of farms with at least one family member working outside has significantly increased (from 31% to 46%). This increase appears to result essentially from three factors : the significant rise in the general education level of the wives (22% have a level that is at least equal to long secondary education in 2000 against only 11% in 1988) ; the reduced effect of the number of children on the labour supplied outside ; a more marked impact of the dummy variable indicating the presence of a spouse within the household, which reflects a growing tendency for wives to have an off-farm job whatever be their level of education.

This increase in the frequency of outside employment have contributed to reduce the quantity of family labour supplied on the farm, but to a limited extent as off-farm employment has a moderate, although increasing, negative impact on the labour supplied on the farm by the family members. This tendency has been counterbalanced by two other effects : A dramatic increase in the average size of farms whose SGM has nearly doubled, and an increase in the number of GAECs. In total, the average quantity of on farm family labour has only slightly decreased (from 1.69 AWU on average in 1988 to 1.57 in 2000).

This slight reduction of the family labour supplied on farms, related to the strong increase in the average economic size of farms and in the number of farms where cognitive tasks are performed, as well as an increase in their effects, should have resulted in a growth of permanent wage employment. But, farm operators have simultaneously sought to optimise the quantity of wage labour used, trying to make this factor of production more divisible by developing permanent part-time employment. Moreover, the qualifications of the wage manpower have

[9] A test of equality between these coefficients of the family labour in 1988 and 2000 shows that they are significantly different at the 5% level.

increased. As a result, wage labour has become nearly equivalent to family labour : a family labour unit was only replaced by 1.1 AWU of wage permanent labour in 2000, against 1.29 in 1988. Moreover, there is a tendency in 2000, to externalise labour via agricultural contractors and CUMAs, which have become a substitute for permanent wage labour. This was not the case in 1988. These various factors explain why the increase in permanent wage employment has been moderate.

Finally, we have highlighted a relation of non-substitutability between permanent wage labour and seasonal labour, which requires that both forms of employment be clearly distinguished in the analysis. However, in our model, seasonal labour is considered as an exogenous variable. The next step in our research will be to introduce in the model, an equation of demand for seasonal wage labour. Moreover, our analysis of the factors of evolution of permanent wage labour is based on comparative statistics, that is by observing how the average effects and the mean of the variables affecting the volume of wage employment have evolved between 1988 and 2000. In future, it will be necessary to resort to panel data in order to take into account the changes, which, in each farm, are associated with the variations over time of permanent wage employment.

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A Appendix : Estimations

TAB. 1 – On-farm family labour

Variables	Mean 1988	Mean 2000	β_{88}	β_{2000}	P value 1988	P value 2000
$\widehat{y_2}$ first stage instrumental variable	-0,57	-0,15	-0,029	-0,079	0,000	0,000
Standard Gross Margin (KECU)	39,23	76,06	0,001	0,001	0,000	0,000
Number of tractors	2,62	2,60	0,031	0,034	0,000	0,000
Number of other machines	1,76	1,51	0,016	0,014	0,000	0,000
Use of a computer	0,14	0,28	-0,001	0,006	0,871	0,248
Detailed accounting records	0,40	0,75	0,008	0,034	0,004	0,000
Farmer's AEL at least equal to long secondary	0,07	0,21	-0,077	0,007	0,000	0,307
Spouse's AEL at least equal to long secondary	0,01	0,03	0,105	0,044	0,000	0,000
Farmer's AEL equal to short secondary	0,36	0,46	-0,012	0,024	0,000	0,000
Spouse's AEL equal to short secondary	0,09	0,10	0,133	0,153	0,000	0,000
Farmer's continuing agricultural education	0,17	0,25	0,023	0,051	0,000	0,000
Farmer's age	47,30	45,59	0,019	0,025	0,000	0,000
Farmer's square age	2365,06	2174,10	0,000	0,000	0,000	0,000
Number of children under 10	0,44	0,47	0,029	0,016	0,000	0,000
Farmer's continuing agricultural education	0,18	0,15	0,261	0,198	0,000	0,000
Spouse's continuing agricultural education	2,74	2,68	0,217	0,232	0,000	0,000
GAEC	0,07	0,11	0,675	0,690	0,000	0,000
EARL	0,02	0,16	0,450	0,109	0,000	0,000
Cereals and field crops	0,21	0,22	-0,223	-0,214	0,000	0,000
Horticulture	0,04	0,03	0,118	0,157	0,000	0,000
Other wine-making and fruits	0,06	0,06	-0,207	-0,088	0,000	0,000
Granivores	0,20	0,23	0,024	0,042	0,000	0,000
Field crops and grazing livestock	0,03	0,03	0,077	0,054	0,000	0,000
Quality-wine making	0,12	0,12	0,032	-0,007	0,000	0,553
Beef cattle and other grazing livestock	0,07	0,08	-0,096	-0,048	0,000	0,000
Dairying	0,22	0,19	0,135	0,086	0,000	0,000
Constant term			0,336	-0,038	0,000	0,305

AEL : Agricultural Education Level

Tab. 2 – Off-farm family activity

Variables	Mean 1988	Mean 2000	β_{88}	β_{2000}	P value 1988	P value 2000
$\widehat{y_1}$ first stage instrumental variable	1,69	1,57	-0,652	-0,525	0,000	0,000
Farmer's GEL at least equal to LS	0,07	0,15	0,051	0,027	0,150	0,130
Spouse's GEL at least equal to LS	0,11	0,22	0,542	0,506	0,000	0,000
Farmer's age	47,30	45,59	-0,014	-0,022	0,000	0,000
Spouse on farm	0,82	0,71	0,628	0,866	0,000	0,000
Number of children under 10	0,44	0,47	-0,041	0,015	0,001	0,077
Other family members' GEL at least equal to LS	0,18	0,22	0,033	0,220	0,170	0,000
Household size	2,74	2,68	0,607	0,512	0,000	0,000
Regional unemployment rate	10,30	10,08	-0,021	-0,023	0,000	0,000
Constant term			-0,785	-0,259	0,000	0,000

GEL : General Education Level
LS : Long Secondary

Tab. 3 – Tobit equation of permanent wage labour

Variables	Mean 1988	Mean 2000	β_{88}	β_{2000}	P value 1988	P value 2000
Standard Gross Margin (KECU)	39,23	76,06	0,024	0,013	0,000	0,000
Number of tractors	2,62	2,60	0,192	0,137	0,000	0,000
Number of other machines	1,76	1,51	-0,028	0,064	0,016	0,000
Use of a computer	0,14	0,28	0,658	0,837	0,000	0,000
Detailed accounting records	0,40	0,75	1,146	1,422	0,000	0,000
Farmer's GEL at least equal to long secondary	0,07	0,15	0,985	0,749	0,000	0,000
Farmer's AEL at least equal to long secondary	0,07	0,21	0,111	0,279	0,058	0,000
Farmer's age	47,30	45,59	0,055	0,028	0,000	0,028
Farmer's square age	2365,06	2174,10	0,000	0,000	0,730	0,129
Seasonal wage labour AWU	0,11	0,18	0,136	0,106	0,000	0,000
Agricultural contractor and CUMA AWU	0,01	0,01	0,723	-0,608	0,215	0,029
Regional unemployment rate	10,30	10,08	0,052	0,034	0,000	0,001
GAEC	0,07	0,11	0,315	0,436	0,001	0,000
EARL	0,02	0,16	0,670	0,483	0,000	0,000
Cereals and field crops	0,21	0,22	-1,050	-1,039	0,000	0,000
Horticulture	0,04	0,03	1,937	2,390	0,000	0,000
Other wine-making and fruits	0,06	0,06	0,813	0,454	0,000	0,000
Granivores	0,20	0,23	0,072	-0,148	0,395	0,129
Field crops and grazing livestock	0,03	0,03	-0,400	0,193	0,000	0,105
Quality-wine making	0,12	0,12	-0,445	-0,442	0,000	0,000
Beef cattle and other grazing livestock	0,07	0,08	0,758	0,285	0,000	0,005
Dairying	0,22	0,19	-0,347	-0,493	0,000	0,000
$\widehat{\widehat{y_2}}$	1,69	1,57	-1,291	-1,099	0,000	0,000
Constant term			-5,773	-5,869	0,000	0,000

AWU : Annual Work Units