Demand for seasonal wage labour in agriculture: what does family farming hide?

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Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009

Abstract

Seasonal wage labour was rarely distinguished from the permanent one in farm-household models although it has sharply increased in developed countries. Therefore, we propose to endogenize the demand for this peculiar labour type and highlight the trade-offs for the various labour combinations on farms. We use data on fruit and vegetables farms drawn from the 2000 French agricultural census. We show that seasonal wage labour is a substitute for permanent wage employment, and doesn't entirely follow the seasonality of the agricultural activity: competition on the labour and product markets play a significant role in the employment of labour types.

Keywords : Agricultural household model, wage labour, seasonality, France

JEL classification : J43, D13, J23, Q12

Introduction

Until the mid-1990s the family nature of farming in developed countries seemed to be growing stronger, with a regular increase in the proportion of family labour (Hill, 1993; Schmitt, 1991). However, over the past fifteen years this trend has been reversing, as wage labour becomes common on farms in these countries (Findeis, 2002). This is particularly evident in the labour-intensive fruit and vegetable sector where mechanization is difficult and 7 to 20 times more amount of labour is required per hectare than for other crops.

Parallel to the increase of the proportion of wage labour, many European countries have experienced changes in the wage labour regulation concerning the agricultural sector. In particular, since the late 90's, short term contracts have often been exempted from taxes. In France, Germany, Spain and the Netherlands for example, the fruit and vegetable sector is since then almost totally exempted. Moreover, the use of temporary immigration labour contracts extended. In Germany, temporary migrant workers from Eastern Europe are allowed to work 3 months a year with visa facilities since 1991; leading to the employment of more than 300 000 temporary migrant workers. Spain counts since 2001, with about 70 000 temporary migrant workers per year entering the country to work in agriculture. The number of introductions is less important in France (about 15 000 per year) but it has increased since 2001 (+105%). The migrant workers represent almost 20% of seasonal wage labour in the French fruit and vegetable sector (Darpeix et al., 2009).

These changes in the regulatory framework are likely to impact the wage labour composition at the farm level. However, the economics of agricultural labour has focused primarily on family labour and has either largely overlooked wage labour or failed to take into account differences within it.

The aim of this article is to provide a framework of analysis that covers the three different types of labour on farms: family labour, permanent hired labour, and seasonal hired labour[1]. We investigate the family labour relatively to permanent wage and seasonal wage labour demand to show the complementarities (or substitutions) between these types of labour. We

[1] The externalization of work (via farm work firms or farm equipment cooperatives) represents less than 1% of all farm work in the sector under consideration.

take into account two neglected characteristics of family farming: the fact that it can use hired labour, and the fact that it is characterized by seasonal work.

Our focus is on the French fruit and vegetable sector, in which most farms are family-run, but employ a substantial amount of wage labour. In the 27 European countries, farms specialized in fruit and vegetables represent 6% of all farms but account for almost 14% of the total value generated by agricultural production[2].

Our research question is set out in more detail in the first part of the article. In the second part we present a theoretical model of the farm household, into which we introduce seasonal work. The third section describes the empirical methodology and data used to study the complementarities and substitutions between the different types of labour. Finally, our empirical findings and conclusions are presented.

1 Seasonal wage labour and family farming

Labour force on French fruit and vegetable farms has been undergoing considerable change since the end of the eighties. The share of family labour has declined while that of hired labour – either permanent or most often seasonal – has been increasing. As shown in Table 1, family labour, which accounted for 70% of all farm labour in 1988, had dropped to only 51% by 2005. However, the amount of labour of farmers and business partners[3] has remained stable, while that of other family members decreased drastically.

Conversely, the proportion of wage labour as a whole has increased (+5% for permanent work, +14% for seasonal work). Between 1988 and 2000, the amount of seasonal work rose from 38,838 to 45,854 AWU[4]. This type of work has therefore increased both as a percentage and as an absolute value, in a context where the number of farms and the overall amount of work are declining (-40% and -31%, respectively).

-Insert Table 1-

[2] Eurostat 2007

[3] An agricultural holding can be managed by two or more persons acting jointly, namely business partners, and is hereby considered as a unique economic entity .

[4] AWU: annual work unit, a unit equivalent to one person working full-time for a year.

1.1 Fluctuations of activity versus reductions of wage costs

The use of temporary forms of employment[5] has been studied extensively in the literature since the 1980s, a period that witnessed the upsurge of atypical forms of work, such as temporary contracts or service delivery (Atkinson, 1985, 1987).

Sauze, Thévenot and Valentin (2008) account for the use of temporary employment in two ways: a) firms use temporary employment to cope with intra-annual fluctuations; and b) this type of employment enables them to reduce labour costs, as temporary contracts are generally more flexible than permanent ones (with lower severance pay) and often benefit from substantial exemptions.

According to this framework of analysis, two factors can thus explain the increase in seasonal work in the fruit and vegetable sector. First, it can be linked to the accentuation of intra-annual fluctuations of activity characterizing this sector. As fruit and vegetables are perishables that generally cannot be stored, the sector is by nature subject to steep fluctuations. The amount of work required per hectare can, for example, be multiplied by five in fruit farming during peak periods, that is, at harvest time, compared to slack periods. Certain trends in this sector are tending to increase these fluctuations, for instance concentration and specialization of farms. The concentration of cultivated areas on a small number of larger farms increases the demand for hired labour. Specialization reinforces the seasonality of work, unlike diversification which generally makes it possible to spread out the amount of work in agriculture over the year. Furthermore, since much of the work in this sector cannot be mechanized, the increase in farm yields, stemming from plant variety improvements and/or the use of fertilizers and pesticides, intensifies the need for labour to harvest crops. Hence, the increase of seasonal work appears to result from the accentuation of fluctuations of activity in a context of increasing use of hired labour.

Second, the increase of seasonal work in the fruit and vegetable sector can be related to changes in manpower management. The constraints weighing on the sector are growing and are exacerbating pressure to reduce costs. The integration into the European Union of

[5] Seasonal work is a form of temporary work..

countries with low labour costs and the gradual liberalization of trade within the Euro-Mediterranean zone are intensifying competition. For products such as fruit and vegetables, in which differentiation is limited, competition mainly revolves around costs and especially labour costs which often account for over 50% of a production's expenses. As hyper- and supermarkets are playing an ever-greater part in the distribution of fruit and vegetables (Jeannequin et al., 2005), centralized purchasing and successive mergers of distribution groups are accentuating the monopsony of mass distribution and reducing farmers' power of negotiation (Rey et al., 2000). In this context the increase of seasonal work can reflect an endeavour to reduce labour costs and result in a substitution between two types of hired labour: permanent and seasonal.

1.2 Wage labour in family farming

One of the particularities of farms in developped countries is the important role of family labour. The status and the involvement in the agricultural activity differ among family members. Each member can be a business partner or can have no specific juridical status. As family structures evolve towards a smaller core (children study for longer, grand-parents live far from the farm, the spouse does more often off-farm work, etc.), the number of individuals prepared to work on the farm, either occasionally or regularly, is declining. The substitution of hired labour for family labour may therefore account for the increase in the share of seasonal wage labour.

The evolution of employment in the fruit and vegetable sector may be due either to an accentuation of fluctuations of activity, or to a substitution between different types of labour: between family labour (other than the farmer) and hired labour, and between permanent and seasonal hired labour.

The economics of farm labour has rarely investigated this link between these different types of labour. Many studies examine the labour decisions of farm households (on- and off-farm labour supply) by focusing primarily on the farmer's decisions (Sumner, 1982), and then on those of the couple (the farmer and his/her spouse) (Kimhi et al., 1996). These studies have been based on agricultural household models which integrate the farmers' or the farm household's production and consumption decisions (Singh et al., 1986). Some authors have highlighted the interdependence between the household's labour decisions and the demand for

hired labour on the farm (Benjamin *et al.*, 1996; Benjamin *et al.*, 2006; Blanc *et al.*, 2008; Findeis *et al.*, 1994). But very few authors have broken down hired labour into permanent and seasonal labour. Blanc et al. (2008) distinguish between these two types of labour but treat seasonal labour as an exogenous factor of production for which the demand is not estimated in conjunction with the supply of family labour and the demand for permanent labour. Findeis and Lass (1994) study the interdependence between the farmer's labour supply decisions and the overall demand for hired labour. They show that permanent wage labour and seasonal wage labour are two different categories, but they do not estimate the demand for these two types of demand conjointly. Substitution is therefore not observable between permanent wage labour and seasonal wage labour.

Another stream of literature has explored the existence of under-employed permanent workers during periods of slack activity in seasonal production (Bardhan, 1979, 1983; Eswaran *et al.*, 1985; Gunter *et al.*, 1988; Pal, 1999, 2002). Bardhan (1979) contends that the under-employment of permanent workers generates hoarding costs, but enables the farmer to reduce recruitment costs and to ensure that a certain amount of labour is available for the peak season. Eswaran and Kotwal (1985) and Pal (1999; 2002) argue that wage labour is segmented according to the characteristics of the tasks (monitorable tasks for seasonal workers and non-monitorable tasks for permanent workers). The choice of the type of worker therefore corresponds to a trade-off between supervision costs and hoarding costs. None of these authors however examines the relationship between permanent and seasonal work, except in the context of non-family farming enterprises. The relationship between family labour and hired labour (permanent and seasonal) is therefore not considered.

Our research explores the link between these two streams of literature and integrates two characteristics of agriculture: its seasonal and family aspects. We propose a agricultural household model that allows for dependence between the decision to employ wage labour (by distinguishing permanent and seasonal workers) and the involvement of family labour in the farming activities. The aim is to understand the complementarity/substitutions between the different types of labour. We focus on the fruit and vegetable sector, which is characterized by large-scale use of wage labour, yet where family labour remains important enough to justify the use of a farm household model[6].

[6] In 5% of the largest farms in our sample (cf. paragraph 3), family labour still accounts for over 20% of all labour.

2 Seasonality in an agricultural household model

Drawing on the traditional literature on unitary agricultural household models (Benjamin, Corsi and Guyomard, 1996; Benjamin and Kimhi, 2006; Blanc, Cahuzac, Elyakime and Tahar, 2008; Singh, Squire and Strauss, 1986), we propose to investigate the properties of a two–season agricultural household model in which we distinguish between a planting season (denoted 1) and a harvesting one (denoted 2) (Bardhan, 1979, 1983; Innes, 1993; Saha, 1994) that differ according to farm activities. In order to allow for flexible labour decisions across the two seasons - representing a whole crop season-, labour can be hired on a permanent –that is for the whole- or fixed-term –that is one season- basis.

We assume that the household utility (U [7]) is a function (u) of consumption (C) and leisure (l)[8] :

$$U = u(C_i, l_i) \quad \text{where } i = \{1, 2\} \tag{1}$$

In the planting season (1), the output is equal to 0. However the amount of labour L_1 is used to produce Q in the following harvesting season (2) [9].

$$Q = q(L_1) \tag{2}$$

We assume that the labour input in the harvesting season (L_2) is proportional to harvested crop *(Q)*, which is in its turn determined by the labour decision in season 1 :

$$L_2 = k.q(L_1) \text{ with k>0} \tag{3}$$

As there is no agricultural revenue in the planting season, we allow for a money transfer (S) between two seasons to sustain the household consumption (Saha, 1994)[10].

We consider that the labour force working on-farm may be composed of family labour F, permanent wage labour L^{perm} and seasonal wage labour L^{seas}.

$$L_i = F_i + L_i^{perm} + L_i^{seas} \qquad i = 1, 2 \tag{4}$$

[7] u is twice differentiable and quasi-concave.

[8] The prices of the goods are normalized to unity.

[9] q is twice differentiable and quasi-concave.

[10] Alternativelty, the farmer borrows S in season 1and pays it back in season 2.

Furthermore, the family may work off-farm (F^o) where their exogenous wage rate is w^o [11]. Let $\overline{w}$ be the wage rate for on-farm labour (wage permanent and seasonal). Workers on farm (family members and hired workers) are homogeneous. Contrarily to the original approach of agricultural household models, we consider that w^o can be different from $\overline{w}$.

We define permanent workers as being hired over the two seasons. As seasons have the same duration, we draw from this definition that:

$$L_1^{perm} = L_2^{perm} = L^{perm} \tag{5}$$

Following Bardhan (1979; 1983), we consider the cost of seasonal labour is stochastic across seasons: $\tilde{c}_i$ is a random variable : $\tilde{c}_i \mapsto N\left(0, \sigma^2\right)$ and stands for the search costs borne by the employer as we assume a potential local agricultural labour shortage. This choc is wage additive and proportional to the quantity of labour: $\tilde{c}_i L_i^{sais}$. It reflects the difficulties to find a seasonal worker and depends in particular to the importance of this type of labour force and to its disponibility.

Following Innes (1993) et Saha (1994), the model has an overlapping structure, namely the end of season 2 is also the beginning of the next season 1 (Annex 1). The outcomes of the random variable $\tilde{c}_i$ are independent across seasons and there is no learning process across cropping cycle.

In season 2, the household optimisation problem with respect to time, budget and intertemporal constraints is:

$$\begin{aligned}
&\underset{\{C_2, l_2\}}{Max}\, Z_2 \equiv U\left(C_2, l_2\right) + \rho EU\left(C_1, l_1\right) \\
&\text{subject to} \\
&pQ - \overline{w}(L^{perm} + L_2^{sais}) - c_2(L_2^{sais}) + w^o F_2^o + I_2 - S = C_2 \\
&S - \overline{w}(L^{perm} + L_1^{sais}) - \tilde{c}_1(L_1^{sais}) + w^o F_1^o + I_1 = C_1 \\
&L_i = F_i + L_i^{perm} + L_i^{sais} \\
&T = F_i + F_i^o + l_i \\
&S > 0 \\
&F_2 \geq 0 \\
&F_2^o \geq 0
\end{aligned} \tag{6}$$

[11] The disutility of work is the same for farm and non-farm activities.

where I_2 is the family non-labour income, *T* the household total time endowment and ρ an intertemporal discount factor (0<ρ<1). The endogenous variables are F_2, F_2^o, S.

In season 1, the optimal choice for the endogenous variables $L_1, F_1, F_1^o, L^{perm}$ is derived from:

$$
\begin{aligned}
&\underset{\{C_1,l_1\}}{Max}\, Z_1 \equiv U\left(C_1,l_1\right)+\rho EU\left(C_2,l_2\right)\\
&\text{subject to:}\\
&S-\overline{w}(L^{perm}+L_1^{sais})-c_1(L_1^{sais})+w^oF_1^o+I_1=C_1\\
&pQ-\overline{w}(L^{perm}+L_2^{sais})-\tilde{c}_2(L_2^{sais})+w^oF_2^o+I_2-S=C_2\\
&L_i=F_i+L_i^{perm}+L_i^{sais}\\
&T=F_i\ +F_i^o+l_i\\
&L_1\geq 0\\
&F_1\geq 0\\
&F_1^o\geq 0\\
&L^{perm}\geq 0
\end{aligned}
\qquad (7)
$$

A first result shows that (see Annex 2 for demonstration) the intertemporal constraint is:

$$\left(\frac{\partial U}{\partial C_2}/\frac{\partial U}{\partial C_1}\right)=\rho \qquad (8)$$

Non surprinsingly, the marginal rate of substitution between the value of consumption in season 1 and in season 2 equals the intertemporal discount factor.

We derive the optimal production choice (*Q)* as a second preliminary result:

$$
\begin{aligned}
&\rho^2 p\frac{\partial q}{\partial L_1}=(\overline{w}+c_1)+\rho^2\frac{\partial L_2}{\partial L_1}E\left(\overline{w}+\tilde{c}_2\right)\\
&\left(\text{if } \rho^2 p\frac{\partial q}{\partial L_1}<(\overline{w}+c_1)+\rho^2\frac{\partial L_2}{\partial L_1}E\left(\overline{w}+\tilde{c}_2\right) \text{ then } L_1=0\right)
\end{aligned}
\qquad (9)
$$

At the optimum, the discounted marginal product of labour in season 1 equals the sum of the labour cost in season 1 and the discounted cost of the marginal variation of labour in season 2 induced by the variation of the amount of labour in season 1. In other words, the marginal product of labour in the planting season (L_1) is linked not only to the labour cost in season 1 but also to the cost of extra-labour needed in season the harvesting season 2. Indeed, the amount of labour in season 1 determines the production *(Q)* to be harvested in season 2, and thus the amount of labour in this season (L_2).

In the rest of the text $\left(\frac{\partial U}{\partial l_i} / \frac{\partial U}{\partial C_i}\right) = MRS_{C_i/l_i}$ where MRS_{C_i/l_i} is the marginal rate of substitution of consumption in season *i* for leisure in season *i*.

Family labour

Family off-farm labour supply

For each season, the family is engaged in off -farm activities if $(F_i^o > 0)$:

$$\begin{gathered} MRS_{C_i/l_i} = w^o \\ \left(\text{if } MRS_{C_i/l_i} > w^o \text{ then } F_i^o = 0\right) \end{gathered} \tag{10}$$

The off-farm labour supply of the family members depends on the wage they can get from non-agricultural activities (w^o). The more remunerative external job opportunities, the more the family works off the farm.

Family on-farm labour supply

The family works on the farm if $(F_i > 0)$:

$$\begin{gathered} MRS_{C_i/l_i} = \overline{w} + c_i \\ \left(\text{if } MRS_{C_i/l_i} > \overline{w} + c_i \text{ then } F_i = 0\right) \end{gathered} \tag{11}$$

For each season, the on-farm labour supply of the family depends on the seasonal labour cost $(\overline{w} + c_i)$. The higher this cost, the more the family works on the farm.

The family labour supply depends jointly on the wage labour cost (seasonal) and on the wage the family members can get from non-agricultural activities.

Demand for permanent workers

The decision to hire permanent workers on the farm $(L^{perm} > 0)$ depends on the following condition:

$$\begin{gathered} (\overline{w} + c_1) + \left[\overline{w} + \rho^2 E\left(\tilde{c}_2\right)\right] = 2\overline{w} \\ \left(\text{if } (\overline{w} + c_1) + \left[\overline{w} + \rho^2 E\left(\tilde{c}_2\right)\right] < 2\overline{w} \text{ then } L^{perm} = 0\right) \end{gathered} \tag{12}$$

Thus, the farmer hires permanent workers instead of seasonal or family workers if the cost of a permanent worker over the two seasons is less than the sum of the cost of a seasonal worker in season 1 and his expected discounted cost in season 2.

The amount of permanent work is determined in relation to the anticipated cost of seasonal labour. Additional needs on the farm are met either by seasonal labour or by family labour if the family's reservation wage is lower than the cost of seasonal labour (taking into account the surplus cost in this event $(c_i > 0)$). Permanent workers therefore serve as an ex-ante insurance against the uncertainties of seasonal labour costs. The family has a role of ex-post adjustment, depending on the actual event.

The table below summarizes the different trade-offs in the joined labour decision.

-Insert Table 2-

The model takes into account the seasonality of agricultural production and considers different categories of farm labour. It emphasizes the fact that the existence of each category of farm labour depends on wages and costs and that each category of workers may have different roles on the farm.

Thanks to the model, we described the conditions under which each category of farm labour exists. Several combinations of these categories, that we call labour regimes, are possible. In the rest of this article we estimate the probability of a farm belonging to each of the labour regimes, to show the complementarities/substitutions between the different types of labour. As our model considers the seasonality and emphasizes the role of wages and costs, we use original variables in our econometric model to reflect seasonality of farm activity, wages and search costs for seasonal workers.

3 Presentation of the econometric model and the data

3.1 Econometric model

Like Benjamin et al. (1996), Findeis et al. (2002), and Benjamin et al. (2006), we use a multinomial logit model to estimate the probability of a farm to belong to a specific labour regime (namely particular combination of the different categories of labour: family[12],

[12] We do not consider the business partners' labour supply.

permanent, and seasonal). The eight labour regimes in the theoretical model are presented in Table 3. The reference regime is the one in which the farmer works only with family labour. This regime corresponds to the so-called traditional farm: a purely family farm.

-Insert Table 3-

We see that the farm belongs to one of the regimes: $V_{kj}=1$ if the farm k belongs to the regime j. We consider here that the farmer k chooses the regime that affords him/her the greatest indirect utility (latent variable U_{kj}*), depending on characteristics X_k (characteristics of the farmer and his/her family, and of the farm and its location).

We thus choose the following model:

$$U_{kj}^{*} = \alpha + X_k \beta + \varepsilon_k$$

$$\text{with } \begin{cases} V_{ki} = 1 \text{ if } (\beta'_j - \beta'_i) X_k > \varepsilon_{ki} - \varepsilon_{kj} \ ; \ \forall i \neq j \\ V_{ki} = 0 \text{ or else} \end{cases}$$

3.2 Data description and model specification

We lead a static analysis, using individual data from the French agricultural census of 2000.

The sample

We study professional farms[13] on which fruit and vegetables account for at least 50% of the farming production[14]. To work with homogeneous systems of production, we focus on three large technico-economic orientations categories (Ote[15]). The farms of the sample are family farms[16] in which there exists a pool of potentially active family labour (members of the family other than the partner, between the ages of 15 and 70).

[13] In the sense of French agricultural statistics, i.e. a farm of economic dimensions (SGM) > 9,600€ and using at least 0.75 AWU. The Standard Gross Margin (SGM) determines the business size of a farm. It is equal to the value of the production less the cost of variable factors (in €).

[14] Fruit and vegetable SGM > 50% of the total SGM.

[15] The OTE (which stands for Technico Economic Orientation) is determined by the relative contribution of the different productions to the total SGM of the holding.

[16] In order to work on only one family per farm, we have eliminated the 96 farms on which at least one business partner is not directly related to the farmer.

A total of 16,181 farms are thus selected. These farms are subject to the same changes as all fruit and vegetable farms.

The distribution of farms in our sample across the various regimes corresponds to the proportions presented in Table 3. The purely family regime (100), which is the reference regime, accounts for 24.1% of the sample.

Most of the farmers in our sample work full-time on the farm and have no off-farm employment[17]. This justifies our choice not to study the farmer's own labour supply.

The variables

We sort our explanatory variables into four groups: the farmer's individual characteristics; those of the family; those of the farm and its production; and the local characteristics (see Annex 5 for the definition and description of the variables).

The farmer is characterized by his/her age (*age*), experience[18] (*exp*), general education (lower than secondary (*ge1*), equivalent to secondary (*ge2*) or higher than secondary (*ge3*)) and agricultural training (lower than secondary (*at1*), equal to secondary (*at2*) or higher than secondary (*at3*)). The farmer's human capital may reflect his/her agricultural skills and managerial skills.

Family labour consists of the members of the family living with the farmer or working regularly on the farm. We take into account the size of the pool of family labour (number of members who are not business partners, between the ages of 15 and 70 (*nf1570*)). Within this pool we check whether there is at least one person with training in farming (*fat*) and at least one with general higher education (*fge*). This gives us the agricultural competence of this labour as well as the opportunities for off-farm employment. We note the number of children under the age of 12 (*nc012*) and the existence of at least one business partner (*part*). The work provided by the partners is not counted in our category of family work. On farms with partners (8% of the sample), the global amount of family work is therefore under-estimated[19].

The farm is defined in terms of its economic dimension, measured by its total standard gross margin (*SGM*). We have very little information on the farm capital. We use the number of

[17] 85% of the sample.

[18] Number of years since he entered farming.

[19] *Part* is therefore a control variable designed to capture the under-estimation of family work on farms run in business partnership.

tractors *(tract*) variable as a proxy of this capital. We note the presence of an autonomous structure for commercializing products (*Comm*), as the incorporation of packaging can generate an increase in the demand for labour at harvest time. Likewise, we note the presence of signs of quality[20] (*qual*). In the fruit and vegetable sector the implementation of quality signs generally results in an increase in the demand for labour. We also note whether the farmer has an hail insurance policy (*insur*) or not.

Classically, we characterize the production in terms of the farm's technico-economic orientation (*Ote*). We distinguish between the following orientations: open-field vegetables (*OteOf*), open-air vegetables (*OteOa*), greenhouse vegetables (*OteG*), open-air and greenhouse vegetables (*OteOaG*), fruit (*OteF*) and mixed farming (*OteM*). The description of the production often stops with this single variable but, although it is relevant, we consider it inadequate to grasp farm work. We therefore calculate the degree of specialization of fruit and vegetable production (*H*) and the weight of highly perishable produce on the farm (*P*). We consider that the degree of specialization corresponds to the concentration of the production on a small number of products. We calculate a Herfindhal indicator of production in relation to its economic weight (see Annex 3)[21]. Since specialization concentrates the farming activity on a period of the year, *H* represents the degree of concentration of the activity. The weight *P* of highly perishable fruit and vegetables[22] in the total farm's produce is used as a proxy of the constraint of commercialization (Annex 4). The more perishable a product, the shorter the lapse of time in which it has to be harvested, and the less it can be stored. Perishable crops have to be sold rapidly, which increases the constraints of commercialization by reducing the farmers' outside options. Perishability may also compel the farmer to reduce costs and especially labour costs[23].

[20] Organic farming, quality labels, certificates of conformity, etc.

[21] $H \in]0;1]$. The closer H is to 1, the more specialized the farm is in a small number of crops.

[22] Group 4 of perishability in the classification of Emlinger, C., Lozza, E. C. and Jacquet, F. (2006) Eu market access for mediterranean fruit and vegetables: A gravity model assessment. *Working paper MOISA* Working paper MOISA, Montpellier, 16, 1-21.]. $P \in]0;1]$. When P tends towards 1, the weight of highly perishable produce increases.

[23] This variable is meant to capture the seasonality of the production. Moreover, some of the crops are proved to be highly seasonal without being perishable (for example, asparagus).

Finally, *local characteristics* are the characteristics of the area[24] in which the farm is situated. We note whether farming in this area is predominantly fruit and vegetable production (*FV*). Access to certain types of seasonal labour is differentiated according to the area. The possibilities of access to temporary immigration labour contracts vary from one district to another. They are often greater in districts that are large producers of fruit and vegetables (Darpeix, 2008). We also note the type of employment area, which can be an urban employment area (*urban*), a rural employment area (*rural*) or a remote rural employment area (*rrural*). These variables give indications as to competition from other sectors for wage labour, and the possibilities of off-farm work for the family (opportunity cost of off-farm work). Hence, the fact of being situated in an urban area would increase the family's employment opportunities while creating competition on wage labour likely to be employed in other sectors (e.g. building).

We also include regional dummies as control variables in the regression (22 French administrative regions).

4 Empirical results

The pseudo R^2 of the logit multinomial is 0.21 and the hypothesis of the absence of explanatory power of the model is rejected[25]. The model is robust when removing the explanatory variables according to the categories described above. Each coefficient represents the effect of the considered variable on the probability of belonging to a particular labour regime, relatively to belonging to a reference regime (regime 100). All our variables have a significant effect in at least one of the regimes. We calculate the marginal effects[26] enabling us to directly interpret the coefficients. The results are reported in Table 4.

-Insert Table 4-

[24] Living area (*Bassin de vie)*: space in which most inhabitants look for employment and key public facilities. French zoning (DATAR 2003, data for 1999).

[25] No heterocedasticity was found.

[26] As we include sets of dummy variables and polynomial terms in our regression model, we calculate these marginal effects using the procedure developed by Bartus Bartus, T. (2005). Estimation of marginal effects using margeff. *STATA JOURNAL* 5: 309-329..

4.1 Characteristics of the farmer and the family

The farmer's level of agricultural education reduces significatively the propensity to be in the purely family labour regime (100) and increases the propensity to be in the purely wage labour regime (011). The farmer's level of general education reduces the propensity to be in the non-wage regimes (100 and 000) and in the regimes with seasonal wage workers (101 and 001). It increases the propensity to be in the purely wage labour regime (011) and in the permanent labour regime (010). In fact, the farmer's level of education may reflect his/her managerial competencies (administrative procedures, corporate management, etc.): a high level of education seems to facilitate the use of permanent wage labour, which generally requires more anticipation and higher managerial skills. With regard to the influence of the household head education level, permanent wage labour and seasonal wage labour seem to fulfil distinct requirements. Whereas seasonal wage labour turns out to be used as a complement to family labour, permanent wage labour appears to be a substitute to family labour.

The number of family members between the ages of 15 and 65 increases the propensity to be in the family regimes (100, 101, 111) and decreases the propensity to be in the regimes where there is no family labour but that of the family head (000,001,010,011). Thus, unsurprisingly, the bigger the pool of family labour, the more the farmer uses it. However, these effects are less clear when permanent wage labour exists, suggesting that family labour and permanent wage labour are substitutes.

When one of the family members has technical farming skills, the propensity to be in the regimes with family labour increases. In contrast, the family members' level of general education has the inverse effect: a high level reduces the probability of the regimes using family labour. The higher the general education of family members is, the more likely the latter are to find a job off the farm. The results suggest that they are then replaced by wage labour.

The existence of young children also reduces the propensity to be in the purely family regime (100) and increases the propensity to be in the purely wage labour regime (011) and in the permanent labour regime (010). As spouses are counted as family members[27], the presence of

[27] Only 2.9% of the spouses in the sample are partners.

children causes them to focus their activity on domestic production. Farm work is then given to wage labour and more particularly to permanent wage labour.

These findings show, as expected, that wage labour, and more particularly permanent wage labour, are a substitute for family labour. Family members who disengage from farm work are replaced by permanent hired workers. These results are consistent with the literature (Benjamin, Corsi and Guyomard, 1996; Benjamin and Kimhi, 2006; Blanc, Cahuzac, Elyakime and Tahar, 2008; Findeis and Lass, 1994). However, the fact the present study distinguishes particularly the seasonal wage labour shows that the latter is used as a complement to family labour.

4.2 Characteristics of the farm and its production

Large farms are associated with a higher probability to be in the regimes with permanent wage labour (110, 010) or wage labour as a whole (111, 011). They are less likely to be in the non-wage regimes (100, 000) or in the regime with seasonal wage labour (101, 001). As the size of farms increases, they slide from traditional family farming to an entrepreneurial type of farming that uses hired labour, and where family members have the status of partners or work off the farm.

A large number of tractors is associated with a lower propensity to be in the non-wage regimes (100, 000) and with a greater propensity to be in the wage regimes (111, 011). As mechanization is limited in the fruit and vegetable sector, labour capital substitution is weak. Investment in productive structures often leads to an intensification of work (e.g. the introduction of off-soil production in greenhouses). It can therefore be argued that capital and labour are complementary rather than substitutable.

The existence of a commercialization structure and the presence of signs of quality decrease the propensity to be in the non-wage regimes (100, 000) and with a lower propensity to be in the wage regimes (111, 011). Packaging and quality signs induce an increase in the demand for labour. This increase is essentially met by seasonal wage labour in the case of signs of quality (there is a positive effect of the variable on the regimes 101 and 001). On the contrary, it is met by permanent wage labour in the case of a commercialization activity (there are a negative effect on 101 and 001 and a positice effect on 101).

The increase in the size of farms as well as the expansion of farming to include related activities such as packaging, increase the demand for wage labour. These findings are also

consistent with the literature (Benjamin, Corsi and Guyomard, 1996; Benjamin and Kimhi, 2006; Blanc, Cahuzac, Elyakime and Tahar, 2008; Findeis and Lass, 1994).

The existence of an hail insurance policy is associated with a lower propensity to be in the non-wage labour regime (100) and with a greater propensity to be in the wage regimes (111, 011). In fact, if the farmer hired employees, he is responsible for the regular payment of their wage so that he may be more inclined to lower the risk of low cash flow in case of bad weather.

To stick to the analytical proposition we made in the first part of the article, we introduce further variables that should influence the type of labour used: namely, the seasonality of production, the perishability of produce, and, latter in the text, the location of the farm.

First, the greater the degree of seasonality of the production (concentration of production – *H*), the less probable family labour regimes are - compared to labour regimes without family. But, the distinction between the two types of wage labour is obvious. On the one hand, as expected, a higher degree of seasonality corresponds to a higher probability to observe seasonal wage labour on the farm. On the other hand, family labour turns out to be associated with more permanent activities.

The presence of highly perishable produce on the farm decreases the propensity to be in the non-wage regimes (100, 000) and the propensity to be in the wage regimes (111, 011). The non-wage regimes are less probable because the highly perishable crops generally require seasonal labour for the peaks of activity. However, the negative effect of the perishability on the wage labour regimes suggests that the farmer facing a high commercialization constraint is less disposed to use permanent wage labour, which is less flexible and more costly.

4.3 Characteristics of location

The location of the farm in an urban employment area (compared to a rural area) increases the propensity to be in the regimes with seasonal hired workers and reduces the propensity to be in the regimes with permanent hired workers. Inter-sector competition with urban jobs (urban employment area) increases permanent employment and reduces seasonal employment. This suggests a substitution between seasonal labour and permanent labour. In urban areas, to

avoid the loss of labour to other types of employment, farmers seem to prefer to keep their wage labourers.

Local specialization in the production of fruit and vegetables increases the propensity to be in the regimes with seasonal hired workers and reduces the propensity to be in the regimes with permanent hired workers. Regional specialization therefore seems to create the conditions for the constitution of a pool of temporary labour (especially with access to temporary immigrant jobs -ANAEM contract- which differs, depending on the district). Farmers therefore do not seem to want to keep their wage labourers; they prefer to use the available pool of temporary labour.

Our variables of location enable us to highlight the insurance role that permanent labour can play in contending with difficulties of recruiting seasonal labour. This role increases when the opportunity cost of off-farm work for the family is high.

Thus, our findings show that family labour is complementary to seasonal wage labour and substitute for permanent wage labour. Moreover, seasonal labour and permanent labour are substitutes since competition for wage labour in urban contexts reinforces the permanent nature of employment and reduces its seasonal nature. On the contrary, the existence of a pool of temporary labour reinforces the seasonnal nature of employment.

5 Discussion and conclusion

This study has provided a framework of analysis with which the heterogeneity of hired labour in family farming can be taken into account. It has enabled us to take two neglected characteristics of family farming into consideration: the fact that it uses wage labour, and the fact that it is characterized by seasonality.

The breakdown of hired labour into permanent and seasonal labour is relevant since seasonal wage labour turns out to be used as a complement to family labour and permanent wage labour appears to be a substitute to family labour. Distinguishing both labour types also brings to light that substitutability exists between permanent and seasonal wage labour. The increase in the share of seasonal wage labour corresponds not only to an increase in intra-annual fluctuations of agricultural activity, but also to changes in manpower management due to intensifying competition and pressure to cut costs as it can occur in other activity sectors.

In many European countries, policies that make the use of seasonal workers cheaper and/or easier have been implemented: tax exemption on agricultural short term contracts (Germany, Spain, Netherlands, France…), increase of quotas on temporary immigration labour contracts (Spain, Germany, Italy, France…), for instance. One major point of these policies relies on the exogeneous nature of the seasons in the agricultural sector: indeed, the two hired labour types, permanent and seasonal, seem to meet specific temporalities of work.

However, the results of this work question the fact that the distinction between permanent workers and seasonal workers in this sector only reflects the seasonality of work. Competition and pressure to cut costs can however push the boundaries between these two types of labour. We show that wage labour in agriculture can’t be treated as a homogeneous category. Moreover, the fact that the farming sector can experience the same phenomena as the rest of the economy (e.g. flexibilisation of employment) is overlooked. The family nature of farming has often caused the growing role of wage labour in this sector to be excluded from analysis. The development of large farms suggests however that this trend is likely to increase in the future.

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7 Tables and Annex

Table 1- Evolution of labour in professional farms with fruits and vegetables in 1988, 2000 and 2005

	1988	2000	2005
Number of farms	**102800**	**61747**	**47912**
Farmer and partners labour (AWU) *(% total AWU)*	98 304 *39%*	70 861 *40%*	57 594 *38%*
Other family members labour (AWU) *(% total AWU)*	80 897 *32%*	28 317 *16%*	19 592 *13%*
Total family labour (AWU) *(% total AWU)*	179 201 *70%*	99 177 *56%*	77 185 *51%*
Permanent wage labour (AWU) *(% total AWU)*	36 235 *14%*	30 805 *17%*	27 654 *18%*
Seasonal wage labour (AWU) *(% total AWU)*	38 838 *15%*	45 778 *26%*	43 421 *29%*
Outsourced labour (AWU) *(% total AWU)*	960 *0%*	1 086 *1%*	1 119 *1%*
Total AWU	255 230 *100%*	176 846 *100%*	150 795 *100%*

Sources : French agricultural census (1988, 2000, 2005)

Table 2- Summary of existence conditions of the different labour types on the farm

On-farm family work	Permanent wage labour	Seasonal wage labour
if $MRS_{C_i/l_i} = \overline{w} + c_i$ then $F_i > 0$ if $MRS_{C_i/l_i} > \overline{w} + c_i$ then $F_i = 0$ if $MRS_{C_i/l_i} = w^o$ then $F_i^o > 0$ if $MRS_{C_i/l_i} > w^o$ then $F_i^o = 0$	$L^{perm} > 0$ si $(\overline{w} + c_1) + \left[\overline{w} + \rho^2 E\left(\tilde{c}_2\right)\right] = 2\overline{w}$ $L^{perm} = 0$ si $(\overline{w} + c_1) + \left[\overline{w} + \rho^2 E\left(\tilde{c}_2\right)\right] < 2\overline{w}$	$L_i^{sais} = L_i - F_i - L^{perm}$

Table 3- Labour regimes

Family on-farm work[28]	*Permanent wage labour*	*Seasonal wage labour*	*Regime*	Frequency in the sample	Percentage in the sample
No	*No*	*No*	*000*	1 130	7.0%
No	*No*	*Yes*	*001*	2 091	12.9%
No	*Yes*	*No*	*010*	269	1.7%
No	*Yes*	*Yes*	*011*	1 379	8.5%
Yes	*No*	*No*	*Reference 100*	3 903	24.1%
Yes	*No*	*Yes*	*101*	4 724	29.2%
Yes	*Yes*	*No*	*110*	501	3.1%
Yes	*Yes*	*Yes*	*111*	2 184	13.5%
				16 181	100.0%

[28] Members who are not business partners, between the ages of 15 and 70.

Table 4- Marginal effects on the probability of belonging to a particular labour regime

		100	**101**	**110**	**111**	**000**	**001**	**010**	**011**
Farmer	age	0.003***	-0.001	0.000	0.001	-0.001**	-0.004***	0.000	0.001
		(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
	exp	-0.001**	0.000	0.000*	0.001*	-0.001**	0.000	-0.000	-0.000
		(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	at1°	0.041***	0.022	-0.002	-0.010	0.006	-0.012	-0.001	-0.014***
		(0.016)	(0.017)	(0.003)	(0.007)	(0.006)	(0.008)	(0.002)	(0.005)
	at2°	ref	ref	ref	ref	ref	ref	ref	ref
	at3°	-0.011	-0.025	-0.001	0.013	0.001	0.001	0.002	0.024**
		(0.013)	(0.023)	(0.004)	(0.013)	(0.007)	(0.015)	(0.003)	(0.010)
	ge1°	0.048***	0.033**	-0.003	-0.011	0.005	-0.005	-0.002	-0.022***
		(0.014)	(0.016)	(0.003)	(0.008)	(0.005)	(0.009)	(0.002)	(0.006)
	ge2°	ref	ref	ref	ref	ref	ref	ref	ref
	ge3°	-0.016	-0.058*	0.002	0.012	-0.019*	-0.041**	0.013***	0.037***
		(0.020)	(0.030)	(0.006)	(0.016)	(0.010)	(0.018)	(0.004)	(0.011)
Family	part°	-0.054**	-0.037	-0.027***	-0.080***	0.062***	0.088***	0.012***	0.017**
		(0.027)	(0.031)	(0.007)	(0.018)	(0.010)	(0.015)	(0.004)	(0.008)
	nc012	-0.021**	-0.007	-0.001	0.002	-0.000	0.001	0.002*	0.008***
		(0.008)	(0.009)	(0.002)	(0.004)	(0.003)	(0.005)	(0.001)	(0.003)
	nfl1570	0.053***	0.057***	0.002	0.019***	-0.009***	-0.024***	-0.006***	-0.012***
		(0.007)	(0.009)	(0.002)	(0.005)	(0.003)	(0.005)	(0.002)	(0.003)
	fat°	0.042**	0.102***	0.007*	0.061***	-0.026***	-0.028**	-0.015***	-0.014**
		(0.017)	(0.018)	(0.003)	(0.010)	(0.007)	(0.012)	(0.004)	(0.007)
	fge°	-0.078***	-0.103***	-0.004	-0.024**	0.010*	0.041***	0.013***	0.033***
		(0.013)	(0.017)	(0.003)	(0.010)	(0.005)	(0.009)	(0.002)	(0.006)
Farm	sgm	-0.053***	-0.008***	0.003***	0.010***	-0.012***	-0.003***	0.001***	0.009***
		(0.003)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
	tract	-0.036***	-0.002	0.005***	0.028***	-0.020***	-0.005	-0.001	0.019***
		(0.006)	(0.006)	(0.001)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)
	comm°	-0.289***	-0.165***	0.030***	0.049*	-0.044*	-0.059**	0.009	0.043**
		(0.078)	(0.053)	(0.010)	(0.026)	(0.024)	(0.029)	(0.007)	(0.017)
	qual°	-0.032*	0.040**	-0.005	0.045***	-0.018**	0.026***	-0.000	0.028***
		(0.017)	(0.019)	(0.004)	(0.009)	(0.007)	(0.010)	(0.003)	(0.006)
	insur°	-0.042***	0.011	-0.000	0.040***	-0.006	0.018**	-0.005	0.035***
		(0.014)	(0.017)	(0.004)	(0.008)	(0.006)	(0.009)	(0.003)	(0.006)
	otef°	ref	ref	ref	ref	ref	ref	ref	ref
	oteof°	0.103***	-0.291***	0.022***	-0.175***	0.020***	-0.139***	0.002	-0.133***
		(0.023)	(0.035)	(0.004)	(0.015)	(0.007)	(0.018)	(0.003)	(0.011)
	oteoa°	0.117***	-0.387***	0.028***	-0.120***	0.016***	-0.215***	0.011***	-0.111***
		(0.024)	(0.036)	(0.004)	(0.013)	(0.006)	(0.020)	(0.003)	(0.011)
	oteg°	0.026	-0.416***	0.030***	0.001	-0.038***	-0.239***	0.005**	0.005
		(0.017)	(0.038)	(0.003)	(0.014)	(0.006)	(0.021)	(0.003)	(0.010)
	oteoag°	0.060***	-0.486***	0.032***	-0.086***	-0.016**	-0.299***	0.009***	-0.075***
		(0.022)	(0.040)	(0.003)	(0.014)	(0.007)	(0.025)	(0.003)	(0.012)
	otem°	0.075***	-0.242***	0.011***	-0.082***	0.007	-0.123***	0.001	-0.068***
		(0.020)	(0.035)	(0.003)	(0.012)	(0.006)	(0.018)	(0.002)	(0.009)

Continued on the next page

		100	101	110	111	000	001	010	011
	h	-0.067***	0.018	-0.016***	-0.021	0.014*	0.081***	0.005	0.026***
		(0.022)	(0.026)	(0.006)	(0.014)	(0.008)	(0.015)	(0.004)	(0.009)
	p	-0.062***	0.030	0.006	-0.044***	-0.021***	-0.004	0.003	-0.046***
		(0.018)	(0.022)	(0.005)	(0.010)	(0.007)	(0.011)	(0.003)	(0.007)
Location	fv°	0.015	0.068***	-0.011***	0.021**	0.015**	0.030***	-0.007**	0.013*
		(0.017)	(0.020)	(0.004)	(0.009)	(0.006)	(0.010)	(0.003)	(0.007)
	rural°	ref	ref	ref	ref	ref	ref	ref	ref
	urban°	0.007	-0.083***	0.008*	-0.006	0.003	-0.021**	0.004	-0.004
		(0.018)	(0.020)	(0.004)	(0.010)	(0.007)	(0.011)	(0.003)	(0.007)
	rrural°	0.013	-0.014	0.000	-0.002	-0.007	-0.011	0.004	-0.019**
		(0.022)	(0.033)	(0.004)	(0.013)	(0.008)	(0.016)	(0.003)	(0.009)

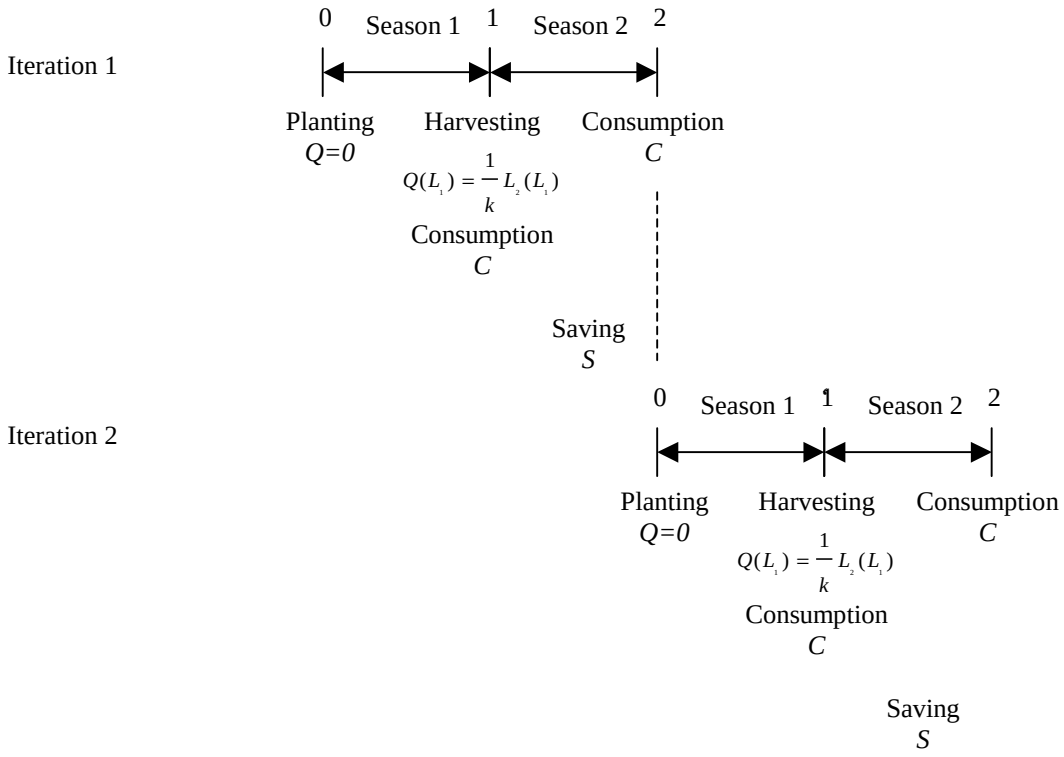
Observations = 16181 Pseudo-R2 = 0.212

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

° dy/dx is for discrete change of dummy variable from 0 to 1

Regional dummies were included in the regression

Annex 1- Model structure



Season 2:

$$\underset{\{S,F_2,F_2^o\}}{Max}\ Z_2 \equiv U\begin{pmatrix} pQ-\overline{w}(kQ-F_2)-c_2(kQ-F_2-L^{perm})+w^oF_2^o+I_2-S, \\ T-F_2-F_2^o \end{pmatrix} + \rho EU\begin{pmatrix} S-\overline{w}(L_1-F_1)-\tilde{c}_1(L_1-F_1-L^{perm})+w^oF_1^o+I_1, \\ T-F_1-F_1^o \end{pmatrix}$$

with $S>0$ (a)

$F_2 \geq 0$

$F_2^o \geq 0$

Thus,

$$\frac{\partial Z_2}{\partial S}=-\frac{\partial U}{\partial C_2}+\rho\frac{\partial U}{\partial C_1}=0\ ; \quad \text{(b)}$$

$$\frac{\partial Z_2}{\partial F_2}=(\overline{w}+c_2)\frac{\partial U}{\partial C_2}-\frac{\partial U}{\partial l_2}+\mu_1=0 \text{ with } \mu_1F_2=0\ ; \quad \text{(c)}$$

$$\frac{\partial Z_2}{\partial F_2^o}=w^o\frac{\partial U}{\partial C_2}-\frac{\partial U}{\partial l_2}+\mu_2=0 \text{ with } \mu_2F_2^o=0\ ; \quad \text{(d)}$$

(b) is equivalent to:

$$\left(\frac{\partial U}{\partial C_2}/\frac{\partial U}{\partial C_1}\right)=\rho \quad \text{(e)}$$

Let $\left(\frac{\partial U}{\partial l_2}/\frac{\partial U}{\partial C_2}\right)=MRS_{C_2/l_2}$. Depending on the endogeneous variables being an interior solution or not, we obtain :

$F_2>0$ if $MRS_{C_2/l_2}=(\overline{w}+c_2)$ et $F_2=0$ if $MRS_{C_2/l_2}>(\overline{w}+c_2)$

$F_2^o>0$ if $MRS_{C_2/l_2}=w^o$ et $F_2^o=0$ if $MRS_{C_2/l_2}>w^o$

Season 1:

$$\underset{\{L_1,F_1,F_1^o,L^{perm}\}}{Max} Z_1 \equiv U\begin{pmatrix} S-\overline{w}(L_1-F_1)-c_1(L_1-F_1-L^{perm})+w^oF_1^o+I_1, \\ T-F_1-F_1^o \end{pmatrix}$$
$$+\rho EU\begin{pmatrix} pQ(L_1)-\overline{w}(kQ(L_1)-F_2)-\tilde{c}(kQ(L_1)-F_2-L^{perm})+w^oF_2^o+I_2\text{-S}, \\ T-F_2-F_2^o \end{pmatrix} \quad \text{(f)}$$
with $L_1 \geq 0$
$F_1 \geq 0$
$F_1^o \geq 0$
$L^{perm} \geq 0$

Thus,

$$\frac{\partial Z_1}{\partial L_1} = -(\overline{w}+c_1)\frac{\partial U}{\partial C_1} + \rho E\left[\frac{\partial U}{\partial C_2}.\left(p\frac{\partial q}{\partial L_1} - \overline{w}k\frac{\partial q}{\partial L_1} - \tilde{c}k\frac{\partial q}{\partial L_1}\right)\right] + \mu_3 = 0 \text{ with } \mu_3 L_1 = 0 \text{ ;} \quad \text{(g)}$$

$$\frac{\partial Z_1}{\partial F_1} = (\overline{w}+c_1)\frac{\partial U}{\partial C_1} - \frac{\partial U}{\partial l_1} + \mu_4 = 0 \text{ with } \mu_4 F_1 = 0 \text{ ;} \quad \text{(h)}$$

$$\frac{\partial Z_1}{\partial F_1^o} = w^o\frac{\partial U}{\partial C_1} - \frac{\partial U}{\partial l_1} + \mu_5 = 0 \text{ with } \mu_5 F_2^o = 0 \text{ ;} \quad \text{(i)}$$

$$\frac{\partial Z_1}{\partial L^{perm}} = c_1\frac{\partial U}{\partial C_1} - \rho E\left(\tilde{c}\frac{\partial U}{\partial C_2}\right) + \mu_6 = 0 \text{ with } \mu_6 L^{perm} = 0 \text{ ;} \quad \text{(j)}$$

Depending on the endogeneous variables being an interior solution or not, we obtain :

With respect to L_1 :

$$* \; L_1 > 0 \text{ if } \rho E\left(p - \overline{w}k - \tilde{c}_2 k\right)\left(\frac{\frac{\partial U}{\partial C_2}}{\frac{\partial U}{\partial C_1}}\right)\frac{\partial Q}{\partial L_1} = (\overline{w}+c_1)$$

or if, from (e), $\rho^2 p\frac{\partial Q}{\partial L_1} = (\overline{w}+c_1) + \rho^2\frac{\partial Q}{\partial L_1}kE\left(\overline{w}+\tilde{c}_2\right)$ *

or if $\rho^2 p\frac{\partial Q}{\partial L_1} = (\overline{w}+c_1) + \rho^2\frac{\partial L_2}{\partial L_1}E\left(\overline{w}+\tilde{c}_2\right)$

$$* \; L_1 = 0 \text{ if } \rho^2 p\frac{\partial Q}{\partial L_1} < (\overline{w}+c_1) + \rho^2\frac{\partial L_2}{\partial L_1}E\left(\overline{w}+\tilde{c}_2\right)$$

With respect to F_1 and F_1^o :

$F_1 > 0$ if $MRS_{C_1/l_1} = (\overline{w} + c_1)$ and $F_1 = 0$ if $MRS_{C_1/l_1} > (\overline{w} + c_1)$

$F_1^o > 0$ if $MRS_{C_1/l_1} = w^o$ and $F_1^o = 0$ if $MRS_{C_1/l_1} > w^o$

With respect to L^{perm} :

* $L^{perm} > 0$ if $c_1 \frac{\partial U}{\partial C_1} + \rho \frac{\partial U}{\partial C_2} E\left(\tilde{c}_2\right) = 0$

  or if, from (e), $c_1 + \rho^2 E\left(\tilde{c}_2\right) = 0$

  or if $(\overline{w} + c_1) + \left[\overline{w} + \rho^2 E\left(\tilde{c}_2\right)\right] = 2\overline{w}$

* $L^{perm} = 0$ if $(\overline{w} + c_1) + \left[\overline{w} + \rho^2 E\left(\tilde{c}_2\right)\right] < 2\overline{w}$

Annex 3- Concentration degree of the production, Herfindal Index[29]

$$H_i = \sum_{l}^{n1}\left(\frac{sgmhaV_i * X_{i,v}}{sgmFV_i}\right)^2 + \sum_{f}^{n2}\left(\frac{sgmhaF_i * X_{i,f}}{sgmFV_i}\right)^2$$

$X_{i,v}$ vegetable surface v for the farm i

$X_{i,f}$ fruit surface f for the farm i

$sgmhaV_i$ sgm per vegetable ha for the farm i

$sgmhaF_i$ sgm per fruit ha for the farm i

$sgmFV_i$ fruit and vegetable sgm for the farm i

Annex 4- Weight of perishable fruits and vegetables in total production

$$P_i = \frac{\left((SurfV4_i * sgmhaV_i) + (SurfF4_i * sgmhaF_i)\right)}{\left(TotSurfFV * sgmhaFV_i\right)}$$

$SurfV4_i$ highly perishable vegetable surface for the farm i

$SurfF4_i$ highly perishable fruit surface for the farm i

$TotSurfFV$ fruit and vegetable surface for the farm i

$sgmhaV_i$ sgm per vegetable ha for the farm i

$sgmhaF_i$ sgm per fruit ha for the farm i

$sgmhaFV_i$ sgm per fruit and vegetable ha for the farm i

[29] We take into account the difference of intensity of fruit and vegetable productions.

Annex 5- Definition and summary statistics, explanatory variables

	Variable		Definition	Mean	Sdt error	Min	Max
Farmer	Age		Age (in year)	47	10	19	88
	Exp		Experience (in year)	17	10	0	63
	Agricultural training	At1	1 if farmer agricultural training is lower than secondary, else 0	0.58		0	1
		At2	1 if farmer agricultural training is equal to secondary, else 0	0.27		0	1
		At3	1 if farmer agricultural training is higher than secondary, else 0	0.15		0	1
	General education	Ge1	1 if farm general education is lower than secondary, else 0	0.41		0	1
		Ge2	1 if farm general education is equal to secondary, else 0	0.52		0	1
		Ge3	1 if farm general education is higher than secondary, else 0	0.07		0	1
Family	Nf1565		Number of members between the ages of 15 and 70	2	1	1	15
	Nc012		Number of children	1	1	0	7
	Fge		1 if there is at least one family member with general higher education, else 0	0.26		0	1
	Fat		1 if there is at least one family member with agricultural traning, else 0	0.21		0	1
Farm	SGM		Business size total SGM (in 10^4 euros)	9.10	17.04	0.96	986.30
	Tract		Number of tractors	2.52	2.50	0	160
	Part		1 if there is at least one business partern else 0	0.08		0	1
	Comm		1 if there is an autonomous structure for commercializing products, else 0	0.02		0	1
	Qual		1 if there are production signs of quality, else 0	0.19		0	1
	Insur		1 if there is an hail insurance policy, else 0	0.29		0	1
Production	Ote	OteOf	1 if the Ote is open-field vegetables, else 0	0.16		0	1
		OteOa	1 if the Ote is open –air vegetables, else 0	0.12		0	1
		OteG	1 if the Ote is greenhouse vegetables, else 0	0.11		0	1
		OteOaG	1 if the Ote is open-air and greenhouse vegetables, else 0	0.06		0	1
		OteM	1 if the Ote is mixed farming, else 0	0.17		0	1
		OteF	1 if the Ote is fruit, else 0	0.38		0	1
	H		Degree of the concentration of the production (see appendix 6)	0.59	0.30	0.00	1.00
	P		Weight of highly perishable produce on the farm (see appendix 7 and 8)	0.45	0.38	0.00	1.00
Location	FV		1 if farming in the area is predominantly fruit and vegetable production, else 0	0.26		0	1
	Area type	Urbain	1 if employment area is urban, else 0	0.67		0	1
		Rural	1 if employment area is rural, else 0	0.21		0	1
		Autrerural	1if employment area is remote rural, else 0	0.12		0	1