Subsidies and agricultural employment:

The education channel

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Abstract:

Agricultural employment in industrialized countries has been steadily decreasing despite important levels of farm subsidies. In this paper we provide a new explanation for this puzzle, namely the positive impact of subsidies on the education level of farmers' children. If farmers are credit constrained, they may underinvest in their children's education. By increasing farmers' incomes, subsidies increase investment in education. If more educated children are less willing to become farmers, in the long term subsidies may lead to a reduction of labor supply in the agricultural sector. We provide both theoretical and empirical evidence supporting this argument.

Keywords: Agricultural Employment, Structural change, Subsidies, Education, Credit Constraints,

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Abstract:

Agricultural employment in industrialized countries has been steadily decreasing despite important levels of farm subsidies. In this paper we provide a new explanation for this puzzle, namely the positive impact of subsidies on the education level of farmers' children. If farmers are credit constrained, they may underinvest in their children's education. By increasing farmers' incomes, subsidies increase investment in education. If more educated children are less willing to become farmers, in the long run subsidies may lead to a reduction of labor supply in the agricultural sector. We provide both theoretical and empirical evidence supporting this argument.

1 INTRODUCTION

In the economic literature, agricultural subsidies are widely criticized since they potentially avoid the reallocation of resources, including labour, to sectors in which they can be used more efficiently (e.g. Gardner, 2002). For example, in Europe, one of the objectives of Common Agricultural Policy (CAP) is to protect farmers' income to ensure a fair standard of living for the European farm population and therefore, one would expect agricultural subsidies to have a positive impact on agricultural employment.[1]

This intuition does not seem to be supported by available data on subsidies and agricultural labour adjustments. For example, over the 1987-2007 period, the outflow of labour from the agricultural sector has been strongest in the OECD countries where farmers have been supported most heavily.[2] Of course this negative correlation could be

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[1] Treaty of Rome (1957)

[2] Similar results hold within the agricultural sector in several European countries. For example, figures from Belgium, the Netherlands, Portugal and Greece show that in the subsectors where agricultural subsidies were higher, agricultural labour outflow was stronger in the period 1990-2007 (Eurostat).

due to reverse causation: the political economy of subsidies is such that farmers from countries where the farming population is small are more able to put pressure on politicians to increase agricultural subsidies (see Swinnen, 1994; 2010). However, this explanation does not hold for the observation that the employment decline is the lowest in countries where the reduction in support has been the strongest, which is actually the case illustrated by Figure 1.

The existing literature has failed to reach a consensus regarding the impact of subsidies on agricultural employment. Some find the expected, positive impact (e.g. Foltz, 2004; Key and Roberts, 2006; Breustedt and Glauben, 2007; Pietola et al., 2003), others find a nil impact (e.g. Barkley, 1990; Mishra et al., 2004; Glauben, et al., 2006) and yet others find a negative impact (e.g. Goetz and Debertin, 1996, 2001; Hoppe and Korbi, 2006; Petrick and Zier, 2011).

This lack of consensus in the literature can be explained by the fact that subsidies may also have an indirect (second-order) negative impact on agricultural employment, which in some circumstances (depending on the country and/or time period) may dominate the positive direct (first-order) impact. For example, Goetz and Debertin (1996) argue that subsidies allow farmers to invest more heavily in physical capital, and this leads to capital-labour substitution, which reduces agricultural labour demand. In another paper, Goetz and Debertin (2001) argue that in regions where the number of farmers is decreasing, government subsidies accelerate the rate of decline as subsidies may help farmers that stay in the agricultural sector to buy out farmers that are willing to exit .

Although these explanations are perfectly plausible, one potential important effect has been overlooked by the existing literature. This is the effect of subsidies on the

educational level of farmers' children and the resulting impact on labour supply in the next generation. In Western Europe, as in many other parts of the world, the majority of farmers are self-employed household farmers and farming enterprises are traditionally transferred from one generation to another. As a result, an important share of the long-term decline in agricultural employment is due to farmers' children choosing to work in the industrial or service sector rather than taking over their parents' farm.[3] For example, in 2008 only 27% of the Dutch farm operators older than 50 years indicated to have a successor (De Bont and Van Everdingen, 2010). The situation is even worse in Flanders (Belgium), where only 13% of the farmers reported to have a successor (Vlaamse Overheid, 2009). In case farmers are credit constrained for education, subsidies, by increasing farmers' incomes, may allow farmers to increase investment in their children's' education.[4] If children with higher education levels are less willing to work in the agricultural sector then one long term effect of farm subsidies may be to reduce labour supply in the agricultural sector.

In this paper, we provide a theoretical model and empirical evidence supporting this new argument. Our theoretical framework is a two period model of intergenerational investment in education, similar to Acemoglu and Pischke (2001). The economy is composed of farmers with heterogeneous incomes exogenously given. In period one, each farmer decides whether to use all his income for consumption and saving or to invest part of it in his child's education. In period two, each child decides whether to work in the

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[3] There is a large literature analyzing intergenerational farm transfers and its determinants (e.g. Kimhi, 1994; Stiglbauer and Weiss, 2000; Kimhi and Nachlieli, 2001; Mishra et al. 2004; Glauben et al., 2006).

[4] The cost of education as a percentage of the agricultural GDP per capita is an indicator for the affordability of tertiary education (Usher and Medow, 2010). In the OECD countries, this indicator ranges between 14% in Norway and 82% in Japan (Table1). Hence, in most OECD countries, tertiary education still represents a high share in household expenditures. In general, credit for education is restricted as there are important default risks associated with it due to a lack of appropriate collateral. For example, in the United States and Canada, the rate of default was about 17 percent in the federal programs throughout the 1980s (Salmi, 1999).

agricultural sector or in the industrial sector. Returns to education are assumed to be higher in the industrial sector. Agricultural subsidies are assumed to be proportional to farm income and they increase farm income in both generations. We show that in presence of credit constraints, subsidies may have two opposite effects on agricultural employment. On one hand, for a given education level, they induce more children to opt for the agricultural sector, since they improve its relative attractiveness. On the other hand, increased farm incomes allow more farmers to educate their children, increasing the attractiveness of jobs in the industrial sector for those children. As a result, the overall effect of subsidies on agricultural employment depends on the income distribution in the agricultural sector and the cost of education. When the proportion of credit constrained farmers is sufficiently high and the cost of education is sufficiently high, the long run impact of subsidies is more likely to be negative.

We provide empirical support for the two opposite effects using household level panel data in four European countries, from 1994 to 1999. We show that, given the level of education, an increase in farm income decreases the probability that farmer's child leaves the agricultural sector (direct effect). However, an increase in farm income increases the child's education level, which increases the probability that a child will leave the agricultural sector (indirect effect).

The rest of the paper is organized as follows. In section 2 we present the theoretical model. In section 3 we present the data, the estimation methods and the empirical results. Section 4 concludes.

2 THEORETICAL FRAMEWORK

We build a model of investment in schooling based on Acemoglu and Pischke (2001). The economy is composed of N farmers with incomes w_a, following a cumulative distribution function $F(w_a)$. Each farmer has one child. The game lasts two periods.

In period 1, each farmer consumes c, saves s and may invest an amount h to educate his child. He dies at the end of the period.

In period 2, the child's education level is $e = 1$ if parents invested in his education and $e = 0$ otherwise.[5] Each child decides whether to work in the agricultural sector, i.e. overtake his parents' farm, or work in the non-agricultural sector, i.e. take a job in the industrial or services sector. The child's expected income is denoted w_c and his consumption level is denoted $\tilde{c}$. The game ends at the end of period 2.

The farmer is altruistic towards his child. His utility function depends on his consumption level and on his child's consumption level:

$$U(c, \tilde{c}) = lnc + \beta ln\tilde{c}, \tag{1}$$

Where $0 < \beta < 1$ is the altruism rate.

Each farmer maximizes his utility with respect to his consumption level c, the amount of savings s and his child's education level e, subject to his budget constraint and to his child's budget constraint.

Assuming for simplicity that the interest rate is zero[6], the farmers' and his child's budget constraints are respectively given by:

$$c + he + s \leq w_a \tag{2}$$

$$\tilde{c} \leq s + w_c \tag{3}$$

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[5] For simplicity we assume the level of education to be a binary variable.
[6] Introducing a positive interest rate would not alter the results.

The child's utility only depends on his consumption level. Therefore the child chooses the employment sector that allows him to earn the highest expected income.[7]

We assume that children without education earn the same income as their parents, w_a, if they choose to overtake their parents' farm. If they choose to work in the non-agricultural sector, they earn an expected income of w_{na}.

Education increases productivity and income. We assume that educated children earn $w_a(1 + \theta_a)$ if they choose to work in the agricultural sector and $w_{na}(1 + \theta_{na})$ if they choose to work in the non-agricultural sector, where θ_a and θ_{na} are the rates of return to education in the agricultural and non-agricultural sectors respectively, and

$$\theta_{na} > \theta_a > 0, \tag{4}$$

i.e. the returns to education are lower in the agricultural sector.[8]

Agricultural employment in period one is exogenously given by the number of farmers, N. Agricultural employment in period two is endogenously given by the number of farmers' children who choose to work in the agricultural sector.[9] We denote it $\widetilde{N}$.

Our aim is to assess the impact of farm subsidies on agricultural employment in period two. We solve the model by backward induction. First, we determine the child's employment choice for a given education level. Second, we determine the parents'

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[7] Other factors than income may affect the employment decisions of farmers' children. They may take into account leisure time and the probability of being unemployed in each sector and they may derive additional utility from overtaking their parents' activity. We assume that the monetary values of these other factors are included in the expected incomes of each sector.
[8] Based on a sample of high school graduates in the US, Orazam and Matilla (1991) have shown the returns to schooling are higher for non-agricultural occupations than for agricultural employment. Using data from large sample of different countries, Psacharopoulos (1994) finds that these results hold in a more global perspective. A more recent study by Middendorf (2008) uses 2001 data to estimate the returns to schooling in different EU countries, including the countries used in our econometrical specification. The results show that returns to education are higher in the industrial and services sector compared to the agricultural sector.
[9] We assume that individuals only enter the agricultural sector by taking over the farm of their parents.

education decisions. Finally, we compute agricultural employment in period two and we analyse the effect of subsidies on this variable.

Uneducated children choose to work in the agricultural sector if $w_a > w_{na}$. Educated children choose to work in the agricultural sector if $w_a(1 + \theta_a) > w_{na}(1 + \theta_{na})$. Hence the child's employment choice depends on both the wage differential and their education.

Depending on w_a we can classify farmers in three groups, as represented in Figure 2. Children of farmers with incomes w_a such that $w_a < w_{na}$ choose the non-agricultural sector independently of their education level (Region A). Children of farmers with incomes w_a such that $w_a > w_{na}(1 + \theta_{na}/1 + \theta_a)$ choose the agricultural sector independently of their education level (Region C). Finally, children of farmers with intermediate incomes w_a such that $w_{na} < w_a < w_{na}(1 + \theta_{na}/1 + \theta_a)$ choose the agricultural sector if and only if they are not educated (Region B). The educational choices of these intermediate income farmers will affect agricultural employment in period two.

In order to determine the educational choices of these farmers with an intermediate income (in region B), we maximize (1) w.r.t $c, \tilde{c}, s, e$ subject to (2), (3) and

$$w_c = w_a + e[w_{na}(1 + \theta_{na}) - w_a] \tag{5}$$

i.e. children of farmers with revenues in region B will have an income of w_a if uneducated and $w_{na}(1 + \theta_{na})$ if educated.

We solve parents' optimization problem in two cases. First, we consider the benchmark case in which farmers are not credit constrained, i.e. they can borrow pledging the future income of their child. Second, we consider the case in which farmers are credit constrained, i.e. they cannot borrow pledging the future income of their child.

2.1 BENCHMARK CASE: NO CREDIT CONSTRAINTS

In this section we suppose that farmers can borrow money in period one, pledging on their child's income in period two. Thus, savings can be negative. After solving parents' optimization problem, we obtain that parents invest in education if and only if:[10]

$$w_{na}(1 + \theta_{na}) - w_a > h \tag{6}$$

The right hand side of (6) is the cost of education. The left hand side of (6) is the benefit of education. In absence of credit constraints, farmers invest in education if and only if the benefit of education exceeds its cost. As result, only famers with revenues $w_a < w_{na}(1 + \theta_{na}) - h$ invest in education and their children will not work in the agricultural sector.

There are three possible solutions for the level of agricultural employment in period two, which depend on the position of $w_{na}(1 + \theta_{na}) - h$ w.r.t. w_{na} and $w_{na}(1 + \theta_{na})/(1 + \theta_a)$. For brevity reasons, we only discuss one solution:[11]

In case $w_{na} < w_{na}(1 + \theta_{na}) - h < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)$, farmers with an intermediate income (in region B) invest in their education if $w_a < w_{na}(1 + \theta_{na}) - h$, such that agricultural employment in period two is given by:

$$\tilde{N} = N[1 - F(w_{na}(1 + \theta_{na}) - h] \tag{7}$$

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[10] Note this optimization only takes in account children of whom the parents have an intermediate income w_a such that $w_{na} < w_a < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)$ as children with income $w_a < w_{na}$ will leave the agricultural sector independently on their education level and children with an income $w_a > w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)$ will stay in the agricultural sector independently on their education level. See appendix one for the parents' optimization problems in case there are no credit constraints.

[11] The three possible solutions for the level of agricultural employment in period two in the absence of credit constraints are discussed in appendix two.

Let's now analyse the effect of farm subsidies on $\widetilde{N}$. Assume subsidies are given as a proportion p of farm income, such that they increase farm incomes (in both periods)[12], from w_a to $(1 + p)w_a$. Let $\widetilde{N}_p$ denote agricultural employment in period two in the presence of subsidies.[13]

In the presence of subsidies, farmers with an intermediate income invest in education if:

$$h < w_{na}(1 + \theta_{na}) - w_a(1 + p)^{14}$$

(8)

Similar to the case without subsidies, there are three possible solutions for the level of agricultural employment in period two. For brevity reasons, we only discuss one solution, which corresponds to the solution discussed in the absence of subsidies:[15]

In case $\frac{w_{na}}{1+p} < \frac{(w_{na}(1+\theta_{na})-h)}{(1+p)} < w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right)$, farmers with an intermediate income (in region B_p) invest in education if $w_a < \frac{(w_{na}(1+\theta_{na})-h)}{(1+p)}$, so agricultural employment in period two is given by:

$$\widetilde{N}_p = N\left[1 - F\left(\frac{(w_{na}(1+\theta_{na})-h)}{(1+p)}\right)\right]$$

(9)

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[12] An interesting extension of our model would be to study the effects of temporary instead of permanent subsidies.

[13] Following a similar reasoning, , in the presence of subsidies, children of farmers with incomes w_a such that $w_a < w_{na}/1 + p$ choose the non-agricultural sector independently of their education level (Region A_p). Children of farmers with incomes w_a such that $w_a > w_{na}(1 + \theta_{na}/(1 + \theta_a)(1 + p))$ choose the agricultural sector independently of their education level (Region C_p). Finally, children of farmers with intermediate farm incomes w_a such that $w_{na}/1 + p < w_a < w_{na}(1 + \theta_{na}/(1 + \theta_a)(1 + p))$ choose the agricultural sector if and only if they are not educated (Region B_p).

[14] The solution to the maximization problem of these farmers is obtained by replacing w_a with $w_a(1 + p)$ in the initial problem (see appendix one).

[15] The three possible solutions for the level of agricultural employment in period two in the absence of credit constraints are discussed in appendix two.

Since $F(w_a)$ is a cumulative distribution function, it is increasing in w_a. As a result, agricultural labour supply in the second period is higher in presence of subsidies.

Figure 3 presents a graphical illustration of the impact of subsidies on agricultural employment in the absence of credit constraints for the solution discussed in the main body of the text.

Thus, we can state:

Result 1 *In absence of credit constraints, subsidies have a positive impact on agricultural employment in the next generation.*

In absence of credit constraints, farmers can make all profitable investments by borrowing on the financial market. Thus subsidies do not change their educational choices, but they make the agricultural sector relatively more attractive, changing therefore the employment decision of some of the farmers' children.

2.2 REALISTIC CASE: PRESENCE OF CREDIT CONSTRAINTS

Suppose that farmers cannot borrow money in period one pledging on their child's income in period two. Thus, savings cannot be negative.

Then parents maximize (1) under (2), (3), (5) and the positive savings constraint:

$$s \geq 0 \tag{10}$$

Solving this optimization problem, we obtain that parents invest in education if their income w_a satisfies the following condition:[16]

$$f(w_a) \equiv \frac{(w_{na}(1+\theta_{na}))^{\beta}(w_a - h)}{w_a^{\beta+1}} > 1 \tag{11}$$

The probability that a farmer invests in his child's education, i.e. the probability that (15) is satisfied, decreases with the cost of education, h, and increases with the non-agricultural skilled wage, $w_{na}(1 + \theta_{na})$. Moreover, $f(w_a)$ is increasing in w_a for $w_a < w_a^*$ and decreasing in w_a for $w_a > w_a^*$, where $w_a^* = \frac{(\beta+1)h}{\beta}$. This means that for poor farmers in region B, increases in income make them more likely to invest in education, while the opposite is true for rich farmers in region B.

The relationship between farming income and investment in education is non-monotonic because income has two opposite effects on farmers' educational choices. On the one hand, as farming income increases, the benefit of education decreases, so investment in education should decrease. On the other hand, as income increases, credit constraints become less binding, so investment in education should increase. The positive effect of income is dominant as long as $w_a < w_a^*$.

Assume $f(w_a^*) > 1$, such that there exist $\underline{w_a}$ and $\overline{w_a}$ to be the solutions to $f(w_a) = 1$, with:

$$\overline{w_a} > w_a^* > \underline{w_a}.\text{[17]} \tag{12}$$

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[16] Note that this optimization, similar to the optimization in the absence of credit constraints, only takes in account children of whom the parents have an income w_a such that $w_{na} < w_a < w_{na}[(1 + \theta_{na})/(1 + \theta_a)]$ as children with income $w_a < w_{na}$ will leave the agricultural sector independently on their education level and children with an income $w_a > w_{na}[(1 + \theta_{na})/(1 + \theta_a)]$ will stay in the agricultural sector independently on their education level. See appendix three for the parents' optimization problem in the presence of credit constraints.

Farmers with incomes w_a such that $w_{na} < w_a < \underline{w_a}$ do not invest in education because they are credit constrained, and farmers with incomes w_a such that $(w_{na}(1 + \theta_{na})/(1 + \theta_a) > w_a > \overline{w_a}$ do not invest in education because the returns are not sufficiently high. Farmers with incomes $\underline{w_a} < w_a < \overline{w_a}$ invest in education.

There are three possible solutions for the level of agricultural employment in period two, which depend on the position of w_a^*, $\underline{w_a}$ and $\overline{w_a}$ w.r.t. w_{na} and $w_{na}(1 + \theta_{na})/(1 + \theta_a)$. For brevity reasons, we only discuss one solution: [18]

In case $h > w_{na}(\frac{1+\theta_{na}}{1+\theta_a})[1 - \frac{1}{(1+\theta_a)^\beta}]$ and $\frac{w_{na}}{1+p} > w_a^* > w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right)$, farmers with an intermediate income (in region B), invest in education if $\underline{w_a} < w_a < \overline{w_a}$, so agricultural employment in period two is given by:

$$\widetilde{N} = N\left[F\left(\underline{w_a}\right) - F(w_{na}) + 1 - F(\overline{w_a})\right] \tag{13}$$

Let's now analyse the effect of subsidies on $\widetilde{N}$. As in the previous section, suppose that subsidies increase all farming incomes from w_a to $(1 + p)w_a$. Let $\widetilde{N}_p$ denote agricultural employment in period two in the presence of subsidies.

In the presence of subsidies and credit constraints, farmers invest in education if

$$f_p(w_a) \equiv f(w_a(1 + p)) > 1 \tag{14}$$

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[17] If $f(w_a^*) < 1$ the resolution of the problem is straightforward: none of the famers with an intermediate income in region B will invest in their children's education and the agricultural employment in the second period will equal $\widetilde{N} = N[1 - F(w_{na})]$.

[18] The three possible solutions for the level of agricultural employment in period two in the presence of credit constraints are discussed in appendix four.

Similar to the case without subsidies, there are three possible solutions for the level of agricultural employment in period two. For brevity reasons, we only discuss one solution, which corresponds to the solution discussed in the absence of subsidies:[19]

In case $h > w_{na}(\frac{1+\theta_{na}}{1+\theta_a})[1 - \frac{1}{(1+\theta_a)^\beta}]$ and $\frac{w_{na}}{1+p} > w_a^* > w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right)$, farmers with an intermediate income (in region B_p), invest in education if $\frac{w_a}{1+p} < w_a < \frac{\overline{w_a}}{1+p}$, so agricultural employment in period two is given by:

$$\widetilde{N}_p = N\left[F\left(\frac{w_a}{1+p}\right) - F\left(\frac{w_{na}}{1+p}\right) + 1 - F(\frac{\overline{w_a}}{1+p})\right] \tag{15}$$

In this case, the impact of subsidies on agricultural employment is unambiguous and depends on the distributional characteristics of $F(w_a)$. In fact, subsidies are expected to have a negative impact on agricultural employment in the second period if:

$$F\left(\underline{w_a}\right) - F\left(\frac{w_a}{1+p}\right) < F(w_{na}) - F\left(\frac{w_{na}}{1+p}\right) + F(\overline{w_a}) - F(\frac{\overline{w_a}}{1+p}) \tag{15}$$

The left hand side of (23) is the proportion of farmers who are able to invest in education thanks to subsidies. The left hand side of (23) is the proportion of farmers who are not willing to invest in education because of subsidies.

Figure 4 is a graphical representation of the impact of subsidies in the presence of credit constraints for the case discussed in the main body of the paper. It shows that if the proportion of farmers with incomes between $\frac{w_a}{(1+p)}$ and $\underline{w_a}$ is sufficiently high and the proportion of farmers with incomes between respectively, $\frac{w_{na}}{(1+p)}$ and w_{na} ; and $\frac{\overline{w_a}}{1+p}$ and $\overline{w_a}$ is sufficiently low, subsidies may have a negative impact on agricultural employment.

Hence, we can state:

Result 2 *In presence of credit constraints, the effect of subsidies on agricultural employment can be positive, negative or nil, depending on the cost of education and on the proportion of credit constrained farmers. It is more likely to be negative or nil when the cost of education is high and when a high proportion of farmers are credit constrained.*

In presence of credit constraints, farmers may not be able to undertake all profitable investments. In particular, poor farmers may not be able to invest in their children's' education. By increasing farming revenue, subsidies not only improve the relative attractiveness of the agricultural sector, but also affect some farmers' educational choices. This leads to an ambiguous total effect on the next generations' employment choices.

Note that our results also hold in case farmers face in addition to credit constraints for education, credit constraints for farm investment, which ceteris paribus increase the expected farm income of the child. Then a farm subsidy may be used (i) to invest in the child's education (as in the baseline model); (ii) to invest in the farm; (iii) a combination of (i) and (ii). As a result, the overall effect of the subsidy will depend on the proportion of poor farmers, the cost and the marginal return of educational and farm investment, respectively. However, ceteris paribus, we expect that allowing for farm investments will reduce the potential positive effect of farm subsidies on agricultural employment compared to a situation in which farmers face only credit constraints for education.

The following section provides empirical evidence supporting the idea that farmers are credit constrained for investing in education and that more educated children are more likely to leave the agricultural sector.

3   EMPIRICAL FRAMEWORK

3.1   DATA

We use data from the European Community Household Panel (ECHP). The sampling

scheme of the panel survey enables us to identify identical individuals and households in

different years. This unique feature of the dataset allows us to analyse the actual

educational and occupational decisions taken by respectively, parents and children.

To econometrically estimate the impact of an increase in farm income on agricultural

employment in the next generation, we constructed a sample including parents and their

children based on information obtained from two time periods, namely 1994 (first wave of

the ECHP) and 1999 (sixth wave of the ECHP). [20] We selected households in which at least

one of the parents was self-employed in the agricultural sector in 1994 and at least one of

the children was enrolled in an advanced stage of the educational system in 1994 such the

child finished its education by 1999.[21,22] This resulted in a dataset of 109 households from

Portugal (48), Italy (32), Ireland (21) and Spain (8).

This set-up allows us to use information on the actual behaviour of the children, while

most existing studies on farm succession rely on information from the current generation

of farm operators on what their heirs would do, rather than the decisions taken by the

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[20] The choice to use data from the first and the sixth wave was purely arbitrary.

[21] We only consider self-employed farmers because most of the farms in the EU-15 are family farms and in that case succession takes place within the household (Stiglbauer and Weiss, 2000).

[22] In order to analyze the impact of increased farm income on the farmers' children education, we select only households of which one of the children is enrolled in the educational system in 1994 and finished its education by 1999. Hence, we exclude children that are enrolled in the educational system in 1994 and are still enrolled in the educational system in 1999. We do so to avoid censoring problems as the children that are still enrolled in the educational system in 1999 have not yet made an occupational decision such that we are not able to determine whether they will stay in or leave the agricultural sector.

heirs themselves.[23] However, in general there are substantial differences between stated and revealed behaviour of the child which may cause "generation bias" as pointed out by Väre et al. (2010). By using data on actual behaviour in two time periods, we have information on the actual employment choice of the child and not on the anticipated behaviour by the parents.

Unfortunately the dataset also has an important drawback as it does not contain specific farm characteristics, such farm specialization or land ownership, which may also affect the occupational choice of farmers' children. There are no specific data on farm subsidies included in the dataset, such that we are only able to estimate the impact of an increase in farm income, assuming that subsidies increase farm income.[24] However, this corresponds to our theoretical model where the educational and occupational choice of children depends on farm income. Moreover, although in the period 1994-1999 the transition to direct payments was initiated, still on average 59% of farm support in Europe was market price support, which is captured by the farm income variable.

3.2   EMPIRICAL SPECIFICATION

To econometrically illustrate that farmers are credit constrained for investing in education and that more educated children are more likely to leave the agricultural sector, we estimate a recursive simultaneous bivariate probit model.

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[23] Exceptions analyzing ex-post (actual) succession decisions using panel data are studies by Kimhi (1994), Kimhi and Bollman (1999), Stiglbauer and Weiss (2000) and Väre et al. (2010).

[24] Note that we do not make assumptions on the transfer efficiency of subsidies in farm income, except that it should be higher than zero, which seems a reasonable assumption given that OECD (2002) has estimated that the relative transfer efficiency of subsidies ranges between 17% and 48%, depending on the type of subsidy.

This model estimates two simultaneous equations. The first equation or occupational choice equation allows us to estimate the direct impact of increased farm income on the decision to leave the agriculture, <u>given</u> a certain education level. The second equation or educational choice equation allows to measure the indirect impact of increased farm income through the educational choice of the child.

This estimation approach has been used by Hennessey and Rehman (2007) to analyse the interdependence between occupational and educational choices of Irish family farms in 2002. There are two important reasons to use a recursive simultaneous bivariate probit model to analyse the impact of an increase in farm income on the child's decision to leave the agricultural sector.

First, it is most likely that educational and occupational choices are determined jointly, such that the decision to participate in education is not exogenous of the decision to leave the agricultural sector (Hennessy and Rehman, 2007). In this case, the bivariate model is the appropriate econometric specification as the endogeneity of the educational choice can be ignored, because the log-likelihood is maximized (Maddala, 1983; Greene, 2003).[25]

Second, the model allows us to measure both the direct and indirect effect of farm income on employment choice. Since farm income enters the educational choice equation, it influences the educational choice of the child and because the educational choice also appears in the occupational choice equation, this effect is transmitted back.

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[25] Note when the covariance ρ between the random errors ε and μ is not significant, there is no endogeneity bias present and the model can be estimated separately as binominal probits. If ρ is significant, then the two dependent variables are jointly determined and when the dependent variable in the educational choice equation appears as an independent variable in the occupational choice equation, the recursive simultaneous bivariate probit model is the appropriate estimation technique.

We estimate the following model:

$$LEAVE_i = \alpha_0 + \alpha_1 FARMINC_i + \alpha_2 EDU_i + \sum_{a=3}^{k} \alpha_a X_{i,a} + \varepsilon_i$$

$$EDU_i = \beta_0 + \beta_1 FARMINC_i + \sum_{b=2}^{l} \beta_b Y_{i,b} + \mu_i$$

$$\text{with } \begin{pmatrix} \varepsilon \\ \mu \end{pmatrix} \sim N \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right]$$

where the dependent variable in the first equation, $LEAVE_i$, is a dummy variable that takes a value of one if the child is not employed in the agricultural sector in 1999, and zero otherwise. The dependent variable in the second equation, EDU_i, is a dummy variable that takes a value of one if the child has obtained a higher educational level than "basic or lower secondary education" in 1999, and zero otherwise.[26] Table 2 presents the joint distribution of $LEAVE$ and EDU. The main explanatory variable of interest, $FARMINC_i$, is a the natural logarithm of the average farm income of the household in the years between 1994 and 1999 during which the child was in the educational system.[27] This variable is included as independent variable in both the occupational choice and educational choice equation. If farmers are credit constrained for educational investments, this variable is expected to have a positive impact on the educational variable, and controlling for the level of education, it should have a negative impact on the occupational decision[28]; $X_{i,a}$ represents a

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[26] We choose the educational level "Basic or lower secondary education (ISCED 0-2) according to the ISCED classification level) as the base category since this is in all countries the educational level which can be obtained after finishing compulsory education in all countries in our sample (Murtin and Viarengo, 2008).

[27] For example, in case a child that was the educational system in 1994, finished its education in 1996, we use the natural logarithm of the average self-employed farm income of the household in the period 1994-1996 as the dependent variable. If the same child finished its education in 1999, we use the natural logarithm of the average self-employed farm income in the period 1994-1999. This will allow us to control to some extent for income smoothing behavior.

[28] One could argue that while the occupational choice depends on the expected farm income, the educational choice depends rather on the total household income, including both self-employed farm income as well as

vector of control variables included in the occupational choice equation, $Y_{i,b}$ represents a vector of control variables included in the educational choice equation; and ε_i and μ_i are jointly normal distributed error terms with correlation ρ. Table 3 gives an overview of the variables used in the econometric model.

3.3 RESULTS

Table 4 presents the estimation results.[29] The coefficients found on the main variable of interest *FARMINC* seem to support our theoretical model. Farm income has a positive and significant effect on children's education, which suggests that farmers are credit constrained for investing in education. Controlling for education, farm income has a negative and significant impact on the probability to leave agriculture. The total impact of farm income (i.e. the direct, negative effect plus the indirect, positive impact through education) on the probability to leave agriculture is found to be significant, but small, and it depends on the level of farm income: for farmers with a low income the indirect, positive effect (educational channel) dominates, while for farmers with an intermediate or high income the direct negative effect dominates. Figure 5 presents the overall (direct plus indirect) impact of a ten per cent increase in farm income on the probability to leave the agricultural sector at different levels of farm income.

income from wage labour and other sources, such as social payments. Therefore, as a robustness check, we have included in the educational equation the natural logarithm of the average total household income in the period between 1994 and 1999 that the child was in the educational system, while in the occupational choice equation we included the natural logarithm of the average self-employed farm income of the household in the period between 1994 and 1999 that the child was in the educational system. However, this did not change our main results and the results are available upon request to the authors.

[29] The covariance ρ between the random errors ε and μ is found to be significant, indicating that the two dependent variables are jointly determined and the recursive simultaneous bivariate probit model is the appropriate estimation technique.

With respect to the control variables in the occupational choice equation, we find a negative impact of *MARRIED* on the probability that a child leaves the agricultural sector, which is similar to earlier findings by Dries and Bojnec (2004) who also find reduced labour mobility for married individuals. Further, we find a positive impact of GENDER and SIBLING, indicating that females and individuals which have more siblings (and hence more potential farm successors) are more likely to leave the agricultural sector.

With respect to the control variables in the educational choice equation, we find a negative effect of *AGR* on the probability that a child engages in higher education. This means that in case farming represents a lower share in the family income, the child is more likely to engage in higher education. This may indicate that parents which obtain a higher of their income from non-agricultural sources may have a different attitude to education that parents working only in the agricultural sector (Hennessey and Rehman, 2007). Further, we find a negative impact of *SOCIAL* on the probability that a child engages in higher education, indicating that households that depend on social assistance payments are less likely to send their children to school. Finally, *GENDER* has a positive effect on education, indicating that girls are more likely to engage in higher education than boys.

4   CONCLUSION

Agricultural employment in western countries has been steadily decreasing in the past decades, despite important levels of farm subsidies. Studies that have analysed the impact of subsidies on agricultural employment arrived to contradictory conclusions, suggesting that their direct positive effect on agricultural labour supply is sometimes counterbalanced by indirect negative effects. In this paper we argue that one should also

consider the indirect negative effect of subsidies on agricultural employment through the farmers' children's education, which is overlooked by the literature so far.

The evolution of agricultural employment largely depends on the willingness of farmers' children to overtake their parents' activity. By increasing farmers' incomes, subsidies allow them to increase investment in their children's education. Children with higher education levels have access to better paid jobs in the industrial or services sectors. They are therefore less likely to be willing to work in the agricultural sector. We presented a theoretical model and empirical evidence supporting this argument.

Our findings are relevant in explaining the limited impact of agricultural subsidies on agricultural employment observed in several studies on various OECD countries in the last fifty years. However, they also may have important implications for intergenerational farm transfers in transition and developing countries, where still a large share of the rural population is employed in agriculture. Increasingly, countries such as China and India, which still have a large proportion of poor farmers, are providing agricultural subsidies to farmers. As we have shown in this paper, the impact of these subsidies on agricultural employment in the long run is not straightforward and will depend on the proportion of poor farmers, the wage differential between the agricultural and the non-agricultural sector and the cost of education.

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Table 1: Cost of tertiary education and agricultural GDP in 2010 (in USD)*

	Cost of education	Agricultural GDP per capita	Cost of education as % of agricultural GDP
Japan**	14404	17624	82%
United Kingdom	14844	24004	62%
Austria**	7299	17115	43%
Denmark	9943	29570	34%
Ireland**	6531	19599	33%
United States	23615	71985	33%
Germany	6250	28335	22%
Netherlands	10348	48839	21%
Italy**	6557	32033	20%
Finland	7977	42511	19%
Australia**	10548	56351	19%
Belgium**	5201	29630	18%
France**	7139	42602	17%
Sweden	9265	60365	15%
Norway	8096	57197	14%

* The cost of education includes the tuition fee, additional mandatory ancillary fees as well as the cost of books and study materials. In addition, it also includes living expenses of the students (estimated costs related to rent and food); ** Data for 2005
Source: Cost of education from Usher and Cervenan (2005); Usher and Medow (2010), Agricultural GDP from OECD Online Database (extracted April 12, 2012)

Table 2: Description of the variables in the recursive bivariate probit model

		Child completed higher education (EDU)		
		No	Yes	Total
Child left the agricultural sector (LEAVE)	No	14 (13%)	14 (13%)	28 (26%)
	Yes	31 (28%)	50 (46%)	81 (74%)
	Total	45 (41%)	64 (59%)	109 (100%)

Table 3: Description of the variables in the recursive bivariate probit model

Variable	Description	Mean	Standard Deviation
	Outcome Variable		
LEAVE	Dummy for the child to be not employed in the agricultural sector in 1999	0.74	0.44
EDU	Dummy for the child to have completed higher (upper secondary or tertiary) education in 1999	0.59	0.49
	Dependent variables in the occupational and educational choice equation		
FARMINC	Natural logarithm of the average household farm income (PPP-adjusted, in euros) during the years that the child was in the educational system in the period 1994-1999	7.35	1.84
GENDER	Dummy for the child being a woman	0.43	0.50
SIBLING	Number of siblings of the child	4.16	1.35
	Dependent variables in the occupational choice equation		
MARRIED	Dummy for being married in 1999	0.12	0.33
	Dependent variables in the educational choice equation		
HHSIZE	Household size in 1994, measured by the number of adult equivalents (based on OECD calculation method)	3.74	1.07
OFFFARM	Dummy for the farmer or spouse to have an off-farm income during the years that the child was in the educational system in the period 1994-1999	0.61	0.49
SOCIAL	Dummy for the farmer or spouse to have received social payments during the years that the child was in the educational system in the period 1994-1999	0.88	0.33
AGR	Share of self-employed agricultural income in total household income during the years that the child was in the educational system in the period 1994-1999	0.82	0.16

Source: Own calculations based on a subsample of the EHCP survey

Table 4: Determinants of the decision to leave the agricultural sector for farmers' children, controlling for simultaneity bias (baseline model)

	Occupational choice (outcome variable =LEAVE)		Educational choice (outcome variable= EDU)	
	Coefficient	z-value	Coefficient	z-value
FARMINC	-0.284	-3.92***	0.484	3.10***
EDU	1.610	5.32***	-	-
GENDER	0.768	2.34**	0.518	2.00**
SIBLING	0.437	2.66***	0.195	1.20
MARRIED	-0.475	-2.66***	-	-
HHSIZE	-	-	-0.209	-1.12
OFFFARM	-	-	0.164	0.54
SOCIAL	-	-	-0.866	-2.65**
AGR	-	-	-3.776	-2.11**
Constant	1.671	1.18	-0.173	-0.18
Country dummies	Yes			
Log likelihood	-96.29			
Wald test	124. 49 (0.00)			
Wald test for exogeneity	5.34 (0.02)			
Observations	109			

Note: Robust standard errors are used;
*significant on 10%, **significant on 5% and *** significant on 1%
Source: Own calculations based on a subsample of the EHCP survey

Figure 1:Change in agricultural labour and PSE* (1987-2007)
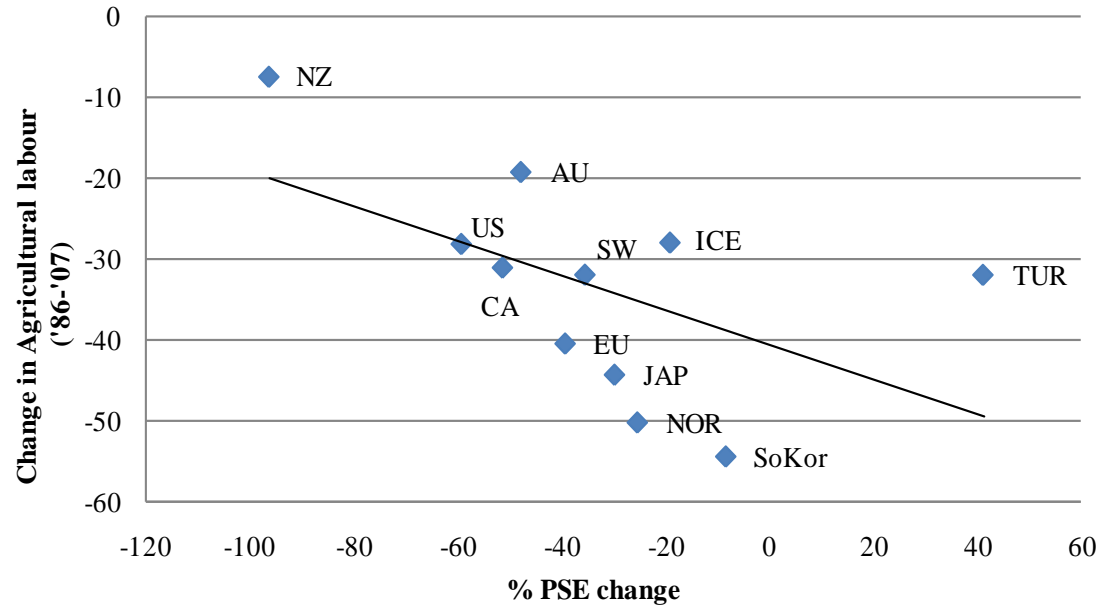
*The Producer Support Estimate (PSE) is "an indicator of the annual monetary value of gross transfers from consumers and taxpayers to support agricultural producers, measured at farm gate level, arising from policy measures, regardless of their nature, objectives or impacts on farm production or income" (OECD, 2011).
Source: OECD, ILO, national statistics
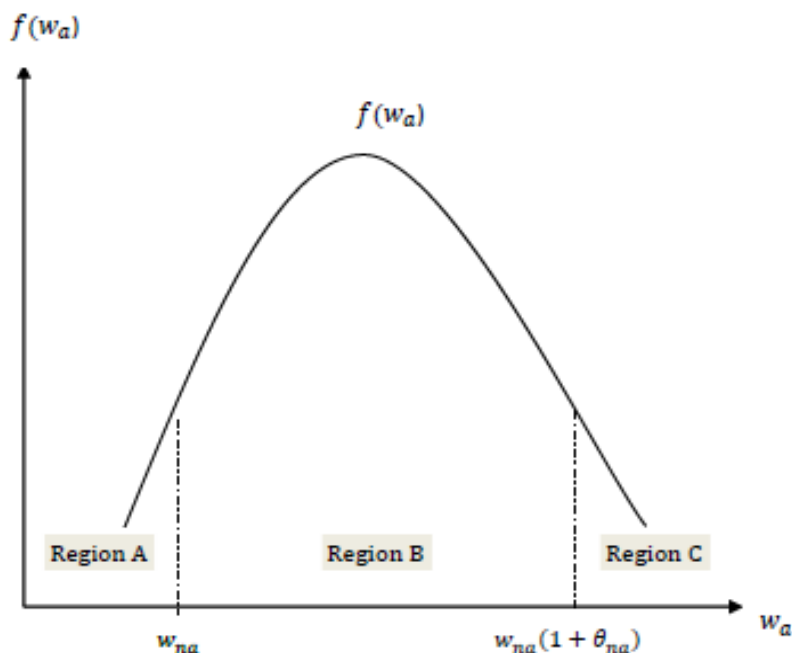
Figure 2: Agricultural employment

Figure 3: Agricultural employment with and without subsidies in the absence of credit constraints
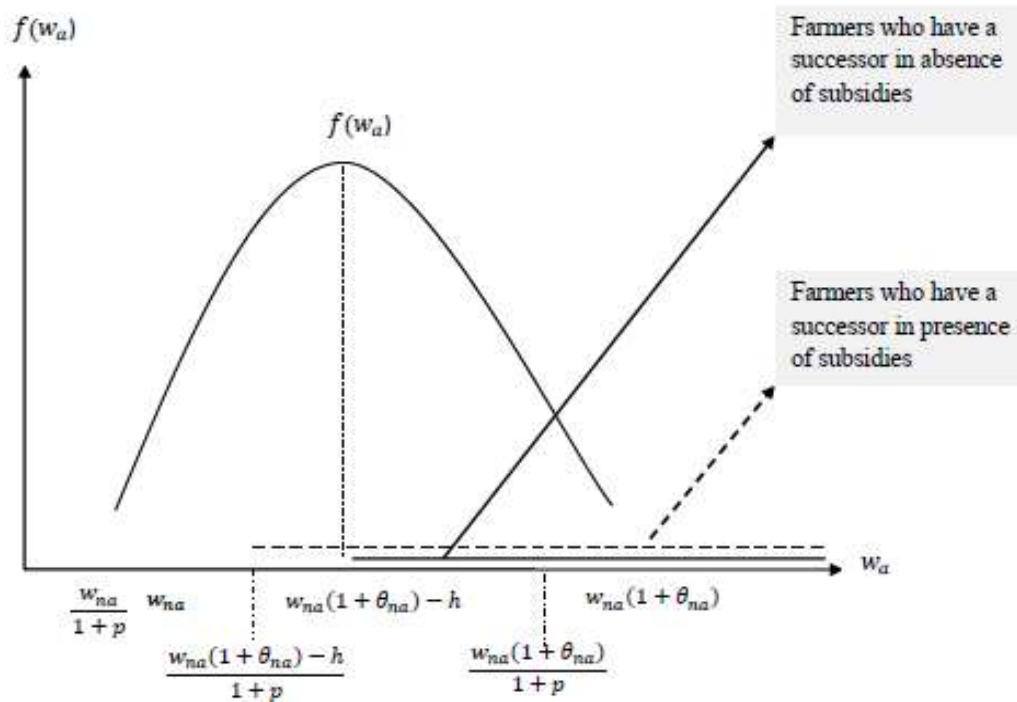

$f(w_a)$

$f(w_a)$

Farmers who have a successor in absence of subsidies

Farmers who have a successor in presence of subsidies

w_a

$\frac{w_{na}}{1+p}$ w_{na}

$w_{na}(1+\theta_{na})-h$

$w_{na}(1+\theta_{na})$

$\frac{w_{na}(1+\theta_{na})-h}{1+p}$

$\frac{w_{na}(1+\theta_{na})}{1+p}$

Figure 4: Agricultural employment with and without subsidies in the presence of credit constraints

$f(w_a)$

$f_p(w_a)$ $f(w_a)$

Farmers who have a successor in absence of subsidies

Farmers who have a successor in presence of subsidies

1

w_a

$\frac{w_{na}}{1+p}$ w_{na} $\frac{\overline{w_a}}{1+p}$ $\overline{w_a}$ $w *$ $\frac{\overline{w_a}}{1+p}$ $\overline{w_a}$ $\frac{w_{na}(1+\theta_{na})}{1+p}$ $w_{na}(1+\theta_{na})$
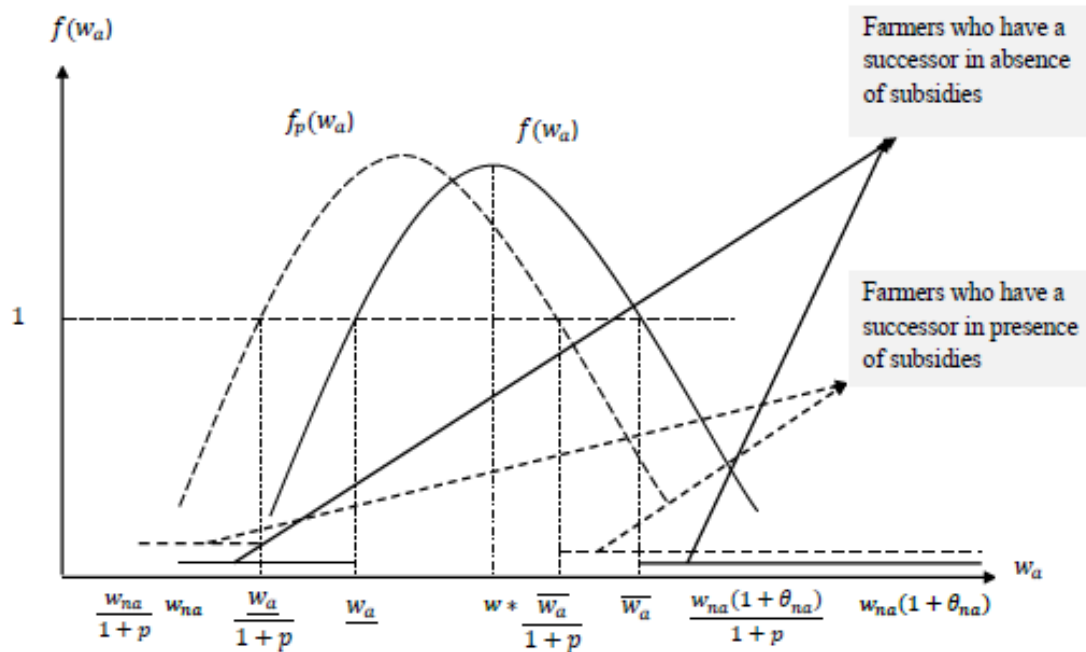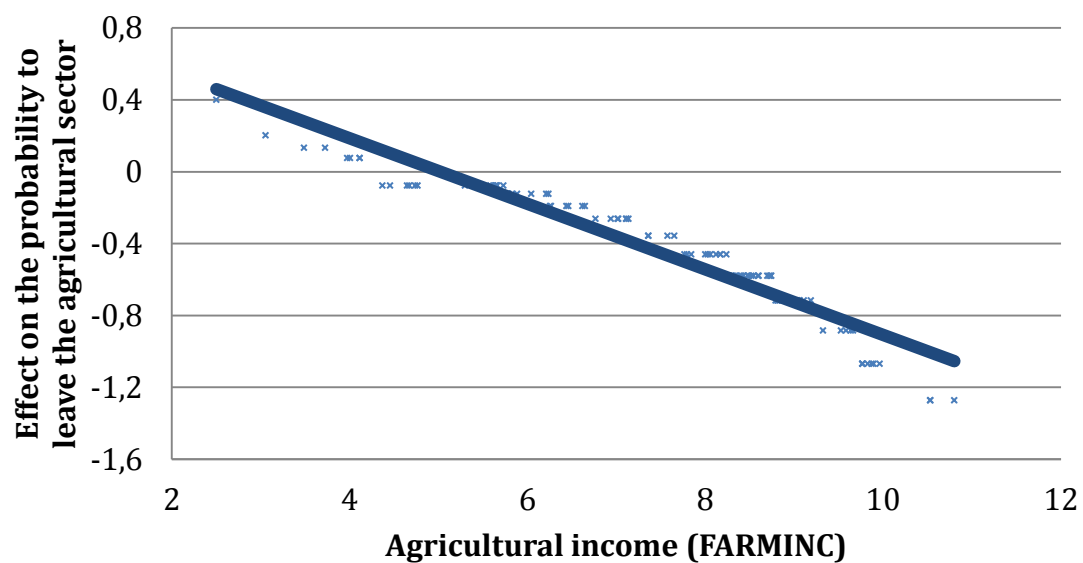
28

Figure 5: Combined impact of agricultural income on the probability to leave the agricultural sector

Source: Own calculations based on a subsample of the EHCP survey

APPENDIX 1: PARENTS' OPTIMIZATION IN CASE OF NO CREDIT CONSTRAINTS

The parents' optimization problem is:

$$\max_{s,e} U(c, \tilde{c})$$

$$s.t. \quad c + he + s \leq w_a \qquad \text{(parents' budget constraint)}$$

$$\tilde{c} \leq s + w_c \qquad \text{(child's budget constraint)}$$

When rewriting the parents' utility function using the farmers' and the child's budget constraints, which we assume to be binding, and substituting the child's expected income (w_c) by (6), we get the following expression for the parents' optimization problem:

$$\max_{s,e} U(c, \tilde{c}) = \max_{s,e} \left[ln(w_a - he - s) + \beta ln(w_a + [w_{na}(1 + \theta_{na}) - w_a]e + s) \right]$$

First, consider the case in which the child receives no education: $e = 0$. Then consider the case in which the child receives education: $e = 1$. Solving the parents' optimization problem gives us respectively:

$$U^*(e = 0) = ln\left[\frac{2}{1 + \beta} \, w_a\right] + \beta \ln\left[\frac{2\beta}{1 + \beta} w_a\right]$$

$$U^*(e = 1) = ln\left[\frac{1}{1 + \beta} \, (w_a - h + w_{na}(1 + \theta_{na}))\right] + \beta ln\left[\frac{\beta}{1 + \beta} (w_a - h + w_{na}(1 + \theta_{na}))\right]$$

Parents only invest in education when:

$$U^*(e = 1) > U^*(e = 0)$$

which is the case when

$$h < w_{na}(1 + \theta_{na}) - w_a$$

Note that in case farmers receive subsidies, we can just replace w_a by $w_a(1 + p)$, such that

farmers will invest in education if only if:

$$h < w_{na}(1 + \theta_{na}) - w_a(1 + p)$$

APPENDIX 2: AGRICULTURAL EMPLOYMENT IN CASE OF NO CREDIT CONSTRAINTS

The level of agricultural employment in period two depends on the position of $w_{na}(1 + \theta_{na}) - h$ w.r.t. w_{na} and $w_{na}(1 + \theta_{na})/(1 + \theta_a)$. There are three possibilities. First, if $w_{na}(1 + \theta_{na}) - h < w_{na}$, none of the farmers with an intermediate income (in region B) invests in education, so agricultural employment in period two is given by:

$$\tilde{N} = N[1 - F(w_{na})]$$

Second, if $w_{na} < w_{na}(1 + \theta_{na}) - h < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)$, farmers with an intermediate income (in region B) invest in their education if $w_a < w_{na}(1 + \theta_{na}) - h$, so agricultural employment in period two is given by:

$$\tilde{N} = N[1 - F(w_{na}(1 + \theta_{na}) - h]$$

Finally, if $w_{na}(1 + \theta_{na}) - h > w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)$, all farmers with an intermediate income (in region B) invest in education, so agricultural employment in period two is given by:

$$\tilde{N} = N\left[1 - F(w_{na}\left(\frac{1 + \theta_{na}}{1 + \theta_a}\right))\right]$$

When we analyse the effect of subsidies on agricultural employment in period two, there are three possibilities, depending on the position of $\frac{(w_{na}(1+\theta_{na})-h)}{(1+p)}$ w.r.t. $\frac{w_{na}}{1+p}$ and $w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right)$.

First, if $\frac{(w_{na}(1+\theta_{na})-h)}{(1+p)} < \frac{w_{na}}{1+p}$, none of the farmers with an intermediate income (in region

B$_p$) invests in education, so employment agricultural sector in period two is given by:

$$\widetilde{N}_p = N\left[1 - F(\frac{w_{na}}{1+p})\right]$$

Second, if $\frac{w_{na}}{1+p} < \frac{(w_{na}(1+\theta_{na})-h)}{(1+p)} < w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right)$, farmers with an intermediate income

(in region B$_p$) invest in education if $w_a < \frac{(w_{na}(1+\theta_{na})-h)}{(1+p)}$, so agricultural employment in

period two is given by:

$$\widetilde{N}_p = N\left[1 - F(\frac{(w_{na}(1+\theta_{na})-h)}{(1+p)})\right]$$

Finally, if $\frac{(w_{na}(1+\theta_{na})-h)}{(1+p)} > w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right)$, all farmers with an intermediate income (in

region B$_p$) invest in education, so agricultural employment in period two is given by:

$$\widetilde{N}_p = N\left[1 - F(w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right))\right]$$

In all three possible cases, agricultural subsidies have a positive impact on the level of employment

in period two.

APPENDIX 3: PARENTS' OPTIMIZATION IN CASE OF CREDIT CONSTRAINTS

In the presence of credit constraints, the parents' optimization problem becomes:

$$\max_{s,e} U(c, \tilde{c})$$

$$s.t. \quad c + he + s \le w_a \qquad \text{(parents' budget constraint)}$$

$$\tilde{c} \le s + w_c \qquad \text{(child's budget constraint)}$$

$$s \ge 0 \qquad \text{(credit constraint)}$$

When rewriting the parents' utility function using the farmers' and the child's budget constraints, which we assume to be binding, and substituting the child's expected income (w_c) by (6), we get the following expression for the parents' optimization problem:

$$\max_{s,e} U(c, \tilde{c}) = \max_{s,e} \left[ln(w_a - he - s) + \beta ln(w_a + [w_{na}(1 + \theta_{na}) - w_a]e + s) \right]$$

$$s.t. \quad s \ge 0$$

First, consider the case in which the child receives no education: $e = 0$. Then consider the case in which the child receives education: $e = 1$. Solving the parents' optimization problem gives us respectively:

$$U^*(e = 0) = ln[\, w_a] + \beta \ln[w_a]$$

$$U^*(e = 1) = ln[\, w_a - h] + \beta ln[w_{na}(1 + \theta_{na})]$$

Hence parents only invest in education when:

$$U^*(e = 1) > U^*(e = 0)$$

which is the case when

$$\frac{[w_{na}(1 + \theta_{na})]^\beta (w_a - h)}{w_a^{\beta+1}} > 1$$

which equals expression (11).

Note that in case farmers receive subsidies, we can just replace w_a by $w_a(1 + p)$, such that

farmers will invest in education if only if:

$$\frac{[w_{na}(1 + \theta_{na})]^\beta [w_a(1 + p) - h]}{[w_a(1 + p)]^{\beta+1}} > 1$$

APPENDIX 4: AGRICULTURAL EMPLOYMENT IN THE PRESENCE OF CREDIT CONSTRAINTS

Agricultural employment in period two depends on the position of w_a^*, $\underline{w_a}$ and $\overline{w_a}$ w.r.t. w_{na} and $w_{na}(1 + \theta_{na})/(1 + \theta_a)$.

First, there are three possibilities w.r.t. to the position of w_a^* (Possibilities A):

$$w_a^* < w_{na} \tag{P1A}$$

$$w_{na} < w_a^* < \frac{w_{na}(1+\theta_{na})}{1+\theta_a} \tag{P2A}$$

$$w_a^* > \frac{w_{na}(1+\theta_{na})}{1+\theta_a} \tag{P3A}$$

Second, then we have to determine the possible positions of $\underline{w_a}$ and $\overline{w_a}$ w.r.t. w_{na} and $w_{na}(1 + \theta_{na})/(1 + \theta_a)$. Therefore we determine the conditions under which $f(w_{na}) > 1$ and $f(w_{na}(1 + \theta_{na})/(1 + \theta_a))>1$. This results in the following two conditions on h:

$$\text{For } f(w_{na}) > 1, \text{then } h < w_{na}[1 - \frac{1}{(1+\theta_{na})^\beta}]$$

$$\text{For } f(w_{na}(\frac{1+\theta_{na}}{1+\theta_a}))>1, \text{then } h < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)[1 - \frac{1}{(1+\theta_{na})^\beta}]$$

As a result, the position of h will determine the position of $\underline{w_a}$ and $\overline{w_a}$ w.r.t. w_{na} and $w_{na}(1 + \theta_{na})/(1 + \theta_a)$. There are three possibilities (Possibilities B):

$$\text{For } h < w_{na}[1 - \frac{1}{(1+\theta_{na})^\beta}], \text{ then } \underline{w_a} < w_{na} \text{ and } \overline{w_a} > \frac{w_{na}(1+\theta_{na})}{1+\theta_a} \tag{P1B}$$

$$\text{For } w_{na}\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right] < h < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right],$$

$$\text{then } \underline{w_a} > w_{na} \text{ and } \overline{w_a} > \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$$

<div align="right">(P2B)</div>

$$\text{For } h > w_{na}\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right], \text{ then } \underline{w_a} > w_{na} \text{ and } \overline{w_a} < \frac{w_{na}(1+\theta_{na})}{1+\theta_a} \qquad \text{(P3A)}$$

Combining the possibilities for w_a^* (possibilities A) and the possibilities for $\underline{w_a}$ and $\overline{w_a}$ (Possibilities B) yields a total of nine cases, which will determine agricultural employment in the second period.

However, given the assumptions of our model, only six cases are possible, namely[30]

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[30] Three cases are not possible because they conflict with (18), namely

- $w_a^* < w_{na}$ and $w_{na}\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right] < h < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right]$: In case the condition on h holds, then $f(w_{na}) < 1$ and $f(\frac{w_{na}(1+\theta_{na})}{1+\theta_a}) > 1$ such that $\underline{w_a} > w_{na}$ and $\overline{w_a} > \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$. However when $\underline{w_a} > w_{na}$ and $w_a^* < w_{na}$, then $\underline{w_a} > w_a^*$, which contradicts with (18) which states that $\underline{w_a} < w_a^* < \overline{w_a}$.

- $w_a^* < w_{na}$ and $h > w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right]$: In case the condition on h holds, then $f(w_{na}) < 1$ and $f(\frac{w_{na}(1+\theta_{na})}{1+\theta_a}) < 1$ such that $\underline{w_a} > w_{na}$ and $\overline{w_a} < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$. However when $\underline{w_a} > w_{na}$ and $w_a^* < w_{na}$, then $\underline{w_a} > w_a^*$, which contradicts with (18) which states that $\underline{w_a} < w_a^* < \overline{w_a}$.

- $w_a^* > \frac{w_{na}(1+\theta_{na})}{(1+\theta_a)}$ and $h > w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right]$: In case the condition on h holds, then $f(w_{na}) < 1$ and $f(\frac{w_{na}(1+\theta_{na})}{1+\theta_a}) < 1$ such that $\underline{w_a} > w_{na}$ and $\overline{w_a} < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$. However when $\overline{w_a} < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ and $w_a^* > \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$, then $\overline{w_a} > w_a^*$, which contradicts with (18) which states that $\underline{w_a} < w_a^* < \overline{w_a}$.

- *Case 1:* $w_a^* < w_{na}$ and $h < w_{na}[1 - \frac{1}{(1+\theta_{na})^\beta}]$

  In this case $\underline{w_a} < w_a^* < w_{na} < \frac{w_{na}(1+\theta_{na})}{1+\theta_a} < \overline{w_a}$ holds. As a result, all farmers in region B with an intermediate income w_a invest in their children's education and all their children will leave the agricultural sector. Hence, agricultural employment in the second period becomes

$$\tilde{N} = N[1 - F(w_{na}(1 + \theta_{na})/(1 + \theta_a)]$$

- *Case 2:* $w_{na} < w_a^* < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ and $h < w_{na}[1 - \frac{1}{(1+\theta_{na})^\beta}]$:

  In this case $\underline{w_a} < w_{na} < w_a^* < \frac{w_{na}(1+\theta_{na})}{1+\theta_a} < \overline{w_a}$ holds. As a result, all farmers in region B with an intermediate income w_a invest in their children's education and all their children leave the agricultural sector. Hence, agricultural employment in the second period becomes:

$$\tilde{N} = N[1 - F(w_{na}(1 + \theta_{na})/(1 + \theta_a)]$$

- *Case 3:* $w_{na} < w_a^* < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ and $w_{na}\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right] < h < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right]$:

  In this case $w_{na} < \underline{w_a} < w_a^* < \frac{w_{na}(1+\theta_{na})}{1+\theta_a} < \overline{w_a}$ holds. As a result, the farmers in region B with an intermediate income w_a such that $\underline{w_a} < w_a < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ invest in their children's education and the educated children leave the agricultural sector. Hence, agricultural employment in the second period becomes:

$$\tilde{N} = N\left[F\left(\underline{w_a}\right) - F(w_{na}) + 1 - F(w_{na}(1 + \theta_{na})/(1 + \theta_a)]\right]$$

- _Case 4:_ $w_{na} < w_a^* < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ and $h > w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right]$:

In this case $w_{na} < \underline{w_a} < w_a^* < \overline{w_a} < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ holds. As a result, the farmers in region B

with an intermediate income w_a such that $\underline{w_a} < w_a < \overline{w_a}$ invest in their children's

education and the educated children leave the agricultural sector. Hence, agricultural

employment in the second period becomes

$$\widetilde{N} = N\left[F\left(\underline{w_a}\right) - F(w_{na}) + 1 - F(\overline{w_a})\right]$$

- _Case 5:_ $w_a^* > \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ and $h < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right]$:

In this case $\underline{w_a} < w_{na} < \frac{w_{na}(1+\theta_{na})}{1+\theta_a} < w_a^* < \overline{w_a}$ holds. As a result, all farmers in region B

with an intermediate income w_a invest in their children's education and all their children

leave the agricultural sector. Hence, agricultural employment in the second period becomes

$$\widetilde{N} = N[1 - F(w_{na}(1 + \theta_{na})/(1 + \theta_a))]$$

- _Case 6:_ $w_a^* > \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ and $w_{na}\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right] < h < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)\left[1 - \frac{1}{(1+\theta_{na})^\beta}\right]$:

In this case $w_{na} < \underline{w_a} < \frac{w_{na}(1+\theta_{na})}{1+\theta_a} < w_a^* < \overline{w_a}$ holds. As a result, farmers in region B with

an intermediate income w_a such that $\underline{w_a} < w_a < \frac{w_{na}(1+\theta_{na})}{1+\theta_a}$ invest in their children's

education and the educated children leave the agricultural sector. Hence, agricultural

employment in the second period becomes

$$\widetilde{N} = N\left[F\left(\underline{w_a}\right) - F(w_{na}) + 1 - F(w_{na}(1 + \theta_{na})/(1 + \theta_a))\right]$$

In summary, we can distinguish between three possible solutions:

First, if $w_{na}\left[1 - \frac{1}{(1+\theta_a)^\beta}\right] > h$ and independently of the value of w_a^*, all farmers in region B invest in education, so agricultural employment in period two is given by:

$$\widetilde{N} = N\left[1 - F(\frac{w_{na}(1+\theta_{na})}{1+\theta_a})\right]$$

Second, if $w_{na}\left[1 - \frac{1}{(1+\theta_a)^\beta}\right] < h < w_{na}(\frac{1+\theta_{na}}{1+\theta_a})\left[1 - \frac{1}{(1+\theta_a)^\beta}\right]$ and $w_a^* > w_{na}$, farmers in region B invest in education if $\underline{w_a} < w_a < w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)$ so agricultural employment in period two is given by:

$$\widetilde{N} = N\left[F\left(\underline{w_a}\right) - F(w_{na}) + 1 - F(w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right))\right]$$

Third, if $h > w_{na}(\frac{1+\theta_{na}}{1+\theta_a})\left[1 - \frac{1}{(1+\theta_a)^\beta}\right]$ and $w_{na} > w_a^* > w_{na}\left(\frac{1+\theta_{na}}{1+\theta_a}\right)$, farmers in region B invest in education if $\underline{w_a} < w_a < \overline{w_a}$, so agricultural employment in period two is given by:

$$\widetilde{N} = N\left[F\left(\underline{w_a}\right) - F(w_{na}) + 1 - F(\overline{w_a})\right]$$

When we analyse the effect of subsidies on agricultural employment in period two in the presence of credit constraints, these three possibilities become the following:

First, if $w_{na}[1 - \frac{1}{(1+\theta_a)^\beta}] > h]$ and independent on the position of w_a^*, all farmers in region B_p invest education, so agricultural employment in period two is given by:

$$\widetilde{N}_p = N\left[1 - F[(\frac{w_{na}(1+\theta_{na})}{(1+\theta_a)(1+p)})\right]$$

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Second, if $w_{na}[1 - \frac{1}{(1+\theta_a)^\beta}] < h < w_{na}(\frac{1+\theta_{na}}{1+\theta_a})[1 - \frac{1}{(1+\theta_a)^\beta}]]$ and $w_a^* > \frac{w_{na}}{1+p}$, farmers in region

B_p invest in education if $\frac{w_a}{1+p} < w_a < w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right)$, so agricultural employment in

period two is given by:

$$\tilde{N}_p = N\left[F\left(\frac{w_a}{1+p}\right) - F\left(\frac{w_{na}}{1+p}\right) + 1 - F\left(\frac{w_{na}(1+\theta_{na})}{(1+\theta_a)(1+p)}\right)\right]$$

Third, if $h > w_{na}(\frac{1+\theta_{na}}{1+\theta_a})[1 - \frac{1}{(1+\theta_a)^\beta}]$ and $\frac{w_{na}}{1+p} > w_a^* > w_{na}\left(\frac{1+\theta_{na}}{(1+\theta_a)(1+p)}\right)$, farmers in region B

invest in education if $\frac{\underline{w_a}}{1+p} < w_a < \frac{\overline{w_a}}{1+p}$, so agricultural employment in period two is given

by:

$$\tilde{N}_p = N\left[F\left(\frac{w_a}{1+p}\right) - F\left(\frac{w_{na}}{1+p}\right) + 1 - F\left(\frac{\overline{w_a}}{1+p}\right)\right]$$

In the first case, subsidies are found to have a positive impact on agricultural employment.

In the second and third case, the impact of subsidies on agricultural employment is

unambiguous and depends on the distributional characteristics of $F(w_a)$.

In the second case, subsidies are expected to have a negative impact on agricultural

employment in the second period if:

$$F\left(\underline{w_a}\right) - F\left(\frac{w_a}{1+p}\right) < F(w_{na}) - F\left(\frac{w_{na}}{1+p}\right) + F(\overline{w_a}) - F\left(\frac{\overline{w_a}}{1+p}\right)$$

In the third case, subsidies are found to have a positive impact on agricultural employment

in the second period if:

$$F\left(\underline{w_a}\right) - F\left(\frac{w_a}{1+p}\right) < F(w_{na}) - F\left(\frac{w_{na}}{1+p}\right) + F\left(\frac{w_{na}(1+\theta_{na})}{1+\theta_a}\right) - F\left(\frac{w_{na}(1+\theta_{na})}{(1+\theta_a)(1+p)}\right)$$