Working-Paper : A micro-econometric analysis of care for the dependent elderly living at home in France: Is there a crowding-out effect of informal caregivers when an elderly dependent receives professional home care ?*

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Abstract

This paper focuses on the trade-off between formal care and informal care for disabled elderly people living at home in France. Using data from the French" Handicap Santé Ménages " survey (2008), we try to answer the question of the effect of an increase in formal home care hours on the participation of informal caregivers. We extend previous literature, which almost exclusively focuses on the effect of informal care on formal home care. We first estimate a two-part instrumental variable model, to account for endogeneity of formal home care. Then we estimate a bivariate Tobit model in order to take into account the censor of our formal home care variable. Our results confirm that there is a crowding-out effect of informal caregivers, when the elderly dependent person receives more hours of formal home care. Nevertheless, the crowding-out effect of informal caregivers is much lower, when only medical formal home care increases.

1   Introduction

In France, as in most developed countries, population aging is in progress and will continue for the next decades. According to the French National Institute of Statistics (INSEE), the proportion of persons aged 65 and older already reached 13.9% in 1990 and 16.6% in 2008. The preliminary estimates for January 2011 are evaluated at 16.9%. In 2025, the elderly population will represent 21.7% of the French population and this figure is expected to raise to 26.2% in 2050. This inescapable aging could have many consequences in terms of public health. Even if it is now possible to age healthy, population ageing could increase the number of elderly individuals in a situation of dependence.

An elderly dependent person can be helped by his/her family or by professional caregivers, at home or in institutions. Home health care can be formal, which means provided by professional caregivers, and/or informal, which means provided by one or several members of the circle of acquaintance. Most European countries encourage elderly dependent people to stay home because it seems to reduce public expenditure. Given the actual economic situation in the world, governments will certainly count on families to maintain an adequate level of care for elderly dependent persons. But in the next few years , the number of informal caregivers per elderly dependent person is expected to go down. In addition to demographic trends, the increase of active seniors will make children less available to help their elderly dependent parent. The smaller number of siblings and the growing physical distance between parents and children are other explanations to this phenomenon.

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In such a difficult economic context, where the number of elderly dependent people should increase and informal caregivers should lack, a better understanding of the care arrangement of elderly dependent people living at home is urgent. It could allow to anticipate and evaluate the effect of future public policies devoted to reduce the cost of the care arrangement and maintain its efficiency. More than simply analyze their determinants, we would like to understand how formal home care and informal care are related to each other. How would the quantity of informal care vary if the quantity of formal home care increased? Studying the relationship between formal home care and informal care could help the public administration to answer an important question in terms of public health policies: is there a crowding-out effect of familial solidarities by public solidarities devoted to elderly dependent persons in France? Will a public subsidy helping elderly dependent persons to pay formal home care decrease the quantity of care provided by their family?

Studying the potential crowding-out effect of informal caregivers is directly linked with the societal question of the role of the French public administration in long-term care. Should a benefit for formal home care attributed by the French public administration only be offered to elderly dependent individuals, who cannot receive informal care from their family? In other terms, should the French public administration play a subsidiary role to the family structure? Or does the French public administration have to help every elderly dependent persons, without restriction ? If a philosophical answer to this question cannot be given by economists, they could anticipate the economic implications of each scenario in studying the potential crowding-out effect of informal caregivers and in understanding its meaning.

Although studies have been published for about thirty years, there has not been a decisive answer to the following question yet: are informal and formal care complements or substitutes? The most studied effect in the recent literature is the one of informal care on the use of formal care. Most of the existing results go in the same direction: informal care substitutes for formal care, once we control for endogeneity. An old study by Greene [12] controls for endogeneity and concludes that informal care reduces formal care use, but data in that study only comes from one American state. Lo Sasso and Johnson (2002) [14] and Charles and Sevak (2005) [5] conclude that informal care reduces the risk of entering into a nursing home and that it can thus be seen as a substitute to institution. Van Houtven and Norton (2004) [19] find that informal care is a substitute to formal long-term care (nursing home entry and home based care) as well as health care (hospital and doctor visits), using instrumental variables techniques. Bolin et al. (2008) [2] work on the same topic using European data and follow the strategy used by Van Houtven and Norton (2004) [19] of employing child characteristics as instruments of informal care. They find that informal care acts as a substitute for formal home care but as a complement for doctor and hospital visits. Bonsang (2009) [3] uses instrumental variables too but extends the two previous articles in making the distinction between skilled (nursing care) and unskilled (paid domestic help) formal home care. Using European data from the first wave of SHARE (2004), he constructs a two-part utilization model and finds that informal care is found to decrease low-skilled home care use while it is a complement to high-skilled home care.

We are more concerned about the reversal effect of public support on informal care for elderly dependent persons living at home in France. If several past studies focus on the same topic using American or European data, the provided results are mixed. Christianson (1988) [6], working on a National long-term care demonstration that took place in the United States in the 1980's (the Channeling), and Motel-Klingebiel et al. (2005) [16], using data from four European countries and Israel, do not find a significant crowding-out effect of informal caregivers. Pezzin et al. (1996) [17] use data from the Channeling experiment too and also find that the effect of an increase of the publicly provided home care hours on informal care hours is limited, after controlling by the living arrangement of the elderly dependent person. By contrast, Viitanen (2007) [20] finds a significant crowding-out effect of informal caregivers living outside the household after an increase in long-term care expenditure, using panel data from 12 European countries including France. In the same direction, Stabile et al. (2006) [18] find that an increased availability of public home care is associated with a decline in informal care giving in Canada. They use instrumental variables correlated with the generosity of the public home care program in each province. Golberstein et al.(2009) [11] point out the fact that data used by Stabile et al. (2006) [18] is limited in only having information on whether or not informal care is delivered. Moreover, the truly exogeneity of their instrument for formal care, i.e. the generosity of the public home care program per province, is put into question. Using longitudinal data from AHEAD and HRS surveys, Golberstein et al.(2009) [11] find that informal care provided to individuals exposed to more restrictive payment caps for Medicare home health care increases.

Although it could have major implications for future public policy, the effect of formal home care on informal care for elderly dependent people living at home is not as often studied as the reversal one. To our knowledge, Stabile et al. (2006) [18] are the only one to suggest an instrumental variable model using Canadian data to treat the question. But instruments for formal home care are difficult to find and subject to controversy. In the present study, we extend previous findings to different directions: first, we look at the French case, in studying the effect of formal home care on informal care using French data of HSM survey (2008). Second, in contrast with Stabile et al. (2006) [18], we possess a quantitative variable of hours of informal care received by each elderly dependent of our sample. Third, we extend the classical two-part model in constructing a bivariate Tobit model, in order to take into account the censor of our formal home care variable. Fourth, we use a new instrument adapted to the French situation to treat the problem of endogeneity of formal home care.

2 Background and conceptual framework

2.1 Relationship between formal home care and informal care

Theoretical models related to the utilization of formal and informal care among the elderly are mainly based on the family-decision making process and a health production function, where formal home care and informal care are regarded as two factors of production. The model described by Van Houtven and Norton (2004) [19] is an extension of the classic Grossman (1972) [13] model of health demand, altered to include formal and informal care. The relationship between informal and formal care depends on the sign of the derivative of the marginal product of formal care (in the production of health) with respect to informal care. According to Bolin et al. (2008) [2] and Bonsang (2009) [3], complementarity or substitution between formal home care and informal care is essentially an empirical issue. The decision to provide informal care to an elderly dependent parent and the one to ask for formal care, taken by the dependent person, are simultaneously determined. In this article, we only focus on the effect of formal home care on informal care, little studied up to now and still subject to mixed results.

Two main hypotheses are tested in this article (cf. Van Houtven and Norton (2004) [19]). First, the nature of the empirical relationship between formal and informal care. This relation is not straightforward. Contrary to what we could think, formal home care and informal care are not necessarily substitutes. We can imagine them as complements if formal home care consists more in medical care (like nursing or personal care) and informal care more in domestic tasks for example. Several normative or emotional considerations can also have an impact on the degree of participation of family members. An informal caregiver can say for example: " I help 1 hour a day, whatever the other quantities of care my parent receives ". That would imply an absence of substitution between formal and informal care. We then test whether the effect of formal home care on informal care is likely to differ according to the type of formal home care used. In the manner of Bonsang (2009) [3], we isolate medical formal home care (nursing or personal care) and expect the substitution effect between formal home care and informal care to be lower than for " unskilled " formal home care.

2.2 Specificities of the French case

It would be a mistake to consider the nature of the relationship between formal home care and informal care obtained with American or European data as valid for the French situation. French care institutions are very different from American ones or from the ones of most of the European countries. In the United States, the public supply of formal home care is mainly restricted to disabled persons with Medicare, or is means-tested with Medicaid. The private market of formal home care is well developed but also very costly for elderly dependent people. In the United States, an elderly dependent person may consider the probability of benefiting from refunded formal home care before deciding the amount of informal care received.

In France, formal home care given to elderly dependent people can be provided through different ways. Service providers of formal home care hire and pay employees to care for elderly dependent persons. Since service providers do a regulated activity, they are subject to agreements provided by French public agencies. We can distinguish service providers agreed by French District Councils from those agreed by French Regional Offices for Labor. The first ones cannot choose their prices, while the second ones have

more flexibility as long as their prices do not vary dramatically from one year to another. The elderly dependent person can also pay the care provider directly in recruiting it over-the-counter. The panorama of formal home care providers is thus very different from a French district to another. Moreover visiting nurses and housekeepers can practice their job anywhere in France, which means that they are totally free to select the area, where they work. As a result, there is a huge geographical disequilibrium between districts in terms of supply. In addition, in France as in many European countries, the out-of-pocket expenses for an elderly dependent person receiving formal home care is reduced thanks to the French benefit for autonomy (APA). Since 2002, this benefit is attributed by French District Councils. To benefit from the APA, people have to fill out an application. Each district has its own application, more or less complicated, with more or less supporting documents required. Eventually, out-of-pocket expenses for formal home care that an elderly dependent has to carry out vary a lot from a district to another.

To sum up, there is a huge variability between French districts in terms of access to formal home care and of formal home care providers. These differences should have an impact on individual demands for formal home care. We thus have to take them into account in order to build a strong instrumental variable for formal home care.

3   Estimation strategies

3.1   A two-part model with instrumental variables

Our first empirical model consists in analyzing the causal effect of formal home care provided to elderly dependent persons on the quantity of informal care received. To test the two hypotheses mentioned in the subsection 2.1, we first estimate a two-part model introduced by Duan et al. (1983) [9]. It allows the separation of behavior into two stages: the first stage is a Probit model that predicts the probability of receiving any informal care. The second part uses least squares to predict the continuous amount of informal care received, conditional of having any. The utilization of informal care (y) is a function of formal home care (fc) and of a vector of exogenous characteristics of the individual (X). The subscript i represents the individual. The two-part model assumes that part one, $\Pr(y_i > 0)$, is described by a Probit model such that:

$$\Pr(y_i > 0 | fc_i, X_i) = \Phi(\gamma_0 + \gamma_{fc} \ln(1 + fc_i) + \gamma'_X X_i), \tag{1}$$

where $\Phi(.)$ represents the cumulative density function of the standard Normal, γ_0 and γ_{fc} are the parameters to be estimated and γ_X is a vector of parameters to be estimated. Part two corresponds to the following equation assuming that the logarithm of the positive values of y is linear in $\ln(1 + fc)$ and X:

$$E(\ln(y_i) | y_i > 0, fc_i, X_i) = \beta_0 + \beta_{fc} \ln(1 + fc_i) + \beta'_X X_i, \tag{2}$$

where β_0, β_{fc} and β_X are the parameters (or vectors of parameters) to be estimated.

Because the formal home care variable (fc) is skewed, we take the log in both part of our model. The dependent variable y in the second part is logged to diminish the influence of outliers. To treat the problem of endogeneity of formal home care, we estimate instrumental variable (IV) models which produce consistent parameter estimates. For the first part of our two-part model, the discrete outcome of utilization, we use the instrumental variables Probit (IV Probit) ado program in Stata 11, estimated with maximum likelihood techniques. Part two (continuous utilization) uses the standard two-stage least squares estimation.

3.2   A bivariate Tobit model using maximum likelihood estimation

The previous two-part IV model can be criticized for two main reasons. First, the endogenous formal home care variable (f_i) is treated as a continuous one, although there is a large number of individuals (more than 31 % of our population of interest) for which this variable equals 0. This variable has a large mass point in 0, and the previous model does not take it into account. Second, contrary to Heckman's selection model, both parts of our two-part model are independent. Considering the probability to receive informal care and the amount of informal care received as independent processes is a very strong assumption, which should be relaxed.

Our second model solves these problems. It is a bivariate Tobit model, which does not separate the probability of receiving care from the quantity of care received and takes into account the censor of both care variables. It looks like the well-known IV Tobit model, except the fact that our formal care variable in the structural equation is censored. The first equation (the structural one) has the form of a Tobit model that predicts the (logged) number of hours of informal care received (y), which is censored in 0. And the second equation (the instrumental one) has also the form of a Tobit model explaining the (logged) quantity of formal home care received (fc, censored in 0) by exogenous variables and an exclusion variable (Z, also named instrument). We use the density of self-employed midwives in each district as an exclusion variable. The two error terms follow a bivariate Normal distribution. The utilization of informal care (y) is a function of formal home care (fc) and of a vector of exogenous characteristics of the individual (X). The subscript i represents the individual. Our bivariate Tobit model can be written as follows :

$$\begin{cases} y_i^* = \gamma_0 + \gamma_{fc} \ln(1 + fc_i) + \gamma_X' X_i + \epsilon_s \\ fc_i^* = \delta_0 + \delta_Z' Z_i + \delta_X' X_i + \epsilon_f \end{cases}$$

with : $\quad \ln(1 + y_i) = \begin{cases} y_i^*, & \text{if } y_i^* > 0 \\ 0, & \text{else.} \end{cases}$ $\qquad$ and : $\quad \ln(1 + fc_i) = \begin{cases} fc_i^*, & \text{if } fc_i^* > 0 \\ 0, & \text{else.} \end{cases}$

where y^* and fc^* are latent variables (only observed when they take positive values) related to informal care and formal home care respectively and γ_0, γ_{fc}, γ_X, δ_0, δ_X are parameters (or vectors of parameters) to be estimated.

This bivariate Tobit model is simultaneously estimated with Stata 11 using maximum likelihood techniques. The log-likelihood is easily calculated following Amemiya (1974) [1], Lollivier (2006) [15] and Fontaine (2011) [10]. The explicit version of the log-likelihood is available upon request.

4 Data

We use the 2008 Disability - Healthcare data on households (Handicap Santé Ménages - HSM 2008) of the French National Institute for Statistics and National Studies (INSEE). The aim of this survey is to ask for as many information as possible about care dependent people in France. It thus includes both information about health status, socio-economic status, living situation and information about care received by individuals. In total, 29,931 individuals answered the questionnaire.

4.1 Sample selection criteria

The aim of our work is to describe how elderly people in France are cared for. We define elderly people as being at least 60 of age and thus exclude thus younger people, who might nevertheless be care dependent.

Furthermore we exclude all completely autonomous people. We use a very broad definition of dependence in order not to exclude accidentally individuals, who are only slightly care dependent. We base our definition of dependence on the number of difficulties in doing activities of daily living (ADL in what follows) or instrumental activities of daily living (IADL in what follows). The ADL include fundamental tasks, which are necessary for an individual to live and survive on its own. Instrumental activities of daily are not necessary to survive but enable the person to live on its own. Seven ADL are taken into consideration in our work: bathing, dressing and undressing, cutting food, eating and drinking, using the toilet, lying down and getting up from bed, sitting down in and getting up from a chair. Eleven IADL are considered: shopping, preparing the meals, doing common household chores, doing less common chores, doing common administrative processes, taking medication, moving around, leaving home, using a method of transportation, finding the way, using a telephone. For each ADL and IADL, the individuals are asked the following question: " How much difficulty do you have... ". People are considered care dependent if they report having at least " some difficulty " in doing alone at least one ADL or IADL. They also are considered care dependent if they suffer from Alzheimer's disease.

Moreover, we only consider single living persons because informal caregivers living with the care recipient often have problems to declare the exact amount of time they spend on caring their cohabitant. This leads to a high proportion of missing values for this particular group of caregivers. The amounts of care declared are also not as robust as the one given by informal caregivers living somewhere else. The distinction between care and regular household duties is sometimes very difficult to make. Many spouses seem to consider any caring tasks as marital duties and report then a very small number of care hours, even if they actually help a lot more. Eventually, information about the health status of the spouse is not available in our data. Assuming that there is a significant proportion of spouses in need of care themselves, we cannot distinguish them from those able to help their partner. We have thus decided to only look at single-living care dependent people.

We also discard observations with missing or unreliable values for the variables of interest and the other explanatory variables, which finally leaves us with a sample of 1526 individuals meeting all the previous criteria.

4.2 Formal home care and informal care variables

Our variable of interest is the weekly hours of informal care received by the respondent. This amount is aggregated. It consists in the sum of care hours provided by all informal caregivers per week. For each informal caregiver, the respondents have three possibilities: they can answer in terms of hours per day, per week or per month. We transform each answer in hours per week. We focus on " physical care ", which means that financial help and moral support are not taken into account to build our variable of interest. Formal home care variable consists in the weekly hours of formal home care received by the respondent. Like informal care, this amount of formal home care received is aggregated. It consists in the amounts of care provided by each formal caregivers, transformed in hours per week.

Later in our article, we isolate medical formal home care from the total amount of formal home care. This distinction is made according to the profession of the formal caregiver. Formal home care provided by a nurse, a nurse's aid, another paramedical professional or a psychologist/psychomotor therapist is considered as medical. It is harder to consider the remaining modalities as belonging to an unskilled non-medical formal home care group for two reasons. First, we do not really know what the modality "other professionals" includes. Second, is it fair to consider social care as unskilled, in the sense that it can be provided by informal caregivers? The question remains open.

4.3 The instrumental variable

The success of IV estimation hinges in finding a good instrument for formal home care, which means a variable highly correlated with formal home care but not correlated with the error term in the utilization model of informal care. This is the reason why the effect of formal home care on informal care for the elderly dependent people is not as often studied as the reversal one. To our knowledge, Stabile et al. (2006) [18] are the only one to suggest an instrumental variable model using Canadian data to treat the question. Their instruments for formal home care are correlated with the generosity of the public home care program: the share of the population aged 65 and older in each province, the level of provincial spending on education in each province and the provincial tax rate as a share of federal taxes in each province. As discussed before, their exogeneity is subject to controversy (cf Golberstein et al.(2009) [11]).

We use a new instrument, which is assumed to be more adapted to the French situation. We want to catch differences between French Council Districts, which can explain the fact of receiving more or less formal home care. We try to find an instrumental variable correlated with the supply of formal home care in each French district, because we think the global supply can have an effect on the individual demand. Visiting nurses or housekeepers can practice their job anywhere in France. It would have been interesting to introduce the density of visiting nurses or of housekeepers in each district as a potential instrument for formal home care, but we would have suspected endogeneity. Indeed, high individual demands for formal home care can have a positive effect on the number of visiting nurses in the district. We introduce the number of self-employed midwives per women aged between 15 and 50 in each district, which is highly correlated with the density of visiting nurses and housekeepers, and is exogenous in our context. Empirically, there is no effect of our instrument neither on the probability of receiving informal care, nor on the amount of informal care received, conditional of having any. The density of self employed

midwives by French districts in 2007 is obtained thanks to data from the statistical office of the French department of health (DREES).

Later in the paper, we check robustness in estimating our bivariate Tobit model with another exclusion variable (instrument). According to Delattre and Samson (2011) [7], the average annual hours of sunshine per district should be highly positively correlated with the supply of formal home care, and thus with the individual demand for formal home care. The variable is constructed using data from *Météo France* between 1991 and 2011.

4.4   Explanatory variables

We can group the explanatory variables in several classes. First, the group of variables related to the elderly person's health and dependence state: the fact of suffering (or not) from Alzheimer's disease and a score of dependence. To build our score, we selected each of the seven ADL and only eight IADL among the eleven at our disposal: we exclude those, which are highly correlated with the Alzheimer's variable. For each ADL or IADL, the score is increased by one if the individual reports having " some difficulty " in executing it alone, by two if he or she reports having " great difficulty " in executing it alone and by three if he or she cannot execute it alone. The score of dependence of each individual is the sum of his or her values for each ADL-IADL. Then we have a group of variables related to socio-economic characteristics of the elderly dependent person: having or not a diploma, income group (a categorical variable in five modalities). A third group of variables concerns children, as potential informal caregivers. The number of daughters is indeed introduced as a continuous variable, as well as the number of sons. We could focus only on children living close to their dependent parents, since their probability of caring their parent is greater. However the variable of geographical proximity is potentially endogenous (cf. Charles and Sevak (2005) [5], Bonsang (2009) [3]): the child can come to live closer to his or her dependent parent if the number of tasks that he or she has to execute for his or her parent increases. To prevent the estimations from endogeneity bias, we exclude this variable. Eventually, control variables are added: the age of the elderly dependent person and its gender.

Table 1 gives descriptive statistics for the most important variables. At first sight it is surprising that 82% of the individuals in the data sample are women. An explanation can be found in the construction of our sample. We are only looking at elderly individuals, who do not live with a spouse. Women have a higher life expectancy and they tend to be younger than their partners, which leads to a higher proportion of women among our sample. The individuals have at the mean slightly more than two children, with a few more sons than daugthers. The average age of all individuals in our sample is 79. On average, the number of IADL limitations is just under 4 and the one of ADL limitations is just over 1. The high figure for IADL limitations could be expected because of the construction of our data sample and the fact that some IADL are very far-fetched. 5.7% of our sample are suffering from Alzheimer's disease. While proportion of individuals receiving formal home care is higher than the one of those receiving informal care (about 69% against 42 %), the average number of hours of formal home care conditional of having any is higher than the one for informal care (14.7 hours against 10.6 hours).

Table 1: Summary statistics

Variable	Mean	Std. Error	Min.	Max.	N
Being a female	0.820	0.384	0	1	1526
Number of daughters	1.109	1.216	0	8	1526
Number of sons	1.117	1.183	0	7	1526
Age	79.151	8.461	60	101	1526
Receiving formal home care	0.689	0.463	0	1	1526
Receiving informal care	0.423	0.494	0	1	1526
Amount of formal home care received	10.638	17.596	0.232	168	1043
Amount of informal care received	14.674	19.327	0.233	140	637
Suffering from Alzheimer's disease	0.057	0.232	0	1	1526
Number of limitations in ADL	1.026	1.609	0	7	1526
Number of limitations in IADL	3.959	2.729	0	11	1526

Source: HSM 2008.
Sample: elderly dependent persons aged 60 or older living alone in metropolitan France.

5   Results and Interpretation

In this section we present the estimation results for our two models. We start with presenting the results of the two-part IV model and we then discuss the estimation of the bivariate Tobit model. Third, we estimate both models in isolating medical formal home care. We finally check the robustness of our bivariate Tobit estimates, in modifying the exclusion variable.

5.1   The two-part IV model

The estimates of the two-part IV model are presented in Table 2. First we can have a look at the two instrumental equations of the IV Probit and the IV Regress respectively, explaining the quantity of formal home care received. Our instrument is the density of self-employed midwives in each French district. The variable is significant at a 1% level and is thus a strong predictor of formal home care, considering both our entire sample and the sample of informal care users only. The adjusted-R^2 of our two equations are 0.42 and 0.43 respectively: the explanatory power of our instrumental equations is very high, which assures that formal home care is not being replaced by a noisy measure in IV estimation. It is interesting to notice that two main factors seem to explain the quantity of formal home care received: first, the level of dependence since the score of dependence, the age group and the fact of suffering from Alzheimer's disease are strong predictors of formal home care utilization. Second, the education level since the fact of having a diploma has a positive impact on the use of formal home care.

We can now focus on the structural equations predicting the fact of receiving informal care (IV Probit) and the quantity of informal care received, conditional of having any (IV Regress). The probability of receiving informal care and the quantity of informal care received are both significantly positively influenced by the level of dependence. Parameters associated with the score of dependence, Alzheimer and age group are significant at 5%. Number of daughters is also a strong predictor of the fact of receiving informal care and the quantity received. Daughters are known to help more their parents than sons.

Looking at the effect of formal home care, we can observe that the quantity of formal home care has a significant negative impact on informal care in both equations. Receiving more formal home care would reduce both the probability of receiving informal care and the quantity of informal care received conditional of having any. The model predicts a crowding-out effect of informal caregivers when hours of formal home care increase.

Wald test and Wu-Hausman tests are close to reject exogeneity of formal home care in each part of the model, but they do not. That is why we compute the same two-part model without assuming that formal home care is endogenous on informal care utilization. This model can be found in Appendix A, Table 7. Anyway, the coefficients related to hours of formal home care are also both negative and significant at a 5% level. We think it still makes more sense to consider the IV two-part model as the model of reference for two reasons. First, there is a growing litterature, which shows that the inverse effect of informal care on formal home care utilization exists. Second, it is highly plausible that several unobserved characteristics of the individual, such as the geographical proximity of informal caregivers or wealth characteristics of the elderly dependent and his/her family, influence both formal home care and informal care utilizations.

Table 2: Two-part IV model

	IV Probit : Receive Inf. Care		IV Regress : Hours of Inf. Care	
	Instrumental eq.	Structural eq.	Instrumental eq.	Structural eq.
Hours of formal care		-0.911*** (0.298)		-0.614* (0.337)
Score of dependence	0.0809*** (0.003)	0.105*** (0.018)	0.0804*** (0.005)	0.0931*** (0.029)
Alzheimer (Ref: No)	0.273** (0.115)	0.570*** (0.183)	0.0900 (0.152)	0.604*** (0.155)
Has a diploma (Ref: No)	0.140*** (0.0518)	0.0976 (0.0932)	0.170** (0.0804)	-0.0521 (0.103)
Income (Ref: ≤ 600 €)				
600 €- 1000 €	-0.0457 (0.0625)	-0.0317 (0.0788)	0.115 (0.0968)	0.103 (0.0963)
1000 €- 1500 €	-0.0178 (0.0753)	-0.0596 (0.0889)	0.117 (0.121)	0.0894 (0.142)
1500 € and +	0.0371 (0.0894)	-0.331* (0.174)	0.0752 (0.164)	-0.208 (0.196)
Missing	0.0577 (0.0933)	-0.104 (0.131)	-0.105 (0.149)	-0.163 (0.204)
Number of sons	-0.0181 (0.0210)	0.0389 (0.0345)	0.0136 (0.0316)	0.0480 (0.0302)
Number of daughters	-0.0252 (0.0207)	0.137** (0.0556)	-0.0180 (0.0303)	0.0993** (0.0466)
Is a female (Ref: No)	-0.0159 (0.0640)	-0.0763 (0.0819)	0.00859 (0.107)	-0.452*** (0.110)
Age Group (Ref: 60-64)				
65-69	0.0742 (0.122)	0.332** (0.133)	-0.0364 (0.218)	0.277 (0.321)
70-74	0.243** (0.103)	0.396*** (0.132)	0.219 (0.195)	0.352 (0.230)
75-79	0.384*** (0.0966)	0.566*** (0.150)	0.462** (0.183)	0.562** (0.271)
80-84	0.577*** (0.0983)	0.791*** (0.183)	0.686*** (0.183)	0.760** (0.302)
85-90	0.462*** (0.103)	0.760*** (0.164)	0.532*** (0.187)	0.879*** (0.287)
90+	0.590*** (0.123)	1.091*** (0.204)	0.826*** (0.202)	1.092*** (0.338)
Density of midwives	0.0387*** (0.0129)		0.0582*** (0.0208)	
Intercept	0.0789 (0.121)	-0.643** (0.268)	-0.495** (0.216)	1.220*** (0.301)
Observations	1526	1526	637	637

Standard errors in parenthesis

* $p < .1$, ** $p < .05$, *** $p < .01$

5.2 The bivariate Tobit model

The previous model can be criticized for two main reasons. First, the endogenous formal home care variable (f_i) is treated as a continuous one, although there is a large number of individuals for whom this variable equals 0. This variable has a large mass point in 0, and the previous model does not take it into account. Second, contrary to Heckman's selection model, both parts of the two-part IV model are independent. Considering the probability to receive informal care and the amount of informal care received as independent processes is a very strong assumption, which should be relaxed. The bivariate Tobit model solves these problems. It no longer contains two parts. But it is not really problematic. In the previous two-part IV model, we can indeed observe that the estimated parameters for each explaining variable are very close from one part to the other.

The estimates of the bivariate Tobit model can be found in Table 3. Our instrumental variable, the density of self-employed midwives by district, is still significant at a 1% level. We try to include our instrument in the equation of informal care, even if the model is then only identified by the censor of the two dependent variables. As expected, the coefficient is not significant at a 10% level, which tends to underline that our instrument is not correlated with informal care. Formal home care and informal care are both positively influenced by the level of dependence, even if the fact of suffering from Alzheimer's disease has only a significant impact on informal care. People suffering from Alzheimer's disease at early-stages must be over-represented in our sample of Alzheimer's patients living alone at home. These people may not need other help than family support. Or it is maybe what members of their family believe. It must also be hard for people suffering from Alzheimer's disease to collect the necessary paperwork to benefit from formal home care. The fact of having a diploma has a positive impact on formal home care utilization: educated individuals may find information about the market of formal home care more

easily and have an easier access to it. Informal care utilization increases with the number of children: it is very consistent with the existing literature on the subject.

Similarly to the previous two-part IV model, the formal home care variable has a significant negative effect on the hours of informal care received in the bivariate Tobit model. This model confirms the hypothesis of a substitution effect, a crowding-out effect of informal caregivers when the quantity of formal home care received increases.

Table 3: Bivariate Tobit model with formal home care

	Formal care	Informal care
Hours of formal care		-0.660*** (0.231)
Score of dependence	0.0993*** (0.00551)	0.132*** (0.0207)
Alzheimer (Ref: No)	0.244 (0.182)	0.984*** (0.245)
Has a diploma (Ref: No)	0.201** (0.0890)	-0.0654 (0.130)
Income (Ref: Less than 600 €)		
600 €- 1000 €	-0.0538 (0.0776)	0.0329 (0.145)
1000 €- 1500 €	0.0313 (0.0944)	-0.0218 (0.187)
1500 € and +	0.0827 (0.123)	-0.863*** (0.280)
Missing	0.0820 (0.115)	-0.275 (0.227)
Number of sons	-0.0299 (0.0287)	0.116** (0.0451)
Number of daughters	-0.0435 (0.0291)	0.341*** (0.0547)
Is a female (Ref: No)	0.0219 (0.0800)	-0.335** (0.170)
Age group (Ref: 60-64)		
65-69	0.146 (0.174)	0.668** (08.267)
70-74	0.450** (0.214)	0.524** (0.254)
75-79	0.637*** (0.168)	0.695** (0.280)
80-84	0.931*** (0.177)	1.054*** (0.312)
85-89	0.770*** (0.146)	1.213*** (0.29)
90+	0.880*** (0.253)	1.743*** (0.338)
Density of midwives	0.0577*** (0.0192)	
Intercept	-0.713*** (0.232)	-1.539*** (0.309)
σ	1.255*** (0.0479)	2.141*** (0.0716)
ρ	-0.074 (0.086)	
Observations	1526	

Standard errors in parenthesis
* $p < .1$, ** $p < .05$, *** $p < .01$

The two-part IV model and the bivariate Tobit model lead to the same conclusion: the number of hours of informal care decreases significantly when the number of hours of formal care increases. In the next subsection, we calculate elasticities to evaluate the strength of this crowding-out effect.

5.3 Elasticities

In the previous subsection we showed that both two-part IV model and bivariate Tobit model valid the existence of a crowding-out effect of informal caregivers, when formal home care increases. In order to quantify this effect, we compute average elasticities of informal care with respect to formal home care. The way we proceed to compute these average elasticities is described in Appendix B. Following DiCiccio and Efron (1996) [8] we estimate bias-corrected bootstrapped confidence intervals, performing 500 bootstrap replications. These effects are presented in Table 4. For the first part of two-part IV model, the elasticity equals -0.618 and is significant at a 5% level. It means that a 10% increase in formal home care hours would reduce the probability of receiving informal care by 6.18%. For the second part, the elasticity is -0.298 and still significant at a 5% level. A 10% increase in formal home care hours would reduce by 2.98% the quantity of informal received by informal care users.

Table 4: Bootstrapped elasticities by model

Model	Bootstrap elasticity [95% C.I.]	A 10% increase in formal home care hours leads to a...
Two-Part model		
$\Pr(y > 0)$	-0.618* [-0.888,-0.134]	6.18% decrease in the probability of informal care use.
$E(y\|y > 0)$	-0.298* [-0.870,-0.000]	2.98% decrease in the quantity of informal care received for informal care users.
Bivariate Tobit model		
$E(y)$	-0.355* [-0.573,-0.132]	3.55% decrease in the quantity of informal care received.

Source: HSM 2008.
Sample: elderly dependent persons aged 60 or older living alone in metropolitan France.
* indicates that the elasticity is significant at the 5% level. We report the bias-corrected bootstrapped confidence intervals.

We now look at the bivariate Tobit model, which, in our opinion, makes more sense to answer our question. The elasticity reaches -0.355 and is significant at a 5% level. A 10% increase in formal home care hours would lead to a 3.55 % decrease in the quantity of informal care received. There is a non-negligible crowding-out effect of informal caregivers when formal home care increases. The point now is to try to know if this effect is different between medical formal home care and non-medical formal home care.

Medical formal home care is isolated according to the profession of the formal caregiver. Formal home care provided by a nurse, a nurse's aid, another paramedical professional or a psychologist/psychomotor therapist is considered as medical. It is harder to consider the remaining modalities as belonging to an unskilled non-medical formal home care group for two reasons. First, we do not really know what the modality "other professionals" includes. Second, we do not think that it makes sense to consider social care as unskilled. That is the reason why we only estimate both of our two-part IV model and bivariate Tobit model with medical formal home care. The estimates of the bivariate Tobit model can be found in Appendix A, Table 8 (the two-part IV model is available upon request). Elasticities are computed for each model and are presented in Table 5.

Table 5: Bootstrapped elasticities by model for medical formal home care only

Model	Bootstrap elasticity [95% C.I.] for medical formal home care	A 10% increase in medical formal home care hours leads to a...
Two-Part model		
$\Pr(y > 0)$	-0.173* [-0.297,-0.067]	1.73% decrease in the probability of informal care use.
$E(y\|y > 0)$	-0.081 [-0.184,0.001]	0.81% decrease in the quantity of informal care received for informal care users.
Bivariate Tobit model		
$E(y)$	-0.112* [-0.178,-0.144]	1.12% decrease in the quantity of informal care received.

Source: HSM 2008.
Sample: elderly dependent persons aged 60 or older living alone in metropolitan France.
* indicates that the elasticity is significant at the 5% level. We report the bias-corrected bootstrapped confidence intervals.

Each elasticity is negative and significant (at least at a 10% level), which suggests that there is a crowding-out effect of informal caregivers when medical formal home care increases. But, it is interesting to note that the computed elasticities of informal care with regard to medical formal home care are much lower than elasticities of informal care with regard to total formal home care (see Table 4). As expected, the crowding-out effect of informal caregivers is lower when medical formal home care increases. Thus,

according to the bivariate Tobit model estimates, a 10% increase in hours of medical formal home care leads only to a 1.12% reduce in hours of informal care received against 3.55%, when we considered a 10% increase in total hours of formal home care.

5.4 Sensitivity analysis

To check robustness, we estimate our bivariate Tobit model using another exclusion variable (instrument) in the equation of formal home care. Following Delattre and Samson (2011) [7], we use the average annual hours of sunshine per district. As our previous instrumental variable, this one is highly positively correlated with the density of self-employed nurses in each district. The estimates of the bivariate Tobit model with formal home care appear in Appendix A, Table 9. Our sunshine instrument is a strong predictor of formal home care since its coefficient is positively significant at a 5% level. On the contrary, it does not impact the utilization of informal care at a 10% level. The results of the same bivariate Tobit model with medical formal home care only are available upon request. Elasticities can be calculated for each of these two models. Their values can be found in Table 6.

Table 6: Bootstrapped elasticities with the sunshine instrumental variable (sensitivity analysis)

Model	Bootstrap elasticity [95% C.I.] for total formal home care	Bootstrap elasticity [95% C.I.] for medical formal home care
Bivariate Tobit model with the sunshine instrument (sensitivity analysis)		
$E(y)$	-0.336* [-0.555,-0.143]	-0.105* [-0.166,-0.052]

Source: HSM 2008.
Sample: elderly dependent persons aged 60 or older living alone in metropolitan France.
* indicates that the elasticity is significant at the 5% level. We report the bias-corrected bootstrapped confidence intervals.

Both elasticities are negative and significant at a 5% level. There values are very close to the ones obtained with our first instrumental variable (-0.336 against -0.355 and -0.105 against -0.112). First, it confirms the existence of a crowding-out effect of informal caregivers. Then it highlights the fact that this crowding-out effect is much lower, when only (skilled) medical formal home care increases.

6 Conclusion

Two simple empirical models are estimated in order to understand better how French informal caregivers would react if the quantity of formal home care received by their elderly dependent relative increased. Three main results can be highlighted in this study.

First, variables related to formal home care supply per district are strong predictors of individual demand for formal home care. Like the one of general practioners, there are districts where the density of formal home care suppliers is too small in France. More formal home care suppliers in these districts would lead to higher individual demands for formal home care. Acting on the density of formal home care suppliers per district is thus a way for French public administration to make individual demands for formal home care increase.

Second, there is a crowding-out effect of informal caregivers when formal home care increases. And third, the crowding-out effect of informal caregivers is much lower when formal home care consists in medical tasks than when it consists in non-medical or social ones. Either informal caregivers are not fitted for formal medical care or they are less ready to take on some of these tasks, such as personal care. On the contrary, the substitution effect of informal caregivers is high for other kinds of formal home care, such as paid home help brought by housekeepers or social care brought by social workers. This high substitution effect raises the societal and philosophical question of the role of the French public administration in long-term care. Should a benefit for formal home care attributed by the French public administration only be offered to elderly dependent individuals, who cannot receive informal care from their family? In other terms, should the French public administration play a subsidiary role to

the family structure? Or does the French public administration have to help every elderly dependent persons, without restriction ? On the one side, the subsidiary position is controversial: it would break the natural link between a family caregiver and his or her elderly dependent relative. If individuals benefiting from a familial support are not publicly helped, then their family caregivers are forced to care for them: it no longer is a deliberate choice but it becomes a moral duty. On the other side, the position for an universal benefit is also subject to controversy: it would encourage family caregivers to give up their role and so to take advantage from the benefit initially granted for their elderly relative.

This societal question has to be answered *a priori*, apart from any economic consideration. Nevertheless, economically speaking, one could try to understand which answer is the most acceptable. In conducting cost-effectiveness and cost-utility analyses, we could extend our study and understand better, what this crowding-out effect of informal caregivers really means. If it allows overburdened informal caregivers to feel better and leads most of them to come back to the labor market (c.f. Fontaine (2011) [10]), then this crowding-out effect should not be fought. And a universal formal home care benefit could be economically and socially efficient. On the contrary, if utility gains for informal caregivers are too small and if former informal caregivers do not come back to the labor market anymore, playing only a subsidiary role to the family structure could be the most socially and economically efficient option for the French public administration.

Appendices

A Tables

Table 7: Two-part model with formal home care considered as exogenous

	Probit : Receive Inf. Care	IV Regress : Hours of Inf. Care
Hours of formal care	-0.438*** (0.0400)	-0.142*** (0.0472)
Score of dependence	0.0718*** (0.00584)	0.0553*** (0.00660)
Alzheimer (Ref: No)	0.486*** (0.180)	0.557*** (0.179)
Has a diploma (Ref: No)	0.0242 (0.0749)	-0.134 (0.0952)
Income (Ref: Less than 600€)		
600€- 1000€	0.000950 (0.0901)	0.0610 (0.114)
1000€- 1500€	-0.0524 (0.108)	0.0341 (0.143)
1500€ and +	-0.401*** (0.134)	-0.253 (0.194)
Missing	-0.148 (0.136)	-0.104 (0.176)
Number of sons	0.0563* (0.0306)	0.0419 (0.0373)
Number of daughters	0.175*** (0.0306)	0.111*** (0.0357)
Is a female (Ref: No)	-0.0784 (0.0932)	-0.455*** (0.127)
Age group (Ref: 60-64)		
65-69	0.331* (0.181)	0.286 (0.258)
70-74	0.301* (0.155)	0.238 (0.231)
75-79	0.412*** (0.146)	0.333 (0.217)
80-84	0.557*** (0.149)	0.428* (0.219)
85-90	0.584*** (0.154)	0.618*** (0.223)
90+	0.886*** (0.184)	0.689*** (0.241)
Intercept	-0.873*** (0.167)	1.363*** (0.242)
Observations	1526	637

Standard errors in parenthesis
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 8: Bivariate Tobit model with medical formal home care

	Medical formal home care	Informal care
Hours of medical formal care		-0.789*** (0.302)
Score of dependence	0.154*** (0.00946)	0.117*** (0.0154)
Alzheimer (Ref: No)	1.230*** (0.408)	1.178*** (0.258)
Has a diploma (Ref: No)	-0.0334 (0.148)	-0.162 (0.129)
Income (Ref: Less than 600 €)		
600 €- 1000 €	-0.195 (0.218)	-0.0128 (0.150)
1000 €- 1500 €	0.0829 (0.226)	-0.0249 (0.206)
1500 € and +	-0.0424 (0.324)	-0.910*** (0.287)
Missing	0.367 (0.312)	-0.234 (0.242)
Number of sons	0.0423 (0.0616)	0.133*** (0.0475)
Number of daughters	-0.104 (0.0737)	0.360*** (0.0605)
Is a female (Ref: No)	0.259 (0.245)	-0.340* (0.174)
Age group (Ref: 60-64)		
65-69	0.734 (0.458)	0.681** (0.288)
70-74	0.918** (0.427)	0.441* (0.261)
75-79	1.093*** (0.373)	0.546** (0.268)
80-84	1.221*** (0.439)	0.799*** (0.304)
85-89	1.662*** (0.405)	1.116*** (0.273)
90+	1.546*** (0.519)	1.557*** (0.355)
Density of midwives	0.211*** (0.0318)	
Intercept	-5.746*** (0.439)	-1.873*** (0.342)
σ	2.304*** (0.117)	2.320*** (0.0874)
ρ	0.302** (0.144)	
Observations	1526	

Standard errors in parenthesis
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 9: Bivariate Tobit model with the sunshine instrumental variable (sensitivity analysis)

	Formal home care	Informal care
Hours of formal care		-0.624*** (0.242)
Score of dependence	0.0984*** (0.00552)	0.130*** (0.0219)
Alzheimer (Ref: No)	0.260 (0.184)	0.974*** (0.246)
Has a diploma (Ref: No)	0.206** (0.0888)	-0.0709 (0.126)
Income (Ref: Less than 600 €)		
600 €- 1000 €	-0.0664 (0.0772)	0.0351 (0.144)
1000 €- 1500 €	0.0296 (0.0917)	-0.0210 (0.187)
1500 € and +	0.0935 (0.118)	-0.864*** (0.281)
Missing	0.0847 (0.114)	-0.277 (0.228)
Number of sons	-0.0301 (0.0279)	0.117*** (0.0447)
Number of daughters	-0.0455 (0.0290)	0.342*** (0.0551)
Is a female (Ref: No)	0.0218 (0.0818)	-0.334** (0.171)
Age group (Ref: 60-64)		
65-69	0.144 (0.173)	0.666** (0.266)
70-74	0.449** (0.211)	0.516** (0.254)
75-79	0.632*** (0.163)	0.682** (0.283)
80-84	0.917*** (0.171)	1.034*** (0.320)
85-89	0.766*** (0.143)	1.196*** (0.301)
90+	0.870*** (0.249)	1.721*** (0.333)
Hours of sunshine	0.000226** (0.000110)	
Intercept	-0.924*** (0.310)	-1.549*** (0.310)
σ	1.257*** (0.0479)	2.144*** (0.0729)
ρ	0.302** (0.144)	
Observations	1526	

Standard errors in parenthesis
* $p < .1$, ** $p < .05$, *** $p < .01$

B Computation of elasticities

Elasticities computed in this article are average elasticities. Elasticities are computed for each individual of our sample, and the mean of these elasticities is then considered. To obtain confidence intervals, we bootstrap this mean performing 500 replications. Cameron and Trivedi (2009) [4] give a lot of details about computing bootstrapped confidence intervals with Stata. Bias-corrected intervals are estimated following DiCiccio and Efron (1996) [8].

B.1 IV Probit

For the first part of the two-part model (the IV Probit part), the conditional expectancy of s_i (the variable which equals 1 if the individual receives informal care) takes the following form :

$$E(s_i|fc_i, X_i) = \Pr(y_i > 0|fc_i, X_i) = \Phi(\gamma_0 + \gamma_{fc}\ln(1 + fc_i) + \gamma'_X X_i)$$

Then the elasticity of s_i with respect to fc_i (formal home care) can be written as follows:

$$\epsilon_i = \frac{\partial E(s_i|fc_i, X_i)}{\partial fc_i} \cdot \frac{fc_i}{E(s_i|fc_i, X_i)} = \frac{\gamma_{fc}fc_i}{1 + fc_i} \cdot \frac{\phi(\gamma_0 + \gamma_{fc}\ln(1 + fc_i) + \gamma'_X X_i)}{\Phi(\gamma_0 + \gamma_{fc}\ln(1 + fc_i) + \gamma'_X X_i)}$$

B.2 IV Regress

For the second part of the two-part model (the IV Regress part), the expectancy of y_i conditional on being positive (the quantity informal care received for informal care users) takes the following form :

$$E(y_i|y_i > 0, fc_i, X_i) = \exp(\beta_0 + \beta_{fc}\ln(1 + fc_i) + \beta'_X X_i + \frac{\sigma^2}{2})$$

with σ the standard error of the error term of the structural equation (informal care equation).
Then the elasticity of $y_i|y_i > 0$ with respect to fc_i (formal home care) can be written as follows:

$$\epsilon_i = \frac{\partial E(y_i|y_i > 0, fc_i, X_i)}{\partial fc_i} \cdot \frac{fc_i}{E(y_i|y_i > 0, fc_i, X_i)} = \frac{\beta_{fc}fc_i}{1 + fc_i}$$

B.3 Bivariate Tobit

For the bivariate Tobit model, the expectancy of y_i conditional on being positive (the quantity informal care received for informal care users) takes the following form :

$$E(y_i|y_i > 0, fc_i, X_i) = \exp(K + \frac{\sigma^2}{2})\frac{\Phi(\sigma + \frac{K}{\sigma})}{\Phi(\frac{K}{\sigma})} - 1$$

with $K = \gamma_0 + \gamma_{fc}\ln(1 + fc_i) + \gamma'_X X_i$ and σ is the estimated standard error of the error term from the informal care equation.
This expression is different from the expected one of a Tobit model since our variable of interest is $\ln(1 + y_i)$.

We have then the expression of the expectancy of y_i :

$$E(y_i|fc_i, X_i) = E(y_i|y_i > 0, fc_i, X_i).\Pr(y > 0)$$

$$E(y_i|fc_i, X_i) = \exp(K + \frac{\sigma^2}{2})\Phi(\sigma + \frac{K}{\sigma}) - \Phi(\frac{K}{\sigma})$$

with $K = \gamma_0 + \gamma_{fc}\ln(1 + fc_i) + \gamma'_X X_i$ and σ is the estimated standard error of the error term from the informal care equation.

Then the elasticity of y_i (informal care) with respect to fc_i (formal home care) can be written as follows:

$$\epsilon_i = \frac{\partial E(y_i | fc_i, X_i)}{\partial fc_i} \cdot \frac{fc_i}{E(y_i | fc_i, X_i)}$$

$$\epsilon_i = \frac{\gamma_{fc} fc_i}{1 + fc_i} \cdot \frac{\exp(K + \frac{\sigma^2}{2})(\Phi(\sigma + \frac{K}{\sigma}) - \frac{\phi(\frac{K}{\sigma})}{\sigma}) - \phi(\frac{K}{\sigma})}{\exp(K + \frac{\sigma^2}{2})\Phi(\sigma + \frac{K}{\sigma}) - \Phi(\frac{K}{\sigma})}$$

with $K = \gamma_0 + \gamma_{fc} \ln(1 + fc_i) + \gamma'_X X_i$ and σ is the estimated standard error of the error term from the informal care equation.

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