Testing for asymmetric information in the *viager* market*

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Abstract

This paper tests for the presence of asymmetric information in the *viager* real estate market. Sellers who use the *viager* mechanism are entitled to stay in their property until death. Buyers have to make a down payment at the purchase date, and pay regular sums of money until the seller dies. Thanks to a no arbitrage condition (buyers must be indifferent between purchasing on the standard and *viager* market), we identify the type of the seller as a specific sum of death probabilities. By comparing these sums with analogously defined national-level sums we can check whether *viager* sellers have the same survival distribution as individuals in the population. We then develop, estimate and test a symmetric information model of *viager* sales. The model also encompasses a donation motive. Notarial data are used on transactions in Paris between 1992 and 2001. We find that sellers do not have the same survival distributions as comparable persons in the population, and hence they have information about their death probabilities. The hypothesis that information is symmetric is accepted and there is no evidence of asymmetric information in the market. This highlights that this information is no longer private when the contract is signed. Finally, we are able to recover the probability that a seller donate a fraction of the down payment.

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-You are quite sure that you do not want to sell your farm?
-Certainly not...
-Very well; only I think I know of an arrangement that might suit us both very well.
-What is it?
-Just this. You shall sell it to me and keep it all the same. You don't understand? Very well, then follow me in what I am going to say. Every month I will give you a hundred and fifty francs. You will have your own home just as you have now, need not trouble yourself about me, and will owe me nothing; all you will have to do will be to take my money. Will that arrangement suit you?
-It seems all right as far as I am concerned, but I will not give you the farm.
-Never mind about that; you may remain here as long as it pleases God Almighty to let you live; it will be your home. Only you will sign a deed before a lawyer making it over to me, after your death. You have no children, only nephews and nieces for whom you do not care a straw. Will that suit you?

From *The little Cask*, by Guy de Maupassant (1884).

1 Introduction

In most developed countries the life expectancy of populations has increased substantially over the last decades. Policy makers have recently responded to these increasing survival times by making publicly provided pension schemes less generous and augmenting the minimum retirement age. Given these trends, it appears important to study the way the elderly finance their retirement. Of particular interest is the question what role alternative and complementary mechanisms may play in alleviating the financial needs of retired people.

One mechanism is the life annuity. This is an insurance product that pays the insured person monthly or yearly sums of money for life, in exchange of a premium. Life annuities thus protect the beneficiaries against the risk of outliving their personal resources. As shown in a theoretical literature initiated by Yaari (1965) and further developed by others, optimally behaving economic agents should annuitize all or large parts of their wealth. However, in practice annuity markets are generally very thin,[1] so apparently individuals do not annuitize as much as theory predicts. The most natural explanation for this puzzle is the presence of asymmetric information between insures and annuitants. Since potential annuitants have private information on their health status and parents' mortality, they are likely to be better informed about their survival prospects than insurers. They may exploit this advantage by deciding whether or not to purchase annuities. Given the insurance premiums, only individuals who are expected to live sufficiently long would purchase an annuity, as they are the ones who, on average, can benefit from it. To compensate for

[1]Mitchell, Poterba, Warshawsky, and Brown (1999) indicate that "the market for individual life annuities in the United States has historically been small"; James and Song (2001) give statistics on the size of annuity markets in Australia, Canada, Chile, Israel, Singapore, Switzerland, and the UK, and state that "annuities markets are still poorly developed in virtually all these countries."

this auto-selection, insurers need to increase their premiums, making their product financially uninteresting for yet another subgroup of the population. This process may repeat itself and exclude more and more individuals from the market. In the extreme case the market may completely unravel–like the lemons market described by Akerlof (1970)–until all individuals are driven out of the marketplace except the riskiest annuitants (those with the highest expected survival time). In a series of papers, (Finkelstein and Poterba, 2002, 2004, 2006) have tested for asymmetric information in the UK annuity market. Their findings are consistent with the presence of asymmetric information, which may (partly) explain the limited size of this market.

Another potentially interesting mechanism for older people, at least for those who are home owners, is a specific type of real estate sale. The mechanism exists in several European countries (Belgium, France, Germany, Italy, Spain), and is known in France as *viager*. A *viager* sale has some unusual features. Unlike a standard real estate sale, it allows sellers to remain in their property after the transaction date. They are entitled to stay in their home until death (hence the term *viager*: it comes from *viage*, which means "time of life" in old French). Another distinctive feature is that a *viager* contract typically stipulates not one but two transaction prices. The first is the so-called *bouquet*, which is the down payment that the buyer has to make at the date of purchase, and the second is the *rente*, which is the amount of money the buyer has to pay on a regular basis until the seller eventually dies.[2] A *viager* sale can thus be attractive for older property owners as they may stay in their own home and earn extra money for the rest of their live. The principle is also quite flexible. For instance, the *rente* is typically indexed to a consumer price index, which guarantees sellers that they will receive a constant real income flow; most contracts include a clause stipulating that sellers may leave their property at any time (to go to a retirement home for example) in exchange for a higher *rente*; sellers may donate part of the *bouquet* to their family members.

In spite of these advantages the *viager* market is, like the annuity market, quite small. Only about 0.5% of the real estate sales in France correspond to *viager* sales.[3] The most natural explanation for this low rate of occurrence is again the presence of asymmetric information between buyers and sellers. Indeed, many people in France associate the *viager* principle with the story of Jeanne Calment. Back in 1965, when Mrs Calment was aged 90, she sold her apartment in Arles to a 44-years old man, on contract-conditions that seemed reasonable given the value of the apartment and the life-expectancy statistics that prevailed at the time. The man turned out to be unlucky since Jeanne Calment lived a very long life.[4] He died in 1995, 2 years before Mrs Calment, after having paid about FFr900,000 (twice the market value) for an

[2] A *viager* transaction is clearly akin to a life annuity. The method is even more reminiscent of a reverse annuity mortgage. This is a relatively new financial product and has recently been introduced in the USA, Canada, the UK and Singapore (See Chan (2002), for a survey). A reverse mortgage is basically a loan (typically up to between 20 and 50 percent of the value of the property) against the borrower's home. The borrower may continue living in her home (as in the case of a *viager* sale), and the loan plus accrued interest and other charges is repaid upon death of the borrower (but there is also the possibility of voluntary redemption of the loan by the borrower).

[3] The picture may change though as the mechanism is receiving renewed interest. The French government actively promotes *viager* transactions as an efficient way to reduce the dependency on the social security system. There are even some radio spots advertising its merits, and an advisory body of the French government has recently published a detailed report on the subject (see Griffon, 2008).

[4] On February 21, 1996, she celebrated her 121st birthday, making her the oldest living person on earth according to the Guinness Book of World Records.

apartment he never lived in. Of course there are other anecdotes that tell the complete opposite story, but still the Jeanne Calment case is the one that comes to most French minds. Real estate buyers may therefore fear the presence of adverse selection in the market and this may in part explain why the method is not that popular.

This paper studies the *viager* market and attempts to answer the question whether the market is indeed hindered by asymmetric information. We do this by using notarial data on sales in Paris and its suburbs. For each transaction we observe the most important contract parameters (*bouquet* and *rente*), the market value of the property, and some characteristics of buyers and sellers (age, gender). However, the notarial database does not record what happens after the date of signature of the contracts. In particular we do not know when sellers died. Therefore, to establish whether there is asymmetric information in the market, we cannot implement the kind of test introduced by Chiappori and Salanié (2000). The idea of their test is to look at the correlation, conditionally on all observables, between the contract choice (type of automobile insurance contract in their case) and an ex-post measure of the agent's type (an indicator for the occurrence of an accident). There is asymmetric information if these variables are correlated, and symmetric information otherwise. In the absence of mortality data, we do not have an ex-post measure of the seller's type, and hence we cannot apply the Chiappori-Salanié test.

Our approach relies on the fact that we can actually directly identify the seller's type. The type of the seller is a sum of weighted death probabilities. This sum can be identified via a non arbitrage condition. The no arbitrage condition states that the (expected) value of a property is the same, regardless of whether it is purchased on the standard real estate market or the *viager* market. It thus reflects that buyers should be indifferent between purchasing a given property on the two types of markets. The condition can be rewritten such that the sum of death probabilities of a seller is expressed in terms of the observable contract parameters.

The fact that we can infer each seller's type is first exploited to check whether *viager* sellers have the same survival distribution as representative individuals in the population. We do this by comparing the seller-specific sums with analogously defined national-level sums calculated using national-level life tables. The hypothesis that the survival distributions of sellers and comparable individuals from the population are the same is not supported by the data. This finding implies that sellers have information about their own death probabilities. Indeed, as the survival distributions of *viager* sellers and the representative individual from the population do not coincide, sellers apparently realize that their personal mortality probabilities may differ from national mortality probabilities. This is in line with Hurd and McGarry (2002) who find that respondents in the Health and Retirement Study (HRS) modify their personal survival probabilities as new and relevant information is acquired (such as the onset of an illness), and that subjective survival probabilities accurately predict actual mortality. Our finding also implies that the survival information is somehow shared with the buyer. Indeed, for a buyer to sign a *viager* contract with a seller who claims to have a life expectancy that differs from the population life expectancy, the buyer should be able to believe he should believe her. This can be the case only if the seller is able to transmit the information in a credible way.

The fact that the seller's type is identified is also exploited to answer the next question: how and when do sellers transmit the personal knowledge about their survival probabilities. This is in fact just another way of formulating the main question of the paper: are buyers and sellers symmetrically or asymmetrically informed about the survival probabilities. Under symmetric information both parties have the same knowledge of these probabilities before they actually start negotiating about the contract conditions. This possibility is not incompatible with our previous finding that sellers initially possess personal information about their survival distribution. Before the contract is signed, sellers may reveal their type when they enter into contact with the buyers. Buyers may get an accurate picture of the survival prospects of sellers by seeing their physical condition and visiting their apartments.[5] The interaction between buyers and sellers ensures in this case that all agents end up being symmetrically informed. Under asymmetric information buyers and sellers do not have the same knowledge of the survival probabilities before contracting. The buyers remain imperfectly informed about these probabilities, even after interacting with the sellers. The sellers could nevertheless overcome the problem of asymmetric information and signal their true survival probabilities via the contract parameters using both the *bouquet* and the *rente* (signalling equilibrium).

As *viager* sales only concern old people, bequest motives have to be studied. The house/appartment is usually the main asset of an individual. Very often, this asset is bequeathed. At first view, the *viager* sale deprives heirs from this capital. It is commonly believed that *viager* sellers do not have bequest motives because either they do not have children or they do not have enough to bequeath. However, this intuition is wrong as a *viager* sale by making liquid this main asset provides the seller with cash. Therefore, she can immediately donate part of the value of her property to whoever she desires. The bequest motives become donation motives. Moreover about half of the sellers do have children.[6]

We thus develop a symmetric information model of a *viager* sale (in which the seller maximizes an expected utility function under a set of consumption constraints and the no arbitrage condition) with donation motives. Two groups of sellers emerge at the equilibrium, depending on the strength of their donation motives. The first group is composed of donators and the second of non donators. For donators, the *bouquet* is an increasing function of the death probability, whereas the *rente* is invariant with this probability. For no donators, both the *bouquet* and the *rente* increase with death probability and at the same rate. On the contrary, in an asymmetric information model, the *bouquet* increases but the *rente* decreases with the type of the seller.

The intuition of these predictions is the following. To begin with, sellers with a shorter life expectancy can obtain more from their sale. Next, sellers want to smooth their consumption over time. Thus, in a symmetric environment, when they have a shorter life expectancy, they can ask for both a higher *bouquet* and a higher *rente*. However, when the *rente* reaches a certain level (which depends on the strength of the donation motives), the seller stops asking for a *rente* increase as she prefers to start donate. On the contrary, in an asymmetric setting, sellers with a shorter life expectancy cannot signal their type by asking for both a larger *bouquet* and a larger *rente* as this would be imitated by sellers with a longer life expectancy. They have to credibly signal their type by asking for a higher *bouquet* and a smaller *rente*. A combination sellers with a longer life expectancy would find too costly to imitate.

To estimate the symmetric information model, we regress the observed *bouquet* and *rente* on the inferred type of the sellers. To take into account the equilibrium pattern, we use a

[5]The law does not oblige sellers to produce medical certificates indicating their health status. According to the *viager* experts with whom we spoke it is very rare in practice that sellers transmit their health records to buyers.

[6]*Association Nationale pour la Défense des Intérêts des Rentiers Viagers* (ANDIRV).

switching regression (as in Kopczuk and Lupton (2007)) that endogenously determines if a seller is more likely to be a donator or not. We find that the results are consistent with the symmetric information predictions and there is therefore no evidence of asymmetric information. Allowing the *rente* to increase with the seller's type in both groups, the switching regression finds it to be significantly increasing in only one group. As predicted by the model, the probability of being in this group is stronger for sellers with longer life expectancy.

The main conclusion that can be drawn from our empirical results is thus that the *viager* market is not much affected by the problem of asymmetric information and its possible consequences. The question that remains is what other factors may explain the small size of the market. In the conclusion of the paper we offer some alternative explanations. Although some explanations are purely economic, most are based on psychological arguments. Therefore, like in the case of annuity market (see Brown (2007)), behavioral factors may obstruct the development of the market.

This paper is closely related to a series of recent empirical studies on tests for asymmetric information in several markets. Besides the articles on life annuities cited above (Finkelstein and Poterba, 2002, 2004, 2006), these papers have considered the automobile insurance market (Puelz and Snow (1994); Chiappori and Salanié (2000); Dionne, Gouriéroux, and Vanasse (2001); Chiappori, Jullien, Salanié, and Salanié (2006); Abbring, Chiappori, and Pinquet (2003)), the credit card market (Ausubel (1999)), the health insurance market (Cutler and Reber (1998)), and the slave market (Dionne, St-Amour, and Vencatachellum (2009)). Our approach has also similarities with the bequest motives literature ((Hurd, 1987, 1989) and Kopczuk and Lupton (2007)).

The next section of the paper describes the institutional setting of the *viager* market and our notarial database. Section 3 presents the model and the predictions derived from the model, and explains how the predictions can be tested. Section 4 presents the results and section 5 concludes.

2 Description of the *viager* mechanism and the notarial database

2.1 The *viager* market in France

Little is known about the precise origins of the *viager* mechanism. According to the relatively small literature on the subject,[7] it dates from the Middle Ages. *Viager* transactions were inscribed in the *Ancien Droit*, indicating that such sales were legally authorized under the judicial system that prevailed in France until 1789. At the beginning of the 19th century, a commission of experts was charged to write a new civil law system. At that time there were fierce debates between opponents and proponents of the *viager* principle,[8] but the commission finally decided

[7] Two sociological studies: Drosso (1993), and Drosso (2002); two books on the financial and juridical aspects of *viager* sales: Artaz (2005), and Le Court (2006); and a report by Griffon (2008), written on behalf of the *Conseil Economique et Social*, an advisory body of the French government.

[8] Those against the principle argued that it was unethical, anti-social (because sellers could, by selling their property *en viager*, selfishly leave nothing to their heirs), and that it might give buyers bad ideas and even incite

to maintain it in the new law text, published in 1804, and known as the *Code civil*. The articles of the *Code civil* that refer to the *viager* mechanism (articles 1964 to 1983) have been revised and modified for the last time in 1954. These articles juridically regulate all aspects of *viager* sales.

As with a standard real estate transaction, all sale conditions of a *viager* transaction must be formally specified in a written contract, which, in order to have legal value, must be signed by the seller and the buyer in the presence of a notary. Unlike a standard real estate contract, a *viager* contract binds the parties even after the date of sale since it typically requires the buyer to make payments to the seller until the latter dies. *Viager* contracts thus establish long-term relationships between the contracting parties and are therefore more complex than standard real estate contracts.

A *viager* contract usually stipulates two transaction prices: the *bouquet*, which is the down payment the buyer has to make at the date of signature, and the *rente*, which is the amount of money the buyer has to pay on a regular basis (mostly on a monthly basis) until the moment of death of the seller. The contract may also stipulate that the seller should pay the *rente* until death of (an)other person(s) designated by the seller. If this is the case the buyer has payment obligations until both the seller and the person(s) designated by the seller have died. This option is often used by sellers who are married as it offers a financial safety net for the surviving partner. The legislation also gives sellers the possibility to retain the usufruct of their property until the moment of their death. Sellers thus have the right to remain and live in their property after the date of sale, or rent it to somebody else. If a contract involves multiple beneficiaries then the seller and the person(s) designated by the seller have this right. In practice the vast majority of *viager* sellers stay in their property themselves after the transaction date,[9] indicating that real estate owners who use the *viager* mechanism primarily do this because it allows them to remain at home and earn extra income at the same time (thanks to the *bouquet* and *rente*).

There are no legal restrictions on how the *bouquet* and *rente* should be chosen by the parties involved in a transaction. Indeed, article 1976 of the *Code civil* indicates that "the contracting parties are free to fix the level of *rente* as they wish". There is, however, a body at the Ministry of Economics and Finance that keeps an eye on all *viager* transactions (*Comité répressif des abus de droits*). It verifies whether contract terms are reasonable on economic grounds and checks that transactions do not constitute a disguised donation between the buyer and the seller. A transaction can also be blocked and canceled if the judges of the Court of Appeal find that the sale conditions of a given *viager* contract cannot be justified.

In practice the height of the *bouquet* is influenced by several factors. As the *bouquet* is a fraction of the value of the house or apartment, it is to a large extent determined by the price of the property. The *bouquet* generally varies between 20 and 30% of the price (Griffon, 2008), but can sometimes exceed 60% of the value (Le Court, 2006). Variations in the *bouquet* can be explained by the short-term financial needs of the seller. A seller who has debts to pay or who plans an expensive trip abroad may require a large *bouquet*, while a seller with no immediate need for money may ask for a lower one. Finally, the *bouquet* may be influenced by the amount

them to murder; those in favor argued that the choice to sell *en viager* was entirely up to the home-owners (and thus not unethical), and that it was ideal to alleviate their financial problems.

[9]According to Griffon (2008) about 90% of the properties remain occupied by the sellers. According to the real estate agency *Centre Européen de viagers* the proportion is even 95% (see http://www.fgp-cev.com).

of money sellers may want to donate to family members. Many sellers give (part of) the down payment to family members as a donation. Those who wish to give a lot may want a large *bouquet*, and vice versa.

The height of the *rente* also depends on various factors. Important determinants are the age and gender of the seller. Age and gender influence the seller's life expectancy and hence the expected number of periods the buyers has to pay money to the seller, which in turn affects the level of *rente*. If the contract involves multiple beneficiaries, the age and gender of the person(s) designated by the seller should affect the *rente* as well. Keeping all other things constant, the parameter should be relatively lower in contracts with multiple beneficiaries since they are riskier for buyers than contracts with a single beneficiary. The *rente* also depends on whether the seller retains the usufruct of the property. Keeping everything else fixed, it should be relatively lower when the seller retains the usufruct since in this case the property is less worth to the buyer. Yet another determinant of the *rente* is the height of the *bouquet* itself. If the *bouquet* is relatively large (resp. small) the "remaining value" of the property is small (resp. large) and consequently the *rente* should be relatively small (resp. large). Hence, fixing all other things, the two parameters are negatively correlated.

Besides the *bouquet* and *rente*, *viager* contracts may specify a number of additional sale conditions. Practically all contracts explicitly indicate that the *rente* should be indexed to a consumer price index. This guarantees that the seller's real income does not fluctuate over time.[10] Some contracts include a clause stating that the seller can, at any time, decide to stop benefitting from the usufruct of the property in exchange for a higher *rente*. Such a clause is useful for sellers who anticipate that they may need to enter a retirement home somewhere in the future (because of failing health), and need extra resources to finance it.

The mechanism is fiscally interesting for sellers. The amount of *rente* received is partly deductible from the seller's total income over which tax has to be paid (before the age of 69, sellers can deduct 60% of the *rente* from their total income; after 69, the abatement rate augments to 70%). There are, however, no fiscal incentives for buyers.

From data sources compiled by Drosso (1993,2002) we know a few things about the two parties engaged in *viager* sales. The average age of sellers is between 72 and 75 years. They typically had professions which allowed them to buy a home when they worked, but whose pension plans are not generous enough to live well after retiring (self-employed workers, individuals with liberal professions, etc.). The majority of sellers are female. Many female sellers are widows who ran into financial problems after their husband passed away and therefore needed to sell their property. Many sellers are not well-off: 66% (resp. 100%) of the male (resp. female) sellers belong to the five lower income deciles. Contrary to conventional wisdom (according to which *viager* sellers are mostly childless), as much as 50% of the sellers have children. 90% of these children agree

[10] In principle any price index may be chosen but nowadays most contracts stipulate that the *rente* should be indexed to the consumer price index published by *Insee* (Artaz, 2005, page 138). Le Court (2006) gives historical examples of sales where the *rente* is linked to exotic price indices such as the price of beef meat, the price of grapes from the Champagne region, and the price of wheat. In the popular movie *Le Viager*, by Pierre Tchernia, the main character Mr Galipeau buys the house of Mr Martinez, a tired man of almost 60, and they decide to index the *rente* to the price of aluminum. The sale is not really the financial success the buyer had hoped for: Mr Martinez turns out to live a long time, feeling fitter and better each year, and the aluminum price rockets sky-high, literally driving Mr Galipeau crazy.

with the fact that their parents had sold their property.[11] Buyers are mostly individuals (less that 15% of the *viager* properties are purchased by companies such as banks or insurers), aged on average between 40 and 50 years. They are executives or senior managers from large firms or have liberal professions, and are generally wealthy individuals. This is not surprising given that in France one cannot obtain a loan from a bank to finance a *viager* operation. Two types of buyers can be distinguished. There are those who use the *viager* procedure primarily to increase their patrimony. Their main objective is to occupy the property themselves once the seller has died, or leave it as a future home for their children. And there are the "gamblers", that is to say a group of sellers who act as investors and speculators and whose only objective is to maximize profits. These sellers typically buy several proprieties to smooth out the risk.

The extent and popularity of the *viager* market has fluctuated over time and the economic cycles. The market flourished in the 19th century in particular because of the weak social security system in that century. Strong inflation combined with high interest rates increased the number of *viager* transactions in the 1980s. In the 1990s the *viager* mechanism became less popular as interest rates and inflation fell. Nowadays there are about 4000 *viager* sales per year. Given that the total number of real estate sales in France is around 650,000 per year (excluding sales of new houses or apartments), the fraction of *viager* sales is approximately 0.6% (Griffon, 2008). The market is characterized by a demand that largely exceeds the supply of *viager* proprieties (Drosso, 1993, and personal discussions with Mr Bruno Legasse). Most of the *viager* transactions are concentrated in Paris and its suburbs, and in the large cities of the southern region *Provence-Alpes-Côte d'Azur* (like Cannes, Menton, Nice, and Saint-Raphaël).

2.2 Notarial database

The database at our disposal was obtained from the *Chambre des Notaires de Paris* (federation of Parisian notaries). This federation collects the bills of sale which the notaries are required to transmit. The database contains information on all real estate transactions (standard sales and *viager* sales) in Paris and its suburbs between 1992 and 2001. For each *viager* transaction we observe the characteristics of the property (kind of property, geographic location, size, number of rooms, etc.), and some characteristics of the buyers and sellers (age, gender). We also observe the *bouquet*, the *rente* (on a yearly basis), and the market value of the property. The value is estimated by the notary in charge of the transaction and corresponds to the price of the property had it been sold in the standard way.

From the initial sample of *viager* observations, we only keep sales of apartments and houses and exclude sales of plots of land. We also exclude sales for which the age and/or the gender of the seller are missing.[12] We also delete extreme values from the data, i.e., observations such that the relative bouquet and/or relative *rente* (*bouquet* and *rente* divided by the market value) were above the mean plus three times the standard error. We hereby obtain a sample of 874

[11] These last statistics are calculated on a sample of members from the *Association Nationale pour la Défense des Intérêts des Rentiers Viagers* (ANDIRV), an association that defends the interests of *viager* sellers. The sample is therefore not necessarily representative for the whole population of sellers in France.

[12] Consequently, we had to exclude sales where the contract specifies that there are multiple beneficiaries since only the gender of the first beneficiary is specified and since the ages of the additional beneficiaries are often missing.

observations. Table 1 contains information about the contract parameters in this sample, the characteristics of the properties, and some characteristics of buyers and sellers. All monetary values are in thousand €.

Table 1: Summary statistics ($N = 874$)

variable	mean	sd	min	p10	p25	p50	p75	p90	max
Property Value	103.95	77.54	12.96	41.16	54.88	83.85	121.96	198.18	655.53
Bouquet	33.96	39.53	0.00	6.10	11.43	22.87	42.69	73.18	381.12
Rente	6.84	5.42	0.00	2.01	3.66	5.49	8.96	12.81	71.81
Relative *bouquet*	31.05	18.59	0.00	10.20	16.23	28.00	42.55	58.26	84.91
Relative *rente*	7.36	3.72	0.00	3.00	5.10	7.20	9.47	12.00	26.00
Nb rooms	2.74	1.28	1.00	1.00	2.00	3.00	3.00	4.00	11.00
Size (sq. m.)	58.46	31.01	10.00	27.00	36.53	53.50	71.43	96.85	258.00
Seller's age	77.97	7.76	60.00	68.00	72.00	78.00	84.00	88.00	99.00
Male (seller)	0.29	0.46	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Buyer's age	44.96	12.03	18.00	29.00	36.00	46.00	53.00	61.00	83.00
Male (buyer)	0.74	0.44	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Buyer is a firm	0.16	0.36	0.00	0.00	0.00	0.00	0.00	1.00	1.00

The average property has a value around 104,000€ its size is about 60 square meters, and it has three rooms. The average *bouquet* in the sample is approximately 34,000€, and the average *rente* per year is nearly 7,000€. The relative *bouquet* is on average around 31% while the relative *rente* is on average around 7.5%. On average sellers are 78 year old and the majority is female (70%). All these figures are similar to the national-level statistics given in the previous subsection. Among the buyers, 16% are firms and 84% are individuals. On average these individuals are 45 years old, and most are male (74%).

Our dataset does not however record all possible contract terms. We do not observe what particular price index is used but this does not really matter since, as mentioned above, in the majority of cases the contracts stipulate the use of the *Insee* consumer price index. We do not observe either whether the seller actually retains the usufruct of the property. This is probably not problematic as the vast majority of sellers do retain the usufruct (Section 2.1). Hence, the resulting bias from not observing these pieces of information are expected to be negligible.

Figure 1 shows the values of the relative *bouquet* and the associated *rente* in our data. Although if these observations take into account the variations in the property values, the figure shows that there is still a huge amount of heterogeneity left. This remaining heterogeneity in the relative contract parameters may result from variations in the age, gender, and preferences of the sellers (for example, some sellers need a large *bouquet* whereas others prefer a smaller one). It may also result from sellers having different survival probabilities. The relative contract parameters are negatively correlated: the correlation coefficient is -0.34. This is confirmed by regression (I) of Table 2 where we report the results of a regression of the relative *bouquet* on the relative *rente* . This pattern is reinforced in regression (II) where we also control for the seller's age and gender. The relative *rente* still has a negative sign and is significant. The negative correlation between the relative contract parameters is not surprising. Keeping all other things fixed, when the relative *rente* increases, the relative *bouquet* should also decrease as the total amount paid by the buyer should remain the same. The other coefficients also have the expected signs and are significant. For a given *rente*, older sellers and men obtain a larger *bouquet* as they have a shorter life expectancy.

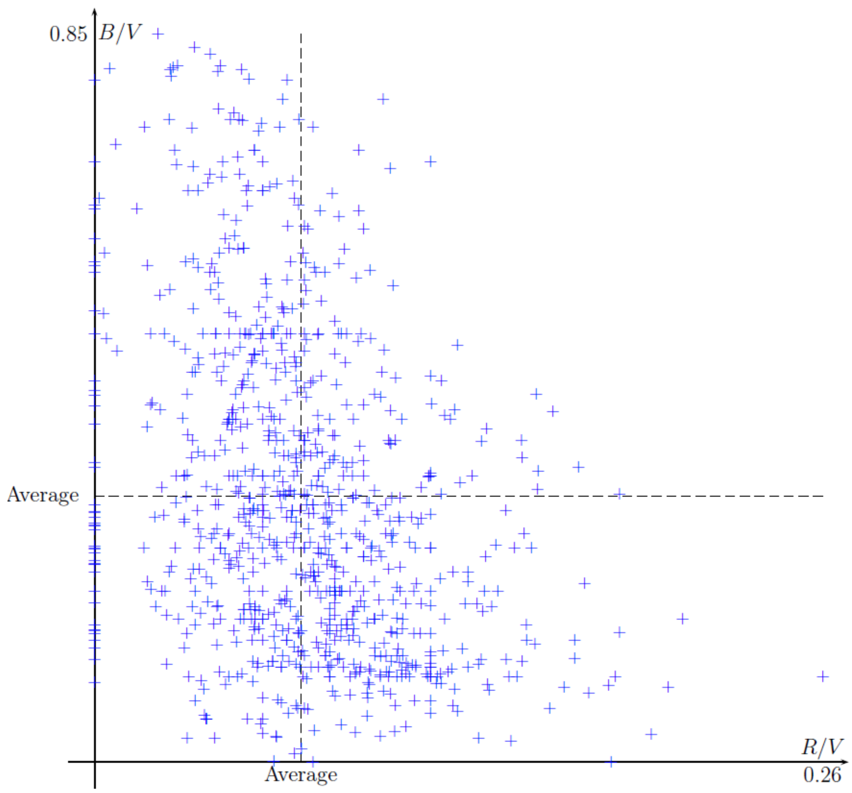

Figure 1: *Viager* contracts (relative *bouquet* and *rente*)

Table 2: Relationship between the relative *bouquet* and the relative *rente*

	(I)	(II)
Relative *rente*	-1.696**	-2.084**
	(0.16)	(0.15)
Age		0.861**
		(0.07)
Male		5.373**
		(1.22)
Constant	43.538**	-22.342**
	(1.31)	(5.66)
R^2	0.115	0.242
N	874	874

Significance levels: † : 10% $*$: 5% $**$: 1%

Both the age and gender of the seller are variables which are known by the buyer. As on average older sellers and men have a smaller life expectancy, we expect them to obtain more favorable contract terms. They should ask for both a higher *bouquet* and a higher *rente*. To check this prediction, we regress separately the relative *bouquet* and *rente* on age and gender. Despite their negative correlation, both variables increase with age and are higher for men than for women (the gender variable is not significant in the *rente* equation though), as predicted.

However, both R-square values are low, suggesting that age and gender only explain a small part of the heterogeneity in the contract terms.

Table 3: Effect of age and gender on the relative *bouquet* and *rente*

	Relative *bouquet*	Relative *rente*
Age	0.633**	0.109**
	(0.08)	(0.02)
Male	5.426**	-0.025
	(1.34)	(0.27)
Constant	-19.905**	-1.169
	(6.24)	(1.27)
R^2	0.078	0.052
N	874	874

Significance levels: † : 10% ∗ : 5% ∗∗ : 1%

3 Recovering the type of the seller

The first part of this section presents the no arbitrage (or accounting) condition on which most of the analysis relies. It allows us to recover the type of each seller (i.e., the sum of death probabilities of the seller). In the second part of this section, we empirically analyze the sellers' types.

3.1 No arbitrage condition

We start by introducing some notations. Let B represent the *bouquet*, R the *rente* on a yearly basis, and V the market value of the property at the date of sale. Let L be the annual rent paid by a tenant had the new owner rented the property of value V. Let π_t be the true probability that the seller dies exactly t years after signing the contract, $t = 0, 1, ..., T$, with $\Sigma_{t=0}^{T} \pi_t = 1$. Finally, we note δ the discount factor, r the associated rate that $\delta = 1/(1+r)$. We assume that $V = \sum_{1}^{+\infty} \delta^t L$ and therefore $L = rV$.

In a *viager* sale, the value V is paid by the buyer through the *bouquet* B, the *rente* R, and the foregone rent L.[13] The *bouquet* B is paid by the buyer when the contract is signed, i.e., at the beginning of year $t = 0$. Without loss of generality we assume that the *rente* R (and L) is paid at the beginning of each of the following years. Therefore, if the seller dies in year t (this can happen with probability π_t), the buyer pays R and does not collect L during t years. The total discounted cost in this case equals $B + \sum_{t'=1}^{t} \delta^{t'} (R + L)$. Therefore, equalizing V and the expected discounted cost of buying the property on the *viager* market gives

$$V = B + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} (R + L).$$

This is both an accounting and a no arbitrage condition as it reflects that buyers should be indifferent between purchasing a property on the standard real estate market and the *viager* market.

The condition can be reformulated in a useful way. Letting $\alpha = \sum_{t=0}^{T} \pi_t \delta^t$ denote the sum of weighted death probabilities of the seller which is simply the expected present value of one € received upon the death of the seller, it can be rewritten as (see the Appendix):

$$\alpha V = B + \frac{1-\alpha}{r} R. \tag{1}$$

Rewriting the no arbitrage condition in this way is helpful because it shows that, given the relative contract parameters and a value for r, the sum of death probabilities α can be recovered.

In the absence of arbitrage on the real estate market, the (relative) contract parameters must necessarily be related as in equation (1). It turns out that the death probabilities π_t do not separately play a role in this relationship. The only thing that matters is the sum of weighted death probabilities α. The sum α is thus the key parameter which summarizes all the relevant

[13] As both R and L are, in practice, indexed on the consumer price index, we can assume without loss of generality inflation away.

information about the death probabilities of seller, and can therefore be viewed as the type of the seller. When the expected survival time decreases, α increases, and vice versa.[14]

The left hand side of (1) can be interpreted as the net value of the property, i.e., the value that remains after deducting from the market value V the expected value of the usufruct retained by the seller. The term α can be seen as a rebatement factor. It captures the fact that the buyer receives the value of the property only in the future. The higher α, the more valuable the property is as the seller is expected to die relatively soon. A buyer who expects to receive the property earlier, is, therefore, ready to pay more.

The right hand side of (1) indicates that the expected value of the property equals the *bouquet* plus the *rente* R multiplied by the term $(1-\alpha)/r$. The inverse of this term, $r/(1-\alpha)$, can be interpreted as the factor of conversion of capital into *rente*. Indeed, once the *bouquet* is paid, the buyer still has to pay a remaining capital $\alpha V - B$ to the seller. This capital is converted into a *rente* equal to $\frac{r}{(1-\alpha)}(\alpha V - B)$. In particular, if $r \to 0$, then $\frac{1-\alpha}{r} \to X$, where X is the life expectancy of the seller. That is, in the absence of discounting, the buyer pays, on average, the *rente* during X years. In this case we have: $V = B + XR$.

As mentioned in Section 2.1, buyers and sellers are in principle free to fix the contract terms as they wish. Notaries and real estate agencies specialized in *viager* transactions often help in the negotiations (Drosso, 1993; Le Court, 2006). These financial experts advise the parties and suggest how the contract parameters may be calculated. Their methods are similar in spirit as the calculations underlying Equation (1). For instance, the Paris-based agency *Legasse Viager*[15] uses the so-called Daubry table which contains for each age and gender a rebatement factor and a conversion coefficient.[16] Another Parisian agency, the *Centre Européen de Viagers*, also adopts similar calculations (see Artaz (2005), pages 81-86). There are also agencies that claim to use their own mortality tables. These agencies construct their tables based on survival time data of earlier clients (Le Court (2006), page 127). Whatever the precise methods used by these agencies, they all first apply a rebatement factor to V. Next, once B is fixed, they transform the remaining owed capital (the equivalent of $\alpha V - B$) into a life annuity using a conversion coefficient. Therefore, V, B, and R are in practice constrained by an equation very similar to (1) where the type α of the seller is the crucial element.

3.2 Estimation of the sellers' type

Rewriting equation (1), we get

$$\alpha = \frac{rB + R}{rV + R} = \frac{rB/V + R/V}{r + R/V}. \tag{2}$$

Hence, for a given value of the interest rate r, the relative contract parameters allow us to recover the type of the seller on which the parties agreed. The value of α increases with both B/V and R/V. This is consistent with the idea that a seller who is expected to die earlier is able

[14]Formally, if the distribution of death probabilities of seller 1 stochastically dominates the distribution of seller 2, then $\alpha_1 > \alpha_2$.

[15]Information obtained from personal conversations with Mr Bruno Legasse, director of the agency.

[16]In the Daubry table $\alpha = \delta^X$, where X is still the life expectancy of the seller. That is, the distribution of survival times is approximated by a Dirac mass at $t = X$.

to obtain better contract terms. In the following, we use $r = 0.05$.[17] Table 4 presents summary statistics for α. The mean value of α is 0.7, and 80% of the observations are between 0.56 and 0.83.

Table 4: Summary statistics for α ($N = 874$)

variable	mean	sd	min	p5	p10	p25	p50	p75	p90	p95	max
α	0.699	0.128	0.093	0.462	0.563	0.654	0.721	0.773	0.828	0.856	0.926

To check whether the survival probabilities of *viager* sellers are similar to national survival probabilities, we can compare the seller-specific types with national-level types. The latter are computed in the same way as the former except that the individual death probabilities are replaced by population probabilities. We thus define $\alpha_{Insee} = \sum_t \pi_{Insee,t}\delta^t$, where the $\pi_{Insee,t}$ are population-level death probabilities calculated from life tables published by *Insee*. These life tables allow us to determine the probabilities $\pi_{Insee,t}$ separately for men and women, for each age group, and by cohort. It should thus be understood that $\pi_{Insee,t}$ stands for the probability that a representative person from the population, aged say a, and of a given sex and year of birth, dies in year $a + t$ (for notational simplicity we have omitted the age, gender and cohort indicators).

Table 5 compares the results of the linear regressions of α_{Insee} and α on age and gender. As expected, α_{Insee} and α increase in both age and male. In the population older sellers and men have a smaller life expectancy, and this translates into a higher type. With an R-square of 0.98, age and gender explain almost perfectly α_{Insee}. On the contrary, with an R-square of only 0.11, age and gender are imperfect predictors of α. Furthermore, the coefficients are three times smaller than in the previous regression.

Table 5: Effect of age and gender on α_{Insee} and α

	α_{Insee}	α
Age	0.018**	0.006**
	(0.00)	(0.00)
Male	0.072**	0.019*
	(0.00)	(0.01)
Constant	-0.769**	0.249**
	(0.01)	(0.04)
R^2	0.987	0.117
N	874	874

Significance levels: † : 10% ∗ : 5% ∗∗ : 1%

The results of Table 5 indicate that the conditional expectations of α_{Insee} and α differ. The empirical distribution functions of the two variables (see Figure 2) also differ considerably.

[17] It is important to recall that the *rente* is indexed on the consumer price index and that r is the real interest rate. The value $r = 0.05$ is used by practitioners. It is also consistent with the discount factor used in the literature. In Keane and Wolpin (1997) $r = 0.064$, in Carneiro, Hansen, and Heckman (2003) $r = 0.03$, and in Aguirregabiria and Mira (2007) $r = 0.053$. Our results are robust to variations in r. The results remain stable for values of r varying between 0.03 and 0.07.

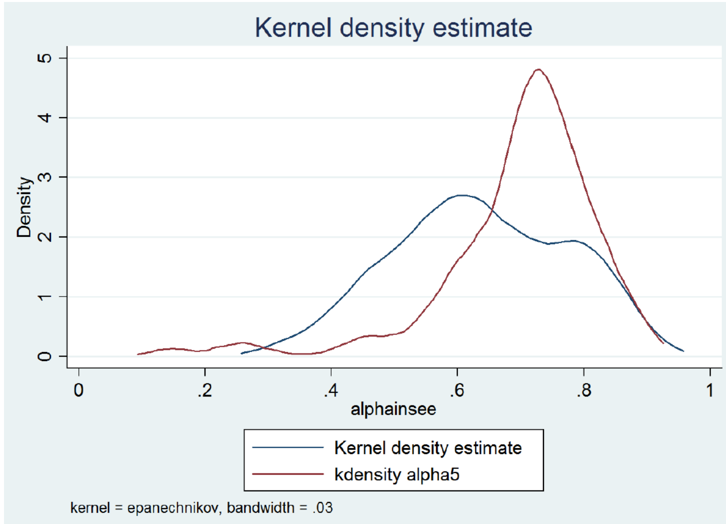

Figure 2: Densities of α_{Insee} and α

The seller-specific types and the national-level types are therefore not the same, and hence the underlying death probabilities are not the same for the two groups either. The fact that the seller-specific and national-level survival distributions differ means that sellers must have realized, before signing the contract, that their death probabilities diverged from those of the average person in the population. This is not surprising as individuals know more than just their age and gender. They may have a more accurate idea of their survival prospects through their life-style habits (diet, alcohol consumption, smoking habits), their illness records, and the life histories of close family members, and this may translate in their personal survival distributions being different from the population distribution. This idea is in line with the findings of Hurd and McGarry (2002). They show that the subjective probability distributions revealed by HRS respondents may differ from population distributions. Furthermore, subjective distributions not only evolve with new relevant health information that subjects may acquire over time, but also predict actual survival. The idea is also in line with Finkelstein and Poterba (2004) who conclude that there is asymmetric information when insurance firms propose life annuity contracts based only on the age and gender of annuity buyers. This result suggests that annuity buyers know more than their age and gender and that their subjective death probabilities incorporate other information.

Sellers must be able to somehow transmit their information to the buyers. If they cannot reveal their true type an unraveling process à la Akerlof would take place and only the sellers with very long life expectancies (i.e. with a very low α) would be able to sell their property on the *viager* market. Such a pattern is not consistent with our data. There is a very strong heterogeneity in the types α and the *viager* market is not just made up of the highest-risk sellers. On the contrary, Figure 2 shows that in our data, sellers have a better type than the average (equivalent) population. The next section studies how sellers transmit their personal knowledge to the sellers.

A key feature of the analysis in the next section is that the no arbitrage condition identifies the type of the seller. Put in other words, α should summarize all the relevant information about the seller. If this is the case, age and gender should not play any role once α is known. To test this critical assumption, we regress the relative *bouquet* and *rente* on powers of α, age, and gender as a way to measure the effect of age and gender, conditionally on α. First, the *bouquet* and the *rente* are regressed on age and gender only (Columns I). Then we add different powers of α to the specifications (Columns II to IV). Table 6 displays the results.[18]

Table 6: Effect of age and gender on the relative *bouquet* and *rente* conditionally on α

	Bouquet (I)	*Rente* (I)	*Bouquet* (II)	*Rente* (II)	*Bouquet* (III)	*Rente* (III)	*Bouquet* (IV)	*Rente* (IV)
Age	0.633**	0.109**	0.294**	0.014	0.054	0.016	-0.004	0.025†
	(0.08)	(0.02)	(0.08)	(0.01)	(0.07)	(0.01)	(0.07)	(0.01)
Male	5.426**	-0.025	4.286**	-0.346	1.805	-0.333	0.813	-0.178
	(1.34)	(0.27)	(1.23)	(0.23)	(1.11)	(0.23)	(1.05)	(0.22)
α			59.523**	16.732**	-222.430**	18.263**	501.342**	-94.497**
			(4.61)	(0.85)	(19.44)	(4.00)	(67.62)	(14.35)
α^2					245.547**	-1.333	-1198.503**	223.642**
					(16.54)	(3.41)	(130.85)	(27.77)
α^3							867.681**	-135.180**
							(78.07)	(16.57)
Constant	-19.905**	-1.169	-34.725**	-5.335**	57.819**	-5.838**	-36.945**	8.926**
	(6.24)	(1.27)	(5.83)	(1.07)	(8.13)	(1.67)	(11.43)	(2.42)
R^2	0.078	0.052	0.226	0.345	0.383	0.345	0.460	0.392
N	874	874	874	874	874	874	874	874

Significance levels: † : 10% $*$: 5% $**$: 1%

As additional powers of α are included in the regressions, the magnitudes of the coefficients of age and gender decrease. When α and α^2 enter the regressions, age and gender male are no longer significant. Such a pattern is thus consistent with the underlying assumption that α captures all the relevant information about the seller's type.

The empirical contract literature usually relies on *ex-post* observations of the agents' types (having an accident in car insurance, date of death in life insurance,...). Having such information is of course very useful for the econometrician. However, even without such *ex-post* observations, the *viager* contracts themselves can be used to recover some information about the types. In a *viager*, it is clear that a seller who obtains both a higher *bouquet* and a higher *rente* should have a higher probability of dying. Equation (1) allows us to extend these comparisons and compare two sellers, one with a higher *bouquet*, the other one with a higher *rente*. The previous regression tends to indicate that our recovered types α are good estimators of the true types, being more informative than age and gender. In particular, the R-square of the regressions increase respectively from 0.078 and 0.052 to 0.458 and 0.390.

However, contrary to ex-post measures, our α is constructed using (2), that is, as a function of the observed *bouquet* and *rente*. Our approach is thus not standard and one can suspect endogeneity issues. The following section shows that this is not the case.

[18] Similar results are obtained for different specifications as well as for different values of r.

3.3 Exogeneity of α

First, it should be noted that a function of endogenous variables can be exogenous. To illustrate this point, take two variables: the price per square feet (p) and the value of apartments (V). It would surprise no one to compute the surface of the apartments by dividing the latter by the former. The recovered surface would be unambiguously seen as an exogenous variable and one could regress the price per square feet on this new variable ($p = \beta_0 + \beta_1 V/p + \varepsilon$) without fearing endogeneity issues.

Equation (1) can be seen as a mathematical relation between α, B/V, and R/V similar to the relation between the surface, the price, and the price per square feet. The type α is an intrinsic characteristic of the sellers and is thus a structural exogenous parameter of the problem (as surface in the previous example).

Yet, the exogeneity of α relies on the assumption that equation (1) is satisfied exactly. If this is not the case, the recovered α are only estimates of the true parameters and endogeneity can be a problem. To emphasize this point, suppose that the true no arbitrage equation takes the form

$$\tilde{\alpha} V = B + \frac{1-\tilde{\alpha}}{r} R + \varepsilon$$

where $\tilde{\alpha}$ is the true type of the seller and ε is an error term that captures, for example, the result of some bargaining between the seller and the buyer.

When ε increases, both the *bouquet* and the *rente* decreases: the buyer is, somehow, successful in the bargaining and reduce the amount he should pay to the seller. By construction, $\alpha = \frac{rB+R}{rV+R} = \tilde{\alpha} - \frac{r\varepsilon}{rV+R}$ decreases with ε. Hence, there is a positive spurious correlation between α and R which creates an endogeneity problem. However, if such a spurious correlation exists, it should not be the case that α captures all the relevant information and the results of Table 6 would not obtain. Indeed, age and gender would be correlated with $\frac{r\varepsilon}{rV+R}$ and still significant in the regressions. The fact that we accept that our estimated α captures all the information about the death probabilities is reassuring that endogeneity, if present, is not too important.

To corroborate this idea, we do a simulation exercice. We add a random term of the form $\frac{r\varepsilon}{rV+R}$ to our variable α where ε follows a normal distribution of zero mean and standard value σ. This process generates a new variable denoted $\widetilde{\alpha}_\sigma$ that can be interpreted as a disrupted measure of the type. When σ increases the noise is larger and one expects age and gender to become significant when regressing the *bouquet* and/or the *rente* on age and gender conditionally on $\widetilde{\alpha}_\sigma$.

Table 7 reports the results of such regressions for several values of σ (0, 1000, 5000, and 10000). In a way, this means that the accounting equation is true respectively at 0, 1000, 5000, and 10000€ (to be compared with the mean value of a property: 100000€). This translates, in term of α into an error of respectively 0, 0.008, 0.036 and 0.085.

For a small noise ($\sigma = 0$ or $\sigma = 1000$), age and gender are not significant whereas this is no longer true as soon as $\sigma = 5000$. Hence, these results support our claim that the accounting equation is almost satisfied in our data and allows us to recover a good estimation of the type of the seller. The endogeneity problem should be small and α can be seen as exogenous.

Finally, in Appendix A, we present four ad hoc different functions of B/V and R/V (which are close but not similar to (2). These arbitrary constructed variables are not able to capture the information contained in age and gender (see Tables 14 to 17). For example, assume that

Table 7: Effect of age and gender on the *bouquet* and *rente* conditionally on α

	Bouquet $\sigma=0$	*Rente* $\sigma=0$	*Bouquet* $\sigma=1000$	*Rente* $\sigma=1000$	*Bouquet* $\sigma=5000$	*Rente* $\sigma=5000$	*Bouquet* $\sigma=10000$	*Rente* $\sigma=10000$
α	501.342**	-94.497**	412.017**	-85.378**	-140.680**	13.614*	-37.535*	4.433
	(67.62)	(14.35)	(66.08)	(13.74)	(32.79)	(6.39)	(15.37)	(3.06)
α^2	-1198.503**	223.642**	-1004.545**	206.549**	275.052**	1.674	96.466**	5.703
	(130.85)	(27.77)	(127.92)	(26.61)	(51.56)	(10.05)	(22.61)	(4.50)
α^3	867.681**	-135.180**	740.683**	-125.513**	-125.669**	-3.713	-43.819**	-3.899†
	(78.07)	(16.57)	(76.25)	(15.86)	(25.43)	(4.96)	(10.36)	(2.06)
Age	-0.004	0.025†	0.006	0.026†	0.358**	0.045**	0.504**	0.077**
	(0.07)	(0.01)	(0.07)	(0.01)	(0.08)	(0.02)	(0.08)	(0.02)
Gender	0.813	-0.178	0.707	-0.201	4.191**	-0.185	5.016**	-0.142
	(1.05)	(0.22)	(1.08)	(0.22)	(1.25)	(0.24)	(1.28)	(0.26)
Constant	-36.945**	8.926**	-26.101*	7.515**	7.997	-5.073**	-15.940*	-3.047*
	(11.43)	(2.42)	(11.28)	(2.35)	(8.97)	(1.75)	(6.77)	(1.35)
R^2	0.460	0.392	0.429	0.384	0.205	0.246	0.160	0.169
N	874	874	874	874	874	874	874	874

Significance levels: † : 10% $*$: 5% $**$: 1%

instead of using $\alpha V = B + \frac{1-\alpha}{r}R$, we use $V = B + \frac{1-\beta}{r}R$. The resulting β has no reason to be exogenous and it is reassuring that age and gender are still significant when powers of β are introduced (see Table 17). The fact that α is defined by a theoretical and economic meaningful equation combined with the results of Table 6 are strong supports for the exogeneity assumption.

4 Modelling and Testing for asymmetric information

To go further, it is useful to model the *viager* sales. The following example gives a first reason why a model is needed.

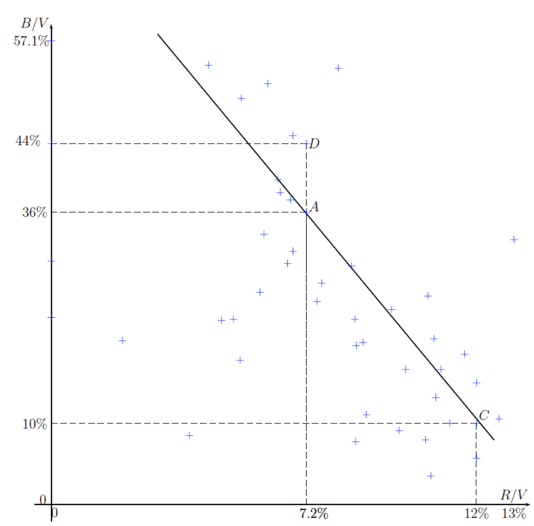

Figure 3: *Viager* contracts for 77 year old female

Figure 3 shows all the contracts for the 48 sellers of our data who are female and 77 year old. As previously mentioned, for a same age and gender, heterogeneity is still important. This heterogeneity has at least two kind of sources. Sellers may have different death probabilities distributions and/or different preferences for the *bouquet* depending, in particular, on their willingness to donate part of it. The accounting equation (1) is a first step to distinguish between them. Let consider the contract A, associated with $\alpha \approx 0.74$. The bold line represents all the contracts $(R/V, B/V)$ with the same value of α. The difference between A and C is thus explained by different preferences for the *bouquet* but these two sellers have the same life expectancy. On the other hand, A and D, even if apparently closer, differ in their death probabilities. A model is thus needed to explain the difference between A and C and more generally to disentangle between both sources of heterogeneity.

Moreover, we have seen that the seller, in a way or another and to avoid an unraveling process *à la* Akerlof, transmits some information to the buyer. The question that still remains open is how sellers share their information to buyers. One possibility is that buyers obtain the information when they get into contact with sellers seeing their physical state and overall condition. The geographical location of the property, the cleanness of the property, and the state of the furniture, painting and other decoration, may also give buyers a precise picture of sellers' health. This corresponds to the case where parties are symmetrically informed (even if sellers are initially better informed). The other possibility is that buyers somehow remain uninformed about the survival probabilities of sellers, even after meeting them. This corresponds to the case of asymmetric information, and the problem can only be overcome by sellers signalling their private information to buyers through the contract terms. To decide which of the two cases best explains our data, a model for a *viager* transaction is useful.

This section entails two parts. In the first one, we present a symmetric information model incorporating donation motives. In a second part, we estimate our model, test and accept that the information on the sellers' death probabilities is symmetric between the sellers and the buyers. Finally, we estimate the probability that a seller is a donator.

4.1 Model

The details of the model are fully explained in Appendix. The seller is assumed to be risk averse and maximizes (under the usual constraints and (1)) the following intertemporal utility function:

$$u(C_0) + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} u(C_{t'}) + \mu D \tag{3}$$

where C_t is date t consumption level. The term μD reflects that the seller has the possibility, at the date of the sale, to donate money to family members, other heirs, or charities. Another interpretation of μD is that the seller wants to keep some money for psychological reasons (see below). Indeed, a *viager* sale allows the seller to recover through the *bouquet* a portion of her wealth. This is very convenient as it allows her to transmit money to her children earlier and have the satisfaction of helping them at a point of time where they need it the most. If someone dies at the age of 90, her children would likely be over 60 and are probably less in need of money than at 40. The intensity of the gift motive is captured by the parameter μ which represents the marginal utility of a gift. Our approach has similarities with the bequest motives modeled by (Hurd, 1987, 1989) and analyzed further by Kopczuk and Lupton (2007) but it differs in that in our model D is given at $t = 0$ whereas in these models D is the amount of money not spent at the date of death. Furthermore, in Hurd's model the bequeathed amount is a random variable while we focus rather on the symmetric case of a deterministic D.

Besides these motives, μ could also capture the psychological need of a seller to keep some money. Brown (2007) mentions several psychological reasons that can explain in our framework why sellers may choose not to annuitize all the value of their property. First, people tend to keep too much money and do not smooth their consumption enough. The small size of the annuity market is one example of this behavior. Second, in a *viager* market, sellers are also afraid to die letting all the value of their property to the buyers. Keeping some money is a kind of insurance against this risk. This loss aversion is also captured by our parameter μ. Third, a large literature relates an "illusion of control" effect: individuals may believe that they have more control over their financial future by holding wealth rather than by receiving income. All these effects are summarized in our parameter μ.

We suppose that the information is symmetric on μ and focus on the information setting about the parameter α which is the parameter of interest for the buyer as it enters directly in the accounting equation and impacts the total amount of money that he has to pay to the seller. Under asymmetric information, the *viager* contract is modeled as a signaling game. Implicitly we thus assume that it is the informed agent (here the seller) who makes the first move by proposing the contract parameters.[19] This seems a plausible assumption since the seller is generally the person who takes the initiative by contacting a real estate agent or by placing an ad in a newspaper.

The following proposition summarizes our results. We only show the equilibrium where both the *bouquet* and the *rente* are positive.[20]

Proposition 1. *(i) The bouquet increases with μ whereas the rente decreases with this parameter.*

(ii) If information about the seller's type, α, is symmetric, then the equilibrium bouquet and rente are increasing functions of α but the former at a higher rate than the latter.

More formally, depending on μ two cases appear: let $\underline{\mu} = u'\left(\frac{r}{1+r-\alpha}(\alpha V + W)\right)$ (where W is the initial net wealth of the seller),

- *If $\mu \leq \underline{\mu}$, the donation motive is too weak and $D^* = 0$. The bouquet and the rente choices reflect the desire to smooth consumption: $B^* + W = R^* = -rV + \frac{r(1+r)V+rW}{1+r-\alpha}$. They both increase with α and V.*

- *If $\mu > \underline{\mu}$, the donation motive is strong enough and $D^* > 0$. The rente is independent of α and V: $R^* = u'^{-1}(\mu)$. The bouquet and the donation are both increasing with α and V: $B^* = D^* + R^* - W = \alpha(V + u'^{-1}(\mu)/r) - u'^{-1}(\mu)/r$.*

(iii) On the other hand, if information is asymmetric, then the equilibrium bouquet is increasing while the rente is decreasing with α.

[19] This contrasts with adverse selection models where the uninformed party moves first (see Salanié (1997), for a classification of contract models into three broad families).

[20] This case corresponds to almost all our data.

The proof is in Appendix C. In this simple model, B^*, D^*, and R^* are always such that the seller smooth her consumption over all dates. In periods $t \geq 1$ she consumes R^* and in $t = 0$ she consumes $B^* - D^* + W$. It is easy to check that in both cases of (ii) $B^* - D^* + W = R^*$.

The parameter μ has an unambiguous effect. If the seller has a higher marginal valuation for donation, she is more likely to give some money and chooses a *viager* contract with a higher *bouquet* (part of the given amount comes from αV and is collected through B, the other part comes from W whenever $W \geq 0$) and (consequently) a smaller *rente*.

Figure 4 helps visualizing the effect of a change of α on the equilibrium values. Let starting from A_0, and assume α increases from α_0 to α_1 (everything else remaining constant). Under symmetric information there are two possibilities depending on μ. First, if μ is such that $D^* = 0$, then the equilibrium moves to A_1': both B^* and R^* increase and they increase at the same rate. Second, if μ is large enough such that $D^* > 0$, then the equilibrium evolves to A_1: the *rente* remains constant and only the *bouquet* increases (the donation increases at the same rate as the *bouquet*). Finally, would information be asymmetric, then the equilibrium would moves from A_0 to A_1''. That is, to a larger *bouquet* but a smaller *rente*.

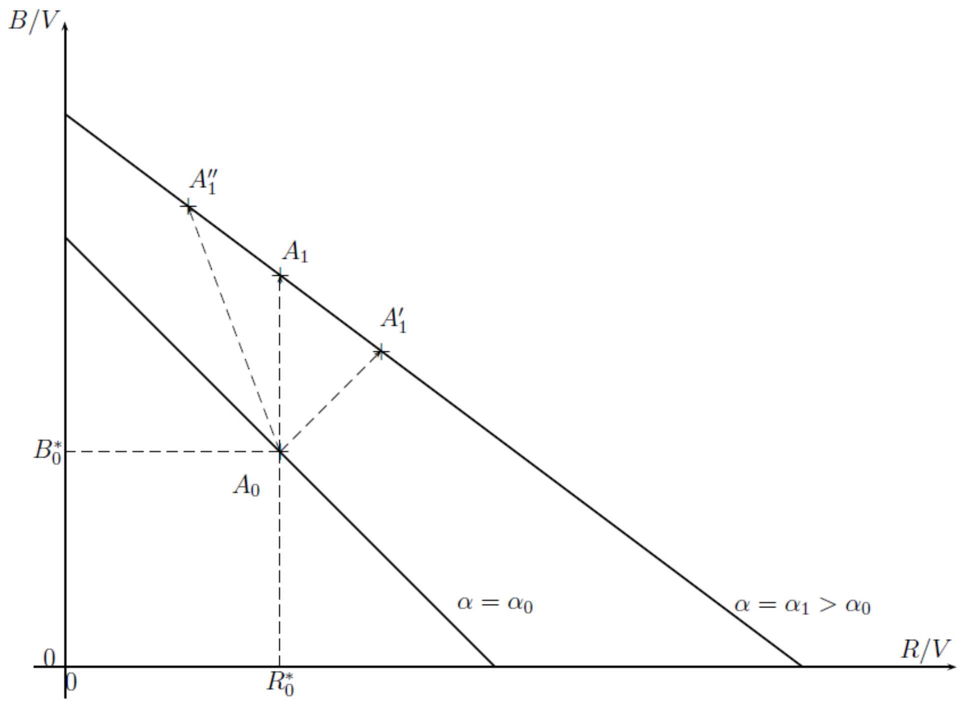

Figure 4: The effect of a variation of α on equilibrium

The proposition (and its formal proof in Appendix) also helps us to understand what the data should show in the symmetric information case. First, for all values of μ, we should observe that the *bouquet* exceeds the *rente* if the seller decides to donate money, or if the seller had debts in the period before the sale. Second, for all values of μ, the *bouquet* is an increasing function of the sum of weighted death probabilities α. The *rente* is increasing in α only for values of μ below a certain threshold, and is constant for values above the threshold. It is likely that our sample contains sellers for whom μ is below the threshold (those who do not donate) as well as sellers for whom μ is above the threshold (those who donate). At the aggregate level we should therefore observe that both the *bouquet* and *rente* increase with α, but the former at a higher rate than the latter. Finally, in the asymmetric information case, we should observe that the *bouquet* increases with α whereas the *rente* decreases, for the seller to be able to signal her type. Indeed, if both variables were increasing in α, all the sellers would have an incentive to lie about their type and benefit from both a larger *bouquet* and a larger *rente*. By reducing the amount of the *rente*, *viager* sellers with a short life expectancy are able to signal their type. Indeed, as a seller with a longer life expectancy needs to smooth her consumption, it is too costly for her to match this contract and such a seller would prefer a contract with a higher *rente*.

4.2 Empirical tests

We test whether buyers and sellers are symmetric or asymmetric in the dimension α. The basic idea of the empirical test consists in studying the shape of the *rente* when α changes. If the *rente* increases with α, the model is symmetric whereas it is asymmetric in the other case. It is important to note that we do not need to condition on observable variables, as usually done in the adverse selection literature. The reason is that α contains all the relevant information, other variables playing no role in the choice of the contracts terms in the death dimension. In a test *à la* Chiappori-Salanie, it would be necessary to condition on age and gender, for example, before looking at the correlation between the *bouquet* and α or between the *rente* and α. We however follow a different approach. In our test, we directly study the impact of the death probabilities on both the *bouquet* and the *rente*. Here again, the exogeneity assumption on α or its small endogeneity is crucial (see Section 3.3).

Proposition 1 shows that there are two regimes for both B^* and R^* depending on D^* being positive or equal to zero. As we do not observe D^*, this property calls for a switching regression, as in Kopczuk and Lupton (2007).

The condition for $D^* > 0$, $\mu > \underline{\mu}$, translates into $\alpha > \underline{\alpha} = ((1+r)u'^{-1}(\mu) - rW) \,/\, (rV + u'^{-1}(\mu))$ and the econometric model for the *rente* finally writes:

$$\begin{cases} R_i/V_i = -r + \frac{r(1+r+W_i/V_i}{1+r-\alpha_i} = \beta_0^1 + \beta_1^1\left(\frac{1}{1+r-\alpha_i}\right) + \varepsilon_{1i} & \text{if } y_i > 0 \text{ (no donation, regime 1)} \\ R_i/V_i = u'^{-1}(\mu_i)/V_i = \beta_0^2 + \beta_1^2\left(\frac{1}{1+r-\alpha_i}\right) + \varepsilon_{2i}, & \text{if } y_i \leq 0 \text{ (donation, regime 2)} \\ y_i = \underline{\alpha_i} - \alpha_i = \beta_0^3 + \beta_1^3\alpha_i + \varepsilon_{3i}, & \text{(switching equation)} \end{cases} \tag{4}$$

where the error terms ε_{ki} ($k = 1, 2, 3$) are supposed to be normally distributed. They capture the heterogeneity in the initial wealth W_i, and in $u^{-1}(\mu_i)$, the parameter reflecting donation motives. W_i and $u^{-1}(\mu_i)$ are supposed to be orthogonal with one another and with α. Under these assumptions, the error terms are orthogonal to α_i. Moreover, ε_{1i} and ε_{2i} are independent. Yet, the model implies that ε_{3i} is correlated with ε_{1i} and ε_{2i}. Hence, normalizing the variance of ε_{3i} to one, ε_{3i} follows a normal distribution $\mathcal{N}(0, 1)$. Conditionally on ε_{3i}, ε_{1i} (resp. ε_{2i}) follows a normal distribution $\mathcal{N}(\rho_1\varepsilon_{3i}, \sigma_1^2)$ (resp. $\mathcal{N}(\rho_2\varepsilon_{3i}, \sigma_2^2)$).

Given the distributional assumptions, the model can be estimated by maximum likelihood. Because sample separation in unknown, each observation contributes for two terms in the likelihood (see Appendix):

$$l(R_i/V_i;\alpha_i,\theta) = \frac{1}{\sqrt{\sigma_1^2+\rho_1^2}}\phi\left(\frac{R_i/V_i-\beta_0^1-\beta_1^1\left(\frac{1}{1+r-\alpha_i}\right)}{\sqrt{\sigma_1^2+\rho_1^2}}\right)\Phi\left(\frac{\beta_0^3+\beta_1^3\alpha_i+\frac{\rho_1}{\sigma_1^2+\rho_1^2}\left(R_i/V_i-\beta_0^1-\beta_1^1\left(\frac{1}{1+r-\alpha_i}\right)\right)}{\sqrt{\sigma_1^2/(\sigma_1^2+\rho_1^2)}}\right)$$
$$+\frac{1}{\sqrt{\sigma_2^2+\rho_2^2}}\phi\left(\frac{R_i/V_i-\beta_0^2-\beta_1^2\left(\frac{1}{1+r-\alpha_i}\right)}{\sqrt{\sigma_2^2+\rho_2^2}}\right)\Phi\left(\frac{\beta_0^3+\beta_1^3\alpha_i+\frac{\rho_2}{\sigma_2^2+\rho_2^2}\left(R_i/V_i-\beta_0^2-\beta_1^2\left(\frac{1}{1+r-\alpha_i}\right)\right)}{\sqrt{\sigma_2^2/(\sigma_2^2+\rho_2^2)}}\right)$$

where $\phi(.)$ is the density of a standard normal distribution, $\Phi(.)$ its associated cumulative distribution function, and $\theta = (\beta_0^1, \beta_1^1, \beta_0^2, \beta_1^2, \beta_0^3, \beta_1^3, \sigma_1, \sigma_2, \rho_1, \rho_2)$.

According to Proposition 1, we expect under symmetric information $\beta_1^1 > 0$ (in the absence of donation, the *rente* increases with α) and $\beta_1^2 = 0$ (in the presence of donation, the *rente* is independent of α). On the contrary, under asymmetric information, the *rente* should decrease. Moreover regime 1 should occur when α is small i.e. $\beta_1^3 < 0$.

The results of the switching regression (4) are shown in Table 8. They are in line with the symmetric model predictions. On average, regime 2 occurs when $\alpha > 0.69$ showing that sellers with a smaller life expectancy are more likely to donate or keep some money for psychological reasons. Furthermore, and as predicted, $\beta_1^1 = 7.14$ is significantly positive for the sellers who do not donate whereas $\beta_1^2 = 0.11$ is not significantly different from zero for those who do.

These results are a strong support for the symmetric information model with donations. As the switching regression does not impose any constraint, it is remarkable that the data split endogenously into two groups and that the *rente* is increasing in the no donation group and constant in the other one correspond exactly to the predictions. Furthermore, the asymmetric model is rejected as the *rente* does not decrease with α_i.

Table 8: Switching regression of the *rente* on α

	$100(R^*/V)$		y_i
	Regime 1 ($D^* = 0$)	Regime 2 ($D^* > 0$)	Switching reg.
$1/(1+r-\alpha)$	7.1384**	0.1052	
	(0.2428)	(0.1679)	
α			-12.9733**
			(1.0868)
Constant	-10.3152**	9.4143**	8.9197**
	(0.5748)	(0.6560)	(0.8209)
N	831	831	831

Significance levels: † : 10% $*$: 5% $**$: 1%
Contracts with $R_i = 0$ are excluded. Log likelihood = -1911.982

A similar switching regression can be written and estimated for the *bouquet*. However, instead of writing this second regression in terms of B, it is equivalent and more convenient to write it in terms of $B^* - R^*$:

$$\begin{cases} B_i/V_i - R_i/V_i = \gamma_0^1 + \gamma_1^1\alpha_i + \xi_{1i} & \text{if } z_i > 0 \text{ (no donation, regime 1)} \\ B_i/V_i - R_i/V_i = \gamma_0^2 + \gamma_1^2\alpha_i + \xi_{2i}, & \text{if } z_i \leq 0 \text{ (donation, regime 2)} \\ z_i = \gamma_0^3 + \gamma_1^3\alpha_i + \xi_{3i}, & \text{(switching equation)} \end{cases} \quad (5)$$

where ξ_{ki} ($k = 1, 2, 3$) are supposed to be normally distributed. ξ_{1i} and ξ_{2i} are supposed to be independent but both are correlated with ξ_{3i}.

According to Proposition 1, we expect $\gamma_1^1 = 0$ (when there is no donation, the *bouquet* and the *rente* increases with α at the same rate so their difference is constant) and $\gamma_1^2 > 0$ (when there is a donation, the *rente* is independent of α while the *bouquet* increases). The results of the switching regression (5) are shown in Table 9. They are, again, in line with the symmetric model predictions: $\gamma_1^1 = 2.35$ is not significantly different from zero whereas $\gamma_1^2 = 231.13$ is significantly positive. Moreover, sellers with a shorter life expectancy ($\alpha > 0.8$) are more likely to donate. These results corroborate the ones of Table 8. As the *bouquet* and the *rente* are linked through equation (1), this does not come as a surprise. However, if our assumptions on the error terms were not correct the results could have been very different. That results of Table 8 and Table 9 are close is reassuring.

Table 9: Switching regression of the *bouquet* on α

	$100(B^*/V - R^*/V)$		z_i
	Regime 1 ($D^* = 0$)	Regime 2 ($D^* > 0$)	Switching reg.
α	2.3579	231.13**	-15.4553**
	(10.6115)	(39.1580)	(2.3005)
Constant	13.3508*	-139.51**	12.3584**
	(6.6972)	(34.9070)	(1.8829)
N	831	831	831

Significance levels: † : 10% ∗ : 5% ∗∗ : 1%

Contracts with $R_i = 0$ are excluded. Log likelihood = -3436.6104

The good fit of the data by the symmetric model is illustrated in Figure 5a and 5b which plot respectively, for each observation i, the relative *rente* R_i/V_i) and the difference between the relative *bouquet* and *rente* $B_i/V_i - R_i/V_i$ (as well as their fitted values) against α_i. In Figure 5a, the fitted values correspond to the ones obtained from the switching regression (see Table 8) of R_i/V_i on $\frac{1}{1+r-\alpha_i}$ and a constant. In Figure 5b, the fitted values correspond to the ones obtained from the switching regression of $B_i/V_i - R_i/V_i$ on α_i and a constant (see Table 9).

Figure 5a in particular provides a strong evidence that the *rente* is increasing and that the symmetric model explains well the data, whereas the prediction of the asymmetric model of a decreasing *rente* is rejected.

Hence, in line with what Finkelstein and Poterba (2004) or Hurd and McGarry (2002) have shown, sellers know more about their death probabilities than just their age and gender. What our results also tend to prove is that the buyers, after their discussions with the sellers, get all the needed information to sign a *viager* contract. Underlying this result, we believe that some information about the death probability of the seller is contained in different characteristics of the sellers and of their properties. For example, Table 10 shows that, in addition to age and gender, the value of the apartment contains some information about α whereas its size does not. Sellers with more valuable properties have a smaller α, reflecting the idea that richer persons live longer. This variable is typically observed by the buyer before signing a *viager* contract.

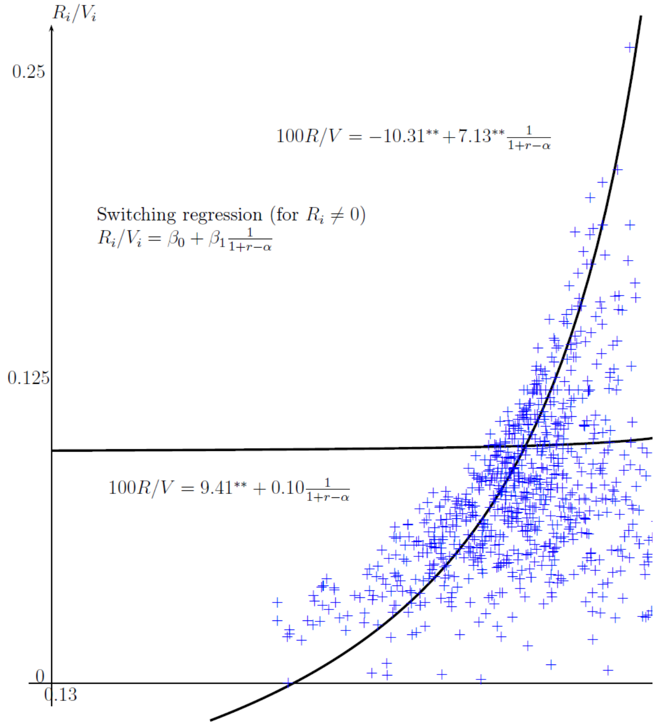

Figure 5a: R/V as a function of α

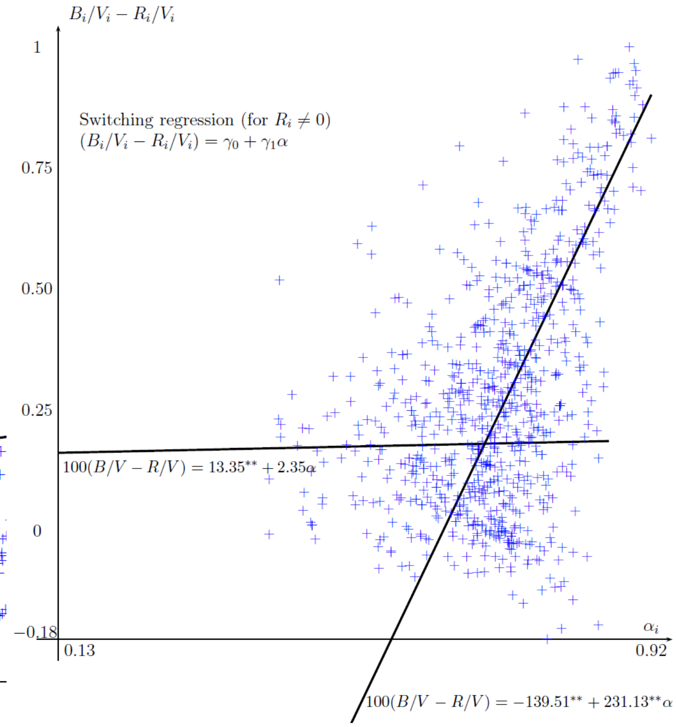

Figure 5b: $B/V - R/V$ as a function of α

Table 10: Effect of observable variables on α

	α	α	α
Age	0.0057**	0.0059**	0.0059**
	(0.0005)	(0.0005)	(0.0005)
Gender	0.0192*	0.0213*	0.0213*
	(0.0090)	(0.0089)	(0.0089)
Property Value (k€)		-0.0003**	-0.0003**
		(0.0001)	(0.0001)
Size (square m.)			0.0001
			(0.0002)
Constant	0.2490**	0.2612**	0.2595**
	(0.0420)	(0.0413)	(0.0417)
R^2	0.117	0.150	0.150
N	874	874	874

Significance levels: † : 10% $*$: 5% $**$: 1%

4.3 Heterogeneity of the sellers

The model helps analyzing more deeply the observed heterogeneity in the *viager* contracts. The *bouquet* and the *rente* are functions of both α and μ which are themselves functions of different variables X, X', X''. Noting $\alpha = \alpha(X, X')$ and $\mu(X, X'')$, we get $B(\alpha, \mu) = B(X, X', X'')$ and $R(\alpha, \mu) = R(X, X', X'')$. In this section, we are interested in finding in our dataset the variables X' that only impact the probability of death α, the variable X'' that only impact the donation parameter μ and in finding and disentangling the effects of the variables X that affect both α and μ.

The fact that age and gender are not significant in the regressions of Table 6 implies two points. First, and as already stated, it is consistent with the idea that α captures all the relevant information about death probabilities. Second, it shows that age and gender do not have any impact on the donation preference parameter μ. Age and gender impact the *bouquet* and the *rente* only through α and thus belong to the X' variables. Another way to test this result is to use the estimated probability that a seller donates. This probability can be recovered from the previous estimations and one can regress this probability on age and gender, once controlling for α. Table 11 presents the result. As expected, both variables are not significantly different from zero. Age and gender do not affect the donation decision except through α.

Table 11: Effect of age and gender on the donation probability

	(I)	(II)	(III)
Age	0.014**	-0.001	-0.001
	(0.00)	(0.00)	(0.00)
Gender	0.063*	-0.007	-0.000
	(0.03)	(0.02)	(0.02)
α		3.170**	-57.526**
		(0.10)	(6.48)
α^2			91.662**
			(9.66)
α^3			-45.208**
			(4.73)
Constant	-0.488**	-1.549**	11.494**
	(0.13)	(0.09)	(1.43)
R^2	0.082	0.593	0.634
N	831	831	831

Significance levels: † : 10% ∗ : 5% ∗∗ : 1%

We now turn to the effects of the property value V and of its size. The results of Table 10 have shown that the property of the value has an impact on α whereas its size does not. The idea behind these results is that V is a proxy for the health of the seller. Richer seller have better access to health care and are thus expected to live longer (REF Becker). The size of the property on the contrary, once controlling for its value, does not contain any information on the health of the seller.

Table 12 presents the regression of the probability of donation on the value and the size of the property controlling for α. It allows us to recover the impact of these variables on μ.

It appears that both variables influence the probability of donation: richer sellers are more likely to donate, as well as sellers with bigger properties. In a sense, the results confirm the intuition that the size of the property can be interpreted as a proxy for the family size and that sellers with children are more likely to donate. The fact that V also influences the probability of donation is coherent with the theory as $\underline{\mu}$ decreases with V. It may also indicate a direct effect on μ reflecting either that richer seller are more generous or that richer seller are more influenced by psychological reasons such as loss aversion or illusion of control.

Table 12: Effect of the value and the size on the donation probability

	(I)	(II)	(III)
Property Value (k€)	-0.000	0.000	0.000†
	(0.00)	(0.00)	(0.00)
Size (square m.)	0.001	0.001**	0.001**
	(0.00)	(0.00)	(0.00)
α		3.193**	-60.126**
		(0.09)	(6.32)
α^2			95.887**
			(9.42)
α^3			-47.391**
			(4.61)
Constant	0.596**	-1.767**	11.827**
	(0.03)	(0.07)	(1.39)
R^2	0.002	0.608	0.653
N	831	831	831

Hence, the size of the property is more a X'' variable that only influences the donation parameter whereas its value V is more a X variable that impacts both the death probability and the donation parameter.

To corroborate these results, it is finally possible to regress directly the *bouquet* and the *rente* on these variables, as we have done for age and gender. Table 13 presents the results of four different regressions: two for the *bouquet* and two for the *rente*, depending if we control or not for the dependence on α. In the first class of regressions (where we do not control for α), we measure the total effect of the variables whereas in the second class of regressions (where we do control for α), we only measure the effect on the parameter μ. If our previous results are correct, we expect the following:

- The variable size of the property only affects the parameter μ: sellers with bigger properties are more likely to donate. Hence, it should have a positive and significant effect on the *bouquet* and a significant and negative effect on the *rente*. This effect should be the same, whereas we control for α or not.

- The variable value of the property influences both α and μ. It has a negative impact on α as richer sellers live longer and thus a negative effect on both the *bouquet* and the *rente*. It has on the contrary a positive impact on μ as richer sellers are more likely to donate and thus a positive effect on the *bouquet* and a negative one on the *rente*. At the end, the effect on the *bouquet* is ambiguous in the first regression, but should be positive, significant and larger in the second one. The effect on the *rente* is unambiguously negative in both regressions, with a smaller coefficient in the first regression as it captures the two negative effects through both α and μ.

The results in Table 13 confirms all these predictions and supports our previous findings.

Our limited number of variables do not allow us to explain more deeply the parameters α and μ. We believe however that these results complement the literature on adverse selection **?** and

Table 13: Effect of property value and size on the *bouquet* and *rente* conditionally on α

	Bouquet (I)	*Rente* (I)	*Bouquet* (II)	*Rente* (II)
Property Value	0.014	-0.010**	0.028**	-0.006**
	(0.01)	(0.00)	(0.01)	(0.00)
Size (square m.)	0.057*	-0.016**	0.064**	-0.014**
	(0.03)	(0.00)	(0.02)	(0.00)
α			471.414**	-87.342**
			(65.32)	(13.88)
α^2			-1138.209**	208.697**
			(126.13)	(26.80)
α^3			834.791**	-126.238**
			(75.00)	(15.93)
Constant	26.268**	9.302**	-40.958**	11.447**
	(1.34)	(0.26)	(10.07)	(2.14)
R^2	0.019	0.093	0.499	0.435
N	874	874	874	874

Significance levels: † : 10% $*$: 5% $**$: 1%

the literature on bequest Kopczuk and Lupton (2007) and support both the accounting equation and the symmetric model we have used in this paper.

5 Conclusion

This paper studies the *viager* real estate market. In spite of the fact that a *viager* sale can be an attractive mechanism especially for older homeowners with otherwise few financial resources, the size of the market is small. We analyzed whether this may be explained by asymmetries of information between buyers and sellers. We find that this is not the case. Contrary to conventional wisdom, this is not a market that has collapsed to a point where only the highest-risk individuals sell their property. Our results suggest instead that both low-risk and high-risk individuals are active in the market. Furthermore, although sellers are initially better informed about their survival prospects, they are able to unveil the hidden information when they enter into contact with buyers and show the state of their apartments.

Moreover, our data are consistent with a model where sellers have donation motives. A switching regression approach allows us to distinguish two types of sellers: those who donate and those who do not. The important heterogeneity in the contracts parameters that we observe in the data are well explained by these two sources of heterogeneity i.e. the probability of death and the donation parameter.

If asymmetric information is not the problem, what other factors may cause the limited size of the market? There may be some purely economic explanations. One is that there are no fiscal measures in France that may act as incentives for potential buyers. The second is related to the fact that banks refuse to provide loans (with the *viager* property as collateral). This can be an obstacle for less rich buyers who may not be able to instantly pay the *bouquet* (even if the down payment represents on average only about 30% of the market value). There may also be explanations of a more practical nature. Many homeowners are simply unaware of how the mechanism works in detail. Also, except in the cities and regions where most of the transactions are concentrated, there are few real estate agencies specialized in the mechanism. Agencies that are not specialized may not wish to deal with a *viager* transaction because they find the technique too complicated, or too costly from an administrative point of view. Finally, many notaries in France are not sufficiently trained in the legal finesses and subtleties of the method (Griffon, 2008), and may refuse to handle a transaction on this ground.

But in our opinion the most important explanations are based on psychological and behavioral considerations.[21] One psychological factor that can hinder the development of the market is that potential sellers may be suspicious when they hear of the mechanism, very much like the farm owner in the above extract from a story by Guy de Maupassant. Another factor is the complexity of the method. Determining the parameters of a contract requires some knowledge of actuarial and statistical concepts. Many homeowners may lack the financial sophistication to fully grasp these concepts, and, in the absence of professional advisers, hesitate to enter the market afraid to be defrauded by unscrupulous buyers. Yet another explanation is that in France, for cultural and historical reasons, much emotional value is attached to real estate property. Many individuals refuse to consider a *viager* sale because the property has been owned by the family for generations, and should therefore remain in family hands. But, admittedly, this argument may be more valid for family houses in the countryside of France than for the Parisian apartments in our sample. Yet, potential seller might not be able to agree with prospective buyers on the decomposition of the price into the *bouquet* and the *rente* due to an endowment effect. Still another explanation is that sellers may fear that (with a small probability) buyers commit a criminal act to get rid of them. The buyer in the story by Maupassant regularly visits the farm owner and offers her casks of a strong spirit in the hope to hasten the old lady's death. Outside the scope of literature, acts of criminality are, however, very rare.[22] A final factor that may explain the small size of the market is that many potential buyers may dislike the gloomy aspect of *viager* sales, or they may opposed the idea of gambling on the instant of their death or of another person's death. In the short story, *Il Viaggio*, Luigi Pirandello adopts the point of view that it is immoral to buy a *viager* and in the story the buyer is punished not being able to benefit from his purchase.[23]

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[21] Our explanations are similar in spirit to the ones offered in a recent paper by Brown (2007). He argues that insights from psychology and behavioral economics may be useful in understanding the limited size of annuity markets.

[22] The French newspaper *Libération* ("*Viager dangereux: les experts se renvoient les balles*", published on 28th August 1991) reports the story of a buyer who had tried to murder the seller.

[23] The buyer, presented as greedy, purchase through a *viager* mechanism a prosperous (small) piece of land from an honest peasant. Once the seller leaves his property, however, the land becomes infertile.

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Appendix

A Effect of age and gender on the *bouquet* and *rente* conditionally on various functions of B/V and R/V

Table 14: Effect of age and gender conditionally on $\beta = B/R$

	Bouquet (I)	*Rente* (I)	*Bouquet* (II)	*Rente* (II)	*Bouquet* (III)	*Rente* (III)	*Bouquet* (IV)	*Rente* (IV)
Age	0.633**	0.109**	0.650**	0.100**	0.650**	0.100**	0.558**	0.120**
	(0.08)	(0.02)	(0.08)	(0.02)	(0.08)	(0.02)	(0.08)	(0.01)
Gender	5.426**	-0.031	5.717**	0.070	5.789**	0.044	4.967**	0.217
	(1.34)	(0.27)	(1.37)	(0.26)	(1.37)	(0.26)	(1.29)	(0.24)
β			0.002	-0.001**	0.015*	-0.005**	0.376**	-0.081**
			(0.00)	(0.00)	(0.01)	(0.00)	(0.04)	(0.01)
β^2					-0.000†	0.000**	-0.000**	0.000**
					(0.00)	(0.00)	(0.00)	(0.00)
β^3							0.000**	-0.000**
							(0.00)	(0.00)
Constant	-19.905**	-1.108	-21.635**	-0.148	-21.730**	-0.114	-16.654**	-1.178
	(6.24)	(1.26)	(6.38)	(1.20)	(6.37)	(1.19)	(6.01)	(1.10)
R^2	0.078	0.052	0.084	0.063	0.087	0.076	0.193	0.211
N	874	874	838	838	838	838	838	838

Significance levels: † : 10% $*$: 5% $**$: 1%

Table 15: Effect of age and gender conditionally on $\beta = B/V + \frac{1}{r}R/V$

	Bouquet (I)	*Rente* (I)	*Bouquet* (II)	*Rente* (II)	*Bouquet* (III)	*Rente* (III)	*Bouquet* (IV)	*Rente* (IV)
Age	0.633**	0.109**	0.778**	-0.039**	0.811**	-0.041**	0.813**	-0.041**
	(0.08)	(0.02)	(0.08)	(0.00)	(0.08)	(0.00)	(0.08)	(0.00)
Gender	5.426**	-0.031	5.674**	-0.284**	6.059**	-0.303**	6.102**	-0.305**
	(1.34)	(0.27)	(1.32)	(0.07)	(1.30)	(0.07)	(1.30)	(0.06)
β			-0.052**	0.053**	0.078**	0.046**	0.191**	0.040**
			(0.01)	(0.00)	(0.03)	(0.00)	(0.06)	(0.00)
β^2					-0.000**	0.000**	-0.001**	0.000**
					(0.00)	(0.00)	(0.00)	(0.00)
β^3							0.000*	-0.000*
							(0.00)	(0.00)
Constant	-19.905**	-1.108	-22.071**	1.104**	-35.363**	1.768**	-41.036**	2.052**
	(6.24)	(1.26)	(6.14)	(0.31)	(6.63)	(0.33)	(7.17)	(0.36)
R^2	0.078	0.052	0.112	0.944	0.136	0.946	0.140	0.946
N	874	874	874	874	874	874	874	874

Significance levels: † : 10% $*$: 5% $**$: 1%

Table 16: Effect of age and gender conditionally on $\beta = (rB/V + R/V)/(r + B/V)$

	Bouquet (I)	*Rente* (I)	*Bouquet* (II)	*Rente* (II)	*Bouquet* (III)	*Rente* (III)	*Bouquet* (IV)	*Rente* (IV)
Age	0.633**	0.109**	0.741**	0.086**	0.675**	0.099**	0.629**	0.109**
	(0.08)	(0.02)	(0.06)	(0.01)	(0.05)	(0.01)	(0.05)	(0.01)
Gender	5.426**	-0.031	4.874**	0.089	3.641**	0.335†	3.350**	0.399*
	(1.34)	(0.27)	(1.00)	(0.19)	(0.92)	(0.17)	(0.87)	(0.16)
β			-39.805**	8.604**	-68.732**	14.393**	-109.185**	23.184**
			(1.52)	(0.29)	(2.53)	(0.48)	(4.93)	(0.91)
β^2					17.116**	-3.426**	65.892**	-14.025**
					(1.25)	(0.24)	(5.32)	(0.99)
β^3							-11.316**	2.459**
							(1.20)	(0.22)
Constant	-19.905**	-1.108	-14.489**	-2.278*	-2.624	-4.653**	7.336†	-6.817**
	(6.24)	(1.26)	(4.67)	(0.89)	(4.33)	(0.82)	(4.26)	(0.79)
R^2	0.078	0.052	0.484	0.529	0.575	0.620	0.614	0.667
N	874	874	874	874	874	874	874	874

Significance levels: † : 10% $*$: 5% $**$: 1%

Table 17: Effect of age and gender conditionally on $\beta = 1 - r(1 - B/V)/(R/V)$

	Bouquet (I)	*Rente* (I)	*Bouquet* (II)	*Rente* (II)	*Bouquet* (III)	*Rente* (III)	*Bouquet* (IV)	*Rente* (IV)
Age	0.633**	0.109**	0.648**	0.100**	0.648**	0.099**	0.643**	0.078**
	(0.08)	(0.02)	(0.08)	(0.02)	(0.08)	(0.02)	(0.08)	(0.01)
Gender	5.426**	-0.031	5.758**	0.061	5.735**	0.032	5.717**	-0.046
	(1.34)	(0.27)	(1.37)	(0.26)	(1.37)	(0.26)	(1.37)	(0.23)
β			-0.021	0.011**	0.013	0.055**	0.481	2.090**
			(0.02)	(0.00)	(0.10)	(0.02)	(0.87)	(0.15)
β^2					0.000	0.000*	0.002	0.007**
					(0.00)	(0.00)	(0.00)	(0.00)
β^3							0.000	0.000**
							(0.00)	(0.00)
Constant	-19.905**	-1.108	-21.466**	-0.114	-21.440**	-0.080	-21.241**	0.785
	(6.24)	(1.26)	(6.38)	(1.20)	(6.39)	(1.20)	(6.40)	(1.08)
R^2	0.078	0.052	0.082	0.063	0.083	0.069	0.083	0.246
N	874	874	838	838	838	838	838	838

Significance levels: † : 10% $*$: 5% $**$: 1%

B Proof of Equation 1

$$
\begin{aligned}
V = B + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} (R+L) &= B + \sum_{t=1}^{T} \pi_t \delta (R + rV) \frac{1-\delta^t}{1-\delta} \\
&= B + \frac{\delta}{1-\delta} \left[\sum_{t=1}^{T} \pi_t - \sum_{t=1}^{T} \pi_t \delta^t \right] (R + rV) \\
&= B + \frac{\delta}{1-\delta} \left[\sum_{t=1}^{T} \pi_t + \pi_0 - \pi_0 - \sum_{t=1}^{T} \pi_t \delta^t \right] (R + rV) \\
&= B + \frac{\delta}{1-\delta} \left[1 - \sum_{t=0}^{T} \pi_t \delta^t \right] (R + rV) \\
&= B + \frac{1}{r} \left[1 - \sum_{t=0}^{T} \pi_t \delta^t \right] (R + rV) \\
&= B + \frac{1-\alpha}{r} R + (1-\alpha) V
\end{aligned}
$$

hence the result.

C Microeconomics of the *viager* contract

Let C_t and S_t and respectively denote the amount of consumption and the amount of savings of the seller in year t. We assume that S_t is positive, i.e., the seller can only save money. This assumption is coherent with the fact that elderly people are not allowed to borrow money from the bank. The nominal interest rate of the bank is denoted r. The initial level of wealth of the seller is denoted W. It is positive if the seller has savings just before the *viager* transaction, and negative if the seller has accumulated debts. It is a given and predetermined variable in the model, i.e., it is not a choice variable for the agent. At the date of sale the seller has the possibility to donate money to family members or other heirs. Let D denote the amount of money the seller wishes to donate. Given these notations, the amount of money that can be consumed in year $t = 0$ equals

$$C_0 = B - D + W - S_0 \tag{6}$$

In year $t > 0$ the consumption level equals

$$C_t = R + (1+r)S_{t-1} - S_t, \; t = 1, ..., T. \tag{7}$$

The expected utility function is therefore

$$u(C_0) + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} u(C_{t'}) + \mu D. \tag{8}$$

The seller maximizes the expected utility function under the participation constraint of the buyer.

The proof of the proposition is facilitated by assuming that buyers and sellers have access to a larger set of *viager* contracts. Specifically, instead of assuming that the *rente* is fixed over time (apart form the variations due to the indexation), the *rente* is now allowed to differ in each time period. Within this larger set of contracts each seller thus maximizes an expected utility function with respect to B, D, S_0, S_1,...,S_T, and R_1,... R_T (instead of just B, D, S_0, S_1,...,S_T, and R). Finally, we only focus on the equilbria where the downpayment and the rents are strictly positive.[24] The proof is in three steps. First we show that it is optimal for the seller never to save, i.e., $S_0^* = S_1^* = ... = S_T^* = 0$. Second, we show that at the optimum the *rente* should not vary over time, i.e., $R_1^* = ... = R_T^* = R^*$. Third, the expected utility function is maximized with respect to B, D and R to obtain the optimal values B^*, D^* and R^*. The first two steps of the proof indicate that the seller's maximum within the extended class of *viager* contracts coincides with the maximum the seller can attain within the class of fixed-*rente* contracts. It is therefore not restrictive to start the proof by considering a more general environment. The more general setting only serves as a device to simplify the proof of the proposition. An interesting by-product of the proof is that it rationalizes the fact that contracts with a time-varying *rente* do not exist in practice. Indeed, although such contracts are more flexible, they do not allow sellers to augment their utility.

The consumption constraint in year $t = 0$ is not affected by the fact that the *rente* is allowed to vary over time. It is still defined by

$$C_0 = B - D + W - S_0 \tag{9}$$

The consumption constraint in year $t > 0$ is, however, different:

$$C_t = R_t + (1 + r)S_{t-1} - S_t,\ t = 1, ..., T. \tag{10}$$

The expected utility function is still given by:

$$u(C_0) + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} u(C_{t'}) + \mu D. \tag{11}$$

Taking into account the time-variation of the *rente*, the participation constraint of the buyer is now given by

$$\alpha V - B = \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} R_{t'} \tag{12}$$

The seller's objective is to maximize (11) with respect to B, D, R_1, ..., R_T, and S_0,..., S_T, given that these variables and C_t must be positive, and the participation constraint (12).

• The first step of the proof consists in showing that at the optimum the seller should never save. Assume, by contradiction, that this is not true. Let B' be the optimal value of the *bouquet*, $R'_1, R'_2, ..., R'_T$ the sequence of optimal values of the *rente*, and t_0 the smallest value of t such that

[24] This case corresponds to almost all our data.

$S'_{t_0} > 0$ (there are no restrictions on S'_t for $t > t_0$). Then define another contract with $B'' = B'$ and a sequence $R''_1, R''_2, ..., R''_T$, defined by

$$\begin{aligned} R''_t &= R'_t \text{ if } t < t_0, \\ R''_{t_0} &= R'_{t_0} - S'_{t_0} \text{ if } t = t_0, \\ R''_{t_0+1} &= R'_{t_0+1} + (1+r)\frac{\sum_{t'=t_0}^{T} \pi_{t'}}{\sum_{t'=t_0+1}^{T} \pi_{t'}} S'_{t_0} \text{ if } t = t_0 + 1, \\ R''_t &= R'_t \text{ if } t > t_0 + 1. \end{aligned}$$

It is straightforward to check that the participation constraint of the buyer remains satisfied, so the buyer still accepts this alternative contract. The *rente* received by the seller remains the same under the alternative contract except in the years t_0 and $t_0 + 1$. In year t_0 it is reduced by S'_{t_0}, and in year $t_0 + 1$ it is increased by $(1+r)\frac{\sum_{t'=t_0}^{T} \pi_{t'}}{\sum_{t'=t_0+1}^{T} \pi_{t'}} S'_{t_0}$. Since $\frac{\sum_{t'=t_0}^{T} \pi_{t'}}{\sum_{t'=t_0+1}^{T} \pi_{t'}} > 1$, the loss incurred by the seller in t_0 is more than offset by the (actualized) gain in $t_0 + 1$. The buyer is willing to give the seller an interest rate larger than $1 + r$ because the seller may die between t_0 and $t_0 + 1$. But as a consequence the seller is better off with the alternative contract as can be seen by comparing the consumption levels in the two situations

$$\begin{aligned} C''_t &= C'_t \text{ if } t < t_0, \\ C''_{t_0} &= C'_{t_0} \text{ if } t = t_0, \\ C''_{t_0+1} &> C'_{t_0+1} \text{ if } t = t_0 + 1, \\ C''_t &= C'_t \text{ if } t > t_0 + 1. \end{aligned}$$

This shows that the contract $(B', R'_1, ..., R'_T)$ with savings S'_{t_0} is not optimal. Since the amount S'_{t_0} and the date t_0 are arbitrarily chose, it is optimal never to save at equilibrium.

• The second step consists in showing that at the optimum the *rente* does not vary with time. Using that $S_t = 0$ and substituting C_t in equation (11), the seller's expected utility function becomes

$$u(B - D + W) + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} u(R'_t) + \mu D \tag{13}$$

which is to be maximized with respect to B, D, and R_1, ..., R_T, subject to $B - D + W \geq 0$, $R_t \geq 0$, the positivity constraints on the choice variables, and the participation constraint (12). Taking into account only the participation constraint, the Lagrangian $\mathfrak{L}$ is

$$\mathfrak{L} = u(B - D + W) + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} u(R'_t) + \mu D + \lambda \left(\alpha V - B - \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} R_{t'} \right) \tag{14}$$

where λ is the Lagrange parameter. The first order condition with respect to R_t is

$$u'(R_t) = \lambda,$$

which proves that $R_t^* = R^*$ for all t.

• The third and last step of the proof consists in determining the optimal values B^*, D^* and R^*. Using the fact that the *rente* is time-invariant, the participation constraint is now given by equation (1), which we reproduce here for convenience:

$$\alpha V - B = \frac{1}{r}(1-\alpha) R. \tag{15}$$

The kind of calculations that led to equation (15) can be used to rewrite the expected utility function as

$$u(B - D + W) + \frac{1}{r}(1-\alpha)u(R) + \mu D,$$

which the seller maximizes with respect to B, D, and R, given the positivity constraints on these choice variables and the participation constraint (15). Taking into account only the constraints $D \geq 0$ and (15), the Lagrangian is

$$\mathfrak{L} = u(B - D + W) + \frac{1}{r}(1-\alpha)u(R) + \mu D + \lambda_1 \left(\alpha V - B - \frac{1}{r}(1-\alpha)R\right) + \lambda_2 D, \tag{16}$$

where λ_1 and λ_2 are the Lagrange parameters. The first order conditions are

$$\begin{aligned} u'(B - D + W) &= \lambda_1, \\ u'(B - D + W) &= \mu + \lambda_2, \\ u'(R) &= \lambda_1, \\ \alpha V - B &= \frac{1}{r}(1-\alpha)R, \\ \lambda_2 D &= 0. \end{aligned}$$

The first four equations follow from imposing that the derivative of the Lagrangian with respect to respectively B, D, R and λ_1 equals zero, and the fifth equation is the complementary slackness condition.

- If $\lambda_2 = 0$, it follows from the first order conditions that B^*, D^*, and R^* are given by

$$\begin{aligned} R^* &= u'^{-1}(\mu), \\ B^* &= \alpha V - \frac{1}{r}(1-\alpha)u'^{-1}(\mu), \\ D^* &= \alpha V - \frac{1-\alpha+r}{r}u'^{-1}(\mu) + W. \end{aligned}$$

In this case, B^* increases with α, and R^* is constant.

- If $\lambda_2 > 0$, then $D^* = 0$, and B^*, R^* are given by

$$\begin{aligned} R^* &= \frac{r}{1+r-\alpha}(\alpha V + W), \\ B^* &= R^* - W = \frac{r}{1+r-\alpha}\left(\alpha V - \frac{1}{r}(1-\alpha)W\right). \end{aligned}$$

In this case, both R^* and B^* increase with α.

Note that $D^* > 0$ if and only if $\mu > \underline{\mu}$ where the threshold value is defined by

$$\underline{\mu} = u'\left(\frac{r}{1+r-\alpha}(\alpha V + W)\right). \tag{17}$$

This ends the characterization of the symmetric information equilibrium.■

To obtain the predictions under asymmetric information it is not necessary to formally develop the signaling model and derive the expressions of the contract variables. Indeed, a straightforward argument allows us to obtain the predictions without explicitly modeling the game. To explain the argument, let $(B(\alpha), R(\alpha))$ be the perfect Bayesian equilibrium of the signaling game. Assume that this equilibrium is a separating equilibrium, i.e., sellers with different values of α propose different contract variables. Consider two sellers, characterized by α and α'. Suppose that $B(\alpha) > B(\alpha')$. Then we must necessarily have $R(\alpha) < R(\alpha')$, since otherwise seller α' would strictly prefer contract $(B(\alpha), R(\alpha))$ to contract $(B(\alpha'), R(\alpha'))$. Inversely, suppose that $B(\alpha) < B(\alpha')$. Then necessarily $R(\alpha) > R(\alpha')$ because otherwise seller α would have preferred contract $(B(\alpha'), R(\alpha'))$ instead of $(B(\alpha), R(\alpha))$. At equilibrium one of the contract variables must therefore be decreasing in α, and the other must be increasing in α.

Furthermore, if $B(.)$ was decreasing and $R(.)$ increasing, a seller of type $\alpha' < \alpha$ would have an incentive to lie about his type and pretend to be of type α. Indeed, he would obtain $B(\alpha) + \frac{1-\alpha'}{r}R(\alpha) > \alpha V > \alpha' V$ instead of $\alpha' V$.

Therefore, in an asymmetric information model, a separating equilibrium implies that $B(.)$ is strictly increasing whereas $R(.)$ is strictly decreasing. ■

D Likelihood function

The probability of observing R_i/V_i conditionally on α_i writes:

$$\begin{aligned} l(R_i/V_i; \alpha_i, \theta) = & \int_{-\infty}^{-\beta_0^3-\beta_1^3\alpha_i} \frac{1}{\sigma_2}\phi\left(R_i/V_i - \beta_0^2 - \beta_1^2\left(\frac{1}{1+r-\alpha_i}\right) - \rho_2\varepsilon_{3i}\right)\phi\left(\varepsilon_{3i}\right)d\varepsilon_{3i} \\ & + \int_{-\beta_0^3-\beta_1^3\alpha_i}^{+\infty} \frac{1}{\sigma_1}\phi\left(R_i/V_i - \beta_0^1 - \beta_1^1\left(\frac{1}{1+r-\alpha_i}\right) - \rho_1\varepsilon_{3i}\right)\phi\left(\varepsilon_{3i}\right)d\varepsilon_{3i} \end{aligned}$$

The first term corresponds to the donation regime whereas the second one corresponds to the no donation one. Both terms can be treated separately and similarly. We consider here only the first one that we denote by $l_2(R_i/V_i; \alpha_i, \theta)$. Expanding it and reorganizing the terms, we obtain:

$$
\begin{aligned}
l_2(R_i/V_i;\alpha_i,\theta) &= \frac{1}{2\pi\sigma_2} e^{-\frac{\left(R_i/V_i-\beta_0^2-\beta_1^2\left(\frac{1}{1+r-\alpha_i}\right)\right)^2}{2\sigma_2^2}} \int_{-\infty}^{-\beta_0^3-\beta_1^3\alpha_i} e^{-\frac{1}{2}\left[\left(1+\frac{\rho_2^2}{\sigma_2^2}\right)\varepsilon_{3i}^2-2\frac{\rho_2}{\sigma_2^2}\left(R_i/V_i-\beta_0^2-\beta_1^2\left(\frac{1}{1+r-\alpha_i}\right)\right)\varepsilon_{3i}\right]} d\varepsilon_{3i} \\
&= \frac{1}{2\pi\sigma_2} e^{-\frac{1}{2\sigma_2^2}\left(1-\frac{\rho_2^2}{\rho_2^2+\sigma_2^2}\right)\left(R_i/V_i-\beta_0^2-\beta_1^2\left(\frac{1}{1+r-\alpha_i}\right)\right)^2} \int_{-\infty}^{-\beta_0^3-\beta_1^3\alpha_i} e^{-\frac{\left[\varepsilon_{3i}-\frac{\rho_2}{\sigma_2^2+\rho_2^2}\left(R_i/V_i-\beta_0^2-\beta_1^2\left(\frac{1}{1+r-\alpha_i}\right)\right)\right]^2}{2\sigma_2^2/(\sigma_2^2+\rho_2^2)}} d\varepsilon_{3i} \\
&= \frac{1}{\sqrt{\sigma_2^2+\rho_2^2}} \phi\left(\frac{R_i/V_i-\beta_0^2-\beta_1^2\left(\frac{1}{1+r-\alpha_i}\right)}{\sqrt{\sigma_2^2+\rho_2^2}}\right) \Phi\left(\frac{\beta_0^3+\beta_1^3\alpha_i+\frac{\rho_2}{\sigma_2^2+\rho_2^2}\left(R_i/V_i-\beta_0^2-\beta_1^2\left(\frac{1}{1+r-\alpha_i}\right)\right)}{\sqrt{\sigma_2^2/(\sigma_2^2+\rho_2^2)}}\right)
\end{aligned}
$$