Testing for asymmetric information in the *viager* market*

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Abstract

A *viager* real estate transaction consists in selling a property in return for a down payment and a rent (life annuity) that the buyer has to pay until the seller dies. This paper tests for the presence of asymmetric information in this market. 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 sum of weighted 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 a model for a *viager* sale and derive testable predictions under symmetric and asymmetric information. Our test for asymmetric information consists in regressing the contract parameters (down payment and rent) on the inferred type of the seller, and comparing the estimates with the predicted outcomes. Notarial data are used on transactions in Paris between 1992 and 2001. We test and accept that our no arbitrage condition is empirically satisfied. 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 symmetrically distributed between buyers and sellers is accepted. This highlights that the information about the seller's survival prospects is no longer private when the contract is signed.

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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 regular sums of money (annuity payments) 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 insurers 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

[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."

from it. To compensate for 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 transaction. The mechanism exists in several European countries (Belgium, France, Germany, Italy, Spain), and is known in France as *viager*. Home owners who sell their property via the *viager* method receive in return a down payment from the buyer, and a monthly or yearly rent until the end of their life. Sellers are allowed to remain in their property after the transaction date. They are entitled to stay in their home until death.[2]

A *viager* transaction is basically identical to a life annuity. The rent received by the *viager* seller is the analogue of the annuity payment received by the annuitant. The level of annuity payment and the level of rent are both calculated on the basis of the invested capital. In a life annuity the capital corresponds to the premium paid by the annuitant, and in a *viager* sale it corresponds to the monetary value that remains once the down payment and the usufruct rebatement (the reduction in the market value due to the fact that sellers retain the usufruct of their property) are subtracted from the market value of the property. The *viager* mechanism is 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 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).

A *viager* sale can clearly be attractive for older property owners as they may stay in their own home and earn extra money for the rest of their life. Currently, the French government actively promotes *viager* transactions as a way to increase revenue at old age and reduce the dependency on the social security system. An advisory body of the French government has recently published a detailed report on the subject (see Griffon (2008)). The principle is also quite flexible. For instance, the rent 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 rent; sellers may donate part of the down payment 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. 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

[2]The term *viager* comes from *viage*, which means "time of life" in old French.

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.[3] He died in 1995, 2 years before Mrs Calment, after having paid about FFr900,000 (twice the market value) for an 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.

Our empirical findings, however, do not support such an explanation. The *viager* market is not much affected by the problem of asymmetric information and its possible consequences. We find that the survival distributions of sellers do not correspond to the one of representative individuals in the population. Sellers have information about their own death probabilities. They apparently realize that their personal mortality probabilities may differ from national mortality probabilities.[4] Most importantly, our findings also imply 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 the seller. This can be the case only if the seller is able to transmit the information in a credible way. In particular, and contrary to Jeanne Calment's story, more than half of the contracts are only compatible with the belief that sellers have a shorter life expectancy than the average population. Such a result reflects that mostly poor people resort to a viager sale to finance their retirement.

To derive our results, we use notarial data on sales in Paris and its suburbs. For each transaction we observe the most important contract parameters (down payment and rent), 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 estimate the seller's type. The type of the seller is a sum of weighted death probabilities. This sum can be identified via a no 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

[3]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.

[4]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.

types of markets. As this condition is crucial to the analysis, we test it empirically and find that it is supported by our data.

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 life tables. As mentioned above, the hypothesis that the survival distributions of sellers and comparable individuals from the population are the same is not supported by the data. Sellers have more information about their death probability than just their age and gender. This result is in line with those of Finkelstein and Poterba (2004) in the annuity market.

The fact that the seller's type is identified is then 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 actual negotiations, 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, even after interacting with the sellers. In this case sellers can nevertheless overcome the problem of asymmetric information by signalling their type via the contract parameters (signalling equilibrium).

Basically our test for the presence of asymmetric information consists in regressing the contract parameters on the type of the seller, and comparing the estimates with the predicted outcomes under symmetric and asymmetric information respectively. We develop a model of a *viager* sale in which sellers may wish to donate to children or other family members. It is important that the model allows for this possibility as many sellers do indeed donate part of the down payment. A *viager* sale deprives the seller's heirs of the property as it can no longer be bequeathed. However, sellers can compensate for this loss by donating part of the down payment.

The predictions are the following. Under symmetric information there are two groups of sellers, those who donate money and those who do not. For donators, the down payment is an increasing function of the sum of weighted death probabilities, whereas the rent is invariant with the type of the seller. For sellers who do not donate, both the down payment and the rent increase with the seller's type and at the same rate. On the contrary, under asymmetric information, the down payment increases but the rent decreases with the type of the seller.

These predictions are intuitive. In a symmetric environment, sellers with a relatively short life expectancy can obtain more from their sale: they can demand a higher down payment and a higher rent. When the rent reaches a certain level (which depends on the strength of the

[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.

donation motive), sellers stop asking for an increase in the rent as they prefer to start donating. As sellers use the down payment to donate money, donators ask for an increased down payment. In an asymmetric environment, however, sellers with a short life expectancy cannot signal their type by demanding both a large down payment and a large rent as this would be imitated by sellers with a relatively long life expectancy. They have to credibly signal their type by asking for a large down payment and a small rent. A combination that sellers with better life prospects would find too costly to imitate.

To estimate the symmetric information model, we regress the observed down payment and rent on the inferred type of the sellers. To take into account the equilibrium pattern, we use a switching regression model that endogenously determines whether a seller is a donator or not. We find that the results are fully consistent with the symmetric information predictions. Allowing the rent to increase with the seller's type in both groups, the switching regression finds it to be significantly increasing only in the group of those who donate. Moreover, the down payment increases with the seller's type, and at the same rate as the rent in the no-donators group.

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, 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)). Since our model accounts for the possibility that agents donate money to family members, our paper is also related to 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 no arbitrage condition, shows how the condition can be used to recover the seller's type, and tests the hypothesis that *viager* sellers have the same survival distribution as representative individuals from the population. Section 4 presents the model and the predictions, and the empirical test for the presence of asymmetric information. Section 5 concludes.

2 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,[6] 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

[6]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.

between opponents and proponents of the *viager* principle,[7] but the commission finally decided 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 down payment (*bouquet* in French) the buyer has to make at the date of signature, and the rent (*rente*) which 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 rent 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,[8] 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 down payment and rent).

There are no legal restrictions on how the down payment and rent 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 rent 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 down payment is influenced by several factors. As the down payment 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 down payment generally varies between 20 and 30% of the price (Griffon (2008)), but can sometimes exceed 60% of the value (Le Court (2006)). Variations in

[7] 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 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.

[8] 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).

the down payment 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 down payment, while a seller with no immediate need for money may ask for a lower one. Finally, the down payment may be influenced by the amount 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 down payment, and vice versa.

The height of the rent 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 rent. If the contract involves multiple beneficiaries, the age and gender of the person(s) designated by the seller should affect the rent 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 rent also depends on whether the seller retains the usufruct of the property. Keeping everything else fixed, it should be lower when the seller retains the usufruct since in this case the property is less worth to the buyer. Yet another determinant of the rent is the height of the down payment itself. If the down payment is relatively large (resp. small) the "remaining value" of the property is small (resp. large) and consequently the rent should be relatively small (resp. large). Hence, fixing all other things, the two parameters are negatively correlated.

Besides the down payment and rent, *viager* contracts may specify a number of additional sale conditions. Practically all contracts explicitly indicate that the rent should be indexed to a consumer price index. This guarantees that the seller's real income does not fluctuate over time.[9] 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 rent. 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 rent 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 rent 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

[9]In principle any price index may be chosen but nowadays most contracts stipulate that the rent should be indexed to the consumer price index published by the *Institut national de la statistique et des études économiques* (*Insee*), the national institute of statistics (Artaz (2005), page 138). Le Court (2006) gives historical examples of sales where the rent 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 rent 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.

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 with the fact that their parents had sold their property.[10] 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 down payment, the rent (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.[11] We also delete extreme values from the data, i.e., observations such

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

[11] Consequently, we had to exclude sales where the contract specifies that there are multiple beneficiaries since

that the relative bouquet and/or relative rent (down payment and rent divided by the market value) were above the mean plus three times the standard error. We hereby obtain a sample of 874 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
Down payment	33.96	39.53	0.00	6.10	11.43	22.87	42.69	73.18	381.12
Rent	6.84	5.42	0.00	2.01	3.66	5.49	8.96	12.81	71.81
Relative down payment	31.05	18.59	0.00	10.20	16.23	28.00	42.55	58.26	84.91
Relative rent	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 market value of around 104,000€ its size is about 60 square meters, and it has three rooms. The average down payment in the sample is approximately 34,000€, and the average rent per year is nearly 7,000€. The relative down payment is on average around 31% while the relative rent 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 record all possible contract terms. We do not observe what particular price index is used. However, 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 unlikely to be 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 is expected to be negligible.

Figure 1 shows all values of the relative down payment and rent in the sample. Although these observations take into account the variations in the market values of the properties (down payment and rent are divided by market value), the figure shows that there is still a huge amount of heterogeneity left in the data. 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 down payment whereas others prefer a small 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 down payment on the relative rent. This pattern is reinforced in regression (II) where we also control for the seller's age and gender. The relative rent still has a negative sign and is significant. The negative correlation between the relative contract parameters is not surprising.

only the gender of the first beneficiary is specified, and the ages of the additional beneficiaries are often missing.

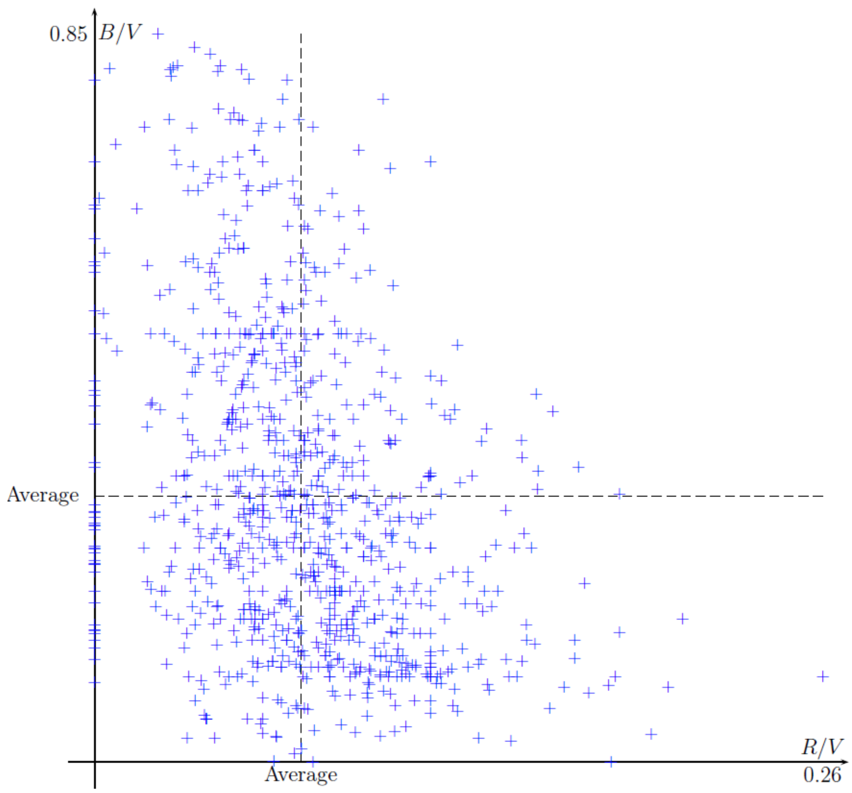

Figure 1: *Viager* contracts (relative down payment and rent)

Keeping all other things fixed, when the relative rent increases, the relative down payment should decrease as the expected total amount paid by the buyer should remain the same. The other coefficients also have the expected signs and are significant. For a given rent, older sellers and men obtain a larger down payment as they have a shorter life expectancy.

Table 2: Relationship between the relative down payment and relative rent

	(I)	(II)
Relative rent	-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%

The seller's age and gender are variables that 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 down payment and higher rent. To check this prediction, we regress separately the relative down payment and rent 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 rent 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 down payment and rent

	B/V	R/V
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: $\dagger$: 10% $*$: 5% $**$: 1%

3 Recovering the type of the seller

The first part of this section presents and tests the no arbitrage condition on which most of the analysis relies. This condition states that buyers should be indifferent between buying a given property on the standard market or the *viager* market. 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 down payment, R the annual *viager* rent, and V the market value of the property at the date of sale. Let π_t be the true probability that the seller dies exactly t years after signing the contract, $t = 0, 1, ..., T$, with $\Sigma_{t=0}^{T}\pi_t = 1$. Let δ be the discount factor and r the associated rate such that $\delta = 1/(1 + r)$. Finally, let L represent the annual amount of money that must be paid by a tenant to rent a property of value V. It corresponds to the yearly income received by the owner if the property is put on the rental market. We assume that $V = \sum_{t=1}^{\infty} \delta^t L$, which implies that $L = \frac{1-\delta}{\delta} V = rV$.

In case the property is purchased on the standard market, the price that must be paid by the buyer is V. In case it is purchased on the *viager* market, the buyer should pay: first, the down payment B when the contract is signed, i.e., at the beginning of year $t = 0$. Second, the rent R at the beginning of each of the following years $t = 1, 2, \ldots$ Moreover, the buyer cannot collect the rental value L since the seller retains the usufruct of the property. 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.[12] The discounted cost of buying the property on the *viager* market thus equals $B+\sum_{t'=1}^{t}\delta^{t'}(R+L)$ and the expected discounted cost is $B+\sum_{t=1}^{T}\pi_t\sum_{t'=1}^{t}\delta^{t'}(R+L)$. If buyers and sellers were indifferent between transacting on either markets, the value V should equalize the expected discounted cost, which gives the following no arbitrage condition:

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

This equation is central in our analysis. In practice, however, one might wonder if this equation is likely to be satisfied. Several reasons suggest that the transaction price in the viager market should be lower than on the regular housing market. This would be the case with risk averse buyers. Indeed, the *viager* purchase is riskier to the buyer than a standard purchase contract, thereby reducing the price buyers wish to pay. The risk takes the form of the uncertainty surrounding the total price buyers will end paying. The alternative for sellers is to sell on the standard market, then keep B, use $V-B$ to buy an annuity from an insurance company and find another apartment to rent. This involves more transaction costs than a *viager* sale. Moreover, sellers do not want to leave their apartment and there would be a utility loss if they had to move. If the outside option of the seller is not V, he might not be able to extract V from the viager sale. This would also be the case with distressed sellers who are willing to transact at lower than normal prices to get access to liquidity quickly. On the contrary, several reasons might also suggest that the transaction price in the viager market should be higher than on the regular housing market. First, recall that *viager* buyers, in general, do not intent to live in their properties. It is primarily a way for them to invest in the real estate market. Hence, if buyers fear that renters will not take sufficient care of the property,[13] they might prefer a *viager* sale. Sellers are indeed sentimentally attached to their property (which is one reason why they use the mechanism) and are thus expected to take better care of the property than ordinary tenants. Buyers also avoid several financial costs. In particular, they do not need to borrow the full amount V from a bank. A *viager* can be seen, by itself, as a loan and buyers should be ready to pay for this service. As a *viager* sale amounts to a lottery, it can attract buyers who are risk lovers and ready to pay a premium for it. Finally, transaction costs and taxes differ slightly in both markets which could also explain that the no arbitrage condition may not hold exactly.

To summarize, there are reasons to believe that V is smaller than the right hand side of the above equation, but also reasons why it may be larger. On balance, we may expect that the total bias is negligible. Moreover the no arbitrage condition should act as a reference point and the deviations should be small. Indeed, if there were important deviation from the no arbitrage condition, investments firms would enter these markets to rip the associated profits. Finally, values V mentioned in the contracts are agreed upon by both sellers and buyers and reflect as much the true value of the transaction than the market price. Hence, we believe that the no arbitrage assumption should be satisfied in our data. To confirm this feeling, we formally test and accept our condition.

[12] Both L and R are assumed to be indexed to the same consumer price index, and hence we can ignore inflation in the analysis.

[13] The reason for this is that the long run costs of some actions (putting holes in the walls, etc.) are not fully internalized by the renter.

Before presenting our test, however, it is useful to reformulate the condition. Letting $\alpha = \sum_{t=0}^{T} \pi_t \delta^t$ denote the sum of weighted death probabilities of the seller (which can be interpreted as the expected present value of one € received upon the death of the seller), it can be rewritten as (proof in Appendix A):

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

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 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 information about the survival prospects of the seller, and can therefore be viewed as the seller's type. 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 is the property 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 net value of the property equals the down payment B plus the rent 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 rent. Indeed, once the down payment is paid, the buyer still has to pay a remaining capital $\alpha V - B$ to the seller. This capital is converted into a rent 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 rent during X years. In this case we have: $V = B + XR$.

It is also worth mentioning that, in practice, V, B, and R are constrained by an equation very similar to (1) where the type α of the seller is the crucial element. Indeed, as mentioned in Section 2.1, even if 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

[14] Formally, if the distribution of death time 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 $t = X$.

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.

Equation 1 is the key element of our testing strategy. Rewriting it, we get

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

Hence, for a given value of r, the relative contract parameters allow us to recover the type of the seller on which the parties agreed. In the remainder of the paper we take $r = 0.05$.[17] Let H_0 be the hypothesis that the no arbitrage condition is satisfied. Under H_0, the recovered α should summarize all the relevant information about the sellers. In particular, under H_0, age and gender should not play any role once α is known. To test this critical assumption, we regress the relative down payment and rent on powers of α, age, and gender as a way to measure the effect of age and gender, conditionally on α. Table 4 displays the results.[18] First, the relative down payment and rent are regressed on age and gender only (Columns I). Then we add different powers of α to the specifications (Columns II to IV).

Table 4: Effect of age and gender on the relative down payment and rent conditionally on α

	B/V (I)	R/V (I)	B/V (II)	R/V (II)	B/V (III)	R/V (III)	B/V (IV)	R/V (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 are no longer significant. Such a pattern is consistent with the assumption that α captures all the relevant information about the seller's type. Hence, we accept H_0, i.e., the no arbitrage condition is satisfied.

One can still wonder if the test is powerful enough and if this pattern would also be found under H_a that the no arbitrage condition is not satisfied. To answer this point, suppose that the

[17] Our value of r is close to the value chosen in other studies. In Keane and Wolpin (1997) $r = 0.064$, in Carneiro, Hansen, and Heckman (2003) $r = 0.03$, and in Aguirregabiria and Mira (2007) $r = 0.053$. All results reported in the paper are robust to variations in r. They remain stable for values of r varying between 0.03 and 0.07.

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

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. The variable ε is an error term that captures, for example, that either the buyer or seller has some bargaining power (the error term could also result from measurement errors in the contract parameters). When ε increases, both the down payment and the rent decrease: the buyer is, somehow, successful in the bargaining and reduces the amounts of money that should be paid 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. However, in the presence of such spurious correlation, α would no longer capture all the relevant information and the results of Table 4 would not hold. In this case age and gender would be correlated with $\frac{r\varepsilon}{rV+R}$, and consequently they would still be significant in the regressions. H_0 should thus be rejected.

To corroborate this idea, we perform the following simulation exercise. 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 deviation σ. This process generates a new variable denoted $\widetilde{\alpha}_\sigma$, which can be interpreted as a contaminated measure of the type. When σ increases the noise is more important and one expects age and gender to become significant when regressing the relative down payment (or relative rent) on age and gender conditionally on $\widetilde{\alpha}_\sigma$. Table 5 reports the results of this simulation study for several values of σ (0, 1000, 5000, and 10000). Recall that the average property value is around €100,000. The order of magnitude of the noise is therefore 0%, 1%, 5%, and 10%, respectively. When there is relatively few noise ($\sigma = 1000$), age and gender are not significant and H_0 is accepted. However, these variables tend to become significant when there is more noise ($\sigma = 5000$ or $\sigma = 10000$), rejecting the null hypothesis that the no arbitrage condition is satisfied. These results prove that our test has some power and is able to reject the no arbitrage condition when violated sufficiently.

Table 5: Effect of age and gender on the relative down payment and rent conditionally on α

	B/V	R/V	B/V	R/V	B/V	R/V	B/V	R/V
	σ =0	σ =0	σ =1000	σ =1000	σ =5000	σ =5000	σ =10000	σ =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%

To conclude, even if not exactly true, the order of magnitude of the errors is less than 5%. Hence, we accept empirically that the no arbitrage condition is (almost) satisfied and will base the rest of our paper on it.

3.2 Estimation of the seller's type

As explained previously, equation 2 allows us to recover the type of the seller on which the parties agreed.

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

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 to obtain better contract terms. Table 6 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. It is worth noting that, empirically, small variations in V have small impacts on α ($\partial\alpha/\partial V = -\alpha/(V + R/r) \approx 4.10^{-6}\alpha$). Hence, even if the no arbitrage condition is not exactly satisfied, the results presented in this section would be very similar.

Table 6: 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 $\alpha_{Insee} = \sum_{t=0}^{T} \pi_{Insee,t}\delta^t$, 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 in the expression of α_{Insee}). For each seller i (of a given age, gender, and cohort) we thus observe α_i, the type of this seller, and α_{Insee}, the corresponding national-level type of a representative individual (of the same age, gender, and cohort).

Table 7 compares the results of the linear regressions of respectively α_{Insee} and α, on age and gender. As expected, both α_{Insee} and α are higher when the seller is male and relatively old. In the population, men and older people 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, these variables are imperfect predictors of α. Furthermore, the coefficients are three times smaller than in the regression equation of α_{Insee}.

Figure 2a and 2b show the empirical density functions of α_{Insee} and α, as well as the empirical densities of the associated life expectancies.[19] The shape of the density functions are clearly not

[19]For a given gender, there is a one to one decreasing relationship between α and the life expectancy.

Table 7: 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% $\quad$ ∗ : 5% $\quad$ ∗∗ : 1%

in line with the predicted outcome in a pure Akerlof world. Indeed, if buyers and sellers were asymmetrically informed about α, and if in addition the latter were unable to signal their type to the former, an unraveling process à la Akerlof would take place, and only sellers with very long life expectancies (i.e., with a very low α) would be able to sell their property on the *viager* market. The estimated density functions show instead that there is much heterogeneity in the types of the sellers. The market is not just made up of the highest-risk sellers. On the contrary, Figure 2a shows that most sellers in our sample have a better type than comparable individuals in the population. This may reflect the fact that *viager* sellers are relatively poorer than comparable individuals in the population, and thus have relatively shorter expected survival times as shown in Figure 2b (see Cutler, Deaton, and Lleras-Muney (2006) for documentation of a positive relationship between income and health even within countries). It is consistent with the idea that the sample of *viager* sellers is a selective sample of the population made up of people who recur to the *viager* mechanism to alleviate their lack of financial ressources.

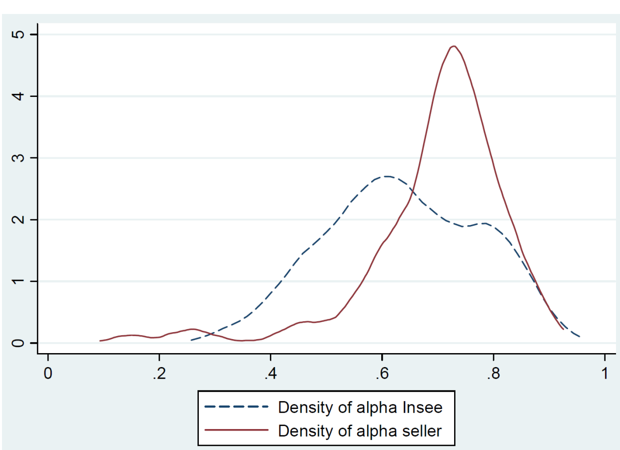

Figure 2a: Densities of α_{Insee} and α

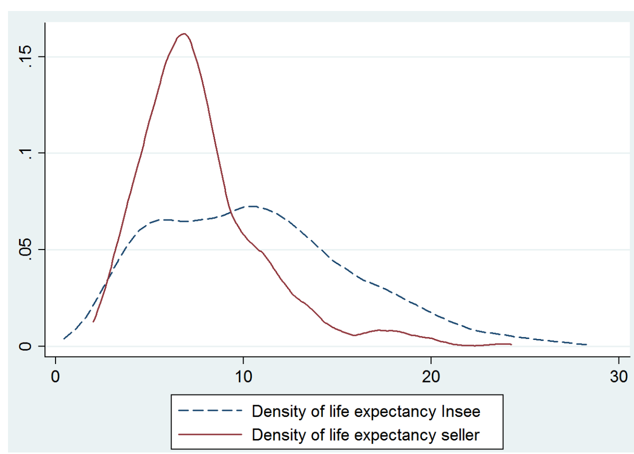

Figure 2b: Densities of life expectancies

Another way to address this point is to compare the market price V mentioned in the contract versus the implied sales price using the down payment and the rent. If we suppose that there is no selection and use α_{Insee} instead of α, we can compute:

$$V_{Insee} = \frac{B + (1 - \alpha_{Insee})R/r}{\alpha_{Insee}}$$

V_{Insee} thus represents the amount that a buyer would expect to pay if the seller has the same survival prospects as the representative seller. Without selection issues, we should observe that both values coincide. Table 8 reports on the contrary that V_{Insee} is, on average, 30% greater than V, in line with the idea that *viager* sellers have a shorter life expectancy than the average population given their age and gender.

Table 8: Summary statistics for V and $V_{Insee}(N = 874)$

variable	mean	sd	min	p5	p10	p25	p50	p75	p90	p95	max
V	103.9	77.6	13.0	30.5	41.2	54.9	83.8	122.0	198.2	254.6	655.5
V_{Insee}	135.1	108.9	7.6	33.3	44.8	67.4	106.2	166.0	254.8	324.0	914.2

Since the seller-specific types and the national-level types are not the same (Figure 2a), the underlying death probabilities and survival functions 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 transmit their personal information about their type to the buyers. Indeed, as shown in Table 8, buyers accept contracts in which they pay 30% more relatively to what they would have paid had sellers been agents with average life expectancies. This difference is too large to be explained by lower transaction cost advantages in the *viager* market. The most reasonable explanation is that buyers do have information about the true life expectancy of the sellers. Sellers can reveal their information before the actual negotiations start (buyers visit the properties, physically meet sellers, may possibly see medical records), or they can signal their type through the contract parameters. The first case corresponds to a symmetric information setting, and the second to an asymmetric information setting. Section 4 develops an empirical test to decide which informational environment explains the data in the best way. Basically the test consists in regressing the contract parameters on the inferred type of the sellers. A key feature of Section 4 is the exogeneity of the seller's type (in a regression of either B/V or R/V on α). Yet, the type α is constructed using (2), i.e., as a function of the observed down payment and rent. If the relationship does not exactly hold the inferred type may be spuriously correlated with the contract terms, which results in α being endogenous. The following subsection shows that this is not the case.

3.3 Exogeneity of α

The fact that the seller's type is a function of the down payment and rent does not necessarily mean that α is endogenous (in the regression equation of one of the contract parameters on a constant and α). Indeed, a function of endogenous variables can be exogenous. To illustrate this point, suppose we are interested in the link between price per square meter of an apartment and its size. To study this link, the two following variables are observed: the price per square meter (P), and the market value (V). The missing variable, the apartment's size (S), can be obtained by dividing the latter by the former ($S = V/P$). If the equation that relates the three variables is exact, there is no reason to believe that S is endogenous, and one could regress the price per square meter on a constant and the inferred variable S (i.e., estimate the model $P = \beta_0 + \beta_1 V/P + \varepsilon$) 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 apartment's size, the price, and the price per square meter. The type α is an intrinsic characteristic of the sellers and is thus a structural exogenous parameter of the problem (as size in the previous example). However, the exogeneity of α relies on the assumption that equation (1) is satisfied exactly. If this is not the case, the inferred α is only an estimate of the true parameter and endogeneity can be a problem.

The endogeneity issue is thus strongly related to the validity of the no arbitrage condition. As explained previously, if the true no arbitrage equation takes the form

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

there is a positive spurious correlation between α and R which creates an endogeneity problem. However, α would no longer capture all the relevant information about the death probability and the results of Table 4 would not hold. The fact that age and gender are not significant is reassuring, and suggests that endogeneity, if present, is not that important. Our previous results are compatible with our hypothesis that the no arbitrage condition identifies the seller's type and that α can be seen as exogenous.

Further evidence in support of our hypothesis is given in Appendix B where four additional sets of regressions results are reported (see Tables 11 to 14). Table 14 for instance presents the results of regressions of the relative contract parameters on age, gender, and β, where β is defined by $V = B + \frac{1-\beta}{r} R$. The resulting parameter β is a somewhat arbitrary function of B/V and R/V and differs from the seller's type α. Therefore β has no reason to be exogenous and we expect that age and gender remain significant, even after additional powers of β are added as explanatory variables. Table 14 confirms this intuition. Tables 11 to 13 report similar estimation results but for yet other specifications of β. Again, age and gender remain significant even when additional powers of β are included in the models. Apparently the parameters β do not capture the information contained in age and gender, which suggests that they are poor estimates of the seller's type. This is reassuring because in each of the four sets of regressions we defined the βs as an ad hoc function of the contract parameters. On the contrary, α, which is defined via an equation with economic foundation, does capture the information contained in age and gender. As already mentioned, this supports the idea that α corresponds to the type of the seller and is exogenous.

4 Testing for asymmetric information

The main conclusion of Section 3.2 is that sellers have personal information about their survival prospects through their type α. The question that still remains open is how sellers transmit this information to buyers. One possibility is that buyers obtain the information when they get into contact with sellers and see 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, the first subsection proposes a model for a *viager* transaction. From the model we obtain predictions on the links between the contract parameters and the seller's type that should prevail under the two information settings. The second subsection confronts the predictions and the outcomes in the data.

4.1 Model

The details of the model are fully explained in Appendix C. The seller is assumed to be risk averse and maximizes (under the usual budget constraints and (1)) the following expected 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 the consumption level in year t. The variable $D \geq 0$ represents the amount of money the seller wishes to donate to family members, other heirs, or charities. A *viager* sale allows sellers to recover a portion of their wealth via the down payment. Sellers may wish to donate part of the down payment to their children for instance and have the satisfaction of helping them at a point in time where they need it most (sellers tend to sell their properties around the age of 75–see Table 1–when their children are mostly around 45; children are probably more in need of money at this age than at the death of the parent, on average fifteen years later). The intensity of the donation motive is captured by the parameter μ which represents the marginal utility of giving.[20] We model the donation motive exactly like the bequest motive in the literature on the saving and bequest behavior of the elderly (see (Hurd, 1987, 1989) and Kopczuk and Lupton (2007)). In this literature D corresponds to the amount of money bequeathed at the moment of the death of the agent.

We assume that the sum of death probabilities α is potentially the only source of asymmetric information between buyers and sellers. Both parties are thus assumed to be symmetrically informed about all other parameters in the model (in particular μ). Under asymmetric information about α, 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.[21] 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 down payment and the rent are positive.[22]

Proposition 1. *(i) The down payment increases with μ whereas the rent decreases with this parameter.*

(ii) If information about the seller's type, α, is symmetric, there is a threshold value $\underline{\mu} = u'\left(\frac{r}{1+r-\alpha}(\alpha V + W)\right)$ (where W is the initial net wealth of the seller, i.e., the wealth in year $t = 0$) such that:

- *If $\mu \leq \underline{\mu}$, the donation motive is too weak and $D^* = 0$. The equilibrium values of the down payment and the rent reflect the desire to smooth consumption (the consumption level is the same in each year): $B^* + W = R^* = -rV + \frac{r(1+r)V+rW}{1+r-\alpha}$. Both B^* and R^* increase with α and V at the same rate.*

- *If $\mu > \underline{\mu}$, the donation motive is strong enough and $D^* > 0$. The rent is independent of α and V: $R^* = u'^{-1}(\mu)$. The down payment 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) If information about the seller's type is asymmetric, then the equilibrium down payment is increasing while the rent is decreasing with α.

The proof is in Appendix C. In this simple model, the equilibrium values B^*, D^*, and R^* are always such that sellers smooth their consumption over all dates.[23] The parameter μ has an unambiguous effect. If sellers have a higher marginal valuation for donations, they are more likely to give some money and choose a *viager* contract with a higher down payment and consequently a smaller rent.

[20] The amount of money D and the associated utility parameter μ can also be interpreted in other ways. For example, μ could capture the psychological need of a seller to keep some money. Sellers may be afraid of dying young and fear that they leave too much of their wealth to buyers. Keeping some amount D aside is a kind of insurance against this risk. Sellers may also believe that they have more control over their financial future by holding wealth rather than by receiving regular sums of income via the rent.

[21] 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).

[22] This allow us to avoid discussing corner solutions. In our data set, $B = 0$ once and $R = 0$ 33 times out of 874 sales.

[23] In periods $t \geq 1$ they consume R^*, and in $t = 0$ the consumption level is $B^* - D^* + W$. It is easy to check that in both cases (μ smaller and larger than the threshold value) we have $B^* - D^* + W = R^*$.

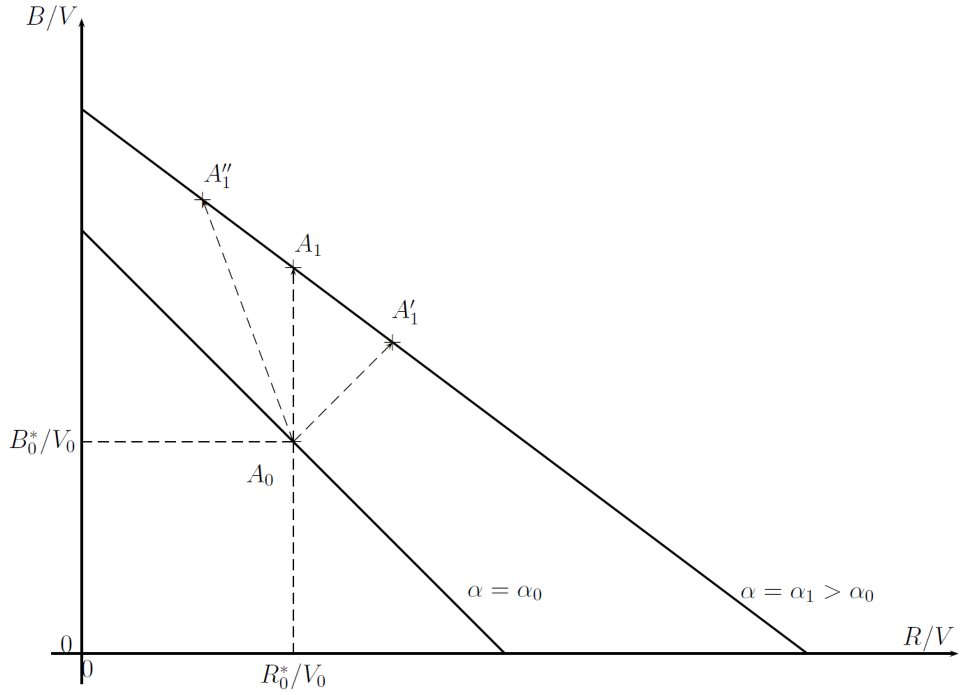

Figure 3: The effect of a variation of α on equilibrium

Figure 3 helps visualizing the effect of a change of α on the equilibrium values. Let us start from the equilibrium point A_0, and assume that α increases from α_0 to α_1 (everything else remaining constant). Note that A_0 is therefore located on the straight line defined by the no arbitrage condition (1) with $\alpha = \alpha_0$). Under symmetric information there are two possibilities depending on the specific value of μ. First, if μ is such that $D^* = 0$, then the equilibrium moves to A_1', a point located on the line defined by (1) with $\alpha = \alpha_1$: both B^* and R^* increase and they increase at the same rate. Second, if μ is large enough such that $D^* > 0$, then the new equilibrium adjusts to A_1: the rent remains constant and only the down payment increases (the donation increases at the same rate as the down payment). Under asymmetric information the consequence of the increase in α is that the equilibrium shifts from A_0 to A_1''. That is, to a larger down payment but a smaller rent.

The proposition also helps us to understand what the data should show under the two information settings. Under symmetric information we should first of all observe that the down payment exceeds the rent if the seller decides to donate money, or if the seller had debts in the period before the sale ($W < 0$). Second, and crucially for our test, the down payment should be an increasing function of the sum of weighted death probabilities α for all values of μ. The rent should be increasing in α only for values of μ below the threshold $\underline{\mu}$ (and at the same rate as the down payment), but constant for values above the threshold. Under asymmetric information we should observe that the down payment (resp. rent) increases (resp. decreases) with α for sellers to be able to signal their type. If on the contrary both variables were increasing in α, all sellers would have an incentive to lie about their type and benefit from both a larger down payment and a larger rent. By requiring a smaller rent, *viager* sellers with a short life expectancy are able to signal their type. As sellers with a longer life expectancy need to smooth their consumption, it is too costly for them to match this contract and such sellers would prefer a contract with a higher rent.

4.2 Empirical tests

The basic idea of the empirical test consists in studying the shape of the down payment and rent when α changes. It is important to note that in our regressions we do not need to condition on observable variables, as is usually done in the literature on tests for the presence of asymmetric information. The reason is that α contains all the relevant information, other variables playing no role in the choice of the contracts terms. In a test *à la* Chiappori-Salanié, it would be necessary to condition on age and gender, for example, before looking at the correlation between the down payment and α or between the rent and α. We however follow a different approach. In our test, we directly study the impact of the death probabilities on both the down payment and the rent. Here again, the exogeneity assumption on α is crucial (see Section 3.3).

Proposition 1 shows that there are two regimes for R^* depending on whether D^* is positive or equal to zero. We do not observe D_i^* in the data so we do not observe in which regime R_i^* falls. We do know however that $D_i^* > 0$ if and only if $\mu_i > \underline{\mu}_i$. The condition $\mu_i > \underline{\mu}_i$ is equivalent to the condition $\alpha_i > \underline{\alpha}_i = ((1+r)u'^{-1}(\mu_i) - rW_i) / (rV_i + u'^{-1}(\mu_i))$. Treating μ_i, V_i and W_i as random variables, the condition $\alpha_i > \underline{\alpha}_i$ can be rewritten as $\underline{\alpha_i} - \alpha_i = \tilde{\beta}_0^3 + \tilde{\beta}_1^3 \alpha_i + \tilde{\varepsilon}_{3i} < 0$. In this expression the constant $\tilde{\beta}_0^3$ equals $E[\underline{\alpha_i}]$ (the expectation of $\underline{\alpha_i}$), $\tilde{\beta}_1^3$ equals -1, and $\tilde{\varepsilon}_{3i}$ is an error term with mean zero. Dividing by the standard deviation of $\tilde{\varepsilon}_{3i}$, the condition $\alpha_i > \underline{\alpha}_i$ can be written as $\beta_0^3 + \beta_1^3 \alpha_i + \varepsilon_{3i} < 0$, where β_0^3 (resp. β_1^3) equals $\tilde{\beta}_0^3$ (resp. $\tilde{\beta}_1^3$) divided by the standard deviation of $\tilde{\varepsilon}_{3i}$, and ε_{3i} is an error term with mean zero and variance 1. If $\alpha_i > \underline{\alpha}_i$ then $R_i/V_i = u'^{-1}(\mu_i)/V_i$, which can be rewritten as $\beta_0^2 + \beta_1^2 \left(\frac{1}{1+r-\alpha_i}\right) + \varepsilon_{2i}$, where $\beta_0^2 = E[u'^{-1}(\mu_i)/V_i]$, $\beta_1^2 = 0$ (since R_i should not vary with α_i in the donation regime, β_1^2 should equal zero when multiplied by any function of α_i), and ε_{2i} is an error term with mean zero and variance σ_2^2. We can in the same way write down the specification of R_i/V_i in the no donation regime (i.e., when $\alpha_i < \underline{\alpha}_i$). We can therefore write down the model for R_i/V_i as the following switching regression model:

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

where the parameters β_0^1 and β_1^1 can be defined analogously as the other parameters, and the error term ε_{1i} has mean zero and variance σ_1^2. We assume that ε_{ki} ($k = 1, 2, 3$) is normally distributed. We furthermore assume that W_i/V_i and $u^{-1}(\mu_i)/V_i$ are independent of each other and independent of α_i. Under these assumptions, the error terms are orthogonal to α_i. Moreover, ε_{1i} and ε_{2i} are independent. However, the model implies that ε_{3i} is correlated with ε_{1i} and ε_{2i}. We therefore have that ε_{3i} follows a normal distribution $\mathcal{N}(0,1)$, and 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, the contribution of each observation to the likelihood is constituted of two terms. The precise form of the contribution to the likelihood is given in Appendix D. According to Proposition 1, we expect that under symmetric information we have $\beta_1^1 > 0$ (in the absence of donation, the rent increases with α), $\beta_1^2 = 0$ (in the presence of donation, the rent is independent of α), and $\beta_1^3 < 0$ (the no donation regime is more likely to occur when α is small). Under asymmetric information the rent should decrease so we expect in this case that $\beta_1^1 < 0$ and $\beta_1^2 < 0$.

The results of the switching regression model (4) are shown in Table 9. They are completely in line with the symmetric information predictions: β_1^1 is positive and significative, and β_1^2 is not statistically different from zero. Finally, β_1^3 is negative and significant, indicating that sellers with high life expectancies are less likely to donate. The predictions of the asymmetric model are rejected as the rent does not decrease with α_i in either regime.

Table 9: Switching regression of the rent on α

	$100(R^*/V)$		y_i
	Regime 1 ($D^* = 0$)	Regime 2 ($D^* > 0$)	Switching reg.
$1/(1+r-\alpha)$	7.0789**	-0.1145	
	(0.2438)	(0.1686)	
α			-13.0916**
			(1.0911)
Constant	-10.1880**	9.4410**	9.0075**
	(0.5772)	(0.6600)	(0.8244)
N	830	830	830

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

Contracts with $R_i = 0$ or $B_i = 0$ are excluded. Log likelihood = -1904.0724

A similar switching regression can be defined and estimated for the relative down payment B/V. However, instead of writing this second regression in terms of B/V, it is more convenient to write it in terms of the difference $B/V - R/V$:

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

where ξ_{ki} ($k = 1, 2, 3$) is assumed to follow a normal distribution. Analogously to the error terms in the switching regression model for R_i/V_i, ξ_{1i} and ξ_{2i} are independent but both are correlated with ξ_{3i}. According to Proposition 1, we expect $\gamma_1^1 = 0$ (when there is no donation, the down payment and rent increase with α at the same rate so their difference is constant), $\gamma_1^2 > 0$ (when there is a donation, the rent is independent of α while the down payment increases in the type), and $\gamma_1^3 < 0$ (sellers with small α are less likely to donate). Under asymmetric information we expect $\gamma_1^1 > 0$ and $\gamma_1^2 > 0$ (the down payment increases and the rent decreases with α).

The results of the switching regression (5) are shown in Table 10. They are, again, fully in line with the symmetric model predictions: γ_1^1 is not significantly different from zero, γ_1^2 is significantly positive, and γ_1^3 is significantly negative. These results corroborate the ones of

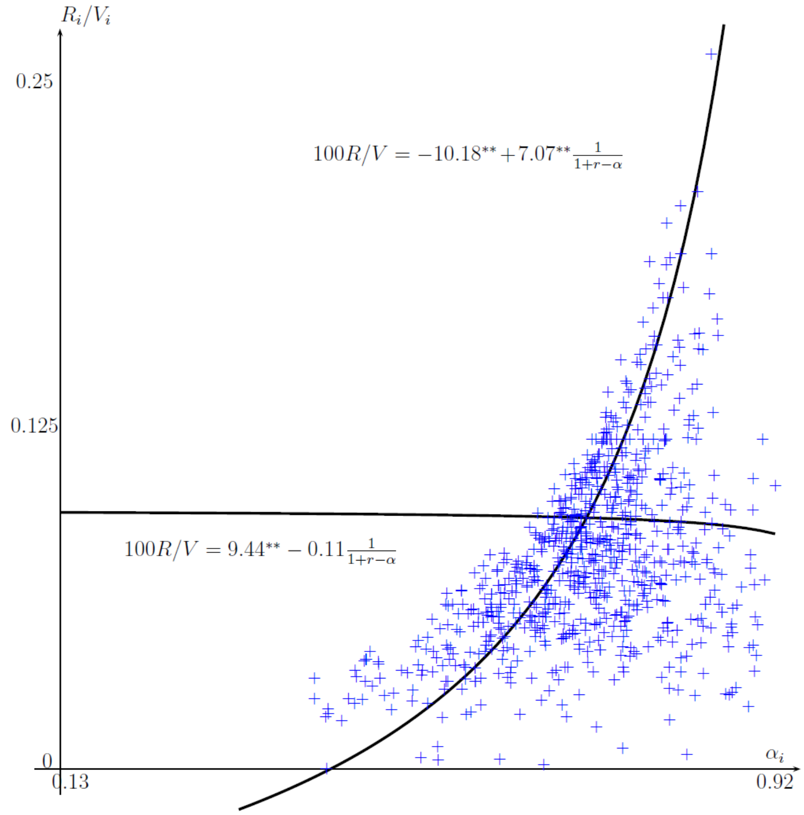

Figure 4: R/V as a function of α

Table 9. As the down payment and the rent are linked through equation (1), this does not come as a surprise. However, the fact that the implications of Table 9 and Table 10 are the same is reassuring.

Table 10: Switching regression of the down payment on α

	$100(B^*/V - R^*/V)$		z_i
	Regime 1 ($D^* = 0$)	Regime 2 ($D^* > 0$)	Switching reg.
α	2.4785	230.9328**	-15.4699**
	(10.8149)	(39.4322)	(2.2811)
Constant	13.2584*	-139.51**	12.3717**
	(6.8042)	(35.1617)	(1.8658)
N	830	830	830

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

Contracts with $R_i = 0$ or $B_i = 0$ are excluded. Log likelihood = -3429.3405

Figure 4 plots, α_i against R_i/V_i and its fitted value, and Figure 5 does the same for the difference $B_i/V_i - R_i/V_i$. In Figure 4, the fitted values correspond to the ones obtained from the switching regression (see Table 9) of R_i/V_i on $\frac{1}{1+r-\alpha_i}$ and a constant. In Figure 5, 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 10). Both figures illustrate that the symmetric model fits the data

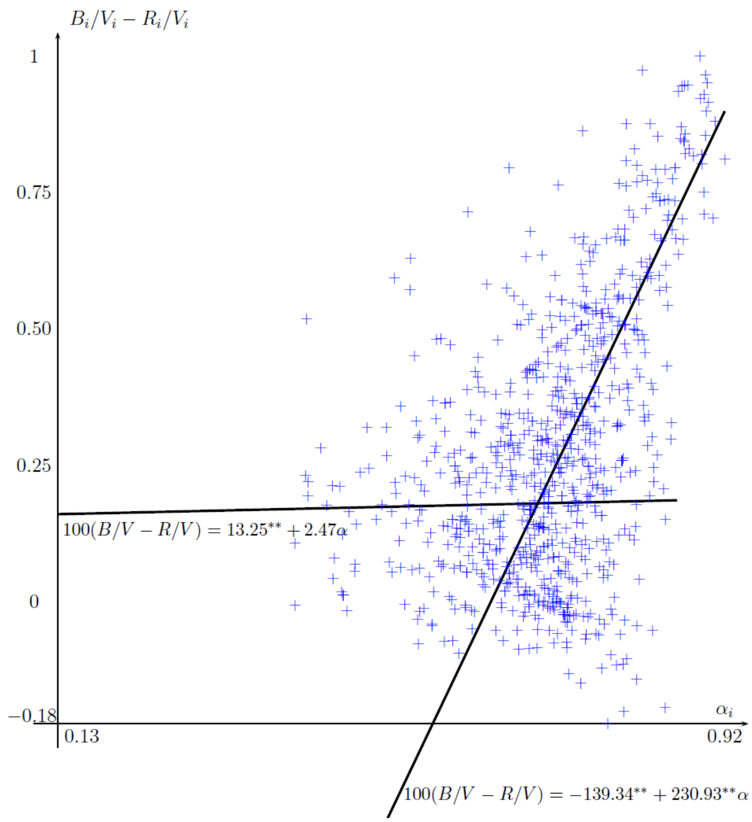

Figure 5: $B/V - R/V$ as a function of α

well. Figure 4 in particular provides strong evidence that the rent is increasing and that the symmetric model explains the data accurately, whereas the prediction of the asymmetric model of a decreasing rent is clearly rejected.

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.

Our results corroborate Finkelstein and Poterba (2004) with respect to the annuity market. Annuity buyers and *viager* sellers know more than just their age and gender about their life expectancy. Contracts only based on age and gender thus suffer from asymmetric information problems. Nevertheless, the *viager* market shows that this problem can be overcome. Buyers succeed in recovering a good estimate of the true type of the sellers and in solving the asymmetric issue. Insurance companies, in the annuity markets, should be able to do the same by designing a scoring system that incorporates more than just age and gender.

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 down payment (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.[24] 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 because they fear that unscrupulous buyers take advantage of them. 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. A related explanation is the endowment effect. Many potential sellers may be unable to come to an agreement with prospective buyers because they overestimate the value of their properties and hence require unfair and unrealistic contract conditions. 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.[25] A final factor that may explain the small size of the market is that many potential sellers and buyers may dislike the gloomy aspect of *viager* sales, or they may opposed the idea of gambling with death.

[24]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.

[25]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.

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Appendix

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

B Effect of age and gender on the relative down payment and rent conditionally on various functions of B/V and R/V

Table 11: Effect of age and gender conditionally on $\beta = B/R$

	B/V (I)	R/V (I)	B/V (II)	R/V (II)	B/V (III)	R/V (III)	B/V (IV)	R/V (IV)
Age	0.633**	0.109**	0.651**	0.096**	0.553**	0.116**	0.497**	0.125**
	(0.08)	(0.02)	(0.08)	(0.02)	(0.08)	(0.01)	(0.07)	(0.01)
Gender	5.426**	-0.025	5.721**	0.016	4.905**	0.184	4.842**	0.194
	(1.34)	(0.27)	(1.38)	(0.26)	(1.30)	(0.24)	(1.14)	(0.22)
β			0.002	-0.001*	0.341**	-0.070**	1.252**	-0.215**
			(0.00)	(0.00)	(0.03)	(0.01)	(0.06)	(0.01)
β^2					-0.000**	0.000**	-0.003**	0.001**
					(0.00)	(0.00)	(0.00)	(0.00)
β^3							0.000**	-0.000**
							(0.00)	(0.00)
Constant	-19.905**	-1.169	-21.639**	0.259	-15.998**	-0.903	-16.431**	-0.834
	(6.24)	(1.27)	(6.44)	(1.20)	(6.11)	(1.12)	(5.34)	(1.01)
R^2	0.078	0.052	0.083	0.056	0.185	0.184	0.377	0.330
N	874	874	831	831	831	831	831	831

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

Table 12: Effect of age and gender conditionally on $\beta = B/V + \frac{1}{r}R/V$

	B/V (I)	R/V (I)	B/V (II)	R/V (II)	B/V (III)	R/V (III)	B/V (IV)	R/V (IV)
Age	0.633**	0.109**	0.777**	-0.039**	0.810**	-0.040**	0.812**	-0.041**
	(0.08)	(0.02)	(0.08)	(0.00)	(0.08)	(0.00)	(0.08)	(0.00)
Gender	5.426**	-0.025	5.677**	-0.284**	6.055**	-0.303**	6.087**	-0.304**
	(1.34)	(0.27)	(1.32)	(0.07)	(1.30)	(0.07)	(1.30)	(0.06)
β			-5.093**	5.255**	7.862**	4.607**	19.001**	4.050**
			(0.89)	(0.04)	(2.73)	(0.14)	(5.94)	(0.30)
β^2					-3.410**	0.171**	-9.592**	0.480**
					(0.68)	(0.03)	(3.01)	(0.15)
β^3							0.962*	-0.048*
							(0.46)	(0.02)
Constant	-19.905**	-1.169	-22.110**	1.105**	-35.374**	1.769**	-40.823**	2.041**
	(6.24)	(1.27)	(6.14)	(0.31)	(6.61)	(0.33)	(7.08)	(0.35)
R^2	0.078	0.052	0.111	0.944	0.136	0.946	0.141	0.946
N	874	874	874	874	874	874	874	874

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

Table 13: Effect of age and gender conditionally on $\beta = (rB/V + R/V)/(r + B/V)$

	B/V (I)	R/V (I)	B/V (II)	R/V (II)	B/V (III)	R/V (III)	B/V (IV)	R/V (IV)
Age	0.633**	0.109**	0.742**	0.086**	0.677**	0.099**	0.634**	0.109**
	(0.08)	(0.02)	(0.06)	(0.01)	(0.05)	(0.01)	(0.05)	(0.01)
Gender	5.426**	-0.025	4.885**	0.092	3.669**	0.339*	3.398**	0.400*
	(1.34)	(0.27)	(1.01)	(0.19)	(0.92)	(0.17)	(0.88)	(0.16)
β			-39.700**	8.626**	-68.310**	14.437**	-107.390**	23.258**
			(1.52)	(0.29)	(2.53)	(0.48)	(4.94)	(0.91)
β^2					16.952**	-3.443**	64.166**	-14.099**
					(1.26)	(0.24)	(5.34)	(0.98)
β^3							-10.964**	2.474**
							(1.21)	(0.22)
Constant	-19.905**	-1.169	-14.611**	-2.319**	-2.937	-4.691**	6.588	-6.840**
	(6.24)	(1.27)	(4.68)	(0.89)	(4.35)	(0.82)	(4.29)	(0.79)
R^2	0.078	0.052	0.482	0.530	0.572	0.622	0.609	0.669
N	874	874	874	874	874	874	874	874

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

Table 14: Effect of age and gender conditionally on $\beta = 1 - r(1 - B/V)/(R/V)$

	B/V (I)	R/V (I)	B/V (II)	R/V (II)	B/V (III)	R/V (III)	B/V (IV)	R/V (IV)
Age	0.633**	0.109**	0.649**	0.096**	0.647**	0.078**	0.535**	0.027*
	(0.08)	(0.02)	(0.08)	(0.02)	(0.08)	(0.01)	(0.08)	(0.01)
Gender	5.426**	-0.025	5.753**	0.012	5.749**	-0.031	5.144**	-0.309
	(1.34)	(0.27)	(1.38)	(0.26)	(1.38)	(0.23)	(1.36)	(0.20)
β			-0.025	0.009*	0.247	2.595**	8.146**	6.221**
			(0.02)	(0.00)	(1.09)	(0.18)	(1.91)	(0.28)
β^2					0.000	0.003**	1.565**	0.722**
					(0.00)	(0.00)	(0.31)	(0.05)
β^3							0.002**	0.001**
							(0.00)	(0.00)
Constant	-19.905**	-1.169	-21.486**	0.254	-21.461**	0.491	-16.836**	2.614**
	(6.24)	(1.27)	(6.45)	(1.20)	(6.45)	(1.07)	(6.43)	(0.95)
R^2	0.078	0.052	0.082	0.055	0.082	0.240	0.109	0.412
N	874	874	831	831	831	831	831	831

Significance levels: $\dagger$: 10% $*$: 5% $**$: 1%

C Model and proof of Proposition 1

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 $\tilde{r}$. 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

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

The expected utility function of the seller 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 no arbitrage condition (1) and the above consumption constraints.

First we prove items (i) and (ii) of Proposition 1. The proof is facilitated by assuming that buyers and sellers have access to a larger set of *viager* contracts. Specifically, instead of assuming that the rent is fixed over time (apart form the variations due to the indexation), the rent 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). We only focus on the equilibria where the down payment and the rents are strictly positive.

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 rent 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-rent 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 rent 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 rent is now 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:

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

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 rent, the no arbitrage condition 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 no arbitrage condition (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 down payment, $R'_1, R'_2, ..., R'_T$ the sequence of optimal values of the rent, and t_0 the smallest value of t such that $S'_{t_0} > 0$ (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

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

It is straightforward to check that the no arbitrage condition remains satisfied. The rent 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 $(1+\tilde{r})\frac{\sum_{t'=t_0}^{T} \pi_{t'}}{\sum_{t'=t_0+1}^{T} \pi_{t'}} S'_{t_0}$. 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 a rate of return larger than $1 + \tilde{r}$ 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 of the proof consists in showing that at the optimum the rent 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 no arbitrage condition (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 rent is time-invariant, the no arbitrage condition 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 (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 proof of items (i) and (ii) of Proposition 1 (characterization of the symmetric information equilibrium.

Next we turn to the proof of item (iii) of Proposition 1. 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 $B(.)$ were decreasing and $R(.)$ increasing, sellers of type $\alpha' < \alpha$ would have an incentive to lie about their type and pretend to be of type α. They would then obtain $B(\alpha) + \frac{1-\alpha'}{r}R(\alpha) > B(\alpha) + \frac{1-\alpha}{r}R(\alpha) = \alpha V > \alpha' V$ 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 contribution to the likelihood of observation i is the probability of observing R_i/V_i conditionally on α_i:

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

where $\phi(.)$ is the density of a standard normal distribution, $\Phi(.)$ its associated cumulative distribution function, and $\theta = (\beta_0^1, \beta_1^1, \beta_0^2, \beta_1^2, \beta_0^3, \beta_1^3, \sigma_1, \sigma_2, \rho_1, \rho_2)$ is the vector of parameters to be estimated. The first term is the (conditional) probability of observing R_i/V_i in the donation regime whereas the second one is the probability of observing R_i/V_i in the no donation regime. 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:

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

The second term in the contribution to the likelihood can be obtained in a similar way. The full contribution to the likelihood of observation R_i/V_i is therefore:

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