Testing for asymmetric information in the *viager* market

Philippe Février†, Laurent Linnemer‡, Michael Visser§

June 2011

Abstract

A *viager* real estate transaction consists in selling a property in return for a down payment and a life annuity that the buyer has to pay until the seller dies. This paper tests for the presence of asymmetric information in this market using notarial data on transactions in Paris between 1993 and 2001. We first derive and test empirically a no arbitrage condition stating that the price of a *viager* has to be equal to its expected returns. We then identify the type of the seller as a sum of weighted death probabilities. By comparing these sums with analogously defined national-level sums we find that sellers have on average shorter survival times than persons in the general 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 annuity) on the inferred type of the seller, and comparing the estimates with the predicted outcomes. The hypothesis that information is symmetrically distributed between buyers and sellers is accepted.

**Keywords:** Symmetric and asymmetric information, life annuity, donation, survival time.

**JEL Codes:** C13, D82

---

*We are grateful to the Co-Editor Hanming Fang, two anonymous referees, Gary Becker, Pierre-André Chiappori, Gabrielle Demange, Alexis Dider, Christian Gollier, Xavier d’Haultfoeuille, Sébastien Lecocq, Steven Levitt, André Masson, seminar participants at CESifo Munich, ECARES Brussels, GREQAM Marseille, INRA-IDEI Toulouse, INRA-LEA Paris, THEMA Cergy-Pontoise, Tinbergen Institute Amsterdam, the University of Chicago, the University of Montpellier, and the Utrecht School of Economics, and attendees at the 2009 North American Winter Meeting of the Econometric Society for their helpful comments and suggestions. We are also grateful to Bruno Legasse for explaining many of the practical aspects of the *viager* market. Philippe Février thanks the hospitality of the University of Chicago where part of this paper was written.

†CREST-LEI, 15 Boulevard Gabriel Péri, 92245 Malakoff, France. Email: fevrier@ensae.fr.

‡CREST-LEI, 15 Boulevard Gabriel Péri, 92245 Malakoff, France. Email: laurent.linnemer@ensae.fr.

§ERMES-CNRS and CREST-LEI, 26, rue des Fossés Saint-Jacques, 75005 Paris, France. Email: michael.visser@ensae.fr.
-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 individuals 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 is important to study in which 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), optimally behaving economic agents
should annuitize all or large parts of their wealth. In practice, however, annuity markets are
generally thin, 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 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

---

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.”
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 homeowners, is a reverse mortgage. This is a relatively new financial product that been introduced in the USA, Canada, the UK and Singapore (see Chan (2002), for a survey). A reverse mortgage is an arrangement in which homeowners receive a loan against the value of their home.\(^2\) Borrowers may continue living in their property, and the loan plus accrued interest and other charges is repaid when they exit their home or when they die. The lender does not have legal recourse to anything other than the value of the home when the loan has to be reimbursed. If the total sum due at the termination date exceeds the property value then the difference is absorbed by the lender. A reverse mortgage can therefore be financially beneficial for homeowners who anticipate that they will remain a long time in their property (because they have high longevity expectations or plan to move out of their property only in the far future). Davidoff and Welke (2007) argue that lenders may anticipate this adverse selection and charge high fees to their clients, which may in turn explain the smallness of the reverse mortgage market in the USA (less than 1% of homeowners are reverse mortgage borrowers).

This paper studies a mechanism that is closely related to a reverse mortgage. It is a specific type of real estate transaction which exists in several European countries (Belgium, France, Germany, Italy, Spain), and is known in France as *viager*. Homeowners who sell their property via the *viager* method receive in return a down payment from the buyer, and a monthly or yearly annuity until the end of their life. Like reverse mortgage borrowers, *viager* sellers are allowed to remain in their property after the transaction date: they are entitled to stay in their home until death,\(^3\) and have the option to move out (to go to a nursing home for instance). Unlike a reverse mortgage, the decision to move out does not necessarily end the contract: *viager* contracts typically stipulate that sellers may leave their properties in exchange for a higher annuity. A *viager* transaction is closely related to a life annuity as well. The annuity received by the *viager* seller is the analogue of the annuity payment received by an annuitant. Both are 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 rebate (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. There is also an important difference between the *viager* market on the one hand and the markets for annuities and reverse mortgages on the other. In the last two markets buyers are mostly individuals, and sellers are banks or insurance companies. These firms determine and propose a menu of contracts from which individual agents can then choose. In the *viager* market, however, both buyers and sellers are typically individuals. Contracts terms are not predetermined but freely chosen by buyers and sellers.

A *viager* sale can clearly be attractive for older property owners as they may stay in their

\(^2\)The loan can take different forms: a lump sum payment transferred to the homeowner when the contract is signed, regular payments during a predetermined period, payments that last until the borrower’s death or exit of home, or a line of credit to which the borrower has access.

\(^3\)The term *viager* comes from *viage*, which means “time of life” in old French.
own home and earn extra money for the rest of their life. The principle is also quite flexible and offers a few advantages. First, the annuity is typically indexed to a consumer price index, which guarantees sellers that they will receive a constant real income flow. As mentioned above, most contracts also include a clause stipulating that sellers may leave their property at any time in exchange for higher annuities. Finally, sellers may donate part of the down payment to their family members. 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)).

In spite of these advantages and the promotion of the French government, the viager market is, like the annuity and reverse mortgage markets, quite small. The most natural explanation for this low rate of occurrence is again the presence of asymmetric information between buyers and sellers. Many people in France associate the viager principle with the story of Jeanne Calment. Back in 1965, when Mrs Calment was aged 90, she sold her apartment in Arles to a 44-years old man, on contract-conditions that seemed reasonable given the value of the apartment and the life-expectancy statistics that prevailed at the time. The man turned out to be unlucky since Jeanne Calment lived a very long life. He died in 1995, two 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.

The purpose of this paper is to investigate whether the market is indeed hindered by asymmetric information about the survival prospects of sellers. We do this by using notarial data on sales in Paris and its suburbs. For each transaction we observe the most important contract parameters (down payment and annuity), the market value of the property, and some characteristics of buyers and sellers. The notarial database does not, however, 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) and Dionne, Gouriéroux, and Vanasse (2001). The idea of this test is to look at the correlation, conditionally on all observables, between the contract choice (type of automobile insurance contract in both these papers) 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 positively correlated, and symmetric information if there is no correlation. In the absence of mortality data, we do not have an ex-post measure of the seller’s type, and hence we cannot apply this so-called positive-association 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. A viager is a financial asset, and our condition states that the price of this asset (the down payment) is equal to its expected returns (expected and discounted value of property minus expected and discounted annuity payments). Another interpretation of the no arbitrage

---

4On February 21, 1996, she celebrated her 121st birthday, making her the oldest living person on earth according to the Guinness Book of World Records.
condition is that buyers must be indifferent between purchasing on the standard and viager market. The no arbitrage condition can be rewritten such that the sum of death probabilities of a seller is expressed in terms of the observable contract parameters and the value of the property. As the condition is crucial to the analysis, we test it empirically and find that it is supported by the data.

The identifiability of the seller’s type is first exploited to check whether viager sellers have the same survival distribution as representative individuals in the global population (conditional on age and gender). We do this by comparing the seller-specific sums of death probabilities with analogously defined national-level sums calculated using life tables. The hypothesis that the survival distributions of sellers and comparable individuals from the population at large are the same is not supported by the data. Contrary to what the anecdote about Jeanne Calment’s story suggests, we find that sellers have, on average, shorter survival times than people in the population. This may reflect the poor financial situation of viager sellers (see Drosso (1993,2002)) combined with the well-known fact that less wealthy individuals have shorter expected life times (see Cutler, Deaton, and Lleras-Muney (2006)). Evidence of selection has also been found in related markets. For reverse mortgages, Davidoff and Welke (2007) show that reverse mortgage borrowers exit their homes more rapidly than non-borrowers. On the contrary, for annuities, Finkelstein and Poterba (2002) find that annuitants are longer-lived than non-annuitants.

The identifiability of the seller’s type is next exploited to answer the following 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. 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 maximize an expected intertemporal utility function. The model accounts for the possibility that 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

---

5The 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.
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 annuity is invariant with the type of the seller. For sellers who do not donate, both the down payment and the annuity increase with the seller’s type and at the same rate. On the contrary, under asymmetric information, the down payment increases but the annuity decreases with the type of the seller.

To estimate the symmetric information model, we regress the observed down payment and annuity 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 annuity 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 annuity 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 and reverse mortgages 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 long-term-care insurance market (Finkelstein and McGarry (2006)), the credit card market (Ausubel (1999)), the health insurance market (Cutler and Reber (1998); Fang, Keane, and Silverman (2008)), 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 shows how the contract parameters are related through a no arbitrage condition. We also show how the condition can be used to recover the seller’s type, and test the hypothesis that viager sellers have the same survival distribution as representative individuals from the population. Section 4 contains our test of the no arbitrage equation, and presents a specific generalization of the equation. Section 5 presents the model and the predictions, and the empirical test for the presence of asymmetric information. Section 6 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, 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

---

6Two 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, 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 stipulates two transaction prices: the down payment (*bouquet* in French) the buyer has to make at the date of signature, and the annuity (*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 annuity 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, 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 annuity).

There are no legal restrictions on how the down payment and annuity 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 annuity 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.

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

---

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).
time. 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 annuity. 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 annuity 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 annuity from their total income; after 69 the abatement rate augments to
70%). There are, however, no fiscal incentives for buyers.

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. Nowadays the market is smaller but characterized by a demand
that largely exceeds the supply of viager proprieties (Drosso (1993), and personal discussions
with Bruno Legasse, director of a Paris-based agency specialized in viager sales). Most of the
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 Summary statistics

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 1993 and 2001. For each transaction we observe
the characteristics of the property (kind of property, geographic location, size, number of rooms,
etc.), some characteristics of the buyers and sellers, and the market value of the property. When
the transaction corresponds to a viager sale, 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. For each viager sale we observe in addition the down payment and the annuity on a yearly
basis.

Our data set 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 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.

From an initial data set of 1,034,427 observations (2495 viager transactions and 1,031,932
standard transactions) we only keep sales of apartments and houses and exclude sales of plots of

---

9In 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 annuity 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 annuity 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.
land, sales for which the age and/or the gender of the seller are missing or for which the seller was less than 60 year old.\textsuperscript{10} We also delete \textit{viager} observations containing extreme values of the contract parameters (down payment and annuity), i.e., observations such that at least one contract parameter exceeds the corresponding mean plus three times the standard error. We hereby obtain a sample of 168,469 observations (874 \textit{viager} sales and 167,595 standard sales). The fraction of \textit{viager} sales amounts to 0.52\% of the total sample (874/168,469). Among real estate sales by owners above 70 (resp. 80) the fraction is 0.9\% (resp. 1.2\%).\textsuperscript{11} The sample of \textit{viager} transactions sales is our main database on which the empirical analysis is performed; the sample of ordinary transactions allows us to compare the features of properties and buyers and sellers across the two types of real estate sales, but will otherwise not be used in the analysis.

Table 1 contains summary statistics on the property value, the contract parameters, the characteristics of the properties, and some characteristics of buyers and sellers. The information is given separately for the two sales mechanisms, and for each variable we report t-tests on the equality of means in both samples. All monetary values are in thousand €.

<table>
<thead>
<tr>
<th>Variable</th>
<th>\textit{Viager} sales ((N = 874))</th>
<th>Standard sales ((N = 167,595))</th>
<th>T-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property value</td>
<td>103.95 77.54 54.88 83.85 121.96</td>
<td>123.91 131.13 56.41 91.47 144.83</td>
<td>19.97 (2.64) 7.56</td>
</tr>
<tr>
<td>Down payment</td>
<td>33.96 39.53 11.43 22.87 42.69</td>
<td>. . . . . .</td>
<td>. .</td>
</tr>
<tr>
<td>Annuity</td>
<td>6.84 5.42 3.66 5.49 8.96</td>
<td>. . . . . .</td>
<td>. .</td>
</tr>
<tr>
<td>Relative down payment</td>
<td>31.05 15.59 16.23 28.00 42.55</td>
<td>. . . . . .</td>
<td>. .</td>
</tr>
<tr>
<td>Relative annuity</td>
<td>7.36 3.72 5.10 7.20 9.47</td>
<td>. . . . . .</td>
<td>. .</td>
</tr>
<tr>
<td>Nb rooms</td>
<td>2.74 1.28 2.00 3.00 3.00</td>
<td>3.00 1.58 2.00 3.00 4.00</td>
<td>.26 (.04) 5.93</td>
</tr>
<tr>
<td>Size (sq. m.)</td>
<td>58.46 31.01 36.53 53.50 71.43</td>
<td>63.34 42.82 35.00 55.00 80.00</td>
<td>4.89 (1.05) 4.63</td>
</tr>
<tr>
<td>Price per sq. m.</td>
<td>1.84 0.96 1.23 1.67 2.29</td>
<td>1.95 1.02 1.28 1.73 2.41</td>
<td>.12 (.03) 3.57</td>
</tr>
<tr>
<td>Owner since (seller)</td>
<td>77.97 7.76 72.00 78.00 84.00</td>
<td>70.96 8.73 64.00 69.00 76.00</td>
<td>-6.58 (.28) -23.69</td>
</tr>
<tr>
<td>Male (seller)</td>
<td>0.56 0.46 0.00 0.00 1.00</td>
<td>0.58 0.49 0.00 1.00 1.00</td>
<td>.28 (.02) 18.39</td>
</tr>
<tr>
<td>Buyer’s age\textsuperscript{1}</td>
<td>41.15 12.74 31.00 40.00 51.00</td>
<td>39.64 13.56 29.00 36.00 47.00</td>
<td>-1.51 (.70) -2.15</td>
</tr>
<tr>
<td>Male (buyer)\textsuperscript{1}</td>
<td>0.56 0.50 0.00 1.00 1.00</td>
<td>0.54 0.50 0.00 1.00 1.00</td>
<td>-.02 (.03) -0.85</td>
</tr>
<tr>
<td>Buyer is a firm</td>
<td>0.16 0.36 0.00 0.00 0.00</td>
<td>0.06 0.23 0.00 0.00 0.00</td>
<td>-.10 (.01) -8.32</td>
</tr>
</tbody>
</table>

\textsuperscript{1}The statistics on the buyer characteristics are based on smaller samples \((N = 333 \textit{viager} sales and \(N = 76,638\) standard sales) first because when the buyer is a firm the buyer’s age and gender are not known; second because when there are several buyers the characteristics are recorded only for the first buyer.

On average, a property sold on the \textit{viager} market has a value of around 104,000€ while a property sold on the standard market is valued around 124,000€. This difference is statistically significant. The price per square meter of a \textit{viager} property (1,840€) is also significantly less than of a standard property (1,950€). \textit{Viager} properties are also significantly smaller: on average they are sized 60 square meters (about 4.9 square meters less than on the standard market), and have slightly less than three rooms (standard properties have exactly three rooms). The average down payment in the sample is approximately 34,000€, and the average annuity per year is nearly 7,000€. The relative down payment (down payment divided by property value) is on

\textsuperscript{10}Consequently, we had to exclude \textit{viager} sales where the contract specifies that there are multiple beneficiaries since only the gender of the first beneficiary is specified, and the ages of the additional beneficiaries are often missing.

\textsuperscript{11}These proportions are consistent with the national ones. In France, there are about 4000 \textit{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 \textit{viager} sales is approximately 0.6\% (Griffon (2008)).
average around 31\%,\textsuperscript{12} while the relative annuity (annuity divided by value) is on average around 7.5\%.

On average \textit{viager} sellers are 78 year old when they sell their property and the majority is female (70\%).\textsuperscript{13} This is in rather sharp contrast with sellers on the standard market who are 6.5 years younger (the difference being significant) and who are mostly male (60\%). At the date of sale, \textit{viager} sellers have owned their property significantly longer than regular sellers: 15.76 vs. 14.26 years. But since \textit{viager} sellers are considerably older at the date of sale they nonetheless purchased their property at a more advanced age than regular sellers: 62.2 instead of 56.7 years. Our data set does not record the financial situation of sellers so we cannot compare the two types of sellers in terms of their wealth. The previous statistics, in particular the fact that the properties owned by \textit{viager} sellers are relatively less expensive, suggest that they are poorer than standard sellers. This is corroborated by Drosso (1993,2002). According to these sociological studies, \textit{viager} sellers typically had professions which allowed them to buy a home when they worked, but their pension plans are not generous enough to live well after retiring. Many female sellers are widows who ran into financial problems after their husband passed away and therefore needed to sell their property. Many sellers are not well-off: 66\% (resp. 100\%) of the male (resp. female) sellers belong to the five lower income deciles. From Drosso we also know that, contrary to conventional wisdom (according to which \textit{viager} sellers are mostly childless), as much as 50\% of sellers have children. 90\% of these children agree with the fact that their parents had sold their property.

Finally, Table 1 shows that \textit{viager} buyers are significantly older than buyers in the standard market (41.15 vs. 39.64 years). There are slightly more male buyers in the \textit{viager} market than in the standard market (56\% vs. 54\%), but the difference is not statistically different. The most striking difference is that 16\% of the buyers in the \textit{viager} market are firms and 84\% individuals, whereas in the standard market only 5\% are firms. According to Drosso (1993,2002), individual buyers are executives or senior managers from large firms or have liberal professions, and are generally wealthy. This is not surprising given that in France one cannot obtain a loan from a bank to finance a \textit{viager} operation. That they are wealthy is also confirmed by comparing the national figures on household disposable income\textsuperscript{14} with the \textit{viager} contract parameters. Average household disposable income amounted, for instance, to 30,100\euro\ in 1997. The average down payment is 1.1 larger than this income and the annuity corresponds to almost one fourth of this average income. Moreover, 95 percent of the households have a disposable income lower than 56,296\euro\ per year. The average down payment (resp. annuity) amounts to 60\% (resp. 12\%) of this figure. Only relatively rich households can thus afford to buy a \textit{viager} property under these conditions.

\textsuperscript{12}According to Griffon (2008), the down payment generally varies between 20 and 30\% of the property value. Le Court (2006) points out that it can sometimes exceed 60\% of the value. This is, indeed, the case in our data for 10\% of the sales.

\textsuperscript{13}According to the national-level statistics compiled by Drosso (1993,2002), sellers are on average between 72 and 75 years and the majority is female.

\textsuperscript{14}Source INSEE, the French National Institute of Economics and Statistics.
2.3 Descriptive analysis of the link between contract parameters

Figure 1 shows all sample observations of the contract parameters, the key variables of our empirical analysis. To make the different observations of the down payment and annual annuity comparable, we divide them by the property value. The horizontal axis depicts $R/V$ and the vertical axis $B/V$, where $B$ is the down payment, $R$ the annual annuity, and $V$ the value of the property. The figure illustrates that there is a lot of heterogeneity in the data. This heterogeneity may result from variations in the age and gender of sellers. Age and gender influence the seller’s life expectancy and hence the expected number of periods the buyer has to pay money to the seller, which in turn affects the level of the annuity and of the down payment. Heterogeneity in the relative contract parameters may also reflect differences in sellers’ survival prospects not captured by the differences in their age and gender. Finally, the observed heterogeneity may be the consequence of variations in seller preferences. For instance, the down payment may be influenced by the amount of money sellers wish to donate to family members.

![Figure 1: Viager contracts (relative down payment and annuity)](image)

The correlation coefficient between the relative annuity and down payment is -0.34. This negative relationship is intuitive. If the relative down payment is large (resp. small) the “remaining value” of the property is small (resp. large), and consequently the relative annuity should be relatively small (resp. large). To study further the link between the contract parameters we run several regressions. The first (resp. fourth) column of Table 2 reports the results of a regression...
of $B/V$ (resp. $R/V$) on $R/V$ (resp. $B/V$). These regressions confirm the negative correlation between those two variables, and the small values of the R-square indicate that there is indeed much heterogeneity in the data.

<table>
<thead>
<tr>
<th>Table 2: Relationship between $B/V$, $R/V$, age and gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B/V$</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>$B/V$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$R/V$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Age (seller)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Male (seller)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
</tr>
<tr>
<td>$N$</td>
</tr>
</tbody>
</table>

Significance levels: *: 5% **: 1%

To study the effect of life expectancy through sellers’ age and gender, we regress $B/V$ (resp. $R/V$) on these variables. Column two (resp. five) reports the results. Age has a positive and significant effect on both the relative annuity and down payment, suggesting that older sellers obtain more favorable contract terms. Gender has a positive and significant effect on the the relative down payment, suggesting that men receive higher down payments, but age does not have a significant effect. Globally these estimates indicate though that older and male sellers obtain more favorable contract, which is as expected since these individuals have a lower life expectancy. All these results are finally corroborated by the regressions shown in column three (resp. six) of $B/V$ (resp. $R/V$) on $R/V$ (resp. $B/V$), the age and the sex of the seller. Note that both R-square values are still relatively small, suggesting that for a given $R/V$ (resp. $B/V$) age and gender explain only a small part of the heterogeneity in $B/V$ (resp. $R/V$).

3 No arbitrage condition and selectivity test

In Section 3.1 we derive the no arbitrage condition on which most of the subsequent analysis relies. It allows us to recover the type of each seller, i.e., the sum of death probabilities of the seller. In Section 3.2 we compare these seller-specific sums with analogously defined national-level sums and thereby check whether the sample of viager constitutes a selective sample of the global population.

15Buyers’ characteristics (age, gender, marital status, whether the buyer is an individual or a firm), when added in these regressions, appear to be non-significant. We therefore do not include them in our analysis.
3.1 No arbitrage condition

We start by introducing some additional notations and defining the precise timing of a viager transaction. Let $\pi_t$ be the probability that the seller dies exactly $t$ period after signing the contract, $t = 0, 1, ..., T$, with $\sum_{t=0}^{T} \pi_t = 1$. Let $\delta$ be the discount factor and $r$ the associated rate such that $\delta = 1/(1 + r)$. The timing of a transaction is as follows. First, the down payment $B$ is paid when the contract is signed at $t = 0$. Second, the annuity $R$ is paid at the beginning of each period $t = 1, 2, ...$ until the seller dies. Third, the buyer receives the apartment right after the death of the seller.

In this setup, a viager sale can be seen as a financial asset similar to a life insurance contract. The owner of this asset (i.e. the buyer of the viager) pays $R$ as long as a given person (i.e. the seller of the viager) is alive and earns $V$ upon the death of this person. The down payment $B$ can be interpreted as the market price of this asset. The no arbitrage condition of financial economics (see Varian (1987)) implies that this price $B$ should be equal to the expected discounted return of the asset.

The latter can be obtained as follows. Given our timing, if the seller dies at $t = 0$ (this occurs with probability $\pi_0$), the buyer receives $V$ at $t = 0$ and does not pay any annuity. If the seller dies at $t$ (this occurs with probability $\pi_t$), the buyer receives $V$ at $t$, and pays $R$ at periods 1, 2, ..., $t$ periods. The discounted return in this case equals $\delta^t V - \sum_{t'=1}^{t} \delta^{t'} R$. The expected discounted return is therefore $\sum_{t=0}^{T} \pi_t \delta^t V - \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} R$, and the no arbitrage condition is

$$B = \sum_{t=0}^{T} \pi_t \delta^t V - \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} R.$$  (1)

The no arbitrage condition links the contract parameters $B$ and $R$ to the property value $V$, the death probabilities $\pi_t$, and the discount factor $\delta$. In the absence of discounting, only the life expectancy of the seller matters. Indeed, if $\delta = 1$ equation (1) becomes $B = V - (\sum_{t} t \pi_t) R$ where $\sum_{t} t \pi_t$ is the life expectancy.

The following proposition reformulates condition (1) and states that the death probabilities enter the no arbitrage equation only through a simple weighted sum.

**Proposition 1.** Denoting

$$\alpha = \sum_{t=0}^{T} \pi_t \delta^t,$$  (2)

the viager parameters are linked together through the following equation:

$$\alpha V = B + \frac{1-\alpha}{r} R.$$  (3)

**Proof.** See Appendix A. \(\Box\)

---

\(^{16}\) If $B$ were lower (resp. larger) there would be an infinite (resp. no) demand. The no arbitrage condition insures that there is a finite positive demand for viager assets.

\(^{17}\) In Appendix A.1, we show that the no arbitrage condition can also be written as $V = B + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} (R + L)$, where $L$ is the per period amount of money that must be paid by a tenant to rent a property of value $V$. Formulated in this way, the no arbitrage condition states that the cost of acquiring the property on the standard market equals the expected cost of acquiring it via a viager transaction.
The term $\alpha$ is a weighted sum of death probabilities of the seller. It is the key parameter in the analysis as it summarizes all the relevant information about the survival prospects of the seller. Indeed, the death probabilities $\pi_t$ do not separately play a role in the no arbitrage condition but only via the parameter $\alpha$. This parameter is the seller’s type. When the expected survival time decreases, $\alpha$ increases, and vice versa. Formally, if the distribution of death time of seller 1 stochastically dominates the distribution of seller 2, then $\alpha_1 > \alpha_2$.

The type $\alpha$ is assumed to be known by the seller. Such an assumption is standard in the literature\textsuperscript{18} and corroborated by two empirical studies: Hurd and McGarry (2002) and Smith, Taylor, and Sloan (2001). Studying the subjective probability distributions revealed by HRS respondents, they show that individuals are not biased and that their subjective death probability distribution predict actual survival. Individuals have an 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.

Equation 3 of Proposition 1 links the type $\alpha$ and the contract parameters together. The left-hand side of (3), i.e., $\alpha V$, can be interpreted as the net value of the property (indeed, $\alpha$ is the expected present value of one $\mathbf{e}$ received upon the death of the seller). It is the remaining value of the property once the expected value of the usufruct retained by the seller has been deducted from $V$. As $\alpha V = V - (1 - \alpha)V$, the expression $(1 - \alpha)V$ corresponds to the expected value of the usufruct and $(1 - \alpha)$ can be seen as a rebatement factor. It captures the fact that the seller stays in the property. The higher $\alpha$, the shorter the life expectancy, and hence the lower the rebatement factor. The right-hand side of (3) indicates that the net value of the property equals the down payment $B$ plus the annuity $R$ 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 annuity. 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 an annuity equal to $\frac{r}{(1-\alpha)}(\alpha V - B)$.

In practice, real estate agencies specialized in viager transactions often help buyers and sellers in their negotiations (Drosso, 1993; Le Court, 2006). These agencies advise the parties and suggest how the contract parameters may be calculated. It is interesting to note that their methods are similar in spirit as the calculations underlying the no arbitrage equation (3). They first apply a rebatement factor to $V$ to take into account that the property remains occupied by the seller. Next, once $B$ is fixed, they transform the remaining owed capital $(\alpha V - B)$ into a life annuity using a conversion coefficient. The precise calculations of the rebatement and conversion factors may differ for each agency. For instance, the Paris-based agency Legasse Viager uses the so-called Daubry table which contains for each age and gender a rebatement factor and a conversion coefficient. 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).

\textsuperscript{18}In the insurance literature, for instance, drivers are assumed to know their actual accident probability, and purchasers of health insurance know their chances of falling ill.
3.2 Selection effect

In the data, we observe $B$, $R$, and $V$ but not the type of the seller $\alpha$. From (3) it follows, however, that

$$\alpha = \frac{rB/V + R/V}{r + R/V}. \quad (4)$$

Hence, for a given value of $r$, the relative contract parameters allow us to recover the type of the seller. In the remainder of the paper we take an annual $r$ equal to 0.05.\(^{19}\)

Table 3 presents summary statistics for $\alpha$ and the associated residual life expectancy (i.e., the life expectancy after the sale). The mean value of $\alpha$ is 0.7 which corresponds to a life expectancy of 8.4 years. Half of the observations are between 0.65 (9.4 years) and 0.77 (5.6 years).

<table>
<thead>
<tr>
<th>variable</th>
<th>mean</th>
<th>sd</th>
<th>p25</th>
<th>p50</th>
<th>p75</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.699</td>
<td>0.128</td>
<td>0.654</td>
<td>0.721</td>
<td>0.773</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>8.4</td>
<td>5.3</td>
<td>9.4</td>
<td>7.1</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Table 3: Summary statistics on the seller’s type and life expectancy ($N = 874$)

To check whether the survival probabilities of viager sellers are similar to national survival probabilities, we 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 $\alpha_{\text{Insee}} = \sum_{t=0}^{T} \pi_{\text{Insee},t} \delta^t$, where the $\pi_{\text{Insee},t}$ are population-level death probabilities calculated from life tables published by Insee. These life tables allow us to determine the probabilities $\pi_{\text{Insee},t}$ separately for men and women, for each age group, and by cohort (i.e., year of birth). It should thus be understood that $\pi_{\text{Insee},t}$ stands for the probability that a representative person from the population, aged say $a$, and of a given sex and year of birth, dies at the age $a + t$ (for notational simplicity we have omitted the age, gender and cohort indicators in the expressions of $\pi_{\text{Insee},t}$ and $\alpha_{\text{Insee}}$). For each seller $i$ (of a given age, gender, and cohort) we thus observe $\alpha_i$, the type of this seller, and $\alpha_{\text{Insee}}$, the corresponding national-level type of a representative individual (of the same age, gender, and cohort as $i$).

Table 4 compares the results of linear regressions of respectively $\alpha_{\text{Insee}}$ and $\alpha$, on age and gender. As expected, both $\alpha_{\text{Insee}}$ and $\alpha$ are higher when the seller is male and relatively old. 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 $\alpha_{\text{Insee}}$. On the contrary, with an R-square of only 0.11, these variables are imperfect predictors of $\alpha$. Furthermore, the coefficients are three times smaller than in the regression equation of $\alpha_{\text{Insee}}$.

Figure 2a shows the empirical density functions of $\alpha_{\text{Insee}}$ and $\alpha$, and Figure 2b the densities of the associated residual life expectancies. The density of $\alpha$ is more concentrated around its mode than the density of $\alpha_{\text{Insee}}$. Similarly, the density of life expectancies for sellers is more concentrated than the one for representative individuals. Figure 2a shows that most sellers in

\(^{19}\)Our chosen value of $r$ is close to the value chosen in other studies. In Keane and Wolpin (1997) the annual rate is .064, in Carneiro, Hansen, and Heckman (2003) 0.03, and in Aguirregabiria and Mira (2007) .053. All results reported in the paper are robust to small variations in $r$. They remain stable for values of the annual rate varying between 0.03 and 0.06.
Table 4: Effect of age and gender on $\alpha_{\text{Insee}}$ and $\alpha$

<table>
<thead>
<tr>
<th></th>
<th>$\alpha_{\text{Insee}}$</th>
<th>$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (seller)</td>
<td>0.018**</td>
<td>0.006**</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Male (seller)</td>
<td>0.072**</td>
<td>0.019*</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.769**</td>
<td>0.249**</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.987</td>
<td>0.117</td>
</tr>
<tr>
<td>$N$</td>
<td>874</td>
<td>874</td>
</tr>
</tbody>
</table>

Significance levels:  * : 5%    ** : 1%

our sample have a larger type than comparable individuals in the population. This means that viager sellers tend to have shorter life expectancies than representative agents, as illustrated in Figure 2b. Note that the shape of the density function of $\alpha$ is clearly not in line with the predicted outcome in a pure Akerlof world. Indeed, if buyers and sellers were asymmetrically informed about $\alpha$, 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 $\alpha$) would be able to sell their property on the viager market. The estimated density function shows instead that there is much heterogeneity in the types of the sellers. The market is not just made up of the highest-risk sellers.

![Figure 2a: Densities of $\alpha_{\text{Insee}}$ and $\alpha$](image1)

![Figure 2b: Densities of life expectancies](image2)

Another way to measure the importance of the selection effect consists in comparing the market price $V$ and an implied market price. The latter is obtained after replacing, in the no arbitrage condition, $\alpha_i$ by $\alpha_{\text{Insee}}$ of a comparable person, and solving for the market price:

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

Thus, $V_{\text{Insee}}$ can be viewed as the expected discounted payment made by a buyer if the seller has the same survival prospects as a representative individual. Without auto-selection of sellers,
we should observe that both market prices coincide. Table 5 reports on the contrary that $V_{\text{Insee}}$ is, on average, 30% greater than $V$. This confirms our previous finding that *viager* sellers have a shorter life expectancy than the average individuals in the population given.

<table>
<thead>
<tr>
<th>variable</th>
<th>mean</th>
<th>sd</th>
<th>p25</th>
<th>p50</th>
<th>p75</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V$</td>
<td>103.9</td>
<td>77.6</td>
<td>54.9</td>
<td>83.8</td>
<td>122.0</td>
</tr>
<tr>
<td>$V_{\text{Insee}}$</td>
<td>135.1</td>
<td>108.9</td>
<td>67.4</td>
<td>106.2</td>
<td>166.0</td>
</tr>
</tbody>
</table>

The selection effect we find in the *viager* market has also been found in the closely related market for reverse mortgages (see Davidoff and Welke (2007)). The shorter life expectancies among *viager* sellers may reflect the fact that these people are relatively poorer than comparable individuals in the population (see section 2.2). Indeed, it well known that there is a positive relationship between income and survival prospects, even within countries (Cutler, Deaton, and Lleras-Muney (2006)).

### 4 Test of no arbitrage condition and extension

The no arbitrage equation is central in our analysis. It states that $V = (B + (1 - \alpha)R/r) / \alpha$. There are, however, reasons to believe that $V$ is smaller than the right hand side of this equation (transaction costs saved by the seller, sellers sentimentally attached to their home in which they want to stay,...). There are also reasons why it may be larger (sellers taking better care of the property than ordinary tenants, transaction costs saved by the buyer, ...). On balance, however, we may expect that the total bias is negligible and that the no arbitrage condition acts as a reference point from which deviations should be small.

To investigate this question, we first present, in Section 4.1, a test of the no arbitrage condition. The test is simple and exploits the fact that under the null hypothesis the seller’s type contains all information that is relevant in determining the contract parameters. Section 4.2 then studies the power of this test in a situation where the no arbitrage equation is measured with error. Finally, Section 4.3 derives the no arbitrage condition under the assumption that buyers are risk averse.

#### 4.1 A test of the no arbitrage condition

Let $H_0$ be the hypothesis that the no arbitrage condition is satisfied. Under $H_0$, the recovered type $\alpha$ should summarize all the relevant information about sellers. In particular, age and gender should not play any role in the determination of contract parameters once $\alpha$ is known. The intuition is the following. If buyers know the survival prospects of the seller, they do not care about the gender or the precise age of the seller because the price they are expected to pay for the property only depends on the survival distribution through $\alpha$. Conditional on the type, the seller’s age and gender of the seller should be irrelevant.

To test the hypothesis we regress the relative down payment and annuity on age, gender, and powers of $\alpha$, as a way to measure the effect of these seller characteristics conditionally on $\alpha$. 

17
Using powers of $\alpha$ is a simple way to control for any arbitrary link between the relative contract parameters and the seller’s type. Table 6 displays the results. First, the relative down payment and annuity are regressed on age and gender only (Columns I). Then we add different powers of $\alpha$ as controls (Columns II to IV).

Table 6: Effect of age and gender on $B/V$ and $R/V$ conditionally on $\alpha$

<table>
<thead>
<tr>
<th></th>
<th>B/V (I)</th>
<th>B/V (II)</th>
<th>B/V (III)</th>
<th>B/V (IV)</th>
<th>R/V (I)</th>
<th>R/V (II)</th>
<th>R/V (III)</th>
<th>R/V (IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (seller)</td>
<td>0.633**</td>
<td>0.294**</td>
<td>0.054</td>
<td>-0.004</td>
<td>0.109**</td>
<td>0.014</td>
<td>0.016</td>
<td>0.025</td>
</tr>
<tr>
<td>Male (seller)</td>
<td>4.266**</td>
<td>4.286**</td>
<td>1.805</td>
<td>0.813</td>
<td>-0.025</td>
<td>-0.346</td>
<td>-0.333</td>
<td>-0.178</td>
</tr>
<tr>
<td>Constant</td>
<td>-19.905**</td>
<td>-34.725**</td>
<td>57.819**</td>
<td>-36.945**</td>
<td>-5.335**</td>
<td>-5.838**</td>
<td>8.926**</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td>None</td>
<td>$\alpha$</td>
<td>$\alpha$, $\alpha^2$</td>
<td>$\alpha$, $\alpha^2$, $\alpha^3$</td>
<td>None</td>
<td>$\alpha$</td>
<td>$\alpha$, $\alpha^2$, $\alpha^3$</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.078</td>
<td>0.226</td>
<td>0.383</td>
<td>0.460</td>
<td>0.052</td>
<td>0.345</td>
<td>0.345</td>
<td>0.392</td>
</tr>
<tr>
<td>$N$</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td></td>
</tr>
</tbody>
</table>

Significance levels: * : 5%   ** : 1%

As additional powers of $\alpha$ are included in the regressions, the magnitudes of the coefficients of age and gender tend to decrease. When $\alpha$ and $\alpha^2$ (or $\alpha$, $\alpha^2$, and $\alpha^3$) enter the regressions, age and gender are no longer significant.\textsuperscript{20} Hence, conditional on the type of the seller, age and gender do not affect the choice of $B/V$ and $R/V$. Such a pattern is consistent with the assumption that $\alpha$ captures all the relevant information about the seller’s type. We thus accept $H_0$, i.e., the hypothesis that the no arbitrage condition is satisfied.

4.2 Power of the test

A natural question that we need to address is the following: what is the power of the above test, i.e., what is the probability of rejecting the null hypothesis when the null is false. To study the power of our test we assume that the no arbitrage equation is measured with error. More precisely, we suppose that the arbitrage equation takes the form

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

where $\varepsilon$ 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). Let $\tilde{\alpha}$ be the value of $\alpha$ that solves the equation, i.e., it corresponds to the contaminated measure of the type of the seller. The contaminated type coincides with the true type $\alpha$ only if the error term equals zero. Indeed, by construction, $\tilde{\alpha} = \alpha + \frac{r \varepsilon}{r V + R}$. In such a case, $\tilde{\alpha}$ would no longer capture all the relevant seller information. In the regressions reported in Table 6, age and gender would pick up the seller information not captured by the contaminated type and become significant.

\textsuperscript{20}If yet additional powers are included ($\alpha^4$, $\alpha^5$, $\alpha^6$, ...), age and gender remain not significant.
To corroborate this idea, we perform the following simulation exercise. We add a random term of the form $\frac{\epsilon R}{V+R}$ to our variable $\alpha$ where $\epsilon$ follows a normal distribution of zero mean and standard deviation $\sigma$. This process generates a new variable denoted $\tilde{\alpha}_\sigma$, which is the contaminated measure of the type. When $\sigma$ 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 $\tilde{\alpha}_\sigma$. Table 7 reports the results of this simulation study for several values of $\sigma$ (0, 1000, 5000, and 10000). Because the average property value is around €100,000, the order of magnitude of the standard error of the noise is therefore 0%, 1%, 5%, and 10% of the value, respectively. When there is relatively little 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 7: Evidence of power of the test

<table>
<thead>
<tr>
<th>$\sigma$ =0</th>
<th>$\sigma$ =1000</th>
<th>$\sigma$ =5000</th>
<th>$\sigma$ =10000</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B/V$</td>
<td>$R/V$</td>
<td>$B/V$</td>
<td>$R/V$</td>
</tr>
<tr>
<td>Age (seller)</td>
<td>-0.004</td>
<td>0.025</td>
<td>0.053</td>
</tr>
<tr>
<td>Male (seller)</td>
<td>0.813</td>
<td>-0.178</td>
<td>0.923</td>
</tr>
</tbody>
</table>

Controls $\alpha$, $\alpha^2$, $\alpha^3$

| $R^2$ | 0.460 | 0.392 | 0.414 | 0.386 | 0.194 | 0.269 | 0.141 | 0.174 |
| N | 874 | 874 | 874 | 874 | 874 | 874 | 874 | 874 |

Significance levels: * : 5% ** : 1%

Further evidence in support of the validity of the no arbitrage condition and the idea that it allows us to identify the seller’s type, can be found in Appendix B. There we show the results of four additional sets of regressions that are similar to those shown in Table 6 except that the type is replaced by other functions of the contract parameters. (see Tables 11-14). For instance in the regressions corresponding to Table 11, we have replaced $\alpha$ by $\beta = B/R$. Similarly, in Table 12, $\alpha$ is replaced by $\beta = B/V + \frac{1}{2}R/V$. In each of the four sets of regressions the parameter $\beta$ is a somewhat arbitrary function of $B/V$ and $R/V$ and differs from the seller’s type $\alpha$. Therefore $\beta$ has no reason to capture all relevant information and we expect that age and gender remain significant, even after additional powers of $\beta$ are added as controls. The results reported in Tables 11-14 confirm this. In each case the variables age and gender tend to remain significant even when additional powers of $\beta$ are included in the models. Apparently the parameters $\beta$ do not fully 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 $\beta$s as ad hoc functions of the contract parameters. On the contrary, $\alpha$, which is defined via an equation with economic foundation, does capture the information contained in age and gender. All these results reinforce the conclusion that $\alpha$ corresponds both theoretically...
4.3 Risk aversion on the buyer side

The no arbitrage condition supposes implicitly that buyers are risk neutral. One may wonder how this condition is modified if buyers are risk averse and if, in our data, risk aversion is an important issue.

In Appendix A.3, we derive the no arbitrage condition in the case where the buyer is risk averse. It is important to remark that, as previously, the survival probabilities enter the condition only through the same weighted average $\alpha$. As before, the extended no arbitrage condition allow us to express $\alpha$ in terms of the contract parameters and $r$. However, the type is now also a function of $\rho$, the absolute risk aversion ratio:

$$\alpha \approx \frac{rB + R + \rho (rB^2 + R^2)/2}{rV + R + \rho (R^2 - r^2V^2)/2}$$

Note that when $\rho = 0$, (5) is identical to (4). For a given $\rho > 0$, we can derive, thanks to this equation, the corresponding values of $\alpha$. As in Section 4.1, we can then regress $B/V$ and $R/V$ on age, gender, $\alpha$, $\alpha^2$, and $\alpha^3$. As $\alpha$ should capture all the information about the seller, age and gender should not be significant in these regressions. This test allows us to find if standard values of $\rho$ found in the literature are compatible with our data.

Table 8 reports the results of the regressions for $\rho$ varying between $10^{-5}$ and $10^{-1}$. These values of $\rho$ correspond to those reported by Cohen and Einav (2007) in their Table 5 (page 764). More precisely, the estimates of the risk-aversion ratio (both from their data and from other papers) vary between $3.2 \times 10^{-2}$ and $6.6 \times 10^{-5}$.

<table>
<thead>
<tr>
<th>$\rho$</th>
<th>$B/V$</th>
<th>$R/V$</th>
<th>$B/V$</th>
<th>$R/V$</th>
<th>$B/V$</th>
<th>$R/V$</th>
<th>$B/V$</th>
<th>$R/V$</th>
<th>$B/V$</th>
<th>$R/V$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-5}$</td>
<td>0.031</td>
<td>0.080**</td>
<td>0.558**</td>
<td>0.121**</td>
<td>0.625**</td>
<td>0.111**</td>
<td>0.619**</td>
<td>0.111**</td>
<td>0.621**</td>
<td>0.110**</td>
</tr>
<tr>
<td>$10^{-4}$</td>
<td>-0.031</td>
<td>0.080**</td>
<td>0.558**</td>
<td>0.121**</td>
<td>0.625**</td>
<td>0.111**</td>
<td>0.619**</td>
<td>0.111**</td>
<td>0.621**</td>
<td>0.110**</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>-0.031</td>
<td>0.080**</td>
<td>0.558**</td>
<td>0.121**</td>
<td>0.625**</td>
<td>0.111**</td>
<td>0.619**</td>
<td>0.111**</td>
<td>0.621**</td>
<td>0.110**</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>-0.031</td>
<td>0.080**</td>
<td>0.558**</td>
<td>0.121**</td>
<td>0.625**</td>
<td>0.111**</td>
<td>0.619**</td>
<td>0.111**</td>
<td>0.621**</td>
<td>0.110**</td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>-0.031</td>
<td>0.080**</td>
<td>0.558**</td>
<td>0.121**</td>
<td>0.625**</td>
<td>0.111**</td>
<td>0.619**</td>
<td>0.111**</td>
<td>0.621**</td>
<td>0.110**</td>
</tr>
</tbody>
</table>

Significance levels: * : 5% ** : 1%

It appears that all values of $\rho$ between $10^{-5}$ and $10^{-1}$ are rejected in our data because age and/or gender are significant in the regressions of the relative contract parameters. The coefficient of age is always significant in the $R/V$ regressions. In the $B/V$ regressions, both the coefficients of age and gender are significant for $\rho$ higher than or equal to $10^{-4}$.
We thus conclude that the data are only compatible with the assumption that buyers are risk neutral.\footnote{We only accept degrees of absolute risk-aversion that are lower than $\rho = 5 \times 10^{-7}$. An individual with a CARA utility function and such a value of $\rho$ is indifferent between participating in a 50-50 lottery of gaining 100€ and losing 99.99€, and not participating in this lottery.} This result is not surprising given that the buyers are wealthy (see Section 2.2). \textit{Viager} sales are only accessible to rich individuals who can pay on average a down payment of 34,000€ and a yearly annuity of 7,000€. This is reinforced by the fact that buyers cannot occupy the apartment before the death of the seller i.e., on average they have to wait eight years after the date of the contract signature (see Table 3).

## 5 Testing for asymmetric information

As previously mentioned, we suppose that sellers know their type $\alpha$. The question that still remains open is how sellers transmit the information to buyers. The main conclusion of Section 3.2 is that sellers have shorter life expectancies than comparable individuals from the population. The personal information they have about their survival prospects through their type $\alpha$ must somehow be shared with the buyer. Indeed, for a buyer to sign a \textit{viager} contract with a seller who claims to have a shorter life expectancy than 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. 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 about $\alpha$ (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.

As we do not have the death dates of the sellers we cannot use the asymmetric information tests developed by Chiappori and Salanié (2000) and Dionne, Gouriéroux, and Vanasse (2001). Instead, to decide which of the two cases best explains our data, Section 5.1 proposes a model for a \textit{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. In Section 5.2 we develop the regression model that allows us to actually test the predictions. Section 5.3 confronts the predictions and the outcomes in the data. Finally, we verify in Section 5.4 that the seller’s type is exogenous in our regression equations.

### 5.1 Theoretical 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 (3)) the following expected intertemporal
utility function:

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

(6)

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 \( \mu \) which represents the marginal utility of giving. \(^{22}\) 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 \( \alpha \) 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 \( \mu \)). \(^{23}\) Under asymmetric information about \( \alpha \), 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. \(^{24}\) 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 annuity are positive. \(^{25}\)

**Proposition 2.** (i) The down payment increases with \( \mu \) whereas the annuity decreases with this parameter.

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

- If \( \mu \leq \mu \), the donation motive is too weak and \( D^* = 0 \). The equilibrium values of the down payment and the annuity reflect the desire to smooth consumption (the consumption level

\(^{22}\)The amount of money \( D \) and the associated utility parameter \( \mu \) can also be interpreted in other ways. For example, \( \mu \) 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 annuity.

\(^{23}\)The issue of multi-dimensional asymmetric information has been studied in Finkelstein and McGarry (2006) and Fang, Keane, and Silverman (2008).

\(^{24}\)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).

\(^{25}\)This allow us to avoid discussing corner solutions. In our data set, \( B = 0 \) for one observation, and \( R = 0 \) for 33 observations. After omitting these observations, the sample size is \( N = 830 \).
is the same in each period): \( B^* + W = R^* = -rV + \frac{r(1+r)V}{1+r-\alpha} \). Both \( B^* \) and \( R^* \) increase with \( \alpha \) and \( V \) at the same rate.

- If \( \mu > \mu \), the donation motive is strong enough and \( D^* > 0 \). The annuity is independent of \( \alpha \) and \( V \): \( R^* = u^{-1}(\mu) \). The down payment and the donation are both increasing with \( \alpha \) 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 annuity is decreasing with \( \alpha \).

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.\(^{26}\) The parameter \( \mu \) 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 annuity.

![Figure 3: The effect of a variation of \( \alpha \) on equilibrium](image)

Figure 3 helps visualizing the effect of a change of \( \alpha \) on the equilibrium values. Let us start from the equilibrium point \( A_0 \), and assume that \( \alpha \) increases from \( \alpha_0 \) to \( \alpha_1 \) (everything else remaining constant). Note that \( A_0 \) is therefore located on the straight line defined by the no arbitrage condition (3) with \( \alpha = \alpha_0 \). Under symmetric information there are two possibilities depending on the specific value of \( \mu \). First, if \( \mu \) is such that \( D^* = 0 \), then the equilibrium moves

\(^{26}\)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 (\( \mu \) smaller and larger than the threshold value) we have \( B^* - D^* + W = R^* \).
to $A_1'$, a point located on the line defined by (3) with $\alpha = \alpha_1$: both $B^*$ and $R^*$ increase and they increase at the same rate. Second, if $\mu$ is large enough such that $D^* > 0$, then the new equilibrium adjusts to $A_1$: the annuity 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 $\alpha$ is that the equilibrium shifts from $A_0$ to $A_1''$. That is, to a larger down payment but a smaller annuity.

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 (resp. annuity) increases (resp. decreases) with $\alpha$ for sellers to be able to signal their type. If on the contrary both variables were increasing in $\alpha$, all sellers would have an incentive to lie about their type and benefit from both a larger down payment and a larger annuity. By requiring a smaller annuity, 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 annuity.

5.2 Empirical model

The basic idea of the empirical test consists in studying the shape of the down payment and annuity when $\alpha$ 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 $\alpha$ 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 $\alpha$, or between the annuity and $\alpha$. 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 annuity.

Proposition 2 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 $\mu_i > \mu^*$. The condition $\mu_i > \mu^*$ is equivalent to the condition $\alpha_i > \alpha_i = ((1 + r)u'^{-1}(\mu_i) - rW_i) / (rV_i + u'^{-1}(\mu_i))$. Treating $\mu_i$, $V_i$ and $W_i$ as random variables, the condition $\alpha_i > \alpha_i$ can be rewritten as $\alpha_i - \alpha_i = \beta_0^3 + \beta_1^3 \alpha_i + \tilde{\varepsilon}_3 < 0$. In this expression the constant $\beta_0^3$ equals $E[\alpha_i]$ (the expectation of $\alpha_i$), $\beta_1^3$ equals -1, and $\tilde{\varepsilon}_3$ is an error term with mean zero. Dividing by the standard deviation of $\tilde{\varepsilon}_3$, the condition $\alpha_i > \alpha_i$ can be written as $\beta_0^3 + \beta_1^3 \alpha_i + \varepsilon_3 < 0$, where $\beta_0^3$ (resp. $\beta_1^3$) equals $\beta_0^3$ (resp. $\beta_1^3$) divided by the standard deviation of $\tilde{\varepsilon}_3$, and $\varepsilon_3$ is an error term with mean zero and variance 1. If $\alpha_i > \alpha_i$ then $R_i/V_i = u'^{-1}(\mu_i)/V_i$, which can be rewritten as $R_i/V_i = \beta_0^3 + \beta_1^3 \left( \frac{1}{1+r-\alpha_i} \right) + \varepsilon_2$, where $\beta_0^3 = E[u'^{-1}(\mu_i)/V_i]$, $\beta_1^2 = 0$ (since $R_i$ should not vary with $\alpha_i$ in the donation regime, $\beta_1^2$ should
equal zero when multiplied by any function of $\alpha_i$), and $\varepsilon_{2i}$ is an error term with mean zero. We can in the same way write down the specification of $R_i/V_i$ in the no donation regime. If $\alpha_i < \alpha_0$, then $R_i/V_i = -r + \frac{\gamma_1}{1+r-\alpha_i}$, which can be rewritten as $R_i/V_i = \beta_0 + \beta_1 \left( \frac{1}{1+r-\alpha_i} \right) + \varepsilon_{1i}$, where $\beta_0 = -r$, $\beta_1 = E[r(1 + r + W_i/V_i)]$, and $\varepsilon_{1i}$ is an error term with mean zero.

We can therefore write down the model for $R_i/V_i$ as the following switching regression model:

$$
\begin{align*}
R_i/V_i &= -r + \frac{\gamma_1}{1+r-\alpha_i} = \beta_0 + \beta_1 \left( \frac{1}{1+r-\alpha_i} \right) + \varepsilon_{1i} \quad \text{if } y_i \geq 0 \text{ (no donation, regime 1)} \\
R_i/V_i &= u^{-1}(\mu_i)/V_i = \beta_0 + \beta_2 \left( \frac{1}{1+r-\alpha_i} \right) + \varepsilon_{2i} \quad \text{if } y_i < 0 \text{ (donation, regime 2)} \\
y_i &= \alpha_i - \alpha_i = \beta_0 + \beta_3 \alpha_i + \varepsilon_{3i} \quad \text{(switching equation)}
\end{align*}
$$

We furthermore assume that $W_i/V_i$ and $u^{-1}(\mu_i)/V_i$ are independent of $\alpha_i$. We finally assume that $\varepsilon_{ki}$ ($k = 1, 2, 3$) is normally distributed. The model implies that $\varepsilon_{3i}$ is correlated with $\varepsilon_{1i}$ and $\varepsilon_{2i}$. We therefore have that $\varepsilon_{3i}$ follows a normal distribution $\mathcal{N}(0, 1)$, and conditionally on $\varepsilon_{3i}$, $\varepsilon_{1i}$ (resp. $\varepsilon_{2i}$) 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. Once the model is estimated we can test whether information is symmetrically or asymmetrically distributed. Under symmetric information we should have $\beta_1 > 0$ (in the absence of donation, the annuity increases with $\alpha$), $\beta_2 = 0$ (in the presence of donation, the annuity is independent of $\alpha$), and $\beta_3 < 0$ (the no donation regime is more likely to occur when $\alpha$ is small).

Under asymmetric information the annuity should decrease with the type so we expect in this case that $\beta_1 < 0$ and $\beta_2 < 0$.

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 $B/V - R/V$:

$$
\begin{align*}
B_i/V_i - R_i/V_i &= \gamma_0 + \gamma_1 \alpha_i + \xi_{1i} \quad \text{if } z_i > 0 \text{ (no donation, regime 1)} \\
B_i/V_i - R_i/V_i &= \gamma_0 + \gamma_2 \alpha_i + \xi_{2i} \quad \text{if } z_i \leq 0 \text{ (donation, regime 2)} \\
z_i &= \gamma_0 + \gamma_3 \alpha_i + \xi_{3i} \quad \text{(switching equation)}
\end{align*}
$$

where $\xi_{ki}$ ($k = 1, 2, 3$) is assumed to follow a normal distribution. Analogously to the error terms in the switching regression model for $R_i/V_i$, $\xi_{1i}$ and $\xi_{2i}$ are both correlated with $\xi_{3i}$. According to Proposition 2, we expect under symmetric information $\gamma_1 = 0$ (when there is no donation, the down payment and annuity increase with $\alpha$ at the same rate so their difference is constant), $\gamma_1 > 0$ (when there is a donation, the annuity is independent of $\alpha$ while the down payment increases in the type), and $\gamma_1 < 0$ (sellers with small $\alpha$ are less likely to donate). Under asymmetric information we expect $\gamma_1 > 0$ and $\gamma_2 > 0$ (the down payment increases and the annuity decreases with $\alpha$).
5.3 Estimation results

The results of the switching regression model (7) are shown in Table 9. They are completely in line with the symmetric information predictions: $\beta_1^*$ is positive and significative, and $\beta_2^*$ is not statistically different from zero. Finally, $\beta_3^*$ 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 annuity does not decrease with $\alpha_i$ in either regime.

Table 9: Switching regression of the relative annuity on $\alpha$

<table>
<thead>
<tr>
<th></th>
<th>Regime 1 ($D^* = 0$)</th>
<th>Regime 2 ($D^* &gt; 0$)</th>
<th>Switching reg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1/(1 + r - \alpha)$</td>
<td>7.0789**</td>
<td>-0.1145</td>
<td>-13.0916**</td>
</tr>
<tr>
<td></td>
<td>(0.2438)</td>
<td>(0.1686)</td>
<td>(1.0911)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>-10.1880**</td>
<td>9.4410**</td>
<td>9.0075**</td>
</tr>
<tr>
<td></td>
<td>(0.5772)</td>
<td>(0.6600)</td>
<td>(0.8244)</td>
</tr>
<tr>
<td>N</td>
<td>830</td>
<td>830</td>
<td>830</td>
</tr>
</tbody>
</table>

Significance levels: * : 5%  ** : 1%

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

Figure 4: $R/V$ as a function of $\alpha$
The results of the switching regression (8) are shown in Table 10. They are, again, fully in line with the symmetric model predictions: $\gamma_1$ is not significantly different from zero, $\gamma_2$ is significantly positive, and $\gamma_3$ is significantly negative. These results corroborate the ones of Table 9. As the down payment and the annuity are linked through equation (3), this does not come as a surprise. In theory, both regressions are strictly equivalent. In practice, however, the fact that the implications of Table 9 and Table 10 are the same is reassuring as it suggests that our assumptions on the error terms are valid.

Table 10: Switching regression of the relative down payment on $\alpha$

<table>
<thead>
<tr>
<th></th>
<th>Regime 1 ($D^* = 0$)</th>
<th>Regime 2 ($D^* &gt; 0$)</th>
<th>Switching reg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>2.4785</td>
<td>230.9328**</td>
<td>-15.4699**</td>
</tr>
<tr>
<td></td>
<td>(10.8149)</td>
<td>(39.4322)</td>
<td>(2.2811)</td>
</tr>
<tr>
<td>Constant</td>
<td>13.2584*</td>
<td>-139.51**</td>
<td>12.3717**</td>
</tr>
<tr>
<td></td>
<td>(6.8042)</td>
<td>(35.1617)</td>
<td>(1.8658)</td>
</tr>
<tr>
<td>$N$</td>
<td>830</td>
<td>830</td>
<td>830</td>
</tr>
</tbody>
</table>

Significance levels: *: 5% **: 1%

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

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

Figure 4 shows all values of $\alpha_i$ and $R_i/V_i$, and the fitted equations obtained from the switching
regression of \( R_i/V_i \) on \( \frac{1}{1+r-a_i} \) and a constant (see Table 9). The roughly horizontal line corresponds to the fitted equation in the donation regime (the probability of being in the donation regime is higher for individuals with large \( \alpha \)), and the increasing curved line corresponds to the one in the no donation regime. Figure 4 clearly illustrates that our findings are in support of symmetric information: the relative annuity is independent of the seller’s type in the donation regime, but increases with the type in the no donation regime. Figure 5 shows all values of \( \alpha_i \), the difference \( B_i/V_i - R_i/V_i \), and the fitted equations obtained from the switching regression of the latter on the former and a constant (see Table 10). Here, the horizontal line corresponds to the fitted equation in the no donation regime, and the increasing line to the one in the donation regime.

The problem of asymmetric information may be more severe when buyers are firms instead of individuals.\(^{27}\) The reasoning is as follows. Typical individual sellers and buyers may have some sort of information transmission mechanism (such as personal connections) which enables them to conquer the asymmetric information problem. However, institutional buyers may not have these personal connections and thus have difficulties to overcome the problem. To test this possibility we split the sample according to whether the buyer is a firm or an individual, and perform the same analysis as above on the two sub-samples. The results are in Appendix E. Although the estimates based on the two sub-samples are somewhat different in magnitude, their signs are the same, and the significance tests lead to the same conclusion: the information between parties is symmetric, both when the seller is an individual and a firm.

Since sellers are not representative of the whole population, the results of this section must be interpreted with care. Our estimates measure the impact of \( \alpha \) on the relative contract parameters for individuals who have decided to sell their property via the viager mechanism. Nothing can be said, however, about the impact of \( \alpha \) for property-owners who have decided to sell on the regular market.\(^{28}\) This auto-selection of viager sellers does not interfere, however, with our test of asymmetric information. As standard in the literature, the test is designed to check for information asymmetries between buyers and sellers who have opted for the mechanism. Finkelstein and Poterba (2004), for instance, use data on purchasers of annuity contracts, and analyze the issue of asymmetric information between the insurer and individuals who have actually chosen to buy the insurance contract.

### 5.4 Exogeneity of \( \alpha \)

In deriving the empirical results of Section 5.3, we have assumed that \( \alpha \) is exogenous in the regressions. One may nevertheless suspect endogeneity problems for at least two reasons. First, \( \alpha \) is not directly observed but recovered as a function of \( B \) and \( R \). Measurement errors in these variables may create a spurious correlation between the recovered \( \alpha \) and the contract parameters and hence bias the estimates. A second source of endogeneity could come from an omitted variable problem. We have assumed for instance that \( W_i/V_i \) and \( u^{-1}(\mu_i)/V_i \) are independent from \( \alpha \). If this does not hold, or if there are other variables both correlated with \( \alpha \) and not included in the model, then \( \alpha \) would be endogenous and our results biased.

\(^{27}\)We thank a referee for this suggestion.

\(^{28}\)We thank another referee for this remark.
To test for the exogeneity of the seller’s type we perform a Hausman test, using $\alpha_{\text{Insee}}$ as an instrument for $\alpha_i$. Recall that $\alpha_{\text{Insee}}$ is the national-level sum of death probabilities for a representative individual of the same age, gender, and cohort as $i$. It is hence clearly correlated to $\alpha_i$. Under our maintained assumption that the age and gender of $i$ have no effect on the relative contract parameters once $\alpha_i$ is controlled for, it is likely that $\alpha_{\text{Insee}}$ is uncorrelated with the error term. Indeed, $\alpha_{\text{Insee}}$ being calculated on the basis of national mortality statistics, there is no reason why it should be related to seller-specific determinants of contract choices (determinants other than the seller’s age and gender, and not included in the regression). The national-level sum seems therefore a good instrument for the seller’s type. Appendix F presents the regressions of $B/V$ and $R/V$ on $\alpha$, instrumented or not by $\alpha_{\text{Insee}}$. For both regression models, the Hausman test implies that the exogeneity of $\alpha$ can be accepted. For the regression model of the relative down payment, the test statistic (distributed as a $\chi^2(1)$ under the null) is 1.33 (p-value is 0.25). For the model of the relative annuity the test statistic is 0.76 (p-value is 0.38). We may thus assume that the seller’s type is exogenous.

6 Conclusion

This paper studies the viager real estate market. Homeowners who sell their property via the viager mechanism get in exchange a down payment from the buyer and regular annuity payments until their death. They also retain the usufruct of their property. In spite of the fact that such sales can be attractive especially for older homeowners with otherwise few financial resources, the size of the market is small. We analyze whether this may be explained by asymmetries of information about the survival prospects of sellers. We use data on viager sales in Paris. The data set records the contract parameters of each transaction and the age and gender of sellers. It does not, however, record the death dates of sellers. For this reason we cannot implement the frequently used positive association test for asymmetric information proposed by Chiappori and Salanié (2000) and Dionne, Gouriéroux, and Vanasse (2001). Instead we take a new approach which consists, in a first step, to identify the seller’s type via a no arbitrage condition. The seller’s type is a sum of death probabilities of the seller. In a second step we check for asymmetric information essentially by regressing the contract parameters on the seller’s type and performing standard significance tests.

By comparing the seller-specific sums of death probabilities with similarly defined national-level sums, we find that viager sellers have shorter life expectancies than representative individuals from the population. Given that people know their future life time distribution, our finding indicates that sellers auto-select in the viager market. Evidence of auto-selection has also been found in the related insurance markets for annuities and reverse mortgages see Davidoff and Welke (2007) and Finkelstein and Poterba (2002).

Our regressions of the contract parameters on the seller’s type indicate that there is no evidence of asymmetric information between buyers and sellers. Apparently sellers are able to unveil the hidden information about their survival prospects when they enter into contact with buyers. In the viager market, buyers thus succeed in recovering the true type of the sellers and in solving the asymmetry problem. Our findings are related with Finkelstein and Poterba (2004) who find that there is asymmetric information in the annuity market. In this market the
different contract prices only depend on the annuitant’s age and gender, which may explain that these contracts are plagued by problems of asymmetric information. Insurance companies selling annuities should be able to solve the issue of asymmetric information by designing a scoring system that incorporates more information about clients than just their age and gender.

As asymmetric information is not the problem, the limited size of the market remains a puzzle. Some explanations could be based on psychological and behavioral considerations in spirit to the ones offered in a recent paper by Brown (2007) who argues that such insights may be useful in understanding the limited size of annuity markets.

References


Appendix

A  No arbitrage condition

It is useful to prove the following property:

\[
\sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} = \frac{\delta}{1 - \delta} \left[ 1 - \sum_{t=0}^{T} \pi_t \delta^t \right] \tag{9}
\]

Indeed,

\[
\sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} = \sum_{t=1}^{T} \pi_t \delta \frac{1 - \delta^t}{1 - \delta} = \frac{\delta}{1 - \delta} \left[ \sum_{t=1}^{T} \pi_t - \sum_{t=1}^{T} \pi_t \delta^t \right] = \frac{\delta}{1 - \delta} \left[ \sum_{t=1}^{T} \pi_t + \pi_0 - \pi_0 - \sum_{t=1}^{T} \pi_t \delta^t \right] = \frac{\delta}{1 - \delta} \left[ 1 - \sum_{t=0}^{T} \pi_t \delta^t \right]
\]

A.1 Another interpretation of the no arbitrage condition

Recalling that \( L \) is the per period amount of money that must be paid by a tenant to rent a property of value \( V \), we have, on a competitive real estate market, \( V = \sum_{t=1}^{\infty} \delta^t L = \delta L/(1 - \delta).^{29} \)

Using (9) we have:

\[^{29}\text{In practice, both } L \text{ and } R \text{ are indexed to the consumer price index, and we can ignore inflation in the analysis.} \]
\[ \sum_{t=0}^{T} \pi_t \delta^t V = \frac{\delta}{1-\delta} \sum_{t=0}^{T} \pi_t \delta^t = \frac{\delta}{1-\delta} \left[ 1 - \frac{1 - \delta}{\delta} \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} \right] \]

\[ = \frac{\delta}{1-\delta} L - \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} L \]

Hence, using (1) we get

\[ B = \sum_{t=0}^{T} \pi_t \delta^t V - \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} R = \frac{\delta}{1-\delta} L - \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} (R + L) \]

Using that \( \delta L / (1-\delta) = V \) we can establish:

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

It provides another interpretation of the no arbitrage condition. A property on the regular market costs \( V \). The expected opportunity cost of the \textit{viager} buyer is the right-hand side. Indeed, he first has to pay \( B \), then \( R \) at every period until the seller dies. Moreover, in addition to these monetary transfers, the buyer cannot collect \( L \) (from \( t = 0 \) up to the date of death) as a normal owner does. This condition can be seen as a no arbitrage condition on the real-estate market. It states that the value of a property is the same on both the standard and \textit{viager} markets.

A.2 Proof of equation (3)

Using (1), (9), and the definition of \( \alpha \) (2) we have

\[ \alpha V = B + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} R = B + \frac{\delta}{1-\delta} \left[ 1 - \sum_{t=0}^{T} \pi_t \delta^t \right] R \]

\[ = B + \frac{\delta}{1-\delta} [1-\alpha] R = B + \frac{1-\alpha}{\delta} R \]

A.3 Proof of equation (5)

Let \( u(.) \) denote the utility function of the buyer and let \( W \) be the buyer’s per period revenue. We now compute the expected and discounted utility when the buyer purchases a \textit{viager} with parameters \( V, B, \) and \( R \). To do that it is key to see \( V \) as an infinite flow of \( L \). The utility is given by:

\[ u(W - B) + \pi_0 \sum_{t'=1}^{+\infty} \delta^{t'} u(W + L) + \sum_{t=1}^{T} \pi_t \left[ \sum_{t'=0}^{t} \delta^{t'} u(W - R) + \sum_{t'=t+1}^{+\infty} \delta^{t'} u(W + L) \right] \]
where the $+\infty$ expresses the assumption that the buyer dies for sure after the seller. This expression can be rewritten, using (9), as

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

where, as under risk-neutrality, the death probabilities are all summarized by $\alpha$. The alternative of buying on the standard market or of not buying (as the standard market is competitive) leaves the buyer with

$$\sum_{t=0}^{+\infty} \delta^t u(W) = u(W) + \frac{1 - \alpha}{r} u(W) + \frac{\alpha}{r} u(W)$$

Hence,

$$u(W - B) + \frac{1 - \alpha}{r} u(W - R) + \frac{\alpha}{r} u(W + L) = u(W) + \frac{1 - \alpha}{r} u(W) + \frac{\alpha}{r} u(W)$$

that is

$$\alpha = \frac{r [u(W) - u(W - B)] + [u(W) - u(W - R)]}{\frac{r [u(W + L) - u(W)]}{r} + [u(W) - u(W - R)]}$$

which is very similar to (4) with $u(W) - u(W - B)$ instead of $B$, $u(W) - u(W - R)$ instead of $R$ and $(u(W + L) - u(W))/r$ instead of $V$ (because $V = L/r$). The utility function $u(.)$ has to be known to compute the exact value of $\alpha$ compatible with the viager parameters. If one does not wish to specify the utility function, one can nonetheless approximates $\alpha$ using Taylor expansions.

In particular, $u(W) - u(W - B) \approx Ru'(W) - B^2 u''(W)/2$ and $u(W + L) - u(W) \approx Lu'(W) + L^2 u''(W)/2$. Moreover, as $V = L/r$, we have $(u(W + L) - u(W))/r \approx Vu'(W) + rV^2 u''(W)/2$. Substituting into the above expression of $\alpha$ leads to

$$\alpha \approx \frac{r [Bu'(W) - B^2 u''(W)/2] + [Ru'(W) - R^2 u''(W)/2]}{r [Vu'(W) + rV^2 u''(W)/2] + [Ru'(W) - R^2 u''(W)/2]}$$

Introducing the absolute risk aversion index: $\rho = -u''(W)/u'(W)$ gives (5).
B Effect of age and gender on $B/V$ and $R/V$ conditionally on various functions of $B/V$ and $R/V$

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

<table>
<thead>
<tr>
<th></th>
<th>$B/V$ (I)</th>
<th>$B/V$ (II)</th>
<th>$B/V$ (III)</th>
<th>$B/V$ (IV)</th>
<th>$R/V$ (I)</th>
<th>$R/V$ (II)</th>
<th>$R/V$ (III)</th>
<th>$R/V$ (IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (seller)</td>
<td>0.633**</td>
<td>0.651**</td>
<td>0.553**</td>
<td>0.497**</td>
<td>0.109**</td>
<td>0.096**</td>
<td>0.116**</td>
<td>0.125**</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.07)</td>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Gender (seller)</td>
<td>5.426**</td>
<td>5.721**</td>
<td>4.905**</td>
<td>4.842**</td>
<td>-0.025</td>
<td>0.016</td>
<td>0.184</td>
<td>0.194</td>
</tr>
<tr>
<td></td>
<td>(1.34)</td>
<td>(1.35)</td>
<td>(1.14)</td>
<td>(0.27)</td>
<td>(0.26)</td>
<td>(0.24)</td>
<td>(0.22)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-19.905**</td>
<td>-21.639**</td>
<td>-15.998**</td>
<td>-16.431**</td>
<td>-1.169</td>
<td>0.259</td>
<td>-0.903</td>
<td>-0.834</td>
</tr>
<tr>
<td></td>
<td>(6.24)</td>
<td>(6.44)</td>
<td>(6.11)</td>
<td>(5.34)</td>
<td>(1.27)</td>
<td>(1.20)</td>
<td>(1.12)</td>
<td>(1.01)</td>
</tr>
<tr>
<td>Controls</td>
<td>None</td>
<td>$\beta$</td>
<td>$\beta^2$</td>
<td>$\beta^2, \beta^3$</td>
<td>None</td>
<td>$\beta$</td>
<td>$\beta^2$</td>
<td>$\beta, \beta^2, \beta^3$</td>
</tr>
<tr>
<td>R²</td>
<td>0.078</td>
<td>0.083</td>
<td>0.185</td>
<td>0.377</td>
<td>0.052</td>
<td>0.056</td>
<td>0.184</td>
<td>0.330</td>
</tr>
<tr>
<td>N</td>
<td>874</td>
<td>831</td>
<td>831</td>
<td>831</td>
<td>874</td>
<td>831</td>
<td>831</td>
<td>831</td>
</tr>
</tbody>
</table>

Significance levels: * : 5%  ** : 1%

Table 12: Effect of age and gender conditionally on $\beta = B/V + \frac{1}{2}R/V$

<table>
<thead>
<tr>
<th></th>
<th>$B/V$ (I)</th>
<th>$B/V$ (II)</th>
<th>$B/V$ (III)</th>
<th>$B/V$ (IV)</th>
<th>$R/V$ (I)</th>
<th>$R/V$ (II)</th>
<th>$R/V$ (III)</th>
<th>$R/V$ (IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (seller)</td>
<td>0.633**</td>
<td>0.777**</td>
<td>0.810**</td>
<td>0.812**</td>
<td>0.109**</td>
<td>-0.039**</td>
<td>-0.040**</td>
<td>-0.041**</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.02)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Gender (seller)</td>
<td>5.426**</td>
<td>5.677**</td>
<td>6.055**</td>
<td>6.087**</td>
<td>-0.025</td>
<td>-0.284**</td>
<td>-0.303**</td>
<td>-0.304**</td>
</tr>
<tr>
<td></td>
<td>(1.34)</td>
<td>(1.32)</td>
<td>(1.30)</td>
<td>(1.30)</td>
<td>(0.27)</td>
<td>(0.07)</td>
<td>(0.07)</td>
<td>(0.06)</td>
</tr>
<tr>
<td></td>
<td>(6.24)</td>
<td>(6.14)</td>
<td>(6.61)</td>
<td>(7.08)</td>
<td>(1.27)</td>
<td>(0.31)</td>
<td>(0.33)</td>
<td>(0.35)</td>
</tr>
<tr>
<td>Controls</td>
<td>None</td>
<td>$\beta$</td>
<td>$\beta^2$</td>
<td>$\beta^2, \beta^3$</td>
<td>None</td>
<td>$\beta$</td>
<td>$\beta^2$</td>
<td>$\beta, \beta^2, \beta^3$</td>
</tr>
<tr>
<td>R²</td>
<td>0.078</td>
<td>0.111</td>
<td>0.136</td>
<td>0.141</td>
<td>0.052</td>
<td>0.944</td>
<td>0.946</td>
<td>0.946</td>
</tr>
<tr>
<td>N</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
</tr>
</tbody>
</table>

Significance levels: * : 5%  ** : 1%

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

<table>
<thead>
<tr>
<th></th>
<th>$B/V$ (I)</th>
<th>$B/V$ (II)</th>
<th>$B/V$ (III)</th>
<th>$B/V$ (IV)</th>
<th>$R/V$ (I)</th>
<th>$R/V$ (II)</th>
<th>$R/V$ (III)</th>
<th>$R/V$ (IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (seller)</td>
<td>0.633**</td>
<td>0.742**</td>
<td>0.677**</td>
<td>0.634**</td>
<td>0.109**</td>
<td>0.086**</td>
<td>0.099**</td>
<td>0.109**</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.06)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.02)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Gender (seller)</td>
<td>5.426**</td>
<td>4.885**</td>
<td>3.669**</td>
<td>3.398**</td>
<td>-0.025</td>
<td>0.092</td>
<td>0.339*</td>
<td>0.400*</td>
</tr>
<tr>
<td></td>
<td>(1.34)</td>
<td>(1.01)</td>
<td>(0.92)</td>
<td>(0.88)</td>
<td>(0.27)</td>
<td>(0.19)</td>
<td>(0.17)</td>
<td>(0.16)</td>
</tr>
<tr>
<td></td>
<td>(6.24)</td>
<td>(4.68)</td>
<td>(4.35)</td>
<td>(4.29)</td>
<td>(1.27)</td>
<td>(0.89)</td>
<td>(0.82)</td>
<td>(0.79)</td>
</tr>
<tr>
<td>Controls</td>
<td>None</td>
<td>$\beta$</td>
<td>$\beta^2$</td>
<td>$\beta^2, \beta^3$</td>
<td>None</td>
<td>$\beta$</td>
<td>$\beta^2$</td>
<td>$\beta, \beta^2, \beta^3$</td>
</tr>
<tr>
<td>R²</td>
<td>0.078</td>
<td>0.482</td>
<td>0.572</td>
<td>0.609</td>
<td>0.052</td>
<td>0.530</td>
<td>0.622</td>
<td>0.669</td>
</tr>
<tr>
<td>N</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
<td>874</td>
</tr>
</tbody>
</table>

Significance levels: * : 5%  ** : 1%
Table 14: Effect of age and gender conditionally on $\beta = 1 - r(1 - B/V)/(R/V)$

<table>
<thead>
<tr>
<th></th>
<th>$B/V$ (I)</th>
<th>$B/V$ (II)</th>
<th>$B/V$ (III)</th>
<th>$B/V$ (IV)</th>
<th>$R/V$ (I)</th>
<th>$R/V$ (II)</th>
<th>$R/V$ (III)</th>
<th>$R/V$ (IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (seller)</td>
<td>0.633**</td>
<td>0.649**</td>
<td>0.647**</td>
<td>0.535**</td>
<td>0.109**</td>
<td>0.096**</td>
<td>0.078**</td>
<td>0.027*</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Gender (seller)</td>
<td>5.426**</td>
<td>5.753**</td>
<td>5.749**</td>
<td>5.144**</td>
<td>-0.025</td>
<td>0.012</td>
<td>-0.031</td>
<td>-0.309</td>
</tr>
<tr>
<td></td>
<td>(1.34)</td>
<td>(1.38)</td>
<td>(1.38)</td>
<td>(1.36)</td>
<td>(0.27)</td>
<td>(0.26)</td>
<td>(0.23)</td>
<td>(0.20)</td>
</tr>
<tr>
<td></td>
<td>(6.24)</td>
<td>(6.45)</td>
<td>(6.45)</td>
<td>(6.43)</td>
<td>(1.27)</td>
<td>(1.20)</td>
<td>(1.07)</td>
<td>(0.95)</td>
</tr>
<tr>
<td>Controls</td>
<td>None</td>
<td>$\beta$</td>
<td>$\beta$, $\beta^2$</td>
<td>$\beta^2$, $\beta^3$</td>
<td>None</td>
<td>$\beta$</td>
<td>$\beta$, $\beta^2$</td>
<td>$\beta^2$, $\beta^3$</td>
</tr>
<tr>
<td>R²</td>
<td>0.078</td>
<td>0.082</td>
<td>0.082</td>
<td>0.109</td>
<td>0.052</td>
<td>0.055</td>
<td>0.240</td>
<td>0.412</td>
</tr>
<tr>
<td>N</td>
<td>874</td>
<td>831</td>
<td>831</td>
<td>874</td>
<td>831</td>
<td>831</td>
<td>831</td>
<td>831</td>
</tr>
</tbody>
</table>

Significance levels: * : 5% ** : 1%

C Model and proof of Proposition 2

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. Another source of income is the pension received from the social security system. As this pension is constant in real term, we can neglect it without loss of generality. 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

$$C_0 = B - D + W - S_0.$$  \hfill (10)

In year $t > 0$ the consumption level equals

$$C_t = R + (1 + \tilde{r})S_{t-1} - S_t, \ t = 1, \ldots, T.$$  \hfill (11)

The expected utility function of the seller is therefore

$$u(C_0) + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} u(C_{t'}) + \mu D.$$  \hfill (12)

The seller maximizes the expected utility function under no arbitrage condition (3) and the above consumption constraints.

First we prove items (i) and (ii) of Proposition 2. 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 annuity is fixed over time (apart from the variations due to the indexation), the annuity 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 $B$, $D$, $S_0, S_1, \ldots, S_T$, and $R_1, \ldots, R_T$ (instead
of just $B, D, S_0, S_1, \ldots, S_T$, and $R$). We only focus on the equilibria where the down payment and the annuities are strictly positive.

The proof is in three steps. First we show that it is optimal for the seller never to save, i.e., $S_0^* = S_1^* = \ldots = S_T^* = 0$. Second, we show that at the optimum the annuity should not vary over time, i.e., $R_1^* = \ldots = R_T^* = R^*$. 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-annuity 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 annuity 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 annuity is now allowed to vary over time. It is still defined by

$$C_0 = B - D + W - S_0.$$  \hfill (13)

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

$$C_t = R_t + (1 + \tilde{r})S_{t-1} - S_t, \; t = 1, \ldots, T.$$  \hfill (14)

The expected utility function is still given by:

$$u(C_0) + \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} u(C_{t'}) + \mu D.$$  \hfill (15)

Taking into account the time-variation of the annuity, the no arbitrage condition is now given by

$$\alpha V - B = \sum_{t=1}^{T} \pi_t \sum_{t'=1}^{t} \delta^{t'} R_{t'}.$$  \hfill (16)

The seller’s objective is to maximize (15) 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 (16).

• 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, $R'_1, R'_2, \ldots, R'_T$ the sequence of optimal values of the annuity, 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 $R''_1, R''_2, \ldots, R''_T$, defined by

$$R''_t = R'_t \text{ if } t < t_0,$$

$$R''_{t_0} = R'_{t_0} - S'_{t_0} \text{ if } t = t_0,$$

$$R''_{t_0+1} = R'_{t_0+1} + (1 + \tilde{r}) \frac{\sum_{t'=t_0}^{T} \pi_{t'}}{\sum_{t'=t_0+1}^{T} \pi_{t'}} S'_{t_0} \text{ if } t = t_0 + 1,$$

$$R''_t = R'_t \text{ if } t > t_0 + 1.$$
It is straightforward to check that the no arbitrage condition remains satisfied. The annuity 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{align*}
    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{align*}

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 (15), the seller’s expected utility function becomes

\begin{equation}
    u(B - D + W) + \sum_{t=1}^{T} \pi_{t} \sum_{t'=1}^{t} \delta^{t'} u(R'_t) + \mu D \tag{17}
\end{equation}

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 (16). Taking into account only the participation constraint, the Lagrangian $\mathcal{L}$ is

\begin{equation}
    \mathcal{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{18}
\end{equation}

where $\lambda$ 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 annuity is time-invariant, the no arbitrage condition now given by equation (3), which we reproduce here for convenience:

\begin{equation}
    \alpha V - B = \frac{1}{\tilde{r}} (1 - \alpha) R. \tag{19}
\end{equation}
The kind of calculations that led to equation (19) can be used to rewrite the expected utility function (17) 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 (19). Taking into account only the constraints \( D \geq 0 \) and (19), the Lagrangian is
\[ \mathcal{L} = u(B - D + W) + \frac{1}{r}(1 - \alpha)u(R) + \mu D + \lambda_1 \left( \alpha V - B - \frac{1}{r}(1 - \alpha)R \right) + \lambda_2 D, \quad (20) \]
where \( \lambda_1 \) and \( \lambda_2 \) are the Lagrange parameters. The first order conditions are
\[
\begin{align*}
    u'(B - D + W) &= \lambda_1, \\
    u'(B - D + W) &= \mu + \lambda_2, \\
    u'(R) &= \lambda_1, \\
    \alpha V - B &= \frac{1}{r}(1 - \alpha)R, \\
    \lambda_2 D &= 0.
\end{align*}
\]

The first four equations follow from imposing that the derivative of the Lagrangian with respect to respectively \( B, D, R \) and \( \lambda_1 \) 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

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

In this case, \( B^* \) increases with \( \alpha \), and \( R^* \) is constant.

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

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

In this case, both \( R^* \) and \( B^* \) increase with \( \alpha \).

Note that \( D^* > 0 \) if and only if \( \mu > \underline{\mu} \) where the threshold value is defined by
\[
\underline{\mu} = u' \left( \frac{r}{1 + r - \alpha}(\alpha V + W) \right). \quad (21)
\]
This ends the proof of items (i) and (ii) of Proposition 2 (characterization of the symmetric information equilibrium.

Next we turn to the proof of item (iii) of Proposition 2. 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 \(\alpha\) propose different contract variables. Consider two sellers, characterized by \(\alpha\) and \(\alpha'\). Suppose that \(B(\alpha) > B(\alpha')\). Then we must necessarily have \(R(\alpha) < R(\alpha')\), since otherwise seller \(\alpha'\) 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 \(\alpha\) 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 \(\alpha\), and the other must be increasing in \(\alpha\).

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 \(\alpha\). 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 \(\alpha_i\):

\[
l(R_i/V_i; \alpha_i, \theta) = \int_{-\infty}^{-\beta_3^3-\beta_1^3+\alpha_i} \frac{1}{\sigma_2} \phi \left( R_i/V_i - \beta_0^2 - \beta_1^2 \left( \frac{1}{1+r-\alpha_i} \right) - \rho_2 \varepsilon_{3i} \right) \phi (\varepsilon_{3i}) \, d\varepsilon_{3i} \\
+ \int_{-\infty}^{-\beta_3^3-\beta_1^3+\alpha_i} \frac{1}{\sigma_1} \phi \left( R_i/V_i - \beta_0^1 - \beta_1^1 \left( \frac{1}{1+r-\alpha_i} \right) - \rho_1 \varepsilon_{3i} \right) \phi (\varepsilon_{3i}) \, d\varepsilon_{3i}
\]

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:
The second term in the contribution to the likelihood can be obtained in a similar way. The full contribution to the likelihood is therefore:

\[
l_2(R_i/V_i; \alpha_i, \theta) = \frac{1}{2\pi\sigma_2} \left( R_i/V_i - \beta_0 - \beta_1 (1 + \rho_2^2) \right)^2 \int_{-\infty}^{\infty} e^{-\frac{1}{2} \left( R_i/V_i - \beta_0 - \beta_1 (1 + \rho_2^2) \right)^2} e^{-\frac{1}{2\sigma_2^2} \left( R_i/V_i - \theta_i \right)^2} d\epsilon_i
\]

\[
= \frac{1}{2\pi\sigma_2} \left( R_i/V_i - \beta_0 - \beta_1 (1 + \rho_2^2) \right)^2 \int_{-\infty}^{\infty} e^{-\frac{1}{2\sigma_2^2} \left( R_i/V_i - \theta_i \right)^2} d\epsilon_i
\]

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:

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

### Switching regression on sub-samples

Table 15: Switching regression of the annuity on \( \alpha \) when the buyer is a firm

<table>
<thead>
<tr>
<th>Regime 1 ((D^* = 0))</th>
<th>Regime 2 ((D^* &gt; 0))</th>
<th>Switching reg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1/(1 + r - \alpha))</td>
<td>4.5667**</td>
<td>-1.1955</td>
</tr>
<tr>
<td>(0.3810)</td>
<td>(0.6407)</td>
<td></td>
</tr>
<tr>
<td>(\alpha)</td>
<td>-16.4186*</td>
<td></td>
</tr>
<tr>
<td>(7.6369)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-4.4676**</td>
<td>9.4355*</td>
</tr>
<tr>
<td>(1.1161)</td>
<td>(3.1761)</td>
<td></td>
</tr>
<tr>
<td>(N)</td>
<td>134</td>
<td>134</td>
</tr>
</tbody>
</table>

Significance levels: * : 5%  ** : 1%

Contracts with \( R_i = 0 \) or \( B_i = 0 \) are excluded. Log likelihood = -293.1132
Table 16: Switching regression of the annuity on $\alpha$ when the buyer is an individual

<table>
<thead>
<tr>
<th></th>
<th>Regime 1 ($D^* = 0$)</th>
<th>Regime 2 ($D^* &gt; 0$)</th>
<th>$\hat{y}_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1/(1 + r - \alpha)$</td>
<td>7.1223** (0.2565)</td>
<td>-.1724 (0.1698)</td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td></td>
<td></td>
<td>-12.0341** (1.2236)</td>
</tr>
<tr>
<td>Constant</td>
<td>-10.2803** (0.5880)</td>
<td>9.3212** (0.6624)</td>
<td>8.1948** (0.9358)</td>
</tr>
</tbody>
</table>

N 696 696 696 696

Significance levels: *: 5%  **: 1%

Contracts with $R_i = 0$ or $B_i = 0$ are excluded. Log likelihood = -1589.4623

F Exogeneity test

Table 17: Regressions of $B/V$ and $R/V$ with $\alpha$ instrumented by $\alpha_{Insee}$

<table>
<thead>
<tr>
<th></th>
<th>$B/V$</th>
<th>$B/V$</th>
<th>$R/V$</th>
<th>$R/V$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>121.194** (5.62)</td>
<td>135.869** (13.93)</td>
<td>17.365** (1.13)</td>
<td>19.592** (2.79)</td>
</tr>
<tr>
<td>Constant</td>
<td>-55.965** (4.07)</td>
<td>-66.490** (10.00)</td>
<td>-4.727** (0.82)</td>
<td>-6.324** (2.00)</td>
</tr>
<tr>
<td>instrumented by $\alpha_{Insee}$</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Hausman Test $\chi^2(1)$</td>
<td>1.33</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hausman Test p-value $&gt;\chi^2(1)$</td>
<td>0.25</td>
<td>0.38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$R^2$ 0.359 0.354 0.223 0.219
N 830 830 830 830

Significance levels: *: 5%  **: 1%