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Demand for annuities: Price sensitivity, risk perceptions, and knowledge☆

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ABSTRACT

The demand for voluntary individual lifetime annuities is low, as merely 10% of soon-to-be retired Canadians care to buy such contracts. To assess the reasons why, we design a stated-preference experiment in which we vary characteristics of annuity contracts to estimate individuals' sensitivity to an annuity's money's worth (that is, the value-to-cost ratio). Using different measures of longevity risk and survival expectations, we investigate how knowledge of annuity products and mortality risk misperceptions affect the take-up and the sensitivity of the demand for annuities. We find that annuities are objectively actuarially neutral in general (meaning that annuity premiums are equal to their expected payment), and can appear to offer great value for the money given an individual's subjective mortality risk. We also find that demand is somewhat price-inelastic so that lowering the price of annuities could increase demand by at most 2 percentage points for a base of 10%. Lack of knowledge of annuities explains another 0.8 percentage points. We find limited additional interest for deferred annuities compared to immediate annuities, although respondents are less sensitive to deferred annuity prices.

1. Introduction

1.1. Motivation

In 2017, the Canadian individual life annuity market was worth 16 billion Canadian dollars in benefits and 14 billion Canadian dollars in premiums (CLHIA, 2017). In comparison, total assets from individual registered retirement savings plans (i.e., non-employer sponsored pension plans) were more than 80 times larger and amounted to the equivalent of 1.15 trillion Canadian dollars in 2016.[1] With respect to registered employer pension plans, the same source evaluated that total assets

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[1] https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610057601; last visited on 1 October 2018.

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under management were worth 2.1 trillion Canadian dollars. Despite the large increase in total assets in registered saving plans and employer-based pensions plans (23.5% total growth from 2012 to 2016 for the former and 31.3% for the latter), and, more importantly, despite significant longevity gains resulting in a growing potential consumer base, the market for individual annuities has hardly grown in size since 2010. In contrast, the total assets of Canadian pension plans has grown at an average annual rate of 6.5% since 2007.[2] The lack of growth in the individual annuity market has led some insurers to announce their decision to exit the market in 2018. This was the case of Manulife[3], one of the largest Canadian insurers, which is known in the United States under the name John Hancock.

In Japan, the variable annuity market declined fourfold (based on premiums paid) between 2000 and 2010.[4] In contrast, annuity sales in the United States have increased by 24% in two years to represent 48 billion U.S. dollars in 2015. Despite this significant growth, the market for annuities remains marginal compared to the country's total pension assets of 25.4 trillion U.S. dollars in 2017.[5] The U.S. pension system grew at an average annual rate of 5.2% from 2007 to 2017.

Against the backdrop of this struggling market, the enthusiasm of academics and financial planners for such products provides a stark contrast. Yaari (1965) showed that in complete markets with actuarially neutral pricing, full annuitization is optimal for all risk averse agents. Even in relatively general settings, with imperfect markets, actuarially non-neutral pricing, and bequest motives, partial annuitization remains an optimal rational choice (Brown, 2001; Davidoff et al., 2005; Maurer et al., 2013). The reason is that lifetime annuities provide an excellent hedge against one's longevity risk and are, therefore, *prima facie* excellent insurance-like instruments for all agents worried about outliving their assets. The fact that individuals do not annuitize much of their wealth (or at least not enough of it), as evident in the current paper where merely 10% of surveyed Canadians have such a contract, is often called the "annuity puzzle" (Benartzi et al., 2011).

The low take-up rate of individual annuities is a challenge in many countries. Rusconi (2008) writes:

> "*While the low demand for lifelong annuities has been strongly established in the literature, and is reasonably well understood, it is not clear what ought to be done about it. Annuitization in the world's largest annuity market, the United Kingdom, continues to be broadly unpopular, despite the efforts of policymakers to improve the flexibility granted around the mandatory requirement to convert savings to a lifelong annuity.*"

One possible hypothesis that explains this low annuity take-up phenomenon is that governments are crowding-out private annuities by providing financial support to older members of society (see Brown and Poterba (1999) for a more detailed explanation of this crowding-out hypothesis). As a consequence, seniors in OECD countries may feel little need to purchase financial products that annuitize part of their wealth. This is not as true in Canada where the government's non-capitalized retirement income system[6] provides an annuity-like income only to poorer households. This suggests that households who are not in the lower part of the retirement income distribution should look favourably at the possibility of annuitizing some of their retirement wealth. A second hypothesis for explaining the low demand for lifelong annuities is that annuity choices are affected by product characteristics that deviate from rational calculations (Benartzi et al., 2011; Beshears et al., 2014; Brown et al., 2017; Schreiber and Weber, 2016). For example, several studies show that consumers are subject to framing biases. Also, low knowledge of financial products in general (Lusardi and Mitchell, 2014) could mean a low comprehension or a misunderstanding of how annuities work in particular. Hence, understanding the demand for annuities and how it reacts to product characteristics is of paramount importance to design and evaluate the effectiveness of public policies geared toward the adequacy of retirement replacement income.

1.2. Contribution

In this paper, we develop a stated-choice experiment designed to elicit preferences for immediate and deferred annuities in Canada. We first estimate the value of annuities to potential recipients relative to the annuities' cost, a ratio known as an annuity's *money's worth* (Mitchell et al., 1999). To value annuities in a Canadian context, we first use pricing data from CANNEX,[7] a quotation service used by brokers, which we combine with individualized longevity risk measures using

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[2] The cumulative average growth rate in U.S. dollars of Canadian pension total assets is closer to 3.9% because of changes in the exchange rate. For more details on the growth of pension assets around the world, see https://www.willistowerswatson.com/-/media/WTW/Images/Press/2018/01/Global-Pension-Asset-Study-2018-Japan.pdf; last visited on 5 February 2019.

[3] *Quitting Annuities: Manulife's exit leaves a big gap*, Investment Executive, July 2018; https://www.investmentexecutive.com/newspaper/news-newspaper/quitting-annuities/; last visited on 15 September 2018.

[4] See OECD (2016), Life Annuity Products and Their Guarantees, OECD Publishing, Paris, https://doi.org/10.1787/9789264265318-en.

[5] www.willistowerswatson.com *op.cit.* Using an exchange rate of 1.30 Canadian dollar per U.S. dollar, pension assets in the United States are 16 times greater ($1.30 \times 25.4/2.1$) than in Canada. In comparison, total annuity premiums in the U.S. are merely 4.5 times ($1.30 \times 48/14$) total annuity premiums in Canada.

[6] The Canadian Retirement system is a three-headed hydra consisting of the capitalized non-means-tested CPP, and the non-capitalized means-tested OAS and GIS. Every individual over the age of 18 who works in Canada and earns more than $3,500 per year must contribute to the Canada Pension Plan (CPP) or to the Quebec Pension Plan if working in that province. Old Age Security (OAS), the Government of Canada's largest pension program, is funded out of the general tax revenues. The OAS pension is a monthly payment available to seniors aged 65 and older who meet the Canadian legal status and residence requirements. The Guaranteed Income Supplement (GIS) provides a monthly non-taxable benefit to Old Age Security (OAS) pension recipients who have a very low income and are living in Canada. The GIS and the OAS are means-tested.

[7] *"CANNEX is an independent and privately held company with operations in Canada and the U.S. Our mission is to provide access and transparency relating to the cost and features of retirement savings and retirement income products offered across the market"* www.cannex.com; last visited on 5 February 2019.

a micro-simulation approach and an individual's subjective life expectancy. We compare those estimates with estimates obtained using cohort life-tables by age and sex. By imposing exogenous variations to characteristics and prices of annuities offered to our survey participants, we are able to estimate a flexible regression model linking elicited choice probabilities with the annuities' money's worth, controlling for the individual respondent's stated preferences and his/her socioeconomic characteristics and knowledge of annuities, inter alia.

Our work builds on the money's worth framework of Mitchell et al. (1999), which was applied to a Canadian context by Milevsky and Shao (2011) for the period 2000–2009. In addition to our stated-preference approach, we deviate from their work by using individual-level objective and subjective survival risk measures to compute the money's worth of the proposed annuities. This allows us to obtain the entire distribution of money's worth, exploiting variations in health and longevity expectations across individuals. We use a stated-preference approach,[8] as opposed to a revealed preference approach, because of the absence of publicly available and detailed Canadian data on actual annuity purchase decisions. Another reason is that the Canadian individual lifetime annuity market does not present enough exogenous variations in prices that could be used to investigate how price sensitive consumers are (see Buetler et al. (2013) and Chalmers and Reuter (2012) for approaches using actual experiments).

Our use of an internet-based stated-preference experiment has several advantages. As argued by Louviere et al. (2000), for instance, exogenous variations in the characteristics of the product offered can be generated such that the experimenter can control the choice set faced by consumers. In addition, and as suggested by Manski (1999), we can elicit choice probabilities that provide more information than binary purchase decisions. Also, using an approach whereby choice probabilities are elicited is better suited when scenarios are incomplete, which is our case. Finally, we are able to make use of both objective and subjective longevity risk measures, which are not available when using data from insurers. Subjective survival probabilities provide additional variations to assess how consumers react to the value of an annuity contract (Hurd, 2009).

1.3. Results

We find that annuity pricing is generally actuarially non-neutral[9] when assuming reasonable discount rates and objective survival probabilities. In particular, using personalized objective longevity risk measures, we find that annuity contracts provide, in terms of expected present value, $0.94 for each dollar of premium paid. Our result is similar to what (Milevsky and Shao, 2011) found in Canada for the period 2000–2009, and is in line with money's worth in many other developed countries (Mitchell and McCarthy, 2002). An annuity's money's worth (i.e., the annuity's value-to-price ratio) grows smaller as the individual purchasing annuities grows older. An annuity's money's worth is also smaller for individuals who have less than a high school education, lower income, and lower wealth and savings.

Non-neutral pricing is not a sufficient explanation for the low demand for annuities, however, since insurers incur operating expenses that must be covered by premiums. What is more interesting about our results is that annuities have a money's worth greater than 1 when we use the individuals' subjective survival risk instead of the objective measures calculated based on prospective life-tables from Statistics Canada. Hence, although risk misperceptions are a factor in many savings and investment decisions (Post and Hanewald, 2013), and demand for long-term care insurance (Boyer et al., 2019b), longevity risk misperceptions cannot explain the low demand for annuities.

When we regress choice probabilities on money's worth, we find that individuals respond to changes in the value of the annuities offered to them. We find individual preferences to be price responsive but relatively inelastic (elasticity ranges from 0.343 using subjective mortality risk probabilities to 0.804 using life-table risk probabilities). While pricing is actuarially non-neutral, correcting pricing would lead to an increase in the demand for individual lifetime annuities of 2 percentage points. Given a base probability of approximately 10%, making annuity prices more accurate would increase demand by 20%. We further find that individuals with a better understanding of annuities tend to purchase more of them. Financial education could increase the take-up rate of annuities by 0.8 percentage points using our baseline specification, which given the same base of 10% represents a market increase of 8%. As a result, we conclude that better awareness of annuities and more attractive pricing could, together, increase the current size of the individual lifetime annuity market by approximately one-third.

Lastly, we find different point estimates for male and female respondents, with male respondents being more likely to state that they would purchase an annuity. Male sensitivity to annuities' money's worth is also higher, although their price-elasticity is smaller.

The paper is structured as follows. Section 2 presents the data we collected from our panel of online respondents. In Section 3 we present evidence on the survey respondents' knowledge of annuities, or lack thereof, as well as the valuation framework we shall use to examine individual lifetime annuities. Section 4 presents the stated-choice experiment we conducted, whereas Section 5 provides the econometric model and methodology that is appropriate in our context. Results are presented and analyzed in Section 6. Finally, Section 7 concludes.

[8] Studies investigating the demand for annuities based on stated-preference experiments include (Brown et al., 2007), Agnew et al. (2008) and Bateman et al. (2017).

[9] In contrast to the traditional economic literature on annuities and insurance, we will refrain from using the words "fair" and "unfair" when qualifying the money's worth of an annuity. As fairness can be subjective, we will therefore use the words "neutral" and "non-neutral". For more on the fairness of annuities, see Shu et al. (2015).

2. Data

As outlined previously, two methods can generally be used to estimate the price elasticity of the demand for individual lifetime annuities. The first consists in taking advantage of exogenous price variations which are usually the result of an unexpected change in the regulatory environment. This is done to assess, through an apparent "natural experiment", the price-elasticity implied in changes in the demand for the product. In other words, this first approach consists in examining what are the individuals' *revealed preferences* following a change in regulation. The second method, which is employed in the current paper, consists in surveying individuals' willingness to buy the product at different price levels. This second approach could be classified as a *stated preferences* approach. To our knowledge, this type of stated preference survey has never been conducted in Canada to examine the demand for annuity products.

To accomplish this stated preference experiment, we partnered with *AskingCanadians*,[10] which is a marketing research firm that designs and implements online surveys, to field and conduct our survey and experiment. Members of the *AskingCanadians* panel answer survey questions for which they receive points redeemable from various loyalty programs such as Aeroplan (which is now part of Air Canada), Petro-Canada (a gasoline distributor), Hudson's Bay (a retailer), and Via Rail (an inter-city passenger train service), inter alia. In June 2017, we solicited *AskingCanadians* to conduct a survey of 3000 Canadians between the ages of 55 and 75, who lived in British Columbia, Ontario or Quebec (1/3 from each province), half of whom came from the metropolitan areas of Vancouver, Toronto, and Montreal.[11] We selected the age range of 55 to 75 to represent the age at which most individuals would consider purchasing an annuity. *AskingCanadians* then randomly contacted individuals from their panel who qualified from an age / city / province / gender perspective, and asked them to fill-out our survey. A total of 13,300 invitations were sent out, and once AskingCanadians had 3000 responses that fit our criteria (which amounted to 96% of those who attempted to fill the survey) the survey link was closed.

This survey is not perfectly representative of the Canadian population. This is mostly seen in the educational attainment of respondents. The divergence is especially apparent in the tails of the distribution as survey respondents are less likely to be very poorly educated (less than high school) and more likely to be highly educated (university) than for the Canadian population as a whole. Our survey also over-weighs metropolitan areas.[12] We stratify respondents by age, gender, province, and education and re-weigh the data using the 2010 Canadian Community Health Survey, a nationally representative survey. We use these weights when presenting descriptive statistics, but not in the regressions since the representative survey weights will be implicitly taken into account by the inclusion of appropriate control variables.

The questionnaire is composed of five sections that are relevant for the study of the demand for annuities[13]:

1. Sociodemographic background, including education, income, health, marital status, number of children, retirement status, and access to a pension plan;
2. Opinions and perceptions on bequest motives, chances of living to 85, risk-aversion, and the role of family in retirement;
3. Financial literacy, such as compound interest and inflation, and general knowledge, such as probabilities;
4. Knowledge of annuities;
5. Preference for annuities using scenarios whereby individuals are asked to evaluate, on a scale of 0–100, the probability of buying the annuity product presented to them.

3. Annuity design and valuation

3.1. A Short Primer an annuity mathematics

Annuities are some of the simplest financial instruments that exist.[14] They offer a stream of (generally) fixed cash flows for a given period time. Mathematically, from basic finance text books, the present value of a *plain vanilla annuity*, which pays fixed amount A per period for N periods starting one period from today is given by

$$PV(A,0) = \sum_{t=1}^{N} \frac{A}{(1+r)^t} = A\left[\frac{1-(1+r)^{-N}}{r}\right], \tag{1}$$

where r is the appropriate discount rate that reflects the risk of this cash flow. This *plain vanilla annuity* is also known as an immediate annuity. If the first annuity payment is delayed for M periods (so that the payments start $M+1$ periods from

[10] www.askingcanadians.com.

[11] The metropolitan residential condition was included because a sub-component of the survey focused on housing and on the available insurance products aimed to extract home equity to finance current spending.

[12] See previous footnote for the reason.

[13] The full questionnaire can be found in the appendix. The two non-relevant sections of the questionnaire are those related to reverse mortgages and the value of housing.

[14] Annuities are typically covered in the first half of the first undergraduate class in finance, or at least in any basic corporate finance textbook (see for instance Brealey et al. (2016)).

Table 1
Annuity take-up and annuity knowledge among the 3000 respondents to our survey. Statistics weighted according to 2010 Canadian Community Health Survey (CCHS).

No Annuity		Annuity	
Fraction (%)	77.98	**Fraction (%)**	10.65
Knowledge of annuities (%)		**Knowledge of annuities(%)**	
A lot	12.36	*A lot*	27.67
A little	62.93	*A little*	65.76
None at all	24.71	*None at all*	6.57
Why don't you have an annuity? (%)		**How did you come to purchase annuity? (%)**	
Never offered or thought about	19.71	*Offered*	67.39
Not yet made decision	9.43	*Searched myself*	21.24
Don't have sufficient savings	17.36	*Other*	11.37
Bad value for money	9.19		
Doesn't cover my needs	8.6		
No need	21.28		
Don't know what it is	9.01		
Other	5.42		

today), then the present value of this *deferred annuity* is equal to

$$PV(A,M) = \frac{1}{(1+r)^M}\sum_{t=1}^{N}\frac{A}{(1+r)^t} = \frac{A}{(1+r)^M}\left[\frac{1-(1+r)^{-N}}{r}\right]. \tag{2}$$

The difference between traditional annuities and lifetime annuities comes from the fact that the last payment is associated with an annuitant's death rather than some arbitrary period N. This means that, for a given group of individuals, the expected present value of the plain annuity (or of the deferred annuity) is reduced by the group's survival probability curve, which can be defined as the probability of surviving to age $a+t$ given survival to age a. Although there are many types of lifetime annuity products in the market place (de-escalating, advanced life deferred, enhanced, inflation indexed, participating, and variable, to name a few), the two most common in OECD countries[15] remain the fixed lifetime annuity and the deferred lifetime annuity products. In Canada, in particular, the most common product is the so-called individual immediate fixed payment annuity. The present value of such a product is

$$PV(A_{s_t},0) = \sum_{t=1}^{\infty}\frac{A\times s_{0t}}{(1+r)^t}, \tag{3}$$

where s_{0t} is the probability of surviving from period 0 to period t. If we know that $s_{0N}=0$ for all $t>N$ (i.e., survival past year N is impossible), then the previous equation becomes

$$PV(A^N_{s_t},0) = \sum_{t=1}^{N}\frac{A\times s_{0t}}{(1+r)^t}. \tag{4}$$

If s_{0t} is a constant geometrically decreasing function such that $s_{0t}=\hat{s}^t=(1-d)^t$ for $t<N$, with d being the constant probability of dying between any periods t and $t+1$ - this is far from true in reality and presented only as a way to visualize the present value of annuity formula - then the present value of the annuity would be

$$PV(A^N_{\hat{s}},0) = \sum_{t=1}^{N}\frac{A\times\hat{s}^t}{(1+r)^t} = \frac{A\times\hat{s}}{1+r-\hat{s}}\left[1-\left(\frac{\hat{s}}{1+r}\right)^N\right] = \frac{A}{r+d}\left[1-\left(\frac{1-d}{1+r}\right)^N\right].$$

The immediate annuity product is often provided by Canadian insurers in an account that is segregated from the insurer's general funds. This product essentially behaves as a *plain vanilla annuity* with the survival probability provision (i.e., $PV(A^N_{s_t},0)$). We will be concentrating on immediate and deferred annuities in our study of the stated-demand for annuities.

3.2. Knowledge

We asked respondents whether they had ever purchased an annuity contract. Table 1 reports that sligthly more than one of out ten respondents (10.7%) report having an annuity while 78% do not have an annuity. The remaining 11.4% of respondents do not know whether or not they purchased an annuity, or whether they currently have one. Hence, the take-up of annuities among respondents aged between 55 and 75 is rather low compared to other insurance products such as life

[15] See Table 2.1 in OECD (2016), Life Annuity Products and Their Guarantees, OECD Publishing, Paris, https://doi.org/10.1787/9789264265318-en page 24.

insurance.[16] Table 2 provides weighted descriptive statistics with respect to the entire sample of respondents. And, although one third of respondents come from each of the three largest Canadian provinces, the averages of the stratified samples are different as they take into account the demographics of each province and the socioeconomic composition of the Canadian population. As a result, 18.0% of weighted respondents live in British Columbia, 48.7% live in Ontario, with the remaining third living in Quebec.

Not surprisingly, knowledge of annuities is higher among those who have an annuity product. Close to 28% of respondents who own an annuity report they know *a lot* compared to 12.4% of those who did not purchased an annuity. Interestingly, the fraction of respondents reporting no knowledge of annuities is low, even among those without an annuity (24.7%). This may be due to the fact that annuity products are among the simplest financial products available, at least in their plain vanilla form.

Although we find that respondents have a range of reasons for not having an annuity, three reasons stand out in particular: 1- Ignorance (28.7% of respondents), which includes respondents who were never offered one or ever thought about such products (19.7%), and respondents who do not know what annuities are (9.0%); 2- Insufficient savings (17.4%); and 3- No need for such products (21.3%). The group of individuals who are essentially ignorant of these products is quite heterogeneous on other dimensions. Among respondents who report not having sufficient savings to acquire annuities, only 23% report having more than 50,000$ in savings. This 23% compares to the 60% of those that have no annuity contract, but have more than 50,000$ in savings, and who reported another reason ($t-stat$ of difference $=-14.24$, $p-value=0.000$) than lack of wealth. Hence, a significant fraction of those who do not own an annuity have limited resources available. Among respondents who feel they do not need an annuity contract, we find that, compared to the rest of the sample, they are disproportionately more likely to have access to an employer-provided pension plan ($t=6.17$, $p<0.001$) and have higher income ($t=-3.99$, $p=.000$). Only 9.2% of respondents without an annuity report that pricing is an issue; more specifically, they report that annuities are a *Bad value for money*.

Table 2a presents basic demographic characteristics of respondents with and without annuities (we shall often refer to them as annuitants and non-annuitants, respectively, hereafter). As a whole, both annuitants and non-annuitants have approximately the same education and income levels. Annuitants are slightly more likely to be married and to have children than non-annuitants. Annuitants do have higher median savings, but lower mean savings, which is consistent with the fact that purchasing an annuity requires a significant amount of accumulated wealth. The mean projected income at retirement is only slightly higher among annuitants. Finally, respondents with annuities are more likely to be retired and to have contributed to an employer-provided pension plan.

3.3. Calculating an annuity Contract's Money's worth

To calculate the money's worth of an annuity, we need the expected discounted payout value (*EDPV*) and the premium paid by the annuitant to obtain the contract (P) An annuity's money's worth is given by the ratio of the two values, or $MW=\frac{EDPV}{P}$. We examine the components of an annuity's money's worth next, focusing on the case of immediate annuities.

3.3.1. Pricing and discounting

There are two key ingredients to computing the expected discounted payout value of the annuity: the interest rate used to discount the cash flows, and the mortality risk to adjust for the fact that not every individual will live to the maximum possible age. The *EDPV* of an annuity paying fixed A is given by

$$EDPV=\sum_{t=1}^{T-a}A\frac{s_{a,a+t}}{(1+r)^t}, \tag{5}$$

where T is some arbitrary maximum possible age (say 99 or 125 years old), and $s_{a,a+t}$ is the probability of surviving to age $a+t$ given survival to age a. This is nothing more than the present value of an annuity corrected for the projected survival rate of an individual (or of a cohort of individuals). We use a common rate of return (r) of 2%,[17] which represents the rate of return on risk-free invested savings. In comparison, the yield on investment grade long-term senior unsecured corporate bonds was between 3% and 4% in June 2017).

[16] In the United States, 60% of adults have a life insurance policy in their name (see https://www.bestliferates.org/blog/2017-life-insurance-statistics-and-facts/; last visited 8 February 2019), and 91 percent have some form of health insurance (see https://www.bestliferates.org/blog/2018-life-insurance-statistics-and-facts/; last visited 8 February 2019). In Canada, the proportion is more like 70% (see https://www.ipsos.com/en-ca/majority-70-canadians-have-life-insurance-however-only-37-review-it-least-once-year; last visited 8 February 2019).

[17] Our choice of a 2% discount rate is partially due to the flat structure used in Friedman and Warshawsky (1990) and to the use by Mitchell et al. (1999) of nominal yields on Treasury bonds. In the case of Canada, at the time of the survey in June 2017, the 5-year bond yield was 1.17%, the 7-year bond yield was 1.34%, the 10-year bond yield was 1.56%, and the 30-year long-term bond yield was 2.05%, with real return bonds yielding 0.55% at that time (see https://www.bankofcanada.ca/rates/interest-rates/canadian-bonds/; last visited 11 February 2019). This is also in line with the Mercer approach: "we look at the yields of long-term government bonds, which drive annuity pricing" (see https://www.mercer.ca/content/dam/mercer/attachments/north-america/canada/ca-2017-mercer-global-pension-buyout-index-august-en.pdf; last visited 11 February 2019). In the same report, we see a yield implied by insurer annuity prices of the order of 3% in June 2017.

Table 2a
Demographics: This table presents descriptive statistics of demographic variables among the 3000 respondents to our survey. Statistics weighted according to 2010 Canadian Community Health Survey (CCHS).

No Annuity		Annuity	
Province of residence (%)		**Province of residence (%)**	
BC	18.58	*BC*	17.74
Ontario	50.38	*Ontario*	31.62
Quebec	31.04	*Quebec*	50.64
Education (%)		**Education (%)**	
Less than HS	23.95	*Less than HS*	19.2
HS	31.5	*HS*	36.32
Trade certificate or diploma	4.46	*Trade certificate or diploma*	4.27
College or Cegep	13.46	*College or Cegep*	13.94
Some Undergraduate	4.74	*Some Undergraduate*	5.3
Undergraduate	13.37	*Undergraduate*	12.21
Graduate	8.51	*Graduate*	8.77
Marital status (%)		**Marital status (%)**	
Married	51.77	*Married*	66.09
Common-law	12.01	*Common-law*	8.83
Widowed	7.19	*Widowed*	5.01
Separated	3.19	*Separated*	1.44
Divorced	13.44	*Divorced*	8.8
Single, never married	12.4	*Single, never married*	9.84
Children		**Children**	
Proportion who have children (%)	72.56	*Proportion who have children (%)*	78.73
Mean # of children	1.58	*Mean # of children*	1.78
Income		**Income**	
Mean household total income	$ 91,729	*Mean household total income*	$ 86,649
Median household total income	$ 60,000	*Median household total income*	$ 63,000
Mean household total savings	$ 265,916	*Mean household total savings*	$ 223,482
Median household total savings	$ 72,000	*Median household total savings*	$ 100,000
Retirement		**Retirement**	
Retired (%)	63.66	*Retired (%)*	74.31
Mean projected income at retirement (% of current)	56.71	*Mean projected income at retirement (% of current)*	58.86
Employer provided pension plan (%)	48.88	*Employer provided pension plan (%)*	63.43

One reason why the pricing might depress market demand for individual annuities below its social optimum, both in the Canadian market place and elsewhere in the OECD, is that annuities in general and individual immediate annuities in particular are not priced neutrally neither in an actuarial or economic sense, nor from an individual's perspective. Non-neutral pricing in an actuarial sense reflects the fact that annuity providers - mostly life insurance companies - face operational costs (such as rent, salaries, commissions and other overhead costs) and require a profit margin to offer the annuity service and bear any of the risk associated with it. These costs and margins must be reflected through an increase in the price of annuity contracts. At the same time, annuity providers are able to keep the excess investment income they make with the annuitants' premium, which could reduce the price of the annuity contract.

Subjective non-neutral pricing comes from various sources that are specific to an individual. We can think, for instance, of the case of one's perceived mortality risk or perceived ability to generate better returns than annuity providers. If, for instance, a respondent perceives his or her mortality risk as higher than what the pricing of annuities has been based on, then an annuity's money's worth, which is calculated as the expected discounted payout value (*EDPV*) divided by the premium paid (P), or $MW = \frac{EDPV}{P}$, could be much less than unity, even if the premium was neutral by actuarial standards. In other words, individuals who have a subjective probability of dying that is greater (resp. smaller) than what mortality tables suggest, would find the annuities' money's worth to be worse (resp. better) than what providers offer.

3.3.2. Survival risk

For survival risk, we use three sources. First, we make use of prospective survival rates by gender and province produced by Statistics Canada (Bohnert et al., 2015). We merge each respondent with mortality rates by cohort, sex and province. This yields survival rates $\{s^C_{a,a+t}(x_i)\}_{t=1}^{T-a}$, where x_i denotes characteristics of the respondent i.

Although life tables allow for good measures of aggregate mortality, they do not account for the fact that respondents differ in terms of predictable mortality risk beyond their province of residence, age, and sex. To account for these individual characteristics, we make use of a micro-simulation model designed to simulate the future health of individuals based on a rich set of demographic and health dimensions (Boisclair et al., 2016). Specifically, we feed information about each respondent's current age, sex, level of education, and self-reported health conditions (heart disease, diabetes, cancer, lung disease and hypertension) into the micro-simulation model to extract more individual-specific estimates of mortality. Denote by x_i the vector of characteristics used in the micro-simulation model. Using 1000 simulations until death for each respon-

Table 2b
Demographics: This table presents unweighted descriptive statistics of demographic variables among the 3000 respondents to our survey.

No Annuity		Annuity	
Province of residence (%)		**Province of residence (%)**	
BC	33.77	*BC*	30.21
Ontario	35.09	*Ontario*	21.66
Quebec	31.14	*Quebec*	48.13
Education (%)		**Education (%)**	
Less than HS	3.05	*Less than HS*	2.94
HS	20.14	*HS*	21.93
Trade certificate or diploma	9.89	*Trade certificate or diploma*	8.40
College or Cegep	21.21	*College or Cegep*	21.66
Some Undergraduate	8.73	*Some Undergraduate*	9.09
Undergraduate	23.19	*Undergraduate*	19.79
Graduate	15.28	*Graduate*	14.71
Marital status (%)		**Marital status (%)**	
Married	56.55	*Married*	60.16
Common-law	11.00	*Common-law*	10.16
Widowed	6.14	*Widowed*	7.49
Separated	2.92	*Separated*	2.14
Divorced	12.27	*Divorced*	9.09
Single, never married	11.12	*Single, never married*	10.96
Children		**Children**	
Proportion who have children (%)	72.98	*Proportion who have children (%)*	74.60
Mean # of children	1.27	*Mean # of children*	1.57
Income		**Income**	
Mean household total income	$ 96,652	*Mean household total income*	$ 106,285
Median household total income	$ 70,000	*Median household total income*	$ 66,770
Mean household total savings	$ 327,935	*Mean household total savings*	$ 237,669
Median household total savings	$ 107,500	*Median household total savings*	$ 100,000
Retirement		**Retirement**	
Retired (%)	67.63	*Retired (%)*	77.54
Mean projected income at retirement (% of current)	57.29	*Mean projected income at retirement (% of current)*	56.71
Employer provided pension plan (%)	57.17	*Employer provided pension plan (%)*	68.45

dents, we compute each individual's projected survival rates at each age as the average of those simulations. We denote as $\{s^O_{a,a+t}(x_i)\}_{t=1}^{T-a}$ these average survival rates, which provide a set of prospective individual mortality risk profiles.

While *actual risk* is what determines the profitability of insurance contracts from the insurers' perspective, it is the individuals' *subjective risk* that determines whether they will become consumers of annuities. Hence, subjective expectations about survival are as important to understanding demand as actual (or objective) risk. As part of the survey, we ask respondents for their subjective probability of living to age 85 (see Hurd (2009) for a survey of the literature using such measures). We can compare those subjective probabilities with the objective probability of surviving to age 85 from the micro-simulation model.

To construct subjective survival curves, we make use of the objective risk to age 85, but add a perturbation to them. Denote by $s^O_{a,85}(x_i)$ the objective risk of surviving to age 85, and by $s^S_{a,85}(x_i)$, the subjective risk so that $s^O_{a,85}(x_i) = \exp(-\Lambda^O_{a,85}(x_i))$ where $\Lambda^O_{a,85}(x_i)$ is the integrated hazard. In our calculations of an individual's subjective probability of surviving to age 85, we will assume that $s^S_{a,85}(x_i) = \exp(-\psi\Lambda^O_{a,85}(x_i))$. We can easily compute ψ by making use of the two data points[18] at age 85. We can then reconstruct subjective curves assuming that ψ is a constant across ages for a given individual. These subjective survival curves generate additional variation relative to objective survival curves. Fortunately, there is a sizable correlation between the subjective and the objective probability of living ten more years; the Spearman rank correlation between $s^O_{a,a+10}(x_i)$ and $s^S_{a,a+10}(x_i)$ is 0.373, which is significant at the better than 0.1 percent level.

Table 3 reports, by province of residence, the average remaining life-expectancy of our respondents calculated using each respondent's subjective expectations as reported in our survey, the COMPAS micro-simulation model, and the Statistics Canada life-table forecasts. We see in the table that a 55 year old female (first line of numbers) has on average between 31.4 and 31.9 years to live according to Statistics Canada projections, depending on the province of residence. The micro-simulation model, which accounts for the current risk composition of that population, yields more conservative figures, in particular for Quebec and British-Columbia (3 to 3.5 years difference). Statistics Canada life-tables generate higher remaining life expectancy among both males and females in the three provinces and for the four ages. The average subjective remaining

[18] That is, knowing $s^O_{a,85}(x_i) = \exp(-\Lambda^O_{a,85}(x_i))$ and $s^S_{a,85}(x_i) = \exp(-\psi\Lambda^O_{a,85}(x_i))$ we can back out ψ. There are cases where respondents reported a 100 percent chance of surviving to age 85. This is of course impossible. Moreover, for our objective-to-subjective transformation, having a 100 percent subjective probability of reaching 85 years of age implies $\psi = -\infty$. For those cases, we substituted the 100 percent subjective probability with a value of 99 percent to obtain finite estimates of ψ.

Table 3
Remaining life expectancies by age, province and gender among the 3000 respondents to our survey, according to the following survival probabilities : Subjective expectations (Survey), microsimulation (COMPAS) and Life-table (Statistics Canada). Statistics unweighted.

Gender	Type province age	Subjective			Microsimulation			Life-Table		
		BC	Ontario	Quebec	BC	Ontario	Quebec	BC	Ontario	Quebec
females	55	32.9	32.0	36.2	28.7	31.0	27.9	31.9	31.6	31.4
	60	32.3	31.4	30.6	24.5	24.2	23.1	27.0	26.7	26.5
	65	25.4	31.6	26.3	20.0	18.8	19.2	22.2	21.9	21.8
	75	20.4	16.0	15.3	12.0	12.0	12.2	13.5	13.3	13.3
males	55	35.8	33.9	35.7	27.7	27.5	26.6	29.7	29.2	28.8
	60	33.5	27.5	28.0	20.4	23.5	21.0	24.8	24.2	23.8
	65	21.3	19.4	26.6	14.6	16.9	19.4	20.1	19.5	19.1
	75	17.9	14.3	20.3	10.7	11.2	11.0	11.7	11.3	11.0

Table 4
Money's worth values of annuities listed on CANNEX, according to socioeconomic characteristics and survival probabilities. Survival probabilities are listed in the following order: Subjective expectations (Survey), microsimulation (COMPAS) and Life-table (Statistics Canada).

		Subjective	Microsimulation	Life-table
Age				
	55–59	1.14	1.00	1.06
	60–64	1.15	0.96	1.03
	65–69	1.14	0.89	0.98
	70–75	1.15	0.83	0.92
Sex				
	Female	1.14	0.93	1.01
	Male	1.15	0.94	1.00
Province				
	British Columbia	1.15	0.91	1.02
	Ontario	1.12	0.95	1.01
	Quebec	1.18	0.93	1.00
Education				
	Less than HS	1.14	0.82	0.99
	High School	1.13	0.92	1.01
	More than HS	1.17	1.03	1.02
Household income				
	1st tercile	1.11	0.90	1.01
	2nd tercile	1.14	0.93	1.00
	3rd tercile	1.19	0.98	1.02
Savings				
	1st tercile	1.10	0.90	1.01
	2nd tercile	1.17	0.93	1.01
	3rd tercile	1.18	0.97	1.01
Own an annuity?				
	Yes	1.15	0.92	1.00
	No	1.15	0.94	1.01
	Don't know	1.14	0.91	1.01
Total		1.15	0.94	1.01

life expectancy of our respondents is much more optimistic[19] than what can be inferred using either the Statistics Canada life-tables or the micro-simulation forecasts.

3.4. Actual Money's worth calculations

In June 2017 we accessed CANNEX, a quotation system, to collect market prices for annuities in Canada. We considered immediate and deferred life annuities. We obtained quotes on annuity payouts, A, and premiums, P, to compute money's worth by age and gender. We used the average payout across quotes from multiple competitors. Table 4 reports average money's worth by gender and by age groups for the three longevity risk measures.

We first note in the two right-most columns of Table 4 that annuities are not priced at actuarially neutral levels when using the micro-simulation survival probabilities (an average money's worth of 0.94), but they are priced neutrally when

[19] Depending on the province and the respondent's age group (such as 55 and 60 year old individuals in British-Columbia, and 65 and 75 year old individuals in Quebec), there are even cases where, men subjectively believe their life expectancy to be higher than that of women.

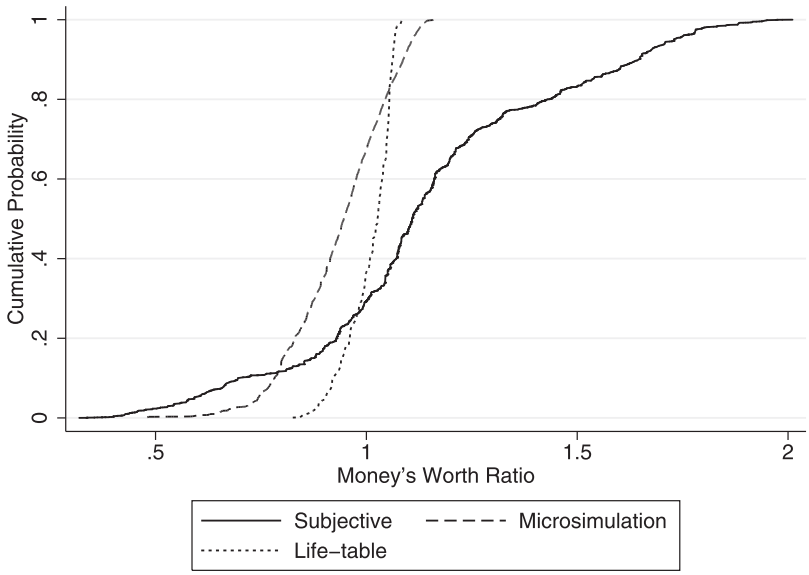

Fig. 1. Distribution of Money's Worth of Annuities listed on CANNEX: Life-table, microsimulation and subjective expectations (Survey).

using the survival rates of Statistics Canada (an average money's worth of 1.01). We thus have that for a premium of $100, individuals receive an expected present value of the purchased annuity of between $94 and $101 when discounting future payments at the risk free rate following the recommendation of Milevsky and Shao (2011). Our objectively calculated money's worth are quite comparable to what others have found previously for the Canadian experience. For instance OECD (2016) reports[20] annuities' money's worth for Canada of between 0.85 and 0.90 using a discount rate based on corporate bond returns. When we compute the annuities' money's worth using the respondents' subjective survival risk, $s^S_{a,a+t}(x_i)$, instead of the two more objective measures, $s^O_{a,a+t}(x_i)$, annuities appear to be priced quite attractively since their average money's worth is 1.15 across different sub-populations.[21]

Another interesting observation from Table 4 is that, objectively, the money's worth of annuities is decreasing in age. This is not the case using subjective survival probabilities as the money's worth increases in age. Differences across provinces are very small. Differences across socioeconomic status are rather large, especially when using the micro-simulation survival estimates. Respondents with more than a high school education have money's worth greater than those without. Similar differences are observed by savings level and income level, with richer households receiving greater money's worth. A reason why annuity pricing appears non-neutral is adverse selection in the sense that, if individuals who purchase annuities expect to live longer, then pricing would be based on their survival prospects and not on those of the general population. We find some evidence that individuals who own annuities are positively selected on survival. Controlling for age, respondents with an annuity have a micro-simulation remaining life expectancy 0.22 years higher (t-stat=3.28, p-value < 0.001) than individuals who do not own an annuity.

Since averages can be deceptive, we report in Fig. 1 the distribution of money's worth using both the respondents' subjective survival risk and their objective survival risks using both the micro-simulation model and the Statistics Canada prospective life-table. We see that the distribution of money's worth using subjective risks has greater dispersion and a higher variance. When using risk measures calculated from prospective life tables, over half the respondents have annuities whose money's worth is greater than one. When using the respondents' subjective survival risks measures, the fraction that face a money's worth greater than 1 is closer to 0.7. Of course, these estimates are somewhat sensitive to the discount rate used; when using a discount rate of 3% there are essentially no respondents whose offered annuity has a money's worth greater than 1 using the micro-simulation model of survival risk, compared to 40% of respondents whose annuity has a money's worth larger than 1 when the discount rate is 2%. Of course, the greater is the discount rate, the lower is the proportion of individuals that have a money's worth greater than 1.[22]

[20] OECD (2016), Life Annuity Products and Their Guarantees, OECD Publishing, Paris, https://doi.org/10.1787/9789264265318-en.

[21] If we were to use corporate bond returns of 3% to discount annuity payments instead of our use of the risk free rate of 2%, the money's worth of annuities would drop to values very close to those presented in the OECD report. To illustrate in Table 4, instead of the average money's worth of 1.15 (resp. 0.94 and 1.01) using the respondents' subjective probability (resp. micro-simulation and Statistics Canada prospective life table), we would find average money's worth of 1.00 (resp. 0.84 and 0.90) when we apply a discount rate of 3% instead of 2%.

[22] See Fig. A.1 in the appendix for a representation of the distribution of money's worth as a function of discount rate give the micro-simulation survival probability model.

4. The experiment

The experiment we designed seeks to investigate individual preference for immediate and deferred annuities, as well as the individuals' sensitivity to the price of these annuities. First, all respondents are shown this introductory text with respect to the section in the questionnaire related to annuities:

> *We are going to show you some simple annuities and ask you to rate them. You can assume that the institution offering the annuity will pay the monthly benefit no matter the circumstances. Once you pay the premium, you receive monthly benefits and have nothing else to pay. Each product has two attributes:*
>
> *(a) a premium you have to pay; (b) a monthly benefit starting at a given age and lasting until death. The benefit is adjusted for inflation (indexed).*

Survey respondents are then asked one of the two following questions:

> *What are the chances, 0% meaning no chance and 100% meaning for sure, that you would purchase this product if it were offered to you by* ***a trusted insurance company*** *within the next year?*; or
>
> *What are the chances, 0% meaning no chance and 100% meaning for sure, that you would purchase this product if it were offered to you by* ***an insurance company*** *within the next year?*

For half the individuals, the word "trusted" is included, but it does not appear for the other half. This is done to test the importance of behavioral factors in decision making. By varying the use of the word "trusted" we are able to study the impact of framing on the annuity purchase decision.

Scenarios are presented in the following manner to respondent aged a, where P represents the premium amount, $a + j$ represents the age at which the benefits come into force, and A is the monthly benefit (which we convert to an annual amount):

When you buy the annuity	Starting at age $a + j$
You pay P	You receive A per month until death,
	indexed annually for inflation

Each individual is then presented with five scenarios, which are randomized on three levels: The age at which the first benefit is paid ($a + j$), the monthly benefit (A) and the load (τ) on the annuity premium. These values are randomized in the following way:

$j = [1, 75 - a + 1, 85 - a + 1]$ with probability [2/5, 2/5, 1/5]

$A = [\$200, \$600, \$1,000]$ each with probability 1/3

$\tau = [0.5, 0.6, 0.7, \ldots., 1.8, 1.9, 2.0]$ each with probability 1/16

By varying the age at which the annuity starts (j), we are able to study both immediate and deferred annuities. By varying the monthly benefit paid (A), we are able to examine whether the demand for annuities is linear in the quantity. Finally, the variation in τ provides the exogenous price variation necessary to estimate the price-elasticity of demand.

Letting $EDPV(A, r, s, j)$ be the expected discounted payout value of the benefits (or the actuarially neutral premium for the annuity), the premium in the different scenarios, P, is obtained using the following formula:

$$P = \tau \times EDPV(A, r, s, j) \tag{6}$$

with

$$EDPV(A, r, s, j) = A \sum_{t=1}^{T-a} \iota_{a+j,a+t} \frac{s_{a,a+t}}{(1+r)^t} \tag{7}$$

where a represents the age at which annuity payouts begin, so that $\iota_{a+j,a+t}$ is equal to one if current age is older than the age at which the annuity starts ($j = 1$ for an immediate annuity). The actuarially neutral premium $EDPV$ is therefore the expected present value of the annual constant income A, given objective survival probability s_t, and the appropriate discount rate r.[23] Setting the monthly benefits to \$200, \$600 and \$1000 (which correspond to annual benefits of \$2,400, \$7,200, and \$12,000 respectively), we are able to calculate the actuarial neutral premium ($EDPV$) for each of these life annuities. Multiplying the neutral premium by a loading factor τ gives the premium (P), rounded to the nearest \$500, shown to respondents.[24]

For given P, A, and j, individuals can then express their preference with respect to the contracts offered. Each respondent is presented 5 different randomly drawn scenarios from the triple (j, s, τ). Coincidentally, the average choice probability across scenarios is 13.1%, which is not far from the fraction of respondents who say they have an annuity (10.65%).

[23] We base s on COMPAS micro-simulation survival rates, and we set r to 2%, the approximate nominal yield on long-term Canadian government bonds in June 2017.

[24] See the detailed questionnaire in the paper's appendix for examples of premiums shown to respondents.

Table 5
Definition of the variables used in the regressions. Dichotomous variables are identified by the entry (1/0) at the end of the definition.

Variable	Definition
Age	Age of the respondent
Male	Respondent is Male (1/0)
British Columbia	Respondent lives in British Columbia (1/0)
Ontario	Respondent lives in Ontario (1/0)
HS or less	Respondent has a high school degree or less (1/0)
College	Respondent has a college degree (1/0)
Married or common-law	Respondent is married or has a common-law partner (1/0)
Log Home Value	Log of respondent's house value
Log Income	Log of respondent's annual income
Log savings	Log of respondent's savings
Savings Above Premium	Respondent's savings are above the annuity premium (1/0)
Bequest Motive	Respondent agrees or strongly agrees it is important to leave a bequest (1/0)
Risk Averse	Respondent unwilling to take average or greater risk for average or greater returns (1/0)
Take Care	Respondent agrees or strongly agrees that family should take care of the elderly (1/0)
No Annuity Knowledge	Respondent states having no annuity knowledge (1/0)
Has Annuity	Respondent already owns one or more annuity contracts (1/0)
Financial Literacy	Respondent answered correctly all three financial literacy questions (1/0)
False Probabilities	Respondent answered incorrectly a question on probabilities (1/0)
Trusted	Respondent is shown the word "trusted" in the preamble (1/0)
Deferred	The proposed annuity contract is a deferred annuity (1/0)
Scenario 2–5	Controlling for scenario order (1/0)
Log Age at First Benefit	Log of the age at which the first benefit payment is received
Log Benefit	Log of the benefit paid
Log Load	Log of the load on the annuity premium

5. Empirical methodology

There are different approaches to studying individual preferences for annuities. One is to construct a life-cycle model and map the choice probabilities to the underlying structural parameters of the model. This requires strong assumptions, in particular with respect to each respondent's subjective expectation about the socioeconomic environment they expect in the future. It also requires that we specify a functional form for preferences. Instead, we follow an a-theoretical approach of mapping choice probabilities onto some of the characteristics of the product offered, as well as characteristics of the respondent. We think this approach is particularly well-suited to our setting since we can allow for considerable heterogeneity in preferences. We posit the following model for choice probabilities for respondent i in scenario n, $C_{i,n}$:

$$C_{i,n} = X_i\beta + \gamma \log MW_{i,n} + \psi T_{i,n} + \alpha D_{i,n} + \epsilon_{i,n} \tag{8}$$

The choice probabilities are assumed to be a function of a vector X_i of respondent characteristics, the money's worth of the annuity, $MW_{i,n}$, whether the scenario mentions that the provided is a trusted insurance company ($T_{i,n}$), and whether the annuity is deferred ($D_{i,n}$). We choose a semi-log specification for the annuities' money's worth since choice probabilities can be zero. We can compute the price elasticity of demand as $\eta_{MW} = \frac{\hat{\gamma}}{\bar{C}}$ where $\hat{\gamma}$ denotes an estimate of the parameter γ and $\bar{C}$ is the average choice probability in the sample. Finally, $\epsilon_{i,n}$ is a disturbance that is assumed orthogonal to all variables, and in particular to $MW_{i,n}$. Given that we randomize proposed annuity characteristics, this orthogonal assumption is not restrictive. We can estimate the parameters of this equation by least squares using clustered standard errors at the respondent level. Clustering errors at the respondent level allows for arbitrary correlation across a respondent's responses and heteroscedasticity across respondents.

We first compute the money's worth of each contract for each scenario using micro-simulation survival risk and a real discount rate of future cash flows of 2%. Consequently, money's worth estimates vary across scenarios but also across respondents for the same contract parameter draw. This provides additional variation to help in identifying γ. We use four different sets of control variables. First, we control for age, gender, education, marital status, and province of residence. Second, we control for the financial situation of these respondents (savings, income, house ownership, and value of house). Third, we control for preference "shifters" such as risk aversion, belief that sacrificing current consumption to leave money to children is desirable (measure of bequest motives), and belief that the family should take care of sick parents. Lastly, we control for scenario order, knowledge of annuities in general, and for financial literacy.[25] Table 5 defines our control variables and Table 6 reports descriptive statistics those same control variables.

[25] Following the work of Lusardi and Mitchell (2014), we care in particular whether the respondent could answer three basic questions on inflation, interest compounding, and diversification.

Table 6
Descriptive statistics of the control variables used in the regressions. Statistics weighted according to 2010 Canadian Community Health Survey (CCHS).

	mean	median	sd	min	max
Male	0.498	0	0.500	0	1
age	63.170	63	5.650	55	75
High School	0.361	0	0.480	0	1
College	0.376	0	0.485	0	1
married or common-law	0.667	1	0.471	0	1
British Columbia	0.180	0	0.384	0	1
Ontario	0.487	0	0.500	0	1
Home Value (thousands)	380.534	275	433.839	0	2000
Total Income (thousands)	88.409	60	350.062	0.001	13000
Savings (thousands)	246.272	75	1639.595	0	100000
Savings Above Premium	0.517	1	0.500	0	1
Bequest Motive	0.175	0	0.380	0	1
Risk Averse	0.451	0	0.498	0	1
Take Care	0.673	1	0.469	0	1
Has Annuity	0.107	0	0.309	0	1
No Annuity Knowledge	0.273	0	0.446	0	1
Financial Literacy	0.440	0	0.497	0	1
False Probabilities	0.212	0	0.409	0	1
Age at First Benefit	72.207	75	8.584	56	85
Monthly Benefit	593.220	600	324.037	200	1000
Load on Premium	1.248	1.3	0.469	0.5	2

Eq. (8) is restrictive in the sense that it does not allow γ to vary across respondents and scenarios. To relax this assumption, we also consider a model where

$$C_{i,n} = X_i\beta + \gamma(Z_{i,n}) \log MW_{i,n} + \psi T_{i,n} + \alpha D_{i,n} + \epsilon_{i,n} \tag{9}$$

with $\gamma(Z_{i,n}) = \gamma_0 + \sum_k \gamma_k Z_{i,n,k}$. We vary the vector Z_i of dimension K to tease out heterogeneity in the price sensitivity. We consider three sets of characteristics: demographics, product characteristics, and knowledge.

6. Results

6.1. Main specification

Table 7 reports OLS estimates for the entire sample (column 1), males (column 2), and females (column 3) using survival risk as estimated from the micro-simulation model. For the full sample the semi-elasticity of choice probabilities to an annuity's money's worth is 0.088 (standard error of 0.006). This translates into an elasticity (at the mean) of 0.67. Price sensitivity does not vary much by gender as the elasticity is 0.649 for males and 0.699 for females (semi-elasticity of 0.099 for males and 0.078 for females). Hence, demand is relatively inelastic. This result is in line with a majority of results from the literature. Brown (2007), Cappelletti et al. (2013), and Chalmers and Reuter (2012) all obtain estimates of price elasticity under one. On average, respondents report a probability of purchasing an annuity of 0.132. The average predicted choice probability if everyone had an annuity with a money's worth of one is 0.147. Therefore, eliminating completely non-neutral pricing (which would be tantamount to saying that annuity-providers have no operational costs or that their excess investment income exactly offsets those costs) would increase demand by only 1.15 percentage points or 11%.

We see in Table 7 that the stated demand for annuities is larger among males (by 2.6 percentage points in column 1) and decreases with age (in all columns). Of the economic variables, we note in particular that wealth and income measures do not seem to have an impact on the stated demand for annuities, although simply having savings above the price of the proposed annuity has an important (positive) effect.[26] Thus, although income or savings alone cannot explain low annuity demand, having savings above the annuity premium significantly increases annuity demand. Intuitively, individuals seem more inclined to purchase a product they believe they can pay for, even in a hypothetical scenario.

Those who have a stronger bequest motive are more likely to purchase annuities. We can think of two explanations for that results. The first is that respondents (erroneously) believe their heirs are entitled to the annuity once they die. A second possibility is that respondents have calculated how much they want to bequest to their heirs and purchase an annuity with whatever wealth remains. The annuity then allows the respondent to hedge almost completely the risk of drawing down savings they intended to leave to their heirs by living older than what they expected.

Risk aversion is negatively correlated with demand for annuities which could be explained by a larger need for precautionary savings. Interestingly, those who think the family should care for aging parents also have a higher demand for

[26] We thank an anonymous referee for suggesting we control for a respondent's ability to purchase an annuity.

Table 7
Column 1 presents regression estimates from the linear regression of annuity contract purchase probabilities on money's worth, socioeconomic controls, scenario dummy variables (not shown) and annuity characteristics. Columns 2 and 3 present the regressions by gender. Column 4 presents an alternative specification which substitutes the money's worth control for the variables that change each time a survey respondent is shown a new scenario.

	(1)	(2)	(3)	(4)
	All	Male	Female	Money's Worth Components
Log Money's Worth	0.088***	0.099***	0.078***	
	(0.006)	(0.009)	(0.007)	
Male	0.026***			0.033***
	(0.007)			(0.007)
Age	−0.002***	−0.002**	−0.002***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
High School	−0.027	−0.035	−0.019	−0.007
	(0.022)	(0.034)	(0.023)	(0.022)
College	−0.026	−0.035	−0.018	0.012
	(0.021)	(0.033)	(0.024)	(0.021)
married or common-law	0.003	0.014	−0.004	0.004
	(0.008)	(0.014)	(0.010)	(0.008)
British Columbia	0.036***	0.033**	0.038***	0.036***
	(0.009)	(0.014)	(0.011)	(0.009)
Ontario	0.039***	0.028**	0.048***	0.043***
	(0.009)	(0.013)	(0.012)	(0.009)
Log Home Value	−0.001	−0.000	−0.002*	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Log Income	−0.007**	−0.011*	−0.005	−0.007**
	(0.004)	(0.007)	(0.004)	(0.004)
Log Savings	−0.000	−0.002	0.001	0.000
	(0.001)	(0.002)	(0.001)	(0.001)
Savings Above Premium	0.022***	0.021**	0.024***	0.017**
	(0.007)	(0.010)	(0.009)	(0.008)
Bequest Motive	0.029***	0.031**	0.025	0.030***
	(0.011)	(0.014)	(0.016)	(0.011)
Risk Averse	−0.031***	−0.035***	−0.028***	−0.031***
	(0.008)	(0.012)	(0.010)	(0.008)
Take Care	0.024***	0.028**	0.020**	0.025***
	(0.007)	(0.011)	(0.009)	(0.007)
Has Annuity	0.087***	0.088***	0.087***	0.086***
	(0.013)	(0.018)	(0.018)	(0.013)
No Annuity Knowledge	−0.031***	−0.050***	−0.020*	−0.032***
	(0.009)	(0.015)	(0.011)	(0.009)
Financial Literacy	−0.004	−0.006	−0.003	−0.004
	(0.008)	(0.012)	(0.010)	(0.008)
False Probabilities	0.016	0.021	0.012	0.017*
	(0.010)	(0.018)	(0.012)	(0.010)
Trusted	0.018***	0.020*	0.018**	0.018***
	(0.007)	(0.010)	(0.009)	(0.007)
Deferred	0.004	0.008	0.000	0.001
	(0.005)	(0.007)	(0.006)	(0.008)
Log Age at First Benefit				−0.013
				(0.039)
Log Benefit				0.003
				(0.003)
Log Load				−0.106***
				(0.006)
N	15,005	7495	7510	15,005
r2	0.072	0.068	0.070	0.076

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

annuities, which may suggest that their need for liquidity to pay for unexpected expenses at older ages, such as long-term care services or long stays in a nursing home,[27] is less of a concern.

Product characteristics in the scenarios we present appear to be connected to demand, albeit in a modest way. Respondents seem to value having a trusted financial institution offer an annuity as demand increases by 1.8 percentage points in the full sample. This might indicate that reputation effects are important in this market as the consumer sacrifices large

[27] See Boyer et al. (2019a) for the state of long-term care insurance in Canada.

Table 8
Column 1 presents regression estimates from the linear regression of annuity contract purchase probabilities on money's worth, socioeconomic controls, scenario dummy variables (not shown) and annuity characteristics, using longevity risk estimates from the COMPAS microsimulation model. Column 2 presents the same results, using longevity risk estimates from Statistics Canada prospective cohort life tables and column 3 uses subjective longevity risk as reported by survey respondents.

	(1) Microsimulation	(2) Life-table	(3) Subjective
log money's worth	0.088***	0.106***	0.045***
	(0.006)	(0.006)	(0.004)
Male	0.026***	0.028***	0.029***
	(0.007)	(0.007)	(0.007)
Age	−0.002***	−0.002***	−0.003***
	(0.001)	(0.001)	(0.001)
High School	−0.027	−0.007	−0.005
	(0.022)	(0.022)	(0.021)
College	−0.026	0.012	0.013
	(0.021)	(0.021)	(0.021)
married or common-law	0.003	0.004	0.004
	(0.008)	(0.008)	(0.008)
British Columbia	0.036***	0.031***	0.038***
	(0.009)	(0.009)	(0.009)
Ontario	0.039***	0.040***	0.047***
	(0.009)	(0.009)	(0.009)
Log Home Value	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)
Log Income	−0.007**	−0.007**	−0.008**
	(0.004)	(0.004)	(0.004)
Log Savings	−0.000	0.001	−0.001
	(0.001)	(0.001)	(0.001)
Savings Above Premium	0.022***	0.014**	0.027***
	(0.007)	(0.007)	(0.007)
Bequest Motive	0.029***	0.030***	0.032***
	(0.011)	(0.011)	(0.011)
Risk Averse	−0.031***	−0.031***	−0.029***
	(0.008)	(0.008)	(0.008)
Take Care	0.024***	0.025***	0.021***
	(0.007)	(0.007)	(0.007)
Has Annuity	0.087***	0.086***	0.086***
	(0.013)	(0.013)	(0.013)
No Annuity Knowledge	−0.031***	−0.032***	−0.031***
	(0.009)	(0.009)	(0.009)
Financial Literacy	−0.004	−0.003	−0.004
	(0.008)	(0.008)	(0.008)
False Probabilities	0.016	0.017*	0.015
Trusted	0.018***	0.018***	0.018***
	(0.007)	(0.007)	(0.007)
Deferred	0.004	−0.005	−0.008*
	(0.005)	(0.004)	(0.004)
N	15,005	15,005	15,005
r2	0.072	0.076	0.066

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

amounts of savings against a promise to be paid until death. A consumer therefore relies on the insurer's solvency for what can become decades. This result is in line with existing research that shows how the demand for insurance decreases with increasing default risk, as in Zimmer et al. (2018).

In contrast to Brown et al. (2017), we find no significant link between *financial knowledge or literacy* and annuity demand. We do find, however, a significant link between *annuity knowledge* and annuity demand. This is reflected in two ways. First, we find that already having an annuity significantly increases the stated probability of purchasing one. We find a stated probability of wanting to buy an annuity that is 8.7 percentage points higher among those who already own an annuity. This is true for both male and female respondents. It therefore appears that the demand for annuities is currently unsatiated since, contrary to what one might think, annuity demand is not negatively correlated to already owning an annuity. In fact, annuity owners seem to value them so much that they are much more likely to buy another than the average respondent. This suggests that the need for annuities has not been completely filled, even for those individuals who have already purchased such products.

Table 9
Price elasticity estimates by gender (Panel A, top) and source of longevity risk estimates (Panel B, bottom). Results were obtained from the regression of purchase probabilities on the money's worth of annuities and other controls described in Eq. (8). Standard errors in parentheses. IN Panel B, Column 1 uses longevity risk estimates from the COMPAS microsimulation model, Column 2 presents the same results, using longevity risk estimates from Statistics Canada life tables, and Column 3 uses subjective longevity risk as reported by survey respondents.

Panel A: Price elasticity by gender

	(1) All	(2) Male	(3) Female
Elasticity	0.669***	0.649***	0.699***
	(.044)	(.058)	(.064)

Panel B: Price elasticity by survival risk model

	(1) Microsimulation	(2) Life-table	(3) Subjective
Elasticity	0.669***	0.804***	0.343***
	(.044)	(.045)	(.029)

In all cases, significance is defined as * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The second way in which we find a link between annuity knowledge and annuity demand is that having no knowledge of annuities prior to taking part in the experiment is associated with much lower demand for annuities. In the full sample, demand is 3.1 percentage points lower among those respondents who, prior to answering our survey, had no prior knowledge of annuities. This effect is even larger among males (-5.0 percentage points compared to -2.0 for females). We documented in Table 1 that individuals have relatively low knowledge of annuities, with approximately 25% of respondents saying they have no knowledge of what annuities are. Hence, the effect of the absence of knowledge among this group on aggregate demand is of 0.8 percentage points.

In column 4, we present the same regression results as column 1, but instead of controlling for the log of the annuities money's worth as a whole, we divide up the money's worth into its three components that change in each scenario: the age at which benefits are received, the benefit itself, and the load on the discounted expected payout value. Through this exercise, we are able to conclude that it is the load on the premium that is the main driver for variations in annuity demand. Coefficient values for the other explanatory and control variables remain essentially the same.

6.2. Other specifications and price-Elasticity measures

6.2.1. Source of longevity risk

In Table 8, we assess the robustness of our main results to the source of longevity risk used to construct our estimates of the annuities' money's worth. Column 1 replicates the specification presented in Table 7, in which survival probabilities are calculated using a micro-simulation model. In column 2, we use survival probabilities taken from Canadian prospective life tables provided by Statistics Canada. We find that the semi-elasticity is slightly larger using the life-tables (0.106 with a standard error of 0.006) while other parameter estimates are very similar. We report in column 3 the same analysis, but using the respondents' subjective survival risk, which results in a smaller semi-elasticity than using objective measures of mortality risk taken from either the micro-simulation model or Statistics Canada life-table.

If longevity risk misperceptions (or privately known risk) were the main drivers of our respondents' decision to purchase life annuities, we should expect to see a larger price effect. We do not see much price-elasticity in the demand for annuities, however, neither by sex as in Panel A of Table 9, nor by survival risk perception as in Panel B. One possible interpretation for the low price-elasticity is that respondents have trouble coupling their expectations regarding survival with the valuation of annuities. Another interpretation is that subjective estimates contain a considerable amount of noise. This interpretation is more likely given that we elicit and then estimate the baseline shift in the mortality hazard from only two data points.[28] Hence, measurement errors may bias downward price sensitivity calculations.

Looking more carefully at the elasticity estimates in Panel B of Table 9, which differ with respect to the survival probability measures used, we note that the price elasticity of the demand for annuities is much smaller when we use the individuals' subjective survival probability than when the two other objective probabilities are used. This tells us that if we were able to educate our respondents about their true survival probabilities, then their demand for annuities would become

[28] Recall that from $s^{O}_{a,85}(x_i) = \exp(-\Lambda^{O}_{a,85}(x_i))$ and $s^{S}_{a,85}(x_i) = \exp(-\psi \Lambda^{O}_{a,85}(x_i))$ we can back out ψ, which we apply to all survival probabilities, $s^{S}_{a,a+t}(x_i)$.

Table 10
Results of the regression of the stated probability of purchasing an annuity contract on money's worth. Price elasticity is allowed to vary depending on an individual's characteristics, as outlined in Eq. (9). Only interacted coefficients are shown.

	(1) Heterogeneity
Log Money's Worth	0.229***
	(0.058)
Male = 1 × Log Money's Worth	0.008
	(0.008)
Log Money's Worth × Age	−0.001*
	(0.001)
High School = 1 × Log Money's Worth	0.003
	(0.014)
College = 1 × Log Money's Worth	0.008
	(0.014)
Married or common-law × Log Money's Worth	0.005
	(0.009)
British Columbia = 1 × Log Money's Worth	0.030***
	(0.010)
Ontario = 1 × Log Money's Worth	0.022**
	(0.010)
Log Money's Worth × Log Home Value	−0.001*
	(0.001)
Log Money's Worth × Log Income	−0.007**
	(0.003)
Log Money's Worth × Log Savings	−0.000
	(0.001)
Savings Above Premium = 1 × Log Money's Worth	0.007
	(0.008)
Bequest Motive = 1 × Log Money's Worth	−0.003
	(0.011)
Risk Averse = 1 × Log Money's Worth	−0.016*
	(0.009)
Take Care = 1 × Log Money's Worth	0.007
	(0.008)
Has Annuity × Log Money's Worth	0.005
	(0.014)
No Annuity Knowledge = 1 × Log Money's Worth	−0.011
	(0.009)
Financial Literacy = 1 × Log Money's Worth	0.012
	(0.009)
False Probabilities = 1 × Log Money's Worth	−0.003
	(0.012)
Scenario 2 = 2 × Log Money's Worth	0.006
	(0.007)
Scenario 3 = 3 × Log Money's Worth	0.005
	(0.007)
Scenario 4 = 4 × Log Money's Worth	0.002
	(0.008)
Scenario 5 = 5 × Log Money's Worth	0.004
	(0.007)
Trusted = 1 × Log Money's Worth	0.002
	(0.008)
Deferred = 1 × Log Money's Worth	−0.068***
	(0.007)
N	15,005
r2	0.077

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

much more responsive to the premium. Whether the demand for annuities would increase is not obvious, however, since educating individuals with respect to their true life expectancy would make them perceive the annuities' money's worth to be smaller than one (see Table 4), which would make the product appear less attractive than when individuals over-estimate their life-expectancy.

6.2.2. Heterogeneity in price sensitivity

Table 10 presents OLS estimates for the interaction terms in Eq. (9). Our results show that there is a certain degree of heterogeneity in price elasticity. Price sensitivity is decreasing in income and increasing in housing value, although the

second effect is relatively small. We also find older individuals to be less price sensitive. Insurers may already be aware of the fact that price sensitivity decreases with age since we recall from Table 4 that the money's worth of annuities decreases in the respondent's age.

From a public policy's point of view, as well as from the point of view of marketing annuities in general, the most fascinating result that can be observed in Table 10 is related to the heterogeneity of the price elasticity of deferred versus immediate lifetime annuities (last coefficient line). Being presented a deferred annuity (which we denoted $PV(A, M)$ earlier in the paper) results in lower price sensitivity. This result is particularly interesting as it suggests insurers could use product characteristics to price discriminate and charge higher premiums for deferred annuities as respondents seem less price sensitive to them. Currently, the most common annuity product in Canada remains the immediate annuity (which we denoted $PV(A, 0)$). By having access to a deferred annuity, asymmetric information cost between annuity providers and consumers would be reduced. In addition individuals would, perhaps, be in a better position to protect more efficiently those years when they no longer have the ability to supplement their retirement income with part-time work.

7. Conclusion

Using a stated-preference experiment, this paper examines the demand for individual annuities in Canada. With respect to the financing of its retirement system, the Canadian situation is similar to that of most developed countries in the sense that the retirement system provides room for private savings (often in tax-preferred accounts). In addition, demand for other insurance products, such as life insurance, is almost identical to that of other OECD countries.[29] We can consequently infer that the results from our study are widely applicable to other financially developed jurisdictions in which insurers play an important and active role in offering financial products aimed at consumers who seek to annuitize part of their wealth. Our results can be summarized along three main themes: 1- Product mispricing, 2- Small but non-zero price-elasticity of demand, and 3- Little potential growth in absolute terms, but large in relative terms.

With respect to product mispricing, we calculate the money's worth of different individual annuity products and examine the demand for them. The money's worth of an annuity contract is calculated as the ratio of the present value of the stream of benefits it will pay, divided by the current price of such a contract. The money's worth thus depends on the discount rate, which is independent of each individual's personal characteristics (in the paper we used a 2% discount rate, which is the rate that corresponds to the return on long-term government of Canada bonds), and the purchasing individual's survival probability, which depends on each individual's personal characteristics. We find that individual annuities are close to neutrally priced when analyzed through the scope of an individual's objective survival probability as calculated using the Canadian prospective life tables of Statistics Canada. When we take into account more individual-specific characteristics in a micro-simulation survival probability model, we find that individual annuities are priced 6% over the actuarially neutral level. With respect to subjective survival probabilities, individual annuities appear to offer great value for the money in Canada since their subjective money's worth is equal to 1.15, which means that annuitants believe they receive, on average, 15% more than what they paid.

The difference between the objective and the subjective money's worth explains our second important result, which is that demand for annuities is price responsive but not very elastic. Given the result from the money's worth experiment, we find a price elasticity of demand that is much lower using subjective mortality risk (an elasticity of -0.34) than using personalized objective risk measures of longevity risk (an elasticity of -0.67).

Despite individual annuities being objectively non-neutrally priced in Canada, increasing competition in the market place, which would surely reduce the price of such a longevity hedging instrument, could lead to an increase in the number of households and/or individuals purchasing annuities. Our estimate is that the increase in the take-up rate would be around 2 percentage points. Given the current take up rate of 10.65%, a 2 percentage point increase, although small in absolute terms, would represent an almost 20% increase in the number of annuity contracts sold. In contrast, increasing the consumers' knowledge of annuities would increase demand by only 0.8 percentage points. Consequently, the potential increase in the number of households that would hedge their longevity risk with annuity products is, in the best possible market conditions, 26%, although the absolute increase would only be 2.8 percentage points (from a take-up rate of 10.65% to 13.45%).

The 0.8 percentage point increase in the take-up rate associated with larger awareness of Canadians has to be weighed against the decrease in the take-up rate associated with telling Canadians that they over-estimate their survival probability. In contrast to increasing competition in the market place which cannot result in fewer consumers acquiring an annuity contract, education is a double-edged sword that could lead current purchasers of annuities to realize that they are paying too high a price compared to the objective expected present value of the stream of cash flows they are being promised. Moreover, the price-elasticity of individuals would be likely to increase if they were better educated about their survival probability, thus further reducing their willingness to acquire an annuity if these are not neutrally priced.

[29] In particular, penetration of life insurance products is close to 60%, as in the United States. For more on this topic, see CLHIA (2017) and LIMRA (2018).

Appendix A. Additional Results on Money's Worth

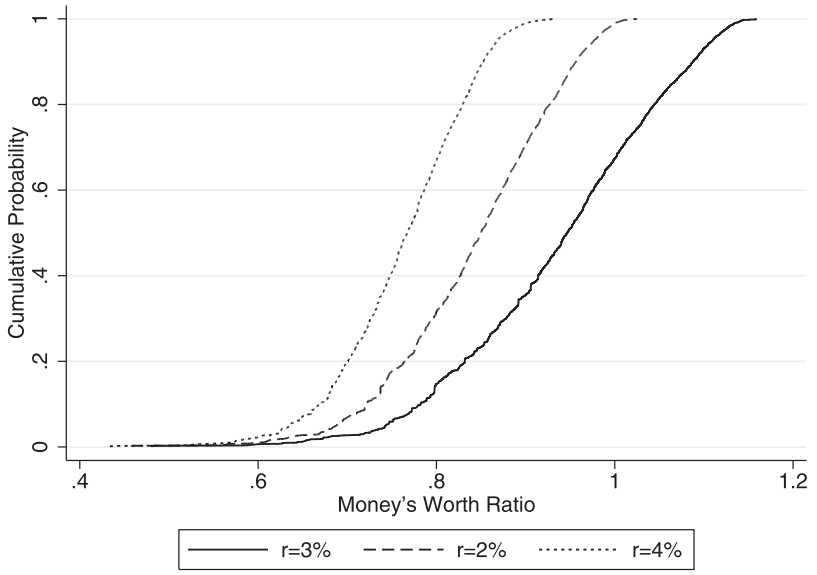

Fig. A.1. Distribution of Money's Worth of Annuities listed on CANNEX: Robustness to Discount Rate. We compare money's worth values according to discount rates ranging from 2-4%.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2019.03.022.

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