Drawing Down Retirement Savings

- Do Pensions, Taxes and Government Transfers Matter Much?

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Abstract

What is the best strategy for retirement spending? Clearly, calculations of the implications of different strategies will be easier and simpler if the complications of pensions, taxes and government transfers can be ignored (as much of the literature now does). What is the cost of such simplification? How much might retirees, their advisors and researchers expect to go wrong in specifying the preferred strategy, if pensions, taxes and transfers are ignored? More specifically, does including them in analysis alter the ranking of commonly advocated alternative drawdown strategies?

This paper examines the importance of pensions, taxes and government transfers for the evaluation of alternative drawdown strategies for the single Canadian elderly population. Using example Canadians at the 10th, median and 90th percentiles of the income distribution, we examine an illustrative set of six popular drawdown strategies. Employing a lifetime utility framework and a longitudinal dynamic micro-simulation model for Canada that features risk aversion, stochastic markets, stochastic mortality and the interactions among sources of retirement income within the complex Canadian tax and social benefit system, we rank six commonly advocated drawdown strategies and ask whether incorporating pensions, taxes and transfers alters those rankings. Our primary finding is that pensions, taxes and transfers do affect drawdown strategy rankings. Notably, annuitization is not always the best strategy once pensions, taxes and government transfers are modeled. Second, the four example Canadians, when sharing the same risk preferences, will have the same drawdown strategy rankings if only private wealth is considered, but these rankings are differentially altered by the inclusion of pensions, taxes and transfers because these components affect people differently at different points in the income distribution. Our findings show the importance of treating the evaluation of alternative drawdown strategies as an integrated problem by including all sources of income – including pensions, taxes and government transfers.

1. Introduction

What is the best strategy to use in drawing down retirement financial savings? Whether the objective is to maximize expected utility, or to minimize the probability of lifetime ruin, published research has conventionally analyzed this question using a gross income concept obtainable from the retirement savings alone[5]. Computational complexity has been the main reason for ignoring other sources of retirement income, taxes and government transfers – for example, Kotlikoff (2006:2) argued that to compute "(t)axation by itself is a factor worthy of a Xeon processor" and "(c)omputing Social Security benefits is another nightmare"[6].

To investigate the impact of pension income, taxes and government transfers on the optimal strategy for drawing down retirement financial savings, this paper uses a longitudinal dynamic micro-simulation model for single Canadians aged 65. We compare estimates of the certainty equivalent income corresponding to the expected discounted present value of utility from six drawdown strategies for four example cases – poor, middle class and affluent retirees with and without defined benefit pension entitlements. Our model traces financial flows across alternative possible scenarios of an individual's retirement. Rather than imagine one possible "future" for an individual, we explicitly model the uncertainty of future inflation, investment returns and mortality using stochastic simulation. Within each run of each scenario, we model the Canadian taxes and social benefits associated with the financial flows of each simulation year. Since we specify the probability distribution of each stochastic variable, we can then add up across all simulation runs and calculate the expected present value of utility corresponding to each alternative strategy.

These taxes and social transfers include income taxes (including taxes on realized capital gains), refundable and non-refundable tax credits, sales taxes, provincial health premiums, and the Canadian social retirement programs – the universal Old Age Security (OAS) and the Guaranteed Income Supplement (GIS) for low-income Canadians[7].

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[5] Beginning with Yaari (1965)'s seminal paper, examples include Milevsky and Robinson (2000), Ameriks et al. (2001), Brown (2001), Jousten (2001), Blake et al. (2003), Dus et al. (2004), Davidoff et al. (2005), Butler and Teppa (2007), Horneff et al. (2008), Webb (2009), Pang and Warshawsky (2010), and Peijnenburg et al. (2011). Although the convention in this line of literature is to use a gross income concept, in the quest to explain the "annuity puzzle" several studies have examined the importance of pension income from employers and social security on the desirability of annuitization (e.g Mitchell et al. (1999) and Brown (2001)), and recently Butler et al. (2011) and Pashchenko (2013) investigated means-tested government transfers/consumption floors. In related research, Doyle and Piggott (2003) compared the desirability of alternative types of annuity products if government transfers are accounted for.

[6] Hubbard, Skinner and Zeldes (1995) found that means-tested government transfers dramatically influenced optimal savings behavior, particularly among low-income households.

[7] OAS is a flat universal benefit for all Canadians meeting a residence requirement. Although "universal", OAS benefits are reduced for high-income Canadians. As of July 2012, the maximum OAS benefit for a single was $544.98 per month, which reduces at a rate of 15% for Canadians earning more than $69,562, until it is eliminated entirely if income exceeds $112,966. GIS is a low-income benefit that, as of July 2012, had a maximum benefit of $738.96 per month for a single, which is reduced by $0.50 for every dollar of income (excluding OAS benefits and

We compare estimates of the expected present value of utility for six drawdown strategies (market annuitization, four distinct self-managed drawdown strategies, and one hybrid strategy) using the four following income concepts as the argument of the utility function:

1. *Savings*: i.e. Gross withdrawals from financial savings brought into retirement –registered and non-registered financial savings
2. *Savings + Pension*: Savings + C/QPP benefits[8] + employer pension plan benefits
3. *Savings + Pension - Taxes*: Savings + Pension – income taxes[9] + non-refundable tax credits + refundable tax-credits (GST/PST/HST) – sales taxes – provincial health premiums
4. *Savings + Pension – Taxes + Transfers*: Savings + Pension - Taxes + OAS/GIS benefits

In our view, the last income concept (i.e. 4: *Savings + Pension – Taxes + Transfers*) corresponds most closely to the appropriate measure of income available for individual consumption[10] – but simple gross withdrawals (the first income concept: *Savings*) is what many researchers have conventionally used in the evaluation of alternative drawdown strategies. To understand the importance of each income component when comparing drawdown strategies, we proceed in steps:

- including other stabilizing sources of income: i.e. comparing #1 to #2;
- including taxes: #2 versus #3; and
- including government transfers: #3 versus #4

We present calculations for 'typical' 65-year old single Canadians corresponding to the 10th, 50th and 90th percentile of the income distribution, using empirically representative levels of Canada/Quebec Pension Plan (C/QPP) benefits, employer pension plan benefits, registered financial assets, and non-registered financial assets. We also include calculations for a stylized affluent senior without pension benefits, but with substantial assets.

There are many possible drawdown strategies and this paper cannot pretend to have evaluated them all. The globally optimal drawdown strategy for any particular individual will, in general, be sensitive to many parameters – e.g.   personal circumstances, preferences, assumed returns on investments, life expectancy, etc. Our objective is the modest one of illustrating the importance of considering the impact of taxes… for the ranking of alternative drawdown strategies using six commonly advocated alternatives. Section 2 outlines our methodology, Section 3 presents the results, and Section 4 contains our conclusions.

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non-registered savings) until the benefit is eliminated at an annual income of $16,512. See http://www.servicecanada.gc.ca. The OAS/GIS amounts incorporated are net of any income-tested repayments.

[8] Canada/Quebec Pension Plan (C/QPP) is an earnings-related benefit aimed at replacing up to approximately 25% of the average industrial wage.

[9] This includes realized capital gains taxes.

[10] We cannot, at this stage, include any measure of the net value of housing services received from owner-occupied housing. We recognize the importance of this type of implicit income, but it is not measured in our data set.

2. Methodology

2.1 Outcome Measure – Utility Framework

Like many others[11], we assume a standard constant relative risk aversion power utility function, exponential time discounting at a fixed rate, and additive separability. We assume no bequest motive and that retirees draw down their wealth at the start of each year and consume that drawdown entirely during the coming year. Given some set of future events (i.e. instantiation *i*) the present value (PV$_i$) of utility for each individual at age 65, conditional on having T remaining years of life, is then:

$$PV_i = \sum_{t=0}^{T-1} \beta^t \frac{(C_{i,t})^{(1-\alpha)}}{(1-\alpha)} , \qquad\qquad (1)$$

where:
- *i* is the specific instantiation of future events – i.e. the specific random draw from the joint probability distributions of asset returns, mortality, and other random processes
- β is the discount factor (subjective time preference) for the individual[12]. We set β = 0.96.
- α is the coefficient of relative risk aversion ($\alpha \neq 1$ and $\alpha \rightarrow 1$ corresponds to logarithmic utility). We test three levels of risk aversion[13], α = 1.5, 2 and 5.
- *t* is time (set to 0 at age 65)
- *T* is the time of death, and
- C_t is consumption between times *t-1* and *t* (in constant dollars).

We model uncertainty in mortality, inflation and financial returns by stochastic simulation and obtain the expected present value of utility by averaging *PV* across one million simulated possible futures of the person under examination[14]. For example, if $PV_i^{DS\#1}$ signifies the present

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[11] Examples include Yaari (1965); Mitchell et al. (1999); Brown (2001); Milevsky and Young (2002; 2007); Davidoff et al. (2005); Butler and Teppa (2007); Horneff et al. (2008, 2010); Koijen et al. (2009); Webb (2009); Peijnenburg et al. (2011); and Pashchenko (2013).

[12] Brown (2001:43) and Pashchenko (2013: 56) used 0.97, Blake et al. (2003:35) used approximately 0.95 and Milevsky and Young (2007:3152) used 0.95. Gustman and Steinmeir (2005:451) found that approximately 40% of the HRS data sample had a time preference rate above 95%, 21% had a time preference between 90-95%, and the remainder were under 90%.

[13] The most commonly used values for α have been between zero and two, (e.g. Mitchell et al., 1999:1314). However, using the U.S. Health and Retirement Survey (HRS), Brown (2001:45) found that two thirds of the sample exhibited a risk aversion of 3.76 and over, which he then represented as five. Milevsky and Young (2007:3152), Horneff et al. (2008:402), Webb (2009:16), Pang and Warshawsky (2010:200), and Peijnenburg et al. (2011:8) similarly tested relative risk values of 5 or more when assuming the standard power utility function to compare alternative drawdown strategies.

[14] The computing time difference between running a million simulations versus a smaller number (such as a thousand) is small – since the choice affects the variability of the upper ends of the distributions, we chose a million.

value of utility in instantiation (simulated life-course) *i* using drawdown strategy #1 (DS#1), then the expected present utility value of DS#1 ($E[PV^{DS\#1}]$) is:

$$E[PV^{DS\#1}] = \frac{1}{1,000,000} \sum_{i=1}^{1,000,000} PV_i^{DS\#1} \,. \tag{2}$$

While time of death (*T*) and consumption (C_t) are stochastic variables, β and α are fixed across all simulations.

2.2 Drawdown Strategies

We compare six drawdown strategies (DS) commonly found in the financial advisory literature (see Appendix A for formulas).

Annuitization: The purchase of a non-indexed single premium immediate life annuity
 - The individual purchases an immediate whole life annuity-due at age 65.
 - Payouts are nominally-fixed until death.

Variable Drawdown to Age 95: Self-managed drawdown over lifetime
 - Variable drawdown strategy (the drawdown amount is re-calculated each year)
 - The individual aims to withdraw equal real amounts each year that exhaust the portfolio by age 95.

Variable Drawdown to Age 80: Self-managed drawdown over 15 years (exhaust by age 80)
 - Variable drawdown strategy
 - The individual aims to withdraw equal real amounts each year that exhaust the portfolio by age 80.

Fixed Drawdown 4% Rule: Self-managed 4% Rule (inflation-indexed)
 - Fixed drawdown strategy (fixed at age 65, adjusted only by inflation).
 - The individual withdraws 4% of the portfolio in the first year, and same amount indexed by inflation in each subsequent year until death or portfolio exhaustion.

Fixed Drawdown 6% Rule: Self-managed 6% Rule (inflation-indexed)
 - Fixed drawdown strategy
 - The individual withdraws 6% of the portfolio in the first year, and same amount indexed by inflation in each subsequent year until death or portfolio exhaustion

Hybrid: Hybrid of annuitization and self-managed 4% inflation-indexed fixed drawdown

Drawdown strategies are commonly categorized as: annuitization (#1), self-managed fixed drawdown strategies (#2 and #3), self-managed variable drawdown strategies (#4 and #5) and hybrid (#6).

▪ **Annuitization**

When annuitizing, the individual uses his financial assets at age 65 to purchase a single premium immediate whole life annuity that pays a guaranteed fixed stream of income until death. The primary advantage is guaranteed future income - even at advanced ages. Beginning with Yaari (1965), existing literature has nearly unanimously agreed that, from a pre-tax, pre-transfer perspective, annuitization improves the financial welfare of retirees owing to the stability of the income stream and the sharing of mortality risk (a surviving annuitant receives an additional

"mortality premium" on top of the underlying rate of return)[15]. Despite this advice, seniors around the world rarely voluntarily annuitize their personal savings[16], a fact now known as the "annuity puzzle".

Annuitization is the only strategy that fixes payments in nominal terms – consequently, the purchasing power of annuity payments in the first and last drawdown strategies become increasingly eroded by inflation year after year. However, if inflation expectations are firmly anchored, this is not necessarily disastrous – indeed, in some circumstances, it can be optimal. Specifically, optimal real consumption changes by a ratio of $\beta^{1/\alpha}$ every year, so if the coefficient of relative risk aversion (α) equals 2 in Equation 1 in Section 2.1, this implies approximately a 2% rate of decrease from one year to the next (that is, $0.96^{1/2} = 98\%$, see Appendix B). Our inflation assumption is 2%, (the mid-point of the Bank of Canada's target range and the actual average inflation rate for the last twenty years), which implies that purchasing a constant nominal dollar annuity satisfies this optimality condition, when $\alpha = 2$.

We assume a 2000-2007 average industry annuity price as described in Section 2.4[17]. The first year payment (before taxes) is 8.36% of initial wealth for males and 7.58% for females.

- **Self-managed strategies**

In a self-managed drawdown strategy, the discretionary management of financial assets has the advantage of availability of liquid assets in the case of large, unplanned expenses[18]. Self-managed "variable" drawdown is when annual withdrawal amounts vary by year according to investment performance so that the funds do not run out prematurely if investments perform poorly. A self-managed "fixed" drawdown strategy fixes the annual withdrawal amount from year to year (either nominally or inflation-indexed) – which implies a risk of running out of wealth in the event of poor market performance (Blake et al., 2003)[19].

In variable drawdown strategies "Variable Drawdown to Age 80" and "Variable Drawdown to Age 95", the individual withdraws equal real amounts until age 80 and until age 95. This

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[15] Babbel (2008) reviewed 70 published papers since 1999 that examined the tradeoffs between annuities and alternatives, and reported "for most people, lifetime income annuities should comprise from 40% to 80% of their retirement assets under current pricing" (pg. 5).

[16] See Milevsky and Young (2007) and Brown (2009) for U.S. evidence, or James and Song (2001) for an international perspective that includes Canada.

[17] Milevsky and Shao (2010) found that an actuarially fair annuity for 65 year-old males (calculated assuming annuitant industry mortality and the Canadian risk-free zero-coupon government treasury yield curve) was more expensive for the annuitant than the market rate from 2000-2009 in Canada. We similarly found that an actuarially fair annuity, calculated assuming population mortality (Section 2.4) with the average annual Canadian treasury-bill yield, was less favorable than market rate annuities between 2000-2007.

[18] As well, assets remaining upon death can be bequeathed – this paper does not address risk aversion with respect to large unforeseen expenditures or bequest preferences.

[19] The availability of government social transfer payments once private wealth is exhausted, however, implies that it is not necessarily irrational to incur a risk of asset exhaustion (see MacDonald et al. (2013) for discussion).

strategy is similar to the more common "1/T Rule"[20] where, if T= 15, then the drawdown amounts at ages 65, 70, 79 and 80 (for example) would be:

- $Drawdown_{65} = Wealth_{65}/15$ at age 65 (the denominator is 80 less 65);
- $Drawdown_{70} = Wealth_{70}/10$ at age 70;
- $Drawdown_{79} = Wealth_{79}/1$ at age 79; and
- $Drawdown_{80} = 0$ for ages 80 and above.

The "1/T Rule" has the advantage of simplicity, but it fails to account for anticipated future real portfolio returns and therefore creates payments that generally increase over time (Dus et al., 2004). The formula for the variable drawdown strategies (see Appendix A) is explicitly designed to account for future expected real portfolio returns so as to target level, inflation-indexed payments that exactly exhaust the portfolio at the end of the chosen horizon[21]. (If real portfolio returns were expected to be zero, then the "Variable Drawdown to Age 80" and the "1/T Rule" described above would render the same drawdown pattern.)

In "Variable Drawdown to Age 95", age 95 is the 'lifetime' target for asset exhaustion – the implicit assumption is that after age 95 the individual will depend on Canada's OAS/GIS system plus any available pension benefits. In "Variable Drawdown to Age 80", 15 years is the approximate number of years in full health over which the individual wishes to deplete personal wealth (health-adjusted life expectancy for 65 year-old Canadians in 2001 was 14.4 years for females and 12.7 years for males[22]). The first year payment (before taxes) is 6.36% of initial wealth for males and females using "Variable Drawdown to Age 95", and 9.31% using "Variable Drawdown to Age 80".

Bengen (1994) argued that funds are likely not to run out under a 4% inflation-indexed fixed strategy (i.e. 4% Rule)[23] and therefore "Fixed Drawdown 4% Rule" is a popular self-managed strategy that represents a desire that funds do not run out before death. A 6% fixed drawdown is considered a more aggressive constant drawdown approach. As in "Variable Drawdown to Age 80/95", if funds run out before life does, then the individual must rely on pension benefits and government social transfers. Note that the real value of payments from "Fixed Drawdown 4%/6% Rule" are only fixed on a pre-tax basis (that is, the after-tax purchasing power of the income generated from the withdrawals is not necessarily fixed in real terms). By definition, the first year payment (before taxes) is 4% of initial wealth for males and females using "Fixed Drawdown 4% Rule", and 6% using "Fixed Drawdown 6% Rule".

- **Hybrid strategy**

A hybrid, or 'mixed', strategy combines annuitization and self-management. The benefits are a guaranteed income stream from the annuitized assets and the flexibility and potential for bequest from the self-managed assets.

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[20] See Dus et al. (2004).
[21] That is, the drawdown amount is only constant in real terms *on average* (each simulation has some variability). If portfolio returns assumed their projected average in each simulation year, the real amount drawn down would be constant.
[22] Source: CANSIM Table 102-0121.
[23] See also Pye (2000) and Ameriks et al. (2001).

In "Hybrid", 25% of the total wealth is used to purchase an annuity, while the remaining is self-managed. We apply the same drawdown strategy to both registered and non-registered wealth in the first five drawdown strategies. In "Hybrid", however, the subject purchases the annuity first from his/her non-registered wealth, and then from his/her registered wealth, until 25% of total wealth is annuitized.

2.3 Example Canadians

Our first three example cases assign empirically representative levels of retirement resources corresponding to a newly retired 65-year old with positive financial assets (in 2005, 78% of 60-70 year old Canadians had net financial savings[24]). In this paper we restrict our attention to single Canadians - government taxes and transfers are much more complex to model for couples (depending, among other things, on the age differential between spouses). Single Canadian seniors are a minority – 19% of male 65 year-olds were single[25] in 2007 and 33% of females (26% were single overall) – but we leave analysis of couples for future work. As these are single Canadians, their financial profiles are much lower than their couple counterparts – for example, in 2005, median total income was $26,200 for 55-64 year old unattached Canadians and $21,800 for unattached Canadians aged 65 and over[26], compared to $75,300 and $47,600 for families with two or more people.

Table 1 lists the representative C/QPP, employer pension plan income, and financial savings (registered and non-registered) for a "representative" single 65-year-old Canadians entering retirement with:
- low income (10th percentile of the income distribution)
- median income (50th percentile of the income distribution); and
- high income (90th percentile of the income distribution).

Appendix D details the underlying methodology and assumptions[27]. We use the median pension

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[24] i.e. more than $0 in net financial assets, based on the 2005 Statistics Canada's Survey of Financial Security (SFS) Public Use Microdata (person file). Financial assets are the sum of registered financial assets (registered retirement savings plus registered retirement income funds) and non-registered financial assets, less non-mortgage debt. Non-registered financial assets consist of deposits held in chequing and savings accounts, term deposits, guaranteed investment certificates, bonds, mutual funds, trust funds and other miscellaneous financial assets. Total non-mortgage debt consists of amounts owing on credit cards, secured and unsecured loans (including lines of credit from banks and other institutions), car loans, and other unpaid bills.

[25] "Single" = single, divorced, or widowed. See CANSIM Table 051-0010

[26] Source: Cansim Table 202-0404.

[27] We estimate income flows from C/QPP and defined benefit employer plans using the 2008 Survey of Labour and Income Dynamics (SLID); wealth stock of registered financial assets (registered retirement savings plus registered retirement income funds) and net non-registered financial assets (total financial assets less total non-mortgage debt) using the 1999 and 2005 Survey of Financial Security (SFS); and income flows from taxes and social transfers (OAS and GIS) generated in the simulation using 2011 published Canadian government values and rules for future indexation (the maximum annual benefits in 2011 were $6,368.25 and $8,634.84). We

values of 66-70 year-old single Canadian respondents within the bottom (10th to 30 percentile), middle (40th to 60th percentile) , and top (80th percentile plus) of the income distribution in the 2008 SLID to impute the C/QPP and employer pension income. The values for registered and non-registered financial assets are taken from the median values of 60-70 year old single Canadian respondents who hold any financial assets within the bottom, middle, and top of the income distribution using the 1999 and 2005 SFS (averaged across the two surveys).

As the choice of drawdown strategy choice is likely most relevant to affluent individuals with a high level of personal savings and a low level of expectable pension income, we also build a stylized High-Asset-No-Pension (i.e. no employer pension plan) individual. We use CPP, OAS, and GIS levels from the high-income example case Canadian in Table 1, set the employer pension benefit to zero, and assume financial savings are $400,000 ($240,000 registered and $160,000 non-registered). We note that $400,000 in financial savings is far from representative of Canadian seniors in general. In 2005, among Canadians between 60 and 70 years old, 25% held over $100,000 in financial savings, 16% held over $200,000, 11% held over $300,000 and only 6.5% held over $400,000[28]. Within each of these wealth groups, 37%, 42%, 43%, and 46% had no employer pension[29].

Table 1: Estimated retirement income resources for four example cases of 65 year-old single Canadians at the start of their retirement: Low, Median, and High Income (2011$); and High-Asset-No-Pension individual.

Income Group	CPP/QPP (in first year)	Private Pension* (in first year)	Registered Financial Assets (at age 65)	Non-Registered Financial Assets (at age 65)	OAS** (in first year)	GIS** (in first year)
Low (10th percentile of income distribution)	1,156	0	0	1,500	6,368	8,027
Median (50th percentile)	7,093	2,207	0	16,000	6,368	3,606
High (90th percentile)	9,195	34,677	59,500	33,000	6,368	0
High-Asset-No-Pension	9,195	0	240,000	160,000	6,368	0

* We assume that employer pension benefits are indexed at 50% of inflation per year.

assume that the individuals have met the full residency requirement for OAS/GIS benefit eligibility and reside in the province of Ontario.

[28] Based on the 2005 SFS weighted data. We divide the household values reported in the SFS by the square root of the number of household members to arrive at adult-equivalent values. We calculate financial assets as the sum of registered financial assets (RRSP and RRIF) and non-registered financial assets (chequing accounts, GICs, trusts, etc), less non-mortgage debt (credit card, lines of credit, car loans, etc). We deem that someone does not have an employer pension plan if the actuarial value of all employer pension plan is less than $100.

[29] Among Canadians between 60 and 70 years-old with no pension, 3% held over $400,000 in financial savings, 4.7% held over $300,000, 6.6% held over $200,000 and 9.4% held over $100,000.

** OAS/GIS benefit flows are income-tested and are calculated year by year in the simulation according to 2011 published Canadian government values and rules for future indexation. This table presents the simulated values in the first year of retirement for each 65-year old example case Canadian under the 4% Rule drawdown strategy of private savings.
Notes: Author's calculations using the 1999 SFS, 2005 SFS, and the 2008 SLID (see Appendix D). Consumer Price Index (annual rates, 1992=100): 1999=110.5; 2005 = 127.3; 2008 = 135.8; 2011 = 142.7)

2.4 Tool of Analysis and Underlying Assumptions

Our analysis uses "Ruthen" – a longitudinal dynamic micro-simulation model that explicitly models the Canadian retirement income system when projecting the financial consequences of alternative drawdown strategies, while accounting for the uncertainty of future financial returns, inflation rates, and mortality. Ruthen is a longitudinal dynamic *individual* microsimulation model. Rather than simulate many separate lives within a population, Ruthen simulates many possible future life-courses for a single subject individual while keeping track of the annual and lifetime consequences of the individual's drawdown strategy as it interacts with the financial market, inflation, and with the set of tax and benefits programs relevant for the individual. In each simulated year, the relevant intra-lifetime measures are tracked, such as each year's discounted utility for each of the income concepts outlined in the introduction.

Figure 1 illustrates the general simulation structure of Ruthen[30]. The top box of Figure 1 represents the personal characteristics of the subject individual, including the chosen drawdown strategy, that serve as the starting point at the outset of each simulated lifetime. Section 2.3 defines the personal characteristics and financial resources in term of the registered and non-registered portfolio sizes at retirement, and the Canada Pension Plan and private (employer) pension benefit levels. Ruthen first determines the various income sources that the person is eligible to receive during the coming year. It then calculates the drawdown amount (using the chosen drawdown strategy of the six given in Section 2.2). The drawdown amount is then subtracted from the portfolio of financial assets[31], which accumulates according to the simulated asset returns, generating dividends, interest income, and a mix of realized and unrealized capital gains. The realization of capital gains, asset returns, and withdrawals from the portfolio all affect both the taxes payable and the composition of the portfolio heading into the next year. The individual pays all relevant income taxes at the end of the year, including repaying any government income-tested benefits that are "clawed back" as a result of the year's income level[32], as well as taxes on capital gains.

This process continues until the individual has died within the year, which is determined by comparing a pseudo-random draw against standard mortality table rates. If the person dies during

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[30] Earlier versions of this flow chart appear in Avery and Morrison (2009: 6; 9)

[31] If the drawdown strategy is annuitization, then the portfolio level is fixed at zero.

[32] GIS and OAS are both income tested benefits - Canadian seniors repay "clawbacks" depending on their income and benefit thresholds in any given year (OAS is only clawed back at high levels of income – as of July 2012, the maximum benefit reduced at 15% for Canadians earning more than $69,562, and is eliminated entirely for retirement income exceeding $112,966.). Source: http://www.servicecanada.gc.ca

the year, an additional pseudo-random draw determines when the death occurs and the various financial flows are accordingly calculated to reflect a partial year. We assume that life-contingent payments are payable through the month of death (from government-administered programs (OAS, GIS, CPP), from the private pension, and from any annuities purchased as part of the drawdown strategy).

The instantiation of a particular individual terminates once s/he dies. Ruthen records the relevant information for the particular lifetime, and moves on to the next instantiation. Each run generates one million independent instantiations of the subject individual for the analysis that we report in this paper.
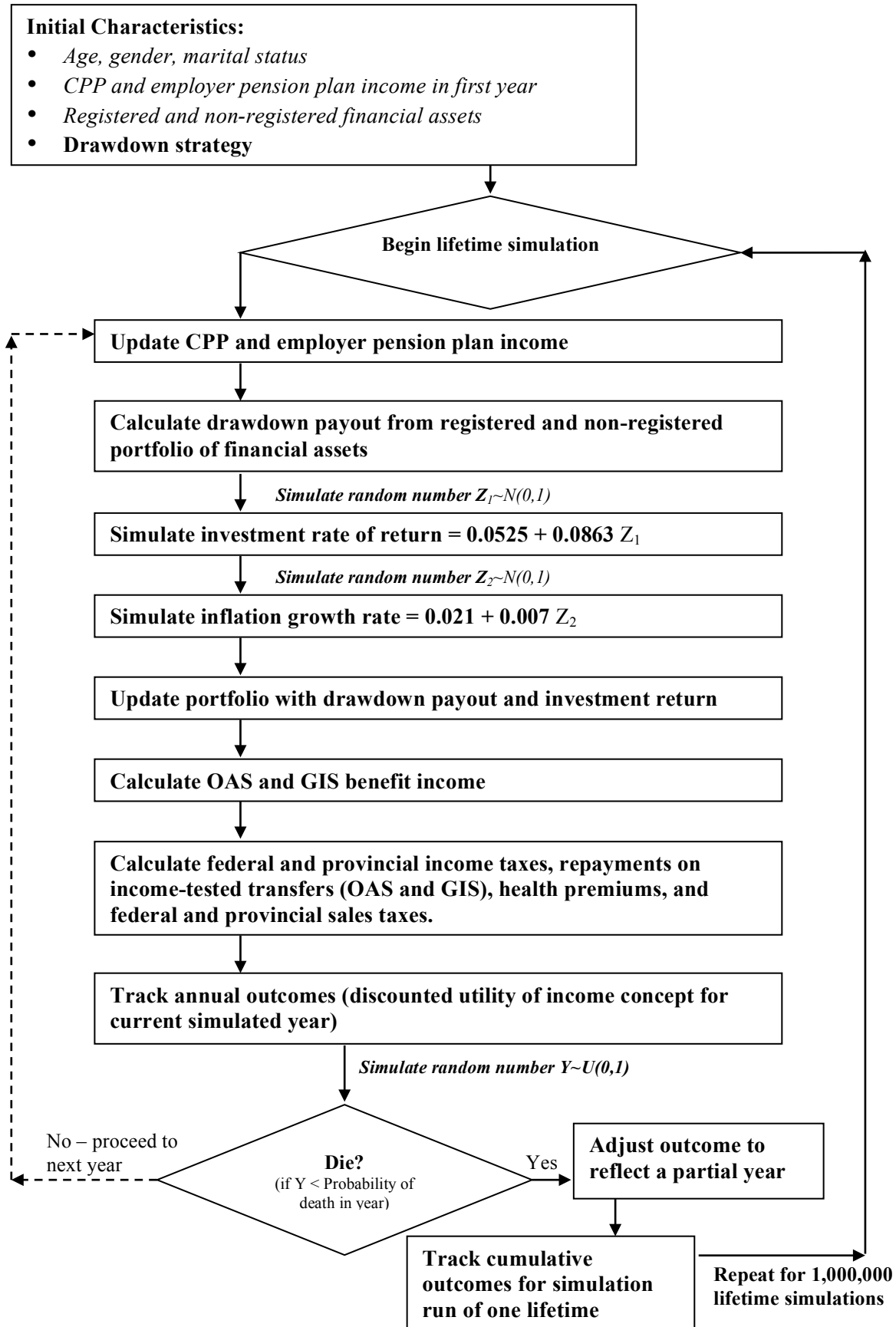
When simulating the drawdown of wealth over the individual's retirement we use:
- 2007 gender-specific Canadian population mortality rates (The Canadian Human Mortality Database, 2007).
- 2011 Canadian Government tax/benefit values assuming that 2011 rules, including those for indexation, extend into the future[33];
- 2000-2007 average industry prices to estimate the cost of purchasing a gender-specific single premium immediate life annuity whose payments are not indexed for inflation (see Appendix C for our methodology in pricing the cost of annuitization). Specifically we assume that a 65-year-old male could purchase a life annuity with an average monthly payout of $697 with a premium of $100,000 ($631 for a female).
- Self-managed portfolio asset portfolio modeling[34]: We assume that financial assets are invested 60% in equities and 40% in bonds. The stochastically simulated annual real returns of the investments are independently and identically normally distributed from year to year with a mean of 5.25% and standard deviation of 8.63% - (based on historical data for 2000-2007). We assume dividends and interest income are a constant 3.15% proportion of the funds under management, and that management expenses equal the value that the fund manager adds to the fund performance beyond the rate of return modeled. We assume a buy-and-hold investment strategy where capital gains are realized only on withdrawal.
- Inflation: We assume that inflation is independently and identically normally distributed from year to year with a mean of 2.0% and a standard deviation of 0.7%, as calculated from historical inflation rates from 1995-2011 (see Appendix C for additional details).

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[33] We assume no individual-specific personal tax deductions – such as childcare or running a business.

[34] See Appendix C for additional details on the asset modeling assumptions described in this section.

Figure 1: General simulation structure of "Ruthen" longitudinal dynamic microsimulation model

Initial Characteristics:
- *Age, gender, marital status*
- *CPP and employer pension plan income in first year*
- *Registered and non-registered financial assets*
- **Drawdown strategy**

Begin lifetime simulation

Update CPP and employer pension plan income

Calculate drawdown payout from registered and non-registered portfolio of financial assets

Simulate random number $Z_1 \sim N(0,1)$

Simulate investment rate of return = 0.0525 + 0.0863 Z_1

Simulate random number $Z_2 \sim N(0,1)$

Simulate inflation growth rate = 0.021 + 0.007 Z_2

Update portfolio with drawdown payout and investment return

Calculate OAS and GIS benefit income

Calculate federal and provincial income taxes, repayments on income-tested transfers (OAS and GIS), health premiums, and federal and provincial sales taxes.

Track annual outcomes (discounted utility of income concept for current simulated year)

Simulate random number $Y \sim U(0,1)$

No – proceed to next year

Die?
(if Y < Probability of death in year)

Yes

Adjust outcome to reflect a partial year

Track cumulative outcomes for simulation run of one lifetime

Repeat for 1,000,000 lifetime simulations

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3. Analysis

In thinking about the findings of this paper, it is useful to remember the basic fact that most 65-year-old single Canadians have very little private wealth. The retirement financial well-being of the median and 10th percentile example case studies is therefore primarily driven by the pensions and social benefits transfer system – alternative drawdown strategies cannot matter much for those who have little or no wealth to draw down. Table 2 illustrates this by presenting the precise flows under each income concept at the start of retirement under each drawdown strategy for the four example cases. The first column of Table 2 further illustrates the differences between the flows from each drawdown strategy.

Table 2: First Year flows ($2011) for four income concepts under six drawdown strategies.

Income Group	Savings	Savings+ Pension	Savings+ Pension - Taxes	Savings+ Pension - Taxes + Transfers
Low (10th percentile of income distribution)				
Annuitization	125	1,281	1,787	15,281
Variable Drawdown to Age 95	95	1,251	1,759	15,253
Variable Drawdown to age 80	140	1,296	1,803	15,290
Fixed Drawdown 4% Rule	60	1,216	1,723	15,223
Fixed Drawdown 6% Rule	90	1,246	1,753	15,248
Hybrid (annuity and variable to age 80)	76	1,232	1,739	15,229
Median				
Annuitization	1,338	10,638	10,881	19,688
Variable Drawdown to Age 95	1,018	10,318	10,665	19,367
Variable Drawdown to age 80	1,490	10,790	11,081	19,767
Fixed Drawdown 4% Rule	640	9,940	10,333	19,049
Fixed Drawdown 6% Rule	960	10,260	10,615	19,319
Hybrid (annuity and variable to age 80)	814	10,114	10,470	19,148

High (90th percentile)

Annuitization	7,733	51,605	39,098	42,822
Variable Drawdown to Age 95	5,883	49,755	38,014	41,736
Variable Drawdown to age 80	8,612	52,484	39,864	43,588
Fixed Drawdown 4% Rule	3,700	47,572	36,575	40,259
Fixed Drawdown 6% Rule	5,550	49,422	37,790	41,513
Hybrid (annuity and variable to age 80)	4,708	48,580	37,428	41,030

High-Asset-No-Pension

Annuitization	33,440	42,635	35,165	39,306
Variable Drawdown to Age 95	25,440	34,635	30,426	34,567
Variable Drawdown to age 80	37,240	46,435	39,017	42,828
Fixed Drawdown 4% Rule	16,000	25,195	23,159	27,724
Fixed Drawdown 6% Rule	24,000	33,195	29,397	33,539
Hybrid (annuity and variable to age 80)	20,360	29,555	26,490	31,212

Notes:
1. The first two income concepts use averages from the first year of retirement and therefore can be directly calculated from Table 1. Owing to the unusual taxes payable on the realization of the capital gains for non-registered funds that occur only in the first year when annuitizing, we use taxes and transfer levels from the second year of retirement in the third and fourth column, which are a better representation of the overall flows in the case of annuitization and the hybrid strategy.
2. The difference between the third and fourth income concepts are less than the OAS/GIS benefits since these benefits bring with them additional income taxes and sales tax.
Source: Authors' calculations.

This section finds that from a pre-tax, simple income perspective (gross withdrawals from financial savings brought into retirement), the ranking of the six drawdown strategies is the same for the first three example case Canadians. The more comprehensive income concepts contain retirement income flows that are much larger than the withdrawals from private savings for the first three example case Canadians, therefore their inclusion is more important to lifetime financial welfare than the chosen drawdown strategy. These other components of retirement consumption also affect the *rankings* of drawdown strategies differentially for our example case

Canadians, as well as between males and females and between different levels of risk aversion, even if the absolute differences between strategies are small. Where drawdown strategy choice matters is at the top end of the income distribution. As our fourth case (below) illustrates, the income concept used for analysis does appreciably alter the best drawdown strategy when we compare affluent individuals with different mixes of pension entitlements and private financial savings.

While Table 2 just looks at first year flows, we get a better measure if we express our results in terms of the annual Certainty Equivalent Income (CEI) corresponding to the expected discounted present value of utility with the average life span (age 83 for males and 86 for females). Using the utility function in Section 2.1 and letting

- $E[PV_{IC(x)}^{DS\#y}]$ represent the "expected present utility value" where
    - IC(x) (x = 1,..,4) is the income concept used as the argument underlying the utility function given in Equation 1 and
    - DS#y (y =1, …, 6) is the drawdown strategy under examination,
- D represent the average life expectancy

then the CEI for IC(x) using DS#y ($C_{IC(x)}^{DS\#y}$) is:

$$E[PV_{IC(x)}^{DS\#y}] = \sum_{t=0}^{D-1} \beta^t \frac{(C_{IC(x)}^{DS\#y})^{(1-\alpha)}}{(1-\alpha)}$$

$$C_{IC(x)}^{DS\#y} = \left[(1-\alpha)E[PV_{IC(x)}^{DS\#y}] \Bigg/ \sum_{t=0}^{D-1} \beta^t \right]^{1/(1-\alpha)}$$

Figure 2 displays the CEI values (y-axis) produced by the six drawdown strategies (labeled) for the (a) low-, (b) median-, (c) high-income and (d) high-asset-no-pension example case single Canadians at each of the four income concepts (x-axis), for a male with a constant relative risk aversion of 1.5. The first income concept (labeled "Savings") in Figures 2 (a), (b), (c), and (d) plots the CEI of each drawdown strategy under the conventional "gross income from retirement savings" concept which is habitually used in this line of research. When withdrawals from retirement savings are the only determinant of consumption, drawdown strategy choice necessarily plays a large role in retirement well-being. When pension income is included in the income concept (*"Savings + Pension"*), the importance of Canada's pension system to the expected retirement well-being of Canadian seniors is apparent - the CEI value for all six drawdown strategies rise dramatically and become less distinguishable for the first three example case Canadians. Indeed, the value of choosing one drawdown strategy over another is nearly invisible. This is not the case for the high-asset-no-pension individual, and Figure 2(d) suggests that drawdown strategy choice does matter for Canadians who do not hold employer pensions and have substantial financial savings – but perhaps not as much as one might have thought.

Including taxes and tax credits implies that drawdown strategies' values again move in unison, although the direction and magnitude of the move is different across the four example case Canadians. The relative CEI of the low income and median Canadian senior improves slightly, as such a person does not pay federal or provincial income tax or provincial health premiums, and the sum impact of tax credits and sales taxes is positive. However, the CEI of

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high-income and high-income-no-pension Canadians decrease owing to income taxes and sales tax that exceed government tax credits.
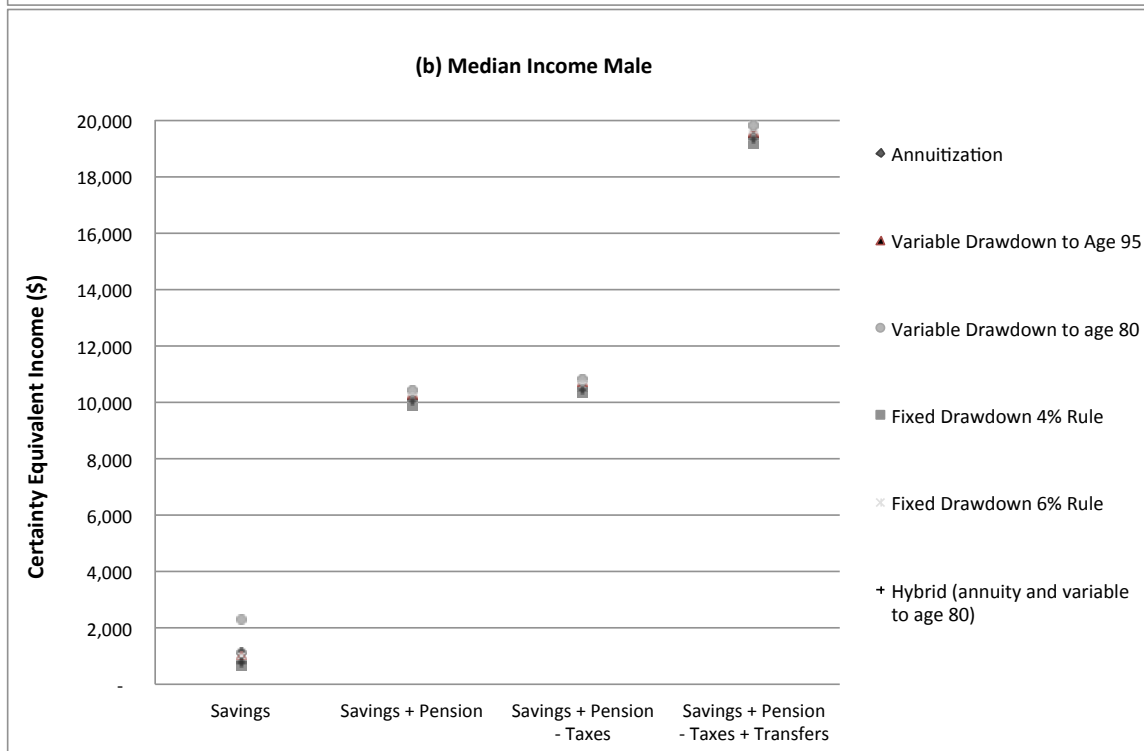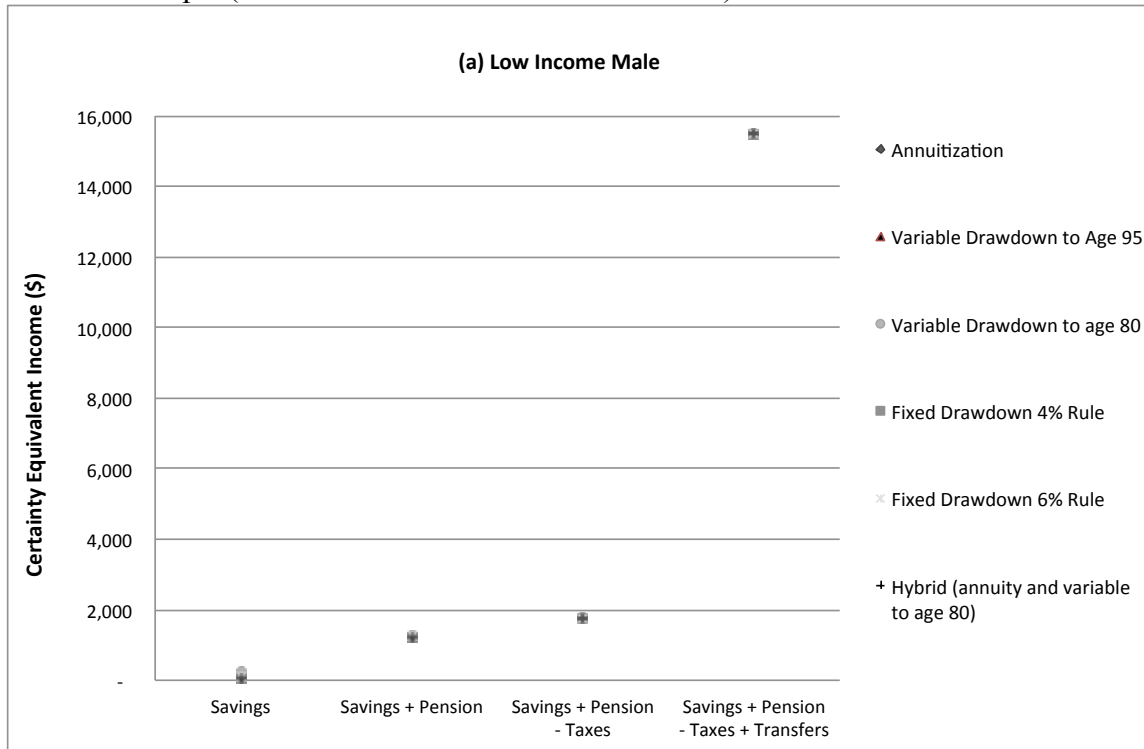
When government transfers are added, all example Canadians increase their incomes, but to varying degrees that reflect the size of the benefit and the relative starting position of the individual. Across the 4% Rule drawdown strategy simulations in Table 2, for example, the low income Canadian generally receives the maximum OAS and nearly the maximum GIS benefits, the median income Canadian similarly receives the maximum OAS benefit and approximately 45% of the maximum GIS benefit, and the high-income Canadian generally receives the maximum OAS benefit and no GIS benefit. Second, the low-income Canadian moves from virtually no income under the third income concept ($1,723) to $15,223 after government transfers under the fourth income concept (783% increase). At the other end, the high-income Canadian begins with $36,575 in income under the third income concept, which increases to $40,259 by the fourth income concept (a 10% increase). As a result, government transfers are strongly progressive, producing the largest improvement in lifetime welfare for the low-income example case, followed by the median-income and high-income cases.
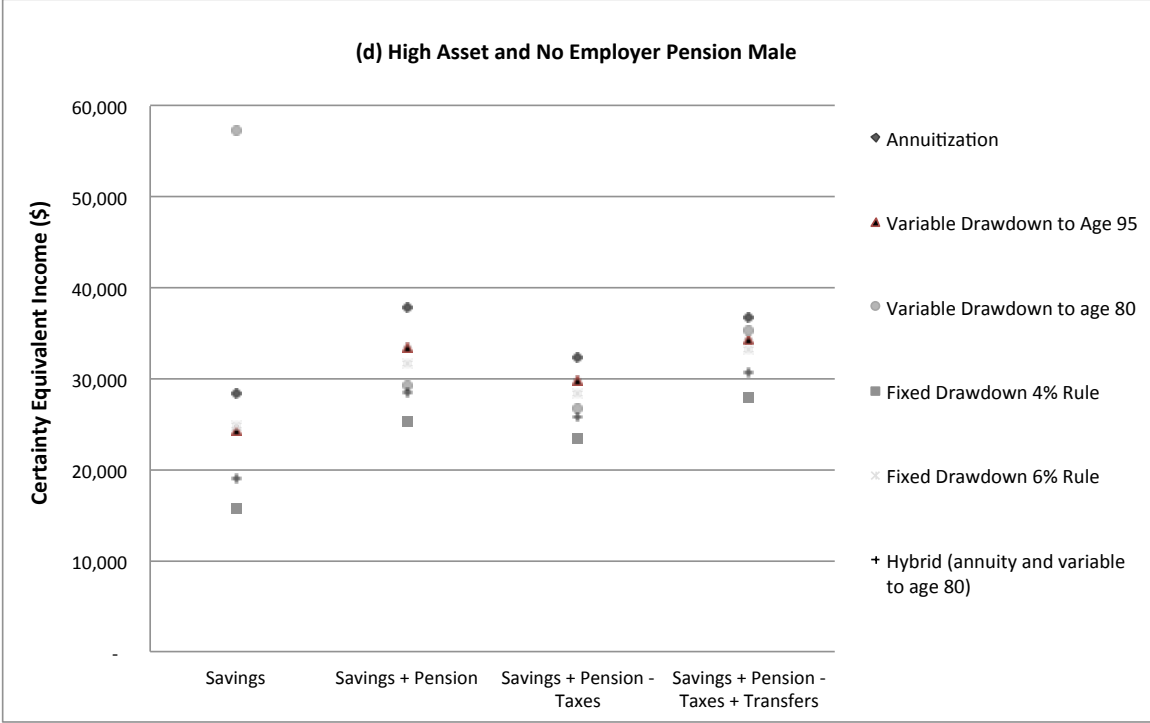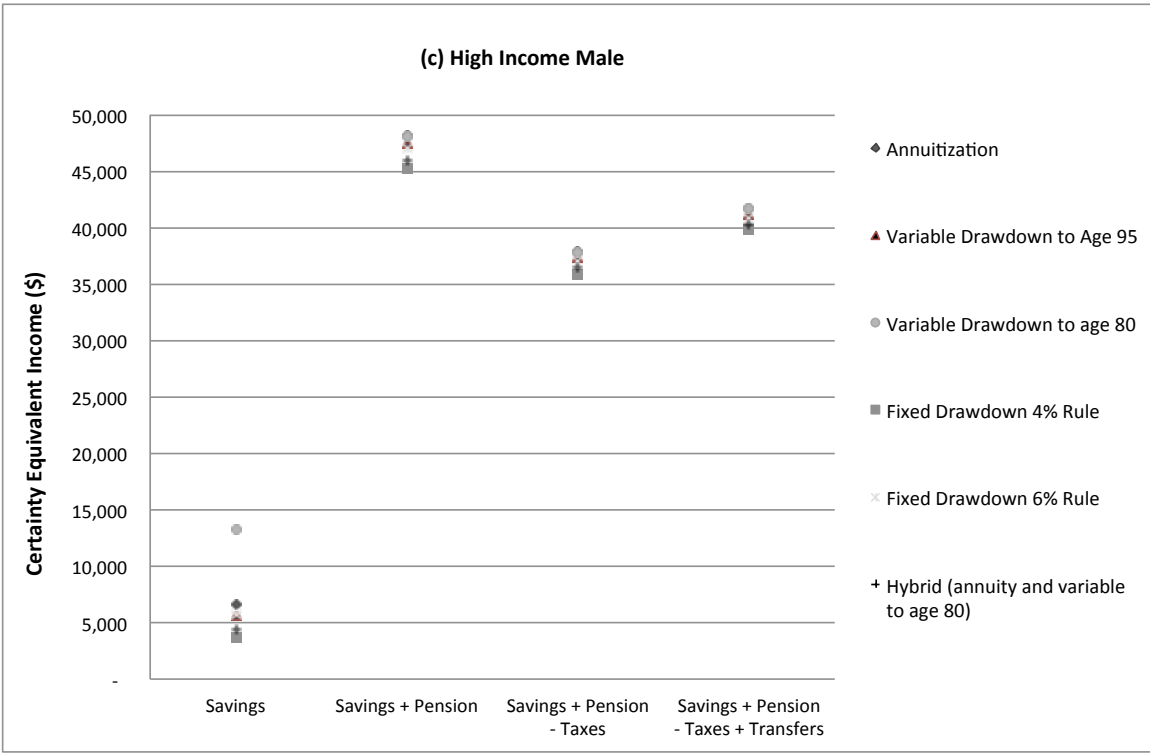
As Figure 2 shows, the drawdown choice of "typical" low-, median-, and high-income single Canadians makes little impact on their retirement financial welfare once we include other sources of pension income, government taxes and social transfers. The financial savings of these example case Canadians ($1,500 for low-income, $16,000 for median-income, and $92,500 for high-income) were just not large enough to make the drawdown choice significant relative to other income sources of retirement consumption. Figure 2 also shows the extent that the Canadian tax and social transfer retirement system reduces dramatically the dispersion of CEI among the example cases. Table 3 lists the ratio of CEIs for "Annuitization" of the example case Canadians to the low-income example case. The introduction of taxes and government social transfers between "Savings + Pension" and "Savings + Pension – Taxes + Transfers" reduces the proportional gap in CEI between the high-income (90th percentile) Canadian and the low-income (10th percentile) single Canadian senior from approximately 3760% to 269%, which is a 95% decline [=(3760% - 269%)/(3760% -100%)].

However, while some high income Canadians are, for example, employed professionals with defined benefit pension plans, other high income Canadians (e.g. small business owners) will depend on defined contribution plans and their private financial wealth in retirement. This heterogeneity among high income Canadians implies that the choice of drawdown strategy choice is especially relevant to affluent individuals with a high level of personal savings and a low level of expectable pension income. As already noted, such individuals are not "typical Canadians". Nevertheless, individuals with high levels of wealth and no employer pension plan are politically important and may be likely to seek out and receive financial planning advice[35].

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[35] In a 2006 survey by the Financial Planning Association (the largest association of personal financial planning experts in the U.S.), 85% of clients served by FPA personal financial practitioners had investable assets of over $100,000, and 48% had investable assets of over $500,000.

Figure 2: Annual certainty equivalent income corresponding to six drawdown strategies for low (a), median (b), high (c) income ; and high-asset-no-pension (d) single Canadians using four income concepts (relative risk aversion = 1.5 and 2011$).

(c) High Income Male

Legend:
- ◆ Annuitization
- ▲ Variable Drawdown to Age 95
- ● Variable Drawdown to age 80
- ■ Fixed Drawdown 4% Rule
- ✕ Fixed Drawdown 6% Rule
- ＋ Hybrid (annuity and variable to age 80)

X-axis categories: Savings, Savings + Pension, Savings + Pension - Taxes, Savings + Pension - Taxes + Transfers

Y-axis: Certainty Equivalent Income ($)

(d) High Asset and No Employer Pension Male

Legend:
- ◆ Annuitization
- ▲ Variable Drawdown to Age 95
- ● Variable Drawdown to age 80
- ■ Fixed Drawdown 4% Rule
- ✕ Fixed Drawdown 6% Rule
- ＋ Hybrid (annuity and variable to age 80)

X-axis categories: Savings, Savings + Pension, Savings + Pension - Taxes, Savings + Pension - Taxes + Transfers

Y-axis: Certainty Equivalent Income ($)

Notes:

Savings: Gross withdrawals from financial savings

Savings + Pension: Savings + Pension Income (employer and state)

Savings + Pension – Taxes: Savings + Pension Income – income taxes/sales tax + tax credits

Savings + Pension – Taxes + Transfers: Savings + Pension - Taxes + government social transfers

Source: Authors' calculations.

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Table 3: Ratio of certainty equivalent income values for full annuitization of the three example-case Canadians compared to the low-income example case.

Income Group	Savings	Savings+ Pension	Savings+ Pension - Taxes	Savings+ Pension - Taxes + Transfers
Low (10th percentile of income distribution)	100%	100%	100%	100%
Median	1067%	813%	610%	127%
High (90th percentile)	6167%	3760%	2137%	269%
High Assets No Pension	26701%	2219%	1605%	183%

Source: Authors' calculations.

Although Figure 2 shows that, for most single people, drawdown strategy choice has a small effect on lifetime welfare when other income sources of retirement consumption are introduced, nevertheless, does the ranking of drawdown strategy (among the six examined) remain constant across the income concepts? Table 4 gives the ranking associated with the small absolute differences of the drawdown strategies in Figure 2. Although the differences between strategies are not large, rankings of drawdown strategy can change depending on the income concept underlying the analysis – in particular, we note that for both the median and high income example, annuitization is <u>not</u> the preferred strategy when the "*Savings+ Pension - Taxes + Transfers*" income concept is used (being dominated by the "Variable Drawdown to Age 80" strategy).

Table 4: Drawdown strategy rankings for of discounted utility across four income concepts for low, median and high income Canadian (relative risk aversion = 1.5).

Income Group	Savings	Savings+ Pension	Savings+ Pension - Taxes	Savings+ Pension - Taxes + Transfers
Low (10th percentile of income distribution)				
Annuitization	2	2	2	1
Variable Drawdown to Age 95	4	3	3	3
Variable Drawdown to age 80	1	1	1	2
Fixed Drawdown 4% Rule	6	6	6	6
Fixed Drawdown 6% Rule	3	4	4	4

Hybrid (annuity and variable to age 80)	5	5	5	5

Median

Annuitization	2	1	1	2
Variable Drawdown to Age 95	4	3	3	3
Variable Drawdown to age 80	1	2	2	1
Fixed Drawdown 4% Rule	6	6	6	6
Fixed Drawdown 6% Rule	3	4	4	4
Hybrid (annuity and variable to age 80)	5	5	5	5

High (90th percentile)

Annuitization	2	1	1	2
Variable Drawdown to Age 95	4	3	3	3
Variable Drawdown to age 80	1	2	2	1
Fixed Drawdown 4% Rule	6	6	6	6
Fixed Drawdown 6% Rule	3	4	4	4
Hybrid (annuity and variable to age 80)	5	5	5	5

High-Assset-No-Pension

Annuitization	2	1	1	1
Variable Drawdown to Age 95	4	2	2	3
Variable Drawdown to age 80	1	4	4	2
Fixed Drawdown 4% Rule	6	6	6	6
Fixed Drawdown 6% Rule	3	3	3	4
Hybrid (annuity and variable to age 80)	5	5	5	5

Source: Authors' calculations.

The first column of Table 4 shows that, using the conventional gross-income concept ("Savings"), drawdown strategy rankings are the same across all example case Canadians[36] - and that the variable drawdown strategy to age 80 (which aims at equal payments in real terms that exhaust the portfolio through the first fifteen years of retirement) is the highest rank for all three. The top drawdown strategy also changes for each example case Canadian between income concepts. For example, for the median-income Canadian (Figure 2(b)), the ranking of the four most optimal strategies in Figure 2(b) re-order between the third income concept and the inclusion of pension income in the fourth income concept. Hence, we interpret Figure 2 as indicating that top ranking of drawdown strategy choice under one income concept does not necessary translate into a "universal" top ranking across all income concepts.

Are these results being driven by the assumed level of individual risk aversion? Not particularly – Table 5 examines the drawdown strategy rankings for the high-asset-no-pension case male at higher levels of risk aversion ($\alpha = 2$ and $\alpha = 5$). In both Table 4 and 5, we find that the strategy "Variable Drawdown to age 80" looks like the best option, if risk aversion is on the lower side ($\alpha = 2$ and $\alpha = 1.5$) and if pre-tax income from savings alone is being considered – but annuitization dominates for all risk aversion levels for the fuller measures of incomes, including pensions, taxes and transfers. For all three levels of risk aversion, the underlying income concept used for analysis affects the ranking of the drawdown strategies – for example, the ranking of the top four drawdown strategies under the first income concept "Savings" are re-ordered under the fourth (consumption-proxy) income concept.

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[36] This is because any drawdown strategy examined is a function of initial wealth and therefore generates a CEI value that is in constant proportions between example-case Canadians with the same utility function specifications and simulation assumptions (for example, the ratio of the simulated expected present utility value for the low-income example case ($1,500 savings) and for the high-income example case ($92,500 savings) is $(1500/92500)^{(1-\alpha)}$).

Table 5: Drawdown strategy rankings for a "High-Asset No Pension" male across four income concepts at alternative levels of relative risk aversion (α =2, α =5)

Income Group	Savings	Savings+ Pension	Savings+ Pension - Taxes	Savings+ Pension - Taxes + Transfers
Relative Risk Aversion = 2				
Annuitization	2	1	1	1
Variable Drawdown to Age 95	3	2	2	2
Variable Drawdown to age 80	1	6	5	3
Fixed Drawdown 4% Rule	6	5	6	6
Fixed Drawdown 6% Rule	4	3	3	4
Hybrid (annuity and variable to age 80)	5	4	4	5
Relative Risk Aversion = 5				
Annuitization	1	1	1	1
Variable Drawdown to Age 95	4	3	3	3
Variable Drawdown to age 80	3	6	6	6
Fixed Drawdown 4% Rule	5	4	4	5
Fixed Drawdown 6% Rule	6	5	5	4
Hybrid (annuity and variable to age 80)	2	2	2	2

Source: Authors' calculations.

Table 6 examines the impact of gender for the high-asset-no-pension case for a female with relative risk aversion of 1.5. Gender affects the annuity price and mortality modeling[37]. Table 6 shows changes in the drawdown strategy rankings from one income concept to the next, and between the male and female at each income concept (for example, at the fourth income concept, "Variable drawdown to age 80" ranks second for the male in Table 5 but third for the

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[37] For illustrative purposes, we set income and wealth entering retirement in Section 2.3 at specific "typical" dollar values that were the same for both genders – but we do not pretend that men and women actually have equal income and wealth.

female in Table 6). Annuitization remains the preferred strategy across second, third, and fourth income concept, but its relative value compared to the other drawdown strategies is reduced for females owing to the higher gender differential in annuity pricing than exists in the population mortality underlying the simulations.

Table 6: Drawdown strategy rankings of discounted utility for a "high-asset and no registered pension plan" female across four income concepts (relative risk aversion = 1.5)

Drawdown Strategy	Savings	Savings+ Pension	Savings+ Pension - Taxes	Savings+ Pension - Taxes + Transfers
Annuitization	3	1	1	1
Variable Drawdown to Age 95	4	2	2	2
Variable Drawdown to age 80	1	5	5	3
Fixed Drawdown 4% Rule	6	6	6	6
Fixed Drawdown 6% Rule	2	3	3	4
Hybrid (annuity and variable to age 80)	5	4	4	5

Conclusion

This paper examines the importance of pensions, taxes and government transfers in the evaluation of alternative strategies for drawing down retirement financial savings. Using a longitudinal dynamic micro-simulation model for Canada that features risk aversion, stochastic markets, stochastic mortality and the interactions among sources of retirement income within the complex Canadian tax and social benefit system, we compare estimates of the expected discounted utility for six commonly advocated drawdown strategies (market annuitization, four distinct self-managed drawdown strategies, and one hybrid strategy). To show the impact of considering alternative measures of income, we ranked these strategies using four different income concepts as the argument of the utility function:
1. Gross withdrawals from financial savings entering retirement
2. Gross withdrawals + pension income (employer and Canada Pension Plan (CPP))
3. Gross withdrawals + pension income (employer and CPP) – taxes
4. Gross withdrawals + pension income (employer and CPP) – taxes + government transfers

We found that moving beyond the simple income concept to more comprehensive measures can alter the drawdown strategy rankings among the six commonly advocated strategies examined. The effects of pensions, taxes and government transfers on the top drawdown strategy are not uniform between males and females, across people at different points in the income distribution, and different levels of risk aversion.

Affluent individuals with substantial assets but no private pension plan are the people whose financial calculations in retirement are most affected by these considerations – but they are a small fraction of the population.

Acknowledgements

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Appendix A: Drawdown Strategy Formulas

This appendix provides the formulas[38] of each drawdown strategy described in Section 2.2. "Drawdown$_x$" is the drawdown amount (payout of drawdown strategy) at age x.

Annuitization:

$$Drawdown_{65} = Wealth_{65} \Big/ \ddot{a}_{65},$$
$$Drawdown_x = Drawdown_{65} \text{ for x > 65}$$

Variable Drawdown to Age 95:

$$Drawdown_x = Wealth_x \Big/ \ddot{a}_{\overline{95-x}|_r} \quad \text{for x} \in [65,94]$$

Variable Drawdown to Age 80:

$$Drawdown_x = Wealth_x \Big/ \ddot{a}_{\overline{80-x}|_r} \quad \text{for x} \in [65,79]$$

Fixed Drawdown 4% Rule:

$$Drawdown_{65} = 0.04 Wealth_{65}$$
$$Drawdown_x = Drawdown_{x-1}(1 + Inflation_{x-1}) \text{ for x > 65}$$

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[38] These formulas use basic standard "International Actuarial Notation" – see Brown et al. (2011) and Dickson et al. (2009).

Fixed Drawdown 6% Rule:

$Drawdown_{65} = 0.06 Wealth_{65}$

$Drawdown_x = Drawdown_{x-1}(1 + Inflation_{x-1})$ for x > 65

Hybrid:

25% Annuitization and 75% Fixed Drawdown 4% Rule

where

- $Inflation_{x-1}$ is the rate of inflation between ages *x-1* and *x;*

- $\ddot{a}_{65}$ is the actuarial present value of $1 at the beginning of each future year for the lifetime of a 65-year old (e.g. whole life annuity-due):

  o $\ddot{a}_{65} = \sum_{t=0}^{\infty} {}_t p_{65}(1+i)^{-t}$, where ${}_t p_{65}$ is the probability of death for a 65-year-old annuitant between ages 65 to 65 + t, and *i* is the underlying net *nominal* rate of return set by the annuity provider in pricing the annuity.

  o Note that "Annuitization" *is not* a self-managed drawdown strategy, and therefore the underlying life annuity pricing assumption relies on industry values (for annuity pricing details, see Appendix C).

- $\ddot{a}_{\overline{y}|_r}$ is the actuarial present value of $1 (inflation-indexed) at the beginning of each future year for y years (e.g. inflation-indexed y-year annuity-certain)

  o $\ddot{a}_{\overline{y}|_r} = \sum_{t=0}^{y-1} \frac{(1+m)^{-t}}{(1+n)^{-t}} = \sum_{t=0}^{y-1}(1+r)^{-t}$, where *m* is the assumed long-term mean inflation, *n* is the assumed long-term mean total nominal return on assets, and *r* is the assumed long-term mean total *real* rate of return on assets assumption

  o Note that "Variable Drawdown to Age 80/95" *are* self-managed variable drawdown strategies. The actuarial present value factor is re-calculated each year using the mean expected real rate of return on self-managed assets (represented by μ_p and set at 5.25% in Appendix C).

Appendix B: Optimal Consumption Path

On the consumption path that optimizes the present value of utility, the marginal utility of the present value of income at times t and times t+1 are equal (Romer, 2011).

Defining u_t as the present utility value of income flow at time t, then:

$u_t = \beta^t \frac{(C_t)^{(1-\alpha)}}{(1-\alpha)}$

The marginal utility of income C_t is defined by:

$$\frac{du_t}{dC_t} = \beta^t(1-\alpha)\frac{(C_t)^{(1-\alpha)-1}}{(1-\alpha)} = \beta^t C_t^{-\alpha} \quad.$$

Similarly

$$\frac{du_{t+1}}{dC_{t+1}} = \beta^{t+1} C_{t+1}^{-\alpha}$$

Setting them equal:

$$\frac{du_t}{dC_t} = \frac{du_{t+1}}{dC_{t+1}}$$

$$\beta^t C_t^{-\alpha} = \beta^{t+1} C_{t+1}^{-\alpha}$$

$$C_t^{(-\alpha)} = \beta^1 C_{t+1}^{(-\alpha)}$$

$$(\frac{C_{t+1}}{C_t})^\alpha = \beta$$

$$\frac{C_{t+1}}{C_t} = \beta^{1/\alpha}$$

Hence, the optimal consumption path changes by a ratio of $\beta^{1/\alpha}$ from one year to the next.

Appendix C: Modeling Annuity Pricing, Inflation, and Self-managed Assets Rates of Return,

Data

We estimate our financial market and inflation models using historical data compiled by the Canadian Institute of Actuaries 2011 report on Canadian financial statistics (CIA, 2012). We price our annuity using historical industry prices compiled by The Individual Finance and Insurance Decisions Centre "Payout Annuity Index" http://www.ifid.ca/payout.htm. The underlying data sources are.
* Bond returns:
  o Yield-to-maturity on Government of Canada marketable bonds (10+ years) from 1936-2011
  o CANSIM I: B14013; CANSIM II: V122487
* Stock returns[39]:
  o Total return on Canadian Common Stock from 1936 - 2011
  o Prices:
    ▪ Urquhart & Buckley H641 December 1936–December 1946 (Corporate Composite)
    ▪ CANSIM B4202 (TSE Corporates) December 1946–December 1956

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[39] Data source summary are taken from CIA (2012).

- ▪ TSX Total Return Index December 1956–December 2011
  - o Dividend Yield, Annual Averages:
    - ▪ Urquhart & Buckley H617 January 1951–December 1955
    - ▪ CANSIM V122628 January 1956–December 2011
- Inflation rate of change:
  - o All-items Consumer Price Index from 1936 - 2011
  - o CANSIM V41690973
- Annuity pricing:
  - o Fixed Single-Premium Immediate Life Annuity with 10-year guarantee purchased from registered funds[40] from 2000 onward
  - o Cannex Financial Exchanges Limited (CANNEX specializes in providing real-time income annuity quotes offered by insurance companies in Canada and the United States http://www.cannex.com).

Calculating Annuity Prices and Self-managed Assets Rates of Return and Inflation Model Parameters

A fair comparison among drawdown strategies requires historical data spanning the same period – but historical industry annuity price quotes are extremely limited. We use the "Payout Annuity Index" by The Individual Finance and Insurance Decisions Centre at York University (http://www.ifid.ca/payout.htm), which compiles the weekly average annuity payout quote across a across a range of Canadian insurers since 2000 (these quotes are provided by CANNEX Financial Exchanges Limited). To avoid the large weight of the recent financial crisis we limit our time period to years 2000-2007 in estimating both the market annuity prices and self-managed portfolio rates of return modeling parameters.

Because the annuity price quotes supplied by IFID are based on average industry quotes of single premium immediate annuities for single 65 year-old male/female with a 10-year payment certain (also known as a 10-year guaranteed period), while the annuity that we require has no guaranteed period, we use the IFID data and calculate the life-only annuity prices from actuarial first principles. Using the Society of Actuaries' annuitant population mortality rates (1996 US annuity 2000 tables with Projection Scale AA) with a 10% margin for error, we then back-out the underlying rate of return within each year from the average cross-industry annuity prices supplied by IFID. We then combine the mortality assumptions with the calculated underlying rates of return to calculate from first principles the annuity prices for 65-year old males and females without the guaranteed period for each historical year 2000-2007. We finally average the life-only annuity prices over all eight years to arrive at our estimate.

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[40] A Canadian insurer's pricing can be slightly different between annuities purchased from registered funds and non-registered funds - for example, the average price quote across nine Canadian insurers supplied by Cannex to the authors through personal correspondence for November 28, 2011, showed a difference of less than 1%.

The average payout from the IFID data was $8,108.33 per year for a $100,000 premium for 65-year old male and $7,436.39 for female. According to our calculations, removing the guarantee increases the payout to $8,358.76 for male and $7,576.77 for females. The change in price is relatively small since insurers assume with high probability (86.5% if male and 90.9% if female) that annuitants will live beyond age 75. For taxation purposes, these annuities are "prescribed" annuities, which enjoy certain tax advantages (see Milevsky (2010) for further information).

We stochastically simulate future self-managed assets' annual real rates of return assuming that they are independently and identically normally distributed with mean (μ_p) and standard deviation (σ_p). To estimate μ_p and σ_p, we first obtain historical real rates of return for our assumed portfolio assets (40% bonds and 60% equities) from the above listed historical data sources. Letting:
- p_t^n represent the portfolio total nominal rate of return,
- p_t^r represent the portfolio total real rate of return,
- b_t^n represent the bond total nominal rate of return,
- s_t^n represent the stock total nominal rate of return, and
- k_t represent the rate of consumer price inflation,

between times t and $t+1$. The real portfolio return (p_t^r) equals:

$$
\begin{aligned}
p_t^r &= \frac{1 + p_t^n}{1 + k_t} - 1 \\
&= \frac{0.4(1 + b_t^n) + 0.6(1 + s_t^n)}{1 + k_t} - 1
\end{aligned}
$$

We estimate mean (μ_p):

$$
\overline{\mu}_p = \frac{1}{2007 - 2000 + 1} \sum_{t=2000}^{2007} p_t^r = 5.25\%
$$

and standard deviation (σ_p):

$$\bar{\sigma}_p = \sqrt{\frac{1}{(2007-2000+1)-1}\sum_{t=2000}^{2007}(p_t^r - \bar{\mu}_p)^2} = 8.63\%$$

If we estimate these parameters from all historical data (1936-2011), we find that it produces a nearly identical μ_p of 5.34% and a reasonably close σ_p of 10.38%. This suggests that the reduced sample period 2000-2007, which was necessary owing to the limited available annuity price data, is also representative of long-term historical data.

We stochastically simulate future annual inflation rates of return assuming that they are independently and identically normally distributed with mean (μ_k), which we estimate with:

$$\bar{\mu}_k = \frac{1}{2011-1995+1}\sum_{t=1995}^{2011}k_t = 2.0\%$$

and standard deviation (σ_k), which we estimate with:

$$\bar{\sigma}_k = \sqrt{\frac{1}{2011-1995+1-1}\sum_{t=1995}^{2011}(k_t - \bar{\mu}_k)^2} = 0.7\%$$

We use 1995-2011 to estimate future inflation parameters because the Bank of Canada has targeted a stable 2% inflation rate[41] since 1991.

Because taxation on non-registered assets depends on the proportion of the portfolio's total return that is dividends and interest income[42], we calculate how much of the stock total return is dividends and how much of the bond return is income. The average 2000-2007 historical annual stock dividend yield was 1.8% (CANSIM v122487: 1936-2011), and the average yield to maturity for 10+ years Government of Canada marketable bonds over this period was 5.15% (CANSIM V122485: 1951-2011). With this, we assume that the proportion of the portfolio returned as dividends and interest income to be 3.15% ($=0.4(5.15\%)+0.6(1.8\%)$).

Finally, as Section 2.4 notes, we assume a buy-and-hold investment strategy where capital gains are realized only on withdrawal. To estimate the proportion of unregistered savings that is unrealized capital gains at retirement, we assume that unregistered savings were accumulated evenly over the ten prior years with ten end-of-year equal payments in real terms, and that the wealth grew with the assumed mean rate of return using a buy-and-hold investment strategy. This calculation leads to 27% of the portfolio constituting unrealized capital gains at retirement

$$(27\% = \left(\sum_{t=0}^{9}(1.0525)^t - 10\right)/10).$$

---

[41] Note that this inflation assumption is lower than the long-term inflation projection made by the Chief Actuary of Canada in his most recent actuarial report on the Canada Pension Plan (Office of the Chief Actuary of Canada 2010), which was 2.3%.

[42] The taxation of dividends and interest income are broadly similar in the Canadian system, though interest income is taxed somewhat more heavily. For simplicity we assume that both sources are taxed as dividends.

Appendix D: Methodology Underlying Example Canadians

This appendix details the construction of the example case Canadians summarized in Section 2.3. As listed in that section, the data sources underlying each retirement financial resource for the example case Canadians are as follows:

- income flows from C/QPP and defined benefit employer plans: 2008 Survey of Labour and Income Dynamics (SLID);
- wealth stock of registered financial assets (registered retirement savings plus registered retirement income funds) and net non-registered financial assets (total financial assets less total non-mortgage debt): 1999 and 2005 Survey of Financial Security (SFS); and
- income flows from taxes and social transfers (OAS and GIS): generated in the simulation using 2011 published Canadian government values and rules for future indexation.

We use the variable "total after-tax income"[43] to define "low income" (10th percentile of the "total after-tax income" distribution), "median income" (50th percentile), and "high income" (90th percentile.) Our sample population of low, median, and high-income is made-up of Canadians whose "total after-tax income" falls within ten percentiles of the 10th, 50th and 90th percentile respectively. We want to estimate "typical" asset and pension values for these different parts of the income distribution while avoiding the chance that the particular individual who is found at the 20th, 50th and 90th percentile of the income ranking has odd pension or wealth data. Hence, for example, the CPP pension income of a high-income Canadian (at the 90th income percentile) is calculated to equal the median CPP income value of those members of the population whose "total after-tax income" falls between the 80th and 100th percentiles of the "total after-tax income" distribution.

Tables A.1 and A.2 lists the summary statistics from the SLID (2008) and the SFS (1999 and 2005). Using the 2008 SLID, our aim is to capture the CPP and employer pension income flows for a 65 year-old beginning retirement. We define full retirement as having neither earnings from paid employment (wages and salaries) nor self-employment, and we filter our sample population according to these criteria. The first line of Table A.1 lists the median income flows from CPP, employer pension plan[44], OAS, and GIS for each income group in the first full fiscal year of retirement after age 65[45]. Owing to the small sample sizes for each income group, however, we extend the age range to the first five years of retirement. Using a broader measurement period is reasonable since the real value of the income flows from CPP, employer pension plans, OAS, and GIS tend to be consistent over time: CPP benefits and OAS/GIS baseline benefits are fully indexed by inflation, and employer pension plan benefits are generally fixed either in nominal

---

[43] In the 2008 SLID, 1999 SFS and 2005 SFS, this variable is defined as the sum of wages, salaries, net income from self-employment, investments, government transfers, pensions, and other incomes such as alimony, minus federal and provincial income taxes.

[44] Employer pension plan income is estimated with the variable "Private Retirement Pensions". Although this variable is primarily employer pension plans, it can also include amounts from annuities, superannuation or RRIFs (Registered Retirement Income Funds).

[45] Including 65 year-old respondents would confuse the income flows since it would include the part of the fiscal year before age 65 when the respondent would not have reached normal retirement age for the purpose of C/QPP benefits, OAS/GIS eligibility, and the majority of employer pension plans.

terms or are indexed by inflation (partially or fully). The third line of Table A.1 illustrates the consistency of these income flows by continuing to broaden the age range to age 75 – the median values are identical or close between the three population samples with the largest difference being between the median employer pension plan income of median-income Canadians. This and other differences are partially driven by the different proportion of people who receive employer pension plan benefits between the three samples - to illustrate this, we also list the proportion of respondents receiving each income and the median income flow of those who are in receipt of it. For our example case Canadians, we choose the median income flows of 66-70 year old Canadians (bolded values in Table A.1).

The choice of sample when assigning wealth levels is much more subjective. Ideally, the sample would consist of retiring 65-year-old single Canadians who hold retirement financial savings. Although this sample specification would be possible in the 2005 SFS, where the respondent provides his/her current age and the age that he/she plans to retire, the sample size is insufficient (only three people). Table A.2 provides the results of some exploratory work, where the median values across the three income groups for ten sample specifications are listed. The first four sample specifications shows an attempt to capture Canadians expecting to retire in the near future (the next five years). Three of these four sample specifications contain sample sizes that are considered of marginal or unacceptable quality having less than 30 respondents (these are marked with an asterisk). In sample specification #1, we chose a broad age range (50-70) and a long retirement intention horizon (5 years) so as to have an adequate sample size. Several issues complicate choosing this sample specification. The assumption in choosing people who have not retired is that we would avoid respondents who have started drawing down their wealth. The median values do not appear to follow this presumption – if we compare sample specification #1 (ages 50-70, not retired and plans to retire within five years) with #5 (ages 60-70 with no filter on retirement status or retirement intentions), the total financial assets for all three income groups is greater in the later sample, indicating possibly some cohort effect, sampling variability, some correlation between retirement intentions and wealth, and/or that many seniors are slow to draw down financial wealth after retirement and even allow it to accumulate[46]. In sample specification #1, moreover, choosing a five year retirement age horizon could be considered too wide as five years still remain to accumulate retirement financial assets.

To avoid small samples and judgments regarding savings behavior, retirement planning, and drawdown behavior, we choose sample specification #5 (ages 60-70 with no filter on retirement status or retirement age expectations) as the sample size is adequate and it is centered on the targeted age of 65. We average the median registered retirement savings and non-registered retirement savings for respondents with retirement financial savings across the two survey years 1999 and 2005 (bolded values in Table A.2) rounding up to the nearest $500. These final values are listed in Table A.3.

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[46] See, for example, the empirical findings of De Nardi et al. (2006), Love et al. (2008), and Smith et al. (2009).

Table A.1: Income flow statistics for three sample populations from the 2008 SLID (in 2011$)

Sample Specifications	Income Groups	Sample Size	Median Income ($)	Canada Pension Plan Income (if receiving)			Employer Pension Plan Income (if receiving)			Old Age Security (if receiving)			Guaranteed Income Supplement (if receiving)		
				Median	% Receiving	Median	Median	% Holding	Median	Median	% Receiving	Median	Median	% Receiving	Median
1. Age <~ 66	Low (<20th percentile of income distribution)	18*	16,209	1,156	91%	1,471	-	8%	499	6,305	100%	6,305	6,830	95%	6,830
No earnings from paid employment	Median (40th-60th percentile)	13*	21,358	6,830	100%	6,830	5,517	87%	6,042	6,305	100%	6,305	2,312	80%	2,312
(wages and salaries) nor self-employment	High (>80th percentile)	14*	35,948	8,932	95%	8,932	25,219	100%	25,219	6,305	100%	6,305	-	0%	NA
2. Age <~ [66,70]	Low (<20th percentile of income distribution)	76	15,946	**1,156**	80%	1,524	-	5%	998	6,305	100%	6,305	6,830	86%	7,093
No earnings from paid employment	Median (40th-60th percentile)	72	21,909	**7,093**	100%	7,093	**2,207**	68%	4,518	6,305	100%	6,305	1,944	78%	2,732
(wages and salaries) nor self-employment	High (>80th percentile)	70	44,917	**9,195**	99%	9,195	**34,677**	99%	36,778	6,305	90%	6,305	-	0%	NA
3. Age <~ [66,75]	Low (<20th percentile of income distribution)	167	16,209	1,839	85%	2,417	-	10%	1,839	6,305	99%	6,305	6,830	87%	7,093
No earnings from paid employment	Median (40th-60th percentile)	181	22,619	7,093	98%	7,093	4,308	80%	4,834	6,305	100%	6,305	1,419	70%	2,837
(wages and salaries) nor self-employment	High (>80th percentile)	146	45,737	8,669	100%	8,669	32,575	98%	32,575	6,305	95%	6,305	-	2%	5,254

Notes: Authors' calculations from the 2008 SLID

* These estimates do not meet Statistics Canada's quality standards and are for illustration purposes only.

Bolded values represent those that are chosen to be used in the example case Canadians

Consumer Price Index (annual rates, 1992=100): 2008 = 135.8; 2011 = 142.7

Table A.2: Financial Asset statistics for ten sample populations from the 1999 and 2005 SFS (in 2011$)

Sample Specifications	Income Groups	Sample Size	Median Income ($)	Median Registered Financial Assets ($)	Median Non-Registered Financial Assets ($)	% Holding Registered Financial Assets ($)	% Holding Non-Registered Financial Assets ($)	% Holding Any Financial Assets ($)	Median (if holding any financial assets) Registered Financial Assets ($)	Median (if holding any financial assets) Non-Registered Financial Assets ($)
2005 SFS										
1. Age <- [50,70], not retired, and plans to retire within 5 yrs	Low (<20th percentile of income distribution)	47	8,968	-	56	13%	61%	63%	-	112
	Median (40th-60th percentile)	61	24,858	1,681	224	53%	61%	79%	8,127	6,614
	High (>80th percentile)	54	56,749	53,246	280	90%	54%	91%	58,851	2,130
2. Age <- [55,70], not retired, and plans to retire within 5 yrs	Low (<20th percentile of income distribution)	27*	7,567	-	67	17%	73%	79%	-	286
	Median (40th-60th percentile)	36	21,383	-	325	37%	62%	73%	224	10,369
	High (>80th percentile)	35	52,770	36,992	-	73%	49%	73%	67,258	4,596
3. Age <- [60,70] and not retired	Low (<20th percentile of income distribution)	13*	10,649	-	-	9%	49%	49%	-	112
	Median (40th-60th percentile)	11*	20,570	-	56	14%	52%	52%	-	54,311
	High (>80th percentile)	15*	42,653	-	-	38%	34%	41%	-	24,717
4. Age <- [55,70], not retired, and plans to retire within 5 yrs OR Age <- [65,70] and retired	Low (<20th percentile of income distribution)	28*	7,567	-	67	18%	74%	77%	-	286
	Median (40th-60th percentile)	84	21,383	-	7,034	38%	79%	83%	-	14,573
	High (>80th percentile)	49	52,770	36,992	5,128	72%	64%	83%	58,851	10,649
5. Age <- [60,70]	Low (<20th percentile of income distribution)	46	11,490	-	22	17%	58%	59%	**-**	**813**
	Median (40th-60th percentile)	41	22,279	-	14,769	47%	80%	90%	**-**	**19,113**
	High (>80th percentile)	49	44,839	33,629	8,127	63%	60%	75%	**53,807**	**24,717**
6. Age <- [65,70]	Low (<20th percentile of income distribution)	26*	14,320	-	112	28%	62%	62%	-	2,130
	Median (40th-60th percentile)	19*	22,279	-	30,266	37%	85%	88%	-	52,686
	High (>80th percentile)	22*	44,839	44,839	23,540	72%	80%	96%	44,839	23,540
7. Age <- [60,65]	Low (<20th percentile of income distribution)	25*	10,369	-	56	16%	56%	56%	-	532
	Median (40th-60th percentile)	24*	22,167	-	19,617	44%	95%	95%	-	25,782
	High (>80th percentile)	31	44,194	16,815	-	60%	48%	60%	56,049	61,654
1999 SFS										
8. Age <- [60,70]	Low (<20th percentile of income distribution)	119	9,556	-	258	20%	64%	68%	**-**	**1,421**
	Median (40th-60th percentile)	136	19,370	-	7,361	38%	75%	79%	**-**	**11,945**
	High (>80th percentile)	145	41,971	61,342	29,573	82%	85%	91%	**64,570**	**40,615**
9. Age <- [65,70]	Low (<20th percentile of income distribution)	73	14,851	-	258	28%	62%	70%	-	1,291
	Median (40th-60th percentile)	77	20,017	-	11,623	47%	79%	84%	1,356	13,560
	High (>80th percentile)	82	39,969	67,799	38,742	78%	90%	94%	89,430	40,615
10. Age <- [60,65]	Low (<20th percentile of income distribution)	62	8,071	-	568	19%	67%	68%	-	1,808
	Median (40th-60th percentile)	61	17,176	-	1,227	37%	72%	76%	-	6,457
	High (>80th percentile)	72	43,133	40,033	12,494	81%	77%	87%	61,342	25,828

Notes: Authors' calculations from the 2008 SLID
* These estimates do not meet Statistics Canada's quality standards and are for illustration purposes only.
Bolded values represent those that are chosen to be used in the example case Canadians
Consumer Price Index (annual rates, 1992=100): 1999=110.5; 2005 = 127.3; 2008 = 135.8; 2011 = 142.7)

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Table A.3: Financial Asset estimates for example Canadians from the 1999 and 2005 SFS (in 2011$)

Income Groups	(a) Registered Financial Assets ($)*	(b) Non-Registered Financial Assets ($)*	Grossed-up (a) to nearest $500	Grossed-up (b) to nearest $500
Low (<20th percentile of income distribution)	-	1,117	-	1,500
Median (40th-60th percentile)	-	15,529	-	16,000
High (>80th percentile)	59,188	32,666	59,500	33,000

Notes:

*Average median financial assets for respondents holding any financial assets across sample specifications #5 and #7 from Table A.2.

Author's calculations using 1999 and 2005 SFS.