

# Adam Smith's reversionary annuity: money's worth, default options and auto-enrollment

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When Adam Smith – author of *Wealth of Nations* (1776) and *Theory of Moral Sentiments* (1759) – was elected a professor at the University of Glasgow in 1751, he also joined an annuity ‘scheme’ that was unique for its time. The Scottish Ministers’ Widows’ Fund, as it was known, offered members of the Presbyterian Church as well as the university a choice of levels at which to contribute investment savings, ranging from 2 to 10 percent of their wages. The life-contingent benefits were in the form of a reversionary annuity to a spouse and/or lump sum death benefit to children. This article (i) describes the scheme in financial and actuarial terms, (ii) values Smith’s reversionary annuity and (iii) examines the choices made by individual participants. The specific research contribution is to compile the archival data to measure the extent of insurance anti-selection and to demonstrate that debates around choice architecture, default options and auto-enrollment, which infuse the literature in the twenty-first century, were prevalent in the mid eighteenth. For the record, Adam Smith actively contributed at the highest allowed rate, but it wasn’t a ‘good’ investment for him, either *ex ante* or *ex post*. As for why, one must read the article.

*In Scotland ... the Presbyterian clergy, accordingly  
have more influence over the minds of common people  
than perhaps the clergy of any other established church...*  
– Adam Smith, *Wealth of Nations*, book 5, ch. 1, part 3

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## I

In late 2022, the US House of Representatives passed the so-called SECURE Act 2.0, an abbreviation for Setting Every Community Up for Retirement Enhancement. This 4,000-page document contains many regulations to remove administrative barriers and make it easier for US employers to offer annuities to employees, help retirees partially annuitize their wealth and 'nudge' people towards acquiring personal longevity insurance. Life annuities are not only a form of coupon-bearing bond but also insurance contracts that hedge longevity risk by pooling mortality across ages and cohorts, a topic of much recent scholarly research.<sup>1</sup> The Act and a summary provided by the Senate Finance Committee noted that 'many individuals are unwilling to elect a life annuity' at retirement, known as 'the annuity puzzle' in the economics literature (Brown *et al.* 2008; Finkelstein and Poterba 2004; Benartzi *et al.* 2001, 2011; Cocco 2012; Pashchenko 2013; Previtero 2014). Again, a substantial part of the 2022 Act was to support and encourage life annuities within retirement savings plans, which many commentators have positioned as a modern solution to the problem created by declining defined benefit (DB) pension coverage (see Horneff *et al.* 2020, as well as Poterba 2014, for more on this). Oddly enough, almost three centuries ago, the Church of Scotland introduced similar ideas into their own (early version) 'annuity plans'. And none other than the founding father of economics, Adam Smith, had a front-seat view of choices that have become part of the twenty-first-century discourse. This article contends that there are financial insights to be gleaned from that episode of eighteenth-century history, and it does so by collecting and interpreting archival data on choices made by participants in that scheme, including Smith himself.

In 1744, the Church of Scotland launched an innovative insurance and investment fund in which many well-known 'literati' of the Scottish Enlightenment<sup>2</sup> participated. Under this scheme, Presbyterian ministers and university professors made ongoing financial contributions of a voluntary magnitude during their lifetimes, which upon their demise entitled their widows to a life annuity or their orphans to a lump-sum death benefit. The 1744 scheme was designed by the Reverend Alexander Webster (b. 1707, d. 1784) and Reverend Robert Wallace (b. 1697, d. 1771), with technical assistance provided by University of Edinburgh Professor of Mathematics Colin Maclaurin (b. 1698, d. 1746). This was the first mandated scheme of its kind,<sup>3</sup> established by an Act of Parliament, although earlier and

<sup>1</sup> For the summary and text, [see this link](#).

<sup>2</sup> For more on the period known as the Scottish Enlightenment and the intellectual giants of that era, see Sher (2015), as well as the popular book by James Buchan (2003), *Capital of the Mind: How Edinburgh Changed the World*.

<sup>3</sup> Without prejudice to the Royal Navy's Chatham Chest in 1590 and the larger scheme created by James, Duke of York, in 1672, neither of which mandated participation by an Act of Parliament or was as broadly based.

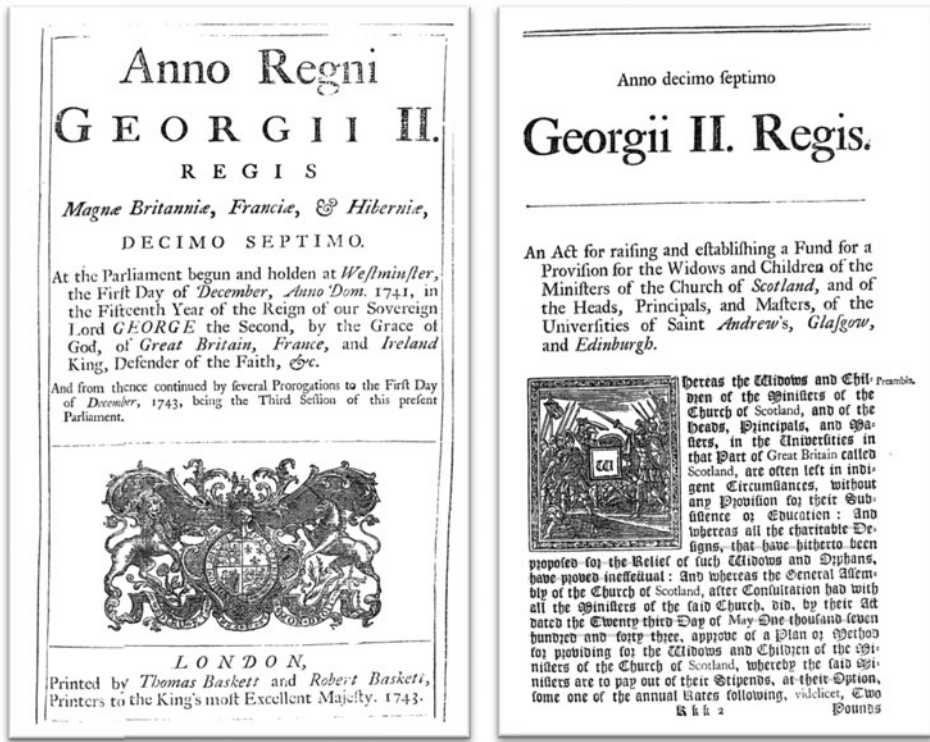


Figure 1. *The Act of Parliament taking effect 25 March 1744*

Source: Great Britain 1743 [1744], *Eighteenth Century Collections Online* (ECCO), [www.gale.com/primary-sources/eighteenth-century-collections-online](http://www.gale.com/primary-sources/eighteenth-century-collections-online)

limited synod-based schemes had been operated as early as 1718 by the Church of Scotland.<sup>4</sup> Indeed, much praise has been heaped on the scheme, especially by actuaries of Scottish origin who treat 1744 with the same reverence as 1693, when Edmond Halley (b. 1656, d. 1742) published the first empirically based valuation of life annuities. To insurance actuaries, the scheme and associated technical documentation is considered an important scientific milestone located between Abraham de Moivre's (b. 1667, d. 1754) book *Annuities Upon Lives* (1725) and Richard Price's book *Reversionary Annuities* (1771).<sup>5</sup> Figure 1 displays the title page and first page of the Act of Parliament. So, knowledge of the scheme is widespread among UK

<sup>4</sup> See Milevsky (2023) for a companion paper on the origins of the scheme, its early pay-as-you-go (PAYGO) features and the rationale for the design within the enlightened milieu of eighteenth-century Scotland.

<sup>5</sup> The relevant scholarly literature is Deuchar (1896); Mackie (1956); Dow (1975); Dunlop (1992); Hare and Scott (1992); Hald (2003); Lewin (2003); Bruneau (2020).

actuaries and select practitioners, although none have noted that Adam Smith was an active member.

Admiration for the scheme has traveled beyond (Scottish) mathematicians or members of the Presbyterian clergy who have written about the scheme. Yuval Noah Harari and Niall Ferguson denoted 1744 as a human milestone in transitioning from religious superstition to scientific modernity. Harari (2014) in *Sapiens* writes that in seeking guidance on designing the scheme, Reverends Webster and Wallace 'did not pray to God to reveal the answer, nor did they search for an answer in the Holy Scriptures or among the works of ancient theologians', but instead consulted with Professor Maclaurin to establish the fund on a sound statistical basis. Echoing a similar sentiment, Ferguson (2008) writes in *The Ascent of Money: A Financial History of the World* that 'modern actuaries still marvel at the precision with which [Webster and Wallace] did their calculations' (p. 193). Now, whether or not the 1744 scheme represented a distinct scientific 'big bang' or whether it was a manifestation of Protestant beliefs and practices, à la Max Weber, is debatable and outside the scope of this article.

Despite the scheme's fame among 'popular' historians, one aspect that has not received attention is what financial and pension economists call the 'choice architecture' and the actual decisions made by participants. Not unlike a retirement plan in the twenty-first century, participants had to make financial decisions regarding savings levels, were 'defaulted' to save at a predetermined level if they did nothing and were 'auto enrolled' – but it was all irreversible. These terms will be explained in due time, but those individual choices – such as the one made by Adam Smith – and their aggregate impact affected the economic fairness of the scheme in subtle technical ways.

The historical *reversionary annuity* in the eighteenth century was not like the defined contribution (DC) plan of the twenty-first century and perhaps was an early precursor to defined benefit (DB) schemes due to the life annuity embedded within the scheme. But in terms of research contribution, this article goes beyond the actuarial and insurance literature, most notably in a comprehensive monograph by Reverend Dunlop (1992), by focusing on the *individual choices* made by participants themselves. This aspect of the scheme has not received any attention and yet is intimately related to the recent literature on what economists have labeled 'default' options, 'auto-enrollment' and anti-selection. The first two phrases describe how employees automatically default into a savings plan if they do not make an active choice. Default refers to the act of not making any decisions (a.k.a. defaulting on one's obligations to make a choice), and the auto in auto-enrollment refers to what happens to participants who do nothing, perhaps out of laziness, ignorance or indifference.

With the decline of guaranteed DB schemes – which require no choices, actions or decisions – and the general apathy or disengagement of younger employees, auto-enrollment has become a popular mantra for retirement plan design. The law allows employers to remove money from paychecks without explicit employee permission. While this might appear overly paternalistic, unhappy employees can reverse it. But alas, inertia is powerful; and the key insights in that literature are that: (i) few

people actively select any investment options; (ii) most employees passively default into whatever the trustee chooses, perhaps because they view it as recommendations; and (iii) most remain in the default (see Madrian and Shea 2001, discussed below). This may be true in the twenty-first century, but not in the eighteenth. That is the contribution of this article in a tweet. Oh, and it appears Adam Smith did not like the default option either.

Now, this article is not intended as an entertaining piece of (Scottish) narrative history, to report on the financial dealings of the founding father of economics, or even to show that auto-enrollment, default options and anti-selection existed in the eighteenth century. Rather, the novel contribution to the financial-economic literature is the mining and analysis of archival-based data regarding choices made by hundreds of participants in the scheme. Results speak to questions around age-based anti-selection, the extent to which defaults were valued, etc.

The archival data are available for analysis due to meticulous (Scottish) book-keeping practices and because each year the Presbyterian trustees of the scheme were required to issue a report documenting all those who enrolled and their choices. Those records were recently transferred from the Church of Scotland to the National Records of Scotland and are now available to the (researching) public. A sample front page of the annual reports is displayed in Figure 2. To this author's

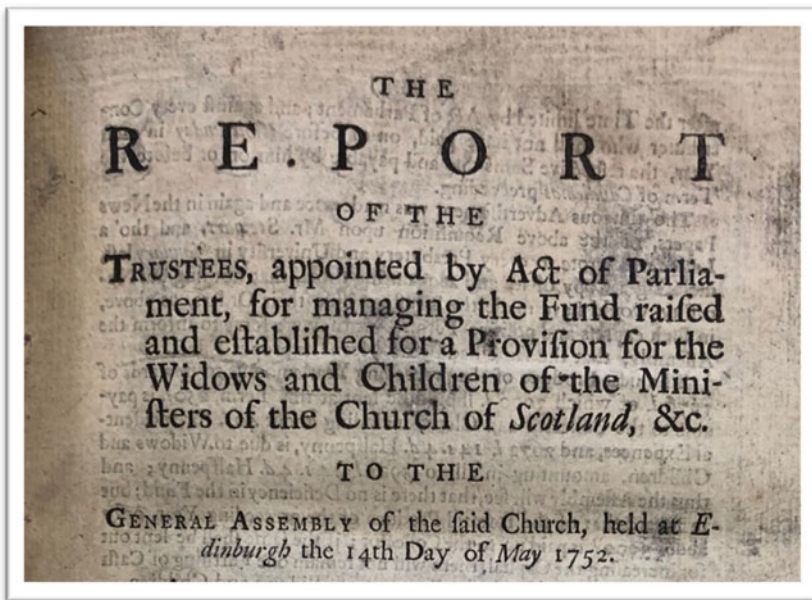


Figure 2. *Report to scheme trustees in 1752*

Source: National Records of Scotland, CH9/16/2, photographed with permission. Authorization to reproduce granted by the office of the Moderator of the Church of Scotland.

knowledge, no economics-based researcher has taken the time to visit the archives, dig out the handwritten minutes and scheme books, collect the data and then systematically report those choices. Why go through this effort? Well, for starters, to test whether eighteenth-century participants behaved in ways that would be deemed 'rational' in the twenty-first century and whether some of the recent 'behavioral' findings could be replicated in what might be the earliest example of 'choice architecture' data. Stumbling upon Adam Smith's name among the long list of scheme participants was purely serendipitous.

To preview some of those archival results – and how they differ from what might have been expected in the twenty-first century – I will quote directly from Madrian and Shea (2001), alluded to earlier and one of the most cited papers in this literature. They write:

a substantial fraction of 401(k) participants hired under automatic enrollment retain both the default contribution rate and fund allocation even though few employees hired before automatic enrollment picked this particular outcome. This default behavior appears to result from participant inertia and from employee perceptions of the default as investment advice. (p. 1149)

In contrast to their results in the twenty-first century, as just one motivating example from the Ministers' Widows' Fund, it seems very few participants (12.6 percent) defaulted, and an even smaller group (8.8 percent) actively selected the default option. Most participants (63.7 percent) opted for non-default contribution levels higher than the default level, and (of those who could) 14.9 percent opted out of the scheme entirely. Put differently, they might have been 'nudged' to contribute at the default rate, but most selected otherwise.

The remainder of this article is organized as follows. Section II provides a high-level summary of the scheme, placed within the financial context of mid-eighteenth-century Scotland and the aftermath of what P. G. M. Dickson (1967) labeled the *Financial Revolution* in England. Section III discusses the Money's Worth Ratio of the embedded reversionary annuity in the spirit and methodology of Mitchell *et al.* (1999). The discussion then moves on to the actions taken by individual participants in Section IV. The article concludes in Section V with insights from Adam Smith's writing on annuities and longevity risk sharing.<sup>6</sup> The detailed archival-based sources upon which this article is based are cited in the references.

#### *A note on money*

British currency in the eighteenth century was reported based on the pound, shillings and pence system, with 12 pence (d) being equal to one shilling (s) and 20 shillings equalling a pound (£). This will be written as X.Y.Z. for consistency and ease of reading: **X** pounds, **Y** shillings and **Z** pence. Since there are  $12 \times 20 = 240$  pence to a pound, the decimal equivalent of this is computed via  $(12Y+Z)/240$ . So, for

<sup>6</sup> Echoing the attempt by Ashraf, Camerer and Loewenstein (2005) to position Smith as a behavioral economist.



example, £1.2s.3d would be equivalent to one pound plus 27/240 or £1.1125 after the date of 15 February 1971, otherwise known as Decimal Day. This article will default to the pre-1971 notation for consistency unless specific computations require decimalization.

## II

The early eighteenth century was a period of ‘financial revolution’ with many proposals for social and economic improvements or ‘projects’, using a term that Daniel Defoe favored in 1697. Defoe proposes a government entity called the Office of Insurance for Widows in his essay ‘Upon Projects’. As it echoes the scheme at the heart of this article, the design contours are quoted here:

We have an abundance of women ... with nothing to support them, which falls generally upon the wives of the inferior clergy, or of shopkeepers and artificers ... If he dies, then she is absolutely undone, unless she has friends to go to ... Suppose an office to be erected, to be called an office of insurance for widows ... Two thousand women, or their husbands for them, enter their names into a register to be kept for that purpose, with the names, age, and trade of their husbands, with the place of their abode, paying at the time of their entering 5s. down with 1s. 4d. per quarter... If any one of the women become a widow at any time after six months from the date of her subscription... she shall receive the sum of £500 in money without any deductions. (Defoe 1697, sec. 2)

Defoe’s plans came to naught, and his pricing was widely off the mark, but a few years later, the Church of Scotland implemented a scheme that rhymed with Defoe’s, who had coincidentally spent time in Scotland in 1706 and (perhaps) might have suggested this to members of the clergy (Novak 2003).

The 1744 scheme – again, the chassis of this article – continued in operation until 1993, when the fund was technically wound up and merged with a larger plan. See Sibbett (1993), Dunlop (1992), Lewin (2003, pp. 361–7) and Sibbett (2004), for more on the narrative history of the scheme over three centuries.<sup>7</sup> At its essence, the idea was to provide all ministers in the Church of Scotland – and university members who later petitioned to join the scheme – the ability to purchase *reversionary annuities* for their wives. The funds or capital of the scheme was invested to earn 4 percent interest by forcing all members to borrow £30 at the listed 4 percent rate, with ample security against non-payment. The remaining funds were lent out and invested locally. Adam Smith borrowed the £30 on 11 June 1751.<sup>8</sup>

To understand the mechanics of the fund’s ‘asset allocation’, a modern equivalent would be a pension plan that forces contributors to take out (i.e. borrow with) a mortgage from the fund itself secured against property at the fund’s required rate of return.

<sup>7</sup> In 1843 the insurance fund split with the Free Church of Scotland then united in 1930, and was wound up in 1993.

<sup>8</sup> CH9/4/2, which also notes it was repaid on 27 June 1754.

Odd, but that is one aspect of the 1744 scheme that is interesting from a financial point of view. Participants could lend out the same funds at a higher interest rate, and many did so as a source of income.<sup>9</sup> The savings options and default annuities are more relevant to this article, otherwise known as the choice architecture.

For the benefit of readers who are not annuity specialists, the mechanics of a *reversionary* annuity differ from a *conventional* annuity in several important ways.<sup>10</sup> The conventional life annuity, which has been available for millennia – and is the backbone of the widely cited Yaari (1965) model in life-cycle economics – is associated with an income benefit for life. Indeed, the literature on life annuities within the context of the life-cycle model is now vast, and a proper literature review is well beyond the scope of this article. But to understand how an immediate or deferred annuity differs from its reversionary cousin, consider a premium of £100,000 to an insurance company that might secure a lifetime payout yield of 8 percent, or £8,000 per annum, starting immediately. These conventional products can also be acquired as a deferred annuity over longer periods by contributing during many years of work in exchange for a lifetime pension at some predetermined calendar or chronological age. Conventional annuities might stipulate that income benefits continue for the life of both a buyer and a spouse, which would be associated with lower income benefits given the longer expected duration.

Nevertheless, conventional life annuities contain two key features: (i) the existence of a buyer who receives some benefit during their lifetime and (ii) a predetermined fixed date upon which those benefits commence. These two features are effectively inverted for a *reversionary* annuity: the buyer never receives any income benefit since the benefit is instead directed to a second person on whose life it depends, and the commencement date of the annuity is not known in advance. Another way to ‘think about’ a reversionary annuity in modern terms is as a qualified longevity annuity contract (QLAC) or advanced life delayed annuity (ALDA); this is purchased and owned by a female, but only begins paying income when her husband dies, not at a fixed chronological (retirement) age.

Indeed, the most common historical incarnation of a reversionary annuity guaranteed a benefit to a wife (only) upon the husband’s death if she was still alive.<sup>11</sup> The purchase rationale – or some might say gamble since in the early eighteenth century many did view this as a gamble, per Clark (1999) – is to generate and secure an adequate income for a spouse upon the husband’s demise. The reversionary annuity is an alternative to simple life insurance that ‘burdens’ the wife with a ‘stock’ that

<sup>9</sup> See the trustee meeting minutes, CH9/1/1, for discussions around this (potential) arbitrage opportunity.

<sup>10</sup> The word ‘mechanics’ is deliberately used to resonate with Newtonian mechanics and eighteenth-century views of mortality.

<sup>11</sup> For the actuarial valuation, see Dickson, Hardy and Waters (2009, p. 141); Bowers *et al.* (1997, p. 285); as well as Boyle (1974). The earliest valuation was by Richard Price (1770). See also Haberman and Sibbett (1995).



must be invested to generate an annual income. The idea that ‘stock’ is a burden – how should we invest the money? – was echoed by Alexander Webster, the co-designer of the scheme. He wrote: ‘The committee cannot help thinking that £20 payable yearly to the mother will better answer the purposes than the [one lump] sum of £200.’<sup>12</sup>

Overall, it is difficult not to find parallels with recent discussions on lump-sum versus annuity payouts from retirement plans in the US.<sup>13</sup> However, the 1744 scheme was not an old-age pension plan. Ministers and professors were entitled to stipends for life, regardless of how incapacitated they became. They might have gained access to an assistant in their very old age but never retired. Rather, the 1744 scheme was intended to continue as a stipend (when dead) in exchange for sacrifice while they were alive. Nonetheless, such a scheme is only a small intellectual step away from a plan that provides joint life annuities at a fixed chronological retirement age. Goetzmann (2016), among others, has noted the influence of these early plans on later national pension annuity plans.<sup>14</sup>

The scheme’s designers made an argument that could be described as *consumption-smoothing*:

The matter appears to us in this light. Whether shall a minister and his family live upon £50, for instance, during the minister’s life, and his family be left wholly destitute at his death? Or shall they live on £46 during his incumbency and have reasonable maintenance notwithstanding decease? We shall only add that this hardship seems to us rather imaginary than real.<sup>15</sup>

But the final 1744 scheme went well beyond an earlier proposal to force everyone to sacrifice £4 for ‘reasonable maintenance’ when they are deceased. Participants could select a relatively high reversionary annuity widow’s benefit of £25 in exchange for contributing (sacrificing) £6.11s.3d p/a, or they could opt for as low as a £10 benefit in exchange for only contributing £2.12s.6d. **Table 1** displays the four categories.

Notice from the right-most column in **Table 1** that regardless of which of the four categories was selected, the ratio of reversionary annuity benefit-to-contribution was identical. This key multiple of 3.81, set by the scheme’s architects in a calculation confirmed by Colin Maclaurin, is a pivotal number. Indeed, whether this multiple was too high and generous, too low and miserly, or just about right is a recurring question in the (historical) actuarial literature and will also be addressed herein.

Nevertheless, regardless of whether the 3.81 multiple was appropriate for a generic individual who is  $x$ -years old and whose wife is  $y$ -years old, pooling longevity risk

<sup>12</sup> CH9/17/2, ‘A Scheme for providing ...’ (p. 6).

<sup>13</sup> This touches upon the behavioral implications of providing information on retirement income versus asset values.

<sup>14</sup> One can perhaps run a national pension thread from Reverend Alexander Webster to Richard Price, to Francis Maseres (b. 1731, d. 1824), to Marquis de Condorcet (b. 1743, d. 1794) and finally to Otto von Bismarck (b. 1815, d. 1898).

<sup>15</sup> CH9/7.

Table 1. 1744 insurance fund: contributions versus benefits

Contribution class	Annual contribution (decimalized)	Widows' annual life annuity	Payout multiple
#1	£2.12s.6d => £2.6250	£10	10/2.625 = 3.81
#2	£3.18s.9d => £3.9375	£15	15/3.937 = 3.81
#3	£5.5s.0d => £5.2500	£20	20/5.250 = 3.81
#4	£6.11s.3d => £6.5625	£25	20/6.562 = 3.81

Source: Great Britain (1744, 1749) and Assembly Acts (1742).

together and charging the *same price* for insurance benefits was problematic and could lead to anti-selection. It effectively undercharges older people, who are not paying enough – since the payout multiple of 3.81 is too high – subsidized by younger members who pay too much. Their payout multiple of 3.81 is too low.

To contextualize these numbers for a typical household's budget in the eighteenth century, the minimum stipend for ministers was fixed (in 1633) at £45 per year, paid in either 'money or victual'. A separate (1749) commission to consider the augmentation of ministers' stipends reported that out of 1,000 or so parish ministers, 16 received a stipend of less than £35 per year, 41 received less than £40 and 147 received the legal minimum of £45. The same commission estimated that the necessary annual expenditures of a minister were at least £83 per year (Sefton 1962, p. 110; Sher 2015, p. 122; Morren 1838, p. 191).

Figure 3 summarizes minister stipends during the mid eighteenth century to illustrate that these contributions were material. Inquisitive readers unfamiliar with the eighteenth-century Scottish Enlightenment might be puzzled by the pooling of church clergy and university faculty. Still, the connection between these two organizations was surprisingly close, as noted by the landmark work by Sher (2015). When the University of Edinburgh faculty heard of the scheme designed for clergy, they petitioned to join. Glasgow followed soon after. Adam Smith – on the matter of clergy wages and whether they were material – writing in the *Wealth of Nations*, offers yet another data calibration point:

By a very exact account, it appears that in 1755 the whole revenue of the clergy of the church of Scotland, including their glebe or church lands and the rent of their manses or dwelling houses, estimated according to reasonable valuation, amounted only to £68,514. This very modest revenue affords a decent subsistence to 944 ministers. The whole expense of the church, including what is occasionally laid out for the building and reparation of churches and the manses of ministers, cannot well be supposed to exceed eighty or eighty-five thousand pounds a year. (Smith 1789/2000, p. 874)<sup>16</sup>

<sup>16</sup> Smith's average works out to approximately £72 per year, and slightly higher than Morren (1838), although it might include other expenses as well.

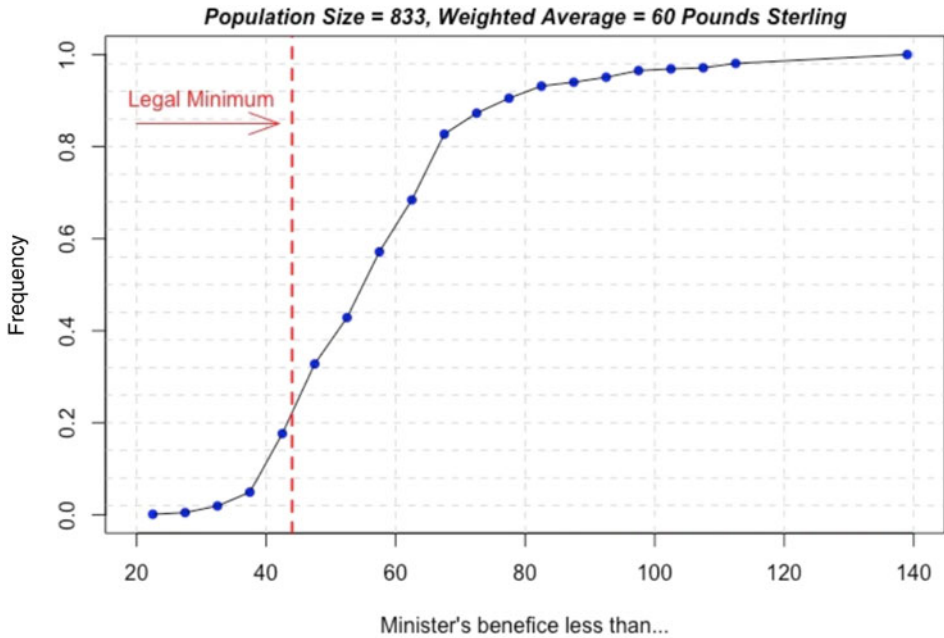


Figure 3. *Church of Scotland benefices and wages in 1750*  
 Source: Data from Morren (1838, p. 162) and Phillipson (2010).

The point is that the contribution rates were between 5 and 15 percent of the minimum stipends and between approximately 2 and 10 percent of the average. They were not trivial sums, and this ‘tax’ placed a relatively high financial burden on ministers, who, as noted by Smith, were paid less than professors. This might help to explain why participation was made optional for all 1744 incumbents. Back to choice architecture, those who did not opt out (in 1744) or did not select a benefit level were automatically placed into the second (£15) category listed in Table 1. All of this might explain why soon after the scheme was amended in 1749, and the individual financial burden became even more onerous, proposals to augment stipends were debated in the General Assembly of the Church of Scotland.

Moving on, due to the prior noted multiple of 3.81 being too advantageous for the older members, the scheme was revised in 1749 to impose additional eligibility criteria on widows when the husband died. For example, husbands had to have contributed for a minimum number of years, or their benefit would be clawed back. Again, see the introductory chapter of Dunlop (1992) for a narrative history of the scheme and revisions, but the key recurring 3.81 multiples itself was not changed. Indeed, in an attempt to justify amendments, the following was noted in the lead-up to the (revised) Act of 1749:

The provisions of such ministers as should die soonest, even in the first year of the scheme, [who] consequently contribute the least were to be as great as the provisions of those who

should live the longest and contribute most, which ... [would] be much too favorable for those of advanced age, were however generously agreed to by the younger brethren. It always be understood that if the fund should not answer, application be made to the legislature for such alternations.<sup>17</sup>

As one example of this 'favorable advantage' – or basic anti-selection in the language of Finkelstein, Poterba and Rothschild (2009) – an early participant to 'exercise' his annuity option was Reverend James Anderson from Roseneath in Dunbarton Presbytery. He died on 28 June 1744, three months after the scheme was enacted. Anderson had fortuitously selected the highest benefit and likely contributed no more than one year's rate of £6.11s.3d and perhaps only half that. But his wife, Margaret Turner, enjoyed a benefit of £25 per annum for the rest of her life.<sup>18</sup>

Other features worth noting are: in the absence of a widow when the husband died, children under 16 would be entitled to a lump-sum benefit of ten times what her annuity might have been. So, if the contributor selected the highest category and left children but no widow when he died, the children would be entitled to split £250 immediately. And, even if a widow were still alive at the time of the husband's death, the children would be entitled to the remaining difference as a lump sum if she died within ten years. Also, vacant stipends were subject to an extra tax, married participants had to double up on their contributions for the year and the annuity payments would be extinguished if the beneficiary ceased being a widow (i.e. married).<sup>19</sup> All of this makes it challenging to measure the (expected) internal rate of return on contributions, but at a summary level, for every unit (e.g. pound) in annual premiums, the reversionary annuity paid 3.81 units to the survivor. This was regardless of age when they started contributing to the scheme, and one, therefore, does not require training in actuarial science to understand this was problematic and created wealth transfers.

In terms of the more granular features that complicate the actuarial valuation, the termination of annuity benefits upon remarriage (of the widow) created a financial impediment to (re)marriage. It was much debated among trustees of the scheme. This practice was not limited to such schemes and was common for pensions by the time of the US civil war, per Salisbury (2017). In numerous cases that reached the Church of Scotland trustees and required legal action, widows remarried but failed to disclose their new status. The annual reports and trustee minutes make for interesting reading, and in one entertaining case, a widow was 'caught' and then denied being married despite a 25-year-old marriage licence. In that case, the trustees

<sup>17</sup> CH9/17/34, 'Calculations with the Principles and Data on which They Are Instituted Relative to a Late Act of Parliament, Showing the Rise and Progress of the Fund'.

<sup>18</sup> CH9/6/2, 'Accounts, Cash Received and Paid, 1744–1755'. In CH9/1/1, the first death is Hugh Munro, on 16 May 1744, less than two months after the scheme came into effect.

<sup>19</sup> See Great Britain (1744), *An Act for Raising ...*, and Great Britain (1749), *An Act for Explaining and Amending ...*

demanded that hundreds of pounds be returned, and in response, she requested that her 25-year-old marriage be annulled. Alas, she lost the case and had to repay the entire annuity, which speaks to the prudence with which benefits were managed.<sup>20</sup>

The above anecdote, which also speaks to the micro-management of scheme affairs, captures another managerial innovation. This author believes the ‘improvement’ was not necessarily the 3.81 contribution multiple computed by mathematicians. Theoretically, it is relatively easy to sketch a plan (on a whiteboard) in which participants make annual contributions, money is collected, funds are invested, and benefits are paid to widows and orphans: this is as true in the twenty-first century as it was in the eighteenth. The challenge in the eighteenth century was implementation, creating oversight and management control. It seems that this is precisely where the bureaucracy of the Church of Scotland shines bright and might be the source of the scheme’s longevity. Presbyterian ministers put in place an infrastructure to combat fraud and continuously monitor life and death. Alexander Webster managed it with an iron fist.

The surprisingly well-preserved documents in the archives contain multiple and repetitive lists of contributors and their entitlements, the number of widows and how long they have been alive, the names and ages of all children, dates, payments, exact sums and who owed what to whom. When viewed in totality, one leaves the archives with the impression that this scheme’s administrative work was breathtaking. As Lewin (2003) writes, the scheme was ‘a splendid tribute’ to prudential Scottish ‘financial management’ (pp. 361–7), perhaps more so than to actuarial science.

To this very point, the same records show trustees, clerks and collectors repeatedly implored the synods, presbyteries and parishes to keep better records, send in their lists of contributors and beneficiaries on time, record them in a particular manner, use specific formatting and to delete empty spaces. Heftier than the interest on tardy contributions, financial fines were imposed on delinquent local administrators. In May 1757, an Act was passed to ensure that ‘separate registers shall be divided into many parts as the respective presbyteries consist of parishes’ and that every clergy and the university should ensure their lists are ‘bound up with a quire of clean paper’.<sup>21</sup> One can only imagine how long it took to get this information and paperwork from the northwest highlands down to Edinburgh while a Jacobite rebellion was raging. The key point – relevant to the valuation of Adam Smith’s reversionary annuity – is that while the administration and bureaucracy created by the plan were enormous, the actuarial and mathematical 3.81 benefit multiple never changed. (Church of Scotland, General Assembly 1743, p. 7). That number is precisely the focus of the next section.

<sup>20</sup> CH9/16/2, ‘Printed Reports’, 1747–90.

<sup>21</sup> This appears immediately after an admonition against attending theatre, as John Home’s play *Douglas* had premiered five months earlier, on 15 December 1756, which experts on the Scottish Enlightenment might appreciate.

Table 2. *Pure life annuity factors*

Initial issue age ( $x$ )	Edmond Halley (1693) article	Analytic fit (appendix eqs. 1 and 5)
30	11.72	11.89
35	11.12	11.35
40	10.57	10.72
45	9.91	10.01
50	9.21	9.21
55	8.51	8.35
60	7.60	7.44
65	6.54	6.50

Note: Valuation assumes  $r = 6\%$ , per Halley (1693).

### III

This section describes the fair pricing of a *reversionary annuity*, with technical modeling in the Appendix. It is intended to enable readers to appreciate the impact of chronological age on contribution rates, and supports the claim that (in 1744) scheme contributions were too low – and the benefits multiple of 3.81 was too generous – for older contributors.

While the economic forces of supply and demand generally determine equilibrium prices, with mortality-contingent claims triggered by life and death, Adam Smith's invisible hand is subservient to matching expected discounted actuarial values (EDAV). The justification for using EDAV versus supply and demand is the so-called Law of Large Numbers (LLN).<sup>22</sup> The intuition is that while it is difficult to forecast life and death in a small group, the aggregate uncertainty of outcomes declines to zero in the limit as the pool size increases. As many contributors are pooled together, the so-called idiosyncratic (or non-systematic mortality) risk is diversified away, and the economic valuation is by expectations (only). A technical appendix provides a brief review of (basic) life annuity valuation and pricing for those unfamiliar with these instruments' actuarial aspects and how they might differ from reversionary annuities. One can then compute the 'fair' multiple using mortality rates that would have been available at the time. The valuation technology (described in the appendix) is derived in continuous time, whereas mortality tables such as the rates in Halley (1693) are given discretely. But to defend this transition from discrete to continuous, Table 2

<sup>22</sup> The earliest historical awareness of the LLN can be traced to the Italian mathematician Gerolamo Cardano (b. 1501, d. 1576), while the first formal proof was provided by Jacob Bernoulli (b. 1655, d. 1705) in *Ars Conjectandi*, published posthumously in 1713. It's unclear whether this 'law' was known or relied upon in the mathematical design of the scheme.



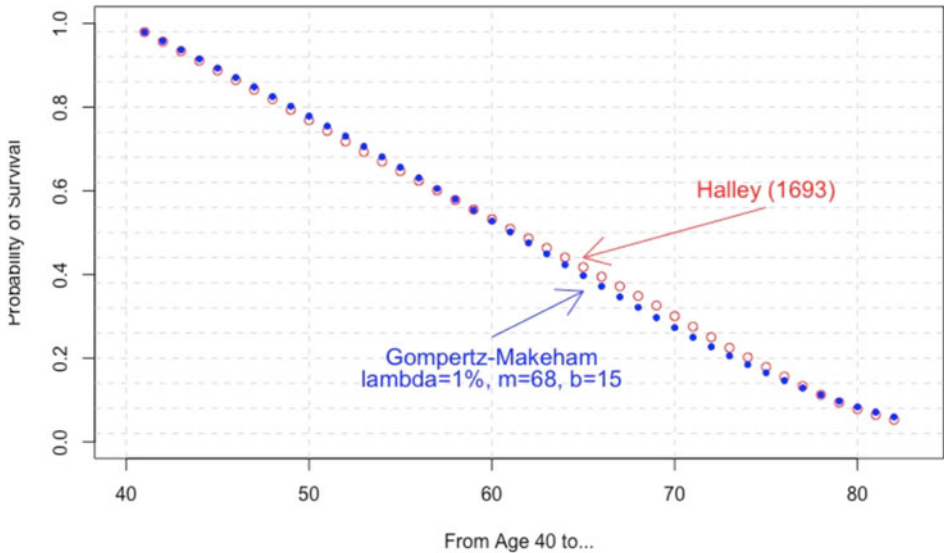


Figure 4. *Gompertz–Makeham fit to Halley’s (1693) mortality table*  
 Source: Author’s calculations. See Milevsky (2020) for methodology.

compares the analytic fit at a 6 percent interest or valuation rate, and Figure 4 compares the survival probabilities using Halley’s original table. They match.

The key takeaway point here is (i) to develop an intuitive sense of the impact of age on the fair actuarial premium as well as (ii) illustrating that moving from clunky-and-discrete time to smooth-and-continuous time does not degrade or distort the valuation results. The 1744 architects (e.g. Maclaurin) used a discrete numerical approximation and assumed the entry age was the same for all.

Moving on to numerical examples for the reversionary annuity. Assume a 45-year-old contributor wants to guarantee his 35-year-old spouse a benefit of £10,000 per year for life upon his death. This reversionary annuity can be acquired with one (large) payment of £44,200 now, the so-called annuity factor (eq. 4a, in the Appendix) times £10,000. Alternatively, that can be amortized by dividing the lump sum by a present value factor (eq. 1 in the Appendix), leading to £3,650 per year while the contributor is alive (even if the spouse died first). The ratio between the £10,000 annual benefit and £3,650 annual contribution is a payout multiple of 2.74, so a £25,000 spousal benefit divided by 2.74 would cost £9,125 per annum. Table 3 illustrates the important age dependency, and all numbers are predicated on the effective valuation rate of 4 percent per annum,  $r = \ln[1.04]$ , which was used by the plan for almost the entire first century of its operation. Recall that was the rate at which interest on the (forced) loans was due, so the fact that market interest rates changed during this period did not pose a material risk to the plan.

Table 3. Fair annual contribution for a reversionary annuity of £10 for life assuming all funds are invested at a 4 percent interest rate

Initial age of contributor	Initial age of beneficiary			
	30	35	40	45
30	£2.198			
35	£2.667	£2.323		
40	£3.299	£2.886	£2.468	
45	£4.147	£3.650	£3.140	£2.633
50	£5.284	£4.683	£4.058	£3.429
55	£6.807	£6.079	£5.311	£4.527
60	£8.849	£7.962	£7.017	£6.037
65	£11.591	£10.505	£9.337	£8.111

Note: Based on appendix equations (1) to (5).

Returning to the table, a contributor who is 55 years old and whose beneficiary is 35 would be required to contribute a fixed £6.08 (versus £3.65) per year to secure the £10 benefit. It's higher due to the contributor's shorter expected lifespan. If contributions are amortized (that is, spread, paid) over shorter horizons, they must be higher to cover benefits. Table 3 illustrates that increasing the age of the spouse reduces the fair contribution. An older spouse reduces the expected time the £10 will be paid. The EDV of benefits is reduced so that contributions can be lower. Finally, the fair benefit multiple is in Table 4. It is another way of expressing what the beneficiary receives per contribution unit.

For example, a contributor who enters into the annuity agreement at the age of 30 with a 30-year-old spouse can secure a lifetime multiple of 4.55. The multiple is quite high – and more generous than what the 1744 scheme offered – because it is expected that the contributor will be making payments for many years. In contrast, the 65-year-old with the same spouse (well, not exactly the same) can only obtain a lower multiple of 0.86 (that is, less than one) because he is not expected to be a part of this scheme for very long before he dies. But, if he swaps his 30-year-old spouse for a 45-year-old (again, not exactly), the benefit multiple jumps to 1.23 because this older spouse is not expected to draw benefits for very long, if and when the contributor dies.<sup>23</sup>

Now let's get back to the question: *Was the 3.81 payout multiple offered to Adam Smith too high, generous and unsustainable?* Well, if everyone in the scheme were exactly

<sup>23</sup> For a contemporary comparison, the maximum annual benefit under the UK state pension is £9,600 (inflation-adjusted) per annum, and the maximum normal National Insurance contribution rate is £4,900. That's a benefit multiple of 1.95, which might be fair to someone who starts contributing at age 50 but not at age 30.

Table 4. *Fair payout multiples for a reversionary annuity assuming all funds are invested at a 4 percent interest rate*

Initial age of contributor	Initial age of beneficiary			
	30	35	40	45
30	4.55			
35	3.75	4.30		
40	3.03	3.47	4.05	
45	2.41	2.74	3.18	3.80
50	1.89	2.14	2.46	2.92
55	1.47	1.65	1.88	2.21
60	1.13	1.26	1.43	1.66
65	0.86	0.95	1.07	1.23

*Note:* Based on appendix equations (1) to (5).

age 45, it would be perfect, given the abovementioned assumptions. For those younger, it would be ‘slightly unfavorable’ – and Adam Smith would have been a good example of someone for whom it was unfavorable. Recall that he joined at age 28. The multiple his (future, potential) wife should have been entitled to should have been higher. However, the scheme was too generous for those who were older – and there were plenty who were in 1744. The multiple should have been lower. The problem would have been magnified if these (older) participants selected the larger benefits, which is examined in the next section.<sup>24</sup>

#### IV

This section examines how individual participants engaged with the scheme, what those interactions might reveal about their financial lives, whether there was, in fact, anti-selection, whether the default option was the most popular actively selected choice and how the totality of their choices impacted the sustainability of the fund. As noted earlier, the research precursor to this discussion is Madrian and Shea (2001). Their main result is that a substantial fraction of employees hired under automatic enrollment retains the default contribution rate and fund allocation. This passive behavior results from participant inertia and employee perceptions of the default choice as recommended investment advice.

<sup>24</sup> The importance of age-dependent pricing for life annuities was known to the early eighteenth-century mathematicians, such as Abraham de Moivre (b. 1667, d. 1754) and Edmond Halley (b. 1656, d. 1742), but appears to have been ignored by all (widow) schemes that issued (reversionary) annuities (see Bellhouse 2011). See also Daston (2023), who argues that actuarial science, in general, was ignored by the insurance industry for most of the eighteenth century.

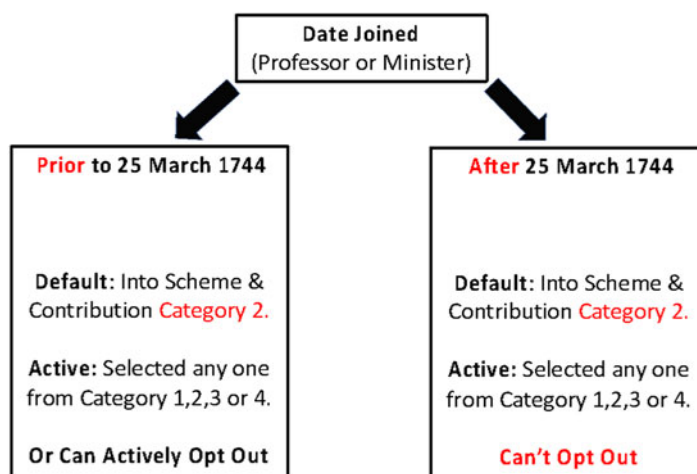
Table 5. *Scheme choice assumptions versus realizations*

	Assumed selection	Actual selection	Deaths (#) 1744–55	Deaths (%) 1744–55
Class #1 (£10)	21.5%	3.6%	10	3%
Class #2 (£15)	53.8%	21.4% =	50 =	18% =
Active & default		8.8% + 12.6%	16 + 34	6% + 12%
Class #3 (£20)	21.5%	33.3%	92	32%
Class #4 (£25)	3.2%	26.8%	79	27%
Opted out	0.0%	14.9%	57	20%
Total	<b>100%</b>	<b>100%</b>	<b>288</b>	<b>100%</b>

Source: column 1, CH9/17/1, 'Representation and scheme...', columns 2, 3, 4, CH9/4/2, Trustees' Scheme Books, 1744–55.

So, in what might be described as the earliest occurrence of auto-enrollment with a default choice, ministers and professors who were already receiving their benefices (that is, employed) before 25 March 1744 had the option of declining to participate. A preliminary count indicates that out of the 1,000 or so eligible participants, approximately 150 actively declined to participate. A precise count based on hand-collected data is reported in Table 5. But if trustees did not receive notice of declination within the prescribed time limit, ministers and professors would be auto-enrolled into the scheme. Anyone who joined after 25 March 1744 was auto-enrolled into the plan, per the schematic in Figure 5.

Recall from the description above that in the absence of an active election, ministers and professors were to be placed into the second class, associated with a yearly

Figure 5. *Schematic of scheme choices*

Note: Adam Smith was hired in 1751 (i.e. after 1744), so he couldn't opt out.

**FORM of a NOTIFICATION, intimating a Minister's Election of the Annual Rate to which he chufes to be subject.**

**I** day of \_\_\_\_\_ admitted upon the \_\_\_\_\_  
 \_\_\_\_\_ One thousand seven hundred and \_\_\_\_\_  
 years, minister of \_\_\_\_\_  
 in the Presbytery of \_\_\_\_\_ and shire of \_\_\_\_\_  
 do hereby, in consequence of an act of the nineteenth year of the  
 reign of his Majesty George the Third, for the better raising and  
 securing a Fund for a Provision for the Widows and Children of the  
 Ministers of the Church of Scotland, &c. give notice to the Tru-  
 stees by the said act appointed, that I make choice of, and do  
subject myself to the yearly Rate of \*  
 lawful money of Great Britain, and to the other payments conse-  
 quent thereupon, in virtue of the said act of parliament, and this  
 my option. And I appoint this Notification to be delivered by  
 any person to whose hands the same may come, at the General  
 Collector or Receiver's office in Edinburgh. In witness whereof,  
 I have written and subscribed these presents, at  
 the \_\_\_\_\_ day of \_\_\_\_\_ One thousand  
 seven hundred and \_\_\_\_\_ years.

Figure 6. *Scheme choice notification forms*

(Adam Smith would have had to complete a form like this.)

Source: Form from the year 1792, National Records of Scotland.

contribution of £3.18s.9d. The justification given for this rate – also known as the default option – was that ‘it was the medium’ of the four available options. Figure 6 illustrates the form the participants had to complete and offers readers a better sense of what (in the twenty-first century) would be called the ‘user onboarding process’.

The Trustees’ Scheme Books of 1744–55 contain the names of every single minister and professor during the decade spanning 1744 to 1755 and the financial choices – or lack thereof – they made.<sup>25</sup> To pre-empt the main result, the scheme’s architects (wildly) misestimated the choices made by participants, which led to financial challenges, but (as will be demonstrated), contrary to Alexander Webster’s assertion, it was not the ‘fault of old men’.

#### *Aggregate choices*

In this subsection, participants’ aggregate choices will be examined in totality. To set the context, begin by examining the original language within the Assembly Acts of 1744:

<sup>25</sup> CH9/4/2, Trustees’ Scheme Books, 1744–55.

After the expiration of the said year, the minister neglecting to make an intimate his election shall be bound to pay the aforesaid sum of £3.18s.9d annually for all the years of his incumbency and that no minister shall be allowed ever to alter or vary the choice he has once made.<sup>26</sup>

So, unlike the twenty-first-century retirement plan 'nudges', the participants were stuck in the plan, and perhaps this echoes some of the (recent) proposals to default into life annuities. Quite presciently, the eighteenth-century justification for not allowing any subsequent changes was given as follows:

If you were to allow the variation of classes, then it would be in the power of one in the immediate view of death, who had chosen formerly a £10 annuity for his widow, to bring up her annuity to £25, for the payment of a very small sum.<sup>27</sup>

This keen awareness of the implications of insurance 'anti-selection' indicates that the scheme's architects are worried about this matter. In a footnote to the same paragraph, they speculated on what might happen if they did not include a 'default' option:

There seems to be an absolute necessity for fixing down those hereafter to be admitted into the church to join in one class or the other. Otherwise, a humour might arise, and the ten thousand accidents defeat the scheme altogether.<sup>28</sup>

Alas, it seems they misestimated what those choices would be. [Table 5](#) summarizes actual versus assumed choices made by close to 1,250 participants noted in the Trustees' Scheme Books.

They assumed that 54 percent of ministers and professors would end up in the second class, the default option. Perhaps they also considered this second category the most appealing choice, so they made it the default option. The scheme's documents did not project how many would actively select this class or would be defaulted into that category. But in practice, only 8.8 percent (77 out of 873) of incumbents actively selected the second class, and a further 12.6 percent (110 out of 873) of incumbents failed to respond and were 'defaulted'. The majority of the 873 incumbent ministers and professors selected the third and fourth classes, although ministers were more likely (17 percent versus 1 percent) to not choose at all. The largest gap between plan assumptions and reality is between the assumed 3.2 percent (in the scheme documents) for the fourth class versus the much larger 26.8 percent actively selecting that class.<sup>29</sup> This might have created a (false) narrative that older ministers and professors were more likely to select the higher benefits.

The most important takeaway from [Table 5](#) is that designers underestimated the number who would opt for the highest benefit. And, since the scheme 'underpriced'

<sup>26</sup> CH9/17/1, 'Representation and scheme ...' (p. 6).

<sup>27</sup> Ibid.

<sup>28</sup> Ibid., note 2.

<sup>29</sup> Trustees' Scheme Books.



reversionary annuities for most participants, the skew towards more expensive (£25) benefits threatened the fund's viability. To exacerbate matters, 59 percent of deaths during 1744–55 were participants in the top two classes.<sup>30</sup>

In a document (purportedly) written by Robert Wallace in April 1744, less than a month after the scheme became operational, the author noted a 'considerable advantage to old men' – which is remarked upon by Colin Maclaurin – and quite interestingly wrote that 'the general voice is for excluding all old men altogether'.<sup>31</sup> In other words, the scheme's architects initially worried about this. To this point, the author of the first (narrative) history produced for the scheme, the 1759 report 'An account of the Rise and Nature of the Fund', notes:

It appeared that a great many old men had claimed the benefit of the highest classes ... and the number of widows to be provided for was considerably greater than had been supposed.<sup>32</sup>

In another document, the scheme's originators noted the following (excuse):

It shall, therefore, only be further observed that it was impossible to calculate with any certainty how the scheme would hold until [they] signified the option of the annual rates to which they chose to be subjected.<sup>33</sup>

Perhaps other fund trustees were questioning Webster since in the final paragraph of the document used to justify the amendments in 1749, Webster writes:

Instead of wondering at the alteration now found necessary [and] be rather surprised that such probable conjectures were made in preparing the scheme as that a very small variation bids fair to perfect a plan so extensive depending on the free choice of near 1000 persons and a variety of incidents which could not be reduced to any certain calculations.<sup>34</sup>

### *Blame the old men?*

Finally, this subsection concludes by asking: was it, in fact, 'old men' and age-based anti-selection that caused financial problems? A proper statistical analysis of choices made during the period 1744–5 reveals a more nuanced perspective and might have surprised Wallace and Webster.

What follows summarizes the reversionary annuity choice data hand-collected from over 70 pages of the Trustees' Scheme Books, 1744–55, currently stored in the archives of the National Records of Scotland (CH9/4/2). At first pass, 1,242 individual name choices made during the entire period 1744 to 1755 were transcribed, which is the larger sample. Of this group of names collected, approximately 93 percent were ministers, and 7 percent were professors. Recall that those who

<sup>30</sup> In addition to the source material, this was noted by Dunlop (1992) and discussed by Lewin (2003).

<sup>31</sup> CH9/17/11, letter from Dr. Wallace.

<sup>32</sup> CH9/17/2 (p. 2).

<sup>33</sup> CH9/17/34 (p. 4).

<sup>34</sup> CH9/17/34, 'Calculations, with the principles and data ..., 1748' (p. 4).

established or were entitled to their parish and university appointments before the year 1744 could, by declaration, opt out of the scheme when it was established in March 1744. However, opting out was not available for those joining after March 1744, such as Adam Smith, who joined the University of Glasgow on 16 January 1751 as a Professor of Philosophy (logic) and then switched on 29 April 1752 to moral philosophy.<sup>35</sup> And, since the focus here is choices made upon inception, the larger sample of 1,242 was reduced to the 868 individual choices made around March 1744. Thus, the smaller sample was limited to ministers and professors who could, in theory, opt out of the scheme entirely, that is, select a zero benefit.

These 868 individuals could select one of five choices for the reversionary annuity or do nothing. They could opt out, which is coded as a zero in the data, or they could opt for a reversionary annuity for £10, £15, £20, and £25. Of this smaller sample, approximately 15 percent of the ministers and professors opted out of the scheme, and an additional 13 percent did not make any active selection and defaulted into the second class, the £15 reversionary annuity. Table 6 summarizes the *estimated* ages in early 1744 and marital status when the choices were made. In the aggregate, two-thirds of the participants were married, and one-third were single when the initial choices were made. Finally, for each age bin, the final column in the table contains the weighted average reversionary annuity selected by that group, which also includes and averages the zero benefit for those who opted out in 1744. That final column directly addressed the question of anti-selection by age.

The trend is downward sloping, echoed by Figure 7, which displays the average annuity selected on a combined basis and separated by marital status basis. To this point, a linear regression of the average annuity value (i.e. dependent variable) on the mid-point of the age bins (independent variable) results in a slope coefficient of -0.07 with a p-value of 0.0004, which is (highly) statistically significant. The intercept value, which was £20.35, also statistically significant, represents the choice of a hypothetical (fictional) minister or professor who was zero years of age when the choice was made. The regression can be interpreted as follows. Each additional year of age at the time of selection (in 1744) is predicated on reducing the average annuity selected by £0.07 from the (intercept) £20.35 baseline. In sum: *On average older participants selected lower, not higher, benefits relative to everyone else. Rather, everyone selected higher benefits. The participant didn't like or stay with the default option.*

One final point worth noting, evident from Figure 7b, is that unsurprisingly the (583) married ministers and professors selected higher benefits relative to the (285) unmarried individuals, on average, so in that sense, there was some element of anti-selection. Recall that this annuity benefits a future widow for which marriage is required. Perhaps those who were single in 1744 didn't think that far ahead. And, while Adam Smith was young and unmarried (in 1751, when he joined) and selected

<sup>35</sup> In both CH9/16/2 and CH9/4/2, Smith is listed (initially) as a Professor of Philosophy and then Moral Philosophy.

Table 6. *Reversionary annuity choices by ministers and professors in 1744*

Age bin	Married	Unmarried	Total	Average annuity
28–33	57	103	160	£ 17.38
33–38	95	41	136	£ 17.50
38–43	96	32	128	£ 17.93
43–48	86	23	109	£ 16.97
48–53	66	15	81	£ 18.83
53–58	60	9	69	£ 17.10
58–63	40	19	59	£ 16.36
63–68	33	12	45	£ 14.56
68–73	40	17	57	£ 13.25
73–78	10	14	24	£ 14.38
Total	583	285	868	£ 16.95

*Source:* Calculated based on transcribed data in Trustee' Scheme Books (CH9/4/2)

*Note:* A linear regression of the average annuity value on the mid-point of the age bins results in a slope coefficient of -0.07 with a p-value of 0.0004, which is (highly) statistically significant. The intercept value of £20.35 is also statistically significant. Residuals at 1Q of -4.84, and at 3Q of 5.088.

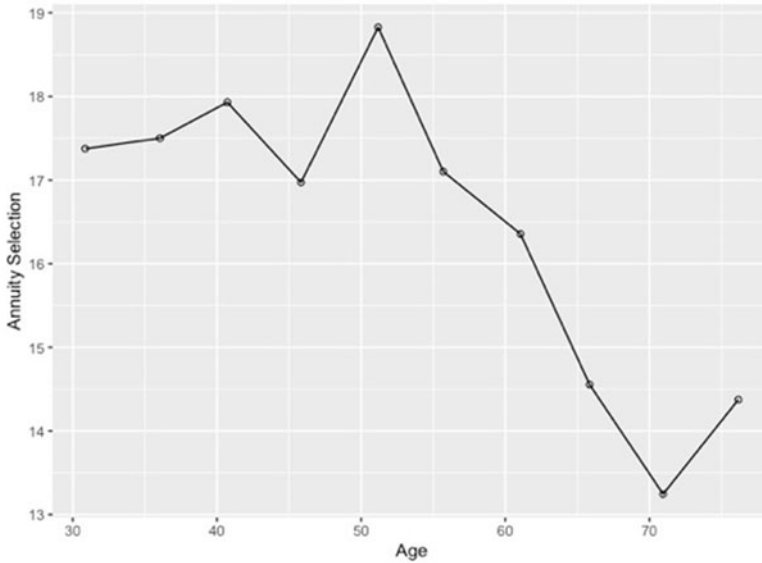
the highest benefit, he stands as a counterexample to the trend. On the same note, the negative age trend is more pronounced for unmarried participants. One is tempted to speculate that older unmarried ministers and professors selected a zero reversionary annuity and opted out of the scheme – thus driving down the weighted average benefit selected – because they faced dim prospects of (re)marriage at their advanced age or had other sources of income for their (future) spouse.

In 1744, the median age of 868 ministers and professors who had established appointments and joined the Church or University before 1744 was estimated at approximately 46. Again, we do not know exactly at what age they joined the ministry or university; only the year is noted in the archival records. This means that roughly speaking, half the group was older, and half was younger than this mid-point age. Yet, of the 127 decliners who opted out, that is 15 percent of the entire sample of 868, over 50 percent were above the age of 50 (older), and 32 percent were above the age of 60 (much older) Once again, it is difficult to reconcile this observed behavior with the claim that the older group anti-selected higher benefits.

#### *Individual choices*

The goal here is not to exhaustively enumerate the choices made by every intellectual celebrity of the Scottish Enlightenment but to highlight how the Trustees' Scheme Books provide an additional resource on the financial aspects of the lives of eighteenth-century ministers, professors and participants in the Scottish Enlightenment. [Figure 8](#) is a photograph of one of the pages containing information

(a) Age and reversionary annuity: joined prior to 1744. Weighted average of benefit selected: combined



(b) Age and reversionary annuity: joined prior to 1744. Weighted average of benefit selected: married vs. unmarried

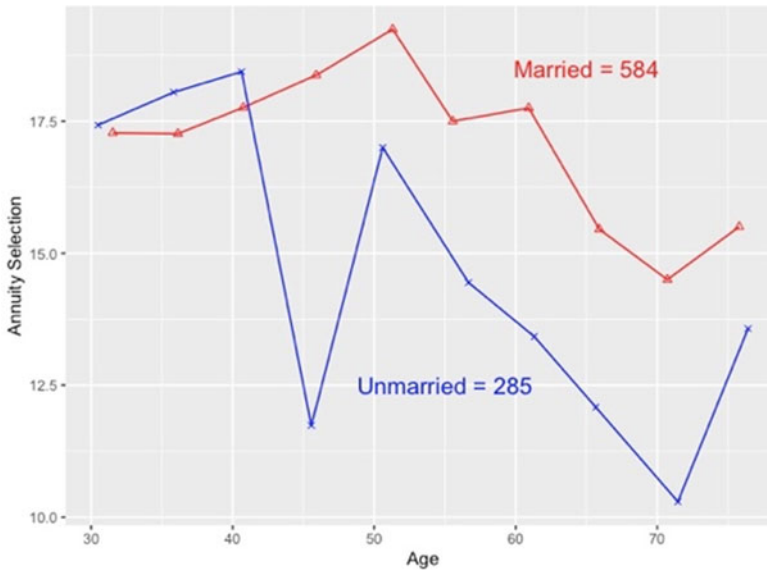


Figure 7. Did older men select higher (or lower) contribution rates?

Source: Data hand-collected by author from CH9/4/2, National Records of Scotland, reported with permission.

Figure 8. Typical page from insurance fund trustees scheme book

Source: National Records of Scotland, CH9/4/2, photographed with permission. Authorization to reproduce granted by the office of the Moderator of the Church of Scotland.

about the choices made by plan participants during 1744–55. The choice of four key and notable participants is discussed here as a micro-sample of the data.<sup>36</sup>

*Colin Maclaurin* (b. 1698, d. 1746) is listed as a Professor of Mathematics at the University of Edinburgh. *Figure 9*, which shows his name spelled as *McLaurin*, is a photograph of the relevant page in the Trustees' Scheme Books. The letter 'm' denotes marriage, and there is a similar column for every year from 1744 to 1755.

As someone incumbent before 25 March 1744, Maclaurin actively requested to join the scheme but only elected to contribute at the third annuity class, committing to pay £5.5s for a widow's reversionary annuity of £20. Perhaps his tight financial constraints forced him into the cheaper option.<sup>37</sup>

Wallace had asked Maclaurin for an opinion on the soundness of the scheme, hoping to use the famous mathematician's authority to gain approval for

<sup>36</sup> The entire list and their choices are available from the author upon request.

<sup>37</sup> Unbeknownst to him at the time of his choice, Anne Stewart (his wife) would be an early beneficiary when Maclaurin died in the aftermath of the Jacobite '45 uprising. See CH9/4/2 for information about the five young children he left behind, as well as the entry by E. L. Sageng in the *Oxford Dictionary of National Biography* (ODNB), <https://doi.org/10.1093/ref/odnb/17643>

Consisting of Offices.	And when full of Professors.	1744.	1745.
Names of Offices	Names of Professors.		
Professor of Philosophy	Robert Stewart Bar <sup>r</sup> .	m	m
Professor of Philosophy	Colin Drummond.	m	m
Professor of History	Charles Mackay	m	m
Professor of Mathematics	Colin M <sup>r</sup> MacLaurin	m	m

Contributors	of the Coll <sup>g</sup> of Edin <sup>g</sup>	of annuities
	1 <sup>st</sup> Class	2. 12. 6
	2 <sup>d</sup> Class	3. 18. 9
	3 <sup>d</sup> Class	5. 5. -
	4 <sup>th</sup> Class	6. 11. 3
	1 <sup>st</sup> or 2 <sup>d</sup> of the scheme.	
	1	2
	3	4
Notifying	76	" " " "
"	79	" " " "
Notifying	3	" " " 1
Notifying	78	" " " 1

Figure 9. Colin MacLaurin’s choice: actively selected second highest rate  
 Source: National Records of Scotland, CH9/4/2, photographed with permission. Authorization to reproduce granted by the office of the Moderator of the Church of Scotland.

the Act.<sup>38</sup> Maclaurin replied (3 June 1743) with minor suggested improvements and concerns, such as a warning that the ‘scheme was remarkably advantageous to the old’ and recommending a tax on ministers who were already married. He seemed to reference earlier smaller micro-local schemes and was able to intuit a ‘law of large numbers’ of sorts since he wrote the following in a letter to Wallace:

A greater improvement can be made of large sums and with less danger from the hazards to which all things are subjected by faithful trustees than of small annual sums by single ministers. As it is a certain rule that no single man, unless he be extremely rich, ought to deal in insurance, but rich men or companies of men only, because loss to a poor man is more sensible than an equal gain.<sup>39</sup>

Maclaurin also wrote: ‘I think myself obliged to say that the design is so good that minute objections against the absolute perfection of the scheme seem improper’,<sup>40</sup> and he petitioned to join. When discussing Maclaurin’s contributions, Olivier Bruneau (2020) writes, ‘It was thanks to Maclaurin’s mathematical treatment that this project was a success.’ And Judith Grabiner (2002) argues, ‘The success of the fund stemmed from the way Maclaurin joined mathematical modeling and empirical data ... to solve an economic problem for the church and the universities in Scotland’ (p. 152). Recall that Maclaurin died in 1746 and thus had no further involvement with the fund.<sup>41</sup> The claim that a simple equation ‘solved the problem’, while

<sup>38</sup> Dow (1975), which is reproduced in Dunlop (1992), mentions his endorsement as being important and one of the reasons the Act was passed with little objection.  
<sup>39</sup> CH9/17/16, letter from Colin MacLaurin to the Reverend Robert Wallace, 23 May 1743.  
<sup>40</sup> Ibid. See also Tanaka (2020) for more on Maclaurin’s contributions.  
<sup>41</sup> He attended a meeting of the fund trustees only once, on 13 November 1744, according to CH9/1/1.



Pro: of Philosophy	19	Adam Smith	"	"
Pro: of Orien: Languages	20	William Ruat	his heirs entitled to an annu.	"
Pro: of Medicine	21	William Cullen	"	"
Pro: of Philosophy	22	Robert Dick	"	"
Pro: of Logick	23	James Clow	his heirs entitled to an annu.	"
Pro: of Moral Philosophy	24	Adam Smith	his heirs entitled to an annu.	"

Figure 10. Adam Smith's choice: actively selected highest rate

Source: National Records of Scotland, CH9/4/2, photographed with permission. Authorization to reproduce granted by the office of the Moderator of the Church of Scotland.

ignoring the immense administrative infrastructure, might overstate the contribution of 'scientists' over 'management'.

Francis Hutcheson (b. 1694, d. 1746), Professor of Moral Philosophy at the University of Glasgow, opted out of the schemes. To those unfamiliar with Hutcheson, he was Adam Smith's ('unforgettable') professor and often called the father of the Scottish Enlightenment. He opted out of the scheme. His notice of declinature was received by the clerk in June 1744 as part of a small group who decided not to provide for wife and children, which arguably might display a certain lack of 'moral sense' unless he thought he (she) was wealthy enough without needing the annuity income. Hutcheson died on 8 August 1746, two months after Maclaurin. According to his entry in the *Oxford Dictionary for National Biography*, he left his wife a life annuity of £20 backed by lands he owned in Ballyhackmer and Longford. One could speculate that he declined to participate due to his acrimonious relationship with the Glasgow Presbytery or his extensive land holdings.<sup>42</sup> His colleagues Professor of Mathematics Robert Sim(p)son and Professor of Botany Robert Hamilton both declined to participate.<sup>43</sup> Now let us examine their (famous) student.

Adam Smith (b. 1723, d. 1790) joined the University of Glasgow as a Professor of Logic in 1751. In the Trustees' Scheme Books, he is listed (only) as a Professor of

<sup>42</sup> For Francis Hutcheson, see entry by James Moore in the ODNB, <https://doi.org/10.1093/ref:odnb/14273>

<sup>43</sup> Perhaps Robert Simpson held a grudge against Webster, whose father had prosecuted and persecuted his uncle, or perhaps 'choices' were contagious.

Philosophy with a date of admission of 16 January 1751 (the *Glasgow Courant* noted his start date as 7 January 1751). Smith is then listed as having transferred on 29 April 1752 to become a Professor of Moral Philosophy, which he remained from 1752 to late 1763 or early 1764. By February of 1764, he was in Paris.<sup>44</sup> Smith (in 1751/2) made an active decision – that is, he sent in an official notice – to participate in the scheme at the highest possible contribution rate. Again, Smith committed to contributing £6.11s.3d for life, and [Figure 10](#) displays his choices in the scheme books. Whether he paid those contributions – or defaulted on his non-default – will be addressed in the conclusion.<sup>45</sup>

Now, Smith's active choice itself is rather interesting. At 28, he selected the largest possible annuity for a (yet) non-existent wife. Indeed, there has been much (frivolous) discussion about the fact that he never married.<sup>46</sup> It is difficult to reconcile innuendoes with the financial commitment he made by joining the scheme. If indeed he had no intention of ever marrying (in 1751), although he could not decline to participate in the scheme – like the 'never-to-be-forgotten' Francis Hutcheson – he could have selected the lowest possible class. Perhaps Smith's annuity choice is just a trivial financial fact, or the sum was trivial relative to his professorial income of £150 to £300 per year (Phillipson 2010, p. 182). Still, to this author's knowledge, his active participation and choices have not been noted by any of the multitudes of historians or economists who specialize in (and have picked over) all things Smith.

*Alexander Webster* (b. 1707, d. 1784) was the architect and main administrator of the scheme during its first half-century. He was elected Moderator of the General Assembly of the Church of Scotland in 1753, conducted the earliest census of Scotland in 1755, and became general collector of the scheme in 1771.<sup>47</sup> Webster was also described as a Popular (and popular) Evangelical preacher. It is noted about his Sunday sermons that: 'it's easier to get into the kingdom of heaven than a seat in Tolbooth church' (Mackie 1956; Mackie lavishes praise on Webster and describes how the scheme was copied by Presbyterians in Philadelphia c. 1761). He enjoyed a sociable lifestyle, and many sources call him a prodigious drinker who could hold his liquor (or claret) better than any. The diary of Alexander Carlyle, who had run-ins with Webster, nicknamed him 'Dr. Bonum Magnum', calling him a 'Proteus-like character' and 'extremely pernicious' (p. 1751 of Alexander Carlyle's autobiography, cited as Carlyle 1910). Webster selected the highest class

<sup>44</sup> See Mossner and Ross (1987) for a detailed chronology.

<sup>45</sup> Note the reference to Philosophy (top) and then Moral Philosophy (bottom), but not Logic. It is worth noting that William Cullen, whom Nicholas Phillipson (2010) called 'Smith's main informant on University matters', also selected the highest class. But Smith's competitor for the position at Glasgow, George Muirhead, selected the lower third class. One can go on and on like this.

<sup>46</sup> For Adam Smith, see the entry by Donald Winch in the *ODNB*, <https://doi.org/10.1093/ref:odnb/25767>. Also, see Phillipson (2010, p. 120).

<sup>47</sup> See entry by Margaret Stewart in the *ODNB*, <https://doi.org/10.1093/ref:odnb/28939>, and Anonymous (1784, p. 61).

(fourth) and made those contributions for almost 40 years. His wife Mary Erskine (whom he married on 13 June 1737) predeceased him by 18 years when she died on 28 November 1766. So, upon his death on 25 January 1784, there was no widow's annuity to be paid to the co-architect and main administrator of the scheme for widows and orphans.<sup>48</sup>

## V

Choice architecture – how to design and position the menu of investment options in a retirement plan – must be approached with caution, especially when there's an element of insurance that could give rise to anti-selection by participants. This issue is timely (in 2023) since, for example, US policymakers are now considering allowing life annuities as qualified *defaults* in 401(k) savings plans.<sup>49</sup>

This article demonstrates that similar debates, issues and concerns arose in the eighteenth century in one of the first such schemes. The results reported herein are based on hand-collected data and choices made by over 1,250 individuals in the Ministers' Widows' Fund from records of the Church of Scotland currently housed at the National Records of Scotland (NRS) in Edinburgh. The research contribution to the (more narrow) insurance literature is that anti-selection was not as bad as the trustees had feared or suspected.

It's important to note that Adam Smith's engagement with the scheme goes beyond the serendipity of being one of the 1,250 names encountered in the archival records. Although he never explicitly commented about his purchase of a reversionary annuity, he actively selected the highest benefit level, which says something about his opinion of the scheme. It is unclear whether he bothered to compute whether it was a 'good deal' for him. However, he didn't seem to have a high opinion of 'Political Arithmetic', as he stated in a letter written in 1786 to George Chalmers (Mossner and Ross 1987, p. 288). Nevertheless, his favorable and widely quoted comments about Reverend Alexander Webster, 'Of all the men I have ever known, Alexander Webster is the most skillful in Political Arithmetic', might have helped burnish the reverend's reputation as the main architect and administrator of the fund. Indeed, early on, the credit seems to have gone to Webster, more so than to Robert Wallace, to whom later historians have attributed the heavy mathematical lifting.<sup>50</sup> Again, Adam Smith endorsed the administrative architect of the scheme, Alexander Webster, who was a 'fan' of life annuities in his writing – see quotes

<sup>48</sup> See the ODNB entry on Alexander Webster.

<sup>49</sup> See, for example, article in *InvestmentNews*, 13 June 2023, by Mark Schoeff Jr.: [www.investmentnews.com/bill-allowing-more-types-of-annuities-in-retirement-plans-tops-iris-lobbying-agenda-238709](http://www.investmentnews.com/bill-allowing-more-types-of-annuities-in-retirement-plans-tops-iris-lobbying-agenda-238709)

<sup>50</sup> Smith's quote appears in Anderson (2011) and burnished his reputation within the context of the first Scottish census. A letter dated 10 November 1785 from Adam Smith praising Alexander Webster was sent to George Chalmers (see Mossner and Ross 1987, p. 248). See also Dunlop (1992) for the Wallace vs. Webster 'credit' debate.

below – and selected the highest possible annuity, all of which might have contributed to the scheme's success and longevity.

But alas, his relationship with the scheme itself was more complex than being a mere impartial spectator. In January 1764, or possibly late 1763, Smith gave up his academic tenure at the University of Glasgow to travel to Europe as a personal tutor to the Duke of Buccleuch.<sup>51</sup> He stopped making the annual contributions of £6.11s.3d, and the November 1763 'Arrears Book', which lists participants who have reneged, notes an outstanding debt owed by Adam Smith for £6.11s.3d, plus interest of £1.4s. The 1764 book lists two missed payments of £6.11s.3d and an outstanding £30 plus interest of £2.8s. This then grows to a total debt owed by Smith to the fund of £48.2s.3d in 1766, at least three years after he left Glasgow.<sup>52</sup> It is not clear from the extant documentation for the scheme whether he paid off his debts (and it would be a gross injustice to label him a 'deadbeat'). This might be yet another sort of Adam Smith inconsistency or historical problem.<sup>53</sup>

Then, in 1767, the outstanding Smith debt was no longer mentioned in the books. Again, to put these sums into perspective, his annual salary for accompanying the Duke to Europe was £500, plus a yearly pension of £300 for life (Phillipson 2010, p. 182). He could have easily paid off the above-noted amounts. So, rather anti-climactically for this article, even if Adam Smith had married – after he resigned from the University of Glasgow – his spouse and/or children would probably not have been entitled to the reversionary annuity, to which he contributed for at least a decade. In some sense, Adam Smith's lapsation supported the plan and perhaps allowed for better pricing.

Nevertheless, the above context might shed light on some of his comments about the embedded insurance aspects of such a scheme. For example, when discussing trade associations, Smith expresses concern about the risk of possible price collusion if these associations dialogued and interacted with each other, an early concern with antitrust matters. He suggested that although laws could not be passed to ban gatherings of workers in the same trade, the law should not encourage these associations. But Smith then went on to write:

A regulation which enables those of the same trade to tax themselves in order to provide for their sick and *their widows and orphans* by giving them a common interest to manage renders such assemblies necessary. (1789/2000, p. 106)

Moving on, in chapter 3 of *Wealth of Nations*, in a section entitled 'On Public Debts', Smith devotes several pages to life annuities and whether (or not) governments that

<sup>51</sup> See Phillipson (2010), chapter 9, for a discussion of the circumstances surrounding his resignation from the University of Glasgow. His resignation letter is dated 14 February 1764 (from Paris), was sent to Thomas Miller and is reproduced in Mossner and Ross (1987, p. 101).

<sup>52</sup> Arrears Book, CH9/15/6, but inconsistent with CH9/4/2, which notes it was paid back on 27 June 1754. Perhaps a second loan was outstanding.

<sup>53</sup> For more on the 'Adam Smith Problem' and inconsistency between *The Theory of Moral Sentiments* (1759) and *Wealth of Nations*, see Montes (2003) or Poitras and Jovanovic (2010).

borrow by issuing these life-contingent instruments are paying too much income (yield) to annuitants and perhaps not charging enough. In particular, when discussing the relative benefits of borrowing via annuities paid to individuals versus annuities paid to syndicates – also called tontines – he makes the following intriguing statement about subjective mortality expectations, which is apropos to the discussion here. He suggests that governments can borrow at lower yields and cheaper rates – that is, they can raise more money for the same price – by issuing tontines to syndicates versus annuities to individual annuities. In Smith's words, the tontine syndicate 'consists of twenty of thirty persons or whom the survivors succeed to the annuities of all those who die before them and the last survivor succeeding to the annuities of the whole lot' (1789/2000, p. 716). Smith then writes: 'the confidence which every man naturally has in his good fortune, the principle upon which is founded the success of all lotteries, such an annuity sells for more than it is worth...' Smith's behavioral argument is that men are overconfident about their longevity prospects.

The Ministers' Widows' Fund was not a tontine but rather based on life annuities that would only commence after the contributor's life was over. However, one could argue it had a participatory structure in which benefits were adjusted (eventually) since the scheme did allow for reductions in the widow's annuity benefit if needed to keep the fund solvent. More to the point, Smith discusses the reason that tontines were more popular in France than in England or Scotland. He writes that Frenchmen who were lending money to the Crown were bachelors who 'have no family of their own nor much regard for their relations' and desired to live in splendor during their life and 'are not unwilling that their fortune should end with themselves' (1789/2000, p. 716). One senses Smith's disdain when he writes that 'to such people who have little or no care for posterity, nothing can be more convenient than to exchange their capital for a revenue that is to last just as long, and *no longer*, than they wish it to do' (1789/2000, p. 717). Recall that Adam Smith himself never married, yet he participated and contributed to a reversionary annuity scheme that would last much longer than his expected life. His revealed (contribution and) preference confirms the views expressed in *Wealth of Nations*. This was Adam Smith's reversionary annuity.

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### Technical appendix

This technical appendix provides a very brief overview of the *reversionary annuity* valuation process, which is standard in the actuarial literature but perhaps unfamiliar to financial historians. More detail is available in actuarial textbooks such as Promislow (2006), Milevsky (2020) or the article by Boyle (1974). The valuation process begins by defining a *net single premium* (NSP) for a standard life annuity equal to the expected discounted value of benefits adjusted for mortality. For the basic (non-reversionary) life annuity, the NSP is computed using the following expression:

$$\bar{a}(r|x) := \int_0^{\infty} p(t|x)e^{-rt} dt \quad (1)$$

On the left-hand side of equation (1), the first argument is the valuation rate (for example,  $r = 4$  percent), and the second denotes an initial age (for example,  $x = 45$ ). On the right-hand side, the integral ranges from time zero to the end of the mortality table (that is, infinity). Then, within the integrand,  $p(t|x) \leq 1$ , denotes the deterministic and known probability that a life currently age  $x$  will survive  $t$  years, and the interest factor:  $e^{-rt}$  discounts cash flows. This is the most basic asset pricing equation for insurance and can be traced to the work by Halley, noted earlier.

Using the same actuarial logic, the NSP for an immediate life annuity that continues for the greater part of *two* separate lives (for example, husband and wife) is:

$$\bar{a}(r|x, y) := \int_0^{\infty} p(t|x, y)e^{-rt} dt \quad (2)$$

The key difference between equations (1) and (2) is the survival probability  $p(t|x, y)$ , which represents a probability that either person currently aged  $x$  (for example, the husband) or person currently aged  $y$  (for example, the wife) survives for  $t$  years. The link between the joint and single is via:

$$p(t|x, y) = 1 - (1 - p(t|x))(1 - p(t|y)) \quad (3)$$

Here is a numerical example of equation (3): Assume the 30-year survival probability for a 45-year-old is  $p(30|45) = 0.185$ , an 18.5 percent chance of reaching age 75. Consider two identical individuals of the same age: The probability that any one dies before age 75 is  $(1 - 0.185)$ , an 81.5 percent chance. The probability that two such (independent) people do not reach age 75 is 0.8152, a 66.4 percent chance. The probability either one or both are alive in 30 years is one minus the probability that both are dead. This is  $(1 - 0.664)$ , a 33.5 percent chance. So,  $p(30|45, 45) = 0.335$ , using the notation of equation (3).

Next is the *reversionary annuity* factor, if a life annuity is delayed – or doesn't begin – until a future point in time, when the first or two people die. The key insight is that the annuity factor for the reversionary annuity can be thought of as the difference between two conventional annuities, one joint-life and one single. The reversionary annuity pays for the longer of two lives ( $x, y$ ) but does not pay anything while the person currently age ( $x$ ) is alive. For a mathematical proof, see any actuarial textbook (Promislow 2006, p. 141; see also Price 1770, as cited in Haberman and Sibbett 1995, III, p. 180).

Using the new symbol (hat)  $\hat{a}$  for the reversionary (i.e. delayed) annuity, versus the symbol (bar)  $\bar{a}$ , for the immediate annuity leads to:

$$\hat{a}(r|x, y) = \bar{a}(r|x, y) - \bar{a}(r|x) \quad (4a)$$

Again, the above is the difference between the joint life annuity and the single life annuity. The equation applies only if the entire premium is paid *upfront* in one lump sum. To arrive at the *periodic* contribution, equation (4a) must be amortized over the life of the contributor. And, given the mandated nature of contributions, the denominator is a simple life annuity and not one that is extinguished at either the first of two deaths or the last of two deaths. Finally, to convert to a benefit multiple, one computes the inverse of the net periodic premium.

$$\text{Multiple} = \frac{\bar{a}(r|x)}{\bar{a}(r|x, y) - \bar{a}(r|x)} \quad (4b)$$

To be clear, the above is the fair actuarial multiple. And the argument in the body of the paper that the scheme failed to charge most participants enough to cover the 3.81 benefit multiple is based on equation (4b). The only step missing before one can provide actual values for the correct or proper multiple, is to

calibrate  $p(t|x)$ . This was done via a linear approximation to the (log) hazard rates from the Halley (1693) tables. The smoothing process is known as a Gompertz–Makeham approximation to mortality rates:<sup>54</sup>

$$\ln [p(t|x)] := -\lambda t + (1 - e^{t/b})e^{\left(\frac{x-m}{b}\right)} \quad (5)$$

In the above equation, there are three (new) parameters. The first ( $\lambda$ ) is the accidental death rate, the second ( $m$ ) is the modal value of life – which is the age at which the person is most likely to die – and the third parameter ( $b$ ) is a dispersion value in years. One can think of this as a standard deviation of life (at birth.) The best-fitting parameters to the Halley mortality table – which is used to value the annuities offered to the ministers and professors – were an accidental mortality rate of  $\lambda = 0.01045$ , and biological parameters of  $m = 68.05$ ,  $b = 14.98$ , in years. Admittedly, these differ from typical parameters, closer to 80 and 10, used in the twenty-first century. Again, the point here is to estimate what each minister or professor should have paid had the reversionary annuities been fairly and properly priced by age, using the technology available in the 1740s. Recall Edmond Halley had already figured out how to value annuities as a function of age, and the scheme's documentation referred to his mortality tables. However, the plan designers assumed that everyone entering the plan was of the same age, which might explain why the dispersion of ages was ignored.

<sup>54</sup> The author is aware that Gompertz was born in 1779, a century after Halley. The point is to obtain a continuous and parsimonious curve for mortality. See Bell and Sutcliffe (2010), who use similar techniques to value historical annuities. For calibration of the Gompertz–Makeham model, see Milevsky (2020). For more on Halley's life table, see 'Edmond Halley's life table and its uses' in Ciecka (2008), as well as 'A new look at Halley's life table' in Bellhouse (2011).