modelling on the market field of life insurance and the epistemic field of actuarial science? This is the question I turn to in the next section.

Living in a stochastic world?

Most unit-linked insurance funds were heavily invested in equities and real estate. With the stock market slump of 1973–74, therefore, the riskiness of maturity guarantees suddenly appeared very real. Insurers that had sold 'guaranteed income bonds' got into significant trouble. The collapse of Nation Life, a mid-sized company, contributed to increasing public pressure on the actuarial profession to deal with the riskiness of guarantees. In an article entitled 'The Men Who Decide What Your Life Assurance Is Worth Should Wise Up', *The Economist* (1974, p 86), for instance, cited the 'absence of an actuarial code of practice' as an 'important reason why these companies boomed and bust'. Actuaries from the Government Actuary's Department, which carried out supervisory tasks on behalf of the Department of Trade and Industry, also started taking an active interest in the controversy, attending, for instance, the sessional meetings at which the issue of maturity guarantees were discussed. At one such meeting, at which Corby's paper was discussed, the Government Actuary Edward Johnston noted "that there is no general agreement on the mechanical models which should be used for assessing … reserves". Although he did not perceive active government interference with the substance of the debate as appropriate ("I am certainly not going to venture any opinion on which mathematical model is right"), he did emphasize the need for "a practical answer … because companies do have to set up reserves of some size or other" (Johnston in Corby, 1977, p 284). By emphasizing the systemic impact of maturity guarantees, moreover, Wilkie also sought to enrol actuaries at non-linked offices. At one of the debates, for instance, he estimated that roughly £2,000 million worth of maturity guarantees had been written and that companies were 'short of around £1,000 million of reserves'. The maturity guarantees that had already been written, he continued to argue, therefore posed a 'practical problem' for the 'Department of Trade' as well as for 'other life assurance companies because … they are going to foot the bill when the companies writing this business - if they go bust - do go bust. So it is up to all life offices as well to think about how it should be done' (Wilkie in Corby, 1977, p 412).

Such pressures undoubtedly contributed to generating acceptance of the results produced by the Maturity Guarantees Working Party's modelling exercises. Maturity guarantees on unit-linked contracts were increasingly perceived as rather costly, and the volume of such policies quickly diminished. Although it is likely that the working party's model contributed to this perception among actuaries, it is less clear to what extent it also influenced decision making at the level of corporate management. Wilkie suspects, for

instance, that the decisive moment for the decline of maturity guarantees was not the publication of the working party's report itself but would come later when Standard Life – Wilkie's employer after he left Scottish Widows – declined to participate in the underwriting of one of the major unit-linked offices founded by Weinberg, Hambro Life. At the time, Wilkie noted, it was common practice for institutional investors to take small stakes in a company when it could not sell all its shares to the public. When Standard Life's investment manager asked Wilkie for his opinion on Hambro Life, he replied: ' "I think we shouldn't touch it", because Hambro had a lot of this [maturity guarantee] business, I knew that it was risky.' Wilkie suspects that 'since it was Standard Life' - a leading Scottish life office - 'those in the market thought that there might be something serious about it – one insurer not being sure about another' (Wilkie in personal communication).

Yet, even if the results produced by this modelling were accepted as legitimate, this did not necessarily imply that stochastic modelling had become part of actuarial expertise and had a major impact on the market field of life insurance. Most actuaries, after all, remained unfamiliar with risk theory and stochastic simulation modelling, and usage of the working party's model by company actuaries remained limited. Of the 22 companies whose regulatory returns the working party member Ben Rowe had seen in late 1980 – ten months after initial publication of the working party's report – only two companies had used the working party's model (Rowe in Benjamin et al, 1980). Many actuaries appeared to have been concerned with the limited practicality of the model - for instance because they had insufficient familiarity with programming or the model's underlying mathematics so that they could adjust it to the specific characteristics of different portfolios - and preferred some deterministic approximation of the model over the stochastic one.

So how, then, did the controversy over financial risk influence the epistemic field of actuarial science? First, a small group of actuaries continued doing research on stochastic simulation modelling of investment returns. Most notable, in this regard, was Wilkie himself, who continued to refine the working party's model in subsequent years (Wilkie, 1984, 1995) and developed what became known as the 'Wilkie model'. Although it is difficult to assess how widely the model was used in corporate decision making, interviews indicate that most life offices used the Wilkie model, or some alternative specification thereof, to get some "insight into how bad things might get" (Interviewee EA). What facilitated the model's uptake was that it was specifically designed for long-term actuarial applications, 'was relatively easy to apply - it could be coded into a spreadsheet' and was 'consistent' with the 'prior belief' that stock markets follow a mean-reverting process (Jakhria et al, 2019). In the 1990s, Wilkie's model was increasingly scrutinized within the profession (see, for example, Geoghegan et al, 1992;

Huber, 1997), and some practitioners developed alternative stochastic asset models (for example Yakoubov et al, 1999), which indicates widespread interest in stochastic asset models. Worries about the implications for actuarial judgement, however, remained. One of the working party reports on the Wilkie model noted for instance that a central topic of debate had been 'the extent to which "actuarial judgement" might comfortably override purely theoretical and statistical considerations' (Geoghegan et al, 1992, p 185). Usage of and familiarity with stochastic investment models thus significantly expanded throughout the 1980s and '90s, even if the extent to which it informed and constrained decision making seems to have been limited for most companies.

Second, with the report of the Maturity Guarantees Working Party, stochastic simulation modelling made inroads into the educational syllabus of the actuarial profession too. Initially, the report was listed as recommended reading under the chapter on the practice of life insurance funds, which in the latter half of the 1980s was replaced by an entry into the syllabus on stochastic methods. These were minimal changes in the structure of actuarial education, but they nonetheless had an impact as interview evidence indicates, because some of the newly trained actuaries had at least some basic familiarity with the concept of stochastic simulation modelling. More substantial reforms of the educational syllabus, however, came only towards the end of the 1990s, when stochastic modelling, financial mathematics, financial economics and an optional specialist certificate in derivatives were taught as distinct subjects.

Third, the now widely held belief that maturity guarantees on unit-linked funds invested in equities were expensive pushed actuaries to think about the relation between investment strategy and the riskiness of guarantees, which built on some early notable works in this regard and anticipated later developments in asset-liability modelling. Particularly noteworthy in this regard is a paper by the Irish actuary Colm Fagan (1977), who maintained close relationships with British colleagues, and who suggested that it was possible to adopt an investment strategy that would 'immunize' the risk embedded in the maturity guarantees. Fagan's approach, which some later argued replicated the option pricing theory developed by the financial economists Black, Scholes and Merton, was examined by the Maturity Guarantees Working Party too. Although the working party concluded that Fagan's immunization strategy 'does seem to have serious practical disadvantages because it depends upon several underlying assumptions', it also noted that it 'merits further investigation' (Ford et al, 1980, p 112). Fagan's immunization approach and option pricing remained a marginal topic in actuarial science, but actuaries like Wilkie nevertheless started to consider their potential actuarial applications in the years that followed (see, for example, Wilkie, 1987).