Charles Babbage and the Assurance of Lives

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In 1824 Charles Babbage was appointed actuary of the Protector Life Assurance Society of London, which led him to prepare a new set of life tables and undertake a study of the life insurance industry. He subsequently wrote his well-known book the Assurance of Lives *(1826).[1] This article describes the role of Charles Babbage in the development of life insurance and the reform of the life insurance industry, and the significance of the* Assurance of Lives *in his intellectual development.*

During his lifetime, Charles Babbage (1791-1871) was a well-known scientific figure, but after his death he was largely forgotten for 80 years. He rose to prominence again in the early 1950s as a result of the remarkable extent to which his Analytical Engine had anticipated the modern computer. Almost as if making up for the decades of neglect, there was at first a considerable critical overreaction and an exaggeration of almost all of Babbage's other accomplishments. However, during the 1970s and 1980s there has been a steady reappraisal of his work, and we are gradually getting a better measure of his achievements — for example, as a mathematician, as a table-maker, as an economist, and as a cryptographer.[2-5] While Babbage made several major contributions to knowledge, notably in computing machinery, mathematics, and economics, many of his other contributions — including life insurance — can be fairly described, if not as second rate, then certainly of the second rank. (For a fuller discussion of Babbage's published output, see Vol. 1 of the *Works of Babbage*.[6])

Prior to his involvement in life insurance, Babbage's background had been largely mathematical and academic. He had graduated from Cambridge in 1814 and had married and settled down in London the following year. With an income that Babbage estimated at £450 a year, made up of an allowance from his father and his wife's own income, he was able to live the life of an amateur gentleman of science.[7] He was elected to the Royal Society for his mathematical researches in 1816, and in 1822 he achieved major scientific stature by his proposal for a Difference Engine for calculating and printing mathematical tables. The construction of the Difference Engine was to be his principal occupation for the next decade, so his interest in life insurance was a diversion that occupied only a fraction of his time during 1824 and 1825.

In 1824 or a little earlier, Babbage was asked to become the actuary of a soon-to-be-promoted joint-stock company, the Protector Life Assurance Society of London. He recorded in his autobiography:

> The proposition made to me was that I should have the entire management of the concern as director and actuary, with a salary of £1500 a year, and apartments in the establishment, with liberty to practise as an actuary.
>
> On consulting my friend the late Francis Baily, F.R.S., who had himself practised as an actuary, he strongly advised me to accept the office. He assured me that the profit arising from private practice could scarcely be less than £1000 a year, and would probably be much more.[8]

For Babbage, now in his early thirties and with growing family commitments, the prospect of a total income in excess of £2500 a year was a golden opportunity.

To set the Protector in context, the period from 1823 to 1825 was one of wild financial speculation, during which many life insurance companies were floated, more than doubling the total number of British life offices to over 50. Actuaries for the rash of newly promoted insurance enterprises from 1823 to 1825 were in very short supply. There were not more than a dozen first-rank actuaries in Britain in the early 1820s, and most of them were already engaged with established insurance companies. For example, William Morgan FRS was actuary of the Equitable Society, William Frend was with the Rock, Joshua Milne FRS was with the Sun, and H.J. Brooke FRS was with London Life. The shortage of established actuaries opened up opportunities for a new generation to embark on actuarial careers. Besides Babbage, others setting out as actuaries in this period included Benjamin Gompertz FRS (1779-1865), actuary of the Alliance Assurance Company;[9] Griffith Davies (1788-1855), actuary of the Guardian;[10] and Thomas Young FRS (1773-1829), who became actuary and physician of the Palladium.[11]

The early development of life insurance

Babbage began his actuarial studies — as with almost all his intellectual endeavors — by reading around the subject.

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Babbage and Life Assurance

Even in Babbage's time the subject of life insurance was well documented and accessible to any well-informed person through encyclopedias and magazine articles as well as specialized monographs.* Babbage also had access to knowledge on insurance through his friendships with Francis Maseres, who had published actuarial works, and Charles Hutton, who had compiled a number of entries on insurance topics in his *Mathematical and Philosophical Dictionary*.[12] Another of Babbage's friends, Francis Baily FRS (1774-1844), was a still better source of information. Besides having practiced as an actuary, Baily was the author of the *Doctrine of Life Annuities and Assurances* (1810), which Babbage used as his principal reference.[13] Baily, who was aged 50 in 1824, was a remarkable man who had made his fortune as an actuary and stockbroker but whose passion was astronomy. He had a great generosity of spirit and had taken something of a paternal interest in Babbage. He had helped publicize the Difference Engine, and Babbage regularly turned to him for advice on a variety of subjects. In 1820 they had both been among the founders of the Astronomical Society.

In the eighteenth century, the life insurance industry had been largely a British phenomenon and a small one at that. The first significant organization to offer life insurance was the Amicable Life Assurance Company in 1706, and the second was the Royal Exchange Assurance Company in 1720. These early companies did not operate on any proper actuarial basis, being "dependent more on rough and ready guesses than life-tables."[14] The first life insurance company to make use of sound actuarial methods, with level annual premiums related to the age of the insured, was the Equitable Life Assurance Society, formed in 1762.[15]

In 1774 William Morgan FRS (1750-1833) joined the Equitable as assistant actuary and then became actuary. Morgan was the nephew of the Reverend Richard Price FRS (1723-1791), the well-known economist and political writer, who had produced a mortality table for the Equitable based on the parish register of Northampton in 1780.[16] Morgan adopted the Northampton mortality table for the Equitable and used it to prepare new life tables, which started to be used in 1781. The adoption of a proper actuarial table by the Equitable was a turning point for British life insurance, which encouraged new competitors into the industry, particularly during the early nineteenth century. By 1810 there were more than a dozen life offices in existence.

An acknowledged defect of the life insurance industry at this time was its reliance on the Northampton mortality table. Because it was based on the mortality of the general population, it underestimated the longevity of the insurance-buying middle classes. This worked to the advantage of the insurance companies, to the extent of about 30 percent of the premium charged, and enabled them to build up substantial surpluses. In most companies, some or all of these surpluses were eventually returned to the policyholders in the form of bonuses. On the other hand, in 1808 the British government had launched an annuity scheme based on the same Northampton mortality table, but because people lived longer than the table indicated, the government lost £2 to £3 million before new tables were produced in 1828. (Incidentally, Babbage later cited this particular instance in his book the *Decline of Science* (p. 25) as an example of an economic loss arising from inadequate actuarial tables in order to bolster the case for government support of science.[17])

In 1815 Joshua Milne, actuary of the Sun Life Assurance Company, used mortality data for the town of Carlisle to produce a new set of life tables for his company. In life tables derived from the Carlisle mortality table, the premiums were more attractive (i.e., cheaper) for young lives, while older lives were charged more realistically. This is illustrated in Figure 1 — taken from Babbage's *Assurance of Lives* — which shows the rates charged by a number of the companies he studied in 1824.[1] Thus a member of the Sun aged 30 would pay an annual premium of £2 9s 2d for a sum assured of £100, which was about four shillings less than with the Equitable; but a 55-year-old member would pay over 13 shillings more with the Sun than with the Equitable. (No distinction was made between male and female lives at this time.)

Although the Carlisle mortality table produced better life tables, these still conformed to the general population rather than to the insured population. Thus, at the time that Babbage became involved in life insurance, the outstanding technical problem in actuarial practice was to produce tables that accurately reflected the mortality experience of the insured classes.

Babbage's life tables

What prevented the computation of life tables based on the insured population instead of the general population was the lack of available data. What Babbage and the other actuaries of the 1820s needed was access to the mortality statistics of an actual life insurance company. The nearest they could get to this was some information given by William Morgan in his "Address to the Equitable Society of April 1800" (which was effectively a general report on the progress of the Equitable Society under his management). In his address, Morgan gave a rough-and-ready comparison of the Equitable's mortality experience over a period of 30 years, compared with the expected deaths from the Northampton table:

From the age of	10 to 20	they have been as	1 to 2
do.	20 - 30	do.	1 - 2
do.	30 - 40	do.	3 - 5
do.	40 - 50	do.	3 - 5
do.	50 - 60	do.	5 - 7
do.	60 - 80	do.	4 - 5

By this statement it appears that in every period the probabilities of life are higher in the society, or, which is the same thing, the number of deaths is less than

*In Britain "life insurance" is commonly known by the synonymous term "life assurance" to distinguish it from marine and fire insurance. In the United States the term "life insurance" is invariably used.

those in the table which is made the foundation of its whole practice, and that at all ages taken together, these probabilities are in the ratio of three to two. The society, therefore, for the last thirty years, has only paid two claims, where the tables supposed that three would become due.[18]

On the basis of this statement, and nothing more, Babbage proceeded to adjust the Northampton mortality table so as to represent the mortality of the population insured by the Equitable Society. As the data given by Morgan was rather coarse, Babbage used the Carlisle and other mortality tables to smooth and annualize the data. From this revised mortality table Babbage then proceeded to compute a new set of life tables. The calculations of premium rates were all based on well-known formulas that Babbage took directly from an appendix in Baily's *Doctrine*, and which he reprinted in his own book. Figure 1 shows, under the column headed "Equitable Experience, increased 30 perCent," the whole-life table that Babbage derived from the Equitable data, which he intended to use for the Protector.

The computation of the tables was fairly straightforward, and in the *Assurance of Lives* Babbage published a total of 21 pages of tables. Altogether, the tables would have required on the order of 10,000 multiplications (which would have been accomplished with logarithms). In the *Assurance of Lives* (p. xiii) Babbage wrote:

> Most of the tables were computed originally by two independent calculators, when unfortunately both copies were lost together: I have since caused them to be recalculated, some of them again twice over, and I hope they will be found correct.[1]

Table III.

PREMIUMS FOR WHOLE LIFE.

Ages.	Alliance and Sun.			Amicable.			British Commercial.			Crown.			Economic			Equitable.			Equitable Experience, increased 30 perCent			European.			Guardian.			London Assurance Bircham Lane.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
0 to 14				1	14	6	1	9	0	1	14	10				1	17	7	1	12	8				1	15	3	1	15	8
15	1	12	8	1	15	6	1	10	0	1	15	9	1	9	1	1	18	7	1	13	6	1	13	7	1	16	2	1	16	8
16	1	13	6	1	16	6	1	11	0	1	16	7	1	9	10	1	19	8	1	14	5	1	14	5	1	17	2	1	17	9
17	1	14	3	1	17	6	1	12	0	1	17	5	1	10	7	2	0	8	1	15	4	1	15	4	1	18	2	1	18	9
18	1	15	1	1	18	6	1	13	0	1	18	3	1	11	4	2	1	3	1	16	4	1	16	2	1	19	2	1	19	8
19	1	16	0	1	19	6	1	14	0	1	19	1	1	12	2	2	2	2	1	17	4	1	17	1	2	0	1	2	0	7
20	1	16	11	2	0	6	1	15	0	1	19	11	1	13	0	2	2	7	1	18	4	1	18	1	2	1	0	2	1	4
21	1	17	11	2	1	6	1	16	0	2	0	10	1	13	10	2	4	6	1	19	5	1	19	0	2	1	10	2	2	2
22	1	18	11	2	2	6	1	17	0	2	1	9	1	14	9	2	5	4	2	0	6	1	19	11	2	2	8	2	3	0
23	2	0	1	2	3	6	1	18	0	2	2	5	1	15	9	2	6	3	2	1	8	2	0	10	2	3	6	2	3	11
24	2	1	3	2	4	6	1	19	0	2	3	9	1	16	10	2	7	1	2	2	9	2	1	10	2	4	5	2	4	8
25	2	2	6	2	5	6	2	0	0	2	4	10	1	17	11	2	8	1	2	3	11	2	2	9	2	5	4	2	5	7
26	2	3	9	2	6	6	2	1	0	2	5	10	1	19	1	2	9	1	2	5	1	2	3	9	2	6	4	2	6	6
27	2	5	2	2	7	6	2	2	0	2	6	11	2	0	4	2	10	1	2	6	4	2	4	10	2	7	4	2	7	6
28	2	6	7	2	8	6	2	3	0	2	8	1	2	1	7	2	11	1	2	7	6	2	5	10	2	8	4	2	8	6
29	2	7	11	2	9	6	2	4	0	2	9	2	2	2	9	2	12	3	2	8	3	2	6	11	2	9	6	2	9	8
30	2	9	2	2	10	6	2	5	0	2	10	4	2	3	11	2	13	5	2	10	1	2	8	1	2	10	7	2	10	7
31	2	10	6	2	11	6	2	6	0	2	11	6	2	5	1	2	14	7	2	11	5	2	9	3	2	11	10	2	11	9
32	2	11	10	2	12	6	2	7	0	2	12	9	2	6	3	2	15	9	2	12	10	2	10	6	2	13	0	2	13	6
33	2	13	4	2	14	0	2	8	0	2	14	0	2	7	7	2	17	1	2	14	4	2	11	10	2	14	4	2	14	2
34	2	14	11	2	15	6	2	9	6	2	15	4	2	9	0	2	18	5	2	15	3	2	13	2	2	15	8	2	15	7
35	2	16	8	2	17	0	2	11	0	2	16	9	2	10	7	2	19	10	2	17	4	2	14	7	2	17	0	2	16	9
36	2	18	5	2	18	6	2	13	6	2	18	2	2	12	2	3	1	4	2	18	11	2	16	0	2	18	6	2	18	2
37	3	0	4	3	0	0	2	15	0	2	19	10	2	13	10	3	2	10	3	0	6	2	17	6	3	0	0	2	19	8
38	3	2	4	3	1	6	2	16	6	3	1	2	2	15	8	3	4	6	3	2	3	2	19	1	3	1	7	3	1	3
39	3	4	5	3	3	0	2	18	0	3	2	10	2	17	6	3	6	2	3	4	1	3	0	9	3	3	3	3	3	9
40	3	6	6	3	5	0	3	0	0	3	4	7	2	19	4	3	7	11	3	6	0	3	2	6	3	5	0	3	4	7
41	3	8	7	3	7	0	3	2	0	3	6	5	3	1	3	3	9	9	3	8	0	3	4	3	3	6	3	3	8	6
42	3	10	9	3	9	0	3	4	0	3	8	4	3	3	2	3	11	8	3	10	2	3	6	3	3	8	8	3	10	6
43	3	12	11	3	11	0	3	6	0	3	10	6	3	5	1	3	13	8	3	12	6	3	8	3	3	10	8	3	12	6
44	3	15	3	3	13	0	3	8	0	3	12	3	3	7	2	3	15	9	3	14	11	3	10	5	3	12	8	3	13	11
45	3	17	9	3	15	0	3	10	0	3	15	0	3	9	4	3	17	11	3	17	7	3	12	7	3	14	11	3	16	1
46	4	0	5	3	17	6	3	12	0	3	17	6	3	11	9	4	0	2	4	0	4	3	15	0	3	17	3	3	18	3
47	4	3	3	4	0	0	3	14	6	4	0	1	3	14	4	4	2	7	4	3	2	3	17	5	3	19	3	4	0	5
48	4	6	6	4	2	6	3	17	0	4	2	11	3	17	3	4	5	1	4	6	1	4	0	0	4	2	4	4	2	10
49	4	10	2	4	5	0	3	19	6	4	5	10	4	0	6	4	7	10	4	9	2	4	2	8	4	5	1	4	5	6
50	4	14	2	4	8	0	4	6	0	4	8	11	4	4	1	4	10	8	4	12	3	4	5	6	4	8	0	4	8	6
51	4	18	9	4	11	0	4	10	0	4	12	1	4	8	1	4	13	6	4	15	0	4	8	6	4	11	0	4	13	6
52	5	3	6	4	14	0	4	13	2	4	15	3	4	12	5	4	16	5	4	18	11	4	11	7	4	14	2	4	16	6
53	5	8	7	4	17	0	4	15	6	4	18	6	4	17	0	4	19	7	5	2	5	4	15	0	4	17	5	4	19	6
54	5	14	1	5	0	0	5	1	0	5	1	11	5	1	10	5	2	10	5	6	1	4	18	7	5	0	11	5	2	9
55	5	19	11	5	3	6	5	5	0	5	5	7	5	7	1	5	6	4	5	9	11	5	2	6	5	4	8	5	6	3
56	6	6	4	5	7	6	5	9	6	5	9	6	5	12	9	5	10	1	5	13	11	5	6	8	5	8	7	5	10	0
57	6	13	2	5	11	6	5	13	2	5	13	6	5	18	11	5	14	0	5	18	0	5	11	2	5	12	10	5	14	0
58	7	0	5	5	15	6	5	17	3	5	18	0	6	5	4	5	18	2	6	2	4	5	15	8	5	17	4	5	18	3
59	7	7	9	6	0	0	6	2	0	6	2	4	6	11	10	6	2	8	6	6	10	6	0	7	6	2	2	6	2	9
60	7	14	11	6	5	0	6	7	4	6	7	2	6	18	4	6	7	4	6	11	8	6	5	8	6	7	2	6	7	3
61				6	10	0										6	12	4	6	16	9	6	11	1						
62				6	15	6										6	17	9	7	2	2									
63				7	1	0										7	3	7	7	8	1									
64				7	7	6										7	9	10	7	14	4									
65				7	14	6										7	16	9	8	1	1									
66				8	2	0										8	4	1	8	8	4									
67				8	10	0										8	12	1	8	16	9									
68				8	19	6													9	4	9									
69				9	9	0													9	14	2									
70				9	19	6													10	4	4									

Figure 1. Comparative annual premiums per £100 for whole-life insurance (Babbage, *Assurance of Lives*,[1] Appendix, Table 3).

The loss of the tables must have been a considerable setback. In a more colorful account, Babbage explained the circumstances to John Herschel in a letter dated September 14, 1824:

> I went on a visit to [William] Fitton who had taken a house at the Isle of Wight... I had taken with me a quantity of mss Annuity tables and notes...to make a small book on Life Assurance; a boat in which these were sent a few miles along the coast whilst we went by

land was sunk. One of the men drowned and my trunk and Fitton's irrecoverable — I had nearly a hundred pounds of property besides included in the same trunk and all the notes of the freshwater formations we had seen. I think my run of luck must now turn and have some idea of buying a ticket in the next lottery."[19]

As well as Babbage, both Benjamin Gompertz and Griffith Davies used Morgan's statement to produce new sets of life tables. All three made their computations from 1823 to 1824. Davies used essentially the same technique as Babbage, although with somewhat more careful smoothing of the data, so that Babbage was forced to admit, "I should say that his [tables] are better than mine, though not so very much better as to induce me, in our present state of the knowledge of facts, to calculate them afresh."[18] Gompertz adopted a more original approach, in which he assumed that life expectancy decreased in a regular manner with the increase of age; this later became known as Gompertz' Law of Human Mortality, and it enabled a mathematical approximation to be used to compute life tables.[21,22] As Babbage noted in the *Assurance of Lives* (p. 161), Gompertz' table was rather better than his own: "from the circumstance of its being deduced from an algebraical formula, it is, perhaps, a little more uniform in its decrements."[1]

Interestingly, Babbage had himself toyed with the idea of an algebraic law of mortality, which he had communicated to Francis Baily in 1823 but never published. Babbage's law of mortality was

$$l_x = 6199.8 - 9.29x - 1.5767\,\frac{x(x-1)}{2}$$

where l_x is the number of people living at the beginning of year x.[23] This particular form of equation (a degree-2 polynomial) would have been ideal for tabulation on the Difference Engine. However, Babbage's law was an approximation of the Swedish mortality table, which — like the Northampton and Carlisle tables — reflected the general and not the insured population. Why Babbage dropped this approach when using the data from the Equitable experience is unknown.

It is interesting that none of the three — Babbage, Gompertz, or Davies — used their life tables to make premiums more competitive in the companies for which they served as actuaries. Although in the *Assurance of Lives* Babbage was critical of the high premiums prevailing in the industry and the lack of transparency of the bonus system that was used to return the surpluses to policyholders, when it came to the Protector Life Assurance Society, he raised his own premiums 30 percent to align them with those of the competition.

The rise and fall of the Protector

Very little is known in detail about the Protector Life Assurance Society because the surviving documentation is fragmentary in the extreme — consisting of the original prospectus,[24] a few advertisements, and some oblique references in Babbage's correspondence. The Protector, however, was one of many insurance companies formed during the speculative boom of 1823 to 1825, and this enables us at least to set it in its economic and historical context.

The first 20 years of the nineteenth century had seen the British economy in a generally stagnant state. A severe depression in the years 1819 to 1821 was followed by a recovery in 1823 and 1824, which rapidly became a speculative boom following the removal of restrictions on joint-stock trading. A financial crash and a banking crisis followed at the end of 1825. An estimated 29 life offices were promoted from 1823 to 1825, of which about one-third had ceased trading within five years.[25] The Protector was one of these. The barriers to entry into the life insurance industry were quite low at this time, since to start up a life office one effectively needed only a number of well-heeled directors, an actuary and manager to direct the business, and a small city office to accommodate the handful of clerks needed to run it. Although the nominal capital of an insurance company was high, paid-up capitals were typically only 10 percent of nominal. Most of that money was tied up in risk-free government bonds simply to guarantee the actuarial risk.

Although the Protector was promoted during the speculative boom of 1823 to 1825, it was not itself in the least speculative, but was a serious and substantial venture. Its nominal capital of £3 million immediately made it the second-ranking proprietary British insurance company in terms of capitalization, exceeded only by the Alliance Assurance Company established the same year with a nominal capital of £5 million. The other major companies launched in the insurance boom included the Crown (capital £1.5 million), the Palladium (£2 million), and Law Life (£1 million). Of these companies, the Alliance (actuary Benjamin Gompertz), the Palladium (Thomas Young), and Law Life (George Kirkpatrick) became highly successful insurance companies and — transformed by takeovers and mergers — are still in existence. The Protector had a prospect every bit as auspicious as these companies.

The Protector had a distinguished, twenty-five-strong board of directors. The directors included Sir Alexander Crichton FRS and Peter M. Roget FRS as medical consultants; the bankers Francis Gore Currie and George Raikes; several people associated with the East India Company; a total of five MPs and four fellows of the Royal Society; and two major generals and two rear admirals. There was also a sprinkling of the nobility including, as president, the third marquis of Lansdowne, a former chancellor of the exchequer; and as a vice president, Lord Abercromby, later Master of the Rolls.*

* The complete list of the Protector's directors as given in the prospectus is as follows: President: Marquis of Lansdowne (1780-1863); Vice Presidents: Lord Edward Somerset MP (1776-1842), James Abercromby MP (1776-1858), Rear Admiral Sir John Gore (1772-1836), Stephen R. Lushington MP (1782-1878); Directors: Charles Babbage FRS, Robert Campbell (1798-1857), Rear Admiral Sir Edward Codrington (1770-1851), Henry Thomas Colebrooke FRS (1765-1837), Sir Alexander Crichton MD, FRS (1763-1856), Francis Gore Currie, Thomas Curtis, Richard H. Davis MP, John Harvey, Nathaniel Hibbert, George Jackson, Major General Sir Edward Kerrison MP (1774-1853), Capt. William Leader Maberly MP (1798-1885), George T. Nicholson, Alexander L. Prevost, George Raikes, George Ranking, Peter Mark Roget MD, FRS (1779-1869), James Scott MP, Major General Sir Henry Torrens (1779-1828).[24]

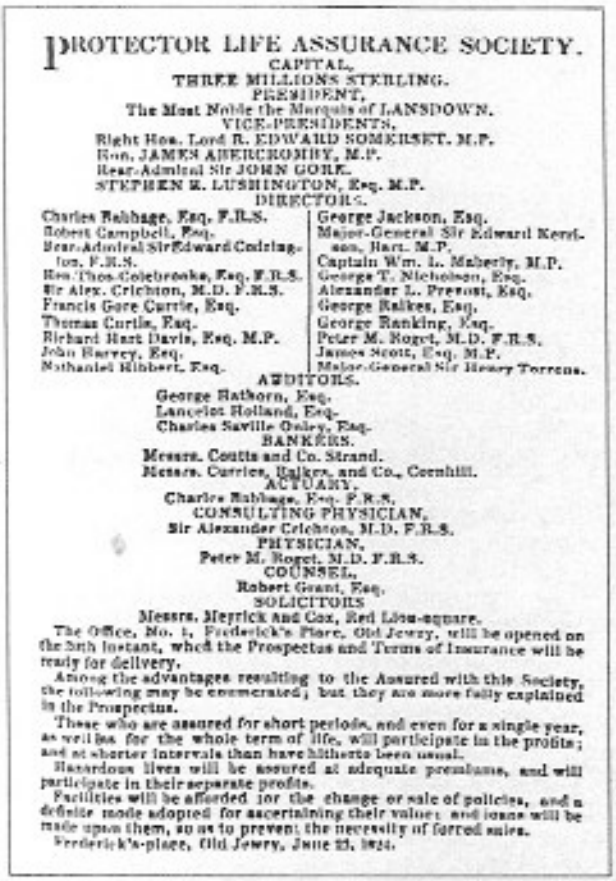
Given the opportunity of running the Protector, Babbage set to work with a characteristic reforming zeal, intending to demonstrate that a profitable business was compatible with his utilitarian ideals. For example, he quickly managed to convince himself and others that a joint-stock profit-making enterprise was no less meritorious than a nonprofit mutual insurance society such as the Equitable. Thus, in a letter dated April 22, 1824, Babbage's friend the explorer Thomas Colby FRS (1784-1852) requested an allocation of shares in the Protector:

> ...you know my opinion respecting mere jobbing catch penny transactions... But from the view you gave me last night of your plan, it appears to be so beneficial to the public, that if carried into execution in a judicious and exemplary manner, the property invested in it must ultimately become extremely valuable.[23]

Although Babbage had some radical ideas for the reform of the insurance business, these did not markedly affect the Protector's general terms of business, as described in the prospectus, which were barely distinguishable from those offered by other companies. The rather minor reforms that Babbage managed to include among "the advantages which are united in this institution" mainly related to the payment of bonuses in a fair manner, the insurance of hazardous lives at "adequate premiums," a loan facility so that distressed policyholders could avoid surrendering their policies, and the ability to change the conditions of a policy without penalty.[24] These were modest reforms indeed, already available from the more progressive companies, and all couched in such vague terms that in practice they would have committed the company to very little. Most significantly, the prospectus was completely silent about the payment of commissions, to which Babbage was vehemently opposed — devoting a full chapter to the topic in the *Assurance of Lives*. Nowhere in his correspondence or writings does Babbage explain why he failed to incorporate any major reforms in the Protector. Perhaps he (or his directors) considered it prudent not to diverge too far from the industry norms.

By spring 1824, the plans for the launch of the Protector were in full swing. On May 20 an advertisement for the Protector was placed in the *Morning Herald*, which gave a list of directors and stated that the office would be open for business on May 31 in Frederick's Place, Old Jewry, London, and that copies of the prospectus would be available at that time. A further advertisement on May 29 stated that the opening was to be postponed until June 30. Another advertisement on June 26 repeated this statement and included some sales points from the prospectus (Figure 2). After that there was silence. There appear to be no further advertisements, nor do the editorial columns of the *Morning Herald* shed further light on the demise of the Protector.

The most likely explanation for the Protector's failure to open is simply that it did not generate sufficient business. The Protector had chosen to open when the boom in new insurance companies was at its height and competition was at its most fierce. The main factor that appears to distinguish



PROTECTOR LIFE ASSURANCE SOCIETY.

CAPITAL,
THREE MILLIONS STERLING.

PRESIDENT,
The Most Noble the Marquis of LANSDOWN.

VICE-PRESIDENTS,
Right Hon. Lord R. EDWARD SOMERSET, M.P.
Hon. JAMES ABERCROMBY, M.P.
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Charles Babbage, Esq. F.R.S.

CONSULTING PHYSICIAN.

Sir Alexander Crichton, M.D. F.R.S.

PHYSICIAN.

Peter M. Roget, M.D. F.R.S.

COUNSEL.

Robert Grant, Esq.

SOLICITORS

Messrs. Merrick and Cox, Red Lion-square.

The Office, No. 1, Frederick's Place, Old Jewry, will be opened on the 30th instant, when the Prospectus and Terms of Insurance will be ready for delivery.

Among the advantages resulting to the Assured with this Society, the following may be enumerated; but they are more fully explained in the Prospectus.

Those who are assured for short periods, and even for a single year, as well as for the whole term of life, will participate in the profits; and at shorter intervals than have hitherto been usual.

Hazardous lives will be assured at adequate premiums, and will participate in their separate profits.

Facilities will be afforded for the change or sale of policies, and a definite mode adopted for ascertaining their values; and loans will be made upon them, so as to prevent the necessity of forced sales.

Frederick's-place, Old Jewry, June 25, 1824.

Figure 2. Advertisement for the Protector Life Assurance Society of London that appeared in the *Morning Herald* on June 26, 1824.

the Protector from its more successful competitors — such as the Alliance, the Palladium, and Law Life — was that all these companies offered generous commissions to agents selling their policies, typically 5 percent of the annual premium.

In a letter to his friend John Herschel, written shortly after the Protector folded, Babbage explained:

> The last letter I wrote told you of a grand scheme for an insurance company and...of my becoming possessed of an income at least four times as large as I ever had before. I worked really very hard and calculated some tables and uncalculated others to see what they were made of; and for two months I thought of nothing else, we had constant committees and meetings to organise and were all ready with our house, office, books neatly ruled, and properly lettered with the printed formulee and every requisite by the 30th June — the day preceeding that in which we were to open — when unexpectedly all was overthrown. I must reserve the reasons why until we meet. It is at present sufficient to say that I was one of the advisors of our dissolution.

Babbage and Life Assurance

> The winding up of our affairs took some time and I was urged by about eighteen of the Directors to form a plan of my own for a new one to exclude two (for reasons you shall hear on your return) and make it entirely after my own heart.[19]

This letter suggests that there was a dispute over policy between Babbage and at least two of the directors. In his autobiography, Babbage simply noted without rancor that "After three months' labour, when the whole of the arrangements had been completed, and the day of our opening had been fixed, circumstances occurred which induced us to give up the plan."[6] Since Babbage was never one to shy from attributing blame, it may be that he had by then come to accept some responsibility for the demise of the Protector.

At all events, Babbage seems to have extracted himself from the debacle with his credibility largely intact. On July 29, about four weeks after the dissolution of the Protector, he received a placatory letter from one of his directors, Alexander Prevost:

> When the Society which had been formed for the establishment of the Protector Life Assurance Company was dissolved, the Gentlemen who had met on that occasion agreed to beg your acceptance of a present as "a mark of their esteem and as a small but unfeigned testimony of their high sense of your valuable services."
>
> I am now requested to inform you that, in consequence of this resolution, One Hundred Guineas have been paid, on your account, into the hands of your bankers, Messrs Praeds & Co.[20]

In December 1824, Babbage was given a second opportunity to run a life insurance company. This time the offer came from his brother-in-law Wolryche Whitmore MP to undertake the management of the Crown Life Assurance office — another of the start-ups of the life insurance boom. Babbage declined the offer stating:

> I find that in the present state of my calculating engine the dutys of that would occupy more of my time than I am willing to divert from an object to whose completion I am most anxiously looking forward. I cannot therefore accede to the proposition you have so kindly made and have only to thank yourself and your friend for the good opinions of which it indicates.[21]

With that, Babbage effectively shut the door on his career as an entrepreneur.

The *Assurance of Lives* and insurance reform

By Babbage's own account he spent a mere three months on actuarial study in preparation for taking on the Protector, but he decided that the information that he had gathered should form the basis for a "small popular work on the subject."[6] He wrote the book over a period of about 18 months "as intervals of leisure admitted," and it was published in early 1826. (The preface is dated December 26, 1825 — his 34th birthday.)

The *Assurance of Lives* was written with three objectives in mind: first, as a popular account of life insurance; second, as a minor technical contribution to the development of actuarial tables; and third, as a reforming tract intended to expose malpractices in the industry.

As a popular exposition of life insurance, the book was competently written, although it added little to the simple explanations of life insurance given in contemporary encyclopedias. Nor, as a consumer's guide, was it particularly original. As Babbage noted, the model he used for his book was a popular pamphlet *An Account of the Several Life-Assurance Companies*, written by Francis Baily and published some 15 years earlier.[22] Babbage saw the rash of new insurance companies as being the justification for updating Baily's survey because "so many new ones have arisen since the period at which he wrote, that they require a volume rather than a chapter for their analysis." Thus, Babbage's book was neither "perhaps the first of the genre"[23] nor anything more than a modest success.

Babbage was not being falsely modest when he claimed that the *Assurance of Lives* was no more than a minor technical contribution to the subject: It was exactly that. There were two lengthy reviews of the *Assurance of Lives*, one in the *Edinburgh Review* (author unknown)[24] and the other in the *Quarterly Review* (written by John Barrow, 1764-1848, the explorer and secretary to the Admiralty).[25] While the reviews were generally warm, both reviewers were surprised by the shallowness of Babbage's exposition. For example, the *Edinburgh Review* "smiled at his occasional blindness to the most prominent features of the question before him," while the *Quarterly Review*, having expected "close mathematical reasoning" and "deep research," found "Nothing of the kind." Nonetheless, Babbage's foray into life insurance, combined with his standing as a leading mathematician, gave him a reputation as a significant authority on actuarial matters, and he was invited to give evidence to the 1827 Parliamentary Select Committee on Friendly Societies set up to investigate tables for government annuities and insurances.[26]

The interest of the *Assurance of Lives* for modern Babbage scholarship is the light it throws on his intellectual development. The next two books that Babbage produced — the *Decline of Science*[17] and the *Economy of Manufactures*[32] — were by far his most important written works. The former was a milepost in the reform of science in England, while the latter was an economics classic that ran to four editions and was translated into five languages. One can see in the *Assurance of Lives* emergent themes that are much more fully developed in these later works.

As the economic historian Maxine Berg has noted, the originality of the *Economy of Manufactures* lay in its mode of economic analysis: "the fact that it was not a mere series of observations, but an *analysis* of the workshop and factory systems of production" (p. 189, Berg's italics).[4] Babbage's style of analysis was typical of his era, and was based on a view of the structure of knowledge that was typified by the

classification of objects from the natural and man-made worlds in museums, and in the taxonomies developed in fields such as botany, chemistry, and geology.[13] Babbage showed great originality in carrying this mode of analysis over to economic topics, and it can be seen very clearly in an embryonic form in the *Assurance of Lives*. Thus he analyzed the life insurance industry in terms of a dozen or so characteristics, such as the choice of mortality tables, capitalization, premium rates, the distribution of profits and allocation of bonuses, and commissions. For each of these characteristics, he attempted to rank the companies according to the extent that they demonstrated that characteristic; or where a quantitative ranking was not possible, he grouped like companies together according to whether they exhibited a particular property. This mode of economic analysis proved very fruitful for Babbage, and in 1829 he applied it more broadly in an essay on the principles of manufacturing in the *Encyclopedia Metropolitana*.[14] This essay was later extended to become the first edition of the *Economy of Manufactures*; his analysis became deeper still in subsequent editions and drew on mainstream political economy.

As a reforming tract, the *Assurance of Lives* can be seen as a forerunner of the *Decline of Science* (1830).[17] In the *Decline of Science*, Babbage's concerns were the conduct of science in England and the organization of scientific societies. It was a "growling, complaining, but wide-ranging book" that questioned the competence of the ruling cliques and exposed what Babbage perceived as fraud and maladministration.[15] In the *Assurance of Lives*, one can see the same concerns expressed for the much smaller world of life insurance. For example, he was critical of the way insurance companies packed their boards with illustrious but uncritical directors and "The readiness with which gentlemen, of respectability, wealth, and intelligence, allow their names to be attached to companies, with whose principles they are but little acquainted" (p. 53). The same theme is taken up in the *Decline of Science*, where he complains of scientific societies that seek officers "from among amateurs...to whom science has been only an occasional pursuit" (pp. 11-12).

In the *Assurance of Lives*, Babbage is very critical of the payment of commissions, which he sees as tantamount to bribery. He makes a specific but anonymous allegation (pp. 136-137) concerning an attorney who advised a clergyman to take a policy with a company that paid a high commission to the intermediary but no bonuses to the insured. As a result, when the clergyman died, his "distressed family were thus deprived of £1200." In the *Decline of Science*, Babbage showed fewer inhibitions about naming names, and there are several detailed allegations of financial corruption.

Both the *Assurance of Lives* and the *Decline of Science* were polemical works, and Babbage's rhetoric tended to portray complex events in stark, black-and-white terms. Just as the *Decline of Science* was later to provoke pamphlets and letters to the press from those he maligned and others who supported him, so the *Assurance of Lives* caused a flurry of published debate. One of Babbage's main targets in the *Assurance of Lives* was the vast financial reserve built up by the Equitable Society. For several years there had been pressure on William Morgan, the venerable 78-year-old actuary of the Equitable, to distribute this reserve in the form of a bonus to the members of the society (of whom Babbage was one). Much to Morgan's disappointment, in the *Assurance of Lives* Babbage added to this clamor. It is probably fair to say that Morgan was a financial conservative and that there was some justice in Babbage's argument, but his case was marred by technical errors and actuarial misunderstandings.

In 1828, Morgan published *A View of the Rise and Progress of the Equitable Society*, in which he answered "the gross misrepresentations by which the society has lately been assailed."[16] Morgan, who was a mild man unused to public squabbling, dealt with his critics impersonally by technical argument. But because of Babbage's high scientific standing, he answered his criticisms with a point-by-point refutation, and concluded in a wounded tone:

> I shall proceed no further in my remarks on Mr Babbage's publication. I cannot, however, conclude them without expressing my surprise and regret that he should be so free in censuring a Society which has conferred such benefits on thousands, without taking a little more trouble to inform himself how far he was justified in those censures.[16]

At the time that Morgan's pamphlet came out Babbage was visiting the Continent, but Francis Baily — another Equitable member — immediately wrote to *The Times* in defense of his friend.[17] Babbage had other supporters, too. The actuary of London Life, H.J. Brooke, published his *Observations* on Morgan's pamphlet,[18] in which *inter alia* he took Babbage's side; and Thomas Young also wrote a letter critical of Morgan in the *Philosophical Magazine*.[19] On balance, the actuarial and scientific community supported Babbage. A few months later, in a paper entitled "On the Proportionate Number of Births of the Two Sexes in Different Circumstances" (a somewhat irrelevant one concerning Prussian mortality data), Babbage came as near as perhaps he ever came to a conciliatory gesture:

> Mr Morgan has honoured my little book with his remarks, and, while I admit the justice of a small part of his criticisms, I cannot but regard that he should have so completely misconceived my meaning, as to have employed any portion of his valuable time in refuting what I have neither thought nor written. That the work alluded to should have induced him to publish his sentiments, is an advantage to the public; at the same time that it is gratifying to me to find that the opinions expressed by a mere amateur are in *reality* so accordant with those of one who has had the most extensive experience.[18]

The Equitable did eventually respond in some small ways to the criticisms made of it (for example, by publishing a

mortality table based on the Equitable's experience). But more generally, the efforts of Babbage and his contemporaries in forcing the pace of reform of the British life insurance industry were largely ineffective.* The 1830s saw several more speculative life insurance companies rise and fall — the most notorious of which was the Independent West Middlesex, which William Thackeray satirized as the "West Diddlesex Fire and Life Insurance Company" in his novel *The Great Hoggarty Diamond*.[43] An 1844 Parliamentary Select Committee on joint-stock companies took evidence from the leading actuaries (who did not include Babbage), but the resulting legislation did little to curb speculative insurance concerns.[44] Indeed, for between 1844 and 1853 it was stated that of 335 offices projected and 149 founded, only 59 had survived.[42] The number of life insurance company failures led to a Parliamentary Select Committee on Assurance Associations in 1853, which took evidence from the then leading actuaries, including William Farr, who cited Babbage's objections to commissions in his "very important book."[45] The Select Committee produced recommendations, but there was no significant legislative follow-through.

It was only after further speculative booms during the 1850s and 1860s that Parliament finally responded to public disquiet by enacting the Life Assurance Companies Act of 1870. If Babbage can be said to have played any part at all in this long slow reform, then it was best put by the insurance writer Cornelius Walford, who described Babbage as a "competent authority" who "did much to draw popular attention to the subject."[46]

The Life Assurance Bank of Gotha

Babbage's posthumous reputation as a significant figure in the development of insurance was almost certainly due to his own account in his autobiography of the impact of the *Assurance of Lives* on the Life Assurance Bank of Gotha:

> This little volume was soon translated into German, and became the groundwork upon which the Great Life Assurance Society of Gotha was founded. Every year since that event I have received a copy of the report of the state of the institution — a gratifying attention which I am happy to have this opportunity of acknowledging.[8]

In the early 1820s the German life insurance industry had been virtually nonexistent, and most life insurance was sold through agencies of British companies. There was, however, some agitation for an indigenous German life insurance industry. The protagonists included Wilhelm Arnoldi — the founder of the Fire Insurance Bank of Gotha — who had written a memorandum on the subject in 1823.[47] Another advocate was a Dr. Stroriep of Weimar, who had arranged for Babbage's *Assurance of Lives* to be translated into German in 1827, with the clear intention — expressed in the preface — of stimulating the German life insurance industry.

Although the translation of the *Assurance of Lives* was one of the stimuli for the formation of the German life insurance industry, the real breakthrough came as a result of a scandal following the death of Duke Frederick IV of Gotha in 1825. Five British life offices had written policies on the duke's life, but in February 1826 three of them — the Atlas, the Eagle, and London Assurance — decided to resist the claim on the grounds that not all the material facts concerning the duke's state of health had been disclosed at the time the policies were written. The three companies joined together to defend an action brought in the English court by the estate of the duke.[48] The case ground on for three inconclusive years, by which time the plaintiff was forced to withdraw in the face of escalating costs: "For a sum in dispute of £3,200, the mere fees of the plaintiff's counsel, the afterwards celebrated Lord Brougham, amounted to not less than £2,700."[49]

The wave of indignation that followed the Gotha case resulted in the launch of the German life insurance industry. Stroriep had earlier presented Arnoldi with a copy of the German edition of the *Assurance of Lives*, and Arnoldi drew on the book to establish the organizing principles and actuarial basis of the Life Assurance Bank for Germany in Gotha (*Lebensversicherungs Bank für Deutschland in Gotha*).[50] The premium rates were derived from Babbage's table of mortality based on the Equitable experience, although with some adjustments for subjects of advanced years.

The first that Babbage heard of all this was during his Continental tour of 1828, when he visited Berlin to attend the Great Congress of Philosophers in September. He wrote home to his mother the following month:

> I found Dr Stroriep here; I had met him at Berlin. He presented me with a translation of the copy of the book on life assurance which he had caused to be translated. He also organised a mutual insurance society which seems very likely to succeed to a great extent.[51]

The Life Assurance Bank of Gotha officially opened for business on January 1, 1829, with a total of 794 members and sums assured of 1,390,900 thalers (£198,700). As the Life Assurance Bank continued to flourish, Arnoldi kept Babbage up to date on its progress. In a letter dated March 7, 1832, he wrote that the organization was "prospering and the number of members thereof amounts to 4,000, the assured to six millions of thalers."[51]

By the turn of the century, the Life Assurance Bank of Gotha had become the leading insurer among the 190 life offices in Continental Europe, and the only one to approach the size of the largest British and American companies.[52] Babbage's table of mortality continued to be used until 1903.

For Babbage, much the most important consequence of the publication of the *Assurance of Lives* was its impact on the German life insurance industry. But it must be said that this was really an accident of timing rather than any special merit of the book itself. Outside of Germany — in France or the United States, for example — it was a book of no great importance.

*For accounts of the nineteenth-century reform of British life insurance, see Trebilcock[42] (chap. 5), Oghom[43] (pp. 228-239), and Supple.[42]

After the publication of the *Assurance of Lives*, Babbage's contribution to actuarial science and practice effectively ceased, although he remained interested in statistical questions all his life and became a founder of the British Association Section F on statistics in 1834. However, the professionalization of statistical science soon left Babbage far behind. His later papers, such as "On the Statistics of Lighthouses" (1853) and the "Analysis of the Statistics of the Clearing House" (1856), are dilettantish contributions of little importance.[53,54]

Yet things might have worked out very differently. Following the constitutional reforms of the Great Reform Act of 1832, which widened the franchise and redistributed parliamentary seats, the General Registration Act of 1836 was passed to bring about a system of civil registration to replace the archaic system of parochial registration. The General Register Office was established the following year for the registration of births, marriages, and deaths; the office was also charged with the taking of a decennial population census and capturing reliable mortality data.[55] Babbage was an obvious candidate for the position of registrar general, and he was urged by Baily and his friends to apply.[5] Sir Edwin Chadwick (1800-1890), the influential sanitary reformer, recommended Babbage as "undoubtedly the fittest appointment they could have made."[56] However, Chadwick probably misjudged Babbage's strengths, which were much more technical than administrative. Moreover, he had a difficult and overbearing personality and had no experience of running an organization of any kind. But under his governance the General Register Office would undoubtedly have evolved as a very different and perhaps more radical organization than it did.

In fact, in an act of patronage typical of the period, the £1,000-a-year post was given to Thomas Lister, a minor novelist who was the brother-in-law of both Lord Clarendon and Lord John Russell, who were members of the Melbourne government. Although Lister had some talent for administration, for technical matters he employed William Farr FRS (1807-1883) as "abstractor of statistics." Farr was given a free rein, and by virtue of benign neglect, he soon became a leading figure in the British statistical movement through his intellectual and practical contributions to the subject, and his insight into social medicine.[57]

In 1864 Farr published the *English Life Table*, which was to endure for decades as the definitive British actuarial table.[57] The *English Life Table* was in part computed using the Scheutz Difference Engine, which was directly inspired by Babbage's Difference Engine.[58] That inspiration was probably Babbage's most enduring, if very minor, contribution to actuarial science. ■

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References

1. C. Babbage, *A Comparative View of the Various Institutions for the Assurance of Lives*, J. Mawman, London, 1826.
2. J.M. Dubbey, *The Mathematical Work of Charles Babbage*, Cambridge Univ. Press, Cambridge, UK, 1978.
3. M. Campbell-Kelly, "Charles Babbage's Table of Logarithms (1827)," *Annals of the History of Computing*, Vol. 10, 1988, pp. 159-169.
4. M. Berg, *The Machinery Question and the Making of Political Economy 1815-1848*, Cambridge Univ. Press, Cambridge, UK, 1980.
5. O.I. Franksen, *Mr Babbage's Secret: The Tale of a Cypher — and APL*, Strandberg, Denmark, 1984.
6. C. Babbage, *Works of Babbage*, 11 vols., M. Campbell-Kelly, ed., Pickering and Chatto, London, 1989.
7. A. Hyman, *Charles Babbage: Pioneer of the Computer*, Oxford Univ. Press, Oxford, UK, 1982, p. 32.
8. C. Babbage, *Passages from the Life of a Philosopher*, Longman, Green, Longman, Roberts and Green, London, 1864, pp. 474-478.
9. W. Schooling, *Alliance Assurance, 1824-1924*, London, 1924, pp. 21-23.
10. A.W. Tarn and C.E. Byles, *A Record of the Guardian Assurance Company Limited, 1821-1921*, privately printed, London, 1921, pp. 47-56.
11. A. Wood, *Thomas Young: Natural Philosopher, 1773-1829*, Cambridge Univ. Press, Cambridge, UK, 1954, pp. 297-302.
12. C. Hutton, *A Mathematical and Philosophical Dictionary*, 2nd ed., London, 1815.
13. F. Baily, *Doctrine...of Life Annuities and Assurances*, John Richardson, London, 1810.
14. M.J. Cullen, *The Statistical Movement in Early Victorian Britain*, Harvester Press, London, 1975, p. 7.
15. M.E. Ogborn, *Equitable Assurances: The Story of Life Assurance in the Experience of the Equitable Life Assurance Society 1762-1962*, Allen and Unwin, London, 1962, pp. 166-192.
16. D.V. Glass, *Numbering the People*, D.C. Heath, Farnborough, UK, 1973, pp. 121-123.
17. C. Babbage, *Reflections on the Decline of Science in England, and on Some of its Causes*, B. Fellowes, London, 1830.
18. W. Morgan, *The Deed of Settlement for the Society for Equitable Assurances...with Six Addresses...*, London, 1820 (quoted in Babbage, *Assurance of Lives*,[1] p. 160).
19. Letter from C. Babbage to J.W.F. Herschel, Sept. 14, 1824, Royal Society, Herschel MSS, Vol. HS2, Letter 198.
20. Babbage's evidence in *Report from the Select Committee on Friendly Societies*, Parliamentary Papers, Session 1826-27, Vol. 3.

Babbage and Life Assurance

21. B. Gompertz, "On the Nature of the Function Expressive of Human Mortality...," *Philosophical Trans.*, Vol. 115, 1825, pp. 513-585.

22. J.M. Eyler, *Victorian Social Medicine: The Ideas and Methods of William Farr*, Johns Hopkins Univ. Press, Baltimore, 1979.

23. Babbage's letter to Baily is quoted in P. Gray, "Tables of Single and Annual Assurance Premiums...," *Assurance Magazine*, Vol. 6, 1857, pp. 185-186.

24. C. Babbage, *Rates of the Protector Life Assurance Society* (1824), *Works*,[5] Vol. 4, pp. 14-19.

25. Letter from T. Colby to C. Babbage, Apr. 22, 1824, British Library, Add. MSS 37183, f. 120.

26. Letter from A.L. Prevost to C. Babbage, July 29, 1824, British Library, Add. MSS 37183, f. 133.

27. Letter from W. Whitmore to C. Babbage, Dec. 6, 1824, British Library, Add. MSS 37183.

28. F. Baily, *An Account of the Several Life-Assurance Companies*, John Richardson, London, 1810.

29. A. Hyman, *Science and Reform: Selected Works of Charles Babbage*, Cambridge Univ. Press, Cambridge, UK, 1989, p. 110.

30. Anon, review of Babbage's *Assurance of Lives*, *Edinburgh Rev.*, Vol. 45, 1827, pp. 482-513.

31. [John Barrow], review of Babbage's *Assurance of Lives*, *Quarterly Rev.*, Vol. 35, 1827, pp. 1-31.

32. C. Babbage, *On the Economy of Machinery and Manufactures*, Charles Knight, London, 1832; 2nd ed. 1832; 3rd ed. 1833; 4th ed. 1835.

33. J.V. Pickstone, "Ways of Knowing: Towards a Historical Sociology of Science, Technology and Medicine," *British J. History of Science*, Vol. 26, 1993, pp. 433-458.

34. C. Babbage, "An Essay on the General Mechanical Principles which Regulate the Application of Machinery to Manufacture and the Mechanical Arts," *Encyclopedia Metropolitana*, Vol. 8, London, 1829, pp. 1-84.

35. J. Morrell and A. Thackray, *Gentlemen of Science: Early Years of the British Association for the Advancement of Science*, Oxford Univ. Press, Oxford, UK, 1981, p. 47.

36. W. Morgan, *A View of the Rise and Progress of the Equitable Society*, London, 1828 (quoted in Ogborn, *Equitable Assurances*,[7] p. 191).

37. F. Baily, letter to the editor, *The Times*, June 26, 1828, p. 4a. See also subsequent correspondence from G. Farren and W. Morgan, July 1, 1828, pp. 3-4.

38. H.J. Brooke, *Observations on a Pamphlet...by Mr Morgan*, London, 1828.

39. T. Young, "On the Experience of the Equitable Society," *Philosophical Magazine*, Vol. 4, 1828, pp. 339-343.

40. C. Babbage, "On the Proportionate Number of Births of the Two Sexes under Different Circumstances" (1829), *Works*,[5] Vol. 4, pp. 104-123; on pp. 105-106.

41. C. Trebilcock, *Phoenix Assurance and the Development of British Insurance, Vol. 1: 1782-1870*, Cambridge, UK, 1985.

42. B. Supple, *Royal Exchange Assurance*, Cambridge Univ. Press, Cambridge, UK, 1970, p. 141.

43. W.M. Thackeray, *The History of Samuel Titmarsh and the Great Hoggarty Diamond*, London, 1841.

44. *Report from the Select Committee on Joint-Stock Companies*, Parliamentary Papers, Session 1844, Vol. 7.

45. *Report from the Select Committee on Assurance Associations*, Parliamentary Papers, Session 1852-53, Vol. 21.

46. C. Walford, *Insurance Cyclopedia*, Vol. 1, C. and E. Layton, London, 1871, p. 152.

47. Wilhelm Arnoldi (1778-1841), *Deutsche Bibliographie*, Vol. 1, pp. 589-591.

48. T. Sibbett, "The Duke of Saxe-Gotha: Glimpses of Early German Life Assurance," *Fiasco*, No. 125, Apr. 1990, and No. 126, May 1990, pp. unnumbered.

49. R.G. Hopf, "Life Assurance Companies of Germany," *Assurance Magazine*, Vol. 3, 1853, pp. 134-147.

50. H. von Karl Samwer, *Hundert Jahre: Gothaer Lebensversicherungsbank auf Gegenseitigkeit*, 1827-1927, Gotha, Germany, 1927.

51. Letters quoted inside the flyleaf of Babbage's copy of the German edition of the *Assurance of Lives* (Weimar, 1827), now in the library of the Royal Observatory, Edinburgh, UK.

52. M. Keller, *The Life Insurance Enterprise, 1885-1910*, Harvard Univ. Press, Cambridge, Mass., 1963, p. 82.

53. C. Babbage, "On the Statistics of Lighthouses" (1853), *Works*,[5] Vol. 5, pp. 57-65.

54. C. Babbage, "Analysis of the Statistics of the Clearing House" (1856), *Works*,[5] Vol. 5, pp. 93-132.

55. M. Nissel, *People Count: A History of the General Register Office*, Her Majesty's Stationery Office, London, 1987, p. 24.

56. S.E. Finer, *The Life and Times of Sir Edwin Chadwick*, Methuen, London, 1952, p. 143.

57. W. Farr, *English Life Table*, Her Majesty's Stationery Office, London, 1864.

58. M. Lindgren, *Glory and Failure: The Difference Engines of Johann Müller, Charles Babbage and Georg and Edvard Scheutz*, MIT Press, Cambridge, Mass., 1990.

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