in the survival function, with the same effect on population, could not hold good for very long without implying probabilities of survival greater than unity.

DISCUSSION BY ROBERT J. MYERS

The paper "Funding Theories for Social Insurance" presented by Mr. Hickman contains an excellent mathematical proof of some theories of insurance financing. Although I have some minor points dealing with his notation and explanation of concepts,[1] his proofs are mathematically rigorous. The same can not be said of the paper by Henry Aaron that is cited by Mr. Hickman.

The proof deals with the readily evident idea that, if income to a pension system is assumed to increase perpetually at a rate faster than interest accumulates, then it is possible to operate that system perpetually at a pay-as-you-go premium rate that is lower than the corresponding entry-age-normal premium rate. This is similar to the old perpetual motion tricks, such as the Ponzi game, that we frequently encounter and that are generally dependent on the power of increasing input into the system. We all know of the many high-risk insurance firms which, due to their low premiums, were dependent on constantly increasing underwriting volume and with which mounting claims finally caught up.

Mr. Hickman is admirably cautious about avoiding the conveyance of the wrong idea that the mathematical concept involved is a panacea to social security financing. I would have preferred that he had delved more on the impracticability of the idea, but of course, each author must be allowed to maintain his own sense of proportions.

The proposition that is presented is highly theoretical and of little practical value. It is entirely based on the assumption that income to a retirement system will perpetually increase (due to both population and average-wage increases) at a rate that is higher than the interest rate. I believe that it is possible to observe in practice, for short periods of time, this

[1] For example, he defines $W(t)$ in terms of $W(0)$, but the latter is not the former, when valued at $t = 0$, as is customary in mathematical notation. Also, the values h and g are defined as annual rates, and δ is also defined as an annual rate (force of interest); as used in the derivations, all three conform to the actuarial concept of "force."

particular differential in rates. In fact, in some developing countries this period may be prolonged due to rapidly increasing populations. However, it is inconceivable that we should assume that population will continue to increase at a high rate forever. After all, there is just so much room on our planet!

It is also inconceivable that interest rates could forever be lower than rates of increase of wages. In fact, it is entirely possible to have a situation in which wages would remain stable and prices would decrease due to better productivity. In that case, the assumptions adopted for the proposition would not be fulfilled, since interest rates would still be positive. Similarly, we can see that over the long run, interest rates will be higher than increases in wages, since in a free economy all factors tend to adjust each other toward a state of equilibrium.

I might point out that the assumptions would be valid for a temporary period in countries with inflationary problems. Under these circumstances, there is no advantage in accumulating reserves unless these are invested in inflation-safe assets. This fact has been recognized earlier (for example, see my paper "Actuarial Analysis of Pension Plans under Inflationary Conditions," *Transactions of the Sixteenth International Congress of Actuaries,* Vol. 1, June 1960).

AUTHOR'S REVIEW OF DISCUSSIONS

As the reviewers perceived, I had a modest objective in mind when I wrote this paper. The objective was to illustrate, by a detailed examination of a simple model, the profound difficulties involved in attempting to establish the superiority of any particular social insurance funding method by a chain of purely mathematical reasoning; even when this reasoning proceeds from apparently plausible assumptions. The two reviewers have contributed to the achievement of this objective in a more colorful and forceful fashion than I did.

Mr. Singer's discussion of the marginal rate of time preference contributes significantly to the establishment of the intended point. I acknowledge the relevance of the questions about time preference rates that Singer, with the help of Aesop, has proposed. The relevance of these questions further reduces the possibility that a single, time invariant, time preference rate assumption may be used to reach any meaningful decision on financing a comprehensive social insurance program.