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# ACT: AN ACTUARIAL PROGRAMMING LANGUAGE

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In the March issue, an article by Mr. De Vries discussed the potential of APL as a basic actuarial programming language. From personal experience I have found that this potential is virtually unlimited, particularly if we treat APL as the fundamental starting point for the long-sought actuarial programming language, rather than the end product.

*Background*

In June, 1970, several members of the planning staff of the Sun Life of Canada began to experiment with APL. The all-around superiority of the APL language as a mathematical computational tool was immediately evident, and by September it had been decided to instal the APL time-sharing system on an "in-house" basis. At that time, apart from some time-sharing companies, the Sun Life was one of the few commercial organizations in North America that were running APL in-house, previous use being restricted basically to several universities and establishments such as NASA.

During the past year many applications have been undertaken using the APL system. A few examples might help to demonstrate the versatility of the APL language—a system to handle the day-to-day calculations of special individual annuity quotations, another to handle prepaid premium calculations, an estate analysis package, property investment cash flow analyses, and special valuations of small groups of business. The latest use has been the construction of simulation models for use in corporate financial planning. There is no question that more and more applications in the future will be handled with the APL system.

The major applications of APL, however, have probably been those involving the ACT language. Of these, the most outstanding has been the creation for our United Kingdom business of a complete rate file of policy values (net premiums, reserves, cash values, and so on), which involved programming the myriad idiosyncrasies to be found in approximately one hundred and forty distinct plans issued over the last sixty years. The actual programming time involved was of the order of ten man-weeks. Those readers with data-processing experience on similar tasks, using the computer in a batch environment and such languages as COBOL, FORTRAN, or ASSEMBLER, will appreciate the extreme significance of this figure.

*Introduction*

ACT is a notational language for use in a time-sharing environment and consists of a comprehensive set of macro functions defined in APL. In the development of ACT, two basic aims were followed: (*a*) the need to provide a high-level user-oriented language, where the high-level macro or function notation used corresponds directly to the existing standard actuarial publication notation, and (*b*) the need to provide complete flexibility of operation of the language in terms of the mortality and interest basis required, without the enormous storage requirements involved in retaining monetary tables of even a few of the simpler functions on all the required bases.

One of the most significant features of APL, the ability to handle vectors as single operands, led to the immediate resolution of the second of the basic aims stated above. At the same time, the ACT language has been developed in such a way that this same powerful feature is incorporated in every macro function. Also, all the symbolic mathematical operators of APL may be intermixed freely with the macro functions of ACT. The ACT language, therefore, extends the scope of APL into the realm of actuarial mathematics.

*Initial Development*

My early experiments with APL as an actuarial tool were almost identical with the simple procedures described in Mr. De Vries' article. APL's unique handling of vectors and matrices, or arrays of higher rank, allows the manipulation of many numbers (such as a table of $l_x$ values) as a single entity. Let us suppose we have entered a table of $l_x$ values and named the vector *TABLX*. The following two simple programming instructions,

$$[1] \quad W \leftarrow (\rho TABLX) - 1$$

$$[2] \quad XR \leftarrow 0\ ,\ \iota W$$

establish the global variables $W$ (the limiting age of the particular table currently stored in *TABLX*) and *XR* (a vector of the range of ages covered by the table). (The APL operator $\rho$ acting monadically on a vector gives the number of elements in the vector; the $\iota$ acting monadically on the scalar $W$ gives a vector of all the integers from 1 to $W$; the comma catenates the integer 0 with the vector $\iota W$.)

Let us now set aside the letter $I$ to be a global variable which will contain any desired interest rate. The following one-line program may now be written for the present-value function $v^x$:

$$\nabla\ Z \leftarrow VX\ X$$

$$[1] \quad Z \leftarrow \div\, (1 + I) * X$$

$$\nabla$$

(The APL operator $*$ raises $(1 + I)$ to the power of $X$; the operator $\div$ acting monadically gives the reciprocal.)

Now we are in a position to write another one-line program to create *in one instruction* the complete table of values of the commutation function $D_x$:

$$[1] \quad TABDX \leftarrow TABLX \times VX\ XR$$

Another two or three minutes of simple programming gives us the facility to produce *all* the commutation function tables (or vectors) on the basis we have selected; for example, we might create *TABMX* as follows:

$$[1] \quad TABMX \leftarrow (TABNX \times VX\ 1) - 1 \downarrow TABNX\ ,\ 0$$

Again we create simultaneously, for all values of $x$, values of $M_x = vN_x - N_{x+1}$. (The APL operator $\downarrow$ is used to drop any number of elements from a vector.)

Perhaps one of APL's striking features is already evident in

Finally, it is worth repeating that, if the execution parameters of any ACT function are set to be compatible ranges of values, corresponding complete range of results will be returned simultaneously.

*Future Extensions*

The basic portions of the ACT language which have already been implemented are concerned primarily with single-life annuity and assurance functions using ultimate mortality. Other features available are sets of pure interest functions, mortality functions, and valuation functions, together with the facility to use projected mortality and interest rates varying with duration.

The basic work necessary to extend the ACT language to use select mortality has also been completed. The notation adopted to indicate the use of select mortality makes use of another feature of APL, namely, the facility to underscore any letter of the alphabet, the resulting composite symbol being treated as unique. Thus, while we would have $l_x$ written as $LX$ in the ACT notation, the expression $l_{[x]+t}$ becomes simply $L\underline{X}$. This beautifully simple device (admittedly artificial and unique at present to an APL implementation of the notation) preserves the one-to-one correspondence of the programming and publication notations as already described, at the same time indicating the use of select mortality. The basic indexing procedures are easily derived, interpreting the $\underline{X}$ parameter as a vector of $(x_i, t_i)$ elements and operating on tables which are now partly matrices.

Future extensions to the incorporation of multilife functions and multiple decrement functions and to areas such as group and health insurance are more than feasible. While the notation development will follow naturally from the guidelines already established, the programming of the macro functions desired will be greatly facilitated by APL's unique handling of arrays.

**Editor's Note:** *Mr. Jamieson is a student of the Society, and he very kindly responded to our invitation to tell us about ACT, a new programming language which he developed.*

## Keynes and Inflation

(*Continued from page 1*)

den forces of economic law on the side of destruction, and does it in a manner which not one man in a million is able to diagnose . . ."

The book made Keynes' name famous. After five years Germany obtained far more lenient terms, but in the long drawn out agony of those five years the value of the German mark was reduced to zero and brought on Hitler and World War II. I have met some who treat this German experience of inflation as a myth of little bearing on present day affairs.

Keynes was consultant to the British Treasury throughout World War II, making six journeys to the United States in connection with financial matters of the greatest importance; his peerage, awarded in 1942, was for this public service.

In May and June 1971 the Canadian Senate had a Committee on National Finance examining economic trends. Thirty briefs were submitted by leading experts from the United States, Canada, Britain, Germany, and Japan; the result was 30 individual viewpoints. The academic economists argued, generally, that control of prices and wages would be ineffective and difficult to administer. A concluding comment by the Governor of the Bank of Canada was: ". . . economics is not yet and probably never will completely be an exact science." One professor of economics (Chicago and London School of Economics) is quoted as stating that a more or less steady rate of inflation of 15—30% or more can be tolerated. After all, some South American countries experience this and survive! The average annual rate of depreciation of money in the ten years 1960-1970 in Argentina was 17.5%; in Brazil 30.6%.

The serious point is that the rate of depreciation of money is quickening in many countries: in the U.S. during the first half of the 1960s, the dollar lost only 6% of its buying power, whereas during the second half of that decade it lost 19% of its domestic value. In most countries 1970 was definitely worse than the average for the decade 1960-70, and in many countries 1971 is worse than 1970. The historical development of this trend is important in watching developments arising from President Nixon's move.

In the 1920s in England prices were falling, unemployment was severe; the government followed a policy of deflation to restore the Gold Standard, which it did in 1925 at the pre-war parity. As a result, the large coal export trade suffered, miners wages were cut followed by a coal miners strike and a general strike. In 1923 Keynes had published *A Tract on Monetary Reform* which would contradict the charge that he was a congenital inflationist. He stresses the necessity for a stable value of money and challenged the role of the Gold Standard in providing stable prices and stable rates of exchange. As stated, his views were ignored. Keynes continued to attack the classical economic theory that the trade cycle was the automatic control of the economic system; that governments should not interfere and wages and prices and unemployment would all adjust themselves—*laissez faire*; the Gold Standard was part of this system. Keynes wanted government direction of the economy, not *laissez faire*.

During the 1920s other countries were prospering. In the United States the general well-being led to the boom when people would borrow at any rate of interest to buy shares or increase money-making facilities in an increasing prosperity which would go on forever! The crash came in October 1929 and not only ruined many Americans but spread ripples of disaster over the entire world. By 1932 the value of world trade had fallen to one-third of the 1929 level and unemployment was calamitous—in the U.S. about 25% and in Britain 22%. The situation was extremely grave in Britain with a serious outflow of gold, and in September 1931 Britain left the Gold Standard. Keynes' advice had been ignored and it was realized what a disastrous mistake had been made.

A Commission appointed by the Labour Government in Britain to advise on government policy reported in 1931. It recommended increases in taxation, drastic cuts in government expenditures such as unemployment benefits and civil service salaries. The whole point was to get a balanced budget. It was the reverse of what Keynes had been urging. Keynes referred to this May report as "The most foolish document I have ever had the misfortune to read." May was an actuary in the service of the Prudential of England, who made his way to the top through the investment side and for his public service was awarded a knighthood, then a baronetcy and finally a peerage. Is he the only actuary to have

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