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ASIR
The Advanced Simulation Model of Insurance & Re-insurance Operations : An Introduction

by Lawrence Galitz and Margaret Brown *

1. Background to the project

All research starts with an initial conception, and here the impetus to develop an advanced insurance model really originated in two stages.

The first stimulus came from the insurance market itself. There is often a significant time lag between the inception of research and the availability of results. With the speed of change that now characterises the insurance environment, the delay in carrying out certain types of research study was seen as undermining its direct utility to the insurance industry. It has not been uncommon to find that by the time a research area had been identified, a proposal formulated and approved, the research carried out, and the results published, the research topic was no longer of current interest. Recognition of this problem led to the idea of using a modelling system capable of examining many different aspects of the insurance market rather than isolated areas.

Once the need for a versatile insurance model had been established, a look at currently available model (GIM and SOFI [1]) soon revealed that nothing in existence could meet the necessary requirements. For example, the GIM model had only the limited application to motor insurance, it could not deal with re-insurance, it permitted only a limited description of the external operating environment, and so on. The general purpose simulation model of financial institution, SOFI, whilst more advanced than the GIM model, also had its limitations (for example, SOFI is a single currency model). Furthermore, apart from a number of specific restrictions, existing models had one major drawback : a fixed structure. A central requirement for an advanced model was the need for *flexibility*.

2. Aim of the project

With this background, the aims of this research project, sponsored by the Geneva Association, emerged :

(i) to create a powerful and flexible system whereby investigations into areas of topical interest in insurance and re-insurance could readily be carried out, and

(ii) to apply the model to areas of theoretical and practical interest.

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1 GIM (Geneva Insurance Model) developed at the Battelle Institute, Geneva. SOFI (Simulation Of Financial Institutions) developed at the Institute of European Finance, Bangor. For more details on the ASIR model see : " Users' Manual " — Etudes & Dossiers No. 43, Geneva Association.

The remainder of the report describes the way in which the work to date has pursued these goals.

3. Initial design concepts

The project commenced in January 1979 with some careful planning. Some important design considerations had to be analysed and assessed, and these are described in the following paragraphs.

3.1. Type of model

The existing models mentioned earlier, GIM and SOFI, were both deterministic. This meant that they would always produce the same set of results for a given set of input data. The essence of the insurance business, however, is uncertainty, and in real life, a given set of circumstances can lead to a wide range of outcomes. In pursuit of realism, there was a temptation to make the model purely stochastic. However, it was recognised that there are drawbacks with stochastic models. The most significant disadvantage concerns the provision of probabilistic data to the model. The data must not only describe the probability distributions of the input variables, but must also fully describe their interactions and correlations. This data requirement could be a formidable one in many cases, to the extent that potential users of the model might be discouraged from actually making use of it. A secondary consideration, though not unimportant, was that of computer resources, with stochastic models being several orders of magnitude more expensive to run than their deterministic counterparts.

With these thoughts in mind, and the need to embody *flexibility*, it was decided to give users several options :

(i) running the model once with a given set of data — the " single shot " mode. This enables the user to obtain a single set of results from the model and is analogous to having a deterministic model ;

(ii) running the model several times, changing the input data slightly between successive runs — the " sensitivity analysis " mode. This enables the user to obtain a spread of results from the model to show how sensitive the results are to changes in the input data. The important thing to note here is that the uncertain elements within the model (for example, the outcomes of claims) are held constant between successive runs by ensuring that each run starts with the same random number seed (RNS) ;

(iii) running the model many times, changing the random number seed between successive runs — the " stochastic " mode. By performing a series of, say, 1000 runs in the stochastic mode, the user can obtain a spread of results which indicates the extent of risk or uncertainty within the insurance business.

Thus, the user can select whichever mode is appropriate for the particular situation under investigation.

3.2. Programming language and techniques

The first decision under this heading was the choice between a general purpose language like FORTRAN, and a specific simulation language like DYNAMO. As stated in a first progress report, after a careful survey, FORTRAN was chosen as the most appropriate language to use. The advantages of FORTRAN which stood out were :

— FORTRAN is widely available on all makes of computer ;

— it is a general purpose language allowing the maximum flexibility ;

— program modification is easy to carry out.

With the language question decided, the type of program structure was the next decision to be made. It was felt that the type of model envisaged was best dealt with as a large number of small program modules rather than as one large program. This would enable the complex structure of an insurance market to be assembled from a number of simpler components or " building bricks ". An additional advantage is that modifications can be made to an isolated module without necessitating the entire model being rebuilt.

Following on from the concept of a series of " building bricks " came the idea of having a number of alternative " plug-in " modules for certain functions within the model. For example, different countries have different taxation systems, and the idea was to make available a series of alternative taxation modules, one for each country. To assemble a French insurance company, one would include the French taxation module within the overall structure, and so on. Whilst this seemed like a commendable idea at first, a better solution emerged.

Instead of physically changing the model's structure to simulate different insurance companies the user can establish the model's internal structure simply by supplying the appropriate data. One obvious advantage of this method is that it enables the user to evaluate the effects of different regulatory regimes merely by changing a few items of data between successive runs rather than having to build a whole series of models. This feature, whereby the input data specify the structure of the model, ranges from low level changes in the details of individual insurance policies right up to high level relationships between simulated companies in the insurance market.

3.3. Planning the overall structure

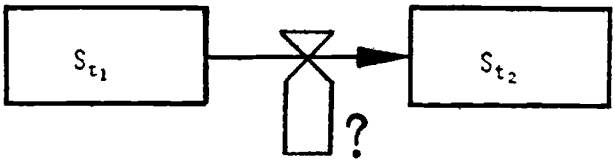
The previous section has discussed why a modular approach to the design of the model was chosen. Before detailed programming could take place, it was necessary to devise the overall structure of the model. This was done in two stages.

The first stage was to identify the force which would drive the model through a simulation. There were two broad choices : stock-driven models as opposed to flow-driven models. Fig. 1 shows the distinction between the two. In a stock-driven model, the calculations are based on the level of variables at different points in time. The derived quantity is the rate of flow that must follow given the levels of stocks at the beginning of a time period and at the end. An example of a stock-driven model in finance would be SOFI, where the levels of deposits at the beginning and end of an accounting period define the interest paid thereon. In a flow-driven model, on the other hand, the calculations are based on the level at the beginning of a period and the flow-rate. The derived quantity is the level of stocks at the end of the period, which in turn can become the initial level of stocks for the next period.

In the insurance context, premiums, claims, commissions and expenses are all flows, whilst premium reserves, loss reserves and investments are all stocks. In insurance it is the magnitude of premium and claims which determines the level of reserves, and not the other way round. For this reason, the flow-driven model was selected as the appropriate choice, and the schematic representation as depicted in Fig. 2 was drawn up to identify the main driving flows and derived levels within the model. Thus, the overall structure from the financial viewpoint had been designed.

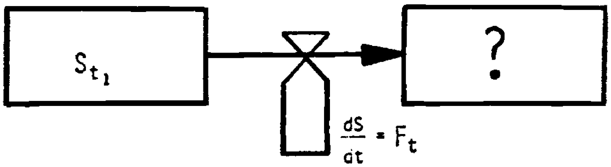
Fig. 1 : Models : the driving force

a) Stock driven models



In a STOCK driven model, the level of stocks at two points in time determines the rate fo flow

b) Flow driven models



In a FLOW driven model, the level of stock at a future time is determined by the initial level and a flow rate

The second stage was to produce a second structural plan, this time from the programming viewpoint. It was at this stage that the modules or building bricks described in the previous section began to emerge as distinct entities. Fig. 3 shows the four main program modules that form the model. These modules are : risks, investments, integrated finance and updating. Within each of these main modules are many lower-level modules, and Fig. 4 shows the principal modules within the main risks modules. These lower-level modules in turn contain various sub-modules, and a distinct hierarchy of structure within the model can be clearly identified.

The initial research proposal described the programming of the model from the block structure as probably being a " straightforward stage ". What was thought to be a simple transformation from the block diagram to program code was, however, fraught with difficulties. The most significant hindrance to rapid progress was recognition of the fact that insurance is a complex business. It was considered of paramount importance to model the intricacies involved as realistically as possible. Another consideration was to ensure that the model was mathematically and statistically sound, and this involved the use of advanced probability distribution and random number generators. A further constraint was the need to keep within the limitations imposed by the computer system itself, for example, size of array storage and speed of execution.

Fig. 2 : Systems dynamics representation of the advanced insurance model

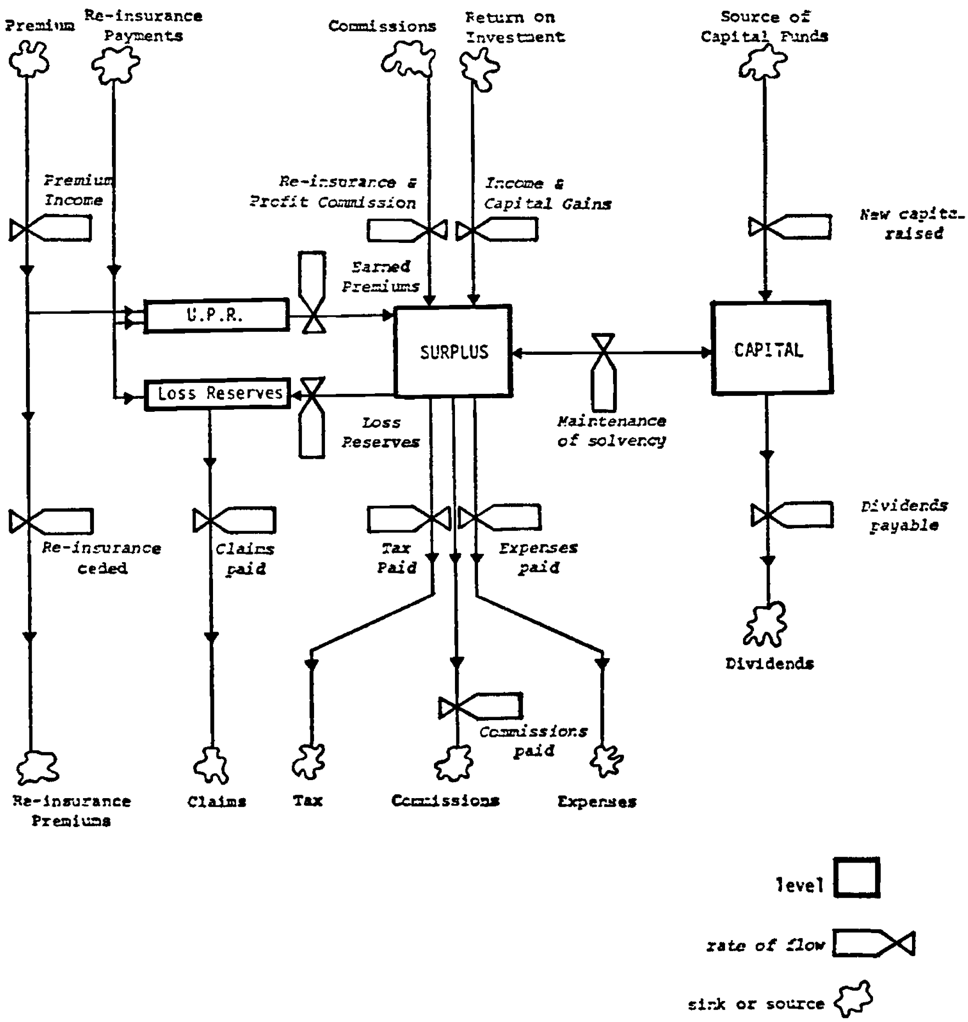


Fig. 3 : The main program modules

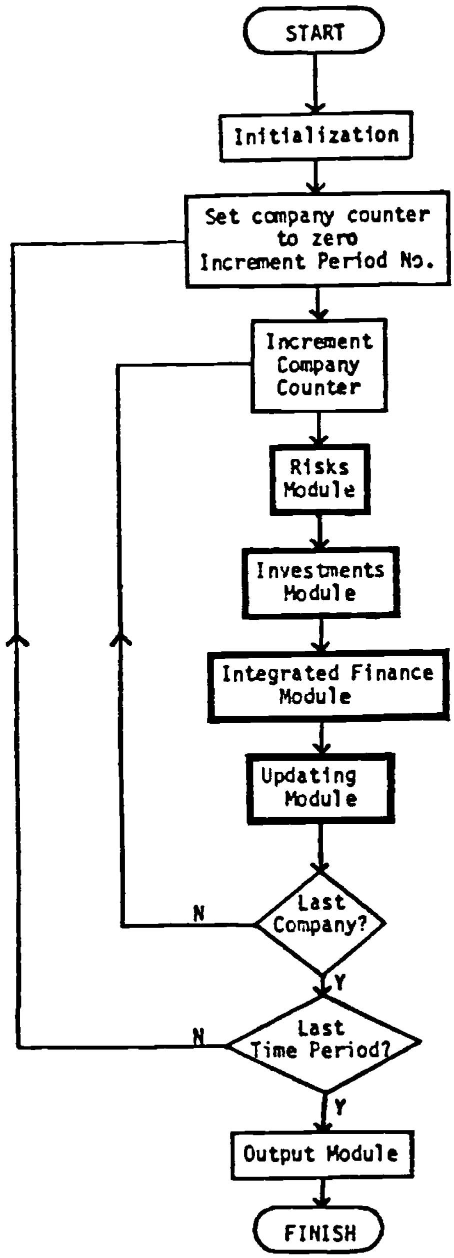
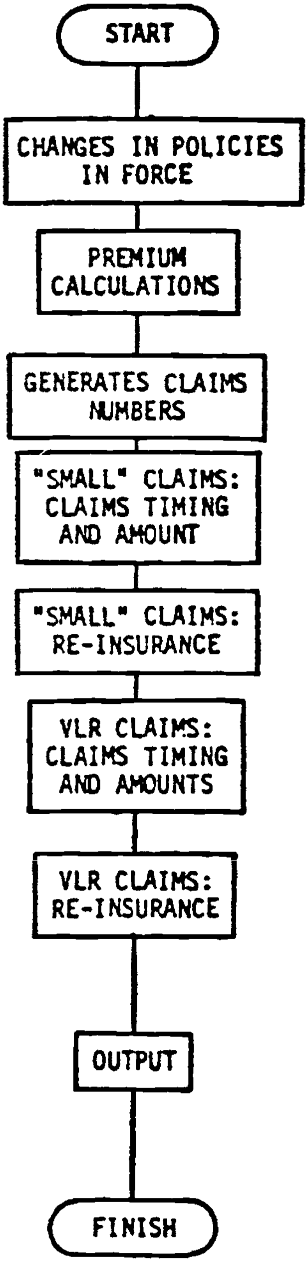


Fig. 4 : Principal modules within the risks module



deals with new policies, renewals and cancellations

deals with premium income, re-insurance premium, commissions, expenses UPR, reserve deposits

deals with the generation of claims numbers for " small " claims and for VLRs

deals with amounts incurred and settled, and updates loss reserves accordingly

deals with small claims transactions between direct company and re-insurer and updates loss reserves of both companies accordingly

deals with amounts incurred and settled, and updates loss reserves accordingly

deals with VLR transactions between direct company and re-insurer, and updates loss reserves of both companies accordingly

prints period results if required ; if at year-end, assembles results and converts to home currency for company's financial statements

It is believed that these problems have now been surmounted, and there exists a complete working version of the model. The main features of this first version are set out in the following section.

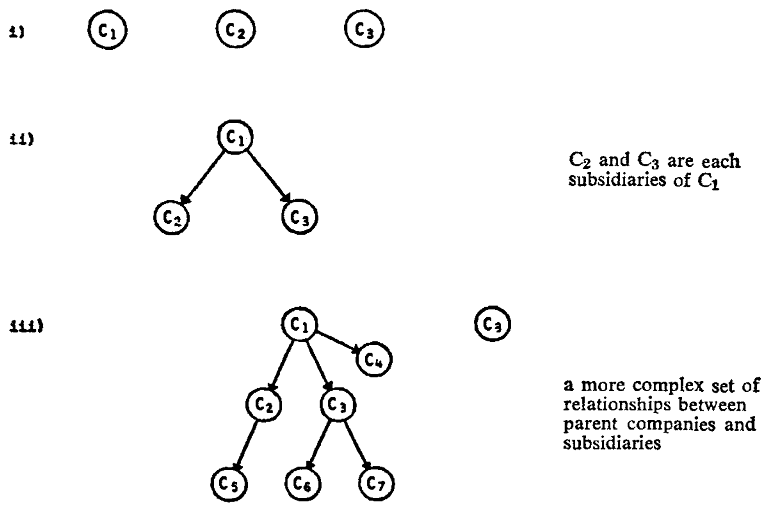
4. Capabilities of the model

A full description of the model's capabilities is given in the User's Manual [1]: however a good idea of the model's potential can also be obtained by examining the main features set out in the following paragraphs.

4.1. Type of market structure

Up to nine active companies can be studied in the simulated market, and each active company may be linked by way of parent-subsidiary relationship to any other company. Some examples of alternative relationships between simulated companies are given in Fig. 5.

Fig. 5 : Alternative relationships between companies

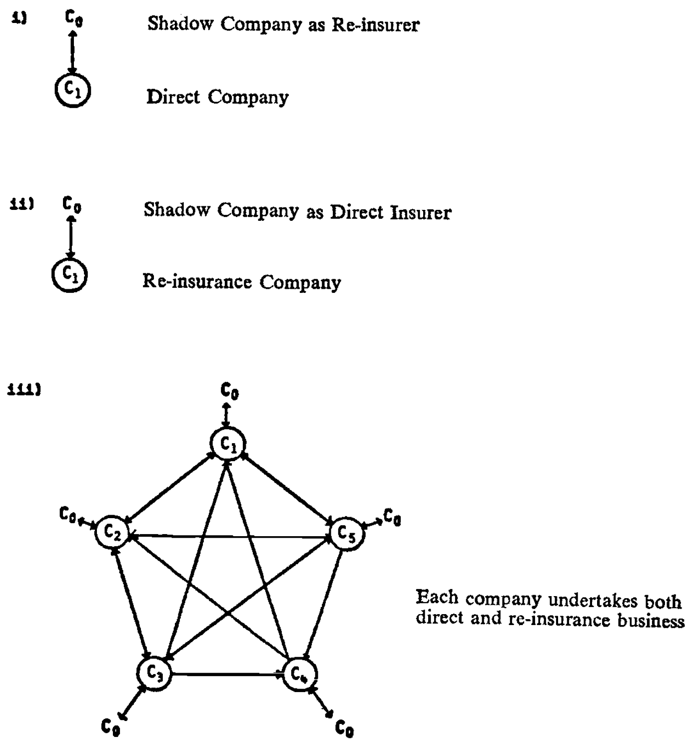


Beyond these links at corporate level, there is also much flexibility in specifying re-insurance relationships within the model. Each active company can cede or receive re-insurance business with any other active company. Thus, a simulated company may be a pure direct insurer, a pure re-insurer, or a direct insurer also handling re-insurance business. Furthermore, it is also possible to specify re-insurance links with companies outside the model. Treaties may be established between active companies within the model and a " shadow company ", which can cede or accept re-insurance business. Provision of this last feature is extremely useful because it allows a user to concentrate on one company, or one side of the insurance industry, without having to model in

[1] See note page 85.

detail the links to other companies. Examples of alternative insurance and re-insurance arrangements are shown in Fig. 6.

Fig. 6 : Alternative insurance & reinsurance arrangements



4.2. Handling of risks

Up to forty direct insurance risk classes may be handled and each risk class can either be a GROUP of risks or a single VLR (very large risk). The idea here is to distinguish between a class of homogeneous risks, for example, part of a motor portolio, and instances of low-probability high value risks, such as an oil platform. This distinction is important from the modelling viewpoint because different statistical processes and procedures are necessary to handle the two main types of risk class. In fact, to obtain more realistic treatment of the claims behaviour of GROUP risks, it has been found necessary to split these further into " small " claims and " large " claims, which are modelled by separate but overlapping statistical distributions.

Some idea of the scope of the data requirement for a simulation run is given in Table 1 which lists the major items of data needed by the model. The data for each risk class includes, amongst other things, parameters describing the country of business, the currency, details of the premiums, and statistical parameters describing the behaviour of claims. A cursory glance at Table 1 may give the impression that the amount of data needed to perform simulation exercises is daunting. Such an impression would be misleading for two reasons. Firstly, default values apply in many instances, so data need only be entered for non-default cases. Secondly, it is possible to create new sets of data from already existing sets ; the user needs only to enter the changes. The clear advantage in allowing the broadest scope for the input data is to provide the user with tremendous flexibility in tailoring a particular simulation exercise to his individual needs.

Table 1 : Main data requirements

GENERAL

— length of simulation run & period length
— no. of companies & their relationships
— countries where risks taken
— countries where reserves held
— initial risks portfolio
— environmental data
— random number seed
— key to solvency requirements

PREMIUMS

— initial premium level
— renewal rate, new business rate, cancellation rate
— rates of commission & expenses on new business & renewals
— premium delays
— commission delays
— rules for calculating new premium prices

CLAIMS

— probability of claims incurrence
— % " large " claims
— size & spread of claims
— max. sum assured
— claims expenses
— IBNR delay
— settlement delays
— length of claim tail
— type of statistical distribution used

RESERVES

— type of UPR estimation
— type of loss reserve estimation

RE-INSURANCE

— type of treaties
— currency of RI premiums
— currency of RI claims
— size of RI premium (% of gross premium)
— commission & profit commission
— size of claim paid (% of gross claims) or claim limited
— % RI cover
— details of UPR & LR deposits

4.3. Re-insurance

For each of the forty direct insurance classes, up to three re-insurance treaties may be specified, allowing up to 120 to be handled within the model as a whole. A treaty may be quota share, surplus, or excess of loss (with or without stability clauses). Table 1 again indicates the wide range of input data options available to the user for modelling re-insurance operations.

4.4. Countries and currencies

The model can handle up to twenty countries of operations, and up to twenty currencies. Moreover, it is not necessary for countries and currencies to match up when dealing with the insurance or re-insurance operations. It would be quite feasible for dollar business to be written by a UK company, with any claims that result being paid in Swiss francs.

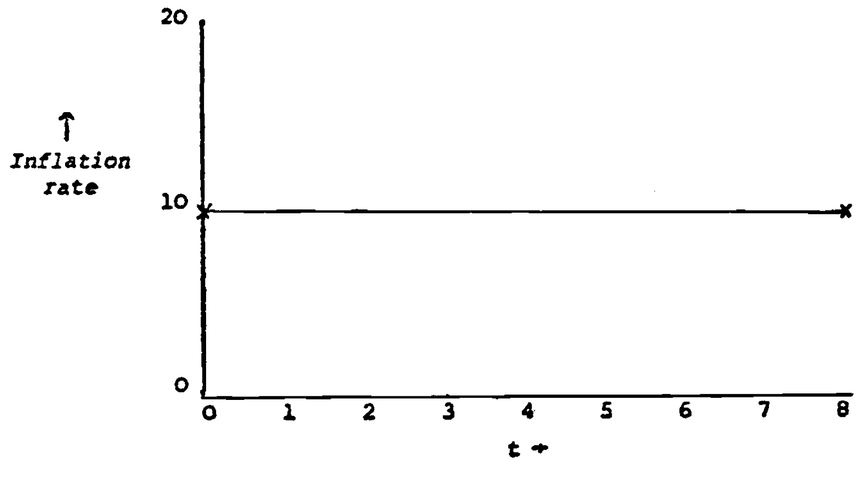
4.5. Operating environment

The user can describe fully the operating environment for each country of operation, and does this by entering data on interest rates, inflation, exchange rates, share prices, taxes, transaction costs, growth rates, and so on. An attractive feature of the model is the INTERPOLATOR system used to interpret environmental data. This system, which is depicted in Fig. 7, greatly simplifies the task faced by the user of describing a particular scenario. For a given environmental variable, for example, an interest rate, the user need only enter data for the points in simulation time where the slope of that variable changes ; the interpolator will calculate all the intermediate values automatically. Fig. 7 a shows the case where a variable stays constant at 10 % throughout the eight time periods of a simulation. In this case the user only enters two figures, each 10, indicating the value at the beginning and at the end of the simulation. Fig. 7 b shows an example where the variable stays at 10 % for the first three

Fig. 7 : The interpolating system used for environmental data

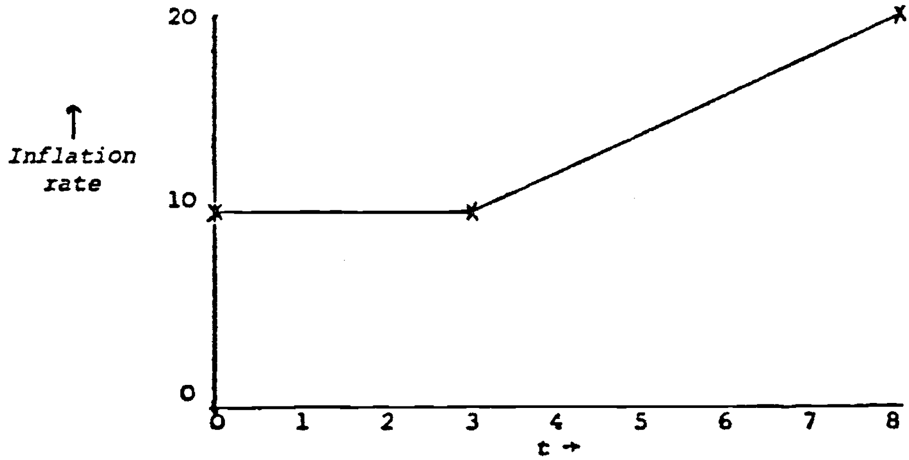
a) No Interpolation points

DATA INFLT/0,0,.../,EINFLT/10,10,.../



b) One Interpolation point

DATA INFLT/1,3,0,.../,EINFLT/10,10,20,.../



Here, the data specifies 1 interpolation point at period 3 to give an intermediate figure between the beginning and end figures.

periods, and then moves through 12 %, 14 %, 16 %, 18 % before finally reaching 20 % at the end of the simulation. Despite this more complex pattern, the user need only enter two extra numbers to fix an interpolation point at period 3 ; the computer will calculate the remaining figures. The great advantage conferred by the interpolator system is that it eases the data requirement, especially for simulation exercises covering an extensive time span.

4.6. Simulation time

It is possible to specify any fixed length of simulation run, or alternatively to run a simulation until some specified contingency occurs, for example, a company becoming insolvent. Thus, fixed span simulation exercises can be carried out, or a company or market can be " tested to destruction ". Although the basic time unit within the model is one year, it is possible to carry out simulations with a semi-annual or quarterly time-step.

Printed reports from the model cover claim settlement analyses, detailed underwriting performance, balance sheets, key ratios, summary financial statistics, and time series listings.

With the features that have been described in the preceding paragraphs it is possible to carry out a wide range of simulations ranging from a " quick and dirty " summary exercise to detailed " in-depth " studies. Above all, the scope of the model ensures *flexibility* at all times.