Dynamic simulation for strategic insurance management

Yaman Barlas[a], Korkut Çırak and Ekrem Duman

Yaman Barlas received his BS, MS and PhD degrees in Industrial and Systems Engineering from Middle East Technical University, Ohio University and Georgia Institute of Technology respectively. In 1985, he joined Miami University of Ohio. He returned to Istanbul, Bogaziçi University in 1993, where he is currently directing the SESDYN group. He is the Past-President of the System Dynamics Society. His interest areas are model validation, modeling/analysis of socio-economic problems and simulation as a learning/training platform.

Korkut Çırak received his BS degree in Industrial Engineering from Istanbul Technical University and his MS degree in Industrial Engineering from Bogaziçi University, in 1994 and 1999 respectively. His MS thesis was on insurance management modeling. He worked for Halk Sigorta insurance company in 1998–1999. He is currently completing his compulsory military service.

Abstract

In this paper, a dynamic model-based management consultancy project carried out for a major insurance company in Turkey is presented. The objective of the project was to address certain strategic managerial problems of the company by using systemic dynamic simulation. The main strategic problem of concern was that the company exhibited a fast growth between 1988 and 1993, followed by persistent stagnation and even a slight decline. This paper describes the main structures of the model, presents the validity tests and lists the major results of the study. The model is developed, calibrated and validated using real data for seven years, between 1989 and 1996. The main benefit of the model is that it generates a systemic and dynamic understanding of the company's internal and external interactions so as to enable creative solutions for existing and potential problems. One of the recommendations of the project has actually been initiated as a pilot project. A new interactive gaming version of the model is in the final stages of completion. The model and the game version can be used as a ''learning laboratory'' in the company, which would be a first step toward ''organizational learning''. Copyright © 2000 John Wiley & Sons, Ltd.

Syst. Dyn. Rev. **16**, 43–58, (2000)

This paper summarizes a model-based management consultancy project carried out for Halk Sigorta, one of the leading firms in the Turkish insurance sector. The managing directors of Halk Sigorta felt that the company had some potential problems and requested that an external team (Bogaziçi University socio-economic system dynamics research group—SESDYN) analyze these problems scientifically. The project was carried out in 1996–1997. The main objective of the project was to address certain managerial/organizational problems of the company by using dynamic simulation analysis. The dynamics behind the organizational problems of the company were analyzed by building a management simulation model of the company. While the project focused mainly on the ''strategic'', long-term management problems, some ''tactical'' short-term problems in the ''claims'' and ''accident'' departments were modeled as well. In this paper, we focus only on the strategic, long-term problems, present the strategic simulation model and summarize the results obtained at the end of the project. (See Barlas *et al.*, 1997, for summary descriptions of the ''claims'' and ''accident'' models.)

The company and strategic problems

Halk Sigorta functions countrywide in five regional divisions and has over 500 agencies. The company is the sixth biggest insurance firm in Turkey in terms

[a]Yaman Barlas, Department of Industrial Engineering, Bogaziçi University, 80815 Bebek, Istanbul, Turkey.

System Dynamics Review Vol. 16, No. 1, (Spring 2000): 43–58
Received May 1999
Accepted August 1999

Ekrem Duman received his BS degree from Bogaziçi University, Department of Electrical Engineering and his MS and PhD degrees in Industrial Engineering, in 1990, 1994 and 1998 respectively. His PhD thesis dealt with the optimization issues arising in the automated printed-circuit-board assembly environments. Currently, he works as a consultant and his main interest areas are simulation (both discrete and system dynamics), scheduling and optimization.

of total premium revenues. The central division, which is located in Istanbul, generates about 45% of total policies. Ninety percent of the policy underwriting is performed by agencies, whereas the remaining 10% is done directly by the sales personnel of the company. The company specializes in ''elementary'' insurance branches (branches other than life and health insurances). Like most elementary insurance companies, most of its revenues (about 80%) are obtained from ''accident'' and ''fire'' policies.

The top management of Halk Sigorta was concerned about two potential problems. The first one had to do with the fact that the company exhibited a fast growth between 1988 and 1993, followed by persistent stagnation and even a slight decline. In 1996, after three years of stagnation, management had enough reason to believe that the problem might not be of a temporary, short-term nature. The second question raised by top management was the continuous demand by various departments for additional employees, in spite of stagnation/decline in policy sales. In order to analyze these two problems and build a simulation model to tackle them, the research team conducted numerous interviews with managers and employees and carried out extensive data analysis (both company data and market/competitor data). It was possible to obtain reliable data only after 1988, i.e. for 96 months. Results of these interviews and data analyses are summarized below:

- The dynamic data collected for most variables confirm top management's problem description: a rapid growth between 1988 and 1992-93 followed by stagnation, even a slight decline in some branches and regions. The total number of policies underwritten per year, plotted in Figure 1, shows this

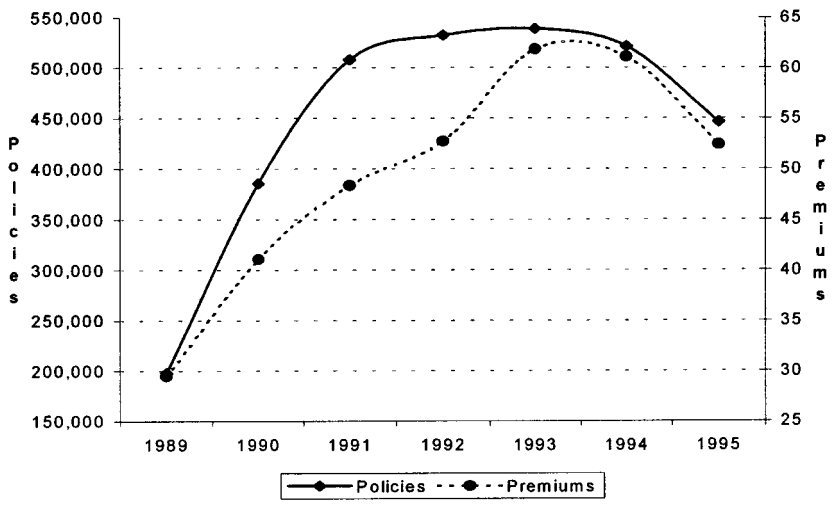


Fig. 1. Total policies underwritten and premiums (US$ millions, in 1989 constant prices)

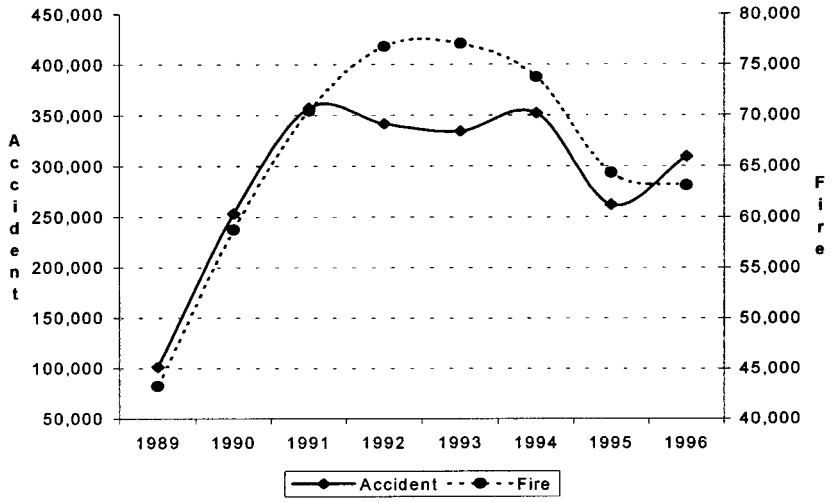


Fig. 2. Accident and fire policies underwritten

behavior. The same dynamics is observed in Figure 2, for policies underwritten in the two major departments: accident and fire. (In the fire department, the situation is worse, declining after 1993.) In Figures 1 and 3, premiums earned (in 1989 constant $ values) are plotted. We see that the total premiums (Figure 1) and accident premiums (Figure 3) exhibit the basic boom-then-stagnation behavior. (Five premiums are fluctuating, which shows that the first price per policy must have varied substantially in order to account for the discrepancy between the dynamics of policies and premiums.)

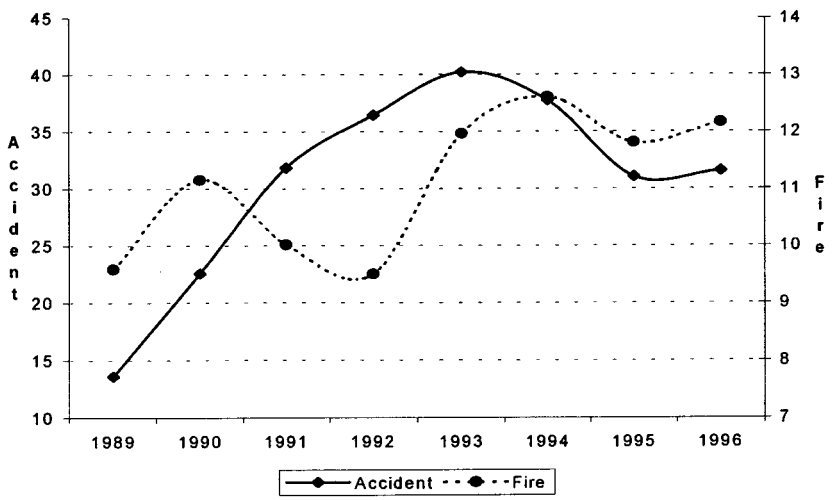
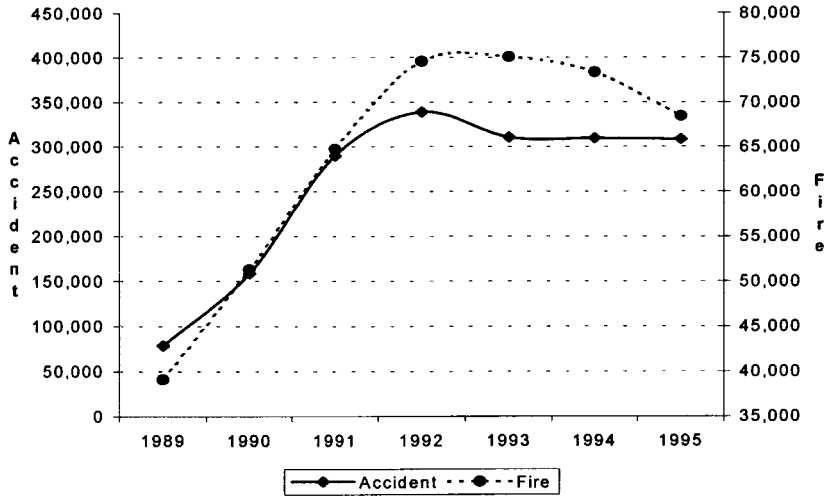


Fig. 3. Accident and fire premiums (US$ millions, in 1989 constant prices)

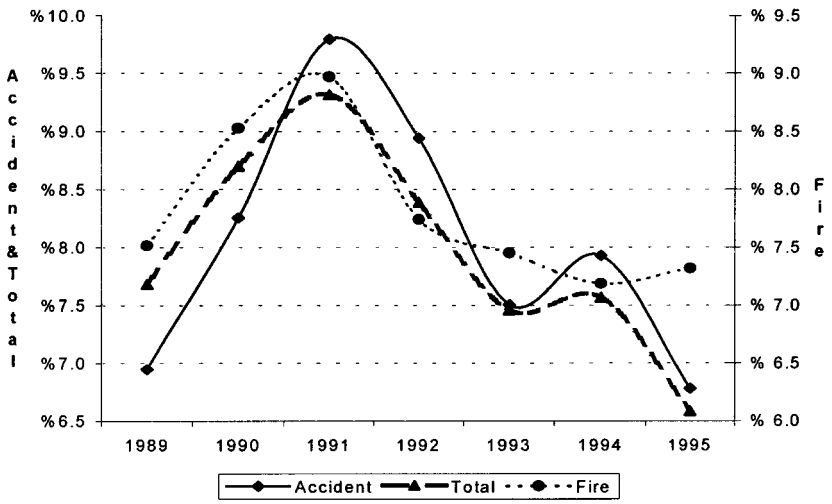
Fig. 4. Active policies (accident and fire)



Finally, in-force (active) policies naturally exhibit dynamics similar to policies underwritten per year: growth-then-stagnation (Figure 4).

- The market share of the company (measured in terms of premium revenues) also displays a growth-then-decline dynamics. The overall market share peaked at 9.5% in 1991 and gradually dropped to 6.5% in 1995 (Figure 5). One difference between the market share behavior and the dynamics of premium revenues is that the premium revenues grow until 1993 (Figure 1). This discrepancy indicates that some competitors began to perform relatively better as early as 1991. The fundamental dynamics of the market share in the

Fig. 5. Market shares



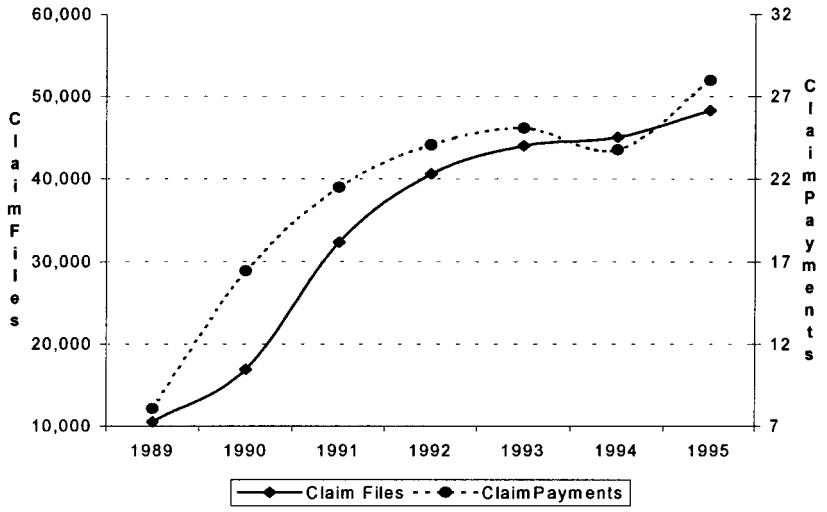


Fig. 6. Total claim files and claim payments (US$ million, in 1989 constant prices)

two major branches, accident and fire, is also the basic growth-then-decline pattern (Figure 5).

- On the ''expenditures'' side, one would normally expect a similar growth-then-decline behavior from the ''clients'' files and claims payments. But data plotted in Figure 6, 7 and 8 tell a somewhat different story: The number of claims files exhibits a mild growth, even after 1993, both in total claims (Figure 6) and in accident claims (Figure 7). This points to a potential problem—in terms of ''quality'' of policies—for the company. As for the claims payments seen in Figures 6 and 8, they boom until 1992 and then display a

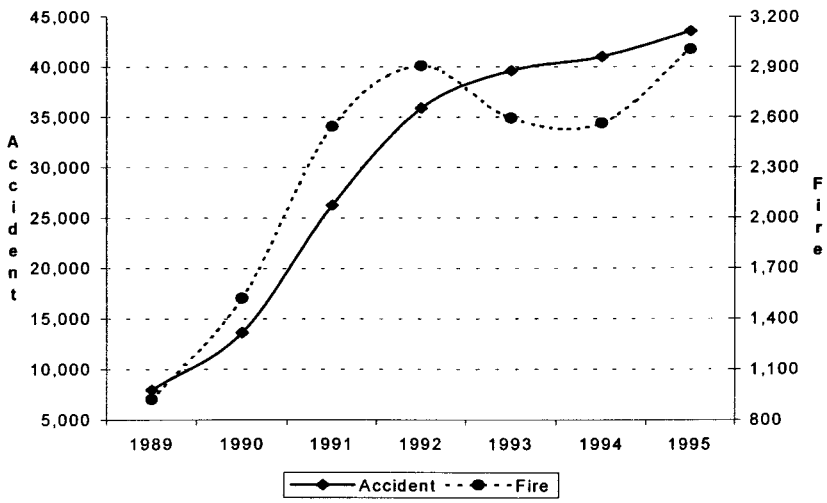


Fig. 7. Accident and fire claims

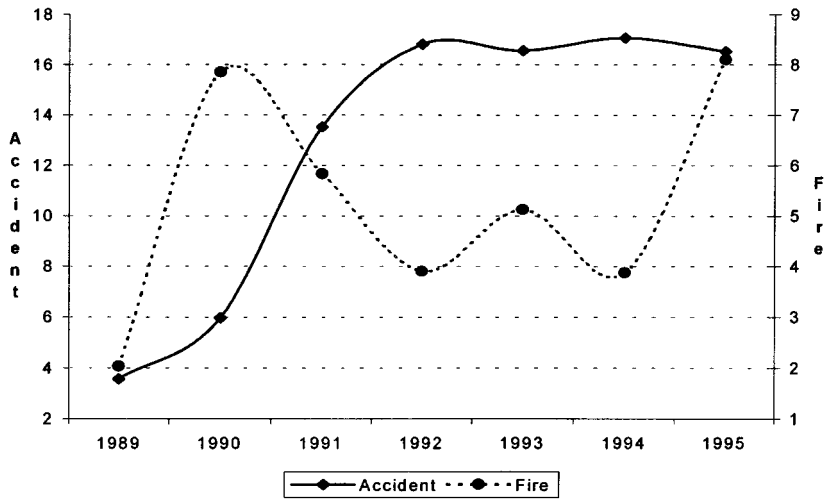


Fig. 8. Accident and fire claim payments (US$ millions, in 1989 constant prices)

mild growth (in accident and in grand total). Again, this indicates a potential problem in terms of profitability after 1992. (Fire payments are on the other hand very unstable, owing to high variability in fire losses.)

- The basic ''growth-then-stagnation'' dynamics of the company is also observed in the ''workplace'' and ''agency'' numbers. (''Technical'' workforce refers to the workforce in each branch department such as accident, fire, etc., in the claims department, in marketing and direct sales, in finance, in automation and in regional branches.) Figure 9 shows that workforce and agency numbers both display a fast growth followed by a rather flat dynamics.
- Certain measures of ''productivity'' of the company are examined in Figure 10. The productivity of agencies (policy/agency) exhibits a sharp increase between 1989 and 1991, then stabilizes at around 850 and finally drops down to 650 in 1995. A global performance measure for the workforce could be ''premiums/workforce'' as seen in Figure 10. Its behavior is similar to that of agency productivity, except that premiums/workforce exhibits a two-phase growth: one in 1989–90 and one in 1992–93. Finally, a typical strategic performance measure used by insurance companies is the ''loss ratio'', defined as ''claim payments/premiums earned''. Naturally, a company would like to keep this as low as possible and certainly not above unity. Overall loss ratio and accident loss ratio plotted in Figure 11 are at satisfactory levels (around 50%), although they have both been increasing over the years. Fire loss ratio is rather unstable, owing to the high variability in both policy prices and claim payments, as noted above.
- Top management's question: ''why do various departments keep demanding

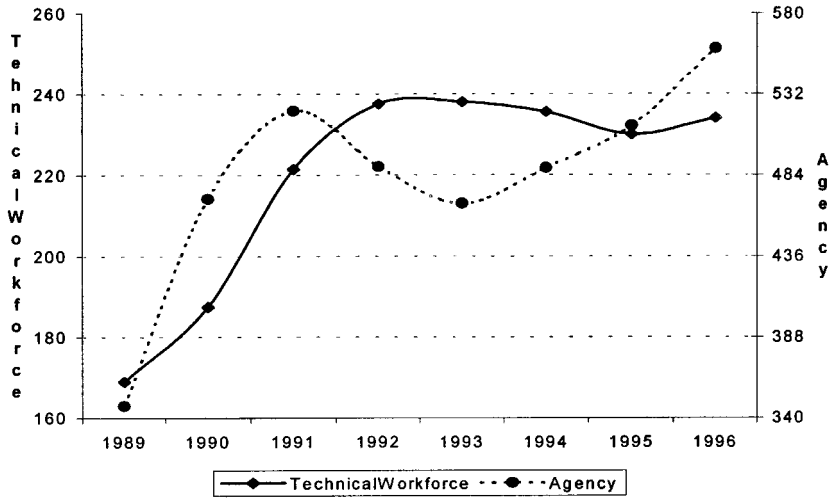


Fig. 9. Technical workforce and agencies

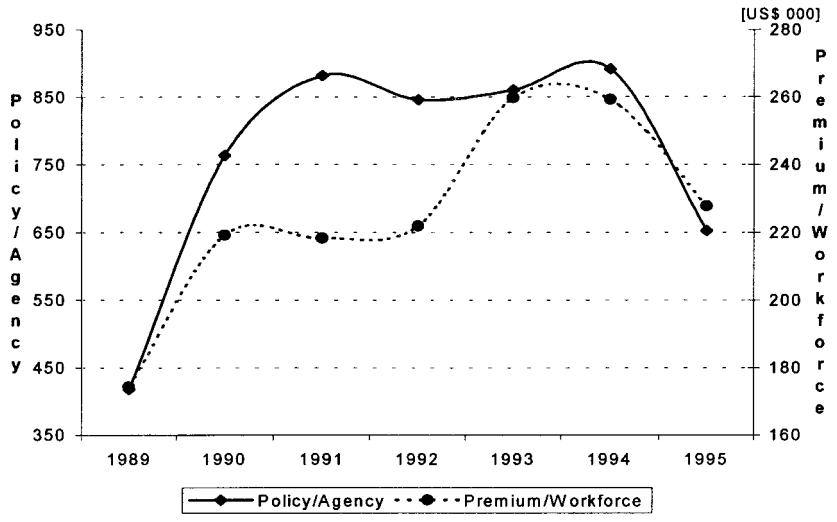
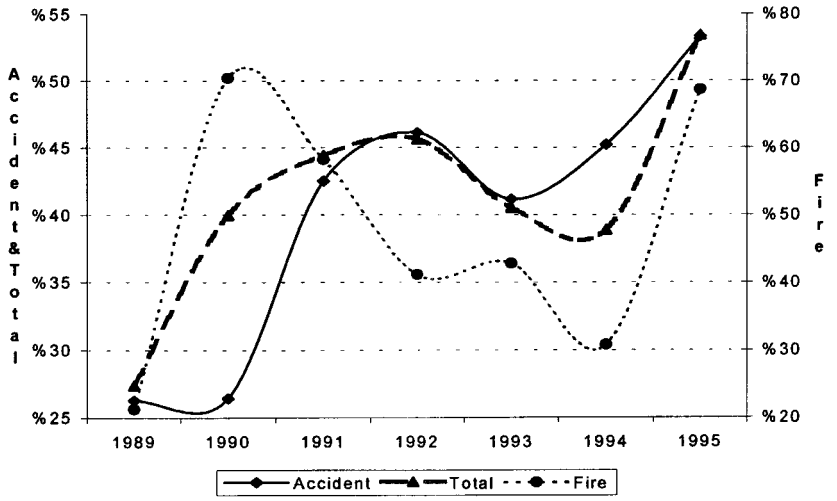


Fig. 10. Productivity ratios

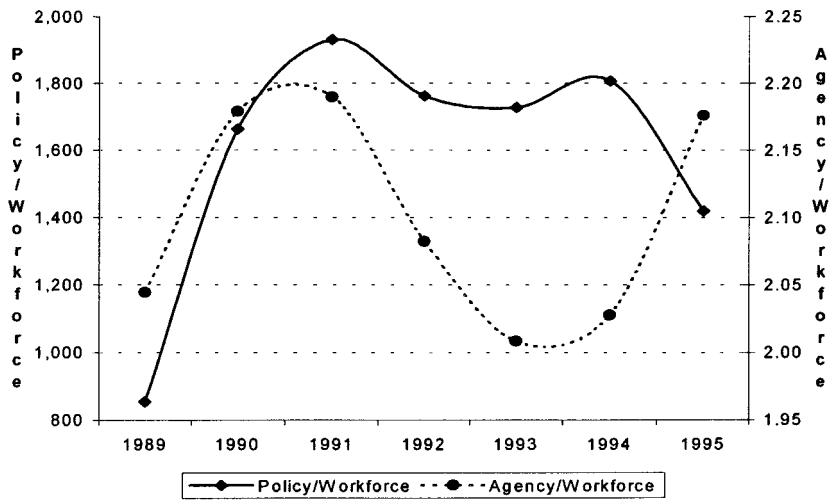
additional employees, in spite of the stagnation/decline in policy sales?'' has several potential answers: In the claims department, the need for additional workforce can be explained by an increase in the claim files, as already seen in Figure 6 and 7. However, in the technical branch departments (such as accident and fire), the policy sales (i.e. the workload) have been declining. The workforce need must then be explained by some other ''hidden'' workload. One such implicit workload discovered in this study is the ''Agency/Workforce'' ratio. A major daily routine performed by the technical workforce

Fig. 11. Loss ratio



is to answer the questions asked by agencies—by telephone or in actual visits. The employees that we interviewed stated that they spent a significant amount of time ''serving'' the agencies. Thus, in addition to the policy volume, the agencies in themselves constitute a workload. In Figure 12, observe that the ''Agency/Workforce'' ratio has increased in the past three years. (Finally, another related fact, not shown in graphs, is that, although the total technical workforce remained almost constant over the past five years, the low-level workforce has decreased from about 150 to 125, while the middle-man-

Fig. 12. Work intensity ratios



agement numbers have increased. It could be that there are ''too many chiefs, not enough indians'' in the company.)

Most of the above observations/problems are supported by data and some are confirmed by interviews with employees and managers. These problems are of a *dynamic feedback* nature (primarily characterized by a boom-then-stagnation or decline). Dynamic feedback problems are chronic problems caused by an inadequate internal structure (such as declining market share caused by an inadequate marketing policy) rather than being purely dictated by an external force (such as an extraordinary competitor). System dynamics methodology is very powerful in dealing with dynamic feedback problems. (The methodology has had previous applications in insurance management: Senge (1987) reports using system dynamics in the analysis of ''claims'' management problems and Doman *et al.* (1995) presents an application of the method to strategic life insurance management.)

Structure of the model

A key decision made in the early phases of the project was to model the company in two parts: Istanbul (central region) and Regions (all other regional divisions). Istanbul and all other regions combined perform almost equally in terms of total number of policies and premiums. Another decision was to take the simulation time unit as one month. The model was built as a discrete one, so that the simulation step DT was also fixed at one month.

The company is modeled in 10 major segments some of which are similar structurally: *Istanbul Accident, Istanbul Fire, Istanbul Claims, Istanbul Agencies, Regions Accident, Regions Fire, Regions Claims, Regions Agencies, Marketing* and *Finance. Accident, Fire, Claims* and *Agencies* segments for Istanbul and Regions are very similar in structure but have different parameters. Furthermore, *Accident* and *Fire* segments are also quite similar, with some minor structural and parameter differences; we may call these ''policy'' segments. In summary, the broad generic structure of the model can be discussed under five headings: *Policies (Accident or Fire), Claims, Agencies, Marketing and Finances.* Such a generic structural summary of the model (several times simpler than the actual one) is given in Figure 13.

Policies (Accident and Fire) segments are the parts of the model where policies are underwritten and maintained. The upper left portion of Figure 13 summarizes this process: policies are underwritten, they maturate through three stages and are finally renewed or cancelled. (The reason for having dif-

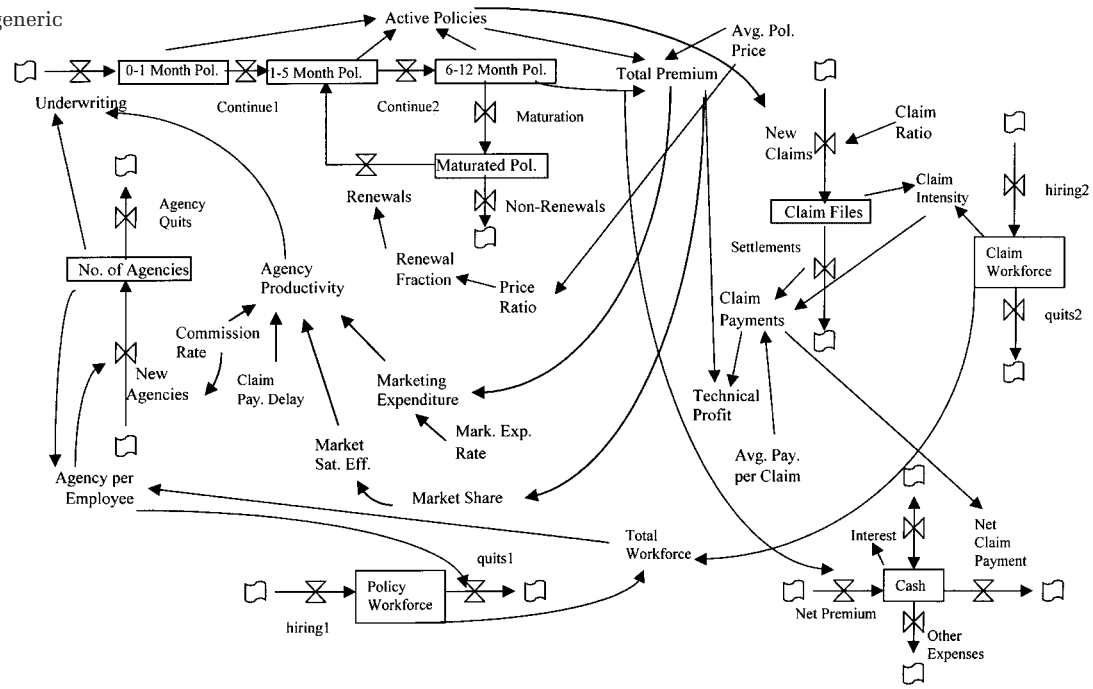


Fig. 13. Broad generic structure of the insurance model

ferent stages is that customers must pay a down payment in their first month and then pay the rest of the premium in five installations over the next five months). Finally, ''Policy Workforce'' at the very bottom in Figure 13 is also part of the *Policies* segment.

Since 90% of underwriting is performed by the *agencies*, they play a very important role in the system. The number of agencies, as well as their productivity, determine the business volume of the company. Agency productivity depends on ''Commission Rate'', ''Claims Payment Delay'', marketing done by the company and finally the ''Market Saturation Effect'' (the closer the market to full saturation, the harder to sell new policies). These influences are shown in the left portion of Figure 13. The influences determining the dynamics of the number of agencies are also represented in the same segment. Agency opening and closing decisions are made dependent on sales volume or profitability of the company and the ratio agencies/employees. This means that, for new agencies to open, the company must not only be profitable enough, but it must also have enough employees to provide the minimum service needed by the new agencies. Otherwise, new agencies constitute an undesired workload for the company employees and both parties become dissatisfied (as discussed above, in the ''problems'' section).

In the *Claims* segment, the structure of claims files generation as a function of the total active policies and the processing rates of these claims and payments are handled. The relationship between the ''Claim Workforce'' and ''Claim Files'' is important in this process, as it determines the speed and quality of ''claim settlements'. This segment is summarized on the right of Figure 13.

The structures and parameters of the market, such as market expansion rate (due to new cars sold and houses constructed), market shares, market saturation level, price and marketing expenditures, are handled in the *Marketing sector* (summarized in the middle of Figure 13).

Finally, the monetary aspects of policies and claims are handled in the *Finance* segment. The premium revenues and claim payments, as well as financial costs and revenues are calculated in this sector. (Premiums and claim payments of the other insurance branches such as *transportation, agriculture* and *engineering* are treated here as simple percentages of *accident* and *fire* policies.) The *Finances* segment is summarized in the lower right-hand portion of Figure 13.

Validation, experimentation and results

Validation of system dynamics models has two major aspects: *structure* validation and *behavior* validation (Barlas 1996). Structure validation means to demonstrate that the model's internal structure (set of relationships) is a good enough description of the real system, with respect to the problems of interest. *Behavior* validity means that the output behavior of the model is close enough to the real dynamic behavior. The structural validation of the insurance model was carried out by numerous logic, extreme-condition, sensitivity and boundary tests (Barlas 1996). The qualitative and long nature of these tests makes it impossible to show the results in the context of such an article. We simply state that the model was found to be structurally reliable and show some results that demonstrate its behavior validity.

The model parameters and input functions were estimated and behavior validation was carried out using numerous real data for the seven years from 1989 to 1995 (in some cases 1996). In Figure 14, the accident and fire policies underwritten by the company and those generated by the model are plotted. Note that in both branches, the fundamental behavior (boom-then-stagnation) of policy sales is fairly well captured by the model. There is also a reasonable numeric fit between the real and model-generated behaviors, although there are of course significant discrepancies on a point-by-point basis. (System dynamics type *ex ante* simulation models are not expected to produce point-by-point forecasts; see Barlas 1996.) In Figure 15, total premiums earned by

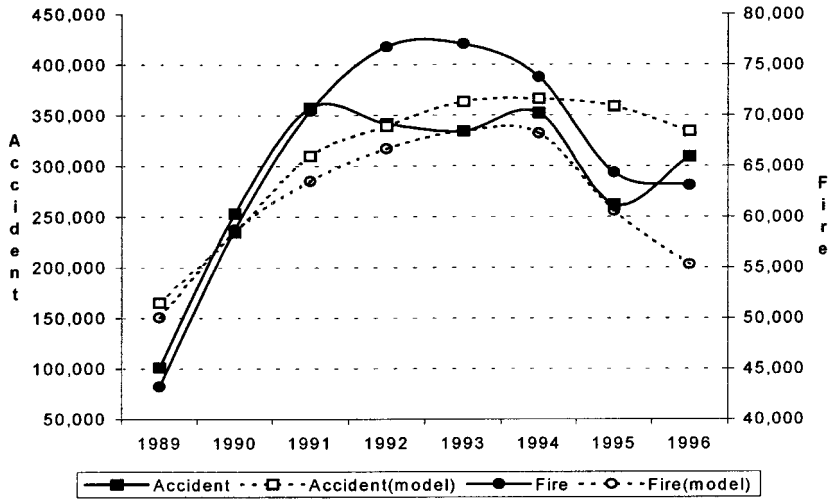


Fig. 14. Accident and fire policies underwritten

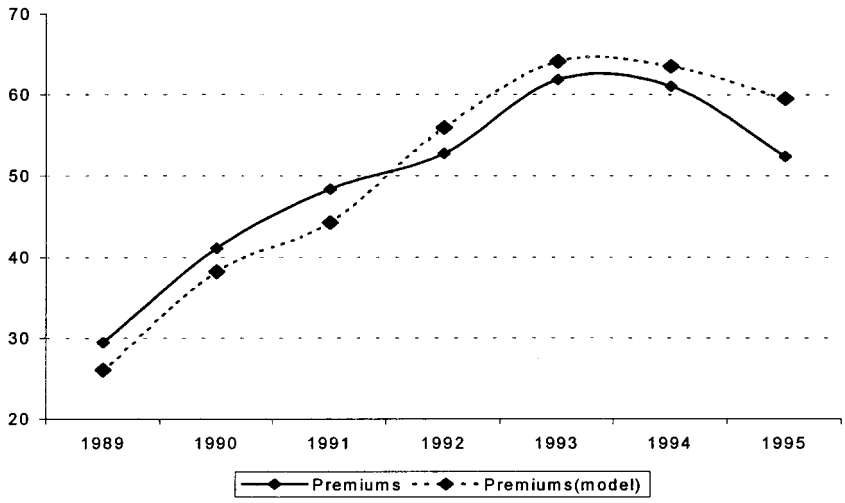


Fig. 15. Total premiums (US$ millions, in 1989 constant prices)

Halk Sigorta and those generated by the model are plotted. There is again a fairly good match between the two behaviors. The premiums earned by branches are plotted in Figure 16. The premiums generated by the model, plotted on the same graph, display very good resemblance to the real data, both in fire and in accident branches. The total market share of the company is given in Figure 17. Although the model slightly overestimates the real market share in the early years and slightly underestimates it in later years, the fundamental dynamics is well captured. On the expenditures side, the total claim payments are plotted in Figure 18, where we once again observe a good fit. Finally, the

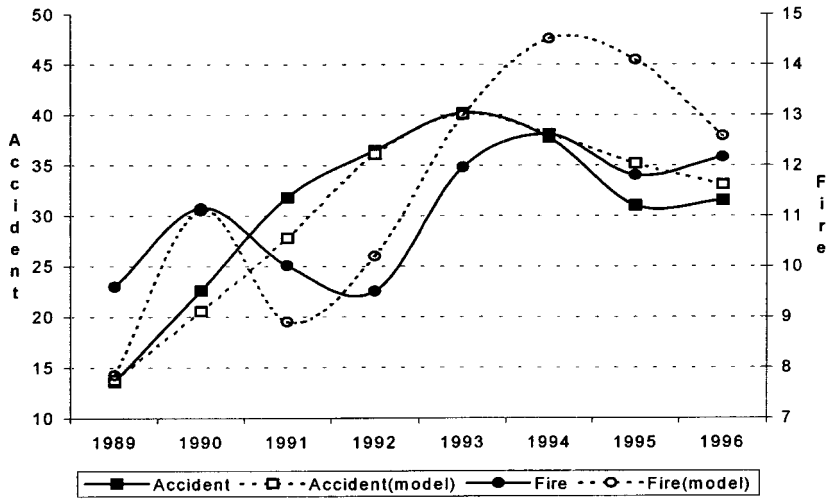


Fig. 16. Accident and fire premiums (US$ millions, in 1989 constant prices)

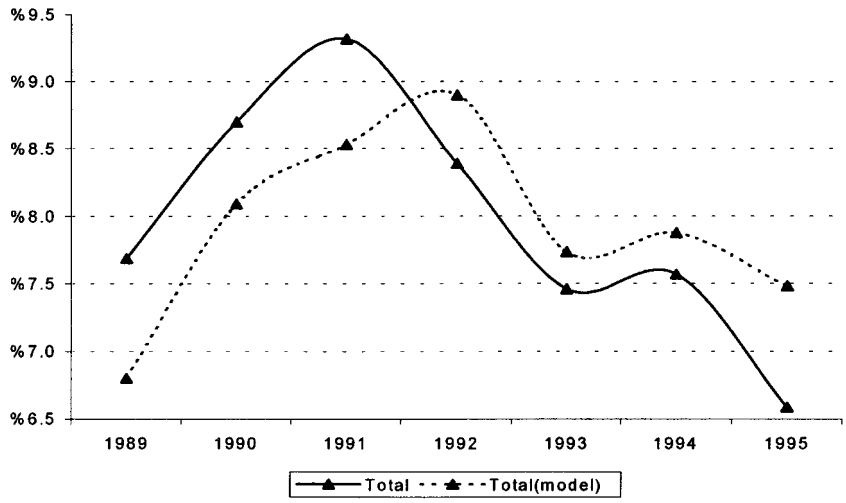


Fig. 17. Market shares

technical workforce and agency numbers are plotted in Figure 19. Although there are some significant differences on a point-by-point basis, we can again state that the fundamental dynamics match reasonably well. The model exhibits more or less the same level of acceptable behavior validity with respect to some other variables; we omit them in this article to avoid repetition. Overall, the model demonstrates a good level of both structural and behavior validity.

Numerous simulation experiments were carried out on the model in order to find some answers to the problems listed above. Simulation results showed what factors have caused stagnation/decline and how to avoid a similar decline

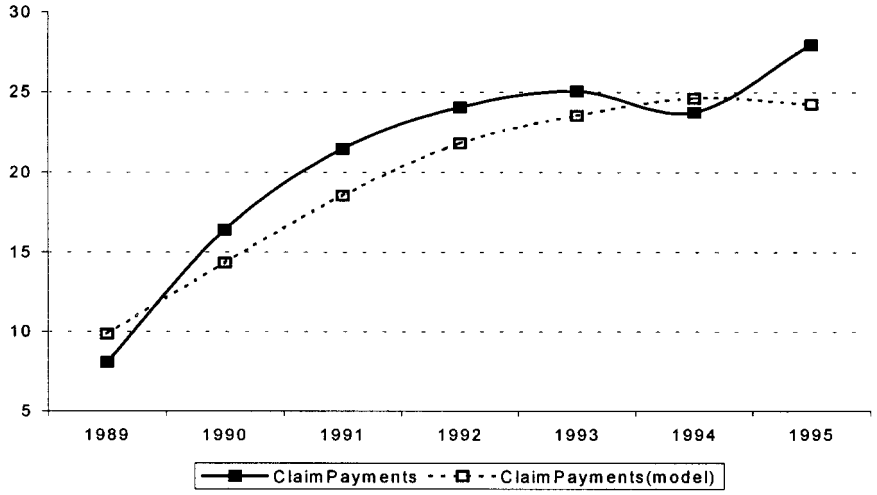


Fig. 18. Total claim payments (US$ millions, in 1989 constant prices)

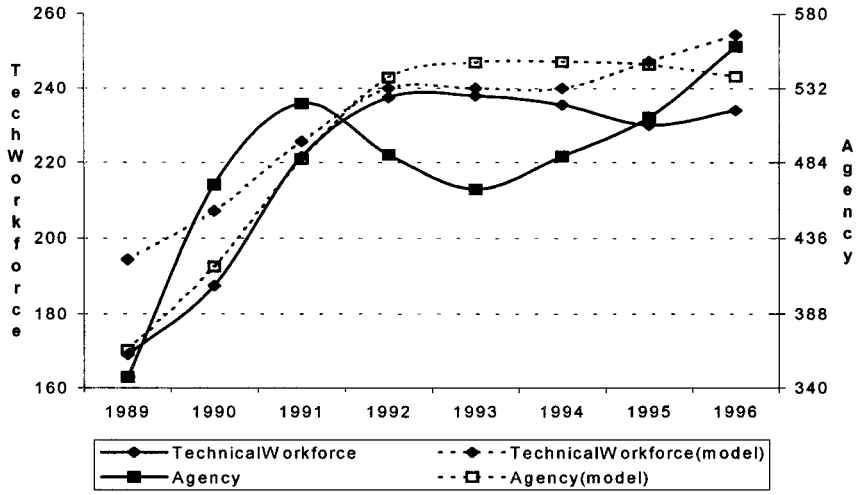


Fig. 19. Technical workforce and agency numbers

in the future. It was concluded that achieving another growth phase and sustaining would be extremely difficult and hence not necessarily desirable. The main results can be summarized as follows:

- In the current structure, the production depends heavily on the agencies. Therefore, for an increase in policy sales/market share, either the number of agencies or the productivity per agency should be increased. Increasing the number of agencies is not an easy solution. There exists a threshold ''agency/employee'' ratio in the sector, which changes between one and two. This ratio means that each agency not only sells policies, but also takes away from

company's own resources by asking frequent questions, visiting company employees etc. If this threshold is exceeded, the agencies are no longer profitable for the company and they basically create an unnecessary workload for the company employees. Therefore, an agency-dependent growth becomes quickly unprofitable, since it requires excessive employee hiring as well.

- Increasing the productivity per agency is not easy either. The productivity of an agency depends on many factors, such as policy price, advertisement and market saturation effect, in addition to its own quality. In order to overcome the market saturation effect, advertising and price reduction strategies should be implemented simultaneously, which may not be profitable. A better strategy for the long term is to start a high-quality agency fleet training program. This would not only increase the agency productivity, but also push the critical ''agency/employee'' threshold upward, since higher-quality agencies would need less help from the company workforce.
- Another suggested strategy is to make the company's policy production less dependent on agencies and more on company's own employees. Such a shift to ''direct sales'' can be achieved by means of the telephone, ATMs, Interactive TV and the Internet. The process must start with training a pilot sales team within the company.
- The renewal percentage of the existing policies is not high ($\approx 60-70\%$). Studies should be carried out to increase the renewal percentage. This is one area where the policy volume can be increased by the company's own workforce, being relatively less dependent on agencies.
- The demand for additional employees by various departments has been discovered to be partly caused by the steady increase in the number of people in managerial positions. It seems that some managerial positions have been created just to promote people, which means a relative reduction in the number of employees who do the daily routine work. To reverse this trend, hierarchical layers must be reduced and the ''artificial' managerial positions must be gradually eliminated. Other promotion and incentive mechanisms must be established.

Conclusion

This simulation-based systemic management consultancy project proved to be useful both for the client and for the analyst team. The main benefit of the model is that it generates a systemic and dynamic understanding of the company's internal and external interactions, so as to enable creative solutions for existing and potential problems. It must be emphasized that the learning that

has occurred during the modeling process itself was extremely valuable. Some of the findings were obtained as a result of simulation experiments and analysis, but other results were already obtained in the earlier phases of model building. As a result of policy runs, a few policies that proved to be particularly effective and robust to alternative assumptions were identified. The model, together with all the findings and recommendations, was submitted to the company. One of the recommendations—gradually switching to ''direct sales by company workforce''—has been initiated as a pilot project in the company.

A new *interactive gaming* version of the model is in the final stages of completion. It promises to be a useful educational and decision-making platform for the company. The model and the game version can be used as a ''learning laboratory'' in the company, which will be a first step toward ''organizational learning''.

References

Barlas Y. 1996. Formal aspects of model validity and validation in system dynamics. *System Dynamics Review* **12**(3): 83–210.

Barlas Y, Çırak K, Duman E, Uzunosmanoglu G. 1997. System dynamics approach to problem solving in an insurance company. *Proceedings of the 15th International System Dynamics Conference*; 689–692.

Doman A, Glucksman M, Mass N, Sasportes M. 1995. The dynamics of managing a life insurance company. *System Dynamics Review* **11**(3): 219–232.

Senge PM. 1987. Catalyzing Systems Thinking within Organizations. MIT Working Report, MIT, Cambridge, MA.