WORKLOAD FLUCTUATION IN MANAGEMENT CONSULTING FIRMS

BY

HENRY BIRDSEYE WEIL

Submitted in Partial Fulfillment
of the Requirements for the
Degree of Bachelor of Science
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
June, 1965

Signature of Author .................................................................
Alfred P. Sloan School of Management, May 21, 1965

Certified by .................................................................
Thesis Supervisor

Accepted by .................................................................
Chairman, Departmental Committee on Theses
Workload Fluctuation in Management Consulting Firms
by Henry Birdseye Weil

ABSTRACT
Submitted to the Alfred P. Sloan School of Management on May 21, 1965, in partial fulfillment of the requirements for the degree of Bachelor of Science.

This thesis investigates the problem of workload fluctuation in management consulting firms. It employs the Industrial Dynamics technique to look deeply into the internal operations of a firm and identify such causes of workload instability as too short an average case length. A consulting firm's reputation, the way in which it acquires prospective clients, and the delays in changing the level of work in house also affect the stability of its workload.

The thesis then examines alternative methods of consulting firm management. Allocation of professional staff to the case work, proposal writing, and promotion functions on a priority basis leads to instability. Organization around a separate promotional group, on the other hand, yields a more stable workload, but inhibits the consulting firm's growth.

Thesis Adviser:  Alexander L. Pugh III
Title:  Research Associate
To: Professor William C. Green,
Secretary of the Faculty,
Massachusetts Institute of Technology

In fulfillment of the requirements for the Bachelor of Science Degree in Industrial Management, I herewith submit a thesis entitled "Workload Fluctuation in Management Consulting Firms."

I should like to take this opportunity to thank my supervisor Alexander L. Pugh III for his invaluable assistance throughout the course of this thesis.

Henry Birdseye Weil
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>2</td>
</tr>
<tr>
<td>Letter of Transmittal</td>
<td>3</td>
</tr>
<tr>
<td>Table of Figures</td>
<td>5</td>
</tr>
<tr>
<td>Author's Note</td>
<td>6</td>
</tr>
<tr>
<td>I. An Introduction to the Problem</td>
<td>7</td>
</tr>
<tr>
<td>II. The System in Brief</td>
<td>10</td>
</tr>
<tr>
<td>III. A Dynamic Hypothesis</td>
<td>15</td>
</tr>
<tr>
<td>IV. A Summary of Conclusions</td>
<td>17</td>
</tr>
<tr>
<td>V. The System in Depth</td>
<td>21</td>
</tr>
<tr>
<td>VI. Analysis &amp; Conclusions</td>
<td>26</td>
</tr>
<tr>
<td>Appendix 1 - An Industrial Dynamics Model of the System</td>
<td>36</td>
</tr>
<tr>
<td>Appendix 2 - Computer Simulation Runs</td>
<td>50</td>
</tr>
<tr>
<td>Appendix 3 - A Complete Flow Diagram of the ID Model</td>
<td>64</td>
</tr>
<tr>
<td>Appendix 4 - Footnotes</td>
<td>66</td>
</tr>
</tbody>
</table>
# TABLE OF FIGURES

<table>
<thead>
<tr>
<th>Figure No.</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>41</td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>45</td>
</tr>
<tr>
<td>9</td>
<td>51</td>
</tr>
<tr>
<td>10</td>
<td>52</td>
</tr>
<tr>
<td>11</td>
<td>53</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
</tr>
<tr>
<td>13</td>
<td>56</td>
</tr>
<tr>
<td>14</td>
<td>58</td>
</tr>
<tr>
<td>15</td>
<td>59</td>
</tr>
<tr>
<td>16</td>
<td>61</td>
</tr>
<tr>
<td>17</td>
<td>62</td>
</tr>
<tr>
<td>18</td>
<td>63</td>
</tr>
<tr>
<td>Complete Flow Diagram of ID Model</td>
<td>65</td>
</tr>
</tbody>
</table>
AUTHOR'S NOTE:

The relationships and numerical values found within this thesis are the product of extensive discussions with people in, and very closely associated with the consulting field.

H.B.W.
"CONSULTANTS CAN RENDER A REAL SERVICE TO MANAGEMENT. BUT THE BEST SERVICE OF ALL IS THE ONE WHICH THEY RENDER TO THEMSELVES."

"Fortune", February 1965, p. 138

I. AN INTRODUCTION TO THE PROBLEM

There exists among management consulting firms a remarkable paradox. They are playing increasingly crucial roles as advisors to all segments of the economy, yet, at the same time, many of the best are having trouble with internal management.

The most pressing internal problem for many consulting firms is a highly variable workload. At some times, a firm might be so busy that everyone is working sixteen hours a day. Deadlines must be extended; there is a temptation to do a less than perfect job. A few months later, however, there may be little work in house, and extra effort must be expended to
bring the workload up to normal.

Why is this important to the consultant? Consulting firms, though very profitable when times are good, are basically high-cost operations. Professional staff costs are quite large, with the most senior members drawing especially healthy salaries. Overhead is high, considering the libraries, computers, print shops, and secretarial staffs found in most large consulting firms. Promotion, too, is very expensive. It generally involves travel and often speculative presentations by the firm's staff.

Obviously, the key to profitable consulting is a steady inflow of new business. Staff size cannot be changed rapidly to follow a fluctuating workload, and idle personnel are very costly. In addition, a steady workload allows better planning, yields a more efficient operation.

A fluctuating workload is important not only to consulting firms but to their clients as well. Internal problems in the consulting firm might mean a delay in completing an important job. They might — especially when the consulting firm's staff is very overloaded — result in compromised quality.

The consultant's fluctuating workload, however, is not a "problem" in the classical sense. Rather, it is a symptom, superficial evidence of a basic underlying fault. One must,
therefore, take a deep look into a consulting firm and its operations to uncover the real problem causing these fluctuations. Specifically, the inflow of business into a consulting firm is directly affected by the policies of its management, and some policies, obviously, must be better than others.

The objective of this study is to analyze the internal management policies of a consulting firm and explain the ways in which they can interact to produce a fluctuating workload. The policies employed by other firms will then be studied; policy changes will be recommended which will lessen, if not cure, the problem.
II. THE SYSTEM IN BRIEF

Defining the problem led to the conclusion that it somehow sprang from the interaction of management policies. It is best, however, to describe in general terms the workings of a consulting firm before presenting a hypothesis of cause and effect. This will serve as both a frame of reference for the hypothesis and conclusions and a point of departure for a more detailed description.

Since there are many ways of running a consulting firm, it might, at first glance, appear quite difficult to be meaningfully specific. This will be accomplished by first considering a "model" which, with minor variations, applies to many firms and then comparing it with the major alternatives.

As a consulting firm finishes the work in house and finds new clients, the cases appear to move through in what resembles a flow. From the universe of all possible clients, the firm, through its promotional efforts, attracts "prospective work": companies (or other users) who are interested in retaining it.

The next move is up to the consultants, for if they make a preliminary study and write a proposal for each prospect outlining problems and a line of attack, there is a chance that the prospects will agree to sign contracts with the firm. If, on the other hand, a prospective client is made to wait
an unreasonable length of time for a proposal, he will grow impatient and go elsewhere for assistance.

Because prospective clients do not accept (or reject) proposals instantaneously, there is usually an amount of "work proposed for and pending a decision" outstanding. The fraction of this which eventually comes to the consulting firm depends on proposal quality, while the decision time varies from situation to situation. When a proposal is accepted, proposed work becomes "work in house" and remains so until the case is completed. (refer to Figure No. 1 for a diagramatical representation of the flow)

What controls the flow of work? As was mentioned before, the consulting firm's promotional effort is (after some delay) a major determinant of the inflow of prospective work -- the prospect acquisition rate. The rate at which proposals are written (and their quality) determines the inflow of work for the consulting firm, while the case completion rate determines its outflow.

The allocation of a consulting firm's relatively fixed professional staff among three activities -- promotion; proposal writing; and working on cases -- determines the magnitudes of the rates mentioned above, and management policies dictate how this is done. As a specific yet commonly seen example, consider a priority system which allocates manpower,
Figure No. 1
as needed, to case work, proposal writing, and promotion in that order.

Reference to Figure No. 2 will reveal the "feedback" nature of this simple system of interacting elements. Promotional and proposal writing effort determine (after delays) the level of work in house. The amount of work in house sets the personnel requirements for case work, and, thereby, the excess available for proposal writing and promotion.
Figure No. 2
III. A DYNAMIC HYPOTHESIS

Given the flow of work through a consulting firm and its control by management's manpower allocation policies, how does this produce the symptomatic behavior: a fluctuating level of work in house?

Imagine a situation in which the consulting firm is terribly overloaded with work. According to management's priorities, all available personnel would be working on cases, and this, of course, means that there is no one promoting or writing proposals.

As the level of work begins to shrink, people become available for these functions, but their efforts produce no immediate new work for three reasons:

1. the delay in realizing the effects of promotion;
2. the delay inherent in writing proposals;
3. the time needed by a prospect to decide on the proposal written for him.

Thus, the consulting firm's workload will continue to decline, freeing more people and leading to additional promotion and proposal writing.

This decline can continue for many weeks before the first proposals are accepted and the firm's workload begins to rebuild. During the slack period, quite a number of the firm's
staff are promoting or working on proposals; the result is a large amount of "work proposed for and pending a decision".

As the first new proposals are accepted, the level of work in house rises -- and continues to do so as more new contracts are signed. More effort is needed for casework, so promotion is restricted. Proposal writing for prospective clients continues, however, replenishing the level of proposed work outstanding. Finally, work in house grows to the point where proposal writing must be restricted too, or even halted -- yet it continues to grow because there is no way to call back the proposals outstanding and many are being accepted.

Thus, another overload situation develops, and the cycle begins over again. Viewed in this way, the priority system of manpower allocation is obviously the "problem", the cause of workload fluctuations. Subsequent detailed analysis, however, will show exactly where the fault lies.
IV. A SUMMARY OF CONCLUSIONS

After some necessary refinement, the system discussed in the preceding sections was formulated as an Industrial Dynamics computer simulation model to facilitate a detailed analysis of its behavior. (refer to Section V and Appendix I)

The use of a computer is an efficient way to portray complex interactions over extended periods of time; even the most active imagination cannot grasp without help the many subtleties of a system such as this. Specifically, the computer permits controlled experimentation, since everything can be held constant except one factor, and the effects of its variation studied.

The following is a description in brief of each major series of computer simulation runs; where appropriate, a more detailed treatment will be found in Section VI:

1. The objective of the first series was to identify the factors which controlled the system's stability and to determine why they are important. It was first thought that lengthening any delay in the system would decrease its stability, for it seemed reasonable that any slowing of the workload's response to attempted changes would aggravate the oscillatory tendencies. This, however, proved to be a faulty assumption.
Simulation revealed that the critical variable in determining system stability was not any one delay, but, rather, the ratio of the delay in acquiring new business to the average case completion time. The larger this number (i.e. the shorter the average case length, since the acquisition delay is largely beyond the consulting firm's control), the less stable the system.

The reason why case length affects stability is most easily seen when one considers an absurd example, the one-man consulting firm. If it takes him one month to find a new client, he is obviously in a more stable situation with one year cases than taking on short two-week jobs.

The implication for a large consulting firm is quite clear. It should, whenever possible, strive to increase the average length of the cases in house. The consulting firm can, of course, take on shorter cases without compromising stability if it somehow reduces the delay in acquiring new business. In particular, shortening the prospect's proposal decision time would greatly reduce the system's oscillatory tendencies.

2. The second series investigated the significance of unsolicited demand (i.e. instances in which the consulting firm's reputation draws prospects without any promotion on its part).
A small, but identifiable relationship was found to exist between system stability and the fraction of prospects which are unsolicited. While really more complex, the basic relationship is a decrease in the amplitude of fluctuations as the fraction of unsolicited demand grows. As unsolicited demand increases, the level of prospective work is decoupled from work in house; this effectively reduces the delay in acquiring new business, making the system more stable.

The phenomenon of promotion-workload decoupling at least partially explains why old, established consulting firms might not be bothered so much by fluctuating workloads as the newer organizations. The older ones, after all, have many more unsolicited prospects.

3. The third series of runs represents a first look at an alternative manpower allocation policy -- a separate promotional staff instead of the homogeneous workforce considered so far. At this point, the alternative policy poses a real dilemma. Exceedingly more stable than straight allocation by functional priorities, its use nonetheless inhibits the normal growth of a consulting firm (see Section VI). The last series, however, demonstrates the advantages of such a policy.

The stability of the "constant promotion policy", of course, results from the high level of prospects it insures.
It has been shown that any reduction of the new business acquisition delay has this effect on the system.

4. The fourth series of simulation runs is undoubtedly the most important, for it compares the behavior of variable and fixed promotion policies under the assumption of a continually changing demand for consulting services.

Here, the "constant promotion policy" demonstrates a startling advantage over its alternative in the realm of stability, yet still acts as a dampener on growth (again see Section VI). Thus, the management of a consulting firm, if it chooses to have a separate promotional group, should be fully aware of its implications.
V. THE SYSTEM IN DEPTH

Section III served as an introduction to a "consulting firm system", yet it was superficial in many respects. The flow of case work, for example, was described well, but its controlling functions require additional explanation. In addition, another important factor has received only the slightest of attention up to this point -- the consulting firm's reputation and the determinants of its value.

The first control function in the flow of case work is the prospect acquisition rate; this is determined by the demand for the firm's services. There are two types of demand: the demand due to promotion and the unsolicited demand which results from a good reputation, both of which can be measured in terms of market share. In the first three series of runs, the total demand for consulting services was assumed constant, while subsequent runs investigated cyclical and random patterns (see Section VI).

Turning now to the other end of the flow, the case completion rate depends on the effort devoted to cases. The required effort, of course, varies with the amount of work in house and the desired completion time (average case length), while management's "allocation by priority" policy dictates that effort devoted to cases equals effort required, so long
as this is less than the consulting firm's total staff.

The firm's proposal-writing activities have first call on any excess after case work requirements have been met. Two factors determine the effort required for proposals:

1. the level of prospective work (i.e. the number of prospects awaiting proposals);
2. the desired writing time.

This requirement is filled in full, so long as it does not exceed the excess from case work.

If there is any idle manpower after case and proposal needs are satisfied, its effort is devoted to promotion. This, after a delay, determines the demand due to promotion; it also, as was mentioned previously (and shown in Figure No. 2), completes a feedback loop. Specifically, the flow of prospects determines work in house, while the level of work fixes case manpower requirements. The excess is devoted to proposals and promotion, thereby affecting the future inflow of new business.

There is, in addition to the "work flow sector", a second feedback loop in the consulting firm under consideration (please refer to Figure No. 3). Only hinted at so far, it concerns itself with the growth of the firm's reputation.

A consulting firm's reputation can be either good or bad. It develops over time as clients relate their opinions
to others and an image of the firm forms in the minds of potential users. The nature of this image depends, of course, on the degree of satisfaction received by those who actually retained the firm.

For simplicity's sake, one can equate client satisfaction with the quality of the work done for him. Quality must, in some way, vary with the amount of work in house for a firm with a fixed professional staff. More specifically, quality is apt to be very good when the consulting firm's workload is light and taper off as it becomes more and more overloaded.

A fine reputation is a valuable asset for any firm -- but why? The answer is found in the consulting firm's promotional function. As was mentioned previously, unsolicited demand is the result of possessing a good reputation. The better a firm's reputation, the greater the unsolicited demand for its services, and the less promoting it must do to keep up the level of work in house.

The increasing number of unsolicited prospects frees personnel for case work and proposal writing; leads to a higher equilibrium level of activity. Thus, the value of a reputation comes from the more efficient utilization of manpower it permits. Another reason for the value of a good reputation is the length of time needed to develop it. Usually, one is earned only through years of satisfying clients.
While discussing the importance of quality, one must not neglect the effect of proposal quality on the proposal acceptance rate. Other things remaining equal, the acceptance rate will vary directly with quality. As with case quality, proposal quality depends upon the amount of work to be done and the time it will take to do it.
VI. ANALYSIS & CONCLUSIONS

To facilitate a more meaningful discussion, the simulation runs will be divided into two main categories: analysis of the "priority policy" of manpower allocation and the investigation of alternatives. Each category is then sub-divided depending upon whether a constant or variable input was used ("input" here referring to the total demand for consulting services).

The significant findings in the first major series of runs (priority policy; constant demand) are the following:

1. The system's stability varies directly with the ratio (average case length)/(delay in acquiring new business). Defining stability as the time it takes for fluctuations to decay to one half the amplitude of the first minimum, Figure No. 4 gives a graphical representation of the relationship.

The cause of the relationship was discussed in Section IV, but, to recapitulate, the system's oscillatory tendencies spring from management's inability to quickly change the inflow of new work. It is hard to restrict the flow as work in house rises above its normal (steady state) level, and equally difficult to increase it as the level drops.

Returning to the example of the heavily overloaded
consulting firm, its workload will begin to decline over time, since the "priority policy" assigns all staff members to case work during an overload. With no effort being devoted to the acquisition of new clients, few will come in to replace those whose work has been completed.

Thus, a decline is inevitable. This will free personnel for new client acquisition, but the delays in attracting prospects, writing proposals for them, and their deciding whether or not to accept could mean many weeks before the effects of manpower reallocation are felt.

Meanwhile, the level of work is continuing to drop, and additional personnel are freed from case work. Their efforts cause the number of prospective clients to grow; the number of proposals outstanding increases too.

Oscillation occurs whenever the levels of prospective and "proposed for" work grow so large during the delay period that their subsequent emptying (particularly the acceptance of outstanding proposals) causes work in house to rise above its normal level. The longer the delay in acquiring new business, the greater this effect.

2. Even the most stable "priority policy" overshoots in its correction of an overload situation. While this behavior can, in part, be attributed to each of the delays in acquiring new business, it is the time taken by
prospects to decide on proposals that contributes most to the overshoots.

Consider a consulting firm whose reputation is so good that it need never promote to find new prospects. As its workload falls from an overload situation, freeing personnel for proposal-writing, their efforts can be immediately effective. Unsolicited demand insures an ample number of prospects for which proposals can be written.

Even this desirable state of affairs, however, will lead to an overshoot (i.e. the level of work in house first dropping well below its normal value instead of directly converging on it from an overload situation). Because it generally takes prospects several weeks to decide on a proposal, the level of in-house work will continue to decline for some time. The drop will finally begin to level off as the rate of new case acquisition approaches the case completion rate, and rise as the former exceeds the latter.

Thus, it is very difficult to avoid at least a small overshoot, given that instantaneous acceptance of proposals is impossible to achieve.

3. It was determined that the amplitude of the system's fluctuations varied inversely with the magnitude of the unsolicited demand.

The discussion of the system's tendency to overshoot
made use of an example in which a very high unsolicited demand insured the presence of prospects whenever personnel was available to write proposals. But what if there were no unsolicited demand? There would be no prospects waiting for proposals, since those acquired by pre-overloading promotion would have grown impatient and gone elsewhere for assistance. Thus, the consulting firm must first attract prospects through promotion (under the assumption of no unsolicited demand) before it can write any proposals.

The absence of unsolicited demand, therefore, greatly increases the new business acquisition delay. As was shown previously, the lengthening of this delay reduces the system's stability in just the manner observed. An additional advantage of unsolicited demand should be reemphasized at this point; it permits a higher level of case work by freeing personnel from the burden of promotion.

Turning now to the second major series of computer simulation runs, these investigated alternatives to the "priority policy" of manpower allocation (retaining the assumption of constant total demand). More precisely, they considered variations of a policy which is probably the most common after the one discussed up to now: the separate promotional group.

There are three basic variations of the "separate promotion" policy:
1. constant promotional effort over time;
2. a constant component plus the excess from proposal-writing, whenever any exists;
3. a separate, but completely variable promotional group whose effort varies inversely with the level of work in house.

No. 1 will now be discussed briefly. Consideration of the others (and No. 1's response to variable inputs) will be deferred until later in the section.

At this point, the policy of constant promotion appears to be a mixed blessing. Although startlingly more stable than the straight "priority policy", constant promotion inhibits the growth of a consulting firm by precluding any increased efficiency from the development of reputation and unsolicited demand.

The increased stability, of course, comes from the decoupling of promotion and the level of work in house. No matter how overloaded the consulting firm becomes, there will always be sufficient prospects to effectively utilize personnel who become free for proposal writing.

Under the "priority policy", however, there is no promotion when the firm is overloaded. Thus, new prospects must be found before any proposals are written. This additional delay causes the level of in-house work to drop well below
its normal level; the extensive promotion during the slack period leads to a future overload.

Because of its stability, the policy of having a separate, constant promotional effort has advantages when a consulting firm is faced with a variable demand. In a subsequent discussion, it will be shown that these advantages can outweigh the accompanying loss of growth potential.

The third series of simulation runs might be called the "raison d'être" of the entire study, for it is here that the straight "priority policy" and two alternatives are subjected to a more realistic variable total demand. This demand has two components:

1. a cyclical one with a two-year period, representing the idea that consultants are most in demand when business conditions are either very poor or booming (i.e. peaks in consulting demand would correspond to both maxima and minima of a four-year business cycle);

2. a random component representing work not directly tied to the business cycle.

The input described above caused the workload of a consulting firm employing the "priority policy" to fluctuate very badly. By making the level of prospective clients very volatile, the variable demand acts as a constraint on the
writing of proposals. After all, personnel allocated to the proposal-writing function are effective only when there are sufficient prospects awaiting proposals.

Lacking sufficient prospects, this effort will be devoted to promotion. The level of prospective work, however, will not begin to grow rapidly until the variable demand has reached a minimum and starts to rise. Then, of course, promotion becomes more efficient; it is always easier to attract new business when the demand for your services is high.

Thus, the level of prospective work will vary closely with demand, as will the number of proposals outstanding. Even if the consulting firm has the manpower available, it usually cannot write more proposals than it has prospects to receive them.

Now it is easy to see why workload, too, varies in a manner similar to demand. It is, after all, dependent on the inflow of new cases.

Two alternative policies were tested with the same input:

1. constant promotional effort over time;
2. a constant component plus whatever excess exists from proposal-writing;

and the results were startling different from the unstable behavior caused by variable promotion. With either policy,
the system oscillated less and less over time until the level of work in house was almost constant — even though demand was as volatile as ever.

Previously, constant promotion policies were called a "mixed blessing" because of the way in which they inhibited a firm's growth. This liability, however, is now the source of the system's stability.

Promotional effort being constant (or almost so in the second case), the level of prospective work will vary directly with demand. However, as the consulting firm's reputation grows, the number of prospects will rise too. This occurs because the fixed promotional effort precludes more efficient reallocations as reputation and unsolicited demand make prospect acquisition easier.

Although prospective work continues to oscillate, its mean will eventually grow to a point where even the minima are no longer constraining the proposal-writing function. Subsequently, it makes little difference how demand oscillates. The level of work in house will assume its "normal" (steady state) value, just as though there were a constant demand for consultants.

To summarize the important conclusions from these three series of computer simulation runs:

1. all other things remaining equal, the longer
the average case length, the more stable the consulting firm's workload;

2. under the straight "priority policy" of manpower allocation, a consulting firm's level of in-house work will grow with the rise of its reputation;

3. constant promotional effort will result in a much more stable workload, but little growth due to reputation increase.
APPENDIX 1
AN INDUSTRIAL DYNAMICS MODEL OF THE SYSTEM

This Appendix contains the DYNAMO\(^2\) equations of the model used for computer simulations. A brief explanation follows each listing, but it is assumed that the reader is generally familiar with Industrial Dynamics, especially such concepts as a "rate", "level", "auxiliary", "third order delay", and "initial condition".

6R PAR.KL=DFS.K

The prospect acquisition rate (man-hours of work/week) equals the demand for the consulting firm's services.

52L PWL.K=PWL.J+(DT)(PAR.JK-PCR.JK-PWR.JK-O)

The consulting firm's prospective workload (man-hours of work) equals its previous value plus the difference between inflow (prospect acquisition rate) and outflow (proposaional completion rate and prospect withdrawal rate).

12R PWR.KL=(PWL.K)(FRACW)

The prospect withdrawal rate (man-hours of work/week)
equals the prospective workload times the fraction which
withdraws each month. This fraction is assumed to be con-
stant; the value of 0.1 implies an average waiting period
of ten weeks before a company withdraws as a prospect.

2OR \( \text{PCR.KL} = \frac{\text{EDP.K}}{\text{MHPMH}} \)

4

C \( \text{MHPMH} = 0.1 \)

4A

The proposal completion rate equals the effort devoted
to proposal-writing divided by the average man-hours of pro-
sposal writing per man-hour of work in a prospective case.
Since the system represents a flow of "workload" rather than
cases, PCR is measured in man-hours of work proposed for/
week.

52L \( \text{PWO.K} = \text{PWO.J} + (DT)(\text{PCR.JK-\text{PACR.JK-\text{PRR.JK-0}}}) \)

5

The level of proposed work outstanding (i.e. the po-
tential increase in workload if all proposals were accepted)
equals its value one month earlier plus the difference be-
tween inflow (proposal completion rate) and outflow (propo-
sal acceptance rate and proposal rejection rate).

12R \( \text{PACR.KL} = (\text{PDR.JK})(\text{FPA.K}) \)

6

The proposal acceptance rate equals the proposal deci-
sion rate times the fraction of proposals accepted.
The proposal rejection rate equals the proposal decision rate times the fraction of proposals rejected (one minus the fraction accepted).

The proposal decision rate is the proposal completion rate after an average delay of six weeks.

The consulting firm's level of work in house equals its value as calculated previously plus the subsequent net change (proposal acceptance rate minus case completion rate).

The case completion rate equals the effort devoted to case work (both measured in man-hours/week).

The effort required for case work equals the amount of work in house divided by the average case length (i.e. the desired case completion time).
The effort devoted to case work (in man-hours/week) equals the effort required or the consulting firm's total workforce, whichever is smaller.

The excess effort from case work, which can now be allocated among the firm's other functions, equals the difference between its total workforce and the effort devoted to cases.

The effort required for proposal-writing equals the prospective workload (man-hours of work) times the manhours of proposal-writing effort generally required per manhour of work being solicited, divided by the average proposal-writing delay (the desired writing time).

The effort actually devoted to proposal writing equals the effort required or the excess from case work, whichever is smaller.
Difference B equals the ratio of effort devoted to proposal-writing to the effort required. It is used as an indicator of proposal quality in equation 17.

Proposal quality is a non-linear table function of difference B; it is measured on a continuous scale from zero to one. The function shown in Figure No. 5 is based on the following assumptions:

1. The curve has a slope of zero until DIFB=0.25. This must be so, since "quality" here refers to the percentage of prospects which would accept a given proposal, and the competitive situation among consultants is such that there is a very definite "threshold" below which few proposals will be accepted.

2. The curve has a slope of zero when DIFB=1.0. This is based on the assumption that a prospect, not knowing exactly what to expect in the proposal, cannot detect a small deviation from DIFB=1.0.

3. The maximum attainable value of PQUAL must be less than one. Even when the consultant feel that he is doing a per-
fect job, the following factors must be considered --

(a) situations change during the writing delay;
(b) sometimes, the client will not admit to a problem as the consultant sees it;
(c) some prospects have unrealistically high expectations;
(d) the proposed cost might be prohibitive;
(e) the prospect might be "fishing" for a way to solve its own problems internally.

6A \( \text{FPA.K}=\text{PQUAL.K} \)

The fraction of proposals accepted equals proposal quality. This is a result of the way in which PQUAL is defined.

7A \( \text{EFP.K}=\text{EXEF.K}-\text{EDP.K} \)

In the straight "priority policy" of manpower allocation, the effort available for promotion equals the excess from case work minus the amount devoted to proposal-writing. In a later section of this Appendix, the equations for the "constant promotion" alternative will be presented.

6A \( \text{PEF.K}=\text{EFP.K} \)

By definition, the promotional effort equals the ef-
SMPEF is promotional effort exponentially smoothed over a period of eight weeks. This "averaging" procedure delays the impact of a sudden change in the amount of promotion undertaken by a consulting firm.

Adjusted promotional effort equals smoothed promotional effort times reputation. This equation represents the concept: the better a firm's reputation, the more effective its promotion.

The fraction of the total demand interested in a particular firm as a result of its promotion is a table function of adjusted promotional effort. Reference to Figure No. 6 will show a "S-shaped" curve with a slope of zero at ADPEF=0.0 and ADPEF=0.021, reflecting the assumptions that:

1. the first small amount of promotion will ac-
complish very little.

2. there is a definite diminishing returns effect and a point beyond which additional promotion will bring few new prospects.

The fraction of the total demand whose interest in a consulting firm is independent of the firm's promotion (i.e. unsolicited demand) is a function of reputation. The exact relationship is shown in Figure No. 7; it is based on the following assumptions:

1. the total billings of management consulting firms (in the U.S.) was estimated at $750 million for 1965. The reputations of several consulting firms were calculated as is done in the model; these plus estimates of the levels of unsolicited demand defined the curve's mid-range.

2. it was assumed that there is a threshold below which very few clients will approach a consultant unsolicited. Thus, the curve will have a slope of zero when REP=0.

3. it was further assumed that as reputation grows, the marginal increase in unsolicited clients
drops after a while for many reasons. These include: the finite number of companies interested in hiring a consultant; the parallel rise of other consulting firms' reputations; the non-homogeneity of a reputation; the inability of any firm to solve all types of problems.

\[ \text{REP}_K = \text{REP}_J + (\Delta T)(\text{RRI}_J - \text{RRD}_J) \]

The consulting firm's reputation equals its previous value plus the subsequent net change (rate of reputation increase minus rate of reputation decrease).

\[ \text{QUAL}_K = \text{TABLE}(\text{QTAB}, \text{DIFA}_K, 0.0, 1.0, 0.125) \]

\[ \text{QTAB}^* = -1.0/-1.0/-0.95/-0.9/-0.8/-0.6/0.0/0.80/1.0 \]

The quality of a firm's work is a function of difference A (see equation 27). The exact shape of the curve, as seen in Figure No. 8, was derived as follows:

1. because clients are not sure exactly what the consulting firm will produce, they are not very sensitive to small amounts of "skimping" (i.e. a less than optimal solution still looks pretty good). Thus, the slope is zero where DIFA=1.0.
2. however, high expectations will cause clients to become dissatisfied very quickly once it is apparent that the consultant is not living up to his promises.

3. the above is amplified by the large number of alternative consulting firms available.

20A \( \text{DIFA}_K = \text{EDC}_K / \text{ERC}_K \)

Difference A equals the effort devoted to case work divided by the required. It serves as a measure of output quality.

51R \( \text{RGR}_{KL} = \text{CLIP}(\text{QUAL}_K, 0.0, \text{QUAL}_K, 0.0) \)

51R \( \text{RRR}_{KL} = \text{CLIP}(0.0, -\text{QUAL}_K, \text{QUAL}_K, 0.0) \)

39R \( \text{RRI}_{KL} = \text{DELAY3}(\text{RGR}_{JK}, \text{TCR}) \)

39R \( \text{RRD}_{KL} = \text{DELAY3}(\text{RRR}_{JK}, \text{TCR}) \)

C \( \text{TCR} = 52 \)

The above group of equations say nothing more than the following: if quality is positive, reputation will increase after a delay which averages 52 weeks; if quality is negative, reputation will decline in a similar manner. The long delay reflects the difficulty of changing an established reputation -- be it good or bad.
The demand due to promotion equals the total demand for consulting times the fraction interested in this firm as a result of its promotion.

Unsolicited demand equals the total demand for consulting times the fraction interested in the firm under consideration, independent of its promotion.

The total demand for a consulting firm's services is the sum of demand due to promotion and unsolicited demand.

The total demand for consulting has three components: a constant level, a cyclical fluctuation, and random variations. The values of each were varied among series of simulation runs.

The Constant Promotion Alternative:

The effort available for promotion equals the constant
promotional workforce.

\[ 7A \quad \text{VARWF}.K = \text{WF}.K - \text{CPWF} \]

The consulting firm's variable workforce then equals its total workforce minus the constant promotional group. VARWF is substituted for WF in equations 12 and 13.
This Appendix contains the graphical output from the four major series of computer simulation runs. Preceding each series is a brief description of the behavior observed and its significance.

**Series No. 1:**

The first four runs demonstrate the effect of varying average case length while the delay in acquiring new business is held constant. Figures No. 9 through 12 show the behavior of work in house (WIH), proposed work outstanding (PWO), and prospective workload (PWL) for average case completion times of 4 weeks, 8 weeks, 16 weeks, and 26 weeks respectively. Notice the obvious increase in stability as average case length grows longer.
Figure No. 11
Series No. 2:

These two runs (both in Figure No. 13) demonstrate the effect of varying the level of unsolicited demand. The first assumes 50% of prospects are unsolicited; the second, 25%, and the difference in stability is noticeable. All other things remaining equal, stability increases with unsolicited demand.
Figure No. 13

TYPE CHANGES IF RUN DESIRED
C
C
RUN
12139

PAGE 2

<table>
<thead>
<tr>
<th>FTAB*1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
<th>#7</th>
<th>#8</th>
</tr>
</thead>
<tbody>
<tr>
<td>-12HBW</td>
<td>0</td>
<td>3.000A</td>
<td>10.00A</td>
<td>17.50A</td>
<td>22.00A</td>
<td>25.00A</td>
<td>27.00A</td>
</tr>
<tr>
<td>THESIS</td>
<td>0</td>
<td>2.000A</td>
<td>6.00A</td>
<td>11.00A</td>
<td>15.00A</td>
<td>19.00A</td>
<td>20.00A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UTAB*1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
</tr>
</thead>
<tbody>
<tr>
<td>-12HBW</td>
<td>0</td>
<td>1.300A</td>
<td>6.50A</td>
<td>8.50A</td>
</tr>
<tr>
<td>THESIS</td>
<td>0</td>
<td>4.000A</td>
<td>11.00A</td>
<td>19.00A</td>
</tr>
</tbody>
</table>

PAGE 3
Series No. 2:

This series examines the policy of having a separate, constant promotional group in a consulting firm. Figure No. 14 assumes 50% unsolicited demand, while Figure No. 15 assumes 25%. Average case length is 16 weeks.

Notice the greatly increased stability over Figure No. 11 (also average case length = 16 weeks). Notice too, however, that the constant promotion policy has little long-term growth compared with the results of variable promotion.
Series No. 4:

Figures No. 16 through 18 compare the behavior of three policies in response to a variable demand for consulting services.

1. allocation of effort by functional priorities (also Figures No. 9 through 13).
2. constant promotional effort (also Figures No. 14 and 15).
3. promotional effort which consists of a constant component plus the excess from proposal-writing.

These runs re-emphasize the stability of policies 2 and 3 as well as their lack of growth potential.
APPENDIX 3

A COMPLETE FLOW DIAGRAM OF THE INDUSTRIAL DYNAMICS MODEL
APPENDIX 4

FOOTNOTES


also:
(used by author but not referenced except in introductory quotation)