CATASTROPHE THEORY AND PUBLIC POLICY
The Dynamics of Provider Behavior In The Nursing Home Industry

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ABSTRACT

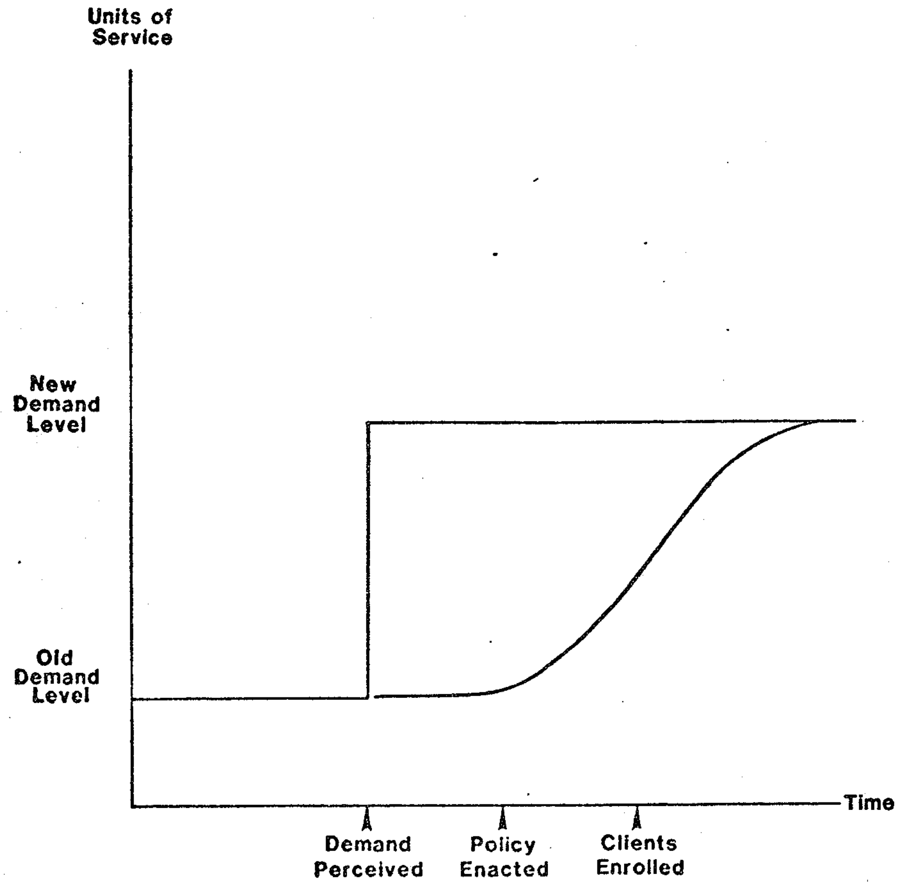
Major changes in the demographics of aging in the United States have created demands for geriatric care which cannot be met by existing services. Most states have elected to address this policy issue by offering incentives to providers to promote investment in long term care facilities. These offerings have been only marginally successful due to the relative attractiveness of competing investment options. This paper explores provider reaction to policy incentives using a System Dynamics model derived from Catastrophe Theory. Provider behavior is seen as unstable under competing investment options; a behavioral condition which conforms to the typical "Cusp Catastrophe".

HUMAN SERVICE POLICY:

The fundamental purpose of public policy for the human services is to match service delivery capacity with the objective needs of citizens. (Levin and Roberts, 1978) Laying aside political concerns, the policy process serves to translate aggregate demands into programs and service delivery systems. From this perspective, the efficacy of a particular policy can be determined by the degree to which resulting services conform to public demand. (Hirsch and Bergan, 1976) This approach is essentially one where the policy maker(s) attempt to respond to a demand 'signal' by implementing appropriate programs.

The key events in this process are pictured in Figure 1. We would expect a well-conceived policy to provide services to match changing demands. The match should be as shown; a smooth, controlled response which 'tracks' the pattern of demand in a timely, proportional manner. (Ammentorp, Gunderson and Broderick, 1977) In effect, the policy system acts as a 'control' on service demand so that there is neither an excess nor a shortage of service capacity.

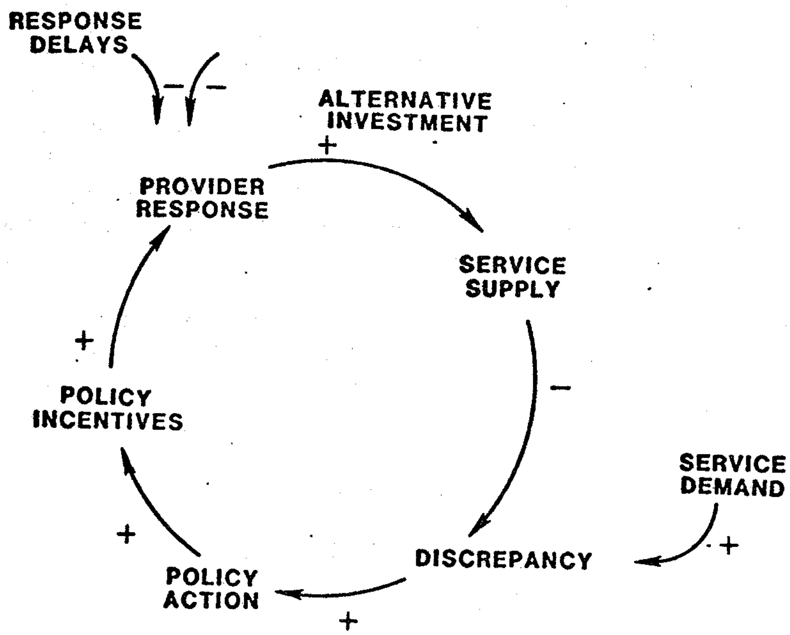
POLICY RESPONSE TO SERVICE DEMAND



The key words in the previous paragraph are 'timely' and 'proportional'. As Figure 1 shows, there is a finite delay between the initiation of policy and the availability of service. There is a second delay which relates to the duration of the service episode. In combination, these two delays result in unfilled demand and continued policy pressure. Proportional response insures that excess service capacity will not be provided and that public resources will be efficiently allocated across several policy areas. The policy system will, in effect, be 'in control'.

Controlled policy responses are due to several interrelated factors. Figure 2 shows how exogenously generated Service Demands result in a Discrepancy between Demand and current levels of Service Supply. This, in turn, leads to Policy Actions and the provision of Policy Incentives to motivate Provider Responses. However, these reactions are Delayed in time and subject to competitive Investment Alternatives. Thus, Service Supply does not immediately adjust to new levels of Demand and, when Incentives are insufficient, may not respond at all.

INCENTIVES IN POLICY SYSTEMS



Many of the human services follow the above incentive model. Medicare prospective payments set a price on specific hospital services so that incentives exist for efficient operation and specialized services can be offered profitably. (Grimaldi and Micheletti, 1983) Long term care services for the elderly and handicapped are similarly priced to offer returns to investments made by providers. (Baldwin, 1980; Deane, 1983) In each policy arena, provider behavior and the resulting supply of services is controlled more or less effectively by the balance between policy incentives and alternative investments.

The events sketched in Figure 2 show that the delivery of human services is at least a three-part problem. First, accurate assessment of needs must occur if services are to be relevant. Second, the policy process must recognize need and translate it into viable programs and services. Finally, service providers must be induced to make appropriate programmatic and institutional arrangements for client services.

In the past, most policy research has concentrated on the link between client needs and public programs. While these studies have helped to refine estimation and program management practices, they have largely neglected the behavior of providers. As a result, policy analysts are often surprised by provider behavior. Witness the 'trafficing' in nursing home facilities brought about by capital funding practices (Scanlon and Feder, 1981), variance in hospital use under Medicare (Gornick, 1982), and manager reactions to attempts to control facility expenditures (Ammentorp, 1985).

LONG TERM CARE POLICY:

The long term care delivery system is one where all three elements of the policy problem are present. There are uncertainties in estimating the need for nursing home care within the elderly population and significant differences in the workings of state policy making systems. But, most importantly, long term care is a service which is, for the most part, provided by for-profit vendors. Thus, the responsiveness of providers to policy incentives becomes the central issue in long term care delivery.

Long term care is a critical policy issue at present. Americans are not only living longer, their survival rates are based on ever-larger age cohorts. The Minnesota data shown in Table 1 illustrate this point.

TABLE 1

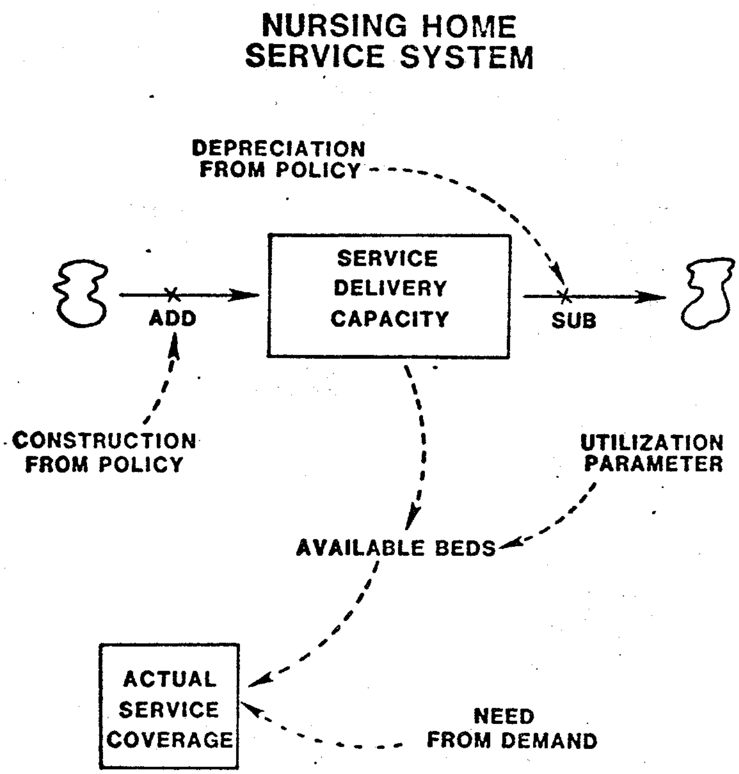
MINNESOTA POPULATION
PROJECTIONS 1985-2005

AGE	1985	1990	1995	2000	2005
65-69	154242	160250	158394	150769	162107
70-74	129842	135719	142602	141643	135566
75-79	99110	108843	116729	123955	124656
80-84	69048	75579	85464	92811	99871
85+	60215	68542	78602	90781	102579

A key observation to be made from the data in Table 1 is that the State will experience substantial growth in the numbers of the very old. Thus, the balance of long term care needs will shift toward institutional systems and the State will need to provide for a greatly increased delivery of nursing home services. As Krebs points out, policy makers must either allocate significantly larger resources to long term care or provide some means of rationing access to services. (Krebs, 1983)

POLICY SYSTEMS DYNAMICS:

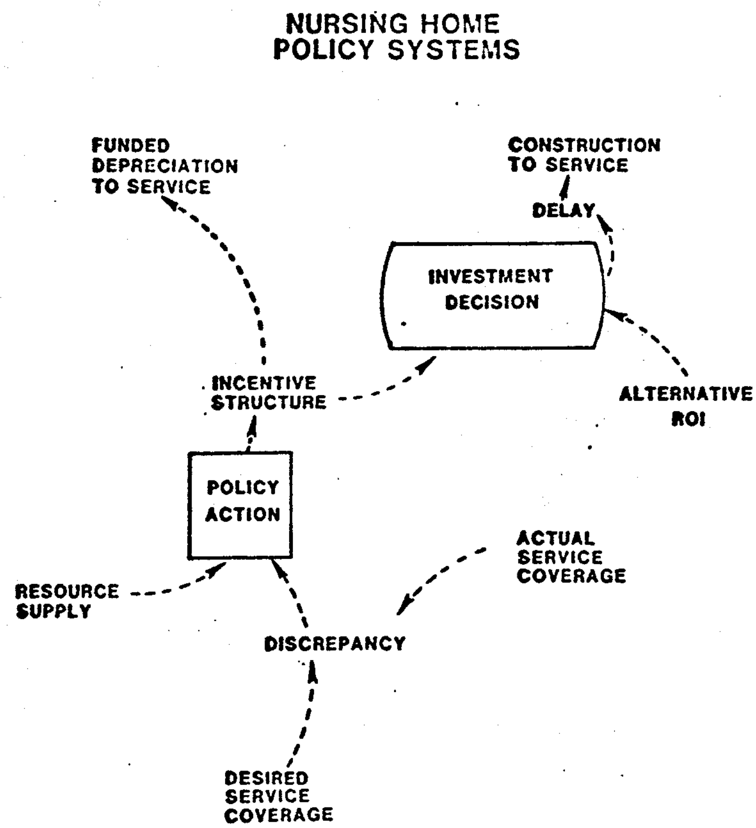
Policy issues raised by the above demographic trends can be addressed by constructing models of service delivery and policy systems. (Ammentorp and Gunderson, 1984) Figure 3 shows how the stock of long term care beds is influenced by several key policy decisions.



The level variable in Figure 3 (Service Delivery Capacity) is the number of approved long term care beds available. It is added to by construction and/or licensure decisions made in the policy system and reduced by depreciation of facilities. This is suggested by the 'From Policy' arrows which impact the ADD and SUB rates above.

The objective number of beds in long term care facilities is adjusted by a Utilization Parameter to arrive at current estimates of Available Beds. This number is compared to the Need estimate to determine the degree of Actual Service Coverage. In this computation, it is important to note that policy makers may adjust both Utilization and Need by setting elgibility and compensation criteria.

The structure of the policy system which controls service delivery is shown in Figure 4.



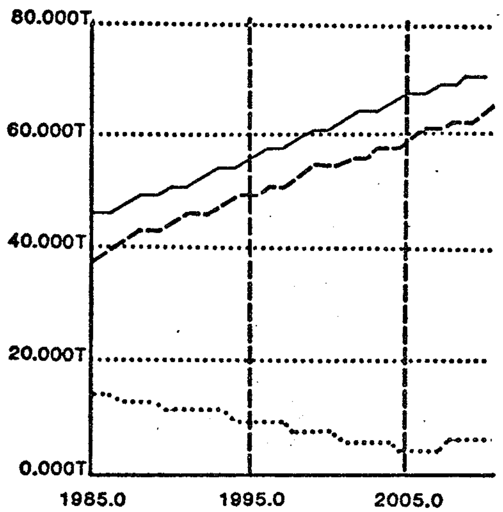
Here, the driving force for Policy Action is the Discrepancy between Actual Service Coverage and Desired Service Coverage. This takes the form of comparison between the numbers of elgible clients estimated by demographic studies and the current count of Available Beds. When a Discrepancy indicates a need for additional service capacity, policy makers weigh the cost of meeting need against alternative demands on public resources. This results in some form of Incentive Structure which is communicated to care providers.

Incentives take two basic forms in this model; Funded Depreciation allows providers to recover capital investment over time, and effective interest rates offered for new investment. It is this latter inducement that is the key to developing long term care facilities in the magnitude necessary. (McCaffree, 1979)

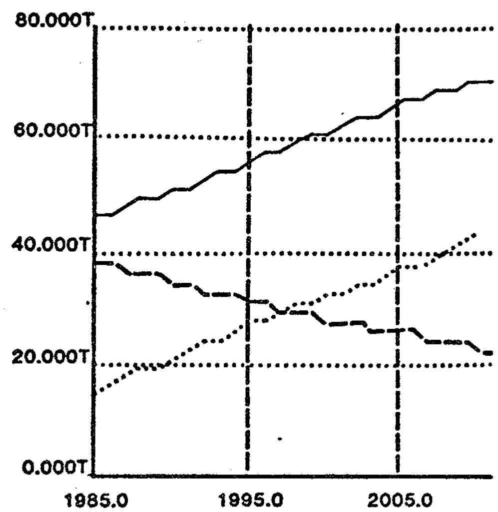
As providers consider potential earnings on capital, they necessarily consider alternative investments. ROI (return on investment) from these alternatives shapes the Investment Decision of the provider. Then, after a construction delay, new capacity can come on line to reduce the need for service coverage.

These assumptions have been programmed as a DYNAMO model and initialized for current Minnesota data and policies. (Ammentorp and Gunderson, 1984) When these assumptions are tested, the model exhibits two distinct modes of behavior.

INCENTIVE MODE



DECLINE MODE



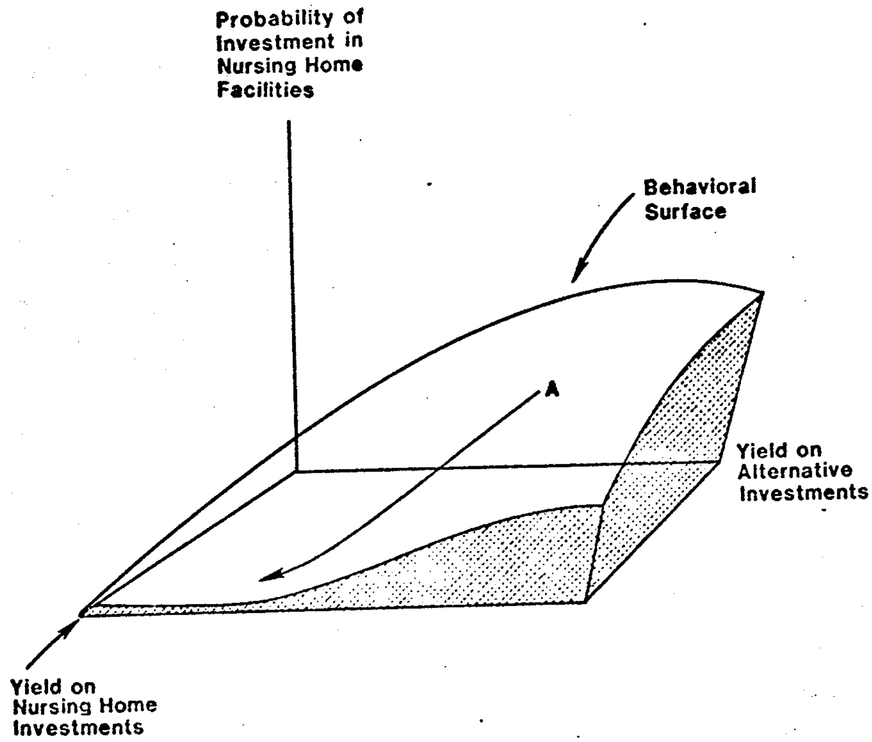
NEEDS = ————
BEDS = — — — —
DISC = ··········

In the 'Decline Mode', the model shows the effect of current State limits on nursing home construction; over time, the gap between need and capacity widens as the elderly population continues to increase while facilities decline through depreciation. The 'Incentive Mode' shows relatively good adjustment of service capacity to need and, in fact, if the incentive assumptions of the model are correct, it should be possible to attain any desired balance between need and capacity.

However, the model is overly simplistic in its treatment of the role of incentives. Due to this limited perspective, the model cannot be used as a reliable guide to policy making. Instead, the model must be enriched to better represent the impact of incentives on an environment where there are varying investment alternatives.

A THEORY OF PROVIDER BEHAVIOR:

We can begin to address the shortcomings of the above policy model by considering the impact of relative rates of return on the investment decisions of providers. If provider behavior is represented as the probability of investment in long term care facilities, we can create a function in three dimensional space.



The surface shown in Figure 6 represents the determination of provider investment probabilities by the relative rates of return on nursing home and competitive investments. As these rates vary, we would expect providers to adjust their long term care investments to improve yield on capital. These variations result in probabilities which range from plus or minus one - corresponding to high long term care facility investment and facility sell-off respectively.

In this model, investment behavior is seen as the dependent variable to be predicted by the relative yields on long term care and alternative investments(the contol variables). If investment (I) and control (C) variables are related by some function, f(I,C), the condition for equilibrium behavior becomes:

$$(1.0) \quad MIN(I,C)=f(I,C)$$

From a dynamic perspective, this becomes:

$$(1.1) \quad I = -\partial f / \partial I = - \text{GRAD } f$$

and MIN f corresponds to:

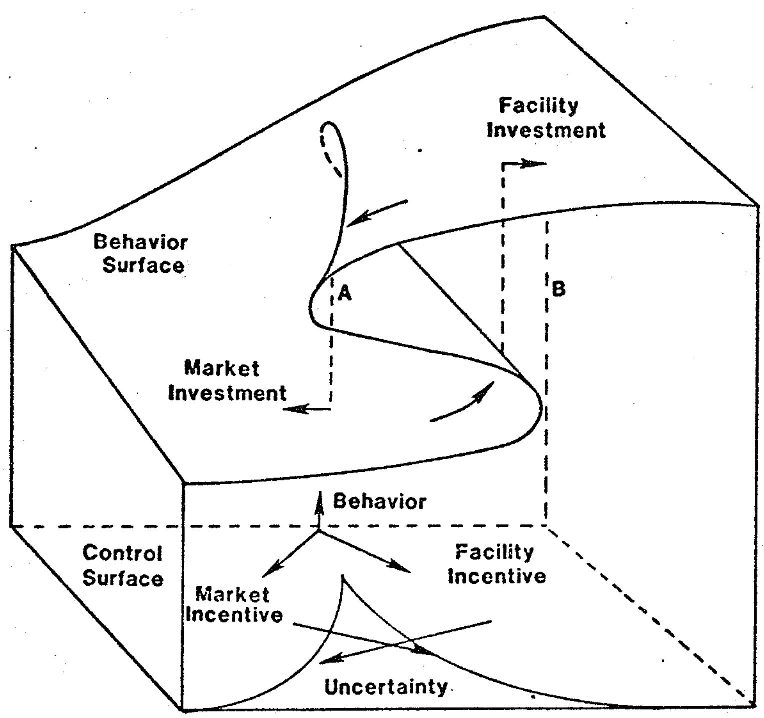
$$(1.2) \quad \text{GRAD } f = 0$$

As the control factors (C) vary, the solutions to (1.2) form the surface shown in Figure 6. (Wilson, 1981) Any changes in the control factors (investment yields) will result in a new solution to (1.2) and a new equilibrium for investment behavior. Thus, the surface of Figure 6 is one which suggests smooth transitions among investment probabilities throughout the range of alternative yields.

This is, however, a somewhat unrealistic view of provider decision making. Provider decisions are more likely to be bimodal in that investors are more or less committed to one alternative or the other and choices are not so easily adjusted. The bimodality of provider behavior suggests that catastrophe theory may better account for investment decision making.(Zeeman, 1976)

Catastrophe theory refers to those behavioral surfaces where there are multiple solutions to equation (1.2). In Figure 7, we show a folded surface in the (I,C) space corresponding to this condition. This surface has been called the 'cusp catastrophe' since the projection of the fold unto the control (C) plane is a cusp-like figure. (Thom, 1975)

INVESTMENT DECISION: CUSP MODEL



Catastrophe theory is well-suited to problems in bimodal choice when the following conditions are fulfilled (Poston and Stewart, 1978)

a) Abrupt Changes In Behavior:
Long term care investment or sell-off is an abrupt change which represents the shift of capital from one investment alternative to the other. Since long term care facilities are not generally stock companies, changes in investment involve significant capital movements and are, necessarily, abrupt.

b) Hysteresis:
This means that an abrupt transition in behavior cannot be directly retraced. For example, considerable changes in alternative yields may be needed before a recent long term care investment would be withdrawn.

c) Inaccessibility:
Catastrophic changes in behavior are possible when the behavior surface is folded as shown in Figure 7. In effect, there are multiple solutions to the gradient equation (1.2) for some combination of the control variables. Solutions represented by the intermediate (shaded) layer in Figure 7 are unstable and, hence, inaccessible. (Wright, 1981)

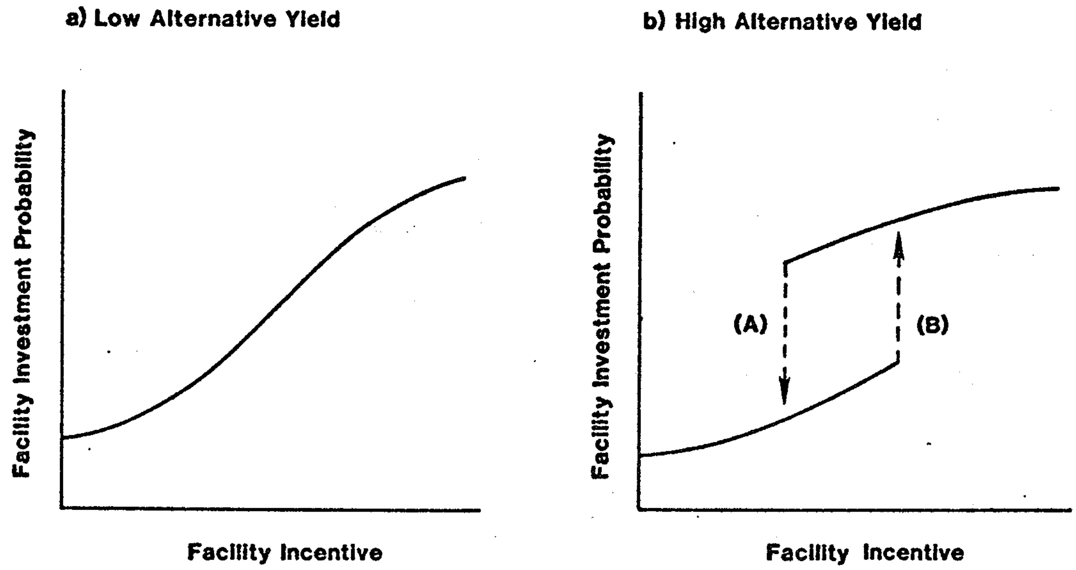
d) Divergence:
As behavior approaches the point of the fold in Figure 7, small differences in the relative magnitude of the control variables can lead the system to either the upper or lower equilibrium surface. In effect, small changes in relative interest rates can 'commit' investors to either long term care or alternative investments.

APPLYING THE THEORY:

Incorporating the behavioral surface in a System Dynamics model is obviously a formidable task. The equation f(I,C) is unknown, except in the very general way it has been described, and estimation of equilibrium points for the system is statistically impossible, given current data bases. Consequently, we must rely on certain typical cases where the theory might contribute to our understanding of provider investment behavior.

To proceed, we distinguish between our two control factors. The yield on long term care investments is called a 'normal' factor and the yield on alternative investments a 'splitting' factor. (Scapens, 1981) The role of these factors in determining investment behavior can best be understood by cutting Figure 7 at two points on the alternative investment yield axis. At low values of alternative yields, we obtain a section which shows investment probability as a function of long term care yields (Figure 8a).

PROVIDER INVESTMENT BEHAVIOR WITH ALTERNATIVE YIELD AS A SPLITTING FACTOR



However, as the 'splitting' factor increases, the section of Figure 7 will cut the behavior surface in the cusp region with a resulting section like that shown in Figure 8b. The increase in alternative yields has effectively 'split' the behavioral options into two modes. The implication of this split is the potential for catastrophic changes in behavior as represented by the overlapping curves in Figure 8b.

Transition marked (A) in Figure 8b represents a catastrophic sell-off of long term care facilities. Similarly, the (B) transition is one which marks an abrupt shift of investment into long term care facilities. It is important to note that these are delayed phenomena. (Wright, 1981, p.8) That is, movement along the upper behavior surface in (8b) will not result in a catastrophic jump to the lower surface until the left-hand edge is reached. This is consistent with the concept of the splitting variable as one which has a delayed impact on behavior.

The two behavioral modes illustrated in Figure 8 were used to modify the long term care model. In effect, the model was enriched to incorporate different provider investment behaviors at several levels of market investment yield. Historical data on nursing home investment, yield on nursing home capital, and market interest rates in Minnesota were used to set the parameters of the model. Where possible, comparisons to National data were used to increase confidence in these estimates.

LONG TERM CARE
MODEL OUTPUT
CATASTROPHE MODE

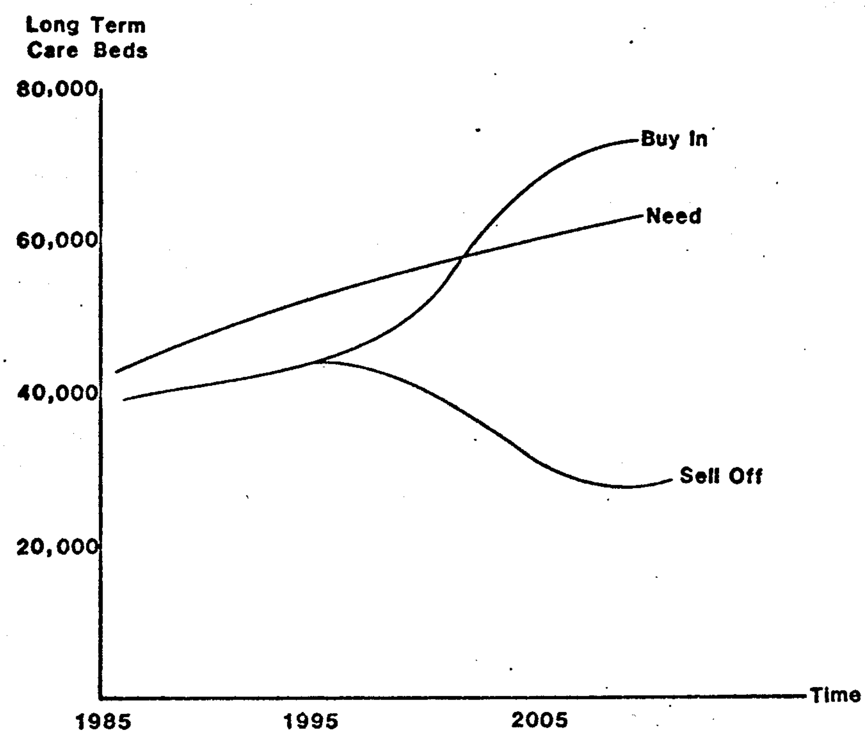


Figure 9 shows how the model responds to two scenerios. With competitive investment yields held constant, a gradual decline in long term care investment yields leads to gradual reductions in capacity until that point where a catastrophic 'Sell Off' occurs.

For Minnesota, the second scenerio is more important. Given constant alternative investment yields, gradual increases in incentives for long term care investment result in steady, but small, increases in capacity. However, at some point in this process, massive shifts of investment are made and the model exhibits a 'Buy In' catastrophe.

If the underlying assumptions are correct, the provision of investment incentives to long term care providers is a matter of the fine tuning of offerings. Policy makers must provide adequate incentives to move needed capital out of alternative investments but not make such attractive offers as to encourage catastrophic responses. Clearly, control over investment must be a balance of incentives and limits imposed by license to prevent construction of excess capacity.

IMPLICATIONS:

At this writing, the catastrophe theory approach to policy incentives appears to hold considerable promise as a general guide to policy makers. However, several elements in the model are in need of additional research. The hysteresis effect postulated by the theory must be emperically grounded. This is a matter of studying bimodal investment choice of providers. (Blase, 1979; Goodwin, 1977) Further, the supply of capital available for long term care investment must be accurately estimated as must the liquidity of these and competing investments.

The model also exhibits a weakness in the way it captures policy maker behavior. It is probably unreasonable to assume that decisions will follow directly from citizens demands. Instead, some complex functions which weighs alternative demands for resources must be included in the model.

Despite these limitations, the catastrophe theory model extends our understanding of the policy process in the human services. It adds a significant dimension to the general theory of Levin and Roberts (1978) and serves to highlight needed research into provider investment decision making.

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