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A DYNAMIC SERVICE QUALITY COST MODEL WITH WORD-OF-MOUTH ADVERTISING

N.P. Archer and **G.O. Wesolowsky**
Faculty of Business
McMaster University
Hamilton, Ontario, Canada L8S 4M4

Telephone (416) 525-9140 ext. 3944
E-mail archer@mcmaster.bitnet

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Abstract

A dynamic cost model is developed which describes the evolution of demand for a service from its beginning transient phase to its long-term equilibrium. The model includes parameters which relate to word-of-mouth advertising, and repeat demand at different rates from satisfied and dissatisfied customers. The demand behaviour of the model is consistent with published data and models for new consumer products with short re-purchase periods. Model simulations reveal some generally useful guidelines for service providers: 1) service operations should not expand excessively to handle strong demand during the early phases of the service offering, 2) cutting service quality in order to reduce costs is a poor policy, and 3) a good strategy is to adopt a high service quality from the beginning of operations, rather than improving it later.

(SERVICE QUALITY; DIFFUSION MODELS, WORD-OF-MOUTH ADVERTISING, COMPLAINT MANAGEMENT MODEL)

1. Introduction

In recent years, there has been a great deal of emphasis in the industrialized nations on improving manufactured product quality. At the same time, the value of services has grown to the point where it substantially exceeds the value of goods produced, so that the economies of these nations are becoming more service-oriented. The quality of services is therefore also becoming a focus for improvement.

A great deal has been written about service quality and its impact on business firm performance (Albrecht & Zemke 1985; Christopher, Schary & Skjott-Larsen 1979; Desatnick 1987). The measurement of customer service has also been discussed (La Londe & Zinszer 1976; Williams & Zigli 1987). It is interesting to note that the oldest of the previous references relate primarily to product service operations, while the more recent ones also consider service as a separate concept. A number of studies have been carried out to gather information on the impact of service quality and customer complaint handling on customer reactions (for example: TARP 1979, TARP 1986). Recent research helps to clarify the relationships between customer perceptions and their reactions concerning service quality. In particular, the SERVQUAL model (Zeithaml et al 1988; Parasuraman et al 1985), and the works of others (Gronroos 1984; Swartz & Brown 1989; Singh 1990) have explored these issues in detail. These have also helped to identify gaps between how customers and service management perceive service quality.

There have been several econometric studies, at the firm or industry level, of the impact of service quality on bus service (Dodgson &

Katsoulacos 1988), airlines (Trapani & Olson 1982; Abrahams 1983; Bennett & Boyer 1990), and hospitals (Friedman & Pauly 1981). However, none of these studies have presented general and dynamic cost models which relate to service quality at the consumer interface. The intent of this paper is to quantify the impact of quality on the cost performance of a service, relating this to the market share for that service and the potential survival of the service-providing enterprise. This attempts to bridge the gap between consumer perceptions and service provider economics which have been mentioned above.

The remainder of the paper will discuss service and quality, followed by the development of a dynamic service quality model. Its performance is demonstrated by analysis and simulations through the transient start-up and equilibrium phases; its response to step changes in service parameters is also shown. A cost model based on service quality parameters is then developed, and integrated with the service quality model. Finally, an example is used to demonstrate the service quality cost model over the startup and equilibrium life of an assumed service operation.

2. Service And Quality

The dictionary definition of service is "useful labor which does not lead to a tangible commodity". Service has a number of attributes, but the ones in which we are most interested in this work are cost and quality, since these will be of great importance to consumers who are interested in purchasing the service. Parasuraman et al (1985) identify three underlying themes relating to service quality: a) it is more difficult for the consumer to evaluate than product quality, b) service quality perceptions result from

a comparison of consumer expectations with actual service performance, and c) quality evaluations are not made solely on the outcome of a service; they also involve evaluations of the process of service delivery. Williams and Zigli (1987) state that the transfer of quality evaluation techniques used in manufacturing organizations to service organizations has inhibited the development of quality specifications and measurement techniques specifically relevant to service. In our study, we will not consider the types of services which support tangible products; this would involve considerations more complex than those which are designed into the current model.

Services are probably performed in and/or by every active organization in existence. However, our focus will be on organizations which rely on service to provide their primary income. Generally, service providers may be classified into regulated or government monopolies, and competitive services. The former classification includes services such as public utilities, government services, much of education, health and social services, and urban transit. The latter classification of competitive services includes 1) finance and insurance, 2) public transportation, 3) accommodation, restaurants and recreational services, 4) general services to business, and 5) personal and household services for consumers. Services 1) and 2) tend to be dominated by large corporations because of the financial investments involved, while 3) and 4) may be either large or small businesses and 5) tend to be mostly small businesses.

Without regard to the size or type of the service organization, in order to provide a service in a planned and organized manner, it is essential that a strategy be developed for delivering its service. "A service strategy is a distinctive formula for delivering service; such a

strategy is keyed to a well-chosen benefit premise that is valuable to the customer and that establishes an effective competitive position" (Albrecht & Zemke 1985). An organization needs to develop a service strategy which fits its approach to business and its long range goals. This strategy will be affected by the widely used rule-of-thumb that it is five times more expensive to get a new customer than it is to retain an existing customer (Desatnick 1987).

Our model is most suitable for geographically localized service operations which attract customers primarily by word-of-mouth, and keep them by providing quality service. Examples are restaurants, maintenance services, professional services, etc. The model assists in the exploration of alternative strategies and the economic consequences of these strategies. It provides rather striking illustrations of the impact of making common errors such as early over-expansion or reducing service quality as a cost-cutting measure.

3. A Service Quality Model

We will assume that there is a static population of N potential customers in a limited geographic area; a small number n_0 of these have initially good impressions of the service being provided, and the remainder are uninformed. Gronroos (1984) has indicated that the actual service interactions and word-of-mouth are more effective than other means of advertising of services, and TARP (1986) has also emphasized the impact of word-of-mouth advertising. In this model word-of-mouth is the sole means of advertising. Both positive and negative effects are included since these are primary forces driving service demand. Unlike product-oriented diffusion

models (Dodson and Muller 1978; Mahajan, Muller and Kerin 1984) we focus on drawing general inferences for a "pure service" system. The model is deliberately parsimonious (forgetting, media advertising, and impulse purchases are not included). The application of the model is therefore primarily applicable to service organizations operating in limited geographical areas, and having repeat service demand at intervals which are relatively short compared to the forgetting time of customers.

Our model is structured as follows. When customers who know about the service actually receive the service, they may be either satisfied or dissatisfied by the service. If satisfied, they will be classed with a subset g of the population. At the same time, these satisfied customers tell, on average, m_g other people who (if they were previously unaware of the service) also join the subset g. If, on the other hand, the served customers are dissatisfied, they join a subset b of the population. They also tell an average of m_b other people who, if they were previously unaware of the service, join the b population subset.

Note that, due to their poor experience or word-of-mouth impressions of the service, the b subpopulation is less likely to request service than the g subpopulation, and is more likely to turn to competing services, if any are available.

The rate of arrival for service from the g subpopulation is μ per person. The arrival rate from the b subpopulation will normally be lower, at $w\mu$ per person, where $0 < w \leq 1$. The resulting rate of growth in the g subpopulation is

$\frac{dn_g}{dt}$ = growth rate due to satisfied customers telling others who are in the "unaware" population

+ growth rate due to previously dissatisfied customers now being satisfied

- loss rate of customers who are dissatisfied.

Also,

$\frac{dn_b}{dt}$ = growth rate due to dissatisfied customers telling others who are in the "unaware" population

+ growth rate due to previously satisfied customers who are now dissatisfied

- loss rate of customers who are now satisfied.

Assuming that a fraction r_s of customers will be satisfied with the service, and applying the usual limiting procedures for state transition rates (Cox and Miller 1965; Mohajan, Muller and Kerin 1984),

$$\frac{dn_g}{dt} = r_s\mu(n_g+wn_b)m_g(1-\frac{n_g+n_b}{N}) + w\mu r_s n_b - \mu n_g(1-r_s) \quad (1)$$

$$\frac{dn_b}{dt} = \mu(1-r_s)(n_g+wn_b)m_b(1-\frac{n_g+n_b}{N}) + \mu n_g(1-r_s) - w\mu r_s n_b \quad (2)$$

The boundary conditions are $n_g(0) = n_0$, and $n_b(0) = 0$.

Figure 1 demonstrates the customer transition rate relationships among the three populations in the service model. We make the assumption that service demand from customers who are satisfied and potential customers who have heard about satisfactory experiences can be grouped together. A similar

assumption is made for dissatisfied customers and potential customers who have heard about unsatisfactory experiences.

*** Place Figure 1 about here ***

If we assume that service is perfect, with $r_s = 1$, then $n_b(t) \equiv 0$ and we can ignore equation (2) for the moment. The revised equation (1) becomes

$$\frac{dn_g}{dt} = \mu m_g n_g \ (1-n_g/N). \qquad (3)$$

This has the analytical solution (Naert and Leeflang 1978)

$$n_g(t) = N/(1 + \gamma \exp - (\alpha + \beta t))$$

which is the (s-shaped) logistic curve, often used to model innovation diffusion processes (Mahajan and Wind 1986).

In the more general case, since the "unaware" population is a transient state, the two mutually exclusive subpopulations g and b will grow until

$$n_g + n_b = N,$$

and the rates of change of the two subpopulations will asymptotically approach zero as t increases. Thus, either (1) or (2) become

$$0 = -\mu n_g(1-r_s) + w\mu r_s n_b \qquad t\to\infty \qquad (4)$$

Solving (4) gives $n_g(\infty) = \frac{wr_s}{(1-r_s)} n_b(\infty)$, and $R_g(\infty)$, the equilibrium ratio of currently satisfied customers to the total population, is

$$R_g(\infty) = \frac{n_g(\infty)}{n_g(\infty) + n_b(\infty)} = \frac{1}{1 + \frac{1 - r_s}{wr_s}} \quad 0 < r_s < 1, \quad 0 < w \leq 1 \quad (5)$$

Also, $R_b(\infty)$, the equilibrium ratio of unsatisfied customers, is

$$R_b(\infty) = 1 - R_g(\infty) = \frac{1}{1 + \frac{wr_s}{1-r_s}} \quad 0 < r_s < 1, \; 0 < w \leq 1 \quad (6)$$

It is evident that the equilibrium ratios $R_g(\infty)$ and $R_b(\infty)$ are independent of total potential customers N, the relative numbers of people m_g and m_b informed by word-of-mouth, or the service rate μ. All of these factors have a strong impact, however, during the startup or transient phase. $R_g(\infty)$ depends directly on the rate w at which dissatisfied customers return for service. Also, $R_g(\infty)$ approaches zero if few of the customers are satisfied ($r_s=\epsilon$), and approaches 1.0 if almost all customers are satisfied ($r_s=1-\epsilon$).

Although equations (1) and (2) are analytically intractable, some comments may be made about the shape of the curves for $n_g(t)$ and $n_b(t)$. The sum of equations (1) and (2) is non-negative. Hence, at least one of the curves must have a positive slope for all $t < \infty$. The speed at which the transient phase is completed depends upon μ, m_g and m_b. Values of other parameters normally expected in a competitive service situation are $r_s \geq 0.7$ and $w \leq 0.3$. For these parameter values, n_g grows faster than n_b for small t. A careful evaluation of the curves for these parameter values indicates that n_g consistently goes through a maximum near the end of the transient phase, and n_b consistently has a positive slope at all times. Beyond the

transient phase, the second derivatives of these equations have signs which are opposite to the signs of the equation slopes. Hence, since in this region n_g has a negative slope, it is concave up; n_b has a positive slope and is concave down.

Figure 2 is a simulation which demonstrates the dynamic performance of the model, with N = 1000, μ = 5 per year per customer, $m_g = 7$, $m_b = 14$, $r_s = 0.8$ and w = 0.2. While N is an arbitrary number for purposes of this demonstration, μ is a function of the type of service and the population characteristics. At time t = 2.0 years, a step change in a service parameter has been applied, which is discussed in the following section.

*** Place Figure 2 about here ***

If the company is offering a unique service, then $R_g(t)$ is simply the current fraction of people with positive perceptions (due to recent service or word-of-mouth) who know about the service. If there is no competition but customers feel that they must purchase the service regardless of quality, then w = 1. However, if the service is highly discretionary, then w could be expected to be quite small, requiring the service provider to keep r_s as close to 1 as possible (excellent service) in order to develop and maintain a customer base and revenue stream large enough for long-term survival. If the service is competing with others, then $R_g(t) + wR_b(t)$ can be interpreted as market share MS(t), so that the equilibrium market share is given from (5) and (6) as

$$MS(\infty) = \frac{w}{wr_s + 1 - r_s}. \tag{7}$$

In a competitive environment, it is therefore also important to keep r_s as high as possible to enhance equilibrium market share.

The model's word-of-mouth parameters, m_g and m_b (the average numbers of people told by customers about good and bad service experiences respectively) are characteristics of the population over which the service provider usually has no control. A published study (TARP 1986) indicates that an average ratio for these parameters should be about 1:2, and suitable values to use for them would be about 7 and 14 respectively. w, the proportion of the dissatisfied population's demand which the provider is likely to experience, is a characteristic of the marketplace. It depends upon a variety of factors such as whether there are competing services, the cost of switching to a different service provider, customer perceptions of competitors relative to the service being considered, whether the service is a discretionary purchase, convenience to potential customers, and pricing (although we will not explicitly consider pricing effects in this discussion). The service provider does control r_s, the proportion of customers who are satisfied with the service, by controlling the quality of the service. This provides the main basis upon which a service strategy can be developed.

4. Model Response To Changes In Service Parameters

To relate the model results to consumers, $R_g(\infty)$ and $R_b(\infty)$ are the probabilities that a particular consumer will find him or herself in subpopulations g or b respectively, at any random time after the system approaches equilibrium. From equation (4), the probability that a consumer in population g will make a transition to population b is proportional to $\mu(1-r_s)$ per unit time. Conversely, the probability that a consumer in population b will make a transition to g is proportional to $wr_s\mu$ per unit time. The matrix of transition probabilities which develops from these results can be related to Markov brand-switching models (Blattberg 1981).

Under fairly general conditions (i.e. neither of the subpopulations g and b are too small, and r_s and w are not too close to the ends of their ranges), it can be shown that the customer arrivals for service from both subpopulations can be approximated as Poisson streams (Cox & Miller 1965). This is possible because the arrivals represent the superposition of a number of independent point processes. These arrivals are at a rate $N\mu R_g(\infty)$ from subpopulation g and $Nw\mu R_b(\infty)$ from subpopulation b when the system is in equilibrium.

Suppose we wish to consider the effect of changing the service parameter r_s to r_s', and/or suppose market conditions result in a change of w to w'. The new equilibrium levels, $R_g'(\infty)$ and $R_b'(\infty)$ can be calculated from equations (5) and (6) by inserting the new parameter values. We can also determine how rapidly the new levels will be approached, using the Poisson

arrival stream assumptions, and treating transitions between system states as being driven by semi-Markov processes.

Using the standard approach described by Howard (1971), if the system state probability row vector $\phi(0)$ before the change is

$$\phi(0) = [R_g(\infty)\ R_b(\infty)],$$

then the time-dependent vector is

$$\phi(t) = \phi(0) \exp(\mathbf{A}t).$$

Here the array **A** is calculated from the transition rates, after the parameters have been adjusted to w' and r_s'.

$$\mathbf{A} = \mu \begin{bmatrix} -(1-r_s') & (1-r_s') \\ w' r_s' & -w' r_s' \end{bmatrix}$$

The resulting solution is

$$\phi(t) = \phi(0) \begin{bmatrix} R_g'(\infty) & R_b'(\infty) \\ R_g'(\infty) & R_b'(\infty) \end{bmatrix} + \exp\left[-\mu t\{1+(w'-1)r_s'\}\right] \begin{bmatrix} R_b'(\infty) & -R_b'(\infty) \\ -R_g'(\infty) & R_g'(\infty) \end{bmatrix}$$

The first term in this result gives the new equilibrium probabilities $R_g'(\infty)$ and $R_b'(\infty)$ for the respective states. The second term is time dependent and

asympotically approaches zero. The approach to the new equilibrium levels is therefore in the form of a decaying exponential with time constant $1/\{\mu[1 + (w' - 1)r_s']\}$.

The time period $t \geq 2.0$ years in Figure 2 demonstrates the reaction of the model to a step change in r_s, in an example where the service provider wishes to improve service quality. In this case, the system is in approximate equilibrium with $r_s = 0.8$, $w = 0.2$, and the step change is to $r_s' = 0.9$, but with $w' = w = 0.2$. With $\mu = 5.0$ per year, the time constant is 0.71 years. This relatively slow approach to the new equilibrium level is due, of course, to the fact that the nominal demand rate for this service is not very high, and previously dissatisfied customers arrive for service only $w\mu = 1.0$ per year per customer.

5. The Service Quality Cost Model

The arrival rate of customers is

$$\omega(t) = \mu(n_g(t)+wn_b(t)). \tag{8}$$

Thus the rate at which service income and variable service costs are accumulated is proportional to $\omega(t)$. For the cost model, we split service costs into three distinct components, each of which has a fixed and a variable contribution. The service cost components arise from: a) primary customer service, b) soliciting customer feedback on service quality, and c) responding to customer complaints on service quality. This is demonstrated conceptually in Figure 3 and described in detail in the following.

*** Place Figure 3 about here ***

a) As customers are serviced, a fraction r_g will perceive that primary service has been satisfactory, making it more likely that they will return in the future. However, the remaining fraction $1 - r_g$ will perceive that primary service has not been satisfactory. If they continue with this perception, they are less likely to return in the future. The variable cost of providing primary service $F(r_g,\omega)$ per customer is normally a monotonic non-decreasing function of r_g and a decreasing function of ω. That is, providing better primary service will tend to be more costly, but the cost per customer will decrease with customer service rate.

b) Of those customers who perceive primary service to be unsatisfactory, a fraction r_c will complain to the service providers, but the remainder $1 - r_c$ will leave without complaining. If customers perceive service to be unsatisfactory, then it is important to the service providers to be made aware of this, giving an opportunity to remedy the poor service. This improves customer perceptions of service, and increases the likelihood that these customers will return in the future. The adoption of effective complaint solicitation and complaint handling procedures can have a markedly positive effect on customer purchasing decisions (TARP 1986; Fornell and Wernerfelt 1988). Encouraging dissatisfied customers to complain has a variable cost function $G(r_c,\omega)$ per customer which will normally be a monotonic non-decreasing function of r_c and a decreasing function of ω.

c) Of those customers who complain about customer service, a fraction r_{sc} will have their problems resolved to their satisfaction, and will be more likely to return in the future. The remaining $1 - r_{sc}$ fraction will not have their problems resolved and will leave dissatisfied. Remedying customer complaints about poor service has a variable cost function $H(r_{sc},\omega_1)$ per customer which will normally be a monotonic non-decreasing function of r_{sc} and a decreasing function of ω_1. Here, $\omega_1 = \omega r_c(1-r_g)$, which is the effective rate of customer complaint arrivals.

Given the above service system characteristics, the fraction of customers who leave in a satisfied state is easily shown to be

$$r_s = r_g + (1-r_g)r_c\, r_{sc}, \tag{9}$$

and the fraction who are dissatisfied is thus

$$1 - r_s = (1-r_g)(1-r_c\, r_{sc}).$$

We have made a simplifying assumption that complaining customers whose complaints are satisfactorily resolved will behave in the future in the same manner as customers who received satisfactory primary service. If no effort is made to service complaints ($r_{sc}=0$), or if no complaints are received ($r_c=0$), then $r_g = r_s$. In these latter cases, customer perceptions of service quality will be based entirely on primary service quality.

The rate at which gross service revenue is accumulated is

$$I_s(t) = v\omega(t) \tag{10}$$

where v is the average charge per service.

The rate at which variable service costs are accumulated is

$$C_{vs}(t) = \omega(t)\ \{F(r_g,\omega) + (1-r_g)G(r_c,\omega) + r_c(1-r_g)H(r_{sc},\omega_1)\}, \tag{11}$$

giving the net variable profit stream as

$$N_s(t) = I_s(t) - C_{vs}(t) \tag{12}$$

The net present value NPV(T), calculated using continuous discounting, of the service operation over a planning horizon of T years is

$$NPV(T) = -FC_F - FC_G - FC_H + \int_0^T e^{-pt} N_S(t)dt + FC_S/(1+u/100)^T$$

Here, FC_F, FC_G and FC_H are the fixed investments in the three service components, primary, complaint encouragement, and complaint resolution, respectively, and FC_S is the service operation's salvage value at the end of the planning horizon T. p is the nominal discount rate for continuous compounding, calculated from the cost of capital u, where

$$p = \ell n \left(\frac{u}{100} + 1\right).$$

6. An Illustration Of The Model

Figure 4 shows an example simulation of the service cost model, where the parameter values shown in Table I have been used. For simplicity, we have assumed that the variable service cost components per unit of service are averages, and do not depend on service rate. The service parameters were derived as much as possible from data quoted in Part II of the 1986 TARP

report on complaint handling in America (TARP 1986), for large ticket ($100+) services. Such parameters might be appropriate, for example, for independent automobile repair services or expensive restaurants. We assume a small startup service operation, and describe both the startup and the equilibrium phases of a business in a localized, relatively competitive market. The internal rate of return for the parameters used here is 27%.

Note the typical behaviour of this model in the transient (startup) phase, where net revenue flow peaks relatively early in the life of the operation, and then tails off to an equilibrium rate. In this particular case, the equilibrium net revenue flow is only 60% of peak net revenue flow.

*** Insert Figure 4 about here ***

It is instructive to consider the impact on net revenue of making changes in the quality of service parameter r_s. Assume for simplicity that the system is in equilibrium. From equation (12),

$$\frac{\partial N_s}{\partial r_s} = \frac{\partial I_s}{\partial r_s} - \frac{\partial C_{vs}}{\partial r_s}$$

Using equations (10) and (11) gives

$$\frac{\partial N_s}{\partial r_s} = \frac{\partial \omega}{\partial r_s} \{v - \frac{C_{vs}}{\omega}\} - \omega \{\frac{\partial F}{\partial r_s} + (1-r_g) \frac{\partial G}{\partial r_s} - \frac{G \partial r_g}{\partial r_s} + r_c (1 - r_g) \frac{\partial H}{\partial r_s} - r_c H \frac{\partial r_g}{\partial r_s} + (1 - r_g) H \frac{\partial r_c}{\partial r_s}\} \quad (13)$$

From equations (7) and (8)

$$\omega = \mu N \; MS(\infty) = \frac{\mu N w}{w r_s + 1 - r_s}$$

Thus

$$\frac{\partial \omega}{\partial r_s} = \frac{\omega(1-w)}{w r_s + 1 - r_s}$$

Also, from (9)

$$\frac{\partial r_g}{\partial r_s} = \frac{1}{\partial r_s / \partial r_g} = \frac{1}{1 - r_c r_{sc}}$$

and $$\frac{\partial r_c}{\partial r_s} = \frac{1}{\partial r_s / \partial r_c} = \frac{1}{(1 - r_g) r_{sc}}$$

Since we have assumed no ω dependence in this example for F, G, and H, we have finally from (13)

$$\frac{\partial N_s}{\partial r_s} = \frac{\omega(1 - w)}{w r_s + 1 - r_s} \left(v - \frac{C_{vs}}{\omega} \right) + \omega \left(\frac{G + r_c H}{1 - r_c r_{sc}} - \frac{H}{r_{sc}} \right)$$

Using the parameter values from Table I, the result is a \$425 change in equilibrium annual net revenue for a change of 0.01 in r_s. This is approximately 0.8% of net revenue, and is caused primarily by demand changes rather than cost adjustments resulting from the service quality changes.

7. Discussion

The general demand behaviour of this model is consistent with existing models of the demand for consumer products with short re-purchase periods (Dodson and Muller 1978); we would expect the demand for services to behave in a similar manner. Kotler (1970) explains that sales for a repurchasable new product tend to have an initial large surge from first purchasers, followed by reduced volume due to repeat purchasers. Massy (1970) shows actual sales for a convenience product that follow a similar curve. This is the type of behaviour built into and exhibited by the current model (see Figure 2).

Dynamic equations (1) and (2) of this model cannot be solved in closed form. However, based on our empirical experience with the model, there are a number of generally useful observations which can be derived, given that the service provider depends only upon word-of-mouth advertising, has developed a particular market strategy for maintaining its position, and that market conditions are not expected to change over the planning horizon. The first point is that the business should not expand to handle excessive demand in the early phase of the service offering's life, since equilibrium long-term demand may be considerably less than that experienced during the transient start-up phase.

Secondly, especially if the service has a rate of return which is marginal, one of the worst possible actions in a competitive environment is to cut service quality to reduce costs. This would probably decrease the long-term viability of the service because of the ensuing reduction in demand and net revenue. Third, improving service quality when operations have reached equilibrium can have beneficial effects on customer

satisfaction, resulting in improved demand, but it takes a long time for these benefits to take effect from repeat customers. A much better strategy is to adopt a high service quality from the beginning of operations, since word-of-mouth advertising is far more effective during the transient phase, when customers are still being attracted from the "unaware" population. Put bluntly, once a reputation for poor service is acquired, it takes a long time to live it down.[1]

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Figures

1. Transition Rates Among The Three Populations In The Service Model

2. Dynamic Behaviour Of The Service Model

3. Service Cost Modeling

4. An Application Of The Dynamic Service Cost Model

Table

I. Service Model Parameters For The Application In Figure 4

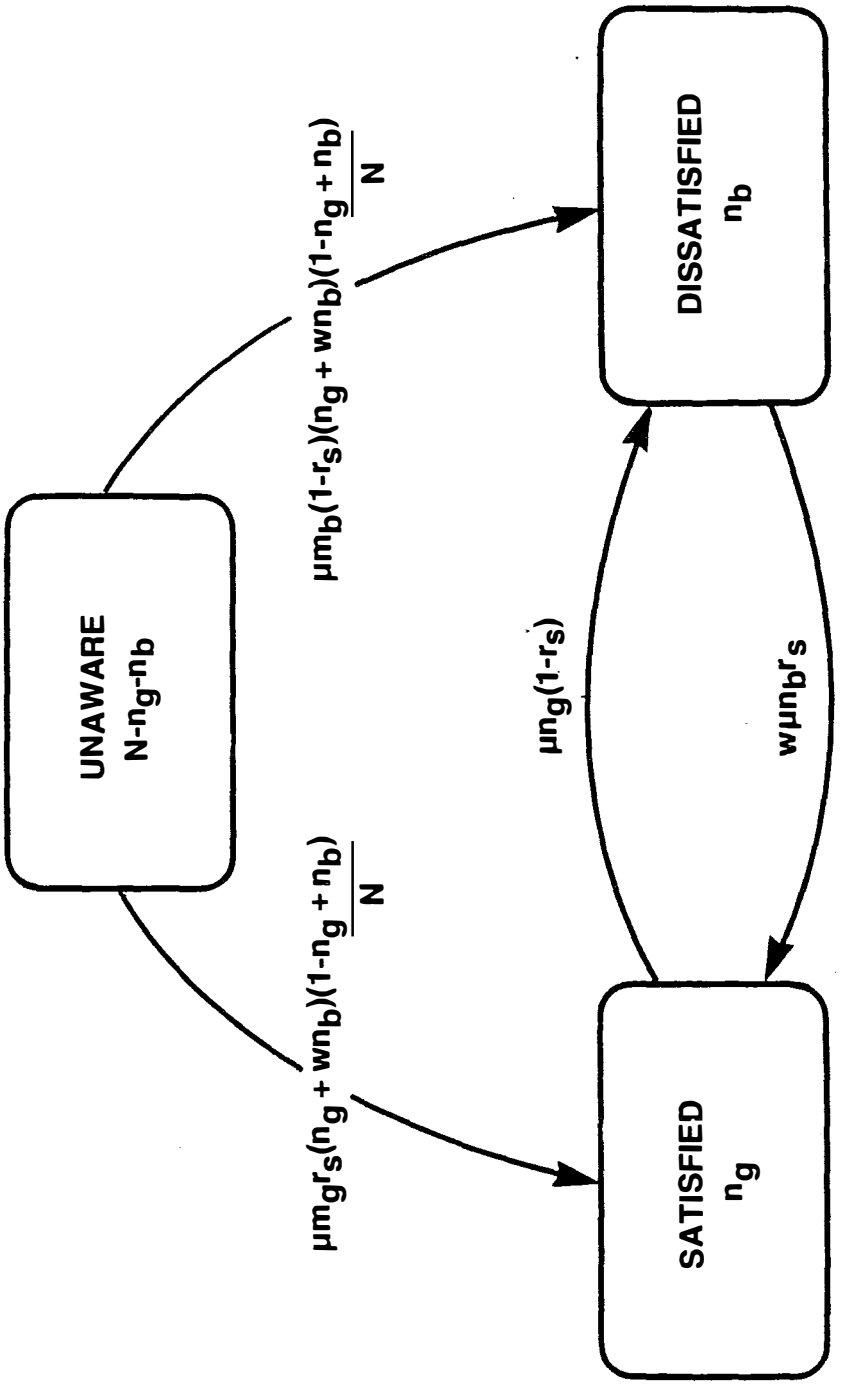
UNAWARE
N-ng-nb
μmb(1-rs)(ng + wnb)(1-ng + nb)/N
μmgrs(ng + wnb)(1-ng + nb)/N
DISSATISFIED
nb
SATISFIED
ng
μng(1-rs)
wμnbrs

Figure 1

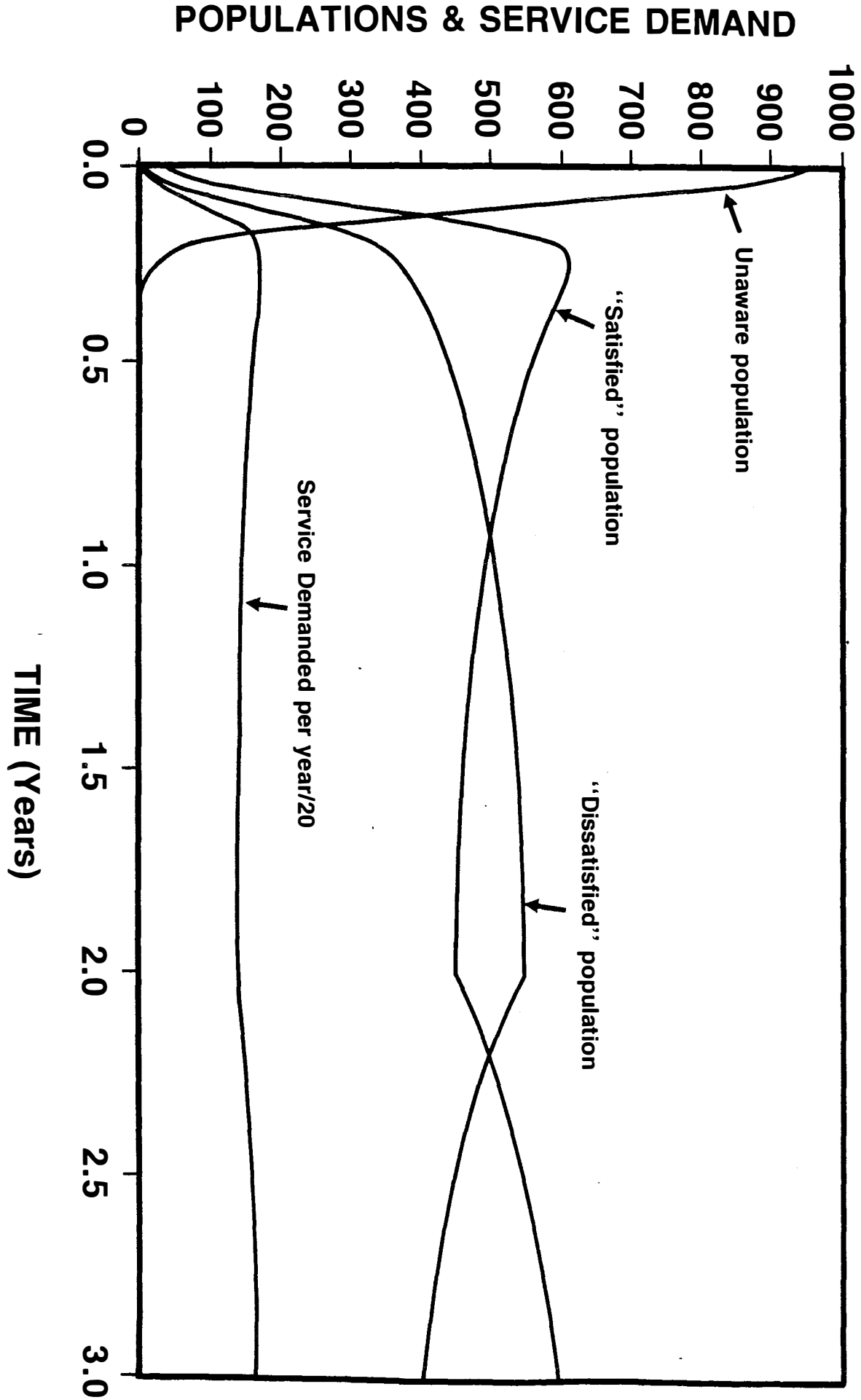
POPULATIONS & SERVICE DEMAND
1000
900
800
700
600
500
400
300
200
100
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
TIME (Years)
Unaware population
"Satisfied" population
"Dissatisfied" population
Service Demanded per year/20

Figure 2

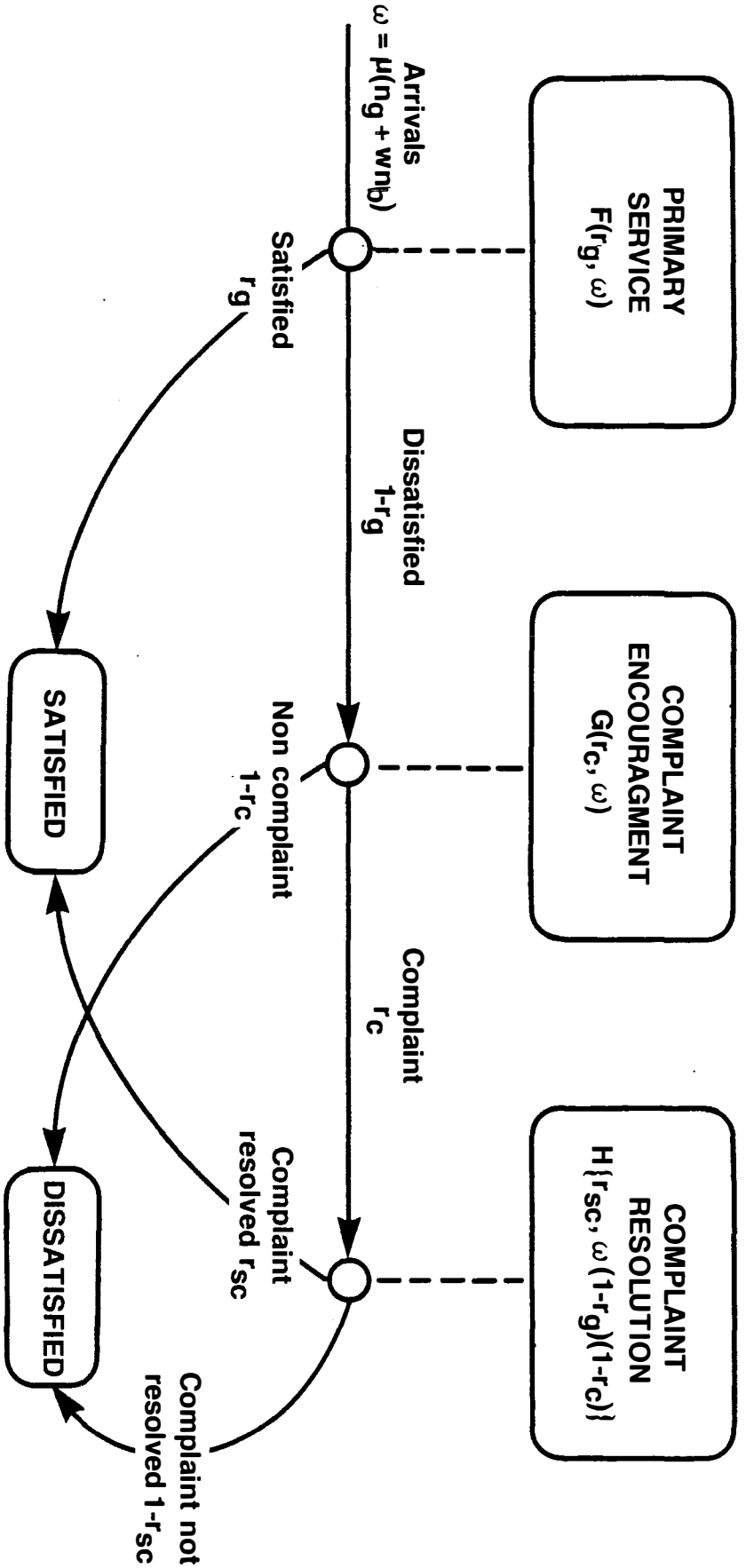
PRIMARY SERVICE
F(r_g, ω)
COMPLAINT ENCOURAGMENT
G(r_c, ω)
COMPLAINT RESOLUTION
H{r_sc, ω(1-r_g)(1-r_c)}
Arrivals
ω = μ(n_g + wn_b)
Satisfied
r_g
Dissatisfied
1-r_g
Non complaint
1-r_c
Complaint
r_c
Complaint resolved r_sc
Complaint not resolved 1-r_sc
SATISFIED
DISSATISFIED

Figure 3

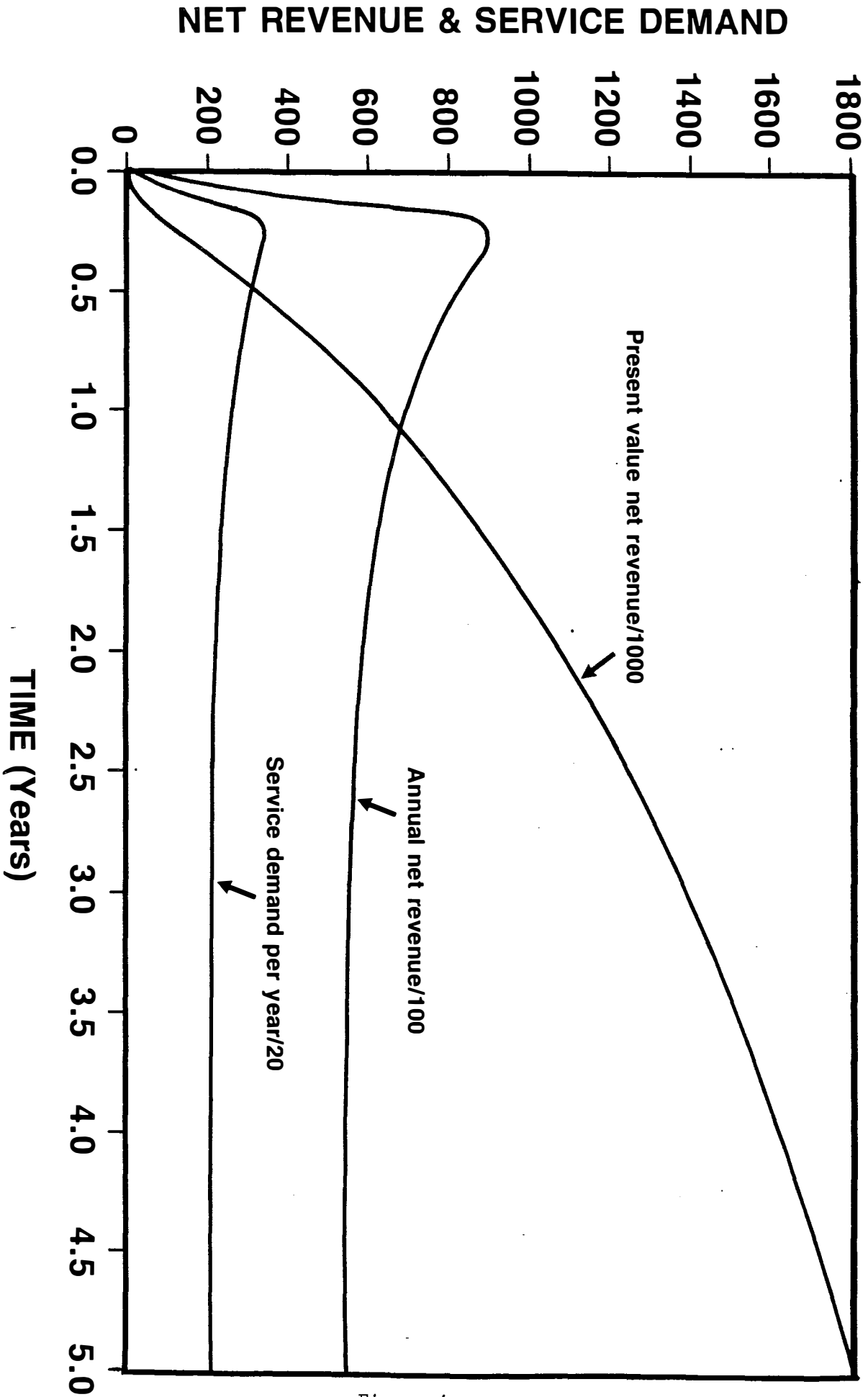
NET REVENUE & SERVICE DEMAND
1800
1600
1400
1200
1000
800
600
400
200
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
TIME (Years)
Present value net revenue/1000
Annual net revenue/100
Service demand per year/20

Figure 4

Table I

Service Model Parameters For The Application In Figure 4

Parameter	Value
μ (arrival rate/cust./year)	5.0
N (total population)	1000
n_0 (initially "satisfied" customers)	20
w (return rate weight for dissatisfied customers)	0.10
m_g (potential customers told by satisfied customers)	7
m_b (potential customers told by dissatisfied customers)	14
r_g (fraction of customers receiving satisfactory primary service)	0.8
r_c (fraction of dissatisfied customers who complain)	0.63
r_{sc} (fraction of complaints satisfactorily resolved)	0.26
r_s (overall fraction of satisfied served customers) $= r_g + (1-r_g)r_c r_{sc}$	0.833
v (customer charge per service)	\$100.
F (variable cost per primary service)	\$70.
G (variable cost to encourage dissatisfied customers to complain)	\$0.50
H (variable cost to improve service per dissatisfied customer)	\$25.
(Note: no dependency on ω is assumed for F, G and H)	
Total variable cost per customer $= F + (1-r_g)\,G + r_c(1-r_g)H$	\$73.25
FC_F (fixed investment in primary service)	\$200,000
FC_G (fixed investment in complaint encouragement)	0
FC_H (fixed investment to fix customer complaints)	\$25,200
FC_S (salvage value of investment after T years)	\$150,000
T (time horizon, in years)	5
$R_g(\infty)$ (equilibrium population fraction of satisfied customers) $1/(1 + (1-r_s)/wr_s)$	0.33

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