THE REGULATION OF THE MARKET FOR INFORMATION IN RENTAL HOUSING: A SIMULATION STUDY

by

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Abstract

Much of the direction to recent proposals for consumer protection lies in improving the quality of pre-purchase information. As with much public policy the legislation frequently proceeds the theoretical justification. In the case of pre-purchase information the theoretical basis stems from the economics of information.

The main purpose of this thesis is to examine the demand and supply of information. In particular, a demand model for information is constructed, which unlike the existing theory, assumes that the searcher is ignorant of the distribution of offers and has limited ability to store market data. The use of an error-learning simulation model permits the study of problems such as decay in the storage vector of market offers and problems due to oversearching and undersearching. It appears that the marginal rules of search are of little use in modelling the truly ignorant consumer.

In addition to analyzing the demand for information, this essay investigates the supply of information. The rental housing market is used as the institutional setting. Empirical analysis of this market, along with a theory of the information broker is integrated into the demand model to create a market model for rental housing information.

Finally, this model is subjected to some explorative policy tests. In dealing with consumer ignorance the government can choose to do nothing, regulate, or nationalize. The benefits, in terms of reduced search costs, are simulated and compared. A full scale cost-benefit simulation is not possible because of limited information of the costs of information production.

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CHAPTER ONE

Introduction and Outline

The purpose of this thesis is to examine the brokerage of information in the market for urban rental housing. The procedure is to construct a simulation model of the demand and supply for rental information, and thereby a model of the market for such information. Several interesting theoretical problems, not in the literature, are studied, and some tentative policies toward markets with imperfect information are evaluated.

The study of markets with imperfect information is important and interesting both theoretically and for policy objectives. Academically, this essay attempts to make headway on several fronts. First, housing economics has been marked by a recurring controversy over the nature, extent, and importance of market imperfections. Many economists who have studied this market remark on what they consider to be imperfections resulting from peculiarities in the commodity such as indivisibility, spatial uniqueness, and sluggish information markets. Some, such as Kirwan and Martin (1970) and Rodwin (1963), despair at what they consider analytic intractability, while others such as Smith (1964), Muth (1960), and Olsen (1969), appear to consider the market imperfections issue a red herring. This essay attempts to shed some light on the matter by examining the difference between perfect markets and perfect competition.

Second, the issue of imperfect information is directly related to models of consumer search recently constructed by Stigler (1961), McCall (1970), and Rothschild (1973, 1974).[1] These models have generally made extremely restrictive assumptions in order to facilitate the application

of analytic solutions. The basic thrust of this thesis is to construct a less restrictive model of information markets. This removes the possibility of applying analytic techniques, and neccessitates the application of simulation methods, but the added insight into the nature of search compensates for the loss in analytic elegance.

Aside from its academic interest, this essay attempts to contribute to current policy discussions. First, it should be noted that the proportion of tenant to owner-occupied dwelling units has increased in the past twenty years. In Table 1 this is demonstrated; note especially the percentage change from 1961 to 1971.[2]

Table 1

	1951	% Change	1961	% Change	1971
Owner-occupied	2,236,955	34.4	3,005,587	21.0	3,636,925
Tenant-occupied	1,172,340	32.1	1,548,406	54.8	2,397,584

Owner-occupied and tenant-occupied dwelling units
1951 - 1971

Second, the role of the information broker is becoming very important in the modern consumption economy. There have been several excellent studies on brokerage in the freehold housing market such as Hempel (1969) and Becker (1972). However these studies do not separate the provision of services such as financial and legal assistance from the provision of information about the commodity. Recent development in the market for rental information, namely the rapid growth of rental information agencies, is a good opportunity to study the role of the information broker and the effects this agent has upon market imperfections.

Finally, and related to the above point, this study attempts to contribute to the growing literature on the economics of consumer protection.

Consumerism has become a focal point for many politically active groups. These groups, ranging from informal local organizations to national bodies such as the Consumer's Union, argue that the consumer needs to be protected from rapacious corporate power. Recently tenant activist groups have argued for centralized government housing registries to prevent the exploitation that they allege, is being perpetrated on low income tenants by rental information agencies.

It should be emphasized that the policy tests are by no means conclusive; they are performed as an indication of the potential of simulation in the evaluation of government action in rectifying market imperfections, and to organize the discussion of policy.

Theoretical Background

This essay uses old terminology in ways that may be slightly unfamiliar to the reader. The first important distinction is between perfect competition and perfect markets. Although the growth of the literature in this area has been extremely rapid, the separation of the two concepts is rarely made explicit.[3]

Simply stated, perfect competition refers to the structure of the set of buyers or the set of sellers. A few large buyers indicates imperfect competition or monoposony in the same way that a few large sellers indicates imperfect competition due to monopoly power. Prices may well diverge from the perfect competition optimum of price equalling marginal cost because of monopoly or monoposony power; in other words because one side or the other has few alternatives.

On the other hand, a perfect market reflects a certain condition in the exchange between a buyer and a seller. In particular, Alchian

(1969) argues that perfect markets involve zero transactions costs. These exchange costs are normally thought to be composed of information costs (search or pre-purchase information acquisition costs), negotiation costs and contract enforcement costs. The last two costs are merely subsets of information costs; with perfect information there would be no need to negotiate or enforce contracts. Perfect markets imply zero information costs.

There is no necessary connection between perfect markets and perfect competition. As Stigler (1957) has argued, perfect markets tend to be more common to monopoly and monoposony than perfect competition. With many atomistic sellers, no buyer can ever hope to know the complete set of prices. With positive costs of information acquisition it is likely that sellers may deliberately set prices which are different and the market price can diverge from marginal cost due to consumer ignorance. With monopoly, there is only one price to know and perfect markets become possible.

Information Costs and Brokerage

Whenever a good or service involves economies of scale in its production, and whenever sufficient demand for this good or service exists, it may pay someone to specialize in its production. Information acquisition is costly to the individual and there are probably significant economies in centralizing the production, collection, and distribution of information. On a wide scale this activity includes scientific and technological research, education, patents, copyright services, etc., but on a narrower focus, information on the price, quality and location of consumer goods and serivces is obviously becoming a commodity

capable of sale. Various specialist hobby magazines ranging from stereo to car journals, and stamps to quarter horse breeding, testify to the extent to which this industry has grown. Adam Smith's dictum about the relationship between the division of labour and the extent of the market is fully demonstrated by the growth of the information industry.

It is possible to use a simple demand and supply analysis to illustrate the basic economics of brokerage.[4] First, the demand for brokerage services in general is a derived demand, which results from both buyers and/or sellers demanding the services of a market intermediary.

Second, it is apparent that the fee charged by the broker must be less than the cost of the buyer or seller performing the market service for themselves. In certain cases it is possible for the broker to assume monopoly power and prevent the buyer or seller from performing these services without the help of the market agent. This is the allegation that is often made about rental information agencies. They 'trap' the supply of information (to be explained in Chapter 3), process this information and then use the monopoly power to extract a rent from tenants who are searching for accommodation. But in general brokers economise on market costs.

Third, brokerage fees can be shifted to one side of the market or the other as a function of the slopes of the demand and supply curves. The 'transaction cost differentiated supply and demand analysis' is useful in illustrating the shifting and incidence of brokerage fees; this analysis will become important later when I examine the supply of rental housing information.[5]

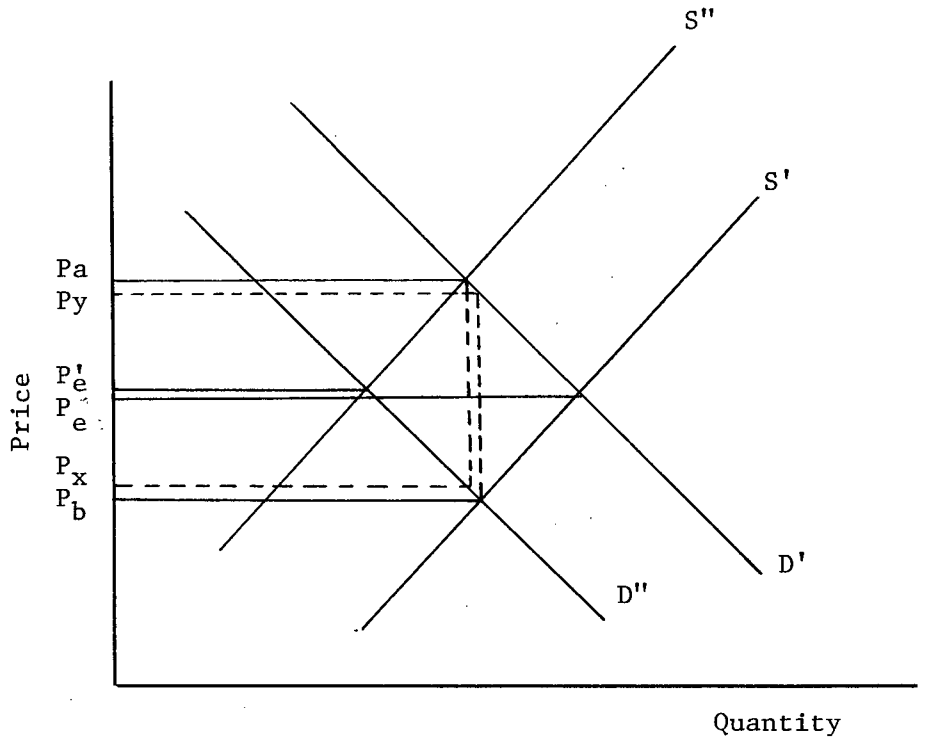


Figure 1

Transactions Differentiated Demand and Supply Curves

In Figure 1 are drawn a conventional set of demand and supply curves. These relationships represent the demand and supply for buyers who are indifferent to the level of service provided by market intermediaries. For the sake of argument, imagine that all transactions between producers and consumers are handled by an agent. Participants in the market who demand market services, in addition to the actual product and its delivery, must pay a premium.[6]

Now suppose the buyer wishes to have a warranty, or equivalently exact information about the failure of a product. The agent who provides such a service will do so only if rewarded. In other words, the price of the product charged to the buyer who demands this service must shift

upward for each unit offered by the agent, by an amount sufficient to cover the costs of producing this information or warranty protection. This is reflected by a shift leftwards in the supply curve from S' to S".

Alternatively, suppose that it is the seller who demands some market service such as a certified service centre for the product. The agent or retailer will be willing to perform such a service only if the price paid for the product is lowered sufficiently to cover the costs of this market service. This is reflected by a shift leftward of the demand curve from D' to D".

Of course, either the producer or consumer may decide that the premium demanded by the agent is excessive and they may perform the market service themselves.

The intersection of the market service differentiated supply curve, S", and the original pre-market or non-market service demand curve, D', yields the ask price. The intersection of the market service differentiated demand curve, D", and the non-market service differentiated supply curve, S', yields the bid price. For market services demanded by the buyer, the market agent will demand a higher than original price ($P_a - P_e$), while for service demanded by the producer, the agent will bid a lower than original price ($P_b - P_e$) for the product. The spread between bid and ask price ($P_a - P_b$) reflects the costs of transacting, given that there is perfect competition prevailing amongst buyers and sellers. According to Demsetz (1968), the greater the bid-ask price spread, the greater are the costs of transacting and hence, according to the above discussion, the greater are the market imperfections.

The similarities of this analysis with excise taxation are obvious, but there is some difficulty in the measurement of incidence in the case

when both the demand and supply curves are shifted. Consider the case where only the buyer desires a market service. This results in a shift to the left of the supply curve. As in the case of excise taxation, both the buyer and the agent would share the costs of transacting, with the buyer's share being $P_a - P_b$ (referring to Figure 1) and the agent's share being $P_e - P_x$. In the case where the producer alone desires market services, only the demand curve shifts, and the proportion of transaction charges borne by the seller is given by $P_e - P_b$ and the portion of market costs borne by the seller is given by $P_y - P_b$. In the case where both curves shift, the agent can generally shift the market charges to both the buyer and seller. The buyer and seller then split the market costs; however, it is ambiguous whether the original price P_e or the point P_e' are the relevant benchmarks. P_e obviously disappears and equally obvious is that P_e' never actually becomes an observed price, since as market imperfections decline and the demand for market services dwindles, both S" and D" shift back to their original positions. It is probably safest to use an average point which lies between P_e and P_e', but this point is somewhat academic.

It is apparent that the incidence of brokerage fees (whether they fall on the buyer or seller) is a function of the relative demands for market services by buyers and sellers and the slopes of demand and supply for the product.[7]

The Use of Simulation Studies in Economics

The relaxation of the restrictive assumptions of search theory, upon which the discussion of market imperfections rests, necessitates the use of simulation, or Monte Carlo methods. This will be justified

inthe subsequent chapter, but now I wish to outline some important guidelines for the construction and use of these models.

Simulation studies have proliferated in the past decade. Doubtless their contribution to economic methodology has been suspect. In a recent critique, Lee (1973) examines the role of large scale simulation models and concludes that these large scale models have revealed little about urban complexity in relation to the insights obtained about how to build large scale models; as the size of the model increases the returns to knowledge about the system being modelled decline, while there are increased returns to knowledge about the construction and use of large scale models.

Lee proposes three guidelines for simulation studies:

1) "A balance should be obtained between theory, objectivity and intuition. Excessive concern for theory results in a loss of contact with the policy problem, but policy cannot be formulated well without a strong theoretical foundation. Over-emphasis on objectivity is one of the mistakes of the large models and results in empty-headed empiricism; on the other hand most social questions have a quantitative component and require quantitative information to resolve.....

2) Start with a particular policy problem that needs solving, not a methodology that needs applying.....

3) Build only very simple models. Complicated models do not work very well if at all, they do not fit reality very well, and they should not be used in any case because they will not be understood.....".[8]

This is not the place to go into a prolonged discussion of simulation methodology; there are several excellent texts (cf. Naylor, T.H. et. al. 1971), however, several points need stressing. First, simulation studies should not be pursued as an end. The use of simulation in this essay is necessitated, simply because the theory of search uses probability theory. But theory can only be applied if

certain restrictive assumptions are made about human behaviour. Once these assumptions are relaxed, as they must if various policies are to be examined, then less elegant methods are necessary. Simulation, in this case the use of random number generators, becomes an essential device for exploring new areas in the economics of information.

Second, as with all research methodology, simulation has assumptions that must be accepted before any progress can be made. One of the debating points between 'simulators and anti-simulators' is the nature of verifying the equations used in the model. Computers are exact. Just any monotonically increasing function will not do; it must be a precisely specified algebraic or logical equation. This required precision has lead many critics to argue that the model holds only for the specified set of equations; vary the equations and it is likely that the model outputs gibberish. Any analyst who has worked with simulation models readily concedes this, but there are procedures which can be used to reduce the likelihood that the model is limited to a particular set of equations.

First, models should be kept simple. The probability of perverse output increases dramatically with additional separate relations and variables. In addition, as the number of equations used in a simulation model are increased, analysts find that they must use more arbitrary assumptions in order to link various parts of the model; calibration or 'fudge factors' seem to grow exponentially with the number of equations and variables.

Second, the equations used in the model must be theoretically sound and must be verified using acceptable empirical techniques.

Parameters obtained from regression analysis that have passed tests of significance can generally be used with confidence.

Third, even those parameters which either fail to be verified with any high degree of confidence or for which adequate data is unavailable can be evaluated using sensitivity analysis. This is one of the powers of simulation methodology. By repeated trial and error, it is possible to evaluate the output of a model using many values of a given parameter. It is at this point that theoretical judgment is used to decide what values of the parameter ought to be employed.

Flowcharting

An important tool used throughout the essay is the flowchart. The simulation model is described and documented at four levels - verbal, mathematical, flowchart and program listings. The first and second forms of description are common to economics, the last presupposes a knowledge of FORTRAN IV, however the third is very simple, even though it may be unfamiliar to the reader. Rather than give an outline of the theory of flowcharting, it is simpler to present the flowchart used by a noted economist to describe the process of getting up.[9]

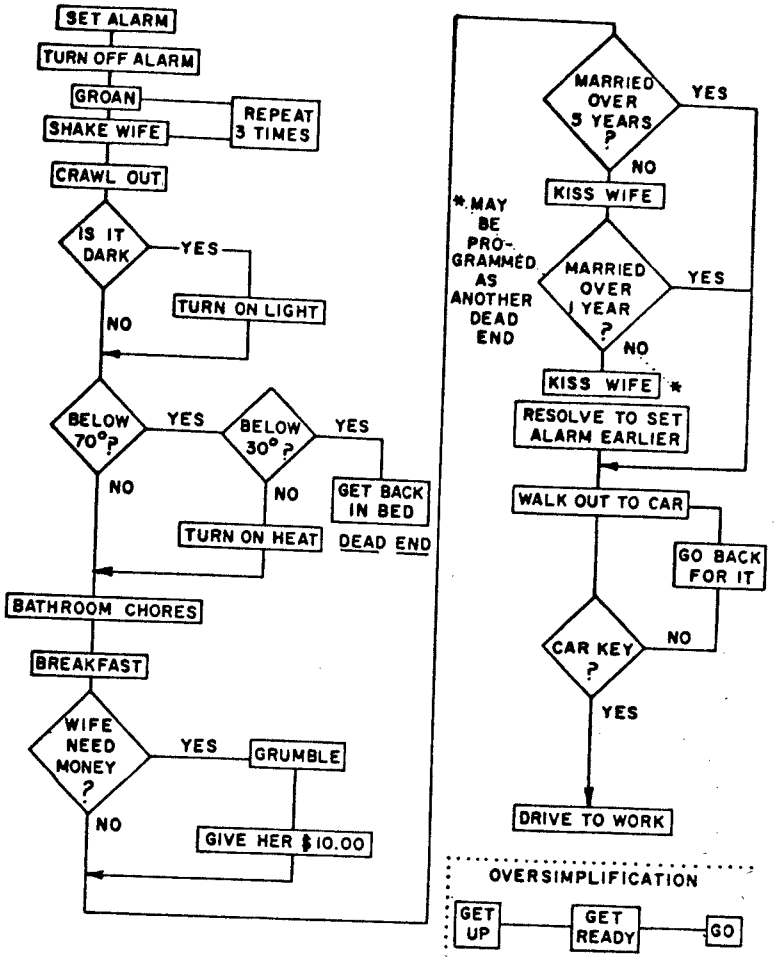


Figure 2

Flowchart Example

Information: Quantity and Qualtiy

The final background required is a brief examination of information as an economic commodity. Superficially it is apparent that more information is better than less, but upon reflection this is often untrue. Searchers have limits to their ability to process market data.

In addition, information has quantity and quality aspects which are frequently related. It is possible to conceive of the information acquisition process as having both an extensive and an intensive

margin. If commodities are composed of separate characteristics, then information can be extensively acquired by considering more and more relevant attributes about the product (price, location, number of rooms etc.). More information can mean gaining information on more attributes. The extensive margin occurs at the point where the marginal returns to expanding search to one more attribute is matched by the marginal costs.

The intensive margin occurs for the attribute which is best known by the consumer. The intensive margin occurs at the point when the marginal returns from more information about a particular characteristic is matched by the marginal costs of obtaining this data.

Obviously, indivisibilities and the problems inherent in identifying appropriate characteristics distort this neat picture. Economists have employed two methods of quantifying and modelling information acquisition. Some have attempted to weld information and mathematical communication theory directly onto economic theory (cf. Marshak, 1968). Others have used the process of sampling from a distribution of prices as an analogue (simulation) of the information acquisition process. In both cases it has been presumed that all the consumer is examining is price. Quality attributes of the commodity are ignored. Obviously this is a gross simplification, however extensions result in extreme complications.

Outline

The next two chapters present the demand and supply models of information acquisition in the rental housing market. The demand model (Chapter Two) moves directly from the basic paradigm developed by

Stigler (1961) and modifies this theory by incorporating error-learning, storage and decay. These modifications result in complexities which are conventiently handled by simulation. Chapter Three extends the work of Chapter Two by integrating supply elements into the basic demand model. Empirical evidence is presented for some of the sources of information (classifieds and rental information agencies); unfortunately the supply model cannot be extended into other important areas such as casual search (street signs, word of mouth) and property management, due to lack of data. Supply is modelled as a function of the vacancy rate and the model is run to show how variations in the vacancy rate alter the supply of information and provoke different search behaviours. The chapter concludes with a sensitivity analysis.

The final chapter presents some explorative and partial policy tests. The three general policies examined are free markets, regulation of price and quality, and government monopolies. The nature of the simulation is such that only comparisons of benefits are possible; there is no provision for examining the direct (administrative costs) of these policies and this chapter should not be viewed as a full blown cost-benefit examination. Extensions and qualification of the model close the thesis.

FOOTNOTES - CHAPTER ONE

1. These are but a few of the theorists who have published work in area recently. Since the essay attempts a substantial revision to the existing theory by revising assumptions common to the vast majority of the published works and since the literature is vast, only a few central articles will be mentioned and surveyed.

2. Source: Canada Year Book 1973, p. 610. It should be noted that these figures omit the recent significant rise in condominium home ownership. Present day figures would probably reveal a higher proportion of fee simple and strata-title ownership than is indicated in Table 1.

3. See Rothschild (1973) for an excellent survey of this literature.

4. This analysis and the diagram are adapted from Demsetz (1968).

5. See Demsetz (1968) for the use of 'time differentiated demand and supply relationships' in the analysis of stock brokerage. In this case the market service performed by the broker is restricted to providing immediacy of purchase or sale to both buyers and sellers.

6. Note that only prices and not quantities are relevant here.

7. See Appendix One for additional details.

8. Lee (1973), p. 176.

9. Baumol (1973), p. 605.

CHAPTER TWO

The Demand for Information

Recently economists have become interested in the economics of information. An important part of this literature is the theory of search which is nothing more than the theory of the demand for information. The literature begins with Stigler's seminal article (Stigler, 1961) and continues with the work of authors such as McCall (1970), Mortensen (1971), Kihlstrom (1973), and Rothschild (1973, 1974). Stigler's model is still very representative and provides a convenient vantage from which recent work may be evaluated. It should be stressed that the simulation proceeds on the criticism of this model, but does not rely upon any of the specific points.[1]

The Basic Paradigm

Two critical assumptions are made by Stigler and all subsequent work in this area (except for Rothschild whose work parallels, in part, the amendments undertaken in this chapter).[2] First, search is likened to sampling without replacement from a distribution for which the mean and variance are known by the searcher prior to undertaking search. Second and equally critically, it is assumed that searchers have two options with regard to accepting offers. They either must accept immediately or they can procrastinate indefinitely; in other words there is no decay or instantaneous decay in the stored offers. These two assumptions permit the application of probability theorems to derive marginal rules for optimal search. Searchers who are forced

into costly search will search until the expected marginal costs of search are equal to the expected returns for an extra unit of search.

Stigler uses simple probability distributions to evaluate some of the implications of costly search. The uniform and normal distributions are used along with the assumption that the wage rate approximates the time spent in search. Needless to say, time costs are an important element of the unit cost of search. Expected returns from search are developed using the properties of cumulative distributions of offers or wages or rents. If F(x) is the cumulative distribution of the set of offers, x, then the expected minimum is given by the formula,

$$E(M) = \int_0^\infty (1-F(x))^n dx \qquad (1)$$

where n is the number of units of search undertaken and E(M) is the expected minimum price after n units of search.[3] For the uniform and standard normal distributions, Stigler shows that this expression is concave which ensures that as n increases E(M) decreases. The expected return from an additional unit of search is given by the difference between n and n+1 units of search, or

$$M_{pn} = m_n - m_{n+1} = \int_0^\infty (1-F(x))^n F(x)dx \qquad (2)$$

where $m_n > m_{n+1}$.[4]

As shown in Figure 3, as long as this function (M_{pn}) increases at a decreasing rate, and as long as the marginal costs of search (MC) are zero (the total costs of search are constant per unit of

search), then the optimal number of units of search will be finite. Infinite search occurs when the returns to an additional unit of search are increasing (M_{pn}^*). The proof that search must stop before infinity rests upon the particular from of the distribution of prices and sets the optimum number of units of search prior to even beginning to sample. This obviously is quite unrealistic, however analytic methods are not sufficiently powerful to model certain critical features of search such as variations in the ability to store offers and the phenomena of oversearch and undersearch.

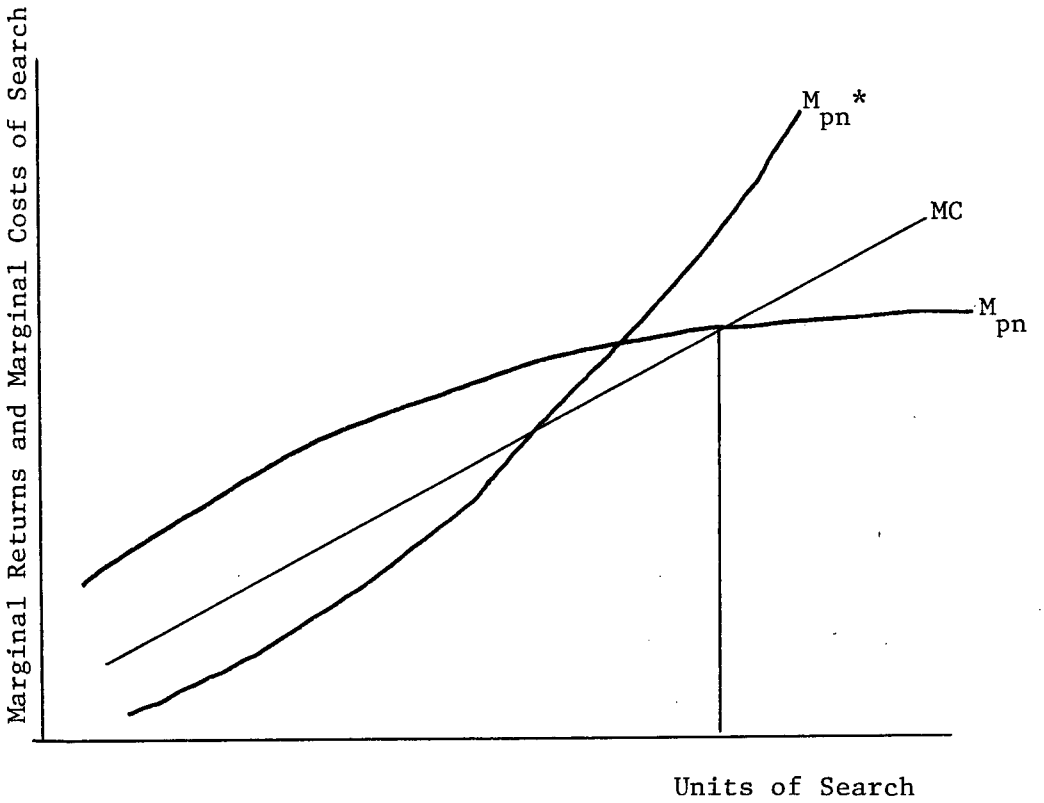


Figure 3
Marginal Cost and
Returns to Search

Second, it is assumed that this distribution remains stable over time. The consumer is presumed to know not only the form of the distribution of prices, but also how it changes over time. This dynamic aspect of optimal search procedure will not concern us in this essay, however the application of error learning is straightforward.

Finally, in the literature, it is assumed that searchers have either complete storage and can act upon offers at their leisure, or that they have no storage ability and offers must be accepted or rejected as soon as they are received.[5] It seems apparent that a model that permits variable degree of storage in the search process permits greater insight into the complex interactions that characterize market processes.

Decay in the vector of stored offers can intuitively be demonstrated using the optimal stopping paradigm. This aspect of search theory is derived from the simple rules developed by Stigler, except that the decision when to stop is somewhat more complex. The optimal stopping problem can best be characterized by the search for a parking lot. As one approaches the destination, for example the theatre, the number of available parking spaces begins to dwindle. The decision that must be made is when to stop, given that one knows the distribution of offers (vacant parking spaces), the unit cost of search and the location of the parking spaces previously given up. With infinite storage or no decay the searcher can simply turn around the block and choose a previous spot; with no storage or infinitely rapid decay, this possibility does not exist.

Stopping rule problems can be structured in the following way. The offers (x_i) are random variables from a known distribution. It

is assumed that the highest offer is retained so that the return to stopping after n periods is

$$g_n = \max(x_1, x_2, \ldots, x_n) - nc \tag{3}$$

where $\max(x_1, x_2, \ldots, x_n)$ is the best offer received after n periods, assuming complete storage, and c is the constant cost for one unit of search. The stopping rule problem is to formulate a strategy that maximizes the value of g_n. If f(x) is the optimal return received when an offer x is received, then after searching n periods the optimal return is given by

$$f(x_n) = \max(x_1, x_2, \ldots) - nc = m = nc \tag{4}$$

In other words we are seeking a procedure that maximizes the expected value of f(x). Letting this be y then,

$$E(f(x)) = y = E(\max(m,y) - c \tag{5}$$

gives the expected gain from any particular unit of search. The optimal policy is to continue search in the event that the expected return from an additional search (y) exceeds the value of the best offer received (m); otherwise stop. In other words, continue to examine the next parking spot for vacancy if the expected utility of being closer to the theatre (the probability of vacancy times its utility) is greater than the utility of the best spot already examined. In the case of searching for a house, the rule is to continue searching if the expected gain will result in an offer better than the one already received.

In effect, m is the best offer already received from the vector of offers $(x_1, x_2, \ldots, x_n)$ examined; to stop is to receive m. The optimal stopping rule is to persist in one extra unit of search as long as the expected gain less the cost is greater than the best offer already received.

Of course this formulation is very close to that of Stigler except that optimal stopping permits what McCall calls a 'myopic' approach to search. In the prior search model of Stigler, the searcher decides before starting, how many units of search to undertake. In the sequential rules developed by McCall the searcher proceeds and evaluates the value of an additional search while in the process of examining various offers. There is a subtle, but real distinction between the two methods.

The optimal stopping rule framework suffers from the same general defects as the prior search models. The distribution is assumed to be known and unchanging, and the searcher is assumed to have complete storage abilities. The stopping rule problem can be varied to admit the possibility that the vector of stored offers is subject to instantaneous decay, in which case the problem collapses to a prior search type problem where the searcher will examine offers until the accumulated search costs outweigh the expected gains from search.

The solution procedures for discovering the optimal number of searches are not trivial. Breiman (1964) evaluates linear and dynamic programming procedures for models with relatively simple analytic structures while McCall (1970) presents the solution in the form of integral equations. The amendments that I propose to the basic search paradigm (error-learning to deal with ignorance about the basic distribution and decay in the storage vector) preclude the possibility of any straightforward solution procedure. For this reason simulation methods are chosen as an attractive alternative to analyze the consumer search problem.[6]

A Simulation Model of the Demand for Information

There are three critical elements to the simulation of the demand for rental information.

First, there is the notion of a reservation price.[7] This concept has been widely used in the study of labour markets. It is hypothesized that the searcher starts by setting a wage below which employment will not be accepted. The higher the reservation price (wage) in relation to the average or market price, the longer the search.

Second, it has been hypothesized (Mortensen, 1971) that failure to find employment results in amendments to the reservation price. In this case the reservation price closely resembles the rule of thumb as developed by Baumol and Quandt (1964). In fact these two authors have introduced the rule of thumb as the decision method of the entrepreneur and developed simple simulation models to mimic firm behaviour under various assumptions about the state of demand. They set out several simple criteria for the rule of thumb, such as measurability and savings obtained from their use.

The concept of error-learning is the third basic element of the demand model. The application of adaptive processes has had a modest, yet impressive role in economics. Meiselman (1962) used error-learning to explain the term structure of interest rate; Arrow (1962) developed the concept of learning by doing; and finally Rothschild (1974) and Axell (1974) have very recently introduced the notion into search theory.[8]

The basic notion of error-learning is simple. If a certain action (rule of thumb) results in greater welfare, the probability rises that it will be repeated in future decisions. If a rule results in lower welfare, the opposite happens; the probability increases that

the rule will be modified. These concepts are, of course, little more than elementary probability matching and learning theory.[9]

The Model; A Verbal Description

The searcher is assumed to be ignorant of general market conditions; i.e., the distribution of actual house rents is unknown. In addition, searchers are assumed to be homogeneous except with respect to income. This simplification reduces the complexity of the model at the expense of ignoring many interesting hypotheses such as the relationship between socio-economic characteristics and the degree of risk aversion. Obviously, this would have an important bearing on the degree to which a searcher would persist in the face of unfavourable market conditions. This behaviour would be modelled by different rates of reformulating the error-learning role.

The actual search process commences with the searcher setting time constraints to search. For the sake of simplicity these constraints are assumed to be equal for everyone. First, there is the maximum period of search which is assumed to be thirty days; tenants typically give notice before finding an alternative dwelling and typically have one month to find suitable accommodation. There are, in addition, two intermediate time constraints. First, there is a time constraint that governs when the searcher alters the extensive margin of search and acquires information on more dwellings (widens the scope of search). Second, there is the time constraint, which when violated will cause the searcher to modify the rule of thumb. Details on these constraints are given in the next section.

Each searcher is stratified by income. The income of searcher

'i' is calculated from a lognormal probability generator that is available in FORTRAN IV. The actual process of calculating these numbers is not germane. The use of the lognormal distribution for income has been well verified in the literature; (see Aitchison, 1973). The parameters that were used were a mean of $5000 and a variance of 2.0.

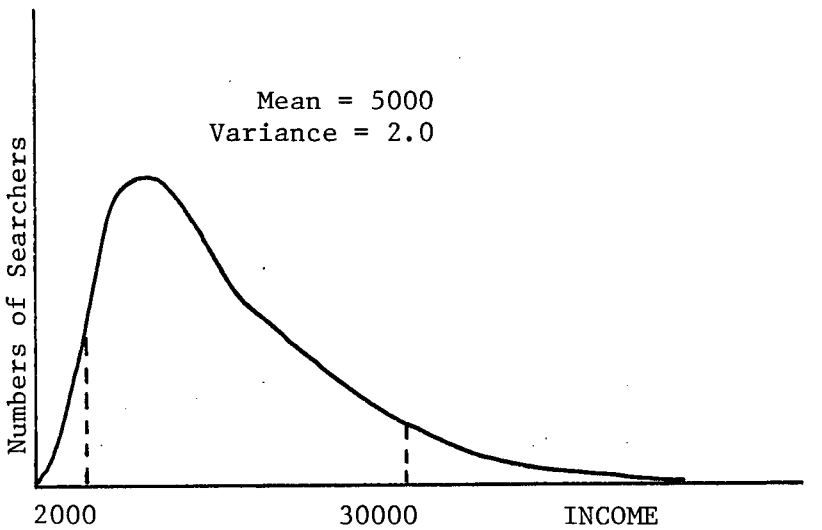


Figure 4
The Lognormal Distribution of Income

Once the searcher has been stratified by income, the model commences the actual search process. On the first day searcher 'i' examines a certain number of dwellings. Prior to search a very simple rule is developed. Along with each dwelling comes a bid and ask rent.

Calculation of the bid and ask rents is performed by a random number generator which produces random variates from the uniform distribution. The bid rents are related to the income of the searcher, while the ask rents are independent of the searcher's income. No attempt was made to examine the reality of the distribution of offers or bids and the use of the uniform distribution follows established practice in this field. If the difference between the bid and ask rents is sufficiently high to satisfy the rule of thumb, the vacancy is accepted; if the difference does not satisfy the rule of thumb, but it is positive that vacancy is stored; if the difference is negative (ask rent greater than bid rent), the vacancy is rejected immediately.

At the beginning of each day the searcher sets both the decision rule and the maximum number of dwellings to be searched. With each dwelling searched, money costs are incremented. Once the maximum number of dwellings per day has been examined the day counter is incremented and the process begins anew for the next day.

The model incorporates error-learning at three levels. Once the first time constraint is violated the searcher will then increment the number of listings (dwellings) examined on each day. This process of incrementation continues for each day beyond the first time constraint until a maximum number of listings is being examined.

The second level of error-learning occurs once the second time constraint is reached (and once the maximum listings per day are being examined). The rule of thumb is relaxed. In other words the difference between the bid and ask rents is no longer required to be as high. With each relaxation the searcher scans the stored vacancies (those

that previously failed the rule of thumb) to discover whether there are any stored vacancies that now satisfy the revised rule.

Finally, this storage vector is subject to decay. The rate of decay is introduced by a random selection of elements in the storage vector. For any given searcher, the proportion of offers or vacancies that are retained throughout the search period is directly related to the vacancy rate. At high vacancy rates the searcher finds that the storage vector is subject to less decay than at low vacancy rates. Of course the vacancy rate is an exogenous variable. The third level of error-learning keys off the rate of decay in the storage vector. It is reasonable to suppose that consumers who discover that they have little ability to store offers will revise their search strategy. In this case the simplifying assumption is made that the rule of thumb is once again revised. In reality, consumers probably check the storage vector frequently and most likely would respond to decay initially by widening the scope of search, however, the model is kept simple.

The Model; A Mathematical Description

The basic elements of the model are set out in order of their appearance.

(1) Time Constraints: There are three time constraints used in the demand model. The first, designated by IDAYMX, is the maximum number of days (in this case 30), search may continue for any particular searcher.[10] The second time constraint indicates the number of days before searchers will alter the scope of search. The scope of search indicates the percentage of total listings examined per day and has a maximum value of 1.00. This value, designated as IDYCR1, is set

arbitrarily since no empirical work was undertaken to verify the particular value used; however, it was subjected to considerable sensitivity analysis. Finally the third time constraint, IDYCR2, indicates the time required before searchers will begin to alter the rule of thumb and permit the accepted or reservation rent to rise. Once error-learning has begun the third time constraint is revised upon each revision according to the following relation,

$$IDYCR2_{t+1} = \frac{IDAYMX - IDYCR2}{2.0}\ t+IDYCR2_t \qquad (6)$$

where t of course refers to the particular day of search and can vary between the values of 1 and 30.

Of course these constraints are quite arbitrary and are set largely as a matter of modelling convenience. To actually verify their values is the subject for a research effort beyond the scope of this essay. The allocation of time is one of the more irrational aspects of economic behaviour, replete with risk aversion dependent upon complex socio-economic factors. A tentative step might be to make the time constraints, IDYCR1 and IDYCR2, functions of income under the assumption that higher income searchers are less risk averse, but this is a digression from the main purpose of this essay.[11]

(2) Supply of Information: Pending further refinement to be introduced in the next chapter, the supply of information is modelled as a simple linear function of the vacancy rate. The maximum number of listings that any searcher can examine on any given day is given by,

$$JMAXX = BETA*VACANT \qquad (7)$$

where VACANT is the vacancy rate, an exogenous variable and BETA is a calibration parameter.[12]

The percentage of listings examined by a searcher is initialized according to the formula,

$$JMAX = PER*JMAXX \tag{8}$$

where PER is an adjustment factor that has a value between 0 and 1 and is incremented each day (to the maximum value of 1) each day after the time constraint (IDAYCR1) is exceeded, and JMAXX is the maximum number of listings each day.

(3) Income: Income for the i^{th} searcher is generated by a random number generator sampling from a lognormal distribution.[13] The log-normal distribution is truncated to produce values lying between 2000 and 30000 dollars. Left unattended, the random number generator could conceivably produce a searcher with an income of $1,000,000 or 57¢ which would surely distort the simulation.

(4) Error-Learning: Error-learning is the heart of the demand model. Time costs are the critical elements which govern the points at which searchers will adjust their search behaviour. Since the direct money costs are relatively small for tenants (except those with very low incomes) the time constraint as the binding barrier seems warranted. As outlined above, there are two critical values of the time constraint. The first governs the point at which search is widened to include more listings per day. A second constraint then governs the point at which error-learning commences and is assumed to have a greater value than the first constraint. Money costs are incremented for each listing examined according to the relation,

$$COST_{it} = COST_{it-1} + ALPHA2_{jt} \tag{9}$$

where $COST_{it}$ is the cost for day t for searcher i and $ALPHA2_{jt}$ is the cost of the listings examined on day t.

Once t exceeds the first critical time constraint (IDYCR1), the scope of search is widened according to

$$PER_{it} = (P + 1) \; / \; PMAX; \; PER_{it} \leq 1.00 \qquad (10)$$

where PER_{it} is the percentage of listings per day examined by searcher i on day t.

The rule of thumb is set by the following relationship,

$$\text{If } SURP_{ij} \geq BP_{ij} \; / \; GAMMA \qquad \text{accept} \qquad (11a)$$

$$\text{If } SURP_{ij} \leq BP_{ij} \; / \; GAMMA \qquad \text{store} \qquad (11b)$$

$$\text{If } SURP_{ij} \leq 0 \qquad \text{reject} \qquad (11c)$$

where $SURP_{ij}$ is the difference between the bid and ask rents of the i^{th} searcher and the j^{th} listing ($BP_{ij} - CP_{ij}$) and GAMMA is the parameter that is used to adjust this rule. In effect, the rule states that the excess of bid rent over ask rent must be greater than the bid rent divided by the adjustment factor. This is the simplest error-learning rule that could be adopted. It conforms to the requirements of a rule of thumb in that it is simple, measurable and requires only that the consumer be able to place a subjective value on the worth of a particular vacancy. If the vacancy (bid-ask rent combination) fails the rule, but is positive, that listing is stored; if the surplus is negative, the listing is rejected outright.

Once the second time constraint (IDYCR2) is exceeded, GAMMA is incremented and the required surplus is reduced. At each relaxation of the rule the stored listings are examined to discover if any satisfy the newly revised rule.

The storage vector is subject to decay. Competition for housing implies that offers are removed from the storage vector in direct relation to the vacancy rate. This decay process is simulated using a

random number generator which removes certain listings at random; the number of listings removed per period depends upon the vacancy rate. Low vacancy rates imply excess demand and high rates of decay while high vacancy rates imply greater ability to store offers. At vacancy rates below .5% there is almost no storage while at vacancy rates higher than 7% there is complete ability to store. Obviously this is a simplification, but in general it is realistic. The exact process of removing these stored offers is that the percentage of stored offers to be removed each day is a function of the vacancy rate,

$$PERSTO_{it} = (VACTES - VACANT)/VACANT \qquad (12)$$

where VACTES = .07 and VACANT is, of course, the exogenous vacancy rate. The first $PERSTO_{it}$ listings on searcher i's storage vector are removed on day t, once error-learning has commenced.

Each time the storage vector is consulted, the rule is revised as a simple function of $PERSTO_{it}$. This merely indicates that the searcher learns not only from failing to find accommodation after a given time, but also adjusts as a result of direct market information (such as returning to find an apartment has been rented). GAMMA is incremented according to the relation,

$$GAMMA_{it} = GAMMA_{it-1} + (1-PERSTO_{it}) \; / \; 1. \qquad (13)$$

In other words higher values of PERSTO (lower values of the vacancy rate) cause more rapid revision of the rule.

(5) Generation of Bid and Ask Rents: The last point is clarification on the method of generating the ask and bid rents. Both are generated from uniform distribution of the form

$$BP_{ij} = 1/(a-b) \qquad a \geq x \leq b \qquad (14)$$
$$= 0 \qquad \text{elsewhere}$$

where a = 0 and b = (.1)*($INCOME_i$). The bid rent is tied to income, implying that higher income households tend to make higher bids than lower income searchers; this is straightforward. A more realistic bid process would have the bids tied to objective characteristics of the house, but this is beyond the scope of the model.[14]

Ask rents are generated in an analogous manner, except that b is constrained to be equal to (.1)*(INCOMX) where INCOMX is equal to 30000 the maximum income allowed in the model. Of course, ask rents would not be directly tied to the income of the searcher, except in the case where there was a self selecting process and low income households bid only on low rent dwellings and vice versa.

The mathematical explanation of the demand model is complete. It must be stressed that while the actual relations are simple, the model derives its power and complexity from the number of times the bid ask rents can be calculated (about 1000 for any individual searcher), and the logical loops that test for constraint violations, rule revisions, state of the storage vector, etc. To appreciate this aspect of the model the flowchart is required.

The Model; Flowchart Explanation

Figures 5 and 6 present a macro and a micro flowchart. The macro flowchart can be examined in relation to the verbal description of the model, while the micro flowchart would make most sense if it is studied in relation to the mathematical explanation. The macro flowchart needs little additional clarification since it is a pictoral representation of the verbal description. In the same way, the micro flowchart is an elaboration of the mathematical description.

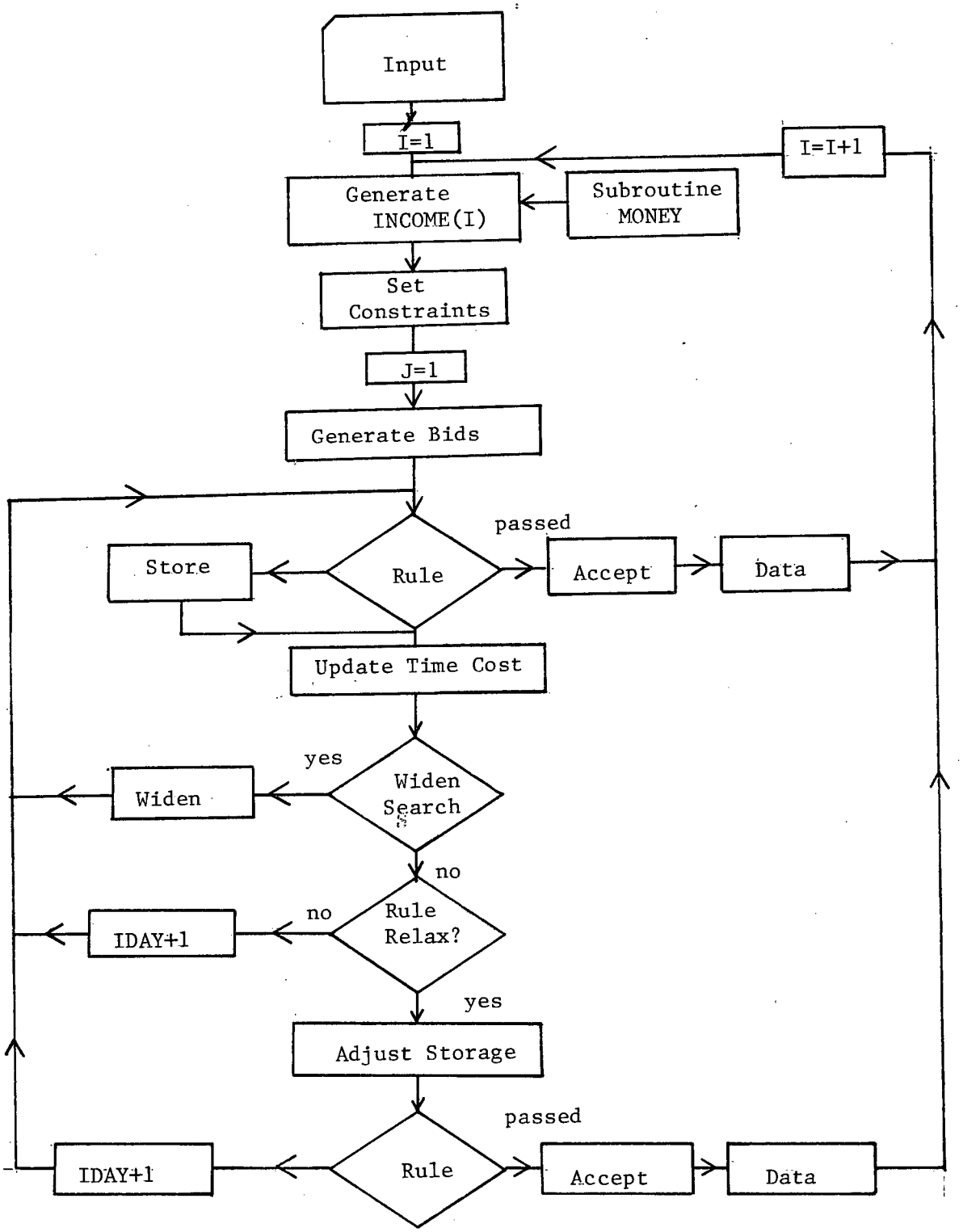
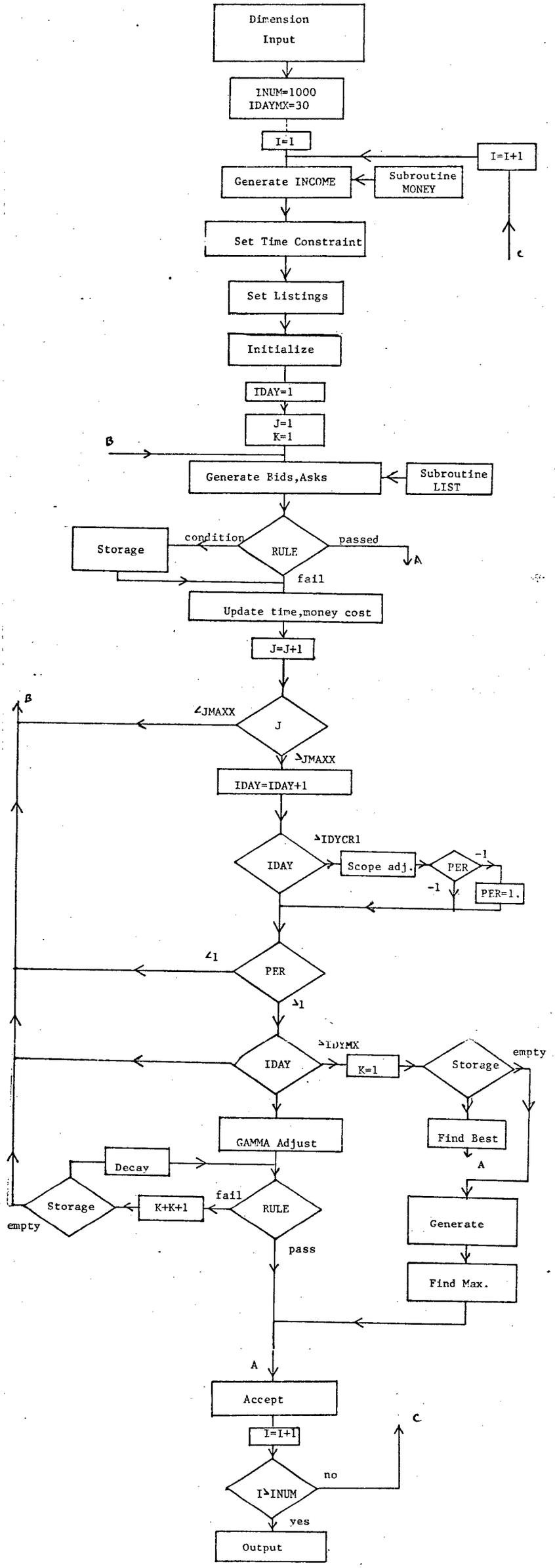


Figure 5

Macro Flowchart of the Demand Model


Dimension Input
INUM=1000
IDAYMX=30
I=1
I=I+1
Generate INCOME
Subroutine MONEY
Set Time Constraint
C
Set Listings
Initialize
IDAY=1
J=1
K=1
B
Generate Bids,Asks
Subroutine LIST
Storage
condition
RULE
passed
A
fail
Update time,money cost
J=J+1
B
JMAXX
J
JMAXX
IDAY=IDAY+1
IDYCR1
IDAY
Scope adj.
PER
-1
-1
PER=1.
1
PER
1
IDYMX
IDAY
K=1
Storage
empty
GAMMA Adjust
Find Best
A
Decay
Storage
empty
K+K+1
fail
RULE
pass
Generate
Find Max.
A
Accept
I=I+1
C
no
I>INUM
yes
Output

Some Results

In this section some initial results are presented which demonstrate the effect of error-learning and decay upon the average search times and money costs of search. Throughout the testing and experimentation with the model, average search times and money costs are used as indicators of the costs of search. Comparative savings from alternate policies will be used to evaluate the benefits from these policies. Also, the model results are presented as the result of trials. Each trial summarizes the search time and money costs for 1000 searchers, each differentiated only by the variable $INCOME_i$. The words trial and run are used interchangeably. Finally, these trials represent different values in the vacancy rate (VACANT), rates of scope adjustment or percentage of listings examined per day (PER_{it}) and error adjustment (GAMMA). Recall also that the subscript i refers to one particular searcher.

The first set of experiments deal with evaluating the impact of different rates of error-learning upon search times and costs. For these runs it is assumed that there is no possibility of storing various offers; the searcher must accept an offer when presented. Later this condition will be relaxes to simulate alternative market conditions.

The following table (Table 2) presents the results of four trials which model the results of 1000 searchers. INUM is an exogenous variable; 1000 is generally used since with this number of runs a reasonable statistical sample can be generated upon which tests may be performed to gain an idea of the performance of alternative conditions and hypotheses.

The rate of error-learning is governed by the rate at which the rule of thumb is relaxed; this is controlled by the rate at which GAMMA is incremented. Since storage is suppressed in these initial trials, GAMMA is incremented only as time runs out for the searcher; later results with storage ability will be even more sensitive to error-learning. Aside from relaxing the rule of thumb the searcher also can vary search at the extensive margin; in other words the searcher can choose to examine more vacancies per day.

Table 2 is a partial view of what is termed a response surface. Response surfaces have been applied to the simulation of physical processes, especially simulations in chemical engineering, and are only just beginning to be applied to simulation studies in the social sciences.[15] The response surface can be depicted as a matrix which shows variations in a key output variable for different values of input or exogenous variables. In this case the input variables are the rate of error-learning (GAMMA) and the rate of scope adjustment (PER). More complex response surfaces are presented in the next chapter when they are used extensively in the sensitivity analysis of the model.

The results in Table 2 are straightforward. As the response to search is adjusted by changing the rates of error-learning and scope adjustment, time and money costs vary in a predictable manner. To

Table 2

Results of Trials with No Storage

INUM (number of searchers per trial) = 1000

Case One — RULE; There is no error-learning (i.e. GAMMA is not incremented in the event of time running out, and the scope of search is not responsive to time.)

MARKET; There is no storage ability (i.e. the market is at the polar extreme 'tightness'.)

Case Two — RULE; GAMMA is incremented by 1.5 each time the rule is revised. The scope of search is incremented by 1 listing per day once the first time constraint is exceeded.*

MARKET; There is no storage.

Case Three — RULE; GAMMA is incremented by 2.0 each revision of the rule; the scope of search is as in two.

MARKET; As above.

Case Four — RULE; GAMMA is incremented by 2.0 each revision and the scope of search is incremented by 2.0 listings per day.

MARKET; As above.

* Note the scope of search increases until 100% of possible listings are examined.

Case	Average Search Times (days)	Average Money Costs	Average Surplus (BP(J) - CP(J))
1	21.65	21.30	21.67
2	10.41	15.39	35.29
3	7.17	12.73	14.66
4	5.87	11.53	17.52

increase the rate of learning is to reduce the average search time and money cost; the same is true when the number of listings per day are incremented. Interestingly, the surplus, or difference between bid and ask rents, seems to be unaffected by adaptive search procedures. Undoubtedly this is due to the simple relations that govern the setting of time constraints and the creation of bid rents. More sophisticated models where income and social class were included explicitly would alter this. In addition, the inability to store would affect the average surplus.

Considering only the time aspect of search, it is possible to show the relation between learning and the average time of search. This is shown in Figure 7. Recall that the rule of thumb adjustment refers to the minimum difference between the bid and ask rents that is accepted by the searcher and is governed by the variable GAMMA. Scope adjustment refers to the percentage of the maximum daily listings that are actually examined by a searcher, where this maximum is given by the variable JMAXX, the actual number examined is given by JMAX and the percentage examined or JMAX/JMAXX is given by the variable PER. Recall also that the time constraints ensure that scope adjustment preceeds rule adjustment and is a necessary precondition to error-learning of the rule of thumb.

An alternative way of measuring the response of the model is to plot the frequency distribution of search times for alternative learning hypotheses. This is presented in Figure 8 for the four cases presented in Table 2.

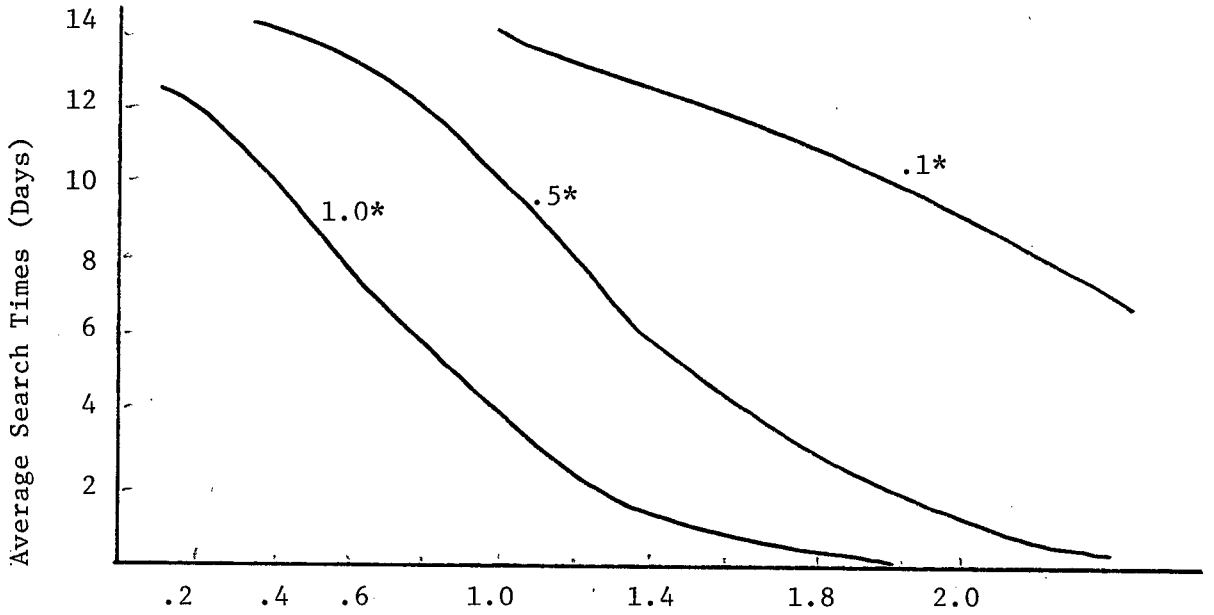


Figure 7
The Relation Between Error Learning and Average Search Time

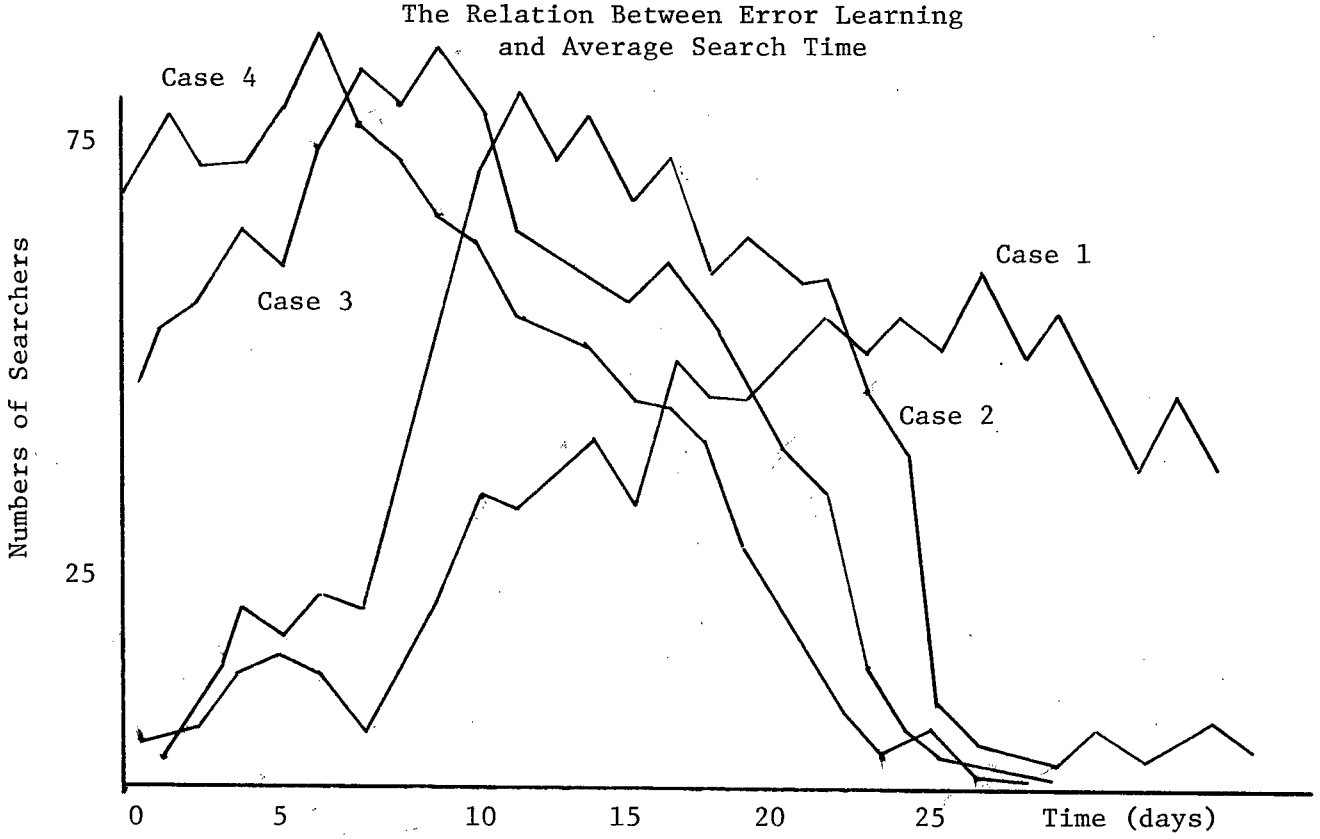


Figure 8
Frequency Distribution of Search Time

Modelling Alternative Market Conditions

Alternative market conditions are modelled by allowing the searcher to store potentially attractive offers. A potentially attractive offer is any offer for which the bid rent exceeds the ask rent. Every offer which does not pass the decision rule for acceptance and which has a positive surplus is placed in a storage vector and periodically examined when the rule of thumb is relaxed. This storage vector decays at a rate linearly related to the vacancy rate. For purposes of examining the relation between various performance indicators of the model and the vacancy rate, assume that the Case Four situation of Table 2 holds.

Table 3 presents the relation between the vacancy rate and the performance indicators used previously in Table 2. Each trial uses a different vacancy rate and the number of searchers per trial remains 1000.

The relationship between the vacancy rate and the average surplus is positive for two reasons. First, the searcher can more easily store offers at higher vacancy rates, and second, the rule of thumb is adjusted faster at lower vacancy rates (in effect the model converges to a solution faster when the vacancy rate is low). A model which incorporated longer-run supply effects (supply of housing, not information) would have to also incorporate the effects of housing shortages upon the surplus paid and the general rent level. Since this is only a model of the market for information, the surplus is the appropriate concept.

Table 3

Alternative Market Conditions with Storage

Case Four

RULE; GAMMA (rate of rule adjustment) is incremented by 2.0 per revision; scope of search is incremented by 2.0 listings per day to a maximum value.

MARKET; Represented by different levels of the variable VACANT.

Vacancy Rate (VACANT)	Average Search Time (days)	Average Money Costs	Average Surplus
6.0	2.65	5.24	67.90
5.0	2.79	6.11	61.35
4.0	3.15	6.71	52.96
3.0	4.86	8.34	37.31
2.0	4.89	8.20	21.68
1.0	5.62	10.39	15.69
0.0*	6.01	10.78	16.37

* Note, this is an equivalent run to the previous case four.

The relation between the vacancy rate and the distribution of searchers can be graphed using the frequency distribution of search times as the response indicator. This is shown in Figure 9.

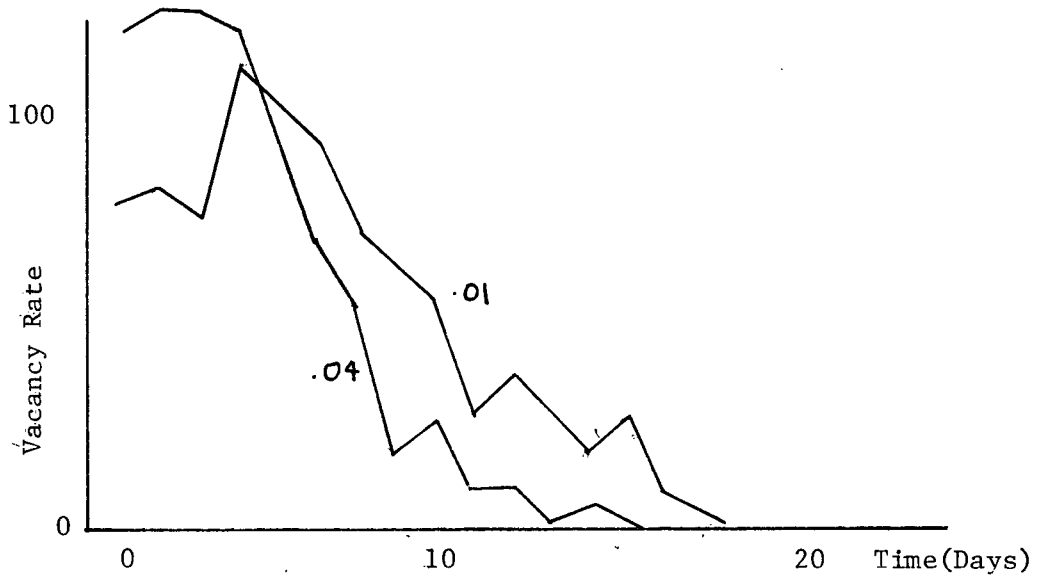


Figure 9

Vacancy Rate and Search Time

Problems of 'Oversearch' and 'Undersearch'

Frequently one encounters the statement; "if I knew then what I know now". This is an example of undersearch. Other common examples are buying a commodity, then discovering that another place had the identical item on sale for half the price.

Oversearch, a more subtle problem for the consumer to discover, results from procrastination. A dwelling may be removed from the market even though the searcher had considered the dwelling as a

possible alternative. Jobs may be snapped up in times of high unemployment and the searcher who dithers loses the opportunity.

Both these aspects of search can be demonstrated within the context of this model. Undersearch is modelled by running each searcher, noting the point at which an offer is accepted (and the time and money costs associated with the acceptance) and then extending the model until IDAYMX is exceeded. During this extension the best alternative (the vacancy with the highest surplus) is noted and compared with the vacancy that was intially accepted. This trial for the model operating under Case Four assumptions is presented in Table 4 for various levels of vacancy rate.

Table 4

The Effects of Undersearch

Vacancy Rate (VACANT)	Difference in Initial and Subsequent Best Surplus
6.0	-3.97
5.0	1.74
4.0	2.48
3.0	9.49
2.0	15.91
1.0	29.59
0.0	48.67

Oversearch can also be modelled. In this case the best offer that a searcher stores in the storage vector is retained and compared with the final offer accepted. This best offer can easily be removed by tight markets and the searcher who tends to 'learn' about the market at a slower rate. Therefore two axes are needed to portray oversearch. Table 5 presents a matrix; the vertical axes shows the vacancy rate as in Table 4 while the horizontal axes shows the various levels of GAMMA incrementation governing the rate of rule adjustment. The entries in the matrix show differences between the final offer accepted and the best offer examined and stored by the searcher.[16]

Table 5
The Effects of Oversearch

GAMMA	Increments (decreasing dithering)					
VACANT						
6.0	36.21	32.73	29.45	24.67	23.19	17.20
5.0	42.91	41.16	40.11	37.75	31.62	29.11
4.0	49.61	41.62	40.21	36.49	36.48	31.01
3.0	57.32	56.21	55.31	50.28	45.31	31.48
2.0	60.28	59.57	56.69	50.10	46.13	37.37
1.0	67.39	62.11	56.73	52.49	46.99	39.72

The Effect of Oversearch and Undersearch

These simple experiments can hardly be regarded as conclusive, however they do indicate an aspect of search theory that has hitherto been ignored by the literature. There are direct implications for the structure of industry and the extent to which consumers search for prices. For example, price dispersion can lead to increased search. Consumers who encounter price variation are likely to engage in search while no price variation is likely to limit search to infrequent, casual checks on alternatives. In spatial markets, of which housing must be considered a prime example, competition is fostered by price variation, where oligopolists are likely to set common prices, in part to avoid price wars amongst themselves, but also to limit search and preserve their market shares.

Summary

In this chapter, several significant modifications to the demand for information have been presented. First, error-learning was introduced as a useful paradigm for the search process. Second, the searcher was assumed to store potentially attractive offers. These offers were in turn subject to decay. The rate of decay was a function of the vacancy rate and in turn caused the rate of error-learning to be modified. This model only considers 'negative' error-learning. The possibility that rules of thumb might become more stringent in the face of favourable market evidence is not considered. Finally, the phenomena of undersearch and oversearch were introduced. Simulation provided a convenient means for evaluating these aspects of hitherto unconsidered search behaviour.

The most sensitive aspect of this model is the relation between the vacancy rate and the average search times and money costs. The vacancy rate operates in two ways. First, by governing the supply of information (number of listings) and second, be governing the rate of decay on the storage vector. The next chapter examines the relation between the supply of information and the vacancy rate and presents a model of the supply of information.

FOOTNOTES - CHAPTER TWO

1. Once again this survey is not exhaustive since the literature relies upon common assumptions which are dropped in the proposed model.

2. In addition to Rothschild (1974), Axell (1974) also incorporates error-learning in the theory of search, but within the context of a simulation model. These two works became known to the author only as the final manuscript was being prepared. In any event neither article attempts to deal with variation in the ability of searchers to store offers, the problem of oversearch and undersearch and the supply of information through brokers.

3. See Appendix One for proof.

4. See Appendix One for proof.

5. McCall (1970) does consider the possibility of variation in the storage ability of searchers, but sets the problem aside due to analytic intractibility.

6. Telser (1973) uses simulation models to analyze the search for the lowest price, but once again he does not consider the types of problems which are of interest here.

7. Mortensen (1971) gives a good account of reservation wages in relation to job search.

8. Cross (1973) has applied stochastic learning theory to economic theory in general.

9. See Estes (1972) for a review of the literature on psychological learning theory.

10. Throughout the rest of the paper the variables are presented in the form they appear in the computer code in Appendix Two.

11. See Linder (1971) for a discussion of the relationships between time intensive activities such as search and real income.

12. * is from FORTRAN IV and denotes the action of multiplication.

13. See Figure Four for the form of this function.

14. A bid price model of housing demand was constructed in the author's Masters Thesis (Mason, 1972). In addition see Kihlstrom (1973) for an attempt to evaluate the demand for information on product quality. In general the use of hedonic price indices and Lancaster's consumer theory has met with limited success.

15. For a detailed explanation of response surfaces see Naylor, et.al. (1971).

16. Note that oversearch is impossible with no decay in the storage vector.

CHAPTER THREE

The Supply of Information

In the previous chapter the supply of daily information was modelled as a maximum number of vacancies that could be examined by a searcher. It is the purpose of this chapter to disaggregate this supply variable (JMAX) into its component parts, analyze the relation between the supply of information from various sources and general market forces (i.e. the vacancy rate), and thereby construct a supply model of information.

Rather than constructing a separate model of information supply, these elements are grafted onto the demand model through the disaggregation of the variable JMAX. This technique avoids the problem of constructing linking models to unite demand and supply and thereby reduces both computer time used in the model and the time required to understand the action of the model. Several alternate suppliers of information are considered sequentially; they are analyzed using a a priori reasoning, or more substantive empirical measures where possible. Finally, these various elements are incorporated into the model.

Rental Information Brokerage; An Overview

There are four general sources of information that can be tapped by the searching tenant, which can, to varying degrees, be isolated and empirically studied.

First there is what Hempel (1970) refers to as the casual information source. This consists of friends, professional colleagues and other acquaintances. In addition, street advertising is also included in this category.[1] Second, there are dwellings managed by professional property managers which consist largely of real estate companies. Typically these firms provide free information about the properties they manage. Third, and most importantly, there are classified advertisements in major daily newspapers. Fourth, there are rental information agencies (RIAs). These firms are common to England, well established in the United States and a recent phenomenon to Canada.

Casual Search

Data on this aspect of housing search is extremely difficult to obtain. Only wide-ranging studies of the allocation of resources within the household could begin to reveal the nature of this aspect of housing search.

Some inroads into the nature of the process can be inferred using studies completed by Hempel (1970) for the home ownership market in Connecticut. These studies indicated that there is a hierarchy of information acquisition. A considerable proportion of searchers begin by first consulting casual sources, then after 'feeling out' the market, move on to more formal information sources such as newspapers and real estate brokers. A significant proportion, however, tend to by-pass the casual sources of information and proceed directly to

utilization of brokers. There tends to be a positive correlation between level of education, professional status and the elimination of casual information sources of market data. Hempel's studies do not investigate the extent to which casual search was the only source of information. In the home purchase process, where investment motives play an important role, it is unlikely that many of the searchers could gain sufficient market knowledge without resorting to formal sources of information. In the rental housing market the amount of information required is much smaller and casual sources, if available, can often yield useful information. At any rate, empirical verification of the relation between market conditions and the amount of information from casual sources is extremely involved and beyond the scope of this paper.

Professional Property Managers

Many firms offer management services to landlords. These services include maintenance, rent collecting and locating suitable tenants. The number of firms specializing in this form of brokerage varies widely from city to city. There seems to be great regional variation in the corporate structure of these firms. For example, in Vancouver much of the property is managed by real estate firms, while in Winnipeg and Montreal there are many firms which appear to specialize in the management of large apartments.

These firms employ a variety of information dissemination techniques to secure tenants. Aside from casual search (especially signs in front of the building and classified ads, these firms appear

to employ a system of waiting lists whereby prospective tenants register in order to be considered prior to general advertising. Of course, the firms are interested in this system since it lowers their information costs and permits a certain amount of control over the type of tenant.

The major real estate firms which advertise property management services were surveyed by telephone in order to gain some notion of their quantitative impact on the supply of information in the rental housing market. All firms were either reluctant to divulge information or could not take the time to provide data on the number of rental suites handled, the advertising devices employed or the revenues obtained from property management. Some crude concept of the number of suites handled by property management firms can be inferred, however.

There are two large trade associations of apartment owners. First, there is the Greater Vancouver Apartment Owners Association with approximately 6,000 members controlling some 40,000 suites and second, there is the Pacific Apartment Owners Association with approximately 600 members and 20,000 suites. Property management firms typically belong to the second organization. Since there are approximately 100,000 rental suites in the Vancouver area, property managers (large ones who manage in excess of twenty suites) who tend to use waiting lists account for 20% of the supply. However this overstates the influence of waiting lists as a source of information for two reasons.

First, only the very large management firms would find it viable to employ a waiting list. Smaller firms would undoubtedly employ casual search techniques such as placing a sign in the front of the

building. In recent public hearings the president of the Greater Vancouver Apartment Owners Association stated that casual search and classified ads were the predominant form of advertising.[2]

Second, it is apparent that the usefulness of waiting lists depends on market conditions. At low vacancy rates they are highly favoured by landlords since advertising costs are low and the deluge of inquiries that tends to occur with excess demand is avoided. At higher vacancy rates more aggressive marketing is required.

The lack of empirical data (since even firms do not keep this information) precludes any tests of these hypotheses. There appears to be no feasible empirical measure of the relationship between the vacancy rate and the use of casual and property management source of information. There are two choices in regard to simulation. First, some assumptions can be made about the direction and form of the relationship between the vacancy rate, and the number of vacancies that are obtained from casual search and waiting lists. It would then be possible to write some linear relationships into the simulation model to generate values of JMAXX which would then be used as part of the supply of listing available to the searcher.[3] Using some assumed cost and time functions it would then be possible to generate values of money and time costs spent in acquiring information from these sources.

The second procedure is to ignore this aspect of search and concentrate upon the other dimensions of rental housing search (classified ads and rental information agencies) which can be more readily quantified. This second course is taken, the justification

being that a partial model, empirically verified (using statistical tests), has more validity than a complete model which is only partially verified. Of course this means that important aspects of search are omitted, and this will surely temper the results of the model.

Classified Advertisements

At vacancy rates of 2-3%, classified advertisements are the most important source of information for the rental housing market. Casual empiricism suggests that for vacancy rates in excess of 3% casual search techniques advertising become important, while the analysis to be described later indicates that for vacancy rates below 2%, the rental information agency becomes an important supplier of information. Low vacancy rates have characterized the housing market in both North America and Europe and show little inclination to rise. For this reason both the empirical analysis and theoretical models concentrate upon this 'tight' market situation.

In order to judge the role of classifieds in providing information some proxy for information as a quantity is needed. This point was examined in an earlier chapter.[4] Information has been modelled in the previous chapter as a particular bid-ask price combination. The vast majority of information acquisition models take this unidimensional view of information; searching for the lowest price is considered to be the objective of the buyer. Classifieds obviously contain more information than price alone. Quality aspects are also included, such as distance from various urban facilities,

number of bedrooms, etc. There appears to be no successful method for including this aspect of information into the analysis. A proxy variable that comes the closest is the number of column inches weighted by the number of ads. As this ratio rises it could be argued that the informational content of the advertisement is increasing. Unfortunately it is apparent that the measure is subject to bias. Advertising and persuasion play an important role in the length of the advertisement. In addition, the same landlord saves by listing several properties in the same space normally occupied by one ad. Even so, it is possible to use this type of data to obtain some reasonably significant relationships between the vacancy rate and information in rental housing.

Table 6 presents column inches and total ads for rental housing that appeared in the Vancouver Sun from June 1971 to June 1974.[5] June and December were chosen since these are the months for which the Central Mortgage and Housing Corporation publish vacancy rates.

Table 6

Classified Ad Information By Month

Month	Column Inches 1	Total Ads 2	Column Inches / Total Ads	Vacancy Rates
June 1971	12047	24633	.489	4.1
Dec. 1971	9226	15354	.601	2.8
June 1972	11206	22564	.497	2.4
Dec. 1972	6272	12312	.509	.6
June 1973	11767	17424	.676	1.0
Dec. 1973	8541	9526	.896	.4
June 1974	9657	10557	.915	.2

There appears to be a straightforward relationship between the decline in column inches and total ads placed and the vacancy rates. Not so understandable is the inverse relation between vacancy rates and the ratio of column inches to total advertisements. When rental information agencies are analyzed, a plausible explanation is provided in that these firms tend to achieve economies of space by placing many vacancies within one advertisement. As will be shown, the proportion of total rental housing ads purchased by these agencies has sharply risen in the recent past.

Using time series analysis these relationships may be more formally analyzed. The general trend is clear, however, more precision is required since the regression parameters will be used in the simulation study. Since total ads and column inches are obviously correlated, (see Table 7) only one can be used as the dependent variable. Total ads was chosen since it corresponds more closely to the limited conception of information used in the model and also results in better specification.

Table 7
Correlation Matrix for Column Inches, Total Ads and Vacancy Rates

	Column Inches (COLINC)	Total Ads (TOTADS)	Vacancy Rate (VACRAT)
Column Inches	1.000	.7462 (s = .027)*	.8546 (s = .007)
Total Ads	.7462 (s = .027)	1.000	.5559 (s = .098)
Vacancy Rate	.5846 (s = .007)	.5559 (s = .098)	1.000

* Figures in bracket indicate level of significance

Regression analysis results in the following set of equations;

$$\text{COLINC} = 8546.81 + 772.90\ (\text{VACRAT}) \qquad R^2 = .30908 \quad (15)$$
$$(2.237)$$

$$\text{TOTADS} = 10491.89 + 3384.94\ (\text{VACRAT}) \qquad R^2 = .73026 \quad (16)$$
$$(13.536)^*$$

* Significant at .01 level

Aside from variation in the total number of ads that results from fluctuations in the vacancy rate (hardly a surprising finding), classifieds exhibit a pronounced daily cycle that has a marked effect on search behaviour. Examples of this variation are shown in Figure 10. Apparently Mondays are the low point in the supply of classifieds while Saturdays are the high point. It is difficult to know a priori whether landlords are second-guessing searchers and placing ads when they believe searcher will be most responsive, or whether landlords are attempting to control the responses of searchers. In particular, this second line of reasoning would argue that in times of low vacancy rates landlords would restrict their advertising effort simply to reduce the amount of time spent in dealing with searchers once the dwelling has been rented. There is evidence that some landlords have received up to 300 applications for one suite in Vancouver.[6]

A test of this would be to measure the variation in daily ads and examine the relationship betweeen this variation and the vacancy rate. If there is a positive correlation (i.e., if the variation grows as the vacancy rate grows) the hypothesis is rejected, otherwise it remains plausible to argue that searchers respond to variation in the supply of classifieds, rather than landlords are catering to the schedules of searchers. Undoubtedly a pronounced inverse relationship would indicate that in times of tight markets searchers are faced with

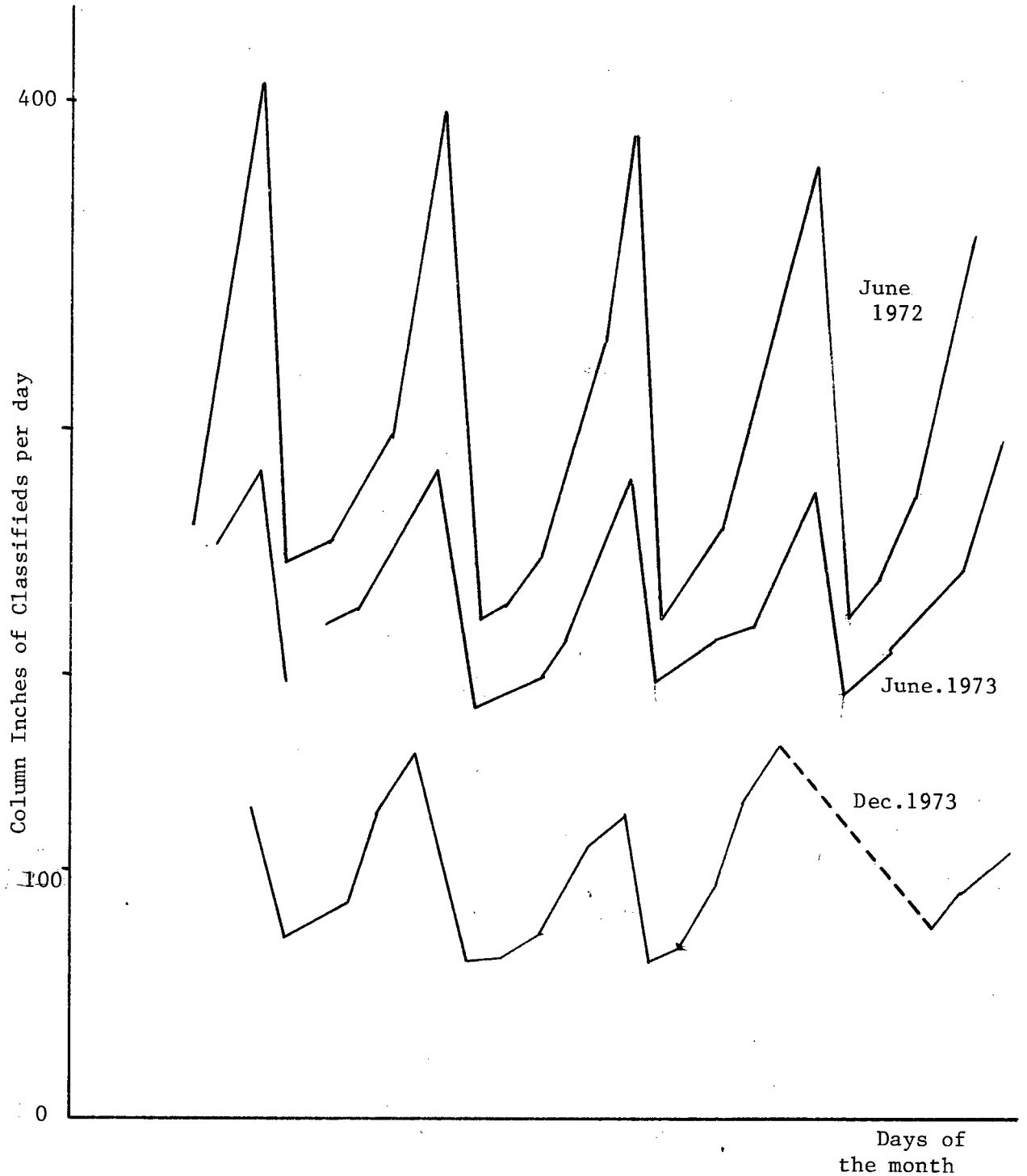


Figure 10

Supply of Classified Information

highly variable supplies of information and must adjust to this.

Two measures of variation were computed. First absolute variation (ABSVAR) is calculated according to the formula,

$$\frac{\text{Max}_m - \text{Min}_m}{\text{Min}_m} \tag{17}$$

where Max_m and Min_m are the greatest and least number of daily column inches that appear in the month i. The average variation (AVGVAR) is computed according to the formula,

$$\sum_{p=1}^{4} \frac{\text{Max}_k/p - \sum_{n=1}^{4} \text{Min}_1/n}{\sum_{n=1}^{4} \text{Min}_1/n} \tag{18}$$

where k is the values of the peaks, p the number of peaks, 1 the value of the troughs and n the number of troughs during a given month.[7]

Both these measures yield a series of six numbers that range between 0 and 1 (zero indicating no variation, 1 indicating extreme variation). These series were regressed against the vacancy rate in a test of the hypothesis that the degree of variation increased as the vacancy rate declined. The results for both measures appear as follows.

$$\text{ABSVAR} = .53121 - .06421\ (\text{VACRAT}) \quad R^2 = .53401 \tag{19}$$
$$(5.730)$$

$$\text{AVGVAR} = .46274 - .03558\ (\text{VACRAT}) \quad R^2 = .36011 \tag{20}$$
$$(2.81388)^*$$

* F ratios

From these results it appears that the hypothesis has been supported, although the relation is neither pronounced, nor the statistical tests

terribly conclusive. However, coupled with intuition, it can be argued that tenants are passive in the provision of information and landlords place ads to optimise the flow of tenants. This may appear to be picayune however, as if the use of error-learning is to be continued, the searcher as a passive responder to the environment must be demonstrated. If the flow of information was in turn affected by searcher behaviour, the interactions of the model would quickly become unmanageable.

Modelling the Supply of Rental Information From the Classifieds

The supply of rental housing information is easily integrated into the basic demand model. A step function is used to simulate both the variation in daily listings and the average number of listings. In other words the level of the step function is made a function of the vacancy rate. For the moment the exact level is arbitrary; however, in the next section when rental information agencies are considered in detail, a more explicit formulation will be provided.

The step function is coded as a series of FORTRAN statements that appear in the subroutine CYCLE (see appendix 2); a representative step function appears in figure 11 below.

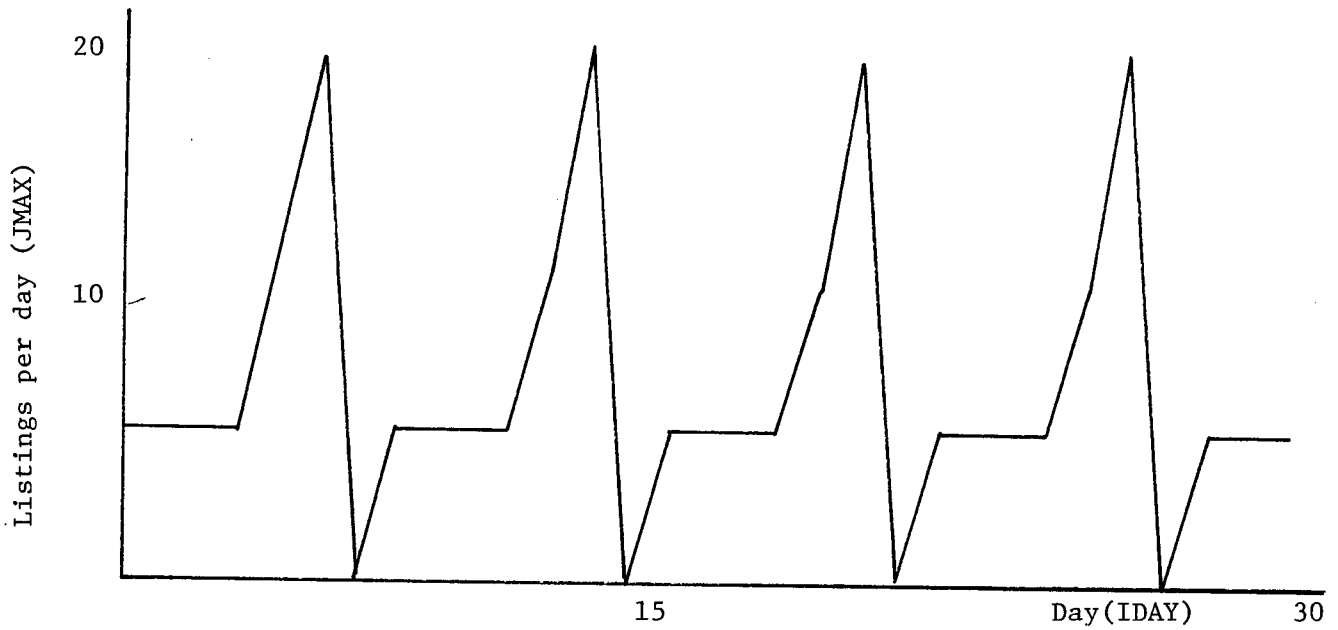


Figure 11

Values of JMAX

Some Results

To avoid a plethora of output at the end of the chapter it is now useful to present some results that demonstrate the effect of varying the supply of information on search times and costs. One interesting phenomenon of heuristic models that employ error-learning is the phenomenon of 'tracking'. The output of the model will begin to mimic the environment as the rate of learning increases; this is closely related to the point made by Day (1967) that rules of thumb and error-learning will lead to a convergence of satisfying behaviour to marginal behaviour. The behaviour of the simulated error-learning searcher will converge to the behaviour of a marginal rule using

searcher.

The step function of Figure 11 is used to repeat the trials of the previous chapter which examined the effects of alternate error-learning rules on search. In Table 8 the top figures are repeated from Table 2.

Table 8

Effects of Variation in JMAXX on Search Costs: No Storage[8]

Case	Average Search Times (Days)	Average Money Costs	Average Surplus
1	21.65 28.07	21.30 38.22	21.67 25.49
2	10.41 19.35	15.39 25.41	35.29 24.61
3	7.17 12.47	12.73 16.29	14.66 14.09
4	5.87 9.45	11.53 14.31	17.52 26.47

The variation in the daily listing produced from the subroutine CYCLE has affected that average search times and costs. Of course altering the step function so that the minimum value of listings per day was very high would produce completely different results. In this respect the results produced by this partial model are not strictly comparable with the results produced in the previous chapter.

If the ability to store offers is now 'turned on' and the same

step function is employed to produce variation in the daily listings, it is possible to analyze the phenomenon of tracking. Recall that the ability to store offers was directly related to the vacancy rate. Figure 12 shows the frequency distribution for case 4 (high rates of error adjustment, both in scope of search and rule adjustment) for the situation storage and no storage. Note that the ability to store (assuming a vacancy rate of 3.0%) smoothes the fluctuations in the number of searchers located for any given day.

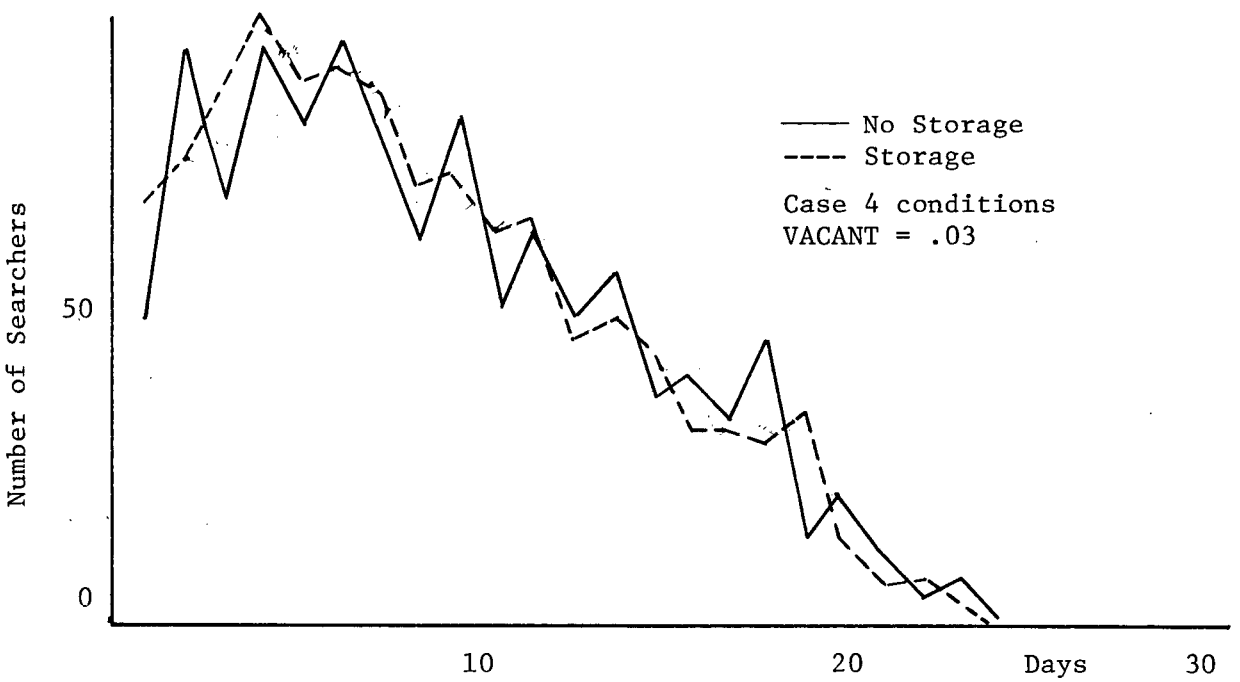


Figure 12

Search Times and Storage

The effects of storage on the 'smoothness' of the frequency distribution can be seen in Figure 13 where case 4 and case 1 (fast and slow error-learning) are compared for a vacancy rate of 3.0%. Of course varying the vacancy rate affects storage and as a result the degree to which search behaviour will mimic or track the supply of listings.

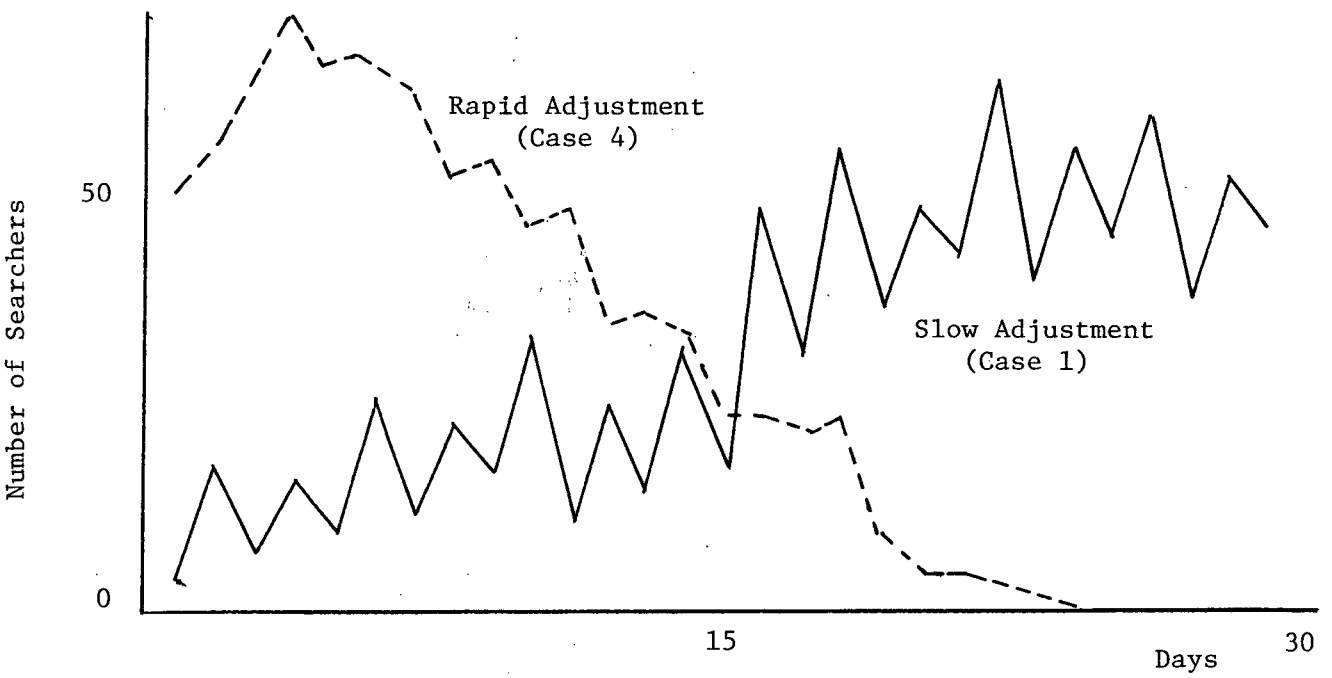


Figure 13
Error Learning Rate and Search Time

The basic outlines of the partial market model of information are now clear. Variation in the supply of information affects the time and money costs of search considerably. The rate of error-learning is directly related to these time and money costs with higher

rate of error-learning being associated with lower levels of search costs.

Rental Information Agencies

Rental information agencies are a recent phenomenon to the Vancouver area, however, they have been incorporated in North America and England for at least a decade.[9] These firms operate as pure information brokers while the other sources of information (classified and property managers) offer their information jointly with other services, which tends to obscure the marketing of information. By providing a free advertising service to buyers or sellers, these rental information agencies (RIAs) assemble a list which is offered, for a front-end fee, to the opposite side of the market. During times of excess demand, sellers are organized and the list of vacancies sold to tenants; during times of excess supply, tenants are organized and a list of tenants sold to landlords. It seems reasonable to suppose that there is some 'grey' area of market condition (perhaps vacancy rates between 2-6 percent) where neither side could be profitably organized.

Recently rental housing markets in North America have been characterized by excess demand (low vacancy rates) and RIAs have entered, offered free advertising to landlords or in some other way obtained a list of vacancies, and sold the right to examine this list to tenants. The right to examine the list lasts for a year and costs approximately $25-$35. The RIA does not permit the removal of the list and limits the time spent in examination. Policing costs are

relatively high since information tends to have very low transactions costs.

With a free advertising service, landlords face little constraint in specifying the attributes of the desired tenant or the attributes of the dwelling in some detail. There is some evidence to suggest that private information agencies aid in the process of facial, sexual and ethnic discrimination, however I found no evidence to support this.[10]

Searchers become aware of the existence of the RIAs either through word of mouth or through the classified ads. Most of the RIAs placed ads (known as 'teasers') in the classified ads which outline the general attributes of properties on the list and then invite the searcher to come to the central office where the complete information on the property is available (for the front-end fee). Teasers never supply enough information that the searcher can contact the landlord without paying for additional information possessed by the RIA.

The front-end fee is slight in comparison to brokerage charges imposed on home buyers, however there are two points to emphasize. First, the aggregate transfer from tenant to RIA is considerable (as is the aggregate transfer from home buyer to real estate broker). A recent study for the Consumer Affairs Department of the city of Seattle estimated that $300,000 had been paid to RIAs in that city during 1973. A similar estimation made by the Social Services Committee of the city of Vancouver estimated the aggregate transfer as $800,000 for the same year. Second, the transactions charge borne by homeowners are simultaneously a consumption and investment cost. Well spent, they enhance not only current consumption but future

investment gains. In the rental housing market, brokerage charges, even if they are well spent, only enhance the current and future consumption levels. Rent and search costs can never be recaptured in future land and building values by tenants.

At issue in recent political debates has been the actual contribution made by these firms to the economic welfare of tenants. Various consumer activist groups have alleged that the information provided by these firms tends to be wrong, duplicated by other firms, and has diverted rental housing information from low cost classifieds to these higher cost private information agencies. Since the quality of information cannot be inspected prior to its consumption by the searcher (since this would leave the RIA with nothing to sell), it has been alleged that tenants can be trapped into paying the front end fee out of desperation (in markets with very low vacancy rates) and end up getting nothing for this money. Since the front-end fees are not scaled in accordance with incomes it is argued that this bears heavily on low income tenants.

These allegations are quite difficult to test. Naturally these firms are extremely circumspect about releasing information on their current listings so the allegation of duplication cannot be evaluated. Similarly the charge that they often list vacancies which have been filled is extremely difficult to treat since that would require the investigator to have complete market knowledge and the complete lists provided by these firms. The allegation that listings have been diverted from classifieds to RIAs can be tested by using the teasers as a measure of RIA activity.

Cross-section analysis is a convenient way of testing the relationship between the vacancy rate and the level of RIA activity. Table 9 presents data which indicates that there tends to be an inverse relation between the vacancy rate and the level of RIA activity.

Table 9

Information in Classifieds By City

City	Vacancy Rate (Dec. 1973)	Level of RIA activity* ADACT
Montreal	2.0	.17
Toronto	1.5	.25
Winnipeg	3.5	.05
Calgary	7.9	.10
Edmonton	5.3	.12
Vancouver	.4	.40

* Column inches of ads placed by RIAs divided by total column inches of rental housing advertising (monthly averages for the largest evening newspaper)

Regressing advertising activity on the vacancy rate results in the following relation,

$$ADACT = .29479 = .03295\ (VACRAT) \qquad R^2 = .51971 \qquad (21)$$

It is probable that the usage of RIAs is affected by the population of an area and the average incomes. Certainly small villages with very low vacancy rates are unlikely to induce any one to enter into information brokerage. Also, as average incomes rise, the Linder Theorem (Linder, 1971) suggests that time intensive activities are dropped from consumption. In other words, brokers who offer saving in search

time are utilized to a greater extent. Introducing these variables into the regression improves the specification somewhat.

$$\underset{}{\text{ADACT}} = .38956 - \underset{(4.226)*}{.03112\ (\text{VACRAT})} + \underset{(5.385)*}{10.3452\ (\text{POP})} + \underset{(2.035)}{.06831\ (\text{INCOME})} \qquad R^2 = .63963 \quad (22)$$

* Significant at .05 level

Before these results can be used in the simulation models more detailed analysis of information brokerage is necessary. In particular the 'Linder' effect is open to considerable question.

The diversion of information from low cost classifieds to higher cost RIAs can be seen from the following table. The time series was computed only for Vancouver since it was difficult to obtain complete data for other cities (since the library did not have a complete collection). This information is presented in graphical form in Figure 14.

Table 10

Month	Vacancy Rate	Percent of Classifieds Space Purchased by RIAs
June 1970	3.1	0
Dec. 1970	2.3	0
June 1971	4.1	0
Dec. 1971	2.8	1
June 1972	2.4	5*
Dec. 1972	.6	11
June 1973	1.0	20
Dec. 1973	.4	26
June 1974	.2	31

* Rentex enters the market

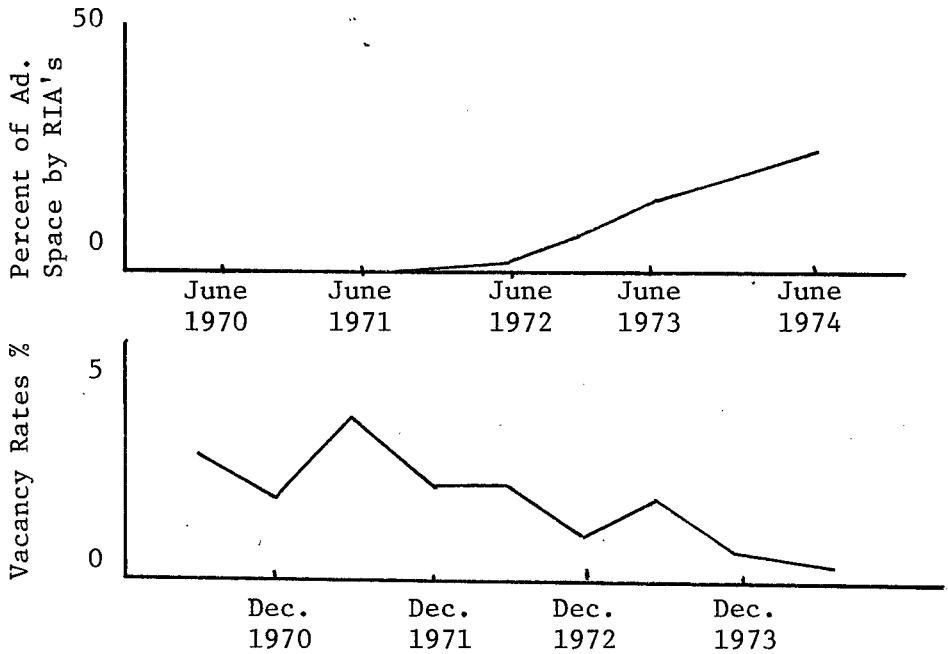


Figure 14

Vacancy Rates and RIA Activity

Simulating the Rental Information Agency

One method of simulating the RIA is simply to use the regression equations in the previous section to generate the lists from RIAs that can be expected at various levels of vacancy rate. The course followed is more ambitious and rests upon making some assumptions that are not verified. The result is a model which is more robust and captures some features of information brokerage that are not normally mentioned. The procedure used is closely related to models of the firm constructed by Baumol and Quandt (1974), Cyert and March (1963)

and Day, Morley and Smith (1974). Combining these simple simulation models of the firm with some insights into nature of information brokerage permits the modelling of entry and exist mechanisms for RIAs. In this way the effect of various regulatory procedures can be more fully explored.

A Simple Theory of Information Brokerage

Brokers derived their revenue from both sides of the market. Both buyers and sellers consume brokerage services, and the extent of the transactions charge borne by a buyer or a seller is a function of the relative elasticities of demand for the actual commodity. Information is an unusual commodity and requires a peculiar environment to support its sale.

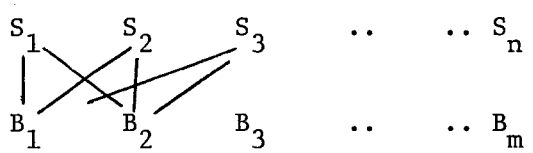
First, information requires strict control. In many ways it is a public good which can exhibit very low marginal costs of production, making it hard to exclude free riders. Patent and copyright laws are evidence of controlling for free riders. For these reasons firms specializing in the sale of information can be required to bear policing costs to control the sale and resale of their commodity.

Second, because of the requirement of policing, information is very hard to evaluate prior to consumption. Of course this difficulty in evaluation is not just because of the policing. Some information, such as the specifications of stereo equipment, requires a certain level of technical competence.

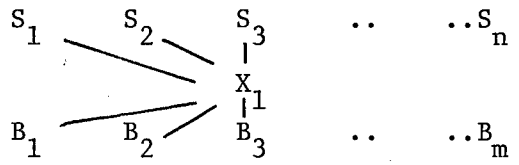
These aspects of information brokerage can imply that consumers of a product or service often have to deal with two or more levels of

uncertainty. First there is uncertainty about the quality of information provided by the market intermediary and second there is the uncertainty about the commodity to be consumed. Imperfect information about brokerage can easily compound the imperfection that may exist in the market without these brokerage services. Generally, brokers function to reduce these transactions costs and uncertainties, but it is easy to devise a simple model to the contrary.

This model is based upon some work by Balderston (1957). Assume that there are S_i (i = 1, 2,.....,n) sellers and B_j(j = 1,2,.....,m) buyers as indicated by



Assume also that each buyer sends a message to each seller and vice versa. This implies that there are a total of mn messages per period. If the cost per message is 'a' then the total costs of information is given by, TC = 2amn. Average costs are 2amn/mn. Brokers enter and position themselves between buyers and sellers if they can reduce the message costs for either buyers or sellers. Obviously, all they have to do is price message costs less than 'a' per message; assuming that there is perfect information on brokerage services, every buyer and seller will now send one message to the broker instead of many messages to the other side of the market. This situation could appear as follows;



Assume that only one broker has entered. If broker's message costs are 'b' per message it can be seen that the total costs of messages in this system are given by TC = (a+b) (m+n) and the average costs are AC = (a+b). The average message costs with a monopoly broker are considerably less than the previous average costs without a broker.

If a second broker enters the market and assuming that each has identical prices, then each will share the market. Total costs are now TC = (a+b)(m+n) + (a+b)/2(m+n) with average costs given by AC = 3(a+b)/2.[11] These results depend upon the assumption that some buyers and some sellers will patronize the wrong broker and fail to make contact with the appropriate member of the opposite side. In this case information costs must be incurred again with the other broker.

In general, with the assumption that the market is exactly shared, and that a certain percentage of buyers and sellers will have to repeat message transmissions (in some cases many times) in order to contact the appropriate opposite party, it can be shown that the average costs of search will be,

$$AC = \begin{cases} N + 1(a+b) & ; N \text{ odd} \\ 2(N+1)(a+b)/N & ; N \text{ even} \end{cases}, \qquad (23)$$

where N is the number of brokers. (See appendix 1).

Of course this is an extremely simple model.[12] It is reasonable to expect that brokers have cost functions and that the theory of the firm will apply. The point of the exercise is to underline the notion

of imperfection in the brokerage market and to indicate that the average cost of message transmission increases as the number of brokers increases; this may be a case where monopoly rather than perfect competition is the appropriate structure of industry.

The Structure of the Simulation Model of RIAs

Several basic assumptions are made. First, searchers are assumed to choose randomly from the brokers. Of course, in theory, advertising effort, competitive pricing and other factors are likely to be important, however incorporation of these aspects is beyond the scope of this paper.

Second, the vacancy rate is directly related to the shifting of brokerage fees. At low vacancy rates most of the fee is shifted to tenants (full shifting below 1.5%) and at higher vacancy rates the fee is shifted to landlords.[13]

Third, it is assumed that the cost structure of each RIA is identical, as are the revenue curves. Actually, measuring cost functions is extremely difficult; this problem is compounded by the fact that information brokerage must, by nature, be a rather secretive operation. By using standard 'u' shaped cost curves and downward sloping demand relations a crude mechanism for entry and exit is possible.

Fourth, it is assumed that the i^{th} searcher will consult a broker under several conditions. First, a money cost constraint is set up. If the difference between this maximum value (1% of income) and the present search cost is greater than the brokerage charges shifted to tenants, then the rule of thumb has been adjusted more

than five times a broker is consulted. Finally, if the time spent in search is greater than 20 days a broker is consulted. Given these conditions a searcher will pay for the additional information possessed by a broker. This sequence is somewhat arbitrary, but it is the only way that a simulation can be accomplished. Once again intuition would suggest that searchers do in fact utilize lower cost forms of information first and then more costly information in the event of failure.

Finally, it is assumed that brokers are of equal size; each supplies the same amount of information and services an equal number of searchers and landlords.

Once the decision to consult a broker has been made, the first step in the model is to increment the costs of search by the amount of the brokerage fee according to the formula,

$$COST_{i\ t+1} = COST_{i\ t} + FIXED1 \qquad (24)$$

where FIXED1 is the brokerage charge passed on to the tenant, and $COST_{ij}$ is the present money costs accumulated by search i at time t.

The model calculates two brokerage charges according to the formulas,

$$FIXED1 = BETA1*VACANT \qquad (25a)$$
$$FEXED2 = BETA2*VACANT^{-1} \qquad (25b)$$

where for vacancy rates in excess of 5%, FIXED1 is set to zero and for rates below 1.5%, FIXED2 is set to zero.

It is important to devise a mechanism for separating the various sources of information. This is accomplished by the following set of formulas,

$$LISBRO_{kt} = (ALPHA3/VACANT_t) / k \quad (26a)$$

$$JMAXX_j = f(VACANT_j) \quad (26b)$$

$$TOTLIS_t = (LISBRO_t * k) + JMAXX_t \quad (26c)$$

where $LISBRO_k$ is the listings carried by the k^{th} firm, JMAXX is the result from the step function and TOTLIS is the sum of the daily listings from both sources. TOTLIS will vary and exhibit the cyclical tendencies of JMAXX, however these will be attenuated by the effects of LISBRO. The supply of listings from brokerage does not exhibit as extreme a variation as the supply of information from classified ads. From regression equations 16 and 21, JMAXX is the average daily listings from classifieds and LISBRO is the number of listings handled by RIAs which is always constrained to be less than or equal to TOTLIS. The relation between TOTLIS, $\overline{JMAXX}$, LISBRO and the vacancy rate is shown in Figure 15.[14]

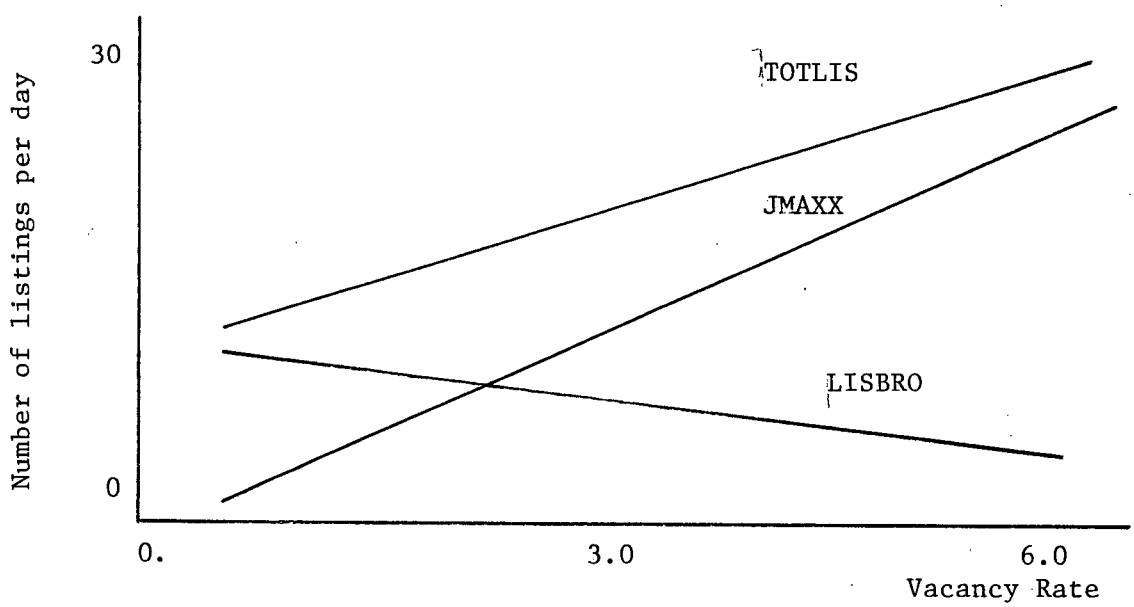


Figure 15

Vacancy Rate and Listing Per Day by Source

The final step in simulating the rental information agencies is the assumption that landlords only list with one information source. Thus a landlord chooses to list only with the classifieds or a rental information agency. Furthermore the landlord will only choose one agency. This is of course quite restrictive, however this assumption will be relaxed shortly. In addition searchers consult only one rental information agent.

Once these input values have been calculated, the model is run for one period. This permits the summation of the number of searchers who are going to use brokers; it permits the calculation of the shifting of charges and the calculation of the number of landlords who are listing with brokers. After all searchers have been settled the monthly clock (m) is incremented and the equilibrium number of brokers is calculated, for the next period.

The calculation of the number of brokers is accomplished simply. The revenues are computed according to the equation,

$$\text{REVENU}(k) = \text{ALIST}(k)*\text{FIXED1} + \text{BLIST}(k)*\text{FIXED2} \quad (27)$$

where REVENUE(k) is the revenue of the k^{th} firm, ALIST(k) is the percentage of searchers that use that firm, BLIST(k) the percentage of landlords that use the firm and FIXED1 and FIXED2 the respective brokerage charges.[15] The calculation of the equilibrium number of firms is performed in a stepwise manner. First, the revenue is calculated as if there were only one firm. This revenue is compared with a cost function given by

$$\text{COST}(k) = A + CC1(\text{ALIST}(k))^{CC2} + CC3(\text{BLIST}(k))^{CC4} \quad (28)$$

where CCL-4 are parameters of the cost function. If a positive profit

is obtained and as long as the level of profit exceeds ten percent, the revenue function and the cost functions are re-calculated, but ALIST(k), and BLIST(k) are adjusted to reflect the assumption that searchers and landlords are indifferent about whom they patronize and landlords only list with one agency (when vacancy rates are low). Therefore when the number of firms increases to 2 the values of ALIST and BLIST are halved. This procedure is followed until the number of firms that can be supported by the market is calculated. The various parameters in the revenue and cost function are calculated using sensitivity analysis which is explained shortly.

Once the equilibrium number of rental information agencies has been established the model returns to the second month and a new batch of searchers. Each time these searchers consult a broker they obtain exactly LISBRO/k listings from which to attempt to select a suitable dwelling. The rules for accepting this dwelling are precisely those which are formulated in the previous chapter.

Sensitivity Analysis

Some of the parameters in the brokerage sub-model and the classifieds sub-model are not supported by empirical evidence. Other elements in the basic demand model are also empirically unsupported. If all parameters were required to be verified with stringent confidence intervals, then it is safe to argue that no simulation models would ever be constructed. In many studies, these parameters are submerged and the authors appear to hope that no one will notice that they have been slipped in through the back

door. The better models incorporate extensive sensitivity analysis of the empirically unverified parameters (and even the parameters for which the statistical evidence is strong). The next section briefly outlines some simple sensitivity tests and presents some of the results. A complete sensitivity analysis would easily double the length of the thesis.)

Sensitivity analyses are conceptually very simple. The model is run for different values of the parameters, a response indicator or indicators are chosen and the resulting output is analysed for evidence of changes that appear to make little sense. Very sophisticated tests have been devised, such as analysis of variance and factor analysis in several dimensions, to test for perversities in the relationship between changes in a parameter and the resulting change in the response indicator. For the present essay only simple examination of the output is required since the model is not especially complex.

An example of a typical sensitivity 'run' is presented in Table 11. The two constraints or parameters to be evaluated are the time constraints that govern basic error-learning. Recall that IDYCR1 was set to 10 days after which searchers would widen the scope of search, while IDYCR2 governed the point at which error-learning would commence. It was asserted that varying these constraints did not materially alter the output from the model. This is now demonstrated.

Various levels of IDYCR2 are depicted horizontally, while down the columns are indicated various levels of IDYCR1. Moving to the right indicates that for any level of IDYCR1 (the decision to

widen the scope of search) the average time and money costs of search increase. For any level of IDYCR2 (the point at which the rule is relaxed) and moving down increasing the value of IDYCR1 also increases the time and money costs of search. Extreme values of IDYCR1 and IDYCR2 result in very wild figures; however, it is important to stress that the direction of change is consistent and that for small changes in these variables the time and money costs also change incrementally.

Table 11

Sensitivity Analysis with the Time Constraints

IDYCR2	5	10	15	16	20	25
IDYCR1						
1	.49*	1.37	1.49	3.69	8.75	24.09
	9.59**	14.34	17.81	35.55	87.45	114.55
5	2.51	4.88	6.72	9.41	17.41	25.66
	11.02	15.12	18.91	39.51	110.39	140.54
11	3.61	4.92	6.91	11.30	21.44	26.07
	12.46	17.20	21.49	41.66	127.66	151.02
12	3.67	4.96	6.77	11.51	23.81	25.98
	13.41	16.87	24.62	44.09	139.54	163.78
20	6.9	8.11	9.75	13.82	24.61	38.93
	15.90	21.63	39.01	67.32	167.37	200.78

VACANT = 2.0
INUM = 1000
*average time costs
** average money costs

A second example of the sensitivity output is provided when the cost parameters are adjusted. For the sake of simplicity if it is assumed that the exponents and coefficients are equal; i.e. CC1 = CC3 and CC2 = CC4.

The results from varying these parameters are indicated in Table 12. In this case the response indicator is the number of brokers. These sensitivity tests were run with VACANT = 2.0 and for INUM = 1000. For any horizontal movement the cost curve shifts upward, while for any vertical movement the curves become more non-linear.

Table 12
Sensitivity Analysis with Parameter of
Brokerage Cost Function

CC1, CC3 / CC2, CC4	1.0	1.2	1.4	1.8	2.0	2.5
.5	0	0	0	1	1	2
1.0	0	0	0	1	2	3
1.5	0	0	1	2	3	6
2.0	0	1	3	5	6	9

Apparently the number of brokers is very sensitive to the parameters of the cost function. The procedure is to choose the set of parameters that allow the model to most closely replicate reality. Needless to say this process of choosing the best combination of coefficients is the outcome of many runs; this is what makes simulation expensive.

Some Results

The complete demand supply model is presented in macro flowchart form in Figure 16. The effects of classifieds and RIAs is presented in relation to the simple version of the demand model introduced in Chapter Two. The complete detailed flowchart is presented in Appendix Two.

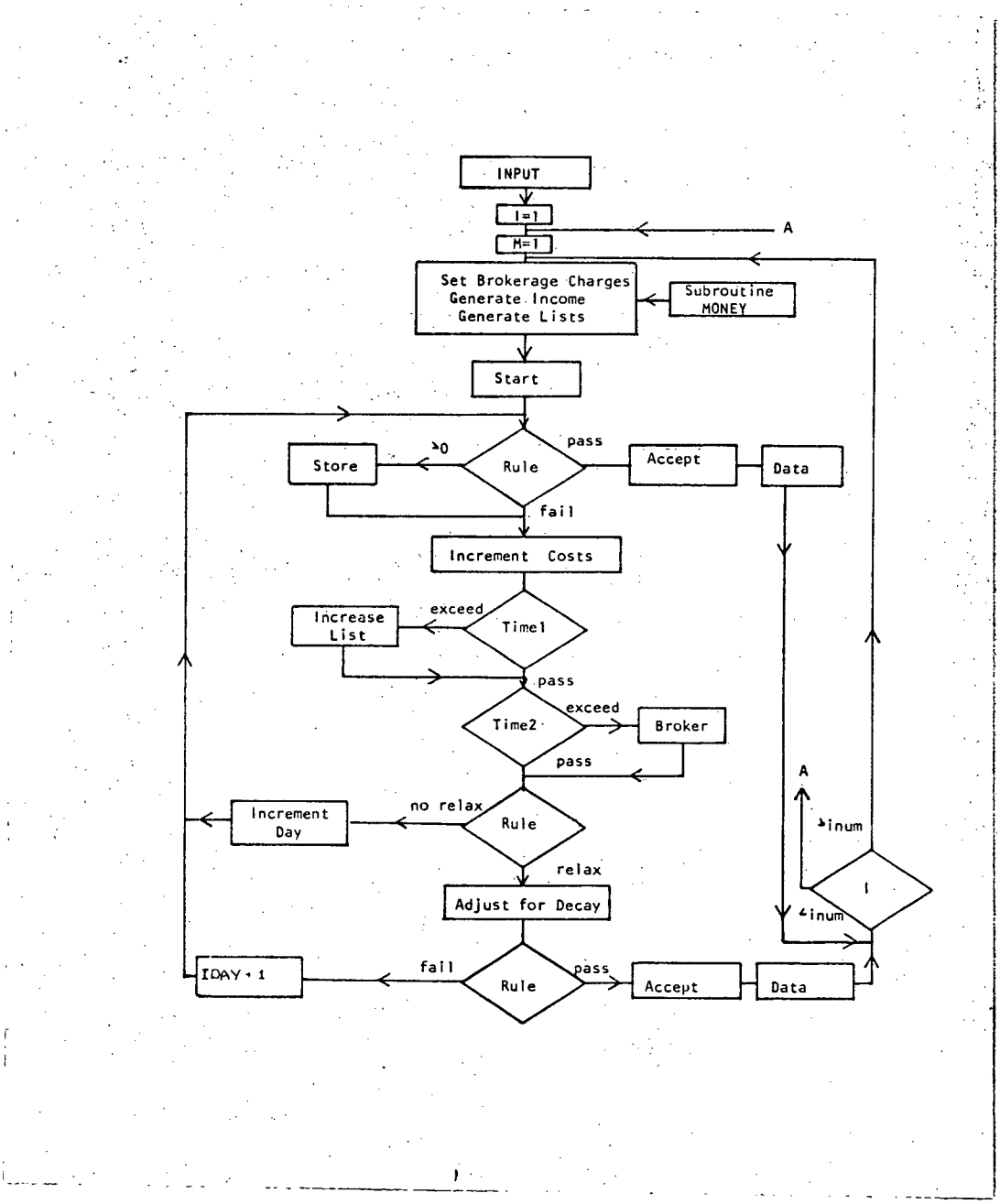


Figure 16

Macro Demand Supply Flowchart

The first interesting test is the relation between the number of brokers supported by a set of market conditions and the vacancy rate. Two such relationships are shown in Figure 17. Obviously the number of searchers is an important variable. It is important to stress that the model results are sensitive to the input variables, however; although the magnitude of the change will vary with the magnitude of the input variables (number of searchers, for example), the direction will be consistent. In this case, increasing the number of brokers supported by given market.

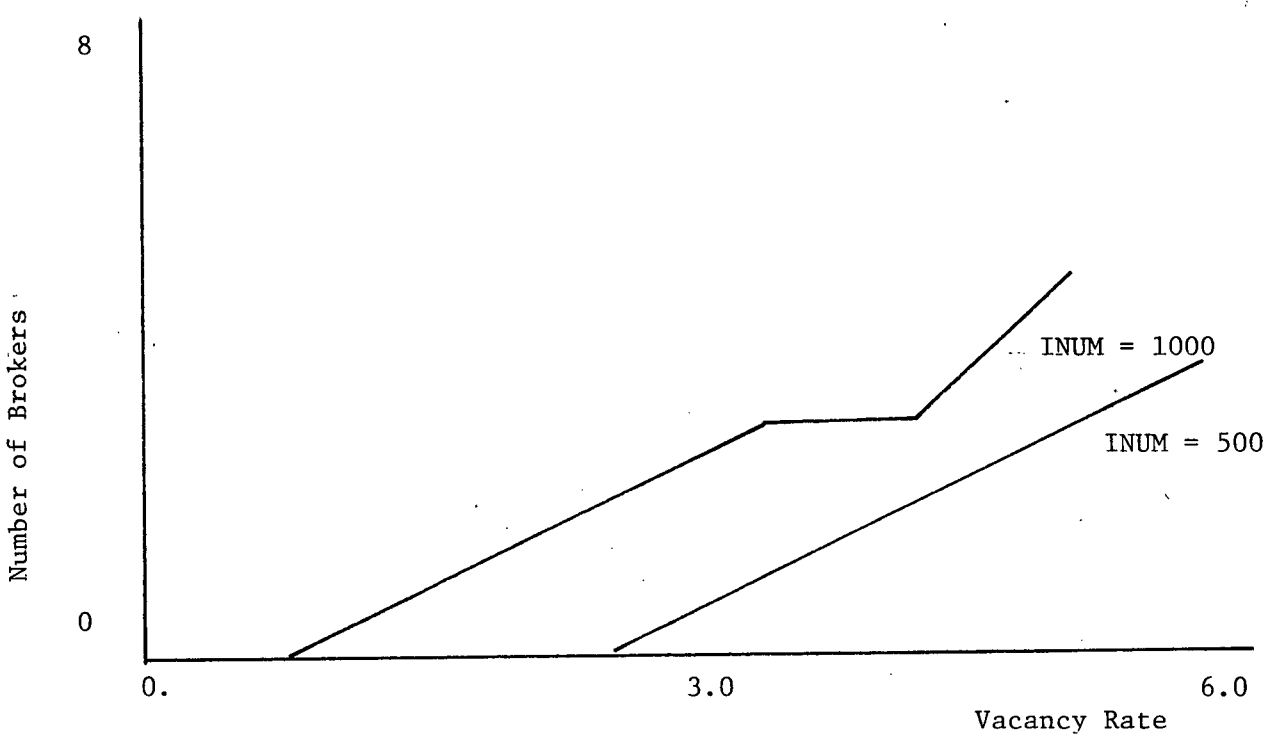


Figure 17

Vacancy Rate and Brokerage

A second interesting relation is the effect of segmenting the supply of information. Obviously the vacancy rate will play an important role. The conditions for case four (the rate of rule of thumb revision equals 2.0 and the rate of scope revision is 2.0) as presented in the previous chapter will be used for the remainder of the essay. It is now possible to analyze the relation between search costs and the vacancy rate. This is shown in Table 13.

Table 13

Information Brokerage and Vacancy Rates

Vacancy Rate (VACANT)	Number of Brokers	Average Time Costs (1)	Average Money Costs (1)	Average Time Costs (2)	Average Money Costs (2)
6.0	0	3.25	5.98	2.65	5.24
5.0	0	3.31	6.58	2.79	6.11
4.0	1	4.01	10.56	3.15	6.71
3.0	1	4.97	15.62	4.86	8.34
2.0	3	5.66	18.35	4.89	8.20
1.0	4	6.43	23.67	5.62	10.39

(1) with brokerage
(2) from table chapter 2
INUM = 1000; Case 4 error-learning

Column 1 shows the time and money costs produced by the model when both brokerage and classified ads are suppliers of information; column 2 presents the output obtained from the simple demand model of Chapter Two. The higher costs imposed by information brokerage are insignificant at high vacancy rates; however, in times of excess demand they can become more substantial.

All of this is quite straightforward. It is more interesting to study the effects of duplication of information. It has often been alleged that the RIAs merely repeat each others' listings. Landlords, of course, have an incentive to list with as many free agencies as possible. Classified ads in this age of conglomerate firms will often be identical from newspaper to newspaper and the marginal costs of listing in extra classifieds are often slight in comparison with the total costs. The simulation model permits one to speculate about these effects in an a priori manner.

It is possible to simulate the effect of redundant information by using the same technique that was used to simulate the effects of decay on the storage of offers. A variable (ZERT) is made a simple linear function of the vacancy rate according to the expression

$$ZERT = ALPHA^* (VACANT) \tag{29}$$

As the vacancy rate declines ZERT increases. A random number is generated each time a classified or RIA list is generated, and if this number (which is between 0 and 1 as is the value of ZERT) is greater than ZERT, the values of the bid and ask prices are left unaltered. Otherwise they are set to zero and the searcher is forced to consider another listing. For the sake of argument (since this section is quite speculative) it is assumed that redundancy of information afflicts all sources of market data (classifieds and information brokers) equally; i.e., as the vacancy rate declines the likelihood increases that any particular bit of information (bid-ask rent combination) is redundant or worthless. Of course this compounds the problem of decay. In fact,

redundancy in information would lead to increased rates or error-learning, however, this aspect of search is ignored simply because the model has become sufficiently complex as it stands. The effects of redundancy are apparent in Table 14.

Table 14

Redundancy in Information and Search Costs

Vacancy Rate (VACANT)	Average Time Costs (1)	Average Money Costs (1)	Average Time Costs (2)	Average Money Costs (2)
6.0	3.25	5.98	3.54	6.01
5.0	3.31	6.58	3.78	7.32
4.0	4.01	10.56	4.86	13.69
3.0	4.97	15.62	6.38	21.76
2.0	5.66	18.35	9.62	29.12
1.0	6.43	23.67	11.17	29.22

(1) from table 15
INUM = 1000; Case 4 error-learning

Summary

The market model of information is now complete. Since important sources of information such as casual search (on-street-advertising, word of mouth etc.) and waiting lists are omitted, no claim to completeness can be made; however, it is possible to analyze various regulations in terms of the effects these regulations have upon search times and money costs, and the number of brokers operating in the market at any given period. In the next chapter several policies are examined which have recently been advanced to improve the welfare of tenants.

FOOTNOTES - CHAPTER THREE

1. On-street advertising includes signs in front of buildings and notices placed in public areas such as supermarkets and laundromats.

2. Evidence given before the Social Services Committee of the city of Vancouver August 2, 1974 by the president of the Greater Vancouver Apartment Owners Association.

3. Recall that JMAXX is the total number of listings available per day.

4. See Chapter 1

5. For the remainder of this essay where classified ads are used the raw data was obtained from the major evening daily. For Vancouver this is the Vancouver Sun.

6. Evidence for this was also given before the Social Services Committee cited in footnote 2.

7. An alternate measure of variation could be $(Ads_m - Min_m)/(Max_m - Min_m)$, where Ads_m measures the average value.

8. Simply be adding a test statement, storage can be completely by-passed in the model.

9. Rentex, the largest firm operating in Vancouver during the summer of 1974, was first incorporated in Delaware in 1964, and in Vancouver they obtained their business licence to operate a franchise in the summer 1972. The other two large firms, Timesavers and Homefinders are more recent.

10. Baake (1963) and Rees (1966) find some evidence that private imployment agencies aid the process of sex, race, ethnic and age discrimination, however as in most cases of discrimination the empirical evidence is meager.

11. See appendix 1 for further details.

12. An extension of error-learning might be possible at this point. Instead of searchers randomly choosing their broker, they might use error-learning to select the broker which provides the best service (greater number of listings). Doubtless many services, such as medical and legal services, are chosen, in part, using an error-learning mechanism. The front end fee, however, is an important barrier to extensive use of trial and error selection procedures. As a first approximation random selection seems reasonable.

13. See appendix 1 for further details on the shifting of fees.

14. Note that in this figure the cyclical nature of JMAXX is not apparent. A three dimensional diagram is required to portray this. JMAXX represents the average value of JMAXX at various vacancy rates.

15. The revenue is simply the value of FIXED2 times the number of searchers who patronize a particular broker. In addition it should be noted that the number of landlords IUNIT is an exogenous variable. Extensions of this aspect of the model are to be found at the end of the next chapter.

CHAPTER FOUR

The Market for Rental Information and Its Regulation

This chapter presents some explorative policy tests. These tests are accomplished by altering the logic or algebra in a way that is completely analogous to shifting simple demand and supply curves in static analysis. In this way alternate policies may at least be conceptually compared. Before describing these tests a brief aside is presented on the nature of regulation.

The Nature of Regulation

Intervention in the free market has been advocated for a variety of reasons, the most common being that the private sector fails to provide a socially optimal level of service at prices which are 'just'. Regulation can range from setting quality constraints on outputs or factor inputs (drug testing requirements and driver's licences), price and quantity controls (rent control and farm quotas) or at the extreme, public provision of the good or service.

Most economists have despaired of finding an objective rule for intervening in the economy. For example, in the provision of public goods Buchanan writes;

> "Decisions on the demand and supply of public goods are made through political not market institutions and there is no analogue to competitive order that eases the analytical task." [1]

The consensus appears to be that economists ought to evaluate the costs and benefits for various policies and then permit the political process to choose, once fully informed. This is the position taken in

this paper.

One of the cases in which government intervention is deemed most appropriate is for decreasing cost industries or 'natural monopolies.' It is thought by some authors that information qualifies as a decreasing costs industry (Zeckhauser, 1970). The argument is that the marginal costs of providing consumers with information are very low; average costs inevitably exceed marginal costs over wide ranges of output and monopoly tends to be the equilibrium structure of the information industry. This conclusion does not conform with casual empiricism. Many firms disseminate information and, while they are not perfectly competitive, they are certainly not monopolies (television, newspapers, consumer testing, magazines, etc.).

In addition to casual empiricism there are good reasons for supposing that information production does not tend toward monopoly. For example, in the rental information industry the entry requirements are very low. In addition, since information cannot be evaluated prior to consumption, ignorance can effectively differentiate the product. Although this differentiation can lead to monopoly power and monopolistically competitive firms, it does not lead to natural monopoly. Of course for some industries such as newspapers, the capital requirements are very large and there has been a tendency for concentration to increase in the past decade. In all likelihood the impetus for this is due to conventional economies of scale that exist in producing newspapers, than in the fact that information may have very low marginal costs.

The argument that information production tends towards natural monopoly must be rejected. It is still possible to condone inter-

vention on the grounds that the present levels of production are less than socially optimal. To estimate the value of additional information service may seem impossible, however it is easier (at least conceptually) than it first appears. Information is an intermediate good, used by consumers to produce (along with the goods and services being 'researched') utility. By postulating the consumer under various environments, with and without information, it is possible to infer the net benefit of alternate policies that affect the supply of information to the consumer.

There are several important provisos that need to be explicit. First, this model does not evaluate utility directly. The net benefit of an increase in information is indicated by change in search costs (time and money). Second, this model only examines the benefit aspect; costs of alternate policies are not calculated. Finally, it should be pointed out that there may be some difficulty due to a violation of the Scitovsky criterion in evaluation of policy changes.[2] The distribution of welfare may not be symmetrical with respect to a policy change. This problem would arise in the model in the event that policies were changed in a short time span. With error-learning and an entry/exit process that may take several months to fully work out, it is necessary to evaluate some policies over a long period of time.

With these points in mind it is possible to proceed. These tests will be described, the changes in logic briefly explained and the resultant output evaluated.

Policy Tests

There are three general types of policies evaluated in this model.

(1) Free Market: Often the option of doing nothing is ignored as a legitimate policy. In addition, the free market option provides a bench-mark against which other policies may be compared. The free market run is presented for different vacancy rates and for the first, sixth and twelfth month. Included in the figure are average search times (top number), average search costs (middle number), number of information brokers (bottom number).

Table 15

Free Market Policy and Search Costs

Vacancy Rate	Month 2	Month 6	Month 12
	3.41*	3.46	3.10
6.0	5.67**	5.94	5.49
	0 ***	0	0
	3.53	3.51	3.17
5.0	5.94	6.01	6.11
	0	0	0
	4.11	3.94	4.17
4.0	9.12	10.87	9.24
	1	1	1
	4.81	4.67	4.98
3.0	14.17	16.35	17.12
	2	2	2
	5.12	5.41	5.24
2.0	17.40	18.31	18.93
	3	3	3
	6.47	6.94	6.53
1.0	22.64	24.67	23.55
	4	4	4

* Average Time Costs
** Average Money Costs
*** Number of Brokers (profit limit set at 10%)

(2) Regulation

Regulation of the rental information market can be accomplished by several policies of varying degree. Three policies will be examined; fee for service, registration fee plus fee for service, and legal actions for false advertising. These policies are all aimed at rental information agencies and have been attempted by governments throughout North America.[3] Unfortunately no studies have been done which evaluate their effect.

(a) Fee for Service: This regulation has been advanced as an appropriate form of regulation whenever the consumer cannot evaluate a service prior to consumption. The notion is simple; the firm cannot charge for a service before it is delivered to the consumer. In the case of RIAs this would mean that consumers cannot be billed for examining a housing list until they had been housed and can be charged only if the firm had provided them with information leading to that vacancy. This policy is very simply tested in the model by amending the incrementation of money search costs so that FIXED1 is not added to search i's costs until searcher i is housed and only if a house was located through a list provided by a broker. There is some possibility for ambiguity once a vacancy is added to a storage list; in this case a particular bid-ask rent combination is flagged to identify it as originating with a RIA.

Of course RIAs are opposed to such regulation since it would increase collection costs. Also, revenue would probably drop in the event that RIAs do not place everyone who signs a contract. It is probable that there will be fewer firms in such a regulated industry

and landlords who hitherto listed exclusively with RIAs would be forced to utilize classifieds and other dissemination devices.

The increase in collection costs will not be modelled; however, the decline in revenues can be demonstrated without changing the structure of the model. Table 16 presents a series of trials with exactly the same initial conditions as Table 15. The reduction in money costs is apparent as is the decline in the number of firms that can earn an acceptable rate of return (10%). The policy tends to have little effect at low vacancy rates, but as the vacancy rate declines money costs of search are substantially altered. Times costs are unaffected and the number of brokers declines. Since this is a hypothetical situation these results merely indicate general tendencies, not exact responses.[4]

Table 16

Fee for Service and Search Costs

Vacancy Rate	Month 2	Month 6	Month 12
	3.31*	3.50	3.17
6.0	5.49**	5.44	5.61
	0 ***	0	0
	3.33	3.57	3.54
5.0	5.87	5.74	6.03
	0	0	0
	4.21	3.87	4.06
4.0	6.98	6.84	5.99
	0	0	0
	5.42	5.38	5.51
3.0	9.27	10.38	8.79
	0	0	0
	5.24	5.41	5.39
2.0	11.32	10.93	10.97
	0	1	1
	6.35	6.29	6.41
1.0	14.33	12.49	15.67
	1	1	1

* Average Times Costs
** Average Money Costs
*** Number of Brokers (profit limit set at 10%)
Number of searchers per run - 1000

(b) Registration Fee plus Fee for Service

It has been pointed out that many services (lawyers) charge a retainer to ensure that the consumer pay for services as they are rendered. The simulation of a pricing structure which permits the charging of a registration fee (about 10% of the full charge) and then collection of the remainder upon successful delivery of the service, is very straightforward. Every time the searcher calls upon an RIA, costs are initially incremented by a small amount and the remainder of FIXED1 assigned when the consumer has been housed by an RIA. The results in Table 17 are very similar as in Table 16, except that more brokers survive and search costs are higher.

Table 17

Registration and Fee for Service and Search Costs

Vacancy Rate	Month 2	Month 6	Month 12
	3.29*	3.57	3.21
6.0	5.32**	5.29	5.53
	0 ***	0	0
	3.43	3.42	3.29
5.0	5.92	5.72	5.59
	0	0	0
	4.36	4.41	3.98
4.0	6.87	6.95	7.05
	0	0	0
	4.96	5.45	5.29
3.0	8.96	11.54	9.17
	0	1	1
	5.31	5.49	5.33
2.0	13.45	12.69	13.01
	1	1	1
	6.67	6.47	6.46
1.0	15.39	16.98	19.54
	1	1	1

*Average Time Costs
**Average Money Costs
***Number of brokers (profit limit set at 10%)
Number of searchers per run = 1000

(c) Requirements on Validity of Housing Lists: It is commonly alleged by various consumer activist groups that rental information agencies, dance studios, correspondence schools etc., misrepresent the service they offer. A policy that is often advocated is class actions that enable the consumer to file suit in the event that a service was not performed once a fee had been paid. Simulating this policy is impossible within the context of the model, however some points should be made about this course of action. First, it is extremely expensive. The responsibility of proving misrepresentation rests on the consumer, and therefore is likely to be ineffective unless the state increases the level of surveillence on 'business ethics'. Price regulation may have side effects such as black markets, but their direct costs to tax-payers tends to be small in comparison to legal sanction.

(3) Nationalisation of Information Dissemination

Economists have occasionally called for centralized housing registries (c.f. Rodwin, 1963). Consumer Activist groups also make this plea in the face of current excess demand for housing. There are two polar possibilities - government agencies that compete wtih the present private services and government monopoly that would eliminate all sources of information except for the public agency.

(a) Public Agencies that Compete with the Private Sector

Many argued that when the government entered the auto insurance business, they should do so in direct competition with the private sector. Private businesses argued that government monopoly was high-handed and arbitrary. They also alleged that the 'typical' ineffi-

ciency of public enterprise would more than offset any economies due to streamlining the litigation process.

In this model the addition of a new firm representing the public information agency, has an impact only if it charges a lower front-end fee than other private agencies. Provision has not been made for market share increasing techniques such as advertising or price cutting; however, in the event that the price charged by the public firm is less than the private industry price (which it would have to be given current political opinion), then it is reasonable to suppose that the public agency will be the first broker to be consulted by housing searchers.

I have simulated two alternatives of this policy. The first, models the possibility that the government underwrites the public information agency and provides a free information service. The second version has the government firm set a break-even price which is charged only in the event that the tenant is actually housed; it is unlikely that governments could use front-end fees.

With the first version the searcher immediately consults the government list (which is formulated in the same way that the various lists for the private agencies were created). Once this has been exhausted on the first day, the vacancies with positive surpluses are stored and the searcher enters the usual search stream as in the free market model.[5] With the second alternative the model is run with the government agency setting a break-even price level which is calculated iteravely. This process is accomplished with the aid of several assumptions. First, it as assumed that landlords are in-

different to information agencies as long as the price charged to them is the same for all firms. Therefore the share of the market from the point of view of the number of landlords listing with the firm is equal for all brokers, private and public. Second, it is assumed that searchers (consumers of information) are price sensitive; they will patronize the firm that has the lowest price before others. The number of searchers attracted to the firm with the lowest price does not vary once it has been established that the firm has the lowest price. It is not necessary to calculate the complex relationship between number of consumers, price, total revenues, costs and profits. All that is really required is to run the model for a series of months, decreasing the price of the government service until it no longer earns a positive profit. This price is then used in the policy simulation and compared with the results of version 1. These results appear in Table 18. Only Month 12 is presented for each version.

Table 18

Public Information Agencies

and Search Costs

Vacancy Rate	Version 1	Version 2	Free Market (from Table 15)
	3.28*	3.12	3.10
6.0	3.45**	3.62	5.49
	1 ***	1	0
	3.21	3.29	3.17
5.0	4.14	4.65	6.11
	1	1	0
	3.79	4.01	4.17
3.0	7.45	10.56	17.12
	3	3	3
	4.67	6.25	5.24
2.0	9.74	16.69	18.93
	3	3	3
	6.22	8.43	6.53
1.0	14.14	20.44	23.55
	4	4	4

* Average Time Costs
** Average Money Costs
*** Number of Brokers (profit limit set at 10%)
Month 12
Number of Searchers = 1000

It is easy to see that the government agencies do cause a reduction in search costs of searchers (at least within the context of this model). The net benefits to searchers of a subsidized housing registry, especially one which had monopoly power, are intuitive. This model omits certain features which undoubtedly qualify these conclusions.

First, there is some problem in estimating the patronage of the government agency by both landlords and tenants. For example, landlords might be reluctant to list with the government agency, given that other private agencies are free simply because they believe that the public

agency would likely have welfare cases, single mothers, poor people and Indians are its most common clients. Middle income tenants might well find as a result that the available listings provided by the public agency are unsuitable and end up going to private agencies. The public agency could become an information broker for the landlords that provided slum type housing and could in fact aid the racial, sex and ethnic discrimination process in housing. Thus, public information agencies in housing could end up being similar to Canada Manpower in their secondary effects.

Second, taxpayers could legitimately complain when this information service was being used to aid the discrimination process. Home owners might regard it as a transfer that should be paid by wealthy tenants, not owners of fee simple properties.

In addition, there is the problem that people could easily use the failure of the public housing registry to provide information as synonomous with failures in government housing policy to provide dwelling units. It could be a politically treacherous exercise.

Finally, it is interesting to note that the time costs of search tend to increase when the government enters into direct competition with the private sector. This may appear to be counter intuitive, but the reasons are straightforward and related to the arguments advanced for government monopoly in car insurance. If it is assumed that there are a finite number of listings available to rental information agencies both public and private, then the creation of an additional agency means that the list possessed by any one agency will be smaller as a new firm enters; this mechanism for increasing search times as the

vacancy rate rises tends to be obscured by the increase in search times due to the unavailability of suitable vacancies (low vacancy rates). The inclusion of public agencies which will be used prior to private agencies implies that the time required to search the information possessed by agencies in general increases as the vacancy rate declines.

(b) Government Monopoly in Information: This policy is very simply illustrated. The supply of information to the market is now derivative form only one source - government registries. There are two forms of the policy. Version one assumes that all rentals must be registered with the central agency and other sources of information are eliminated, while Version two permits other forms of information dissemination except for private rental information agencies. In the first case the model resembles the simple demand model if there is no direct charge for the use of the government agency. In this case the problems of horizontal equity are important. In the second case the government becomes a monopoly broker and the entry exit model is constrained to one broker. The results are presented in Table 19 for Month 6.

Table 19

Government Monopoly and Search Costs

Vacancy Rate	Version 1	Version 2
	2.56*	2.79
6.0	5.01**	5.96
	1 ***	1
	2.81	2.87
5.0	6.03	61.0
	1	1
	3.09	3.24
4.0	6.66	7.34
	1	1
	4.66	4.89
3.0	8.27	9.58
	1	1
	5.62	5.94
2.0	10.24	12.48
	1	1
	6.25	6.54
1.0	10.69	16.25
	1	1

* Average Time Costs
** Average Money Costs
*** Number of Brokers
Number of Searchers for each run = 1000

Summary of Policy Tests

These policies can be summarized (except for legal sanctions) on graphs. This is done for search times in Figure 18. Within the framework of this model it is apparent that nationalization with complete subsidy to the searcher most reduces the costs of tenants in searching for accommodation. It was pointed out at the beginning of this chapter that this model cannot account for the direct costs of providing that service. Furthermore there are important problems of horizontal equity

in that homeowners and non-searching tenants are required to pay for such services even though they do not consume them. This burden will vary depending upon the type of financing. If general income taxes are used, then the burden is distributed over tenants and homeowners. If financing for such agencies is by municipal levels of government, the financing of such agencies comes largely from property taxes. In this case homeowners bear a considerable, although certainly not the total, burden of the service. The exact calculation of the direct costs of such services requires an involved process, the costs of which probably outweigh the benefits. Since the direct costs of price regulation are much smaller in comparison, it is between the free market and the policies suggested in 2 (regulation) that a choice ought to be made. Some qualifications are needed.

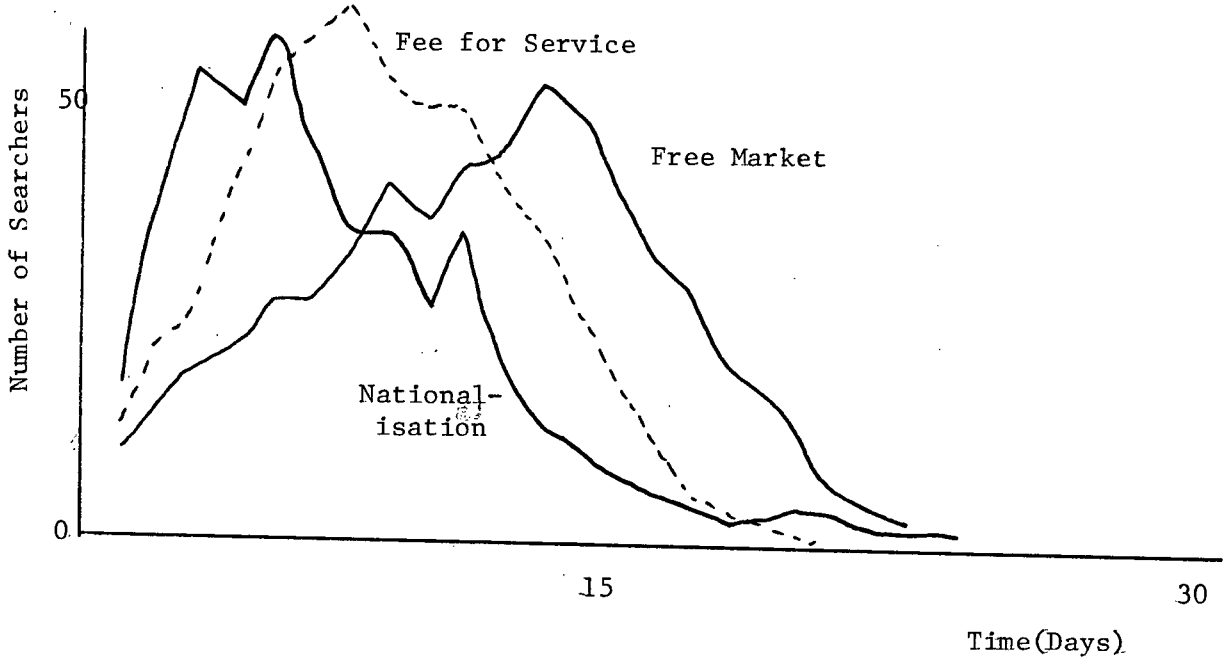


Figure 18

The Effects of Policies On
Search Times

First, it is clear that regulating the fee charged by brokers affects the money costs, and to a much lesser extent the time costs of search. Since this model does not examine the implications of rental information agencies that engage in deceptive information practices (advertising dwellings which are no longer vacant) simply because evidence of these practises is only heresay, a case for intervention must be constructed on the assumption that all listings are exclusive and valid.

Second, it should be apparent that the costs of obtaining information rise dramatically during periods of high excess demand (low vacancy rates) as documented in Chapter Three. Also, during these periods, firms specializing in the sale of information enter the market and sell information to consumers. It seems obvious that if these firms could place everyone who signed a contract, then it would make little difference whether the fee was assigned prior to placement or subsequent to placement. Of course there are higher collection costs and inefficient firms would be eliminated, but there is a well established legal apparatus for securing small debts; a series of well publicized legal decisions relating to the failure of tenants to pay these information fees would no doubt have a profound effect upon tenants who seek to avoid the brokerage charges. A priori, the objections of the industry to fee for service legislation merely raises doubts about whether these firms offer listings which are exclusive and up-to-date.

Finally, the direct costs of such fee for service legislation (or the registration fee plus fee for service proposal) are relatively

small. Certainly this is true in comparison to government housing agencies. Coupled with the observation that truly efficient firms which offer valid and economically useful information would be relatively unaffected by this legislation, there seems to be a clear case for such consumer protection.

An objection to this intervention can be advanced on the general grounds that modern mixed market economies already suffer too much intervention and government control. Recent submissions of the various inquiries into inflation in the United States appear to condemn government intervention and regulation as an important source of inefficiency. Some economists allege that were this regulation eliminated, substantial increases in growth and employment could be realized. Unfortunately the estimates of such increased growth tend to suffer from the same degree of unspecificity as do my estimates of the net benefit of intervention; as do the estimates of the benefits obtained by consumer protection in general and indeed as do the studies that attempt to measure the costs of monopoly. The problem is inherently political in nature and we are forced to return to the quotation from Buchanan.

In summary, it seems clear both from the model, and the statistical evidence presented in Chapter Two that the government will find itself induced to strengthen the market for information in some product markets. This essay has attempted to establish the rules under which this intervention should occur. As in the case of antitrust regulations, the intervention by the government proceeded by some thirty years the economic justification supplied by economists. In the same way, governments are

proceeding to supply information in a wide variety of product and factor markets to reduce the degree of market imperfection. This policy discussion is explorative and incomplete. The main purpose was to establish a framework for discussing the problem of public intervention into the production of market information.

Extensions and Further Research

There are several areas in which the model may usefully be extended. First, there are extensions to the error-learning framework. Throughout the essay I have balked at creating a more complicated model and deferred such embellishments for further efforts. There is obviously a relationship between the rate of error-learning and the benefits obtained from government action. The recognition, on the part of consumers, that caveat emptor may be a useful tool to use in the purchase of information, may reduce the scope for government action. In other words the rate of error-learning may directly affect the benefits of various government policies; i.e., increases in the rate of learning will probably result in greater search cost savings.

The actual error-learning process could be made more interesting by incorporating some explicit socio-economic variable in the rate of learning. For example, it seems intuitive that risk taking plays an important role in the rate of adjustment to uncertainty. If so, then these variables should be included in further extensions of the model.

Related to the above point is the more abstract problem of oversearch and undersearch. Ignorance of the underlying distribution of prices and quality attributes may well induce the consumer to

undersearch. Therefore it is possible for firms who charge greater than marginal cost to survive simply because of consumer ignorance combined with costly search. In this case increased information, provided either by the public or private sector, could decrease the patronage of inefficient firms or firms that are earning greater than normal profits. In the event that firms in a particular industry have different cost curves, increased information will tend to reduce the number of firms. It is even possible that perfect information may indeed lead to the lowest price paid by the consumer, but that only one firm would be able to survive. In this extreme event it is possible for the private sector and even firms whose prime business is not the marketing of information to engage in deliberate mis-information, which may create the need for government action. The model, by increasing the sophisitication of the brokerage submodel to include the choice of broker on price and advertising grounds, could shed some important insights in this area.

Finally, and most significantly, the model should be extended into the fee simple market. Numerically, rental brokers are dealing with an increasing volume of business, however in terms of financial transfers, it is apparent that the fee simple brokerage industry still commands the largest share of housing brokerage business. For example, rental information agencies in B.C. had a gross income of approximately $1,000,000 for the year of 1974, however in terms of commissions alone the fee simple brokerage industry accounted for $90,000,000. Combined with their other charges the real estate

industry in British Columbia is easily a billion dollar activity. The extension of the model into the fee simple domain is reasonably straightforward. The fee simple broker, in addition to furnishing information, provides financial, legal and other market assistance. These would have to be acknowledged in the construction of the model. In addition the actual firm structure is no longer simple. Real estate brokerage firms range from simple one or two person operations, which sell life and car insurance in addition to houses, all the way to extremely large and diversified corporations which engage brokerage service, and construction, mortgage financing etc., etc. Separating the function of the modern real estate corporation is not a trivial task.

FOOTNOTES - CHAPTER FOUR

1. Buchanan (1968), p.5.

2. The basis for Cost-Benefit analysis is the Kaldor-Hicks criterion which affirms that a polciy is beneficial in the event that those who gain could theoretically compensate those who lose. Scitovsky pointed out that this could lead to a paradoxical situation where a policy and its repeal might simultaneously be viewed as socially desirable.

3. At this time many states including Delaware, Hawaii, Colorado and Washington have passed legislation of this variety.

4. An alternate fee for service structure might be a daily charge.

5. Here the free service results in the agency being consulted at the outset, before any type of broker or information source is utilized.

Appendix One
Mathematical Notes

This appendix supplies some additional mathematical details to certain propositions that appear in the text. The notes are presented by chapter and the reader should have little difficulty in relating them to the main body of the essay.

Chapter One

An important part of this chapter deals with the shifting and incidence of the brokerage charges which was asserted to depend upon the amount of market services desired by buyers and sellers and the slopes of the demand and supply curves. This is now demonstrated more rigorously.

Figure 19 is repeated from Chapter One. Assume that the demand and supply relations can be represented by the following equations,

$$S' = c + dp$$
$$S'' = c_m + dp$$
$$D' = a - bp$$
$$D'' = a_m - bp$$

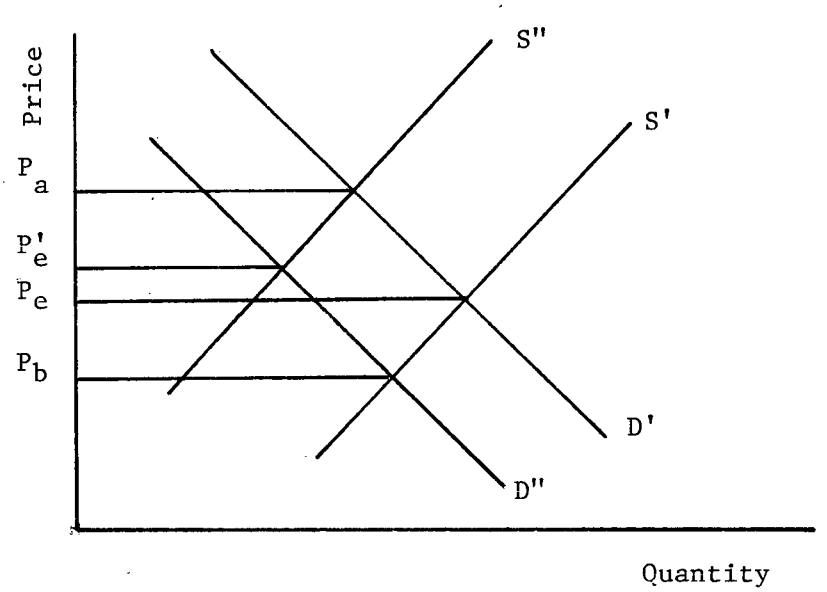


Figure 19

From these equations it is possible to calculate the value of P_a, P'_e, P_e and P_b.

P_a is calculated at the intersection of D' and S". This results in

$$a - bp = c_m + dp$$

$$P_a = \frac{a - c_m}{b + d} \tag{30a}$$

P'_e is calculated at the intersection of D" and S" which results in

$$P'_e = \frac{a_m - c_m}{b + d} \tag{30b}$$

In the same way $P_b = (a_m - c)/(b + d)$ and $P_e = (a - c)/(b + d)$. The shift of brokerage charges to the buyers was shown to be either $P_a - P'_e$ or $P_a - P_e$ depending on which equilibrium price (after or before markets services have been rendered) was taken to be relevant. If P'_e is the relevant benchmark, then the shift to buyers is

$$P_a - P'_e = (a-c_m)/(b+d) - (a_m-c_m)/(b+d)$$

$$= (a-a_m)/(b+d) \tag{31}$$

The shift to sellers is $P'_e - P_b$ and is

$$= (c-c_m)/(b+d) \tag{32}$$

Thus the shifting of brokerage charges depends directly upon the degree of market services demanded by either the buyer or seller, $a-a_m$ and $c-c_m$, respectively, and inversely upon the slopes of the demand and supply curves (b and d). It is interesting to note that the incidence of brokerage charges borne by the seller is dependent upon the slope of the supply curve, as is the incidence of market charges borne by the seller dependent upon the slope of the demand curve. If care is taken in their interpretation, these slopes can be viewed as crude

measrues of elasticity.

Chapter Two

The proofs required for this chapter deal with the basic theorems in the theory of search presented by Stigler (1961). The first deals with the expected minimum value of a set pf prices after a certain specified number off searches. The other proof follows directly from this theorem.

Theorem Given that the set of prices can be presented by a strictly positive set of numbers x_i (i=1,k) with a probability density function f(x), then the expected minimum price after n draws (units of search) is given by the formula,

$$m_n = \int_0^\infty (1-F(x))^n dx \tag{33}$$

where F(x) is the cumulative frequency function of the prices.

Proof The proof is in two stages.

I; By the definition of a cumulative frequency function

$$F(x) = P(X \leq x). \tag{34}$$

Assuming that the prices are independent let M be the minimum price after n draws, or

$$M = \min(X_1, X_2, \ldots\ldots, X_n).$$

Since the X_i are independent,

$$P(M \geq x) = P(X_1 \geq x) \cdot P(X_2 \geq x) \cdot, \ldots\ldots, P(X_n \geq x)$$

$$= (1-F(x))^n$$

$$P(M \leq x) - 1-(1-F(x))^n \tag{35}$$

II; For any strictly positive random variable x, the expected

value is defined by the expression,

$$E(X) = \int_0^\infty xf(x)dx \tag{36}$$

We proceed by integrating by parts. Let u = x, v = 1-F(x) and dv = d/dx(1-F(x)) = -f(x)dx

$$E(X) = -\int_0^\infty x(-f(x))dx$$

$$= -\int_0^\infty udv$$

$$E(X) = -uv\Big|_0^\infty - \int_0^\infty vdu$$

$$= -x(1-F(x))\Big|_0^\infty + \int_0^\infty 1-F(x)dx \tag{37}$$

The first term of this expression vanishes when evaluated for both zero and infinity and we are left with,

$$E(x) = \int_0^\infty 1-F(x)dx$$

The expected value of M defined in part I above is then simply substituted into the above expression to obtain

$$E(M) = \int_0^\infty 1-(1-(1-F(x))^n)dx$$

$$= \int_0^\infty (1-F(x))^n dx \tag{38}$$

which is the desired result. This expression obviously deminishes for increasing values of n.

The second expression used in the chapter involves the expected gain from an additional unit of search. This is the difference between the $n^{th.}$ and the $n^{th.}+1$ search or,

$$M_{pn} = m_n - m_{n+1} = \int_0^\infty (1-F(x))^n F(x)dx \tag{39}$$

Proof;

$$m_n - m_{n+1} = \int_0^\infty (1-F(x))^n dx - \int_0^\infty (1-F(x))^{n+1} dx$$

$$= \int_0^\infty (1-F(x))^n dx - \int_0^\infty (1-(F(x))\ (1-F(x))^n dx$$

$$= \int_0^\infty (1-F(x))^n dx - \int_0^\infty (1-F(x))^n dx + \int_0^\infty (1-F(x))^n F(x) dx$$

$$= \int_0^\infty (1-F(x))^n F(x) dx$$

The function M_{pn} is graphed in figure 3 of Chapter Two. The conditions of concavity that are shown, requires that the first derivative of egn. 39 be greater than zero and the second derivative be less than zero. Obviously these conditions depend critically upon the form of the distribution of random variables. Developing the precise form of the first and second order conditions for M_{pn} is not a trivial task and is left for the time being.

Chapter Four

Given that there are $S_i (i = 1, 2, \ldots n)$ sellers and $B_j (j = 1, 2, \ldots m)$ buyers with messages costs of 'a' between any buyer and seller, if brokers enter with message costs of 'b' between a broker and either a buyer or seller, then the average message costs of the system with brokerage is given by

$$AC = \begin{cases} (n+1)(a+b) & ; \text{ N odd} \\ 2(N+1)(b+b)/N & ; \text{ N even} \end{cases} \qquad (40)$$

where N is the number of sellers.

Proof;

Assuming that the broker charges the recipient 'b' per message and assuming that the cost of sending a message to the broker remains at 'a', then for m buyers, n sellers and one broker the total costs of sending a message are

$$TC = (a+b)(m+n) \qquad (41)$$

and average costs Ac = (a+b)(m+n+N) where N is the number of brokers. If another broker enters and divides the market (messages sent to buyers and sellers) with the existing broker and assuming that the buyers and sellers are ignorant of exactly how this division is made, then all market participants will have to send and receive at least one message. But, there is a fifty-fifty chance that a buyer or a seller will fail to contact the desired party on the opposite side of the market and the message costs will need to be repeated. Denoting as V the average costs for one broker, the average costs now are,

$$AC = 3/2(V) \tag{42}$$

For, three brokers all participants will bear an initial round of message costs, two thirds will then repeat and out of that two thirds one third will need to send message to all three brokers. The average costs are given by,

$$AC = 2V. \tag{43}$$

This can be generalized into a series where the average costs are

$$AC = \begin{cases} N+1/N(V) & , \ N \text{ odd} \\ 2(+1)/N(V) & , \ N \text{ even} \end{cases} \tag{44}$$

Appendix Two

This appendix presents the micro flowchart of the complete market model (Figure 20). In addition a program listing is presented. The program takes approximately 10 seconds of CPU time to compile, and approximately 11 seconds to complete one trial of 1000 searchers. Undoubtedly to run this model for extended periods of time would entail considerable computing expense; most of the comuting cost is due to the many generations of random numbers (approximately 10,000) for an average. It should be pointed out that the listing is merely one version of several used in the various trials. Each policy and experiment required additional subprograms and statements. For this reason the listing may not "mesh" neatly with the flowchart.

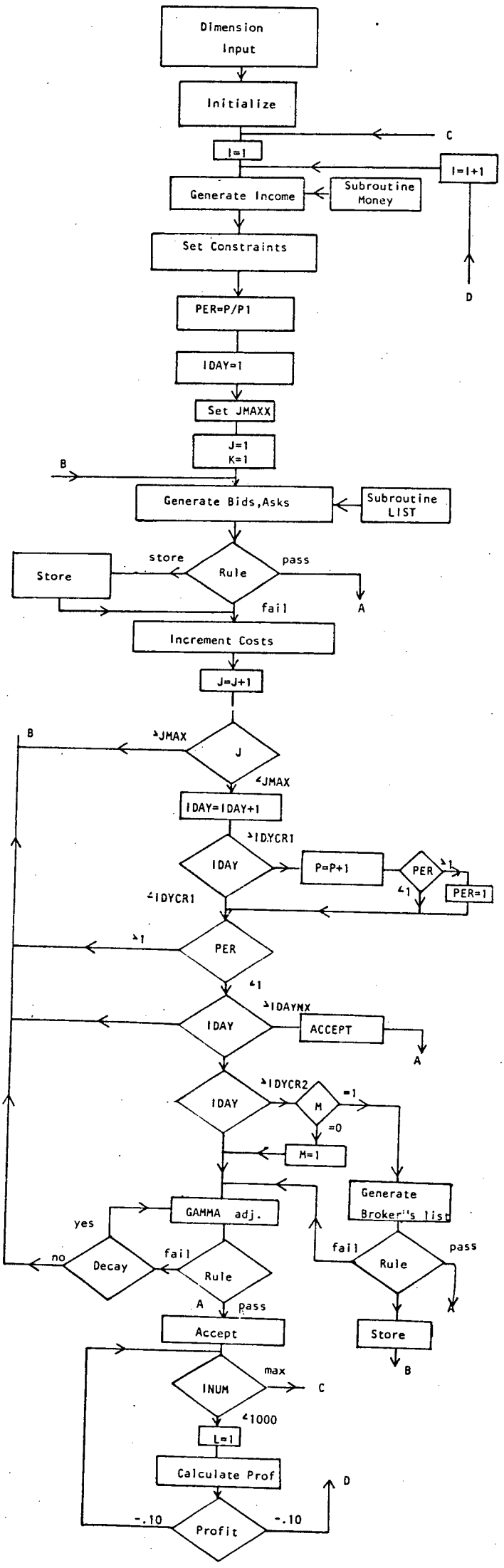


Figure 20

Micro Demand-Supply Flowchart

LISTING OF FILE FILE1 09:22 A.M. MAY 13, 1975 ID=H

```
      C A SIMULATION MODEL OF THE MARKET FOR INFORMATION
      C IN RENTAL HOUSING MARKETS
      C
      C THIS MODEL INCORPORATES A SUPPLY SECTION WITH
      C AND ENTRY AND EXIT MECHANSIM FOR RENTAL
      C INFORMATION AGENCIES AND A SUBROUTINE TO
      C SIMULATE THE SUPPLY OF CLASSIFIED AD
      C INFORMATION.THE DEMAND MODEL IS AN ERROR
      C LEARNING MODEL OF CONSUMER DEMAND FOR INFORMATION
      C
      C THIS LISTING DOES NOT INCLUDE THE POLICY TESTS
      C OR THE TESTS FOR REDUNDANCY.THESE ARE EXPLAINED
      C IN THE TEXT AND ARE STRAIGHTFORWARD EXTENSIONS
      C
            IMPLICIT REAL*4(A-H,O-Z)
            REAL *4 INCOME
            INTEGER TOTLIS
           DIMENSION RES(1000),COST(1000),TIME(1000),INCOME(1000)
          *,SURP(1000),BP(1000),CP(1000)
          *,BIDR(1000),ASKR(1000),SURPP(1000),GAM(1000)
          *,PP(1000),JJJ(1000),ISEAR(1000),JMAXX(35),PROFIT(20)
          *,RATRET(20),REVENU(20),TIME1(20)
          *,BPSTOR(1000),CPSTOR(1000),SRPSTO(1000)
      C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      C DIMENSIONS SET,VARIABLES TYPED
      C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
            COMMON INCOME,IDAYCR,RES,SURP,BP,JMAX,IDAY,COST,TIME,
           *COSTMX,TIMEMX,J,I,CP,CPMEAN,JMAXX,IDAYMX,ADJ,VACANT,TEST
          *,INUM,MONTH,TOTLIS,K,JMXTOT,LISBRO,BROTOT,FIXED1
          *,FIXED2,AGENT,TOTBRO,REVENU,PROFIT,RATRET
            COMMON BPSTOR,CPSTOR,JJ,PERSTO,SRPSTO
      C INUM SETS THE MAXIMUM NUMBER OF SEARCHERS
            DATA TIME1/20*0./
            TIME1(1)=1.
            VACTES=7.
      C THE MODEL BEGINS WITH MONTH SET TO 1
      C THE EXOGENOUS VARIABLE,VACANT, GOVERNS
      C,THE NUMBER OF SEARCHERS,AND THE NUMBER
      C OF LISTINGS THROUGH THE SUBROUTINES
      C CYCLE AND ENTRY1
            DO 500 MONTH=1,12
            VACANT=1.0
            WRITE(6,516) VACANT,MONTH
       516  FORMAT(' ','VACANCY RATE IS ',F5.3,' FOR THE MONTH ',I3)
            IUNIT=200
            INUM=1000
            IF(VACANT.LT.2.0) GO TO 2
            IF(VACANT.GT.7.0) GO TO 3
      C THE SHIFTING OF TRANSACTIONS CHARGES BY
      C BROKERS IS CALCULATED AS A FUNCTION OF
      C THE VACANCY RATE.FIXED1 IS THE CHARGE
      C BORNE BY CONSUMERS WHILE FIXED2 IS THE
      C CHARGE BORNE BY SUPPLIERS.FOR VACANCY RATES
      C IN EXCESS OF 7% THE CHARGE IS BORNE ENTIRELY
      C BY SUPPLIERS;FOR VACANCY RATES LESS THAN 2%
      C THE CHARGE IS BORNE ENTIRELY BY CONSUMERS.
            TOT1=INUM+IUNIT
            BETA1=20*IUNIT
```

```
      BETA2=20*INUM
      FIXED1=BETA1*VACANT
      FIXED2=BETA2/VACANT
      GO TO 1
    2 FIXED2=20.
      FIXED1=0.
      GO TO 1
    3 FIXED2=0.
      FIXED1=20.
    1 IDAYMX=30
C BEGIN TIME PERIODS
      BROTOT=0.
      PERSTO=(VACTES-VACANT)/VACANT
C THE SUBROUTINES CYCLE AND ENTRY ARE NOW
C CALLED TO GENERATE LISTINGS FOR CONSUMER
C 'I' ON DAY 'IDAY'.
   30 CALL CYCLE
C
C THE SEARCH PROCESS IN NOW COMMENCED
C
      DO 400 I=1,INUM
      BROKER=0.
C THE SUBROUTINE MONEY IS CALLED
C TO GENERATE AN ESTIMATE OF
C INCOME FOR SEARCHER 'I'
      CALL MONEY
      ALPHA3=.2*IUNIT
      ALPHA2=.1
      COSTES=.1*INCOME(I)
C THE PARAMETERS THAT GOVERN THE TIME
C AND MONEY CONSTRAINTS HAVE NOW BEEN
C BEEN SET.
      IDYCR1=(.1+.0000034)*INCOME(I)*IDAYMX
      IDYCR2=(.15+.000034)*INCOME(I)*IDAYMX
C THE RULE OF THUMB PARAMETER 'GAMMA' IS
C NOW INITIALIZED
      P=1.
      PMAX=5.
C JMAXX,P,PMAX GOVERN THE NUMBER OF HOUSES EXAMINED PER DAY
      COST(I)=0.
      TIME(I)=0.
      TEST=0.
C
      JJ=1
      IDAY=1
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C BEGIN SEARCH FOR SEARCHER I
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      PER=P/PMAX
   20 IF(IDAY.GT.20.AND.COST(I).GT.COSTES.AND.COST(I)
     *.GT.FIXED1.AND.BROKER.EQ.0.) GO TO 21
C DECISION RULE TO CONSULT BROKERS
      LISBRO=0
      GO TO 22
   21 CALL ENTRY1
      JMAX=PER*JMAXX(IDAY)
      JMAX=PER*JMAXX(IDAY)
      ITEST=JMAXX(IDAY)
```

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```
117             IF(JMAX.GT.ITEST) JMAX=ITEST
118             IF(TEST.GE.1.0) GO TO 410
119       22    TOTLIS=LISBRO+JMAX
120     C GENERATE LISTINGS FROM CLASSIFIEDS
121           DO 600 J=1,JMAX
122           CALL LIST
123     C THE SUBROUTINE LIST GENERATES VALUES OF BP(J),CP(J),SURP(J)
124     C BY RANDOM SAMPLING FROM A 0,1 UNIFORM DISTRIBUTION
125           IF(SURP(J)-BP(J)/GAMMA) 700,701,402
126     C IF THE DECISION RULE IS PASSED THE VACANCY IS ACCEPTED(GO TO 40
127      701  COST(I)=COST(I)+ALPHA2*COSTMX
128           BPSTOR(JJ)=BP(J)
129           CPSTOR(JJ)=CP(J)
130           SRPSTO(JJ)=BP(J)-CP(J)
131           JJ=JJ+1
132     C VACANCY IS STORED
133           GO TO 600
134      700  COST(I)=COST(I)+ALPHA2*COSTMX
135      600  CONTINUE
136            IF(P.GT.PMAX) P=PMAX
137           IDAY=IDAY+1
138           IF(IDAY.GT.IDAYMX) GO TO 100
139           IF(IDAY.LT.IDYCR1) GO TO 20
140           PER=(P+1)/PMAX
141     C SCOPE OF SEARCH WIDENED.FIRST TIME CONSTRAINT EXCEEDED
142           IF(IDAY.GT.IDYCR2) GAMMA=GAMMA+(1+PERSTO)/1.
143           GAMMA=GAMMA+.2
144           CALL STORE
145           DO 300 LL=1,KK
146           IF(SRPSTO(LL).GT.BPSTOR(LL)/GAMMA) GO TO 420
147      300  CONTINUE
148           GO TO 20
149      420  BP(J)=BPSTOR(LL)
150           CP(J)=CPSTOR(LL)
151           SURP(J)=SRPSTO(LL)
152           GO TO 402
153       100 SURPMX=0.
154           ITEST=JMAXX(IDAYMX)
155            DO 601 J=1,ITEST
156            CALL LIST
157           IF(SURP(J).GE.SURPMX) SURPMX=SURP(J)
158       601 CONTINUE
159     C THIS LOOP SEARCHES FOR THE BEST AVALIABLE HOUSES IF TIME COSTS
160     C EXCEED MAXIMUM TIME AVAILABLE
161     C VACANCY ACCEPTED,PROCESSED FOR STATISTICAL ANALYSIS
162      402  BIDR(I)=BP(J)
163           ASKR(I)=CP(J)
164           SURPP(I)=SURP(J)
165           GAM(I)=GAMMA
166           PP(I)=P
167           ISEAR(I)=IDAY
168           JJJ(I)=JMAX
169           GO TO 400
170      403 BIDR(I)=BP(J)
171             ASKR(I)=CP(J)
172             SURPP(I)=SURP(J)
173             ISEAR(I)=IDAY
174             GO TO 400
```

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```
      410      MANTOT=MANTOT+1
      413      DO 411 J=1,20
               CALL LIST
               IF(SURP(J).GT.BP(J)/2.) GO TO 412
      411      CONTINUE
               GO TO 413
      412     BIDR(I)=BP(J)
              ASKR(I)=CP(J)
              SURPP(I)=SURP(J)
              COST(I)=0.
              ISEAR(I)=0
      400     CONTINUE
    C THIS SECTION COMPUTES STATISTICAL
    C SUMMARIES OF THE SEARCH COSTS(TIME AND MONEY)
    C FOR THE SET OF SEARCHERS REPRESENTED BY INUM
              TOT1=0.
              TOT2=0.
              TOT3=0.
              TOT4=0.
              TOT5=0.
              TOT6=0.
              DO 404 I=1,INUM
              TOT1=BIDR(I)+TOT1
              TOT2=ASKR(I)+TOT2
              TOT3=SURPP(I)+TOT3
              TOT5=ISEAR(I)+TOT5
      404     TOT6=COST(I)+TOT6
              AVGCST=TOT6/INUM
              AVGSEA=TOT5/INUM
              AVGREN=TOT1/INUM
              AVGSUR=TOT3/INUM
              WRITE(6,45)  AVGCST,AVGSEA,AVGREN,AVGSUR,MANTOT,BROTOT
      45      FORMAT(' ',4F12.2,I6,F7.0)
    C THE TIME AND MONEY COSTS FOR INUM SEARCHERS HAS NOW BEEN
    C AGGREGATED AND PRINTED OUT
            WRITE(6,501) MONTH
       501  FORMAT(' ','MONTH',I4)
          JMXTOT=0
            DO 502 IDAY=1,IDAYMX
            JMXTOT=JMXTOT+JMAXX(IDAY)
       502  CONTINUE
            TOTLIS=JMXTOT+LISBRO
           WRITE(6,505) TOTLIS,LISBRO,JMXTOT
      505   FORMAT(' ','TOTAL LISTINGS',3I10)
           WRITE(6,510) AGENT,MONTH
      510  FORMAT(' ',F6.0,'AGENTS IN MONTH',I3)
            IF(AGENT.LE.0.) GO TO 500
            DO 511 I=1,K
      511   WRITE(6,512) I,PROFIT(I),RATRET(I),REVENU(I)
       512   FORMAT(' ','BROKER',I3,' HAS PROFIT',F12.2,' RETURN',F6.4
          *' REVENUE',F12.2)
       500   CONTINUE
             STOP
             END
            SUBROUTINE LIST
    C THIS SUBROUTINE GENERATES VALUES OF
    C BP(J) AND CP(J) BY RANDOM SAMPLING
    C FROM A UNIFORM DISTRIBUTION.
```

```
233              IMPLICIT REAL*4 (A-H,O-Z)
234              REAL *4 INCOME,MAXY,MAXTIM
235              DIMENSION RES(1000),COST(1000),TIME(1000),INCOME(1000)
236             *,SURP(1000),BP(1000),CP(1000)
237               COMMON INCOME,IDAYCR,RES,SURP,BP,JMAX,IDAY,COST,TIME,
238             *COSTMX,TIMEMX,J,I
239          4      S=SCLOCK(0.0)
240               X=RAND(S)
241               BP(J)=FRAND(0.0)*500.
242               IF(BP(J).GT.INCOME(I)*.2) GO TO 4
243               CP(J)=FRAND(0.0)*500.
244               SURP(J)=BP(J)-CP(J)
245               IF(SURP(J).GT.BP(J)) GO TO 4
246               RETURN
247               END
248                SUBROUTINE MONEY
249        C THIS SUBROUTINE USSES A LOGNORMAL RANDOM NUMBER GENERATOR
250        C TO GENERATE VALUES OF INCOME(I)
251                 IMPLICIT REAL*4 (A-H,O-Z)
252                 REAL *4 INCOME,MAXY,MAXTIM
253                 DIMENSION RES(1000),COST(1000),TIME(1000),INCOME(1000)
254               *,SURP(1000),BP(1000),CP(1000)
255                 COMMON INCOME,IDAYCR,RES,SURP,BP,JMAX,IDAY,COST,TIME,
256               *COSTMX,TIMEMX,J,I,CP,CPMEAN
257                 FM=.6
258                 STD=2.0
259                 S=SCLOCK(0.0)
260                 X=RANDL(S,FM,STD)
261           1       INCOME(I)=FRANDL(0.0)*10000.
262                 IF(INCOME(I).GT.30000.) GO TO 1
263                 IF(INCOME(I).LT.2000.) GO TO 1
264                 RETURN
265                 END
266                 SUBROUTINE CYCLE
267                  IMPLICIT REAL*4 (A-H,O-Z)
268                  REAL *4 INCOME
269                  DIMENSION RES(1000),COST(1000),TIME(1000),INCOME(1000)
270               *,SURP(1000),BP(1000),CP(1000)
271               *,BIDR(1000),ASKR(1000),SURPP(1000),GAM(1000)
272               *,PP(1000),JJJ(1000),ISEAR(1000),JMAXX(35)
273                 COMMON INCOME,IDAYCR,RES,SURP,BP,JMAX,IDAY,COST,TIME,
274               *COSTMX,TIMEMX,J,I,CP,CPMEAN,JMAXX,IDAYMX,ADJ,VACANT
275                 IZETA=7
276                 L=1
277                  M=7
278          2       DO 1 IDAY=L,M
279           1     JMAXX(IDAY)=ADJ*VACANT
280                 JMAXX(IZETA)=0
281                 IBETA=IZETA-1
282                 IBETA1=IBETA-1
283                  JMAXX(IBETA)=JMAXX(IBETA)+5
284                  JMAXX(IBETA1)=JMAXX(IBETA1)+5
285                    IZETA=IZETA+7
286                    L=M+1
287                    M=M+7
288                    IF(M.GT.35) GO TO 3
289                    GO TO 2
290          3     RETURN
```

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```
      END
      SUBROUTINE ENTRY1
        IMPLICIT REAL*4 (A-H,O-Z)
        REAL *4 INCOME
        DIMENSION RES(1000),COST(1000),TIME(1000),INCOME(1000)
     *,SURP(1000),BP(1000),CP(1000)
     *,BIDR(1000),ASKR(1000),SURPP(1000),GAM(1000)
     *,PP(1000),JJJ(1000),ISEAR(1000),JMAXX(35),PROFIT(20)
     *,RATRET(20),REVENU(20),TIME1(20)
     *,ALIST(20),BLIST(20),PERTIM(20)
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C DIMENSIONS SET,VARIABLES TYPED
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      COMMON INCOME,IDAYCR,RES,SURP,BP,JMAX,IDAY,COST,TIME,
     *COSTMX,TIMEMX,J,I,CP,CPMEAN,JMAXX,IDAYMX,ADJ,VACANT,TEST
     *,INUM,MONTH,TOTLIS,K,JMXTOT,LISBRO,BROTOT,FIXED1
     *,FIXED2,AGENT,TOTBRO,REVENU,PROFIT,RATRET,TIME1
      LISBRO=.2*IUNIT
      DO 22 K=1,20
 22     TIME1(K)=0.
      TIME1(1)=1.0
      DO 20 MONTH=1,12
      IF(MONTH.EQ.2.AND.RATRET(1).GT..10) TIME1(2)=1.0
      TOTIM=0.
      DO 6 K=1,MONTH
 6    TOTIM=TOTIM+TIME1(K)
      DO 7 K=1,MONTH
 7    PERTIM(K)=TIME1(K)/TOTIM
      A=10.
      C=.01
      B=.01
      DO 2 K=1,MONTH
      ALIST(K)=PERTIM(K)*LISBRO
      BLIST(K)=PERTIM(K)*BROTOT
      REVENU(K)=FIXED1*ALIST(K)+FIXED2*BLIST(K)
      COSTS=A+B*(ALIST(K)*ALIST(K))+C*(BLIST(K)*BLIST(K))
      PROFIT(K)=REVENU(K)-COSTS
      RATRET(K)=PROFIT(K)/COSTS
 2    CONTINUE
 4    DO 8 K=1,MONTH
 8    WRITE(6,9) K,REVENU(K),PROFIT(K),RATRET(K),TIME1(K)
     *,ALIST(K),BLIST(K),LISBRO,BROTOT,PERTIM(K)
 9    FORMAT(' ',I3,' BROKER ',6F8.2,I6,2F8.2)
      DO 19 K=1,MONTH
      TIME1(K)=MONTH-K+1
      WRITE(6,17)K,TIME1(K),MONTH
 17     FORMAT(' ',I3,'MONTH',F8.2,'TIME',I4)
 19   CONTINUE
 20   CONTINUE
      IF(RATRET(K).GT..10) TOTBRO=TOTBRO+1.
      RETURN
      END
        SUBROUTINE STORE
        COMMON BPSTOR,CPSTOR,JJ,PERSTO,SRPSTO
       DIMENSION BPSTOR(1000),CPSTOR(1000),SRPSTO(1000)
      KK=PERSTO
        RETURN
        END
```

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