

Computer Assisted Rating Valuation of Commercial and Industrial Properties in Malaysia : Developing an Expert System from a Multiple Experts Knowledge Elicitation Methodology

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Abstract

The feasibility of developing an expert system in the valuation of commercial and industrial properties for rating purposes in Malaysia from several experts was investigated by empirical research. Knowledge was elicited mainly from these experts using various techniques: separate interviews, group interviews and observation. The main source of knowledge came from several core valuers who acted as a panel to provide core domain knowledge. The knowledge was then augmented by knowledge from complementary valuers: seven local authorities' valuers; a private valuer and an academic to contribute local contextual knowledge, market knowledge and legal knowledge respectively. Supporting specialists provided building technology knowledge, spatial knowledge and macro-economic knowledge. The opinions of tenants were also elicited. Secondary sources of knowledge were provided by supporting staff from the local authorities, observation of documents and objection hearings. A simple regression analysis to find the weightings of the main factors was also incorporated in the knowledge-base for the purpose of complementing the heuristic approach and as a possible comparison with that approach. The knowledge-base was analysed and represented in a prototype consisting of four modules: purpose-built office complex, shopping complex, shophouse/flat/office and factory. The prototype was evaluated through valuers commenting upon the knowledge-base contained in the prototype and by a comparison of actual valuation against the prototype's predictions.

Keywords : expert system, rating, knowledge elicitation process, multiple expert

Aim of the Research

The main aim of the research was to investigate the use of knowledge from a number of experts in developing an expert system for rating valuation of commercial and industrial properties in Malaysia.

This paper reviews:

- (1) the background to the research
- (2) the process of eliciting the knowledge
- (3) the knowledge that has been elicited
- (4) a description of the prototype (i.e. the system that represents the knowledge) and its evaluation and

- (5) the conclusions drawn from the research.

Background

Regular revaluations have always been difficult for local authorities in Malaysia (Nahappan, 1968; Manuel, 1986; Hizam, *et al*, 1990). Whilst political pressures may sometimes be contributory to revaluation delays (Othman, 1986), shortage of qualified personnel is significant. Expert systems which were being marketed as a means of “deskilling” areas where “experts” were in short supply (Jenkins, 1992, p.2) was considered to be an appropriate information technology strategy to alleviate the problem.

Expert System

An expert system can be defined as “a computer system which contains knowledge pertaining to an area of human specialisation. The system can also implement that knowledge in such a fashion as to be able to act as a consultant expert in that field of specialisation. Such a system typically requires the user to provide answers to relevant questions in order to supply advice based on those responses. In addition the system is able to justify or explain the reasoning behind a course of action it recommends, in order to defend its deduced solution”. (Scott, 1988, p.27).

The development of an expert system is thus centred on the elicitation of the knowledge from an expert or experts, and representation and validation of that knowledge in a computer program.

Nature of Properties in the Research

The scope of properties in the research includes purpose-built office complexes (of more than 5 storeys), shopping complexes, shophouse/office/flat and industrial

properties. The wide spectrum of commercial and industrial properties was purposely selected rather than the more traditional approach by previous researchers to concentrate on just one particular type of property (Scott, *op.cit* p.18; Jenkins, *op.cit* p.1). This is unique to this current research involving the investigation into the possible variability of knowledge used within the same generic class of property and between different types of properties.

The Core Principle of Rating Valuation in Malaysia - Annual Value

The concept of *annual value* forms the basis for rating assessment in Malaysia (except for the Johor state which uses the “improvement value” i.e. capital value) (Hizam, 1991, p.46). The concept envisages a hypothetical tenancy leading to a hypothetical rent fixed by a hypothetical owner and a hypothetical tenant which in itself is guided by legal principles in the English rating law such as *rebus sic stantibus* and tenancy from year to year.

Annual value can be interpreted from Section 2 of the Local Government Act, 1976 as the *estimated gross annual rent at which the holding might reasonably be expected to let from year to year having no regard to any restrictions or control on rent and also disregarding enhanced rent resulting from use of machinery for certain purposes*.

The knowledge to be elicited from the experts in this research thus is all sub-sets of knowledge related to the process of estimation of the gross annual rent. This involves using the comparative method of valuation, i.e. a method of formulation of opinion of value (in this case rental value) at a particular date (date of revaluation or date of tone of the list) based on comparison of market rentals and characteristics of the subject property and other comparable properties (Mahadi, 1988).

The Knowledge Elicitation Process

The targeted experts

The research commenced with knowledge elicitation from valuers from the City Hall of Kuala Lumpur, the City Hall being the main collaborating local authority in this project. Due to the large number and complex nature of commercial *holdings*¹ in Kuala Lumpur and the range of experience of the valuers in valuing these properties, it was decided that the main source of knowledge of *core valuers* would come from City Hall.

Their knowledge would be complemented by the knowledge of other local authority valuers to bridge the gap of contextual knowledge from valuers having experience of other geographical and market conditions, e.g. the effects of the siting of a shophouse on its rental in towns which mainly consisted of such properties.

Within the valuation, an element of forecasting is necessary, especially when there was a significant gap between rental evidence dates and the date of valuation. Market knowledge of private valuers, who are generally more in touch with the market, could provide assistance to the valuers in making the forecast and so private valuers would form a distinct group within the knowledge elicitation process.

The legal knowledge of the rating valuers was mainly embodied in their working practice in terms of selecting suitable rental evidence and the application of the concept of *rebus sic stantibus*. An academician was included in the knowledge elicitation strategy to bridge any possible gap in the legal knowledge.

Other local authority valuers, private sector valuers and academicians are referred to as “complementary valuers” in this research.

For the purpose-built office complexes and shopping complexes, it was found that certain gaps in the knowledge of the core valuers existed in making objective comparisons on factors related to building characteristics and in the case of shopping complexes, the status and tenant mix. Throughout the knowledge elicitation with the valuers, a more detailed means of comparison would be useful to supplement the broad heuristics in making comparisons and adjustments.

For these reasons the elicitation process was further broadened to encompass supporting specialists, property managers, building related experts, a transport expert and an economic planning officer.

The general framework of the multiple experts knowledge elicitation approach adopted is illustrated in Figure 1.

Although for the majority of the work the knowledge of experts was elicited, the research had also sought to complement the whole knowledge by obtaining opinions from “non-experts” i.e. tenants.

Methodology

Within the methodology defined here, the function of the core valuers is to act as the central knowledge source as well as to act as the main “panel” to comment on the knowledge coming from the other sources.

The knowledge elicitation from the complementary valuers and supporting specialists was undertaken separately but iteratively with the knowledge elicitation from the core valuers.

Essentially, the process involved selection of experts, identification of other knowledge sources and examining the knowledge using a variety of knowledge elicitation and knowledge analysis techniques.

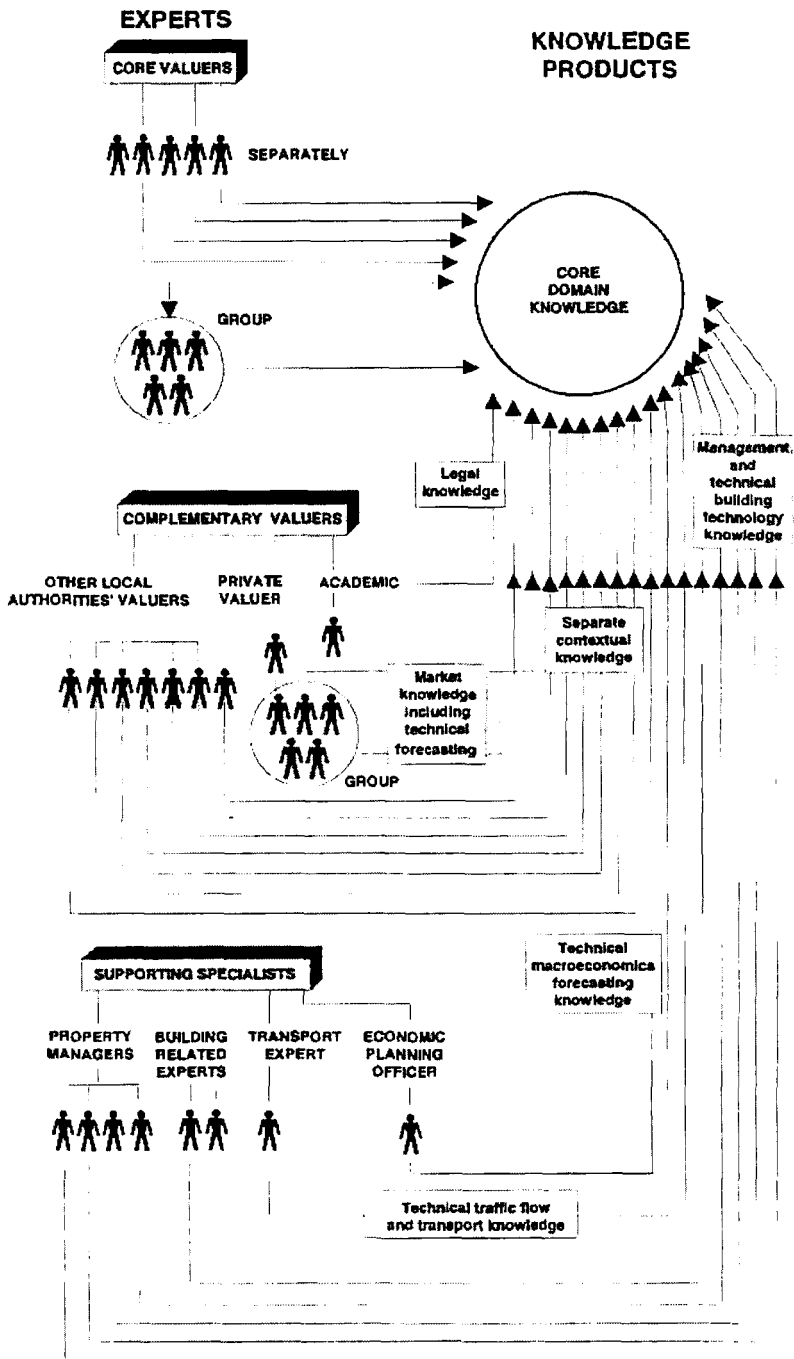


Figure 1: General Framework of The Multiple Expert Knowledge Elicitation Approach

Selection of experts

The criteria in the selection process was mainly divided into first, selection of the organizations from which the experts should come and second, selection of the individual experts themselves.

a. Selection of organizations

This was mainly applicable in selecting the local authority valuers. The criteria applied was a significant number of commercial and industrial properties in

the local authorities to provide the basis for the experience of the valuers. The six local authorities selected were Seremban Municipal Authority, Petaling Jaya Municipal Authority, Klang Municipal Authority, Shah Alam Municipal Authority, Ipoh City Hall and Seberang Perai Municipal Authority (shown in Figure 2).

Factors such as geographical dispersion (Medsker, *et al*, 1994) and the consequent travelling time from the research base to the local authorities and uniqueness of

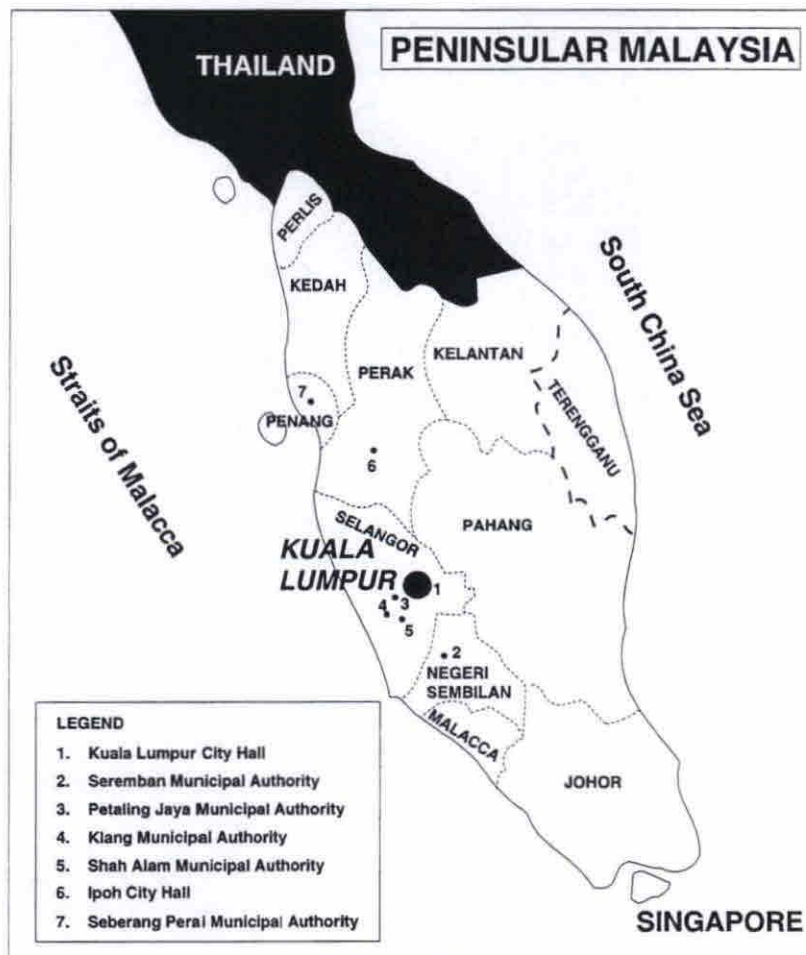


Figure 2: Location of The Local Authorities Selected in The Research

valuation practices (e.g. valuation of plant and machinery) were also relevant selection criteria.

b. Selection of individual experts

The common criteria for selecting the individual experts were academic background and experience in their respective fields (McGraw and Harbisson Briggs, 1989, pp. 97-98).

The group of multiple experts chosen consists of:

- (1) five core valuers;
- (2) nine complementary valuers namely seven local authority valuers (i.e. a valuer from each of the six local authorities and an ex-valuer from the Ipoh City Hall who had wide and long experience in rating valuation), an academic and a private valuer and
- (3) eight supporting specialists namely four property managers, two building related experts, a transport expert and an economic planning expert.

Other knowledge sources

The secondary source served as a form of triangulation (to complement the knowledge from the primary source). This comprised mainly relevant valuation documents, objection hearings, site visits and assistant valuation officers and technicians.

Knowledge elicitation approach

Three configurations were observed: using experts individually, using primary and secondary experts, and using experts in small groups (Medsker, *et al*, op. cit). Using experts individually and as primary and secondary experts eliminate problems of managing groups but may not have the advantages of group interaction such as "rich idea generation."

The research had adopted a combination of the three approaches to reconcile the advantages and disadvantages of each approach.

Individual consultations were adopted for each of the core valuers, complementary valuers and the supporting specialists. The core valuers were consulted individually to allow detailed investigation into possible individual differences of valuation approach between the valuers. The other experts were also consulted individually due to the specialised nature of their knowledge (Chung and Ng, 1989) e.g. building technology and management knowledge.

In addition, the core valuers were also referred to as a group to study the extent to which the differences of approach could be reconciled in a group in the form of a consensus. Where there were differences in approach, the knowledge engineer had the opportunity to accommodate the alternative multiple lines of reasoning based on the separate individual consultations with the respective valuers.

Knowledge elicitation techniques

Traditional active knowledge elicitation techniques (Scott, op.cit p.97) were adopted, namely interviews and observation for both individual and group consultations with the experts. Observations were also made to the secondary knowledge sources. Simulations (Crofts, 1987, p.38) of core valuers' work on actual data were also undertaken individually and discussed in a group.

Knowledge analysis techniques

The data and knowledge were continuously coded into the themes that emerged. For example, in the case of the core valuers, procedural aspects of the valuation process, e.g. selection of comparables, rental analysis,

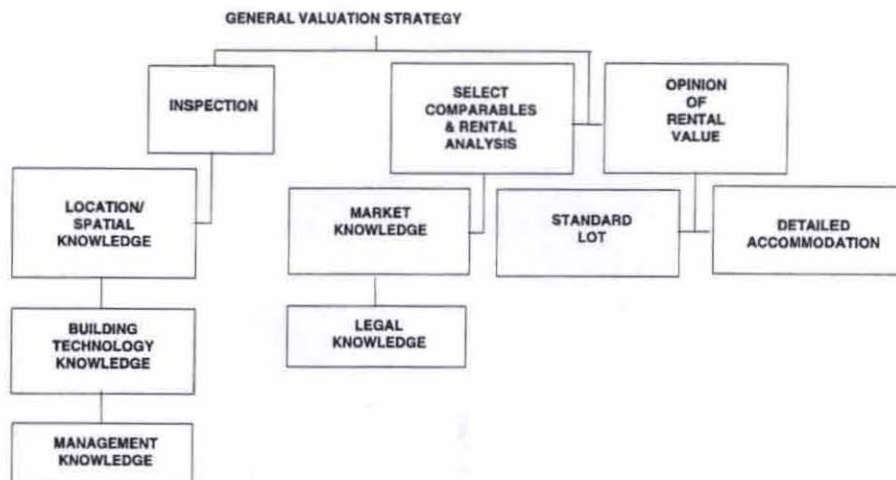


Figure 3: General Valuation Strategy of Core Valuers

inspection/referencing and the formulation of opinion of rental value. The knowledge was identified by codes in respect of each expert.

The Knowledge Elicited

The total amount of hours of formal interview with the core valuers, complementary valuers and supporting specialists was approximately 40 hours, 44 hours and 11 hours respectively.

The general strategy of carrying out a valuation of the core valuers was quite similar, namely that work was looked at from the point of view of a set of stages and for each stage, certain types of knowledge were applied. The local authorities' valuers adopted broadly the same strategy as the core valuers. This is summarised in Figure 3. The "standard" lot for office space as indicated in the diagram was agreed by the valuers as the space used as offices on the second and upper floors of the purpose-built office complex. For the shopping complex, a standard lot was agreed with the valuers as an intermediate shop lot with the standard size (within a particular shopping complex) and not close to the main entrance nor to the escalators.

Inspection

Inspection involved the valuers collecting data and information on the locational and building characteristics of the subject property and its comparables.² The valuers used the inspection information together with rental analysis of the properties to formulate an opinion of rental value per square foot of the subject property.

At this inspection stage, the valuers utilised knowledge related to locational/spatial aspects, building technology and management.

While at a strategic level there was no significant difference among the valuers, in terms of the knowledge related to locational/spatial aspects, building technology and management, there were many variations.

Locational and spatial comparison knowledge

The perception of the valuers as to quality of locations was guided by the address of the properties (Figure 4 shows the classification

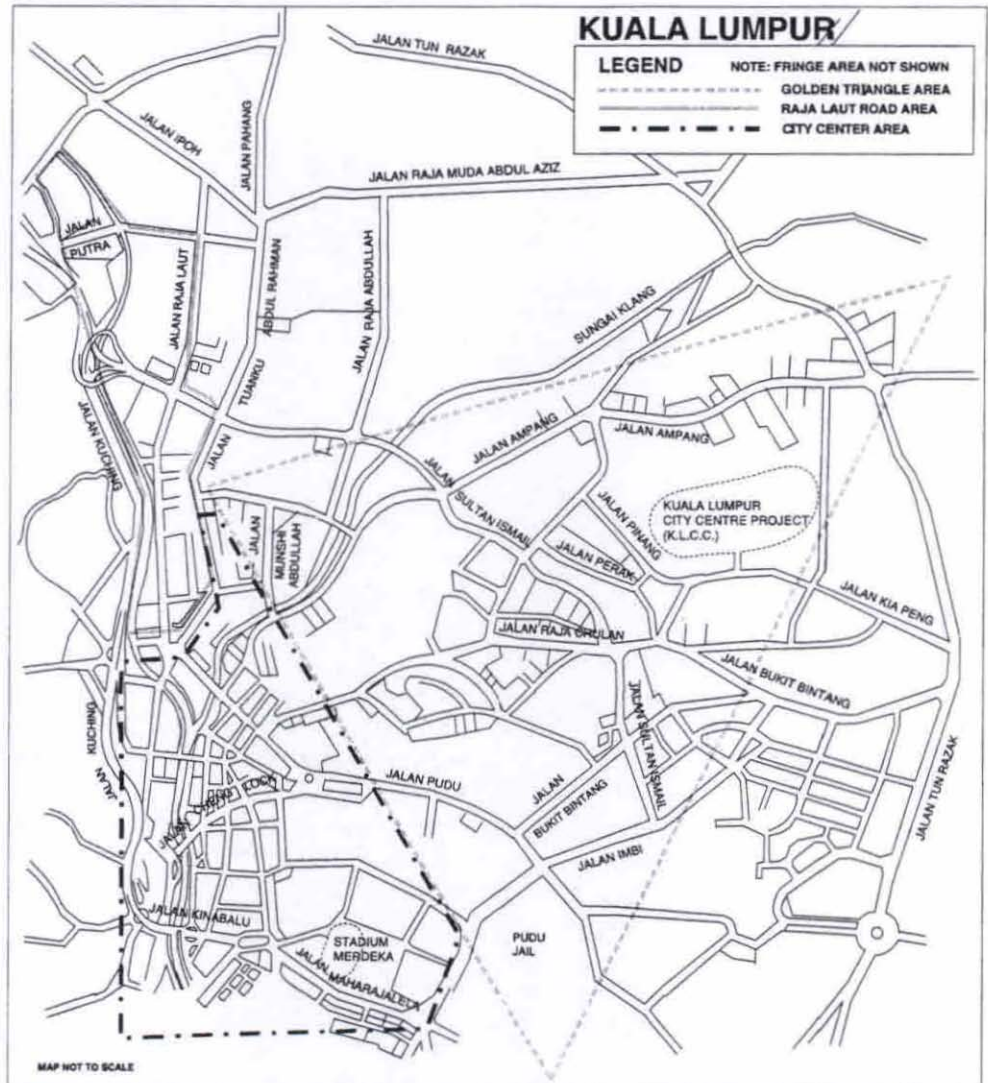


Figure 4: Classification of Office Location in Kuala Lumpur

of office location in Kuala Lumpur). However, some core valuers went deeper by subdividing the main locations into further sub-locations in terms of accessibility, traffic flow and detailed siting and neighbourhood.

There was no significant conflict but greater depth was provided to the knowledge base it self.

Valuers from the growing medium-sized local authorities showed a tendency to discuss more

local issues such as the development of sub-core commercial complexes and their implications in the spatial comparison of rental patterns, thus bridging the gap in contextual knowledge. Among the different local authorities, the approach to valuation differs according to the local layout of the town. For example, rather uniquely, Seberang Perai Municipal Authority based the rental pattern of the shophouse/office/flat on different "blocks" which could be considered to relate broadly to the blocks' distance from the town core.

Building technology knowledge

The building technology knowledge of the valuers is analysed with regard mainly to the quality of the buildings.

The lines of reasoning varied. In the case of shophouses, they range from merely looking at the general age to looking at the detailed specialist uses of the properties, for example the banks and fast food restaurants, both commanding higher rentals compared to other categories of shophouses.

In general, the knowledge of the valuers complemented each other. Some conflicts arose, however, as regards the appreciation of certain recreational facilities in an office complex and whether to value them using a flat rental per square foot or to value them according to the number of units of the facilities. This conflict, however, was resolved by the availability of rental evidence in the former.

Building technology knowledge elicited from the property managers and building experts added depth to the knowledge-base.

The general criteria for purpose-built office building classification such as design, services and facilities were found by the valuers to be beneficial. Deep technical knowledge, e.g. distance between different air-conditioned ducts, were set aside from the knowledge-base.

Management knowledge

The knowledge was mainly exhibited by the valuers in the context of shopping and office complexes.

In general, there was no conflict in the management knowledge of the valuers. In some cases, the management knowledge of certain valuers could help valuers resolve conflicts. For example, the knowledge

regarding the items of the service charges was used to reach a consensus opinion on the deduction of items in the service charge to comply with the definition of annual value.

Marketing strategy knowledge of property managers such as facilities in a shopping complex was useful. These were developed more through consumers' behaviour. The elicitation of opinion from such a group of people will be discussed later in this paper.

Selection of comparables, analysis and formulation of opinion of rental value

The second stage in the valuation was the selection of comparables, their respective rental evidence and the subsequent analysis. This was concurrently undertaken at the inspection stage.

The valuers selected comparables from the same type of property, in the same locality and at the same time of letting (date of valuation). Valuers subsequently divided the rental by the size of the area let to arrive at a common unit of rental per square foot for analysis and comparison purposes.

When valuers selected comparables and subsequently carried out rental analysis, market knowledge and legal knowledge were used.

Market knowledge

In terms of the market, valuers generally tried to classify the market in terms of the general type of property, the location and the rental pattern. They also looked at the general movements or trends of rents.

In general, their approach exhibited strong similarities. However, there were differences in various aspects of their approach. At a general level, observations were made about the order of the strategy and about their differing awareness of the market. At a more detailed level, there were

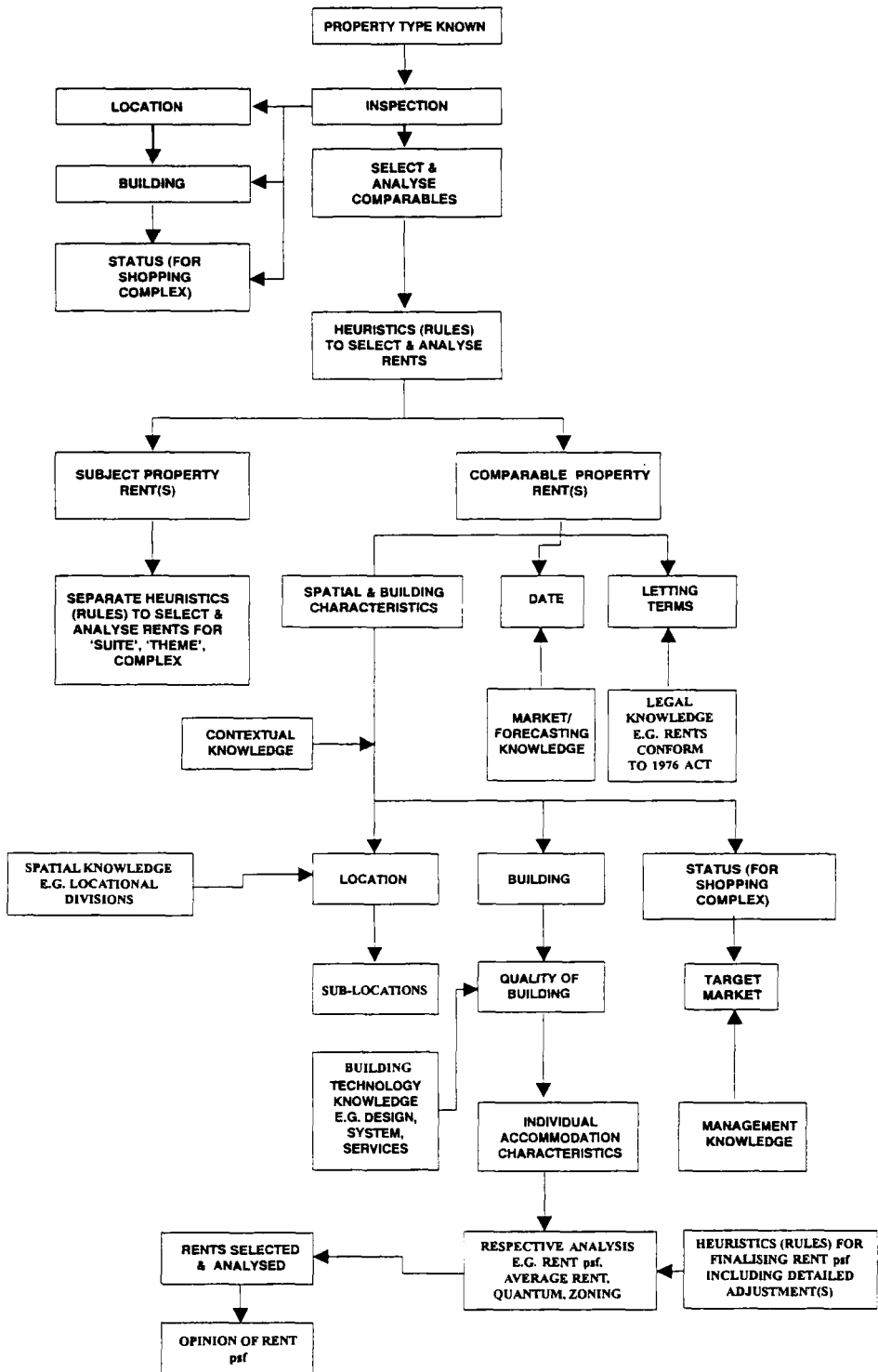


Figure 5: General Representation Of The Knowledge In The Valuation Process

further differences regarding the selection and analysis of rents, and in the formulation of opinion on rents.

a. Order of strategy

Although broad strategies of the valuers in the comparables selection and analysis stage were rather similar, there were some differences in the order or sequence of the strategy (Scott, op.cit p.81).

In the valuation of the office complexes, this ranges from comparison between individual properties to consideration of the rental range of the complexes for the whole of the city of Kuala Lumpur.

b. Market awareness

Another difference in valuation strategy between the valuers was in their awareness of some on the changes that were taking place in the market for commercial properties. This was illustrated by the appreciation of a valuer on the emergence of office buildings having a "suite" concept (where each tenant has exclusive rights to certain facilities in the building) and how to value them.

c. Detailed selection of comparables, analysis and opinion of rental value

The valuers customarily chose the rentals closest to the date of valuation-normally a year before the valuation.

The detailed technical aspect of selection, however, varied. Since there may be several different lettings for a property, some valuers produced a range of rentals of the subject property and comparable properties and then looking at it as a whole gave an opinion of rental per square foot of the subject property. Other valuers, had a simplistic view, just choosing the latest rental of the subject

property and/or comparable properties as a basis for their valuations.

An objective rental forecasting model was explored with one private valuer. The macro-economic variables included were Gross Domestic Product, business, income, inflation and employment levels. These gave an indication of the demand for office space expressed in terms of space. A forecast of demand was considered with the level of future supply of office space. The relationship between the ratio and average rentals was then used to predict future rentals.

Legal Knowledge

Valuers had a general appreciation of the legal framework in which they were operating but did not apply it dynamically until they were "challenged". In situations where their knowledge was challenged, the contribution of the academic was useful. For example, one valuer from a local authority had a unique practice of valuing the first floor of a shophouse based on the majority use of other first floor shophouses in the same locality instead of valuing it based on its existing use. The justification given was more on practical grounds, i.e. the use may be temporary and there was a high possibility for the existing use to change to the majority use. The valuer was aware that such practice did not follow strictly the general *rebus sic stantibus* principle of valuing as it is but was not prepared to go into detail on the legal aspect. The general legal principle from the academic literature was against such practice. Ironically, deeper discussions with an academician pointed to the justification of such an approach which introduced the issue of "potential use", provided the building structure, mode of occupation and planning permission were not in contradiction.

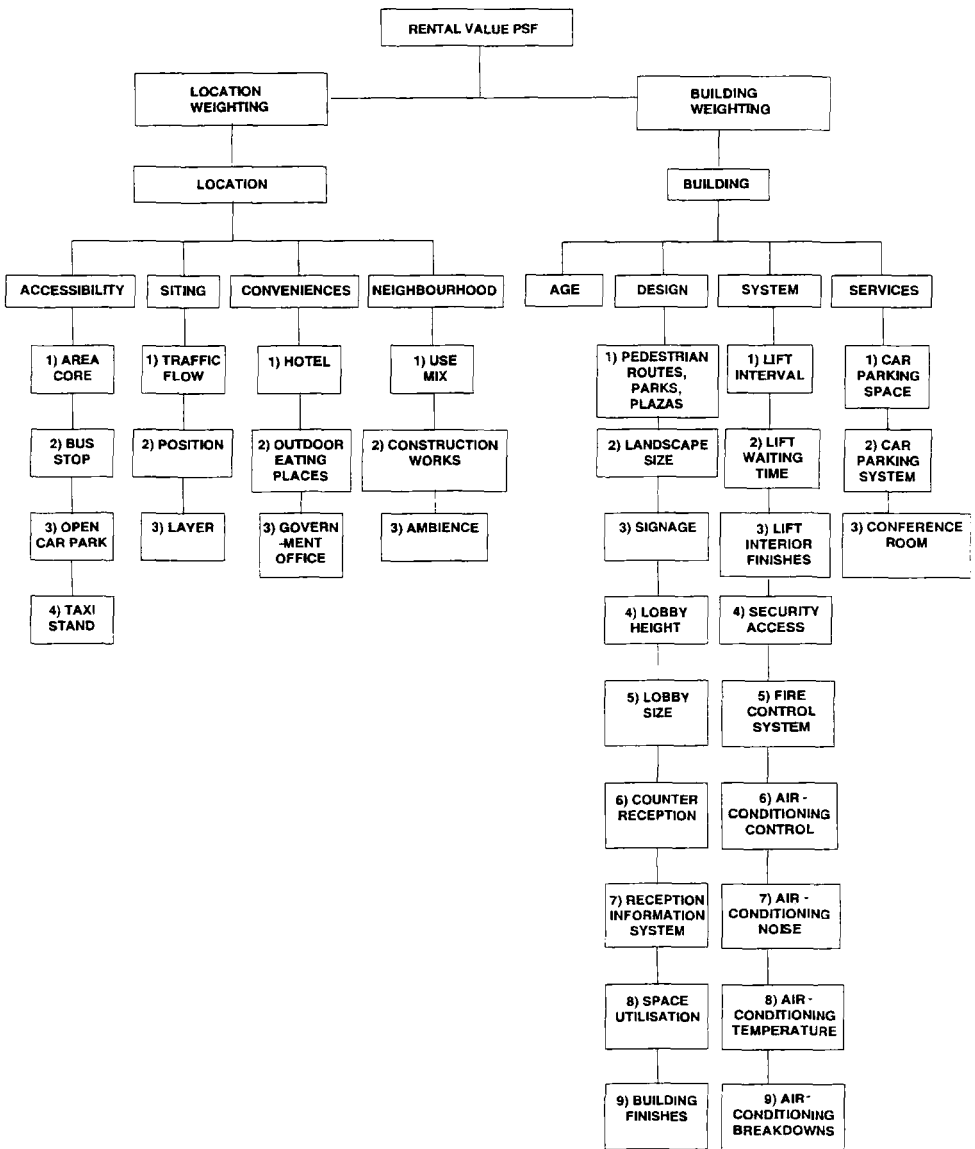


Figure 6: Framework of the Comparison Model for the Valuation of Office Complexes

Knowledge Representation

General heuristical representation of knowledge

Valuers used “reasoned adjustments” (heuristically) to allow for differences between a subject property and its comparables.

Figure 5 illustrates the general diagrammatic representations of the heuristic structure of the valuation process.

The research has also attempted to investigate the application of simple regression analysis to be incorporated in an expert system model (Jensen and Wadsworth 1990³ and Hermann,

et al, 1994⁴) to find location and building weightings (for office complexes) and location, building and status weightings (for shopping complexes).

The philosophy here was not strictly heuristic and was intended to simplify the valuation process, serve as an empirical comparison and complement the heuristic approach.

Incorporation of the simple regression model in the knowledge-base

This was applied to the purpose-built office and shopping complexes in Kuala Lumpur. The purpose of the model was to establish and provide a detailed and structured comparison of the standard lot's rental of the individual properties.

As an illustration, the framework of the comparison model for the valuation of office complexes could be illustrated by Figure 6.

The attributes in the framework were determined through comprehensive discussions with the experts with the core

valuers acting as the main "panel" to comment on them. They represent the rental value laden attributes which the core valuers thought to be relevant in the valuation process. The development of this model comprised several stages.

Stage 1: Knowledge representation and identification of rental value-laden attributes from the knowledge elicitation

The first stage involved structuring the knowledge-base. This involved identification of the main attributes, first level and second level sub-attributes affecting the rental values. In the office complex model, there were thirteen second level sub-attributes to location and twenty-two second level sub-attributes to building. For the shopping complex, there were thirteen second level sub-attributes to location, forty-two second level sub-attributes to building and seven second level sub-attributes to complex's status.

Figure 7 provides an example of the main attributes, first level and second level sub-attributes of the office complex.

Main attributes	1st level sub-attributes	2nd level sub-attributes
Location	Accessibility	Area core distance Bus stop distance LRT distance (subject to completion)
	Siting and traffic flow	Traffic flow Position Layer
Building	General	Age
	External design	Pedestrian routes/parks/plazas distance Landscaping size

Figure 7: An Example of Main Attributes, First Level Sub-attributes and Second Level Sub-attributes of Office Complex

Stage 2: Establishing classes of situations

This stage attempted to refine the granularity of the knowledge-base. For example, in the case of the purpose-built office complexes, the classes of situations for second level sub-attributes for location distance from area core, were “within the city core”, “up to 1 kilometre” and “more than 1 kilometre”.

A whole series of classes of situations were elicited with the valuers both for the second level sub-attributes for location and building in the case of purpose-built office complexes and for location, building and complex status in the case of shopping complexes.

Stage 3: Eliciting valuers' opinions (in terms of point scores) on classes of situations and combining them with tenants' opinions

This involved eliciting opinions from the core valuers on the relative importance of each class of situation for each second level sub-attributes in some form of numerical

measurement. A method more akin to the Likert Scaling (a method of measurement of opinion based on numbered scales) was adopted based on the nature of the many second level sub-attributes (Husin, 1993).

A questionnaire based on the knowledge from the two previous elicitation stages was distributed to each core valuer requesting him/her to provide opinions on the importance based on a point score scheme of 0 (lowest score) to 10 (highest score).⁵

The elicitation of the opinions took place separately. Figure 8 provides a tabular view of the valuers' opinions on the relative importance of each class of situation for two second level sub-attributes to location for purpose-built office complexes namely “area core distance” and “bus stop distance”.

Class of Situations-Valuers' and their Opinions

The average of the point scores of all the participating valuers was adopted. Each core valuer was given equal weighting in terms

	1	2	3	4	5	Average	Standard Deviation
Area core distance							
Within core	10	9	10	7	10	9.200	1.304
Up to 1 km	7	8	5	10	6	7.200	1.924
More than 1 km	5	5	1	6	2	3.800	2.168
Bus stop distance							
Within 50 m	10	10	10	10	10	10.000	0
100 m -150 m	7	7	4	6	4	5.600	1.517
More than 150 m	6	5	1	5	2	3.800	2.168

Figure 8: An Illustration of Five Valuers' Opinions on Different Classes of Situations (Purpose-built Office Complex)

Main attributes	1st level sub-attributes	2nd level sub-attributes	Class situations	Valuer's Score (V)	Mean Tenants' Opinion (T)	Overall V*T (closest integer)
Location	Accessibility	Area core distance	Within core	9.200	0.707	6.508 (7)
			Up to 1 km	7.200	0.707	5.093 (5)
			More than 1 km	3.800	0.707	2.688 (3)
	Bus stop distance	Bus stop distance	Within 50 m	10.000	0.650	6.500 (7)
			50 m -100 m	7.800	0.650	5.031 (5)
			100 m -150 m	5.600	0.650	3.612 (4)
			More than 150 m	3.800	0.650	2.451 (2)

Figure 9: An Example of Purpose-built Office Complex Main Attributes, First Level Sub-attributes; Second Level Sub-attributes; Class Situations and The Point Scores

of opinion as the length and scope of experience were about the same. A survey on tenants' opinions was incorporated to complement experts' consensus opinions (Adair, *et al*, 1996, Pittman and McIntosh, 1992).

Two separate sets of questionnaires of Tenants' Stated Preference Study (TSPS)⁶ were designed in accordance with the knowledge-base, each for the office complexes' tenants and the shopping complexes' tenants. The main aim was to obtain tenants' opinions on the degree of importance of the second level sub-attributes. This was based on a Likert scale of 0 (lowest rating) to 10 (highest rating). A rating of 10 would mean that the tenant was of the opinion that a sub-attribute was very important and this will be "translated" as full (100 per cent) importance and equivalent to multiplier⁷ 1.0. It followed that the middle and lower end of the rating would have multipliers of 0.5 and 0 respectively. The aim of the multipliers was to facilitate the combination of valuers' opinions and tenants' opinions on the importance of the sub-attributes. The tenants were also requested to state other relevant factors. Seventy-five purpose-built office

buildings were selected at random throughout Kuala Lumpur (about 60 per cent of the total number of purpose-built office complexes in Kuala Lumpur city) and 600 questionnaires were sent selectively to the tenants of these office buildings of which 149 replied. In the case of the shopping complexes, 11 shopping complexes were selected (representing 79 per cent of shopping complexes in Kuala Lumpur City). A door to door approach⁸ in distribution and survey was adopted. Two hundred questionnaires were distributed at random and 51 replied (26 per cent response rate).

The tenants' opinions were stored in Minitab software for analysis.

The means of tenants' opinions were combined with the valuers' point scores producing a set of point scores for each second level sub-attribute. This approach, agreed with the valuers, served to complement their opinions, providing a composite point score.

An example of the format for a purpose-built office complex in terms of the main attributes;

first-level sub-attributes ; second level sub-attributes; the different class situations and the respective point scores, is illustrated in Figure 9.

The inclusion of tenants' views to complement opinions of experts is unique to this research. First, the views can be combined with the valuers' consensus point scores to arrive at a composite score for each of the class situations of the second level sub-attributes. Secondly, it provides a formally elicited first-hand knowledge of the market. Thirdly, it provides additional attributes to complement previous knowledge elicitation. Fourthly, the views formed the basis of validating the knowledge of the experts.

The approach to date was to combine the tenants' opinions with the valuers' opinions. It would be useful to consider the valuers' opinions alone and compare the results with the approach undertaken so far. This will be subject to further research.

Stage four: Inspection of properties

The fourth stage in the process of the construction of this model was to conduct the inspection of properties based on the attributes and sub-attributes. Ninety-two purpose-built office complexes and 14 shopping complexes throughout the Kuala Lumpur city were inspected and the point scores for each individual second level sub-factors were noted. The information was stored in Minitab statistical software for later analysis.

Stage five: Finding weightings of main factors

This stage of the process involved the compilation of rentals of "standard lot" for the purpose-built office complexes and shopping complexes. The objective was to find the relative importance of the main attributes, i.e. location and building (in terms of the weighting of each) for the purpose-

built office complexes and the relative importance of the main attributes location, building and status of complex (in terms of the weighting of each) for the shopping complexes.

Several steps were involved :

a. Calculation of maximum score for each main attribute

The maximum score for each main attribute was derived from the maximum sum of scores of all first-level sub-attributes. The sum of the scores of all first-level attributes came from the maximum sum of scores of all second level attributes.⁹

In the case of office complex, the maximum scores of location and building were found to be 87 and 170 respectively.

For shopping complex, the maximum scores of location, building and status were 96, 254 and 54 respectively.

b. Calculation of proportion to maximum score for each main attribute of each individual property

This was achieved by dividing the score for each main attribute of individual property (obtained from inspection in stage four) with the maximum score for each attribute (as derived from step 1 above) and expressing them in terms of percentage.¹⁰

Two separate main lists (each for office and shopping properties) of all the proportion to maximum score for each main attribute of each individual property were compiled.

The main list of the office properties was further divided into several sub-lists according to the area cores in which the properties were located.¹¹

c. Simple regression of rentals against the proportion to maximum score for each main attribute

Simple regressions of the rentals¹² of each individual property against proportion to maximum score for each main attribute¹³ of each individual property (based on the lists from step 2) were then undertaken using the Minitab statistical software.

For the proposed 1997 revaluation exercise, the current rentals at the time when the research was undertaken was mid to late 1995. Rental evidence were searched from the property review section in the media at that time. Rental evidence of standard office space of 54 different purpose-built office complexes were collected. In the case of the shopping complexes, rental evidence of ground, first, second and third floors of 12 different shopping complexes within the Kuala Lumpur city were collected.

From the regressions, the coefficients of each main attribute (and thus regression equations) were obtained for the office complexes and shopping complexes.

As the rental value was generally considered by the valuers to be a function of the main attributes, the total weightings of the main attributes should equal 1.

c. Finding hypothetical maximum rent

Using the coefficients of the main attributes, for both the office and shopping complexes, the hypothetical rent of a hypothetical property having the maximum scores for the main attributes (100 per cent scores for the main attributes of location and building) were predicted.

From this exercise, the hypothetical maximum rent of all the different divisions of the office complex (based on the different area cores) and the shopping complex were predicted.

d. Expressing individual property's rent in terms of rent proportionate to hypothetical maximum rent

This was achieved by dividing the rent of each property with the hypothetical maximum rent and then expressing them in terms of percentage.

e. Finding the weightings of main attributes

This was achieved using simple regressions of rents¹⁴ proportionate to hypothetical maximum rent against the respective proportion to maximum score of the main attributes for each individual property.

An example of the summary of data of purpose-built office complexes in the Golden Triangle - Sultan Ismail Road core which were utilised in finding the weightings of land and building is indicated by figure 10.

In the case of the purpose-built office complexes as in the example provided by Figure 12, the regression was undertaken between columns (4) and (5) as independent variables and column (7) as a dependent variable. For example, in the case of the Golden Triangle - Sultan Ismail Road core, the relative weightings of main attributes location and building (as in Figure 10) were found to be 0.375 and 0.625 respectively.

A summary of the weightings of the main attributes of the purpose-built office complexes and shopping complexes for the different valuers' determined sub-locations are provided in Figure 11 and Figure 12 respectively.

For the purpose of triangulation, attempts were also made to elicit the weightings directly from the core valuers in the case of the office complexes. It was, however, found that not all core valuers were prepared to provide their opinions although they agreed that such an approach could be beneficial and

Building	Location Score (Max. Score=87)	Building Score (Max. Score=170)	Location Proportionate (%) to Max. Score	Building Proportionate (%) to Max. Score	Rent Max. Hypothetical Rent=6.6	Rent Proportionate (%) to Max. Hypothetical Rent
1	2	3	4	5	6	7
KLIH	70	80	80.4598	47.0588	3.80	57.6273
Genesis	66	143	75.8621	84.1176	5.50	83.4079
AMMB	72	139	82.7586	81.7647	5.50	83.4079
S H Chan	69	106	79.3103	62.3529	4.10	62.1768
HLA	74	98	85.0575	57.6471	4.50	68.2428
GHill	70	148	80.4598	87.0588	5.70	86.4409
Boustead	71	117	81.6092	68.8235	5.00	75.8254
WBstead	71	69	81.6092	40.5882	3.70	56.1108
Kewangan	68	93	78.1609	54.7059	4.50	68.2428
Aetna	68	127	78.1609	74.7059	4.80	72.7923
L F Yong	67	87	77.0115	51.1765	3.90	59.1438
WStephen	66	75	75.8621	44.1176	4.00	60.6603
Genting	75	136	86.2069	80.000	5.50	83.4079
SPK	71	94	81.6092	55.2941	4.00	60.6603
Haw Par	70	97	80.4598	57.0588	4.50	68.2428
UBN	80	136	91.9540	80.000	5.80	87.9574
Atrium	68	81	78.1609	47.6471	4.00	60.6603
M Sabre	69	119	79.3103	70.000	4.50	68.2428
SMK	70	76	80.4598	44.7059	3.50	53.0778
IMS	72	61	82.7586	35.8824	3.80	57.6273
Nusantara	71	74	81.6092	43.5294	3.90	59.1428
MUI Plaza	76	106	87.3563	62.3529	4.50	68.2428

Figure 10: An Example of Data Utilised in Finding Weightings of Land and Building

Location	Number of Properties	Location Weighting	Building Weighting	Total Weighting
Sultan Ismail Road Core	22	0.375	0.625	1.000
Ampang Road Core	11	0.354	0.646	1.000
Raja Laut Road Core	4	0.535	0.465	1.000
City Center Road Core	13	0.462	0.538	1.000
Fringe Areas	4	0.225	0.775	1.000
Total	54			

Figure 11: Weightings of Location and Building (Purpose-built Office Complexes)

Floor Reference	No of Rental Evidence	Location Weighting	Building Weighting	Status Weighting	Total Weighting
Ground	6	0.378	0.435	0.187	1.000
First & Second	12	0.340	0.376	0.284	1.000
Third	8	0.272	0.316	0.412	1.000

Figure 12: Weightings of Location, Building and Status (Shopping Complexes)

explored more rigorously. Only the core valuer with the concentrated experience in the valuation of the office complexes in Kuala Lumpur in the 1992 revaluation exercise was willing to give his opinion on the relative weightings of location and building for office complexes in Kuala Lumpur as a whole although he suggested and appreciated the importance of stratifying the sub-location of the office complexes and to find the respective weightings of location and building for each sub-areas. In addition, in the TSPS, the tenants of the office

complexes were also requested to state their opinions of the weightings of location and building when they selected their office space.

The weightings derived from the regression were discussed with the valuer with the concentrated experience in the valuation of the large commercial properties. Insights were highlighted in terms of the significance of the difference of weightings in accordance with the valuers' perceptions.

The weightings from the regression were used to predict rental per square foot of other office buildings in the same geographical area. For example, in the case of the Golden Triangle-Sultan Ismail Road core, the rental per square foot for the standard office space in another building namely Bangunan Yayasan Selangor with location score of 73 and building score of 74, the rental could be predicted as follows.

Proportionate Location Score

(As a percentage to maximum possible location score of 100% (i.e. 87))

$$= 73/87 * 100 = 83.9080$$

Proportionate Building Score

(As a percentage to maximum possible building score of 100% (i.e. 170))

$$= 74/170 * 100 = 43.5294 \%$$

Proportionate Predicted Rental Per Square Foot Score

(As a percentage to maximum possible "Hypothetical" Rent of 100% (i.e. 6.60))

$$\begin{aligned} (0.839080 * 0.375) + (0.435294 * 0.625) \\ = 0.314655 + 0.272059 \\ = 0.586714 = 58.6714\% \end{aligned}$$

Predicted Rental Per Square Foot

$$= 6.60 * (0.586714) = \text{RM}^{15} 3.87 \text{ per square foot}$$

The data for the shopping complexes were analysed as a whole for Kuala Lumpur city (in accordance with valuers' market knowledge) using the same procedure as with the purpose-built office complexes with an addition of main attribute status of complex besides the location and building.

Insights were highlighted in terms of the significance of the difference of weightings in accordance with the valuers' perceptions. For example, in terms of the weightings for the Golden Triangle (Sultan Ismail Road and Ampang Road Cores) purpose-built office complexes, it was explained by the valuers that the great locational advantage of the area may mean that it does not matter where in the Golden Triangle the tenants were located (hence low location weighting), whereas the

Building weighting was higher reflecting the high competition in the Golden Triangle for high class prestigious buildings.

The weightings were used to predict rental per square foot of other buildings in the same geographical area. In the case of the purpose-built office complexes, Figure 13 provides an illustration of the prediction model.

The simple nature of the model provided an objective, easily understood comparison between properties in the form of point scores of each individual main and sub-attributes.

The Prototype and Evaluation

Validation and concept of prototyping

The validation involved valuers' evaluation of the knowledge-base as the knowledge elicitation proceeds (dynamic evaluation) to achieve knowledge completeness (Shaw and Woodward, 1988).

Generally, the research demonstrated that the valuers used a process - rules and relationships and that it was possible to produce heuristics to represent the weighting of attributes. The heuristically assigned weightings representing this process could be as valid as statistically derived data (Jenkins, op.cit, p.8).

The basic prototype

Rapid prototyping (i.e. building the prototype as soon as the knowledge elicitation starts) has not been adopted due to the size of the knowledge-base (Moore and Miles, 1991), the number of experts involved and the availability of only a single knowledge engineer.

Nevertheless, a prototype has been developed at a stage of the project when it was felt that the knowledge was adequate enough to stand as a platform for discussion among experts.

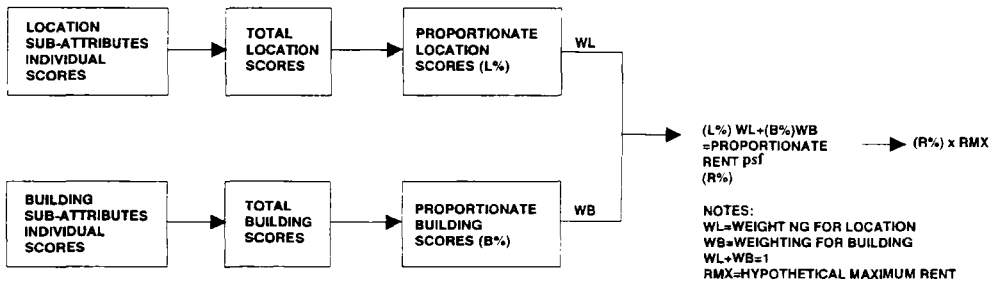


Figure 13: Rental Value Prediction Model for Office Complexes

The prototype is divided into four modules. Each module embodies the specific knowledge-base of a particular type of property. The purpose-built office complex module contains a series of "screen displays" embodying the knowledge of the experts integrated with the structured comparison format based on locational and building attributes (with both first level attributes and second level sub-attributes incorporated). The questions in the system are based on the second level sub-attributes. The computer incorporates rules intelligently to relate the answer given to the system to the combined scores of the valuers and the tenants' opinions through the array facilities in the system.

The individual scores of the second-level sub-attributes to location (to arrive at the total score of the main attribute location) and the individual scores of sub-attributes to building will also be added up (to arrive at the total score of the main attribute building). The proportionate scores of location and building (i.e. proportionate to the respective maximum score of location and building) will be multiplied by their respective proportionate weightings (i.e. proportionate to the maximum scores attainable) to arrive at an opinion of rental per square foot for the standard lot. Options for explanation are also incorporated in the system and these are provided at different levels i.e. shallow and detailed "layers" of explanation (Tayar, 1993).

The class of the purpose-built office complex is decided by the system in terms of categories of "Super", "Class A", "Class B", and "Class C". An option is available for viewing the comparables and their respective Location score, the Building and their respective predicted rentals.

During evaluation, valuers expressed the need for the system to provide information (if any) about the actual rents (average rents) of the subject property and its comparables as a check to the prediction.

The second part of the module contains the detailed accepted heuristic knowledge of the experts which comprise the valuation of individual accommodation in the office complex such as the penthouse and sports club, and swimming pool where rental evidence may be limited.

Module 2 for the valuation of shopping complexes has a similar format as module 1. It contains the knowledge-base relating, for example, to the position of the individual shop lots, the sensitivity of the rentals to size and the layout of the complex.

Module 3 for the valuation of shophouse/ office/flat contains a section analysing the general locational situation of the shophouse and an analysis of their detailed position. Where rental evidence in the immediate

vicinity are scarce, appropriate heuristically assigned adjustment will be made in relation to other comparables located farther away. The second section comprises questions relating to the internal valuation of the shophouse such as valuation between the different floors.

Module 4 consists of a knowledge-base of industrial properties. The rules for location in each is rather broad reflecting the less sensitive nature of factories' rentals to different positions. The second part of the module comprises valuations of accommodation within factories. Heuristical judgment is inherent in the valuation of factories reflecting specialised valuers' knowledge. For example, in making adjustment for size, a sliding scale in the form of a percentage deduction with increasing size of the factory space is embodied in the prototype.

Evaluation and Further Knowledge Elicitation

In general, the valuers were in agreement of the knowledge represented in the system. Further refinement is, however, taking place.

Objective testing of shopping complexes and office complexes modules

An objective testing on the accuracy of the "opinion" of the system which incorporates the simple regression for twenty-one purpose-built office complexes and nine shopping complexes in Kuala Lumpur against the valuation of an experienced core valuer was undertaken. The results of the testing of the model for office complexes valuation is summarised in Figure 14.

The test showed a difference of within 10 per cent compared to the core valuer's valuation for twenty of the properties. There was a difference of 12.75 per cent for LUTH Building with the prediction falling outside the 90 per cent confidence interval. A discussion

with the valuer revealed that LUTH was valued lower by the valuer despite its high building score as a result of lettings to special tenants, namely, government bodies.

Rules relating to type of tenants were subsequently incorporated for flexibility.

As a whole, the valuers agreed that such a model would be useful in providing structured explanation.

The valuers also agreed for an option to value property in broad terms. Where the scores fall within a certain range, the prototype could automatically assign a common rent per square foot for the properties.

Comments On The Use of Regression In The System

Despite the usefulness of incorporating a regression model, based on the dynamic evaluation undertaken, it was found that some elements of rigidity existed. Some examples are:

a. Weightings

The weightings of the main attributes were not strictly following the valuers' actual thought process. Valuers seemed to be put in a position to explain an environmentally determined (Czernkowski, 1990) weighting instead of "utilising" the rental evidence (selecting and analysing) to arrive at an opinion and explaining the process. User acceptance requires *reasoning* rather than the simple implementation of systems and techniques so familiar in traditional data processing chores (Chorafas, 1990, p.4).

b. Amount of rental evidence

Related to (1), the front end of the model requires a substantial amount of rental evidence. In practice, valuers only select several suitable rental evidence, analysing them against similarities and differences to arrive at an opinion. Rules could be developed

Building	Loc Score (Max. Score=87)	Bldg Score (Max. Score=170)	Loc Proportionate (%) to Max. Score	Bldg Proportionate (%) to Max. Score	Rent Proportionate (%) to Max. Hypo. Rent	Predicted Rent psf (RM)	Valuer's Opinion On Rent psf (RM)	Difference (%)	Confidence Level (%)
Sultan Ismail Road									
SPK	71	94	81.6092	55.2941	65.0000	4.29	4.00	7.25	90
SMK	70	76	80.4598	44.7059	58.0303	3.83	3.50	9.43	90
Nusantara	71	74	81.6092	43.5294	57.7273	3.81	3.50	8.86	90
Aik Hua	54	92	62.0690	54.1176	57.1212	3.77	3.50	7.71	90
Ampang Road									
Gedah Asil	62	103	71.2644	60.5882	64.7154	3.98	3.80	4.74	90
S.Dredging	68	108	78.1609	63.5294	68.9431	4.24	4.00	6.00	90
MCA	70	103	80.4598	60.5882	67.9675	4.18	3.80	10.00	90
LUTH	58	130	66.6667	76.4706	73.3333	4.51	4.00	12.75	<90*
RHB	54	129	62.0690	75.8824	71.3821	4.39	4.50	-2.44	95
Raja Laut Road									
Bumi Raya	75	84	86.2069	49.4118	63.0252	3.75	3.50	7.14	95
C&Carriage	65	124	74.7126	72.9412	67.5630	4.02	4.00	0.50	95
PKNS	75	84	86.2069	49.4118	63.1933	3.76	3.50	7.43	95
City Centre									
Public Bank	62.5	96	71.8391	56.4706	63.9344	3.90	4.00	-2.50	95
UMBC	58.5	103	67.2414	60.5882	63.9344	3.90	4.00	-2.50	95
KOP	55.5	69	63.7931	40.5882	51.6393	3.15	3.00	5.00	95
TSMB	58.5	98	67.2414	57.6471	62.4590	3.81	3.50	8.86	90
Bangkok Bank	62	71	71.2644	41.7647	50.8197	3.10	3.00	3.33	95
Bangunan Zainal	62	90	71.2644	52.9412	61.6393	3.76	4.00	-6.00	90
Fringe Area									
IGB Plaza	53	89	60.9195	52.3529	54.5098	2.78	3.00	-7.33	95
Perkim	59	81	67.8161	47.6471	50.5882	2.58	2.50	3.2	95
Pengkalan	51	106	58.6207	62.3529	61.7647	3.15	3.00	5.00	95

Figure 14: Purpose-built Office Complex - Result of Computerised Model Testing against Valuer's Opinion (Rent of Standard Office Space)

in the selection of comparable properties in terms of alternatives provided in the selection strategy where actual close comparables may not be available (Nawawi and Gronow 1991, Nawawi, *et al*, 1993, 1994).

c. New developments in the market

In a dynamic market such as in Kuala Lumpur city, new developments in the market e.g. new concept of "suites" in office complexes may require flexible rules (e.g. rental selection strategy) instead of pre-determined weightings.

The system should grow with additional knowledge on new developments in the market. Despite some of the possible limitations of the incorporation of a regression model in the knowledge-base, the elements of point scores in the model could be helpful in complementing the experts' heuristics in the selection of comparables and possibly in making adjustments.

Conclusions

The research has shown that an expert system for the valuation of commercial properties for rating purposes in Malaysia can be developed from the knowledge of several experts. The system could benefit from an enriched consensus knowledge of experts as well as multiple lines of reasoning.

The regression model incorporated in the system offered a structured and simplified dimension in providing a general weighting of main attributes with a prediction generally within 10 per cent difference from the valuers' opinion. However, it has introduced elements of rigidity, inability to work with limited data and inflexibility to accommodate growing knowledge of the market.

The research is currently refining the knowledge-base to make the system more subtle, modelling both consensus knowledge as well as multiple lines of reasoning. □

Endnote

¹ The Local Government Act 1976 refers to all rateable hereditaments in Malaysia as holdings.

² It is important to note that data and information that the valuers utilised in relation to their knowledge was not necessarily collected by the valuers. Especially in the context of revaluation exercises, the number of properties that needed to be inspected was large (Dewan Bandaraya Kuala Lumpur, 1994) and the need for assistant valuation officers and technicians to inspect the properties (under supervision of the valuers) was a major consideration.

³ For valuation of residential properties.

⁴ Incorporated a quantitative analysis in their intelligent system designed for an interactive floor planning tool.

⁵ A scoring scheme of 0 to 10 was adopted based on the discussion with the valuers. In general, it was found that the valuers were "comfortable" in giving their opinions within the scale of 0 to 10.

⁶ In this research, the preference was in terms of tenants' opinions on the importance of a number of factors when selecting a complex.

⁷ The multiplier represented the weighting (of importance) placed by the tenant on the sub-attributes.

⁸ A door to door approach was adopted as it was found that the response through the postal method was poor.

⁹ The maximum sum of the score of all the second-level sub-attributes technically means that a property obtained the highest class of situations for each second-level sub-attribute.

¹⁰ Percentage of the maximum location score achievable i.e. 100 per cent.

¹¹Area cores of purpose-built office complexes within Kuala Lumpur city (based on a valuer's specialised knowledge of the market agreeable by the team of valuers) namely Golden Triangle; Sultan Ismail Road Core; Golden Triangle Ampang Road Core; City Center core (banking belt) and city fringe.

¹² Rent as a dependent variable.

¹³ Each main attribute as the independent variable.

¹⁴ Rental evidence of standard office space of the 54 different purpose-built office complexes and rental evidence of ground, first, second and third floors of the 12 different shopping complexes within Kuala Lumpur city.

¹⁵ RM stands for Ringgit Malaysia.

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