HOW ATTRACTIVE IS A SHOP: A FUZZY-EXPERT SYSTEM

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ABSTRACT

Professional planners of shopping centres know that intangible factors of a shop, including product type, quality, variety, pricing, branding, and image, are all vital in determining the pedestrian flow into the shop. These intangible factors cannot be easily quantified. Yet by experience, professional planners know how to assess them, and hence assign different shops to different strategic locations within a shopping centre, in order to optimize pedestrian flow. The objective of this study is to model experts' professional judgment on these intangible factors. A model combining a fuzzy expert system and regression is found capable of predicting pedestrian flow at reasonable accuracies. By fine tuning the location of potential tenants, using an integrated simulation model, it is possible to optimise the shopping centre's rental performance, even at the early stage of the shopping centre design.

Keywords: Shopping centre, shop attractiveness, intangible factors, pedestrian flow, fuzzy expert system

INTRODUCTION

Success of any retail shop or shopping centre relies heavily on the pedestrian flow. Dawson (1983) stated that "sales are closely related to the volume of pedestrian traffic passing the shop." Northern (1984) believed that the ultimate success of any shopping centre would be directly proportional to the number of shoppers who pass through the centre.

Location is one of the significant determinants. Various neoclassical theories about location (described by Brown (1992) as traditional statistical models) have been studied, such as Central Place Theory, the Principle of Minimum Differentiation, Spatial Interaction Theory, etc. Further to these theories, regression models have been adopted to analyze the impact of various tangible factors, such as the location, physical dimensions of the shop, the walking distance between the shop and major traffic and attraction points, etc. Yet only using tangible factors is insufficient to predict the pedestrian flow drawn by a shop or at any particular point within a shopping centre (Northern 1984). He has identified various significant qualitative

factors, namely tenant mix, centre/ shop characteristics, brand name and prestige images, nearby competition, the 'quality' of retail space available, etc.

Northern has classified shopping centre image as a qualitative factor; however Dennis et al. (2005) has attempted to quantify the impact of image on the performance of shopping centres. He has investigated the relationship between "image" or "attractiveness" and individual shopper behaviour. He asserted image as the complete mix of cues (e.g. sensory) which communicates with customers and influences shopping behaviour. He has consolidated the gravity, spatial interaction and Central Place approaches in his attitude-behaviour theory. The attractiveness of shopping centres has been quantified and triangulated with a branding framework. His study reported that pleasure and enjoyment, deterrence effect of travel and motivation significantly affected a shopping centre as an object of desire. The 'pleasure' and 'enjoyment' would be affected by atmospheric stimulus, image of the shopping centre environment; image of stores and products, and arousal stimulation affect. Deterrence effect would be influenced by travel distance and time, distance to a competing centre, size and attractiveness of other centres in and near the catchment area. Shopper's motivation was significantly related to self-esteem and relatedness.

Steenkamp and Wedel (1991) stated that retail image was the key parameter reflecting the total value of shopping centres. A unique and favorable image helps create a sustainable competitive advantage and establish a clear marketing position from other competitors. Five identified attributes of shopping centre image are merchandising, accessibility, service, atmospherics and entertainment (Sit et al., 2003).

Besides studying shopping centres, Martineau (1958) has studied and shown that the drawing force of a store was the store personality or image – the way in which the store was defined in the shopper's mind, partly by its functional qualities and partly by an area of psychological attributes. He stated that "whereas the retailer thinks of himself as a merchant concerned with value and quality, there is a wide range of intangibles which also play a critical role in the success or failure of his store".

Current practitioners predict the pedestrian flow mainly with their own experience and judgment. In order to pursue the best performance, as well as its consistency, of a shopping centre, a scientific management system to control the layout design and tenant mix scheme is necessary and desirable. Compared to tangible attributes, intangible attributes are more difficult to measure and study. This paper will investigate the measurement of shop attractiveness, which is one of the most significant intangible attributes, and the relationship between shop attractiveness and pedestrian flow, with the data collected in three shopping centres in Hong Kong.

SHOP ATTRACTIVENESS

The attractiveness of a shop is defined as its ability to draw potential customers into, and around the neighborhood of, the shop. Such attractiveness is determined by both tangible (e.g. shop size, location, etc.) and intangible factors (e.g. branding, market position, etc.). Intangible factors are difficult to be quantified, as individuals have different perceptions on various attributes. A fuzzy expert system, which is a codification of the common sense, imitating how people use their imprecise information to make the right decision, is designed to predict pedestrian flow at specific points inside a shopping centre, It is a widely accepted tool for modeling nonlinear functions of arbitrary complexity and dealing with linguistic variables, which transform descriptive words or sentences into quantitative values. Wong and So (1995), Bagnoli and Smith (1997, 1998) and Ng et al. (2002) applied fuzzy logic on solving problems in the real estate and construction industries. Wong and So have constructed a fuzzy reasoning model and applied the model on contract decision making in Hong Kong. Bagnoli and Smith investigated how to apply fuzzy logic on real estate valuation. Ng et al. have demonstrated how to set up the fuzzy membership functions of procurement selection criteria.

The system proposed in this paper involves three main components: fuzzification, inferencing and defuzzification. Fuzzification is the procedure to convert raw data (i.e. linguistic variables) into membership functions. The membership function is a generalization of the linguistic input functions in classical sets. It can be represented graphically of the participation magnitude of each input with an interval ranging from zero (false) to one (true).

Inferencing refers to the reasoning or logic applied in the system which constitutes the rule base. Rule base specifies conclusions drawn from assertions known or assumed to be true (Jantzen 1999). With the membership functions and truth values of inputs obtained in fuzzification, the rules applied will be invoked to determine the result, which will be mapped onto a membership function and truth value controlling the output variable. In this paper, the centroid method, which determines the centre of the area of the combined membership functions and produces more representative results than other methods (Nurcahyo et al. 2003), is chosen to perform the defuzzification process.

FUZZIFICATION

The first step in fuzzy logic is to establish membership functions of input terms which are generalization of the indicator functions. In fuzzy logic, it represents the degree of truth as an extension of valuation. In other words, common sense is codified and reflected in the membership function. The membership functions are established with

the aid of a questionnaire, which collects and quantifies the views of interviewees with different classical sets.

The framework of the questionnaire (as shown in Appendix A), with reference to Ng et al. (2002), is designed to collect the maximum, minimum and average values of both input and output functions. The questionnaires are distributed to ten current practitioners/ industry experts who could share their experience towards the operation and mechanism of the retail market. Quantitative data of the linguistic variables are collected to develop the membership functions.

Common shapes of membership functions are triangular, trapezoids, smooth triangular and smooth trapezoid. During practical application, the number of curves and their placements are far more critical than the shape type. Three to seven curves (i.e. terms) are generally adequate to cover the universe of disclosure, representing all objects that come into consideration, of the input and output values. In order to design a system for market practitioners who do not process advance mathematical knowledge, a simple triangular function is chosen for simple graphical representation. Another advantage is that simple triangular function can be processed with some common softwares; for example, SPSS, Microsoft Excel.

With reference to previous studies, eight input variables (IVs) and three output variables (OVs) were suggested for the model. Input variables, including shop youth image, quality of goods sold, pricing competitiveness, branding, variety of goods sold, trading, shop size and shop location, are the settings and characters of the shops. Output variables refer to the percentage of pedestrians, belonging to different age groups, being attracted to the shop. They consist of three age groups: OV1 (age 15-24); OV2 (age 25-35) and OV3 (age above 35). Each variable is associated with several terms. The definition of input and output variables are shown in Appendix B.

The interviewees are required to indicate their views towards the variables which will be expressed in percentage terms according to the specified formulas to elaborate the linguistic variables. Maximum, mean and minimum values of terms are recorded and will be adopted in later inferencing. A descriptive statistical table of linguistic variables together with terms is presented in Appendix C.

For example, see IV_{15} in Appendix C. Experts consider that a shop's *youth image* is said to be *mature* if 65% to 85% of the goods found in the shop are *mature* – where a *mature good* is defined as one that shoppers aged above 35 may find interest in. The mean of all 10 experts' opinions is 76%. This would give an overall triangular distribution of: 65%, 76%, and 85%; against which the membership function of 0.0; 1.0; and 0.0 could be assigned respectively. Given this triangular distribution, any shop with a certain percentage of mature goods found inside the shop (ranging from

65 to 85%) could be assigned, by interpolation, a "degree" of membership (from 0 to 1) to the *mature* image.

RULE BASE

Rules of experience constitute the inference engine which is applied to the shops in estimating their drawing power. In this paper, the rules are categorized by trades, namely restaurant, fashion, beauty, jewelry, gift/ furniture, electrical appliance, store/ supermarket and retail services. They are then subcategorized with other aspects, such as image, quality, pricing, branding, goods variety and shop size. 30 rules (as listed in Appendix D) have been formulated and are considered to cover most, if not all, daily situations. The outcome of each rule is the experts' rules of thumb applied in their practices.

For example in Appendix D, Rule 1 – the Youngsters' Café Rule – could be read as follows:

IF the shop's youth image is *teenagers* or *youngster*; AND goods quality is *bad* or *just okay*; and pricing competitiveness is *very cheap* or *cheap*; AND branding is *unknown brand* or *local unpopular* or *local popular* or *international*; AND goods variety is *limited*; AND trade is *restaurant/entertainment*; AND shop size is *tiny* or *small* or *normal*; AND location is *easy to access* or *convenient* or *very convenient*; then the shop's attractiveness to teenagers (age 15-24) is *very high*; AND to middle age (25-45) is *medium*; AND to mature customers (above 45) is *very low*.

How applicable Rule 1 is to a specific shop would depend on (a) the degree of membership of each individual IVs, as assessed in the previous section on fuzzification ; and (b) the use of the Max-Min Rule. i.e. choosing the maximum of the various degrees of membership wherever the logical syntax in-between the IVs (or groups of IVs) is OR; and minimum when it is AND.

PEDESTRIAN FLOW

In this paper, three regional shopping centres in Hong Kong are chosen to study, namely Festival Walk, Langham Place and Pacific Place. All of them share many characteristics in common, such as similar size and scale, managed by leasing and property management professionals, attached to railway/ subway, office buildings attached, etc. These help control the external factors of the subjects.

The main objective of the fuzzy model is to evaluate the pedestrian flow at a particular point in a shopping centre with the estimated attractiveness of individual shops. Membership functions of intangible variables of individual shops are assessed and

then incorporated into the inference engine. An index representing the drawing power of each individual shop is derived accordingly. It is possible that more than one shop would have an impact on a particular measuring point. Hence, three principles are established to select shops with drawing power that would heavily affect the pedestrian flow at the measuring point. These three principles are used in the following order:

1. Select shops with entrances visible from the measuring point.
2. Choose those with entrances within 10m from the measuring point;
3. Select the best three shops – those with the highest drawing power to customers.

A measuring point in Festival Walk is chosen to demonstrate this method. The selected point is at LG1 with a pedestrian flow count of 801 shoppers per a 10-minute interval. The nearest three shops fitting all the above mentioned principles are Page One, Festival China and Cour Carre.

Page One is a book shop with a lettable area approximately 12,600 square feet. It is internationally reputable and adopts a premium pricing strategy. Combined with its wide range of book selection, its marketing strategy focuses on middle class customers with relatively strong purchasing power. Experts' assessment extracted from the questionnaire and its membership functions are summarized in Table 1.

Table 1: Assessment of membership functions of Page One

Linguistic variable	Experts' assessment	Input variable	Membership function
Image	50%	IV_{14}	0.94
Goods quality	45%	IV_{24}	0.71
Pricing	110%	IV_{34}	0.68
Brand name	60%	IV_{44}	0.67
Variety	160%	IV_{54}	0.56
Trade	30%	IV_{62}	0.94
Area	126%	IV_{75}	**0.38**
Location	60%	IV_{82}	0.91

Applying the Max-Min operation, the output strength is 0.38 and the combination of assessments complies with Rule 24 – Large Toy/Book/Music Shop Rule. According to the rule, three output variables are $OV_{15,}$ OV_{24} and $OV_{34.}$ In order to assess the implication of the three output variables, they are defuzzified with the calculation of centroids of the outputs. The defuzzification results of $OV_{1,}$ OV_2 and OV_3 are 69.7%, 66.4% and 61.5% respectively. It could be interpreted as 69.7% of shoppers aged 15 to 24, 66.4% of shoppers aged 25 to 35; and 61.5% of shoppers aged above 35 are "pulled" towards Page One respectively. According to the experts' opinions, the

proportion of the three age groups in shopping centres is approximately 1:2:1. A weighted average index for the shop pedestrian is calculated as 0.66.

Festive China is a local traditional Chinese restaurant, with a lettable area approximately 7,000s.f. Compared with existing nearby competitors, its pricing strategy is positioned at the middle-mass market, providing quality food and beverages at affordable price levels. Food choice is plentiful, although limited to "Chiu Chow" cuisine. The assessment of the shop variable experts' assessment and its representative membership functions are shown in Table 2.

Table 2: Assessment of membership functions of Festive China

Linguistic variable	Experts' assessment	Input variable	Membership function
Image	50%	IV_{14}	0.94
Goods quality	45%	IV_{23}	0.71
Pricing	90%	IV_{33}	0.94
Brand name	30%	IV_{43}	**0.39**
Variety	50%	IV_{52}	0.91
Trade	20%	IV_{61}	0.71
Area	70%	IV_{74}	0.50
Location	60%	IV_{82}	0.91

The assessments conform to Rule 2 – the Young Restaurant Rule. The output strength is 0.39. After defuzzification, the results for OV_1, OV_2 and OV_3 are 14.3%, 66.5% and 42.0% respectively. It could be interpreted as 14.3%, 66.5% and 42.0% of shoppers aged 15 to 24, 25 to 35, and above 35 are "pulled" towards Festive China respectively. The pedestrian index at the point is 0.47.

Cour Carre is a local fashion chain store with a lettable area approximately 1,630s.f. It targets at middle-income working class. Compared with other chain fashion stores, its goods quality and pricing level are reasonable, even though the choices are relatively limited. The assessment of the shop variable experts' assessment and its representative membership functions are given in Table 3.

Table 3: Assessment of membership functions of Cour Carre

Linguistic variable	Experts' assessment	Input variable	Membership function
Image	30%	IV_{13}	1.0
Goods Quality	40%	IV_{24}	0.94
Pricing	85%	IV_{33}	0.63
Brand Name	35%	IV_{43}	0.77
Variety	50%	IV_{52}	0.91
Trade	50%	IV_{63}	0.83
Area	16%	IV_{72}	**0.53**
Location	60%	IV_{82}	0.91

The assessments comply with Rule 11 – the Reasonably Priced Small Popular Fashion Shop Rule. The output strength is 0.53. The defuzzification results of $OV_{1,}$ OV_2 and OV_3 are 14.9%, 46.0% and 42.8% respectively. It could be interpreted as 14.9%, 46.0% and 42.8% of shoppers aged 15 to 24, 25 to 35, and above 35 are "pulled" towards Cour Carre respectively. The pedestrian index generated by Cour Carre at the point is 0.37.

The combined pedestrian index, through summation of three individual indices at the point, is 1.50, with the assumption that the pedestrian drawing power of individual shops is independent from each other. By applying the same methodology, the combined pedestrian indices at other testing points are estimated.

VALIDITY

Three shopping centres (Festival Walk, Pacific Place and Langham Place) have been selected for testing the validity. Combined Pedestrian Index at each particular point was evaluated with the similar mechanism. They are tested against the pedestrian flow at each point using regression models. It is expected that there will be a significant relationship between shop attractiveness (represented by the index) and the pedestrian flow. The results are given in Tables 4-6.

Table 4: Festival Walk

Dependent Variable: Pedestrian Flow PEDP

Sample Size: 53

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Combined Pedestrian Index	481.872	52.350	9.205	0.000
C	70.009	49.144	1.425	0.160
R-squared	0.624255	Mean dependent var		494.874
Adjusted R-squared	0.616887	S.D. dependent var		198.466
S.E. of regression	122.8426	Akaike info criterion		12.497
Sum squared resid	769605.3	Schwarz criterion		12.571
Log likelihood	-329.1623	F-statistic		84.730

The pedestrian flow at 54 measuring points of Festival Walk has been counted and tested against the combined pedestrian index. The model is statistically significant at the 99% confidence level (i.e. $p<0.01$) with adjusted R-squared of 0.62. Combined pedestrian index is identified as significant at the 0.01 level.

Table 5: Langham Place

Dependent Variable: Pedestrian Flow PEDP

Sample Size: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Combined Pedestrian Index	719.553	74.772	9.623	0.000
C	-28.275	70.049	-0.404	0.689
R-squared	0.687985	Mean dependent var		578.705
Adjusted R-squared	0.680556	S.D. dependent var		357.647
S.E. of regression	202.1396	Akaike info criterion		13.500
Sum squared resid	1716137	Schwarz criterion		13.581
Log likelihood	-295.004	F-statistic		92.609

The pedestrian flow at 44 measuring points of Langham Place has been counted and tested against the combined pedestrian index. The model is statistically significant at the 99% confidence level (i.e. $p<0.01$) with adjusted R-squared of 0.68. Combined pedestrian index is identified to be significant at the 0.01 level.

Table 6: Pacific Place

Dependent Variable Pedestrian Flow PEDP
Sample Size: 34

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Combined Pedestrian Index	477.332	61.693	7.737	0.000
C	-153.784	59.166	-2.599	0.014
R-squared	0.651659	Mean dependent var		271.221
Adjusted R-squared	0.640774	S.D. dependent var		213.865
S.E. of regression	128.1809	Akaike info criterion		12.602
Sum squared resid	525770.6	Schwarz criterion		12.692
Log likelihood	-212.2303	F-statistic		59.864

The pedestrian flow at 34 measuring points of Pacific Place has been counted and tested against the combined pedestrian index. The model is statistically significant at the 99% confidence level (i.e. $p<0.01$) with adjusted R-squared of 0.64. Combined pedestrian index is identified to be significant at the 0.01 level.

Results of all three models have demonstrated a significant relationship between the combined pedestrian index and the pedestrian flow. By comparing the fuzzy indices assessed at different points within the same retail development, the shop attractiveness map / pattern would be estimated.

A regression model, compiling all of the above data, is set up to test the predictive power of the indices on the actual pedestrian flow at particular points. The dependent variable is the pedestrian flow at particular points (PED_P), while independent variables are the Combined Pedestrian Index (INDEX) and the Centre's Pedestrian Flow (PED_C). PED_C represents the factor of total pedestrians being drawn under the influence of the overall setting of the shopping centre, while INDEX represents the drawing power of particular points.

Table 7: Pedestrian flow forecast

Dependent Variable PEDP

Sample Size: 131

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Centre's Pedestrian Flow: PEDC	0.548254	0.07314	7.495995	0.000
Combined Pedestrian Index INDEX	573.3924	41.49664	13.8178	0.000
C	-401.5748	63.36572	-6.337414	0.000
R-squared	0.654326	Mean dependent var		464.9835
Adjusted R-squared	0.648924	S.D. dependent var		290.2337
S.E. of regression	171.9682	Akaike info criterion		13.1551
Sum squared resid	3785353	Schwarz criterion		13.2210
Log likelihood	-858.6611	F-statistic		121.1453

The model is statistically significant at the 99% confidence level (i.e. $p<0.01$) with adjusted R-squared of 0.65. Two independent variables are identified to be significant at the 0.01 level. The model shows significant predictive power on the actual pedestrian flow within the retail development.

CONCLUSION

Fuzzy logic has been widely adopted in pedestrian flow simulation models in various scenarios, such as railway stations and stadiums. The established simulation models are mainly designed for emergency purpose only, with very few applications for commercial uses.

This paper is the first to adopt fuzzy logic to assess shop attractiveness within a shopping centre. The results are positive and a map of shop attractiveness would be drawn. The assessment of the performance of different tenant mix schemes would be carried out systematically beforehand and does not need to be relied solely on the experience of the leasing manager. This method is, therefore, potentially beneficial to developers of shopping centres.

Although positive results have been obtained, there are several limitations:

1. The combined pedestrian index was assessed with the assumption that the pedestrian drawing power of individual shop is independent from each other. The

combined drawing power might have been overestimated. Further study of integration of shop attractiveness is suggested.

2. Shop attractiveness is not the sole factor affecting the pedestrian flow of a shopping centre. A comprehensive system should also include other significant tangible factors, such as location, size, shape, layout, number of floors and number of shops, etc.

To assess the overall performance of shopping centres, both tangible and intangible attributes should be taken into account. Compared to shop attractiveness, other factors are more tangible and would be included into a regression-expert system. The system will be desirable for real estate investors, developers, shop tenants and designers, which will allow them to modify the alternative design and tenant mix schemes in the early development stage, without going through the pain of the trail and error stage.

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Appendix A: Individual shop attractiveness assessment

Individual Shop Attractiveness Assessment

Q1. What are the best figures to describe the following five catalogues of shop youth image?
Please indicate your responses in the following boxes.

** Image is defined as the % of mature goods (shopper's age > 35 may be interested on that goods) found in the shop

Teenagers	%
Youngster	%
Young	%
Adult	%
Mature	%

Q2. What are the best figures to describe the following six catalogues of goods quality?
Please indicate your responses in the following boxes.

** Quality is defined as [Material quality + workmanship quality + design concept quality] x 100%

where

Material quality	=	amount of money paid for extra material for better quality than the norm / total material price for the norm x 100%
Workmanship quality	=	amount of money paid for extra workmanship for better quality than the norm / total workmanship price for the norm x 100%
Design concept quality	=	amount of money paid for extra design concept effort for better quality than the norm / total price for design concept effort for the norm x 100%

Bad	%
Just Okay	%
Reasonable	%
Above average	%
Good	%
Prestige	%

Q3. What are the best figures to describe the following six catalogues of shop pricing competitiveness?
Please indicate your responses in the following boxes.

** Pricing competitiveness is defined as [Normal anticipated pricing in the shop / average market price expectation of the same type of goods] x 100%

Very cheap	%
Cheap	%
Okay	%
Reasonable	%
Expensive	%
Luxury	%

Q4. What are the best figures to describe the following five catalogues of shop branding?
Please indicate your responses in the following boxes.

** Branding is defined as [Proportion of shoppers knowing the brand name / Proportion of shoppers knowing the most famous brand name] x 100%

Rarely heard	%
Local	%
Local popular	%
International	%
Prestige	%

Q5. What are the best figures to describe the following four catalogues of goods variety in the shop?
Please indicate your responses in the following boxes.

** Variety is defined as [Normal anticipation of the choices of goods in the shop / Normal anticipation of choices of goods in typical shops] x 100%

Limited choices	%
Average	%
Plenty	%
Abundant	%

Q6. What are the best figures to describe the attractiveness of the following trades?
Please indicate your responses in the following boxes.

** Attractiveness of trade is defined as the [No. of visitor of the shop/ Total no. of visitors of shopping centre] x 100%

Restaurant/entertainment (Trade 1)	%
Book/music/furniture/toy (Trade 2)	%
Fashion/ sports (Trade 3)	%
Beauty/ Jewelry /AV shops (Trade 4)	%
Supermarket/store/retail services (Trade 5)	%

Q7. What are the best figures to describe the following five catalogues of shop size?
Please indicate your responses in the following boxes.

** Size is defined as [Shop size in shopper impression / 10,000sf]

Tiny	%
Small	%
Normal	%
Large	%
Very large	%

Q7. What are the best figures to describe the following five catalogues of shop location in term of convenience?
Please indicate your responses in the following boxes.

** Location is defined as [Travel time from the main entrance to the shop / travel time from the main entrance to the most distant shop]

Very inconvenient	%
Inconvenient	%
Normal	%
Convenient	%
Very inconvenient	%

Appendix B: Input and Output Variables of the Fuzzy Expert System

Input Variable	Description	Term
IV_1 – Shop youth image	Shoppers' general impression on the youth image of the shop Represented formula: % of mature goods (i.e. age of shopper > 35 may be interested) found in the shop	IV_{11} – teenagers
		IV_{12} – youngster
		IV_{13} – young
		IV_{14} – adult
		IV_{15} – mature
IV_2 – Goods quality	Shoppers' general impression on the quality of the goods sold - Represented formula[1]: (Material quality + workmanship quality + design concept quality), where: Material quality = (amount paid for extra materials for better quality than the norm/ total material price for the norm) x 100% Workmanship quality = (amount paid for extra workmanship for better quality than the norm/ total workmanship price for the norm) x 100% Design concept quality = (amount paid for extra design concept quality for better quality than the norm/ total price for design concept effort for the norm) x 100%	IV_{21} – bad
		IV_{22} – Just okay
		IV_{23} – reasonable
		IV_{24} – above average
		IV_{25} – good
		IV_{26} – prestige
IV_3 – Pricing competitiveness	Shoppers' general impression on pricing competitiveness of goods sold Represented formula: (Normal anticipated pricing in the shop / average market price expectation of the same type goods) x 100%	IV_{31} – very cheap
		IV_{32} – cheap
		IV_{33} – okay
		IV_{34} – reasonable
		IV_{35} – expensive
		IV_{36} – luxury
IV_4 – Branding	General impression from shoppers on the brand name of the shop Represented formula: (Proportion of shoppers knowing the brand name / proportion of shoppers knowing the most famous brand	IV_{41} – rarely heard
		IV_{42} – local unpopular
		IV_{43} – local popular

[1] With reference to the methodology suggested by Ng et al. (2002)

	name) x 100%	IV_{44} – international
		IV_{45} – prestige
IV_5 – Goods Variety	General impression from the shoppers on the variety of the goods sold in the shop Represented formula: (Normal anticipation of the choice of goods of the shop/ Normal anticipation of choice of goods in typical shop) x 100%	IV_{51} – limited
		IV_{52} – average
		IV_{53} – plenty
		IV_{54} – abundant

IV_6 – Trading	The drawing power on shoppers by the nature of the shop trade trade 1 – restaurant / entertainment; trade 2 –books, gift, music and similar goods; trade 3 –fashion, sports and similar goods; trade 4 –beauty cosmetic, jewelry, audio & video, & other luxuries trade 5 – supermarket Represented formula: (No. of visitor of the shop/ Total no. of visitors of shopping centre) x 100%	IV_{61} – trade 1
		IV_{62} – trade 2
		IV_{63} – trade 3
		IV_{64} – trade 4
		IV_{65} – trade 5
IV_7 – Shop size	Shoppers' impression on shop size Represented formula: (Shop size in shopper impression / 10,000sf) x 100%	IV_{71} – tiny
		IV_{72} – small
		IV_{73} – normal
		IV_{74} – large
		IV_{75} – very large
IV_8 – Location	Shopper impression on the convenience of shop location Represented formula: (Travel time from main entrance/ Travel time to visit the most distant shop) x 100%	IV_{81} – very inconvenient
		IV_{82} – inconvenient
		IV_{83} – normal
		IV_{84} – convenient
		IV_{85} – very convenient

Output Variable	**Description**	**Term**
OV_1	How many shoppers in the age group between 15 and 24 are attracted to the shop Represented formulas: Number of shoppers (for the age group between 15 and 24) visiting the shop/Total number of shoppers visiting the shopping centre	OV_{11} – very low
		OV_{12} – low
		OV_{13} – medium
		OV_{14} – High
		OV_{15} – Very high
OV_2	How many shoppers in the age group between 25 and 34 are attracted to the shop Represented formulas: Number of shoppers (for the age group between 25 and 34) visiting the shop/ Total number of shoppers visiting the shopping centre	OV_{21} – very low
		OV_{22} – low
		OV_{23} – medium
		OV_{24} – High
		OV_{25} – Very high

OV_3	How many shoppers in the age group above 35 are attracted to the shop	OV_{31} – very low
	Represented formulas:	OV_{32} – low
	Number of shoppers (for the age group above 35) visiting the shop/	OV_{33} – medium
	Total number of shoppers visiting the shopping centre	OV_{34} – High
		OV_{35} – Very high

Appendix C: Statistical summary of expert opinion on intangible variables

Intangible Variable	Term	Minimum	Mean	Maximu
1. Shop youth image	IV_{11} – teenagers	0%	5%	15%
	IV_{12} – youngster	5%	12%	25%
	IV_{13} – young	15%	30%	40%
	IV_{14} – adult	30%	49%	65%
	IV_{15} – mature	65%	76%	85%
2. Goods quality	IV_{21} – bad	0%	6%	15%
	IV_{22} – Just okay	5%	15%	25%
	IV_{23} – reasonable	20%	32%	40%
	IV_{24}– above average	25%	41%	55%
	IV_{25} – good	40%	53%	65%
	IV_{26} – prestige	60%	77%	90%
3. Pricing	IV_{31} – very cheap	20%	36%	50%
	IV_{32} – cheap	50%	69%	80%
	IV_{33} – okay	75%	91%	110%
	IV_{34} – reasonable	80%	103%	125%
	IV_{35} – expensive	125%	140%	160%
	IV_{36} – luxury	150%	170%	200%
4. Branding	IV_{41} – unknown brand	0%	3%	10%
	IV_{42} – local unpopular	5%	11%	30%
	IV_{43} – local popular	25%	38%	55%
	IV_{44} – international	45%	55%	70%
	IV_{45} – prestige	65%	81%	95%
5. Goods Variety	IV_{51} – limited	15%	35%	50%
	IV_{52} – average	30%	52%	80%
	IV_{53} – plenty	50%	75%	120%
	IV_{54} – abundant	120%	144%	180%
6. Trading	IV_{61} – trade 1	5%	16%	30%
	IV_{62} – trade 2	15%	29%	45%
	IV_{63} – trade 3	35%	47%	65%
	IV_{64} – trade 4	50%	68%	80%
	IV_{65} – trade 5	50%	77%	100%
7. Shop size	IV_{71} – tiny	1%	4%	10%
	IV_{72} – small	5%	13%	20%
	IV_{73} – normal	15%	26%	40%
	IV_{74} – large	35%	60%	80%
	IV_{75} – very large	70%	86%	150%

8. Location	IV_{81} – very inconvenient	65%	84%	100%
	IV_{82} – inconvenient	50%	61%	75%
	IV_{83} – normal	28%	36%	50%
	IV_{84} – convenient	10%	17%	32%
	IV_{85} – very convenient	5%	9%	15%
Intangible Variable	Term	Minimum	Mean	Maximum
1. Output Variable I	OV_{11} – very low	5%	14%	25%
(Age group 1)	OV_{12} – low	10%	24%	40%
	OV_{13} – medium	30%	44%	55%
	OV_{14} – high	45%	60%	75%
	OV_{15} – very high	50%	74%	90%
2. Output Variable II	OV_{21} – very low	10%	18%	25%
(Age group 2)	OV_{22} – low	15%	25%	35%
	OV_{23} – medium	30%	49%	60%
	OV_{24} –high	50%	67%	85%
	OV_{25} –very high	60%	73%	80%
3. Output Variable III	OV_{31} – very low	5%	14%	20%
(Age group 3)	OV_{32} – low	15%	23%	35%
	OV_{33} – medium	30%	43%	55%
	OV_{34} –high	50%	61%	75%
	OV_{35} –very high	50%	71%	85%

Appendix D: Rule base – 30 rules