# Risk Assessment in Real Estate Development: An Application of Analytic Network Process

# การประเมินความเสี่ยงในการพัฒนาโครงการอสังหาริมทรัพย์ โดยประยุกต์ใช้การวิเคราะห์แบบเครือข่าย

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**Abstract**

A novel analysis approach to support real estate developers in making decision to deal with potential risks in each project development stage is introduced in this paper. The analysis model applied in this research is a multi-criteria approach, based on Analytic Network Process (ANP) theory. Risk assessment criteria to accomplish the ANP calculation are defined based on both literature review and related experience, against Social, Technological, Economic, Environmental and Political (STEEP) requirements of the real estate development in order to assess the risks in this business effectively. A case study of a residential and commercial mixed-use project in Liverpool City Centre was used to demonstrate the effectiveness of the ANP model. The result of an initial case study revealed that ANP is an effective tool to support developers in making decision based on risks assessment. It was found through this study that the established ANP model is effective and can be adopted by real estate developers to suit for the business needs.

**บทคัดย่อ**

บทความฉบับนี้นำเสนอต้นแบบวิธีการวิเคราะห์ที่ช่วยสนับสนุนการตัดสินใจโดยใช้หลักการการตัดสินใจบนหลายปัจจัย (Multi Criteria Decision Making–MCDM) เพื่อช่วยผู้ประกอบการอสังหาริมทรัพย์ในการตัดสินใจพัฒนาโครงการโดยคำนึงถึงปัจจัยผลกระทบด้านความเสี่ยงของโครงการด้วย ในการนำเสนอดังกล่าวนั้น ทางผู้วิจัยได้ใช้ต้นแบบหรือแบบจำลองการวิเคราะห์แบบ Analytic Network Process (ANP) และใช้มาตรฐานการวัดความเสี่ยงโดยอ้างอิงปัจจัย STEEP ที่ประกอบไปด้วย ปัจจัยความเสี่ยงด้านสังคม เทคโนโลยี เศรษฐกิจ สิ่งแวดล้อม และนโยบายภาครัฐ เพื่อใช้ประกอบในการสร้างแบบจำลองวิเคราะห์ต่อไป ทั้งนี้ผู้วิจัยได้ใช้กรณีศึกษาตัวอย่างโครงการพัฒนาอสังหาริมทรัพย์ในเมืองลิเวอร์พูล ประเทศสหราชอาณาจักร เพื่อทดสอบประสิทธิภาพของแบบจำลองวิเคราะห์การตัดสินใจพัฒนาโครงการโดยคำนึงถึงปัจจัยด้านความเสี่ยงต่าง ๆ จากการวิจัยเบื้องต้นพบว่าแบบจำลองต้นแบบนี้สามารถช่วยให้ผู้ประกอบการตัดสินใจเลือกโครงการที่จะพัฒนาได้อย่างมีประสิทธิภาพมากขึ้น และตัวแบบจำลองดังกล่าวสามารถนำไปพัฒนาต่อยอดให้สอดคล้องกับความต้องการของภาคธุรกิจอสังหาริมทรัพย์ต่อไปในอนาคต

**Keywords**

Analytic Network Process (ANP) (กระบวนข่ายงานการวิเคราะห์)
Real Estate Development (การพัฒนาอสังหาริมทรัพย์)
Risk Assessment (การวิเคราะห์ความเสี่ยง)
STEEP Factors (ปัจจัยที่มีผลต่อการพัฒนาอสังหาริมทรัพย์ ได้แก่ ปัจจัยทางสังคม เทคโนโลยี เศรษฐกิจ สภาพแวดล้อม และนโยบายภาครัฐ)

## 1. Introduction

Risks and uncertainties are always occurred in all real estate development projects, particularly in the complicated real estate project. Risks can strongly influence each project stage from the project conceptual design, project feasibility analysis, design and planning, bidding and tendering, construction and execution, and handover stage. The risk management process is generally an ongoing and iterative process, even each real estate project is different and unique. The typical approach of project risk management consists of three basic steps, which are; Risk Identification and Initial Assessment, Response and Mitigation, and Risk Analysis (Khalafallah, Taha, & El-Said, 2005).

Risks in real estate development business are arisen by several factors e.g. Social, Technological, Economic, Environmental and Political factors or "STEEP" as defined by Morrison (2007), Gehner, Halman, & Jonge, (2006), and Clarke and Varma (1999). For example, risks in real estate development have been considered, in relation to the separation of design from construction, lack of integration, poor communication, uncertainty, changing environment and increasing project complexity and economic changes such as inflation and deflation, and regional economic crisis including greater competition in this business. Thus, risks and their consequence caused by STEEP factors, must be considered and should not be underestimated, since those risks will impact overall project management processes, in regard to project programme delay, project cost overrun and the usage of the property, which cause a huge lost in project income.

Frodsham (2007) defined that the nature of real estate projects are mostly income generated properties. This paper therefore emphatically focused on the risks, which are necessary concerned when developers conduct the project feasibility analysis, because feasibility analysis is a significant tool to assess the real estate projects' vitality in regard to forecast uncertainties towards Return on Investment (ROI) in term of income stream.

The existing "Risk Matrix" method, is generally accepted by real estate developers as the practical risk assessment tool to assess the consequences of risks (Kindinger, 2002; IoMosaic, 2002). Younes and Kett (2007) used the investment of hotels to explain the capability of Risk Matrix, which is also accepted particularly in the real estate investment. However, the data used for matrix calculation are derived from either panel discussion or ranking method, which mostly rely on personal opinion rather than using quantitative measurements, and do not use reliable tools or instruments with strong theoretical basis. (See Figure 1). Another inconvenience is that the risk matrix does not allow the comparison of each criterion. Also, the results calculated by matrix are normally subjective and do not provide the details of data to help the practitioners to structure their decision- making process. This is because risk factors are numerous, particularly in large real estate projects, and the ability of humans to assess many factors at the same time is very limited (He, 1995).

Additionally, due to the "income generated" characteristics of real estate project, developers also assess the risks by measuring the investment return. Many financial ratios such as capitalization rate, Net Operating Income, Profit / Equity (P/E ratio) and discount rate (Sagalyn, 1990) are raised in project feasibility as the tools to forecast the income generated and loss in real estate project. However, Wheaton et al. (2001) and Hendershott, H. P. and Hendershott, J. R. (2002) argued that prior to construe these financial ratios, the developers mostly depend on the past and subjective information which are inaccurate to predict the future risks and the value of the new established real estate project.

According to the results of Investment Property Forum (IPF) survey in UK real estate industry, Frodsham (2007) revealed that real estate risks could be managed within an overall frame-

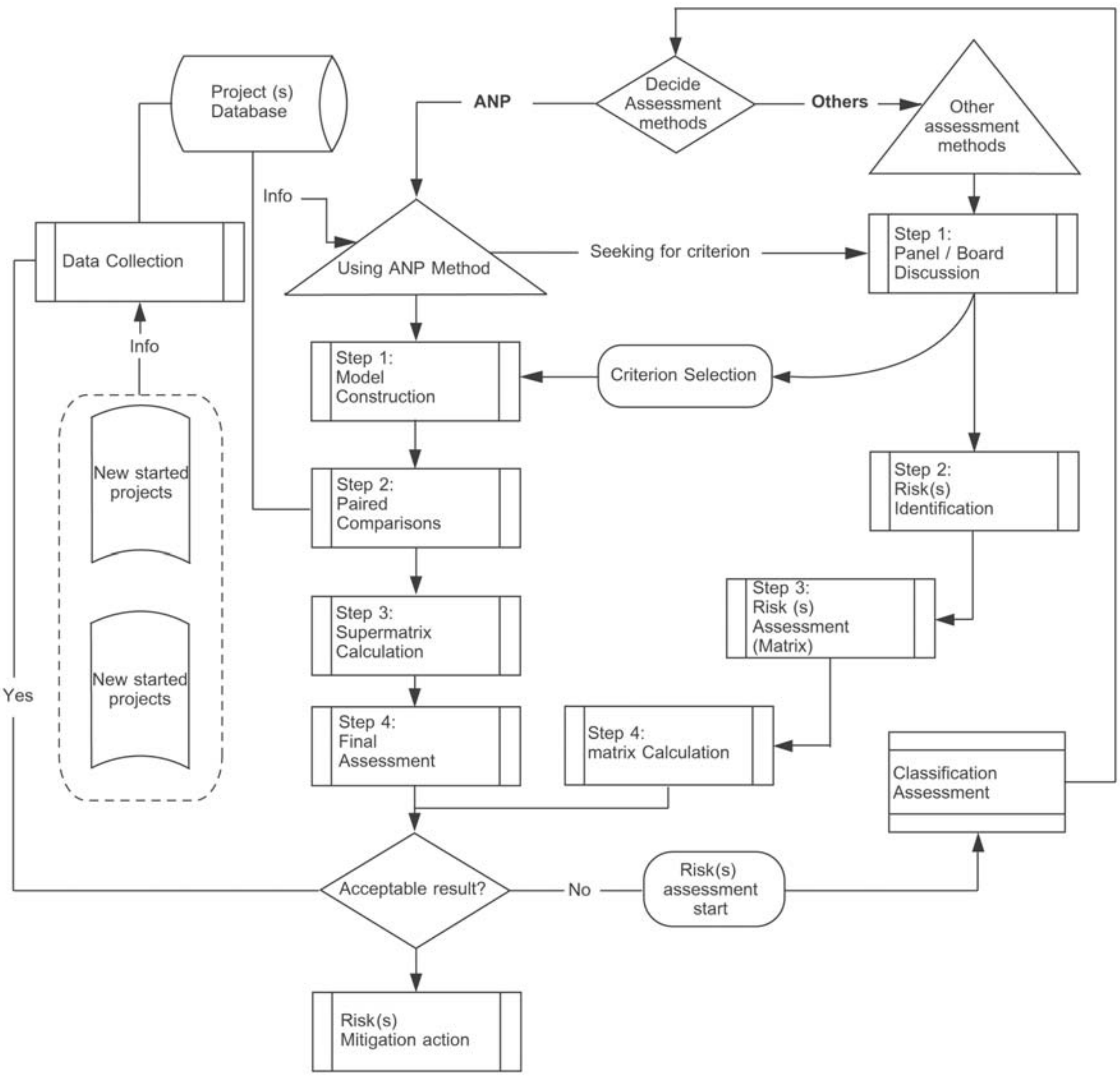


**Figure 1.** ANP and existing risk assessment model. (Applied from Khumpaisal, 2007)

work of risk management processes, those risks shall apply a variety of complimentary approaches, which are grounded in a rigorous and preferably quantitative framework. Therefore, the risk management processes shall include an assorted mix of "Quantitative statistical framework" as well as several techniques such as stress testing and a rigorous analysis of subjective issue. Booth, Matysiak, & Ormerod (2002) suggested that in order to assess risks and their consequences, the practitioners shall use the practical tools, which provided the results in a numerical format. The desirable methodology for this real estate development should allow for the synthesis of the criterion, comparisons of each factor and to help developers structure the decision making process. Thus, it could be concluded that risk assessment process in the real estate development shall be supported by the modern method of mathematical statistics (Titarenko ,1997)

This paper introduces an application of Analytic Network Process (ANP) model to support the decision-making towards risk assessment in real estate development against STEEP factors. Saaty (2005) suggested that ANP is the systematic approach, which is able to deal with both quantitative and qualitative factors under multiple criteria. Because this process deals with a multi-criteria analysis and comparison, the process' outcomes are also in statistical format, which could be adopted for further decision making in regard to the risk response and mitigation. A case study of large retail complex in Liverpool City Centre (named "Liverpool One") has been used to demonstrate the effectiveness of the aforementioned analysis model.

## 2. Methodology

Methodologies adopted in this research consist of the extensive literature review and an interview with a real estate practitioner (the project manager) to gain his opinions/judgements in regard to current situation in risk assessment for real estate development, following by the data analysis to support ANP model. Finally, a residential and commercial mixed-used project in Liverpool City Centre was used to demonstrate the effectiveness of the ANP model to support decision-making in feasibility study for real estate development. A comparison between the existing risk assessment model and ANP is illustrated in Figure 1

Figure 1 illustrates the traditional risk assessment method compared with the adoption of ANP method to assess risks in real estate development projects. The risk assessment process starts at the selection of an appropriate method, which depend on the characteristics of a specific problem and the preference of decision-makers. Risk classification is necessary to define risk assessment criteria. In case of using traditional method, the first step is to conduct a panel/board discussion about risks that affect the project, while each participant uses his/her experience to identify or classify predictable risk events. IoMosaic (2002), Kindinger (2002) and Rafele, Hillson and Grimalai (2005) indicated that the next step is to set up an assessment method, and the current practice is mostly to build a matrix for risk assessment. This matrix is therefore used to describe the likelihood and consequence of each risk in the tabular format. As a result of using the matrix, the panel may find the degree of overall risk events. However, the results derived by matrix assessment method are neither based on non-linear mathematic calculation nor objective assumptions related to a real business case.

## 3. Analytic Network Process (ANP) Backgrounds

Analytic Network Process (ANP) was introduced as the idealistic risk assessment tool in this paper. This model adopts the principles of Multi Criteria Decision Making (MCDM) and was developed based on the grounded theories of Analytic Hierarchy Process (AHP). The ANP model is a powerful and flexible decision making tool that helps investors or decision makers set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered (Saaty, 2005; Chen et al., 2006). The model has been used in several areas of construction research and practice since the late 1970s including construction planning, location selecting, and environmental impact assessing (Chen, Li, & Wong, 2005; Chen et al., 2006). These studies had shown that ANP model is an effective model to assess risks.

Saaty (2005) and Chen et al. (2006) summarised the construction of the ANP model as follows:

- Decomposing the problem into a hierarchy in which the highest level of the structure denotes the primary goal of the problem and the lowest level refers to the alternatives;
- Inviting experts to conduct pair-wise comparisons of each element with respect to their respective adjacently higher level. The interval scale employed in this pair-wise is mostly the 9-point scale of measurement;
- Calculating the relative importance weights (eigenvectors) in each pair-wise comparison matrix and computing the consistency of the comparison matrices;

• Placing the resulting relative importance weights (eigenvectors) in pair-wise comparison matrices within the super-matrix (un-weighted);

• Conducting pair-wise comparisons on the clusters;

• Weighting the unweighted super-matrix, by the corresponding priorities of the clusters, which becomes the weighted super-matrix;

• Adjusting the values in the super-matrix so that it can achieve column stochastic. It means that the decision maker will take the resultant relative importance weights (eigenvectors) and place them into the matrix.

According to the Figure 1 above, in case of ANP selecting, the first step is to develop an ANP model, followed by pair-wise comparison process to form a super-matrix of quantified interdependences between paired criteria and the alternatives of development plan. The results calculated by super-matrix calculation are appropriate to the project team in order to get a numerical suggestion regarding to the most appropriate development plan. The result from ANP is useful to support the decision-making process toward the project risk mitigation. In addition, a project knowledgebase is required to be integrated into the process for using either traditional method or ANP method in order to complete decision-making tasks. The knowledge base provides the adequate and accurate information to achieve reliable results, and the knowledge can be collected from existing or new projects.

## 4. Risk Assessment Criteria

Risk assessment criteria, emphasising on risks and their consequences in real estate development, were set up based on literature review. These assessment criteria were set up based on Social, Technological, Economic, Environmental, and Political factors (STEEP), which are necessary when the developers conduct a project feasibility analysis. Since STEEP factors shall cause the variety of risks throughout each project development stage. In this regard, the assessment criteria including each sub-criterion are summarized in Table 1, which classifies overall on both quantitative and qualitative risks. In addition, it is adopted as the assessment criteria to measure the risks and their impact on the real estate development industry, prior to the Analytic Network Process (ANP) analysis. This table includes five major criteria and their 33 sub-criteria (see Table 1).

## 5. Application of Analyic Network Process (ANP)

The decision-making model proposed in this paper applied ANP to set up the risk assessment at project feasibility study stage. According to the established risks assessment criteria in Table 1, the ANP model herein was based on these 33 defined risk assessment criteria. The model was set up using Super Decisions software for decision-making, created by the Creative Decisions Foundation; and implemented by Saaty (2005). The ANP model comprised 6 clusters and 33 nodes, which was set up accordingly to the criteria and sub-criteria defined in Table 1. The Alternative cluster was used to comprehend alternative plans to be evaluated against risk assessment criteria in a case study; and there are 2 nodes to represent 2 alternative plans for a specific real estate development. ANP method provides an effective mechanism for developers to quantitatively evaluate interrelations between either paired criteria or paired sub-criteria; and this enables the developers to use their expertises to assess all defined risks (see Table 1) occurred in real estate development industry.

The ANP model, as illustrated in Figure 2 consists of 6 clusters which are Alternatives, Environmental Risks, Social Risks, Economic Risks, and Technological Risks. There are 35 nodes inside this ANP model; amongst them, there are 2 nodes inside the Alternative cluster, which are

**Table 1.** Risk assessment criteria for the real estate development.

| Criteria | Sub-Criteria | Evaluation Methods | References |
|---|---|---|---|
| Social Risks | Workforce availability | Degree of Developer's satisfaction to local workforce market (%) | Danter, 2007 |
| | Community acceptability | Degree of benefits for local communities (%) | Danter, 2007 |
| | Cultural compatibility | Degree of business & lifestyle harmony (%) | Danter, 2007 |
| | Public hygiene | Degree of impacts to local public health & safety (%) | CHAI, 2006 |
| Technological Risks | Site conditions | Degree of difficulties in site preparation for each specific plan (%) | Danter, 2007, Saiyarath and Haocharoen, 2009 |
| | Designers and Constructors | Degree of Developer' satisfaction to their performances (%) | Khalafallah, Taha, & El-Said, 2005 |
| | Multiple functionality | Degree of multiple use of the property (%) | Danter, 2007 |
| | Constructability | Degree of technical difficulties in construction (%) | Lam, et al., 2001 |
| | Duration | Total duration of design and construction per 1,000 days (%) | Khalafallah, Taha, & El-Said, 2005 |
| | Amendments | Possibility of amendments in design and construction (%) | Khalafallah, Taha, & El-Said, 2005 |
| | Facilities management | Degree of complexities in facilities management (%) | Moss, Alho, & Alexander, 2007 |
| | Accessibility & Evacuation | Degree of easy access and quick emergency evacuation in use (%) | Moss, Alho, & Alexander, 2007 |
| | Durability | Probability of refurbishment requirements during buildings lifecycle (%) | Chen, 2007 |
| Environmental Risks | Adverse environmental impacts | Overall value of the Environmental Impacts Index | Chen, Li, & Wong, 2005 |
| | Climate change | Degree of impacts to use and value due to regional climatic variation (%) | UNEP, 2007 |
| Economic Risks | Interest rate | Degree of impacts due to increment of loan rate (%) | Sagalyn, 1990; FSA, 2005; Nabarro and Key, 2005; FSB, 2007 |
| | Property type | Degree of location concentration (%) | Adair and Hutchison, 2005 |
| | Market liquidity | Selling rate of same kind of properties in the local market (%) | Adair and Hutchison, 2005 |
| | Currency conversion | Degree of impacts due to exchange rate fluctuation | Morledge, Smith, & Kashiwagi, 2006; FSA, 2005; FSB, 2007 |
| | Demand and Supply | Degree of regional competitiveness (%) | Adair and Hutchison, 2005 |
| | Purchaseability | Degree of affordability to the same kind of properties (%) | http://www.statistics.gov.uk/ |
| | Brand visibility | Degree of Developer's reputation in specific development (%) | D&B, 2007; Adair and Hutchison, 2005; Gibson and Louragand, 2002 |
| | Capital exposure | Rate of estimated lifecycle cost per 1 billion pound (%) | Blundell, Fairchild, & Goodchild., 2005; Moore, 2006 |
| | Lifecycle value | 5-year property depreciation rate (%) | Lee, 2002; Adair and Hutchison, 2005 |
| | Area accessibility | Degree of regional infrastructures usability (%) | Adair and Hutchison, 2005 |
| | Buyers | Expected selling rate (%) | |
| | Tenants | Expected annual lease rate (%) | Booth, Matysiak, & Ormerod, 2002 |
| | Investment return | Expected capitalization rate (%) | Sagalyn, 1990; Watkins, et al., 2004 |
| Political Risks | Political Groups/Activist | Degree of protest by the urban communities (%) | Arthurson, 2001 |
| | Commercial Tax Policy | Rate of Commercial Tax impact (%) | FSB, 2007 |
| | Local Tax Policy | Rate of Council Local Tax (%) | LCC, 2008 (1) |
| | Council Approval | Total Days of construction, design approval process by Liverpool City Council (LCC) | Crown, 2008 (2) |
| | License Approving | Total Days of license approval process | Crown, 2008 (3) |

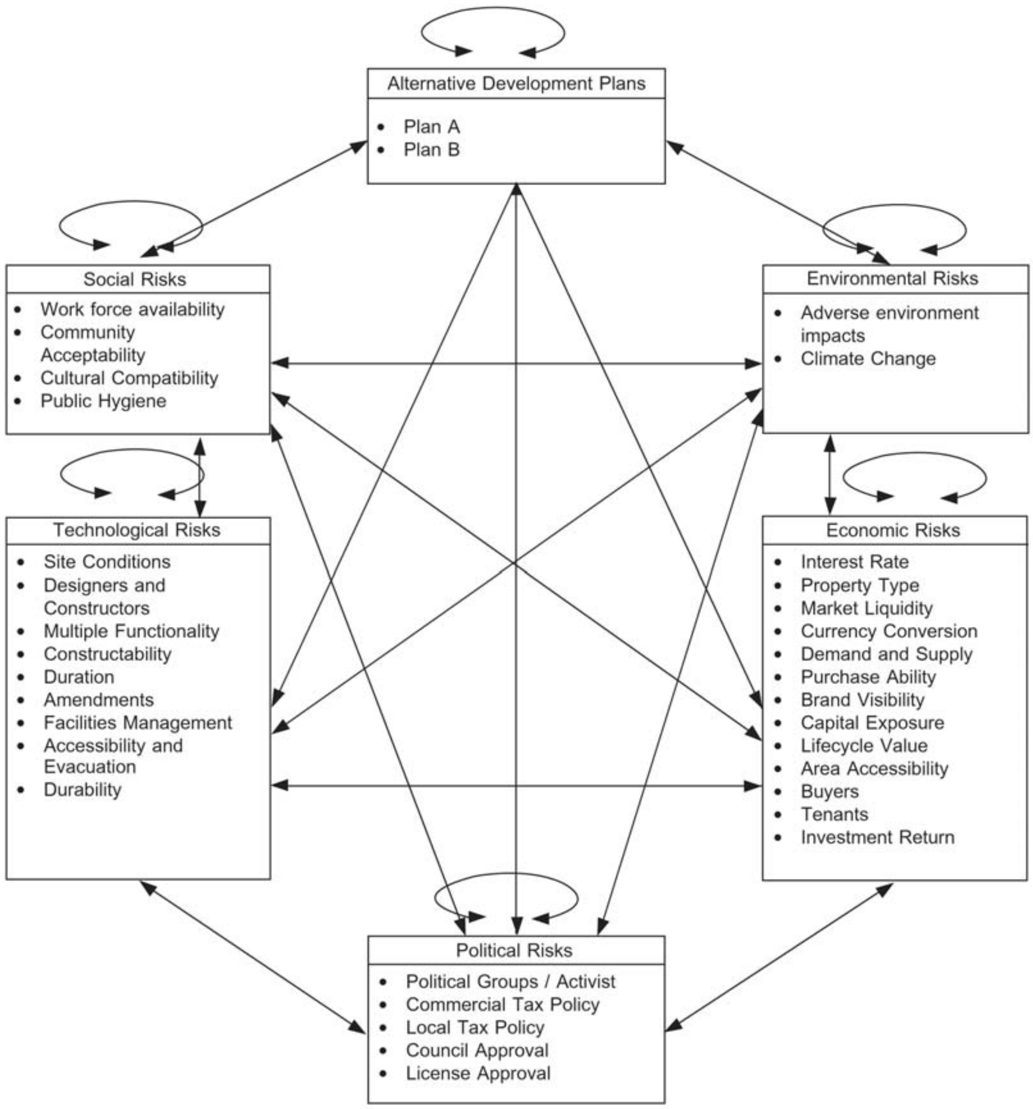


**Figure 2.** ANP model for real estate development risk assessment.

Plan A, and Plan B representing alternative plans for a specific real estate development in Liverpool, in regard to select the most appropriate plan. The other 33 nodes were located in different 5 clusters in accordance with their belongingness to those clusters as described in Table 1. Two-way and looped arrow lines in Figure 2 describe the interdependences that exist between paired clusters as well as nodes (Saaty, 2005 as cited in Chen & Khumpaisal, 2009). In addition, there are fixed interrelations between paired clusters, meanwhile there are fixed interrelations between paired nodes inside one cluster as well as from two different clusters.

In order to measure all interrelations inside the ANP model quantitatively, an interview process with the real estate practitioner has been conducted to compare the relative importance between paired clusters and nodes in order to collect the precise information. This practitioner was a project manager, responsible for planning and cost estimating of the studied project. The interview records gathered from this expert knowledge and information in each specific domain was collected and concentrated into an ANP model. As a result, the ANP model could perform as a decision-making support tool based on knowledge reuse.

**Table 2.** ANP judgements between paired clusters/nodes.

| Clusters/Nodes | | Scale of Pair-wise Comparisons | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ±1 | ±2 | ±3 | ±4 | ±5 | ±6 | ±7 | ±8 | ±9 |
| Cluster I | Cluster J | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |
| Node $I_i$ | Node $J_j$ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |

Note:

1. The fundamental scale of pair-wise judgments: 1 = Not important, 2 = not to moderately important, 3 = Moderately important, 4 = Moderately to strongly important, 5 = Strongly important, 6 = Strongly to very strongly important, 7 = Very strongly important, 8 = Very strongly to extremely important, 9 = Extremely important.
2. The symbol ✗ denotes item under selection for pair-wise judgment, and the symbol ✓ denotes selected pair-wise judgment.
3. I and J denote the number of Clusters, whilst i and j denote the total number of Nodes.
4. The symbol ± denotes importance initiative between compared Nodes or Clusters.

The illustrated ANP model (see Figure 1), structures and quantifies all possible interdependent relations inside the model, and the pair-wise comparison was adopted using subjective judgements made in regard to fundamental scale of pair-wise judgments (Saaty, 2005) were shown in Table 2. The table generally describes how to conduct a pair-wise comparison between paired clusters as well as nodes in regard to their interdependences defined in the ANP model (see Figure 1) and relative importance based on their specific characteristics and experts' knowledge. The ANP model was set up based on the risk assessment criteria to make judgments to quantify interdependences for 33 risk assessment criteria inside cluster 2 to 6 (see Figure 1), and specific characteristics of alternative plans, which were used to make judgments in quantifying interdependences for alternatives in the initial case study.

## 6. Case Study and Results

A case study of a residential and commercial mixed-used project in Liverpool City Centre is used to demonstrate the effectiveness of the ANP model in regard to select the most appropriate plan for a specific real estate development project. A case study was conducted based on information collected from an ongoing real estate project in Liverpool City Centre. Some scenarios such as alternative plans in regard to the requirements of comparison study using ANP were made as the assumption. The proposed real estate development is located in central Liverpool with the site area of 40 acres, located between main retail areas, city central business district (CBD), residential areas, walk streets, main roads, and the historical Albert Dock. The developer partnered with the City Council to revitalise this area for long-term investment in accordance with the Northwest regional and Merseyside County's economic strategies. To complete the initial case study purposes, two development plans are considered in this research, which are: Plan A, a mixed-use property of residential and retail in Liverpool City Centre development; Plan B, a commercial building mixed-use adjacent to inner Liverpool City Centre development (see Figure 3). The scenario was assumed based on the philosophy of local urban regeneration, which aims to attract more population and customers back to Liverpool City Centre, as well as to maximum utilize of the provided transportation and infrastructures. (Mynors, 2006). The researchers employed a face-to-face interview with the practitioner who involved in this studied project to achieve the project information and the developer's opinions in regard to the consequential degree of risks affecting his project. The results of interviewing are therefore indicated in Table 3.

Source: E-Architect (2010)

**Figure 3.** The layout plan of the initial case study.

**Table 3.** Results of alternatives development plan.

| Criteria | Sub-Criteria | Unit | Alternative Development Plans | |
|---|---|---|---|---|
| | | | Plan A | Plan B |
| Social Risks | Workforce availability | % | 90 | **90** |
| | Community acceptability | % | 60 | **50** |
| | Cultural compatibility | % | 70 | **50** |
| | Public hygiene | % | 80 | **50** |
| Technological Risks | Site conditions | % | 60 | **60** |
| | Designers and Constructors | % | 50 | **50** |
| | Multiple functionality | % | 30 | **70** |
| | Constructability | % | 40 | **60** |
| | Duration | % | 95 | **80** |
| | Amendments | % | 60 | **70** |
| | Facilities management | % | 50 | **40** |
| | Accessibility & Evacuation | % | 60 | **70** |
| | Durability | % | 20 | **20** |
| Environmental Risks | Adverse environment impacts | % | 80 | **75** |
| | Climate change | % | 30 | **30** |
| Economic Risks | Interest rate | % | 80 | **90** |
| | Property type | % | 80 | **70** |
| | Market liquidity | % | 80 | **70** |
| | Currency conversion | % | 25 | **25** |
| | Demand and Supply | % | 80 | **60** |
| | Purchase ability | % | 50 | **70** |
| | Brand visibility | % | 80 | **50** |
| | Capital exposure | % | 60 | **60** |
| | Lifecycle value | % | 75 | **50** |
| | Area accessibility | % | 75 | **65** |
| | Buyers | % | 70 | **90** |
| | Tenants | % | 100 | **100** |
| | Investment return | % | 90 | **90** |
| Political Risks | Political Groups / activist | % | 70 | **60** |
| | Commercial Tax Policy | % | 80 | **70** |
| | Local Tax Policy | % | 70 | **60** |
| | Council Approval | % | 95 | **90** |
| | License Approving | % | 50 | **50** |

Notes: PLAN A: Retail-led mixed-use inner Liverpool City Centre

PLAN B: Commercial building led mixed-use adjacent to inner Liverpool City Centre

According to the results in Table 3 above, the practitioner provided his judgements and perceptions to the consequential degree of risks affected to this project. Consequences of each risk are ranked in percentage (%) format, which the higher percentage (%) shows higher risk that affects to each criteria and alternative plans.

As mentioned above, although interdependences among 33 risk assessment criteria can be measured based on experts' knowledge, the ANP model should comprehend all specific characteristics of each alternative plan, which are given in Table 4. According to the fundamental scale of pair-wise judgments (see Table 2), all possible interdependences between each alternative plan and each risk assessment criterion, and between paired risk assessment criteria in regard to each alternative plan were evaluated; Table 2 also provides the result of all these pair-wise comparisons, which were used to form a two-dimensional super-matrix for further calculation. The calculation of super-matrix aimed to form a synthesized super-matrix to allow for resolution of the effects of the interdependences exists between the nodes and the clusters of the ANP model (Saaty, 2005).

In order to obtain useful information for development plan selection, the calculation of super-matrix was conducted following two steps, which are firstly, transform an initial super-matrix or un-weighted one based on pair-wise comparisons to a weighted super-matrix, and then to a synthesized super-matrix. Results from the synthesized super-matrix are given in Table 4, below.

**Table 4.** Comparison or alternatives development plan results.

| Results | Alternative Development Plans | |
|---|---|---|
| | Plan A | Plan B |
| Synthesized priority weights | 0.6326 | 0.3674 |
| Ranking | 1 | 2 |

Alternative plan A is identified as the risky plan for the specific development because it has the higher synthesized priority weight than the other alternative. The difference between Plan A and B results indicates the likelihood of the practitioner to select the most appropriate development plan based on the results of the ANP calculation. By the results above, it is suggested that the developer shall select Plan B as the project development plan of the studied project.

## 7. Conclusion

An application of Analytic Network Process (ANP) to assess risks in real estate development when the developer conduct feasibility study stage was introduced in this paper. Risk assessment criteria are set up in order to precede the ANP calculation was based on literature review and the researchers' experiences in real estate development. All assessment criteria are summarised under STEEP factors theory, which could be categorised as: Social, Technological, Environmental, Economic and Political factors. Those factors shall be concerned by the real estate developers and necessary when the project feasibility study is conducted prior to the project commencement.

To complete this research, an ANP model was therefore established based on the defined risk criteria associated with STEEP factors, as well as the assumption that one of two alternative development plans would be selected to develop in Liverpool City Centre area. There were 33 risks under five clusters, to ensure a comprehensive coverage of possible risks occurred in real estate development. Then, a face-to-face interview with the practitioner involving with this case study was conducted. According to the results, it can be concluded that the Alternative B "the commercial mixed-use property" shall be the more appropriate development plan, according to the calculation of ANP. The Plan A also clarified as the risky alternative plan by the consequences of risk, which higher than the Alternative B.

According to the results of the interviewing, the practitioner's opinion, together with the data calculated by the ANP model. This ANP could be concluded as an effective tool to support developers in making decisions toward risks in the real estate projects. The ANP model therefore can be adopted by real estate developers in the case of business needs to assess risks in a real estate development. However, the further researches are needed for collecting vast information from the real estate developers in the variety of real estate projects to modify and improve the risk assessment model to suit with the developer requirements in order to improve more consistency and reliable to the risk assessment criteria.

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