

## **Applying Analytic Hierarchy Process in Firm's Overall Performance Evaluation: A Case Study in China**

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### **ABSTRACT**

The Analytic Hierarchy Process (AHP) has been proposed in recent literature as an emerging solution approach to large, dynamic, and complex real world multi-criteria decision making problems, such as the strategic planning of organizational resources and the justification of new manufacturing technology. This paper presents an application of the AHP in firms' long-term overall performance evaluation through a case study in China. An effective evaluation of firm's overall performance is a key step for firm's long-term strategic planning process. As such, the methodological approach of evaluating firm's overall performance has attracted recent research interests, especially for firms under its unique economic, financial, and marketing conditions in China. The result of this study shows that such an AHP application can assist managers to effectively evaluate firm's overall performance in their long-term strategic planning process even under complex economic and marketing conditions.

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## I. INTRODUCTION

With the fastest growth rate in the last two decades, China has become one of the largest markets for international business. As a result, China has become one of the top three nations for attracting foreign investment in the international market since 1993 (see Ma [16]). Hundreds of international companies, large and small, have been competing for business opportunities in China, in the form of joint venture or direct investment, since the Chinese government opened its market in 1980s. As its economic reform continues, China's perennial economy expansion scale, huge market potential, and valuable resources have been continuously attracting the attention of international business giants (see Ma [15]). It has been reported that by the end of June 1997, over 230,000 business joint ventures had been registered in China, and 145,000 of them were already in operations. Total foreign direct investment had reached \$204 billions - among them, \$15.7 billions were from U.S. companies, involving 23,200 business investment projects (see CNSB [4]). IMF (International Monetary Foundation) 1997 "*Global Economic Prospects and Policies*" Report predicts that if China can sustain its current growth rate, its GDP will reach the total GDP of European Union and the U.S.A. in 10 years. The 1997 *Annual Report of World Bank* indicates that among world's five largest developing countries - China, Russia, India, Brazil, and Indonesia, all of which will become important parts of world economy in next 20 years, China has the most potential for growth and become one of the largest markets for international business. As evidence, more than 200 international business giants have started to increase their direct investment in China recently (see Ma [16]).

Hundreds of international corporations have explored their business opportunities in China in the last two decades. Both successful joint ventures and failed investments have been reported (see Miller, *et al.* [18]). Research addressing the issues about the conflicts between different cultures (e.g., Western vs. Oriental), traditions, value systems, and the comparison study about different political and economic systems has been emerged in recent literature, but few have been focused on the issues and challenges in evaluating firm's long-term overall performances - for companies under China's current complex social, political, economic, financial, and market conditions. Because such a problem is evidently a typical multi-criteria decision making problem - as there are many factors involved (quantitative vs. qualitative), many attributes interactive (economic, political, cultural, traditional, etc.), and complex relationships among the factors. For such multi-criteria decision making problems, appropriately assessing the managerial priority preferences among performance criteria will play a key role in the solution process. To assess manager's preference explicitly with a preference model, in the current literature, one of the most preferred approaches is the analytic hierarchy process (AHP), as suggested by Falkner and Benhajla [8], and Satty [26].

The AHP approach was developed in the early 1970s in response to military contingency planning, scarce resources allocation, and the need for political participation in disarmament agreements (see Saaty [29, 31]). All these problems rely heavily on measurement and tradeoff of intangibles in a multi-criteria process. The AHP is a structured method to elicit preference opinion from decision makers. Its

methodological procedure can easily be incorporated into multiple objective programming formulations with interactive solution process (see Saaty [29, 30, 31]). The AHP approach involves decomposing a complex and unstructured problem into a set of components organized in a multilevel hierarchic form (see Saaty [30]). A salient feature of the AHP is to quantify decision makers' subjective judgments by assigning corresponding numerical values based on the relative importance of factors under consideration. A conclusion can be reached by synthesizing the judgments to determine the overall priorities of variables (see Saaty [23]).

The AHP approach has been proposed in recent literature as an emerging solution approach to large, dynamic, and complex real world multi-criteria decision-making problems (see Albayrakoglu [1], Carlsson and Walden [3], Tavana and Banerjee [35], Weiss and Rao [38], Zahedi [42]). Successful AHP applications have been reported in marketing, finance, education, public policy, economics, medicine, and sports (see Saaty [23, 24, 26], Sun *et al.* [32], Zahedi [42]). The AHP approach is thus selected to address the multi-criteria decision making problem to be addressed in this research - assessing and evaluating firm's long-term overall performance under China's complex economic and market conditions. The AHP application is illustrated through a case study of *Shanghai Chemicals* (China Shanghai Oriental Chemicals Plant).

## II. LITERATURE REVIEW

A selected literature is briefly reviewed in this section - on the recent trends in international business development in China, and the new development of performance measurement systems.

One trend for many large multi-national (MN) corporations in recent years is to globalize their operations with their best available resources. In order to be competitive in global market, those MN corporations have adopted more aggressive operations strategies, which can often be characterized as "to bring the highest quality products with the lowest price to enter new markets" (Rhinesmith [21]). Two major categories of factors considered by those MN corporations in selecting new market targets are: (1) internal strength, including operational capability, technology advancement, competitive edge, and potential profitability, and (2) external conditions and opportunities, such as: the stability of political and economic systems of the nation to be considered, as well as its technical conditions, labor availability and quality, and potential market size and sales (see Mann [17]). As more international business giants entered China's market and run their businesses within China's economic system, their successes and failures have attracted research interests in recent publications (see Davis [5], Lin [14], Wang *et al.* [37]). For example, a survey research selected 475 foreign investors (including companies from American, Japan, South Korea, European nations, Singapore, Taiwan, and Hong Kong) from three major Chinese cities - Beijing, Tianjin, and Shanghai (see Yuan [41]). A 60% of investors surveyed indicated that their companies will expand future investment in China, 30% will at least maintain their current investment levels, and only 10% will reduce their future investment to some degree. Almost all investors surveyed are very optimistic about the perspective of future foreign investment opportunities in China, as reported by Yuan [41].

In order to evaluate the risks and opportunities involved in doing business in China, GFC (Germany Federation of Commerce) surveyed 74 German companies - which have joint ventures or direct invested manufacturing factories in China. Their final report summarized the following suggestions for foreign investors: (1) be focused on the development of China's new market and its huge long-term sale potential, (2) China's current economic growth rate will be sustained in a foreseeable future, and (3) considering all factors, average production costs at Chinese plants will be more than 30% lower compared to similar plants in Germany. Meanwhile, 70% surveyed are "Very Satisfied" or "Satisfied" with their cooperation from their Chinese counterparts and indicated that their corporations plan to increase their investment and production capacity in next few years. More than 89% are confident their products will be competitive not only in China's market but also on international marketplace. That is, their production facilities in China will be incorporated into their international business strategy (as an integral part of their global manufacturing and service base) for their global competition. In summary, the different cultures, traditions, social value norms, and political and economic systems existing in China and Western countries, as well as the lengthy separation of China from the international business world before the 1980s, do prescribe the issues and challenges for international corporations to successfully operate their businesses in China (see Davis [5]).

An effective evaluation of firm's long-term performance plays a key role in firm's long-term strategic planning. As such, various performance evaluation approaches have been developed - to conduct proposed comparative evaluations based the established strategic objectives (see Maskell [19] and Rivers [22]). Discussions on firm's performance measurement have been reported in the recent publications. The issue of the "inappropriateness" of *traditional* short-term financial analysis based "*balanced scorecard*" systems is addressed with an extensive scale by Kaplan & Norton [10] and Tarr [33]. Arguing that business organizations have undergone dramatic changes during the last two decades (i.e., the implementation of JIT, TQM, team-based organization, time-based competition), firm's performance measurement systems, however, have not appreciably changed to reflect those organizational and environmental changes (see Tarr [34]). That is, the current "*balanced scorecard*" performance measurement methods and systems are much lagged behind the current business process system development (see Tarr [33]). For a modern business organization to be competitive in global market, the firm's overall performance measurement must be driven by its long-term business strategic objectives, and designed as a system - be purposeful, unified, integrated, fluid, and participate to firm's managers, as addressed in Kaplan & Norton [10], Kaplan *et al.* [11, 12], and Tarr [33]. New performance measurement systems (or approaches) have also been suggested in the recent literature, such as: a proactive 10-step performance measurement development procedure (by Wisner and Fawsett [39]), the performance measurement selection matrix method (by Rivers [22]), and a strategic proactive approach in which the performance measurement process is to be categorized into four segments - *financial*, *customer*, *internal business process*, and *learning and growth* (by Kaplan & Norton [10]). Another popular concept recently adopted in the performance measurement literature is "**benchmarking**" - often defined as "... the search for

industry best practices that lead to superior performance” - against which - a firm’s performance will be evaluated and compared with (see Camp [2]).

There are also limitations, however, in the current literature regarding the proposed methods for firm's long-term overall performance evaluation. First, application-oriented procedures that are practical to handle large scaled problems are rare – largely due to the complexity involved. In addition, qualitative criteria are often not incorporated in some reported approaches, while in many real world applications, qualitative criteria are often the primary concerns for the management. Another weakness in the current literature is that many reported methods are deterministic in nature - lack the dynamic capability necessary to deal with the rapid changes occurred in business practice. Finally, there is a need for a system (or a "framework"), which can organize all related criteria (quantitative and qualitative) into a hierarchic structure and present all of them with pre-established priority considerations. Recognizing that firm's long-term performance evaluation is a typical multi-criteria decision making problem, the AHP approach is selected in this research to provide an effective tool to the managers of international corporations in China - in their evaluation of firm's long-term overall performance, which in turn, will make insightful contributions to the business world and the international business literature. It is the primary motivation of this research.

### III. AN AHP APPROACH

The AHP has been proposed in recent literature as an emerging solution approach to large, dynamic, and complex real world multi-criteria decision-making problems (see Albayrakoglu [1] and Carlsson & Walden [3]). The AHP has been used in a wide variety of complex decision making problems, such as the strategic planning of organizational resources (Saaty [26]), the evaluation of strategic alternatives (Yand and Lee [40]), and the justification of new manufacturing technology (Albayrakoglu [1]). An earlier survey provided over 200 known AHP applications (see Zahedi [42]). The AHP has also been applied in a variety of formats such as: the design tool for large-scale systems or composite ratio scales (Weiss and Rao [38]), the instrument for pairwise comparison in the application of artificial neural networks (Wang *et al.* [37]), and the primary structure of decision support systems (Zahedi [42]). As an effective methodology, the AHP approach has been used to determine the optimal facility location site among alternatives under multiple criteria (see Carlsson & Walden [3] and Yang & Lee [40]), and to identify objective coefficient and parameter values in multiple-objective LP problems (Korhonen and Wallenius [13]). In addition, the software package that implements the original AHP (see Saaty [28]) - *Expert Choice*, has been promoted in the recent publications (Expert Choice [7]).

Evaluating firm's long-term overall performance is obviously a complex multi-criteria problem. Such a solution process is often conducted in a dynamic fashion. That is, key criteria may change over time due to unexpected events (e.g., an emerging energy crisis may cause fuel and power costs to assume greater importance over other factors). Furthermore, under a multi-criteria comparison, more often, no single criterion could dominate all other alternatives in a clear-cut fashion. Instead, each criterion may

have an appealing advantage in its favor. As such, the final conclusion would be the result of a compromise – rather than an "optimal" decision in its sense. In this regard, the problem to be addressed in this research - evaluating firm's long-term overall performance under China's current complex economic and market conditions is a particularly suitable application for the AHP approach.

Some concerns have been raised regarding the AHP for the arbitrary ranking occurred when two or more alternatives have similar or quasi-similar characteristics, or the rank reversal caused by the addition or deletion of alternatives (see Dyer [6], Perez [20], and Tversky & Simonson [36]). These undesirable effects, however, do not, invalidate the AHP method, argued by Harker & Vargas [9] and Saaty & Vargas [25]. In fact, almost all ordinal aggregation methods exhibit rank reversal (see Perez [20]). It has been shown that the rank reversal will not be a problem in real world applications because it is very rare to encounter two alternatives with very similar characteristics, and special precautions (e.g., grouping similar alternatives) can easily be taken to avoid any rank reversal (see Saaty [27]). Specifically, three steps have been identified in terms of ranking preservation: (1) allow rank to reverse by using the distributive model of the relative measurement approach, (2) preserve rank by using the ideal mode (in case of irrelevant alternatives), and (3) preserve rank absolutely by using the absolute measurement mode (see Saaty [26]). Pairwise comparison is a key step in an AHP model to determine priority weights of factors and provide a rating for alternatives based on qualitative factors. The procedure focuses on two factors at a time and their relation to each other, so decision makers will be more comfortable to offer relative (rather than absolute) preference information. The relative importance of each factor is rated by a measurement scale to provide numerical judgments corresponding to verbal judgments. The instrument used in this research is a discrete scale, from 1 to 9 with 1 representing the equal importance of two factors and 9 being the highest possible importance of one factor over another, as shown in Table 1 (a). An example of three-factor comparison matrix is shown in Table 1 (b). Determining priority weights is an important step in pairwise comparison. Three methods have been suggested in the literature to calculate such priority weights, including normalized eigenvalues (EM), logarithmic least squares, and least squares methods. While it has proven that the suggested three methods will generate identical solutions in terms of result consistency, the EM is recommended when the data are not entirely consistent by Saaty [28].

The proposed AHP model for evaluating firm's long-term overall performance is depicted in Figure 1. After managerial objectives are defined (Step-1), as shown in Figure 1, the AHP model starts with identifying all relevant and important performance criteria (Step-2). These criteria are then structured into a hierarchy descending from an overall objective to various criteria and subcriteria in successive levels (Step-3). Important guidelines for selecting criteria and constructing the hierarchy structure have been suggested: (1) representing the problem as thoroughly as possible, but not so thoroughly as to lose sensitivity to change in the elements, (2) considering the environment surrounding the problem, (3) identifying the issues or attributes that contribute to the solution, and (4) clarifying the necessary participants associated with the problem (see Saaty [26]). Organizing criteria in a hierarchy serves two purposes: (1) it provides an overall view of the complex relationship inherent in the situation; and (2)

it helps decision makers assess whether the issues in each level are of the same order of magnitude, so homogeneity in comparisons is preserved. The priority weights of structured criteria are then determined through pairwise comparison to reflect the judgments and relative preferences of different decision makers (Step-4). Not surprisingly, the priority weights may vary from one person to another. When there are several levels of criteria and subcriteria, the weight vectors of higher-level criteria are first computed. The weight of the corresponding higher-level criterion is then used to weight the criteria at the lower level in the hierarchy (composite weight). The procedure is repeated by moving downward along the hierarchy, computing the weight of each criterion at a particular level and using these to determine composite weights for succeeding levels (Step-5). When multiple decision makers are involved in developing priority weights, achieving consensus may be difficult. Weight analysis can then be used to assess the extent of differences and the potential impact on final decision. For instance, the means and variances can be calculated and the significance of the differences among sets of weights can be statistically tested. In the final step of the proposed AHP model, the criteria, which have the relative higher overall priority scores, will be identified as the firm's most important long-term overall performance measures and to be analyzed and incorporated in the firm's long-term strategic planning process.

**Table 1**  
Pairwise comparison scale and example

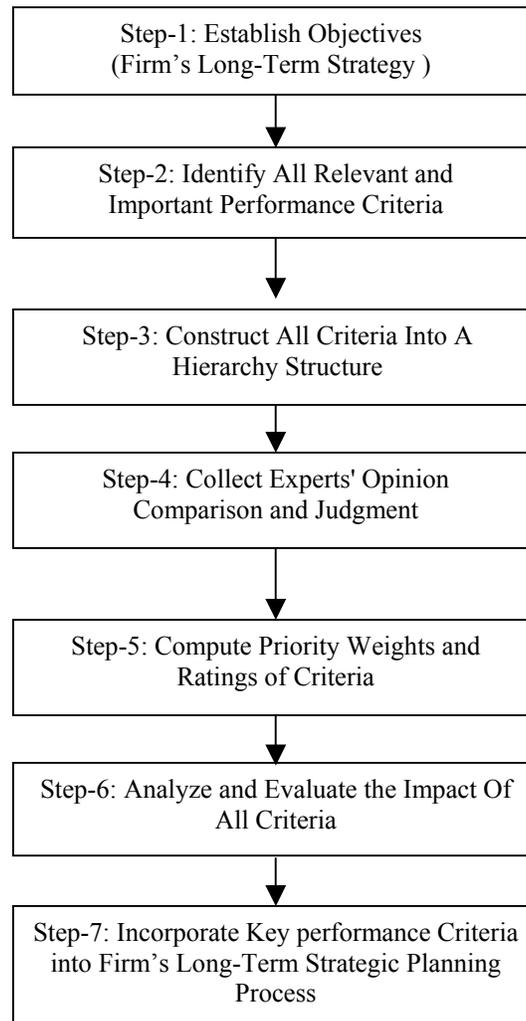
(a) Comparison scale

Intensity	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment favor one factor over another
5	Essential or strong importance	Experience and judgment strongly Favor one factor over another
7	Very strong importance	An factor is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence of favoring one factor over another is of the highest possible order of affirmation
2, 4, 6, 8 Intermediate values when compromise is needed		

(b) An example of three-factor comparison matrix

Factor	A	B	C	Priority Weights
A	1	1/2	4	0.31
B	2	1	8	0.08
C	1/4	1/8	1	0.62

**Figure 1**  
AHP process of evaluating firm's long-term overall performance



Two sets of specific data: (1) the ranks of each criterion, and (2) the scores for each criterion, need to be collected for the proposed AHP model. Quantitative factors are measured by their corresponding values while the qualitative factors will be measured by the rating scale instrument. The criteria are first compared and prioritized based on the rates of the lowest level in the hierarchy. Qualitative analysis is conducted based on the pairwise comparison relative to each criterion and subcriterion. The numerical rating values of each criterion are normalized considering all other ratings of the criteria at the same level of the hierarchy. The ratings of qualitative criteria are the eigenvalues of the pairwise comparison matrix. The results of both quantitative and qualitative analysis will be combined for each criterion at the lowest possible level in the hierarchy. The priority weights of each criterion are the eigenvalues in the corresponding eigenvector of each matrix. This eigenvector is weighted with the weight of the higher-level element, which is used as the criterion in making the pairwise comparison. If the criteria at a particular level do not have any subcriteria, their priorities remain unchanged in the next level of the hierarchy. The overall priority scores for each criterion are the sum of individual products of rating scores by the corresponding priority weight for each subcriterion from the lowest level in the hierarchy. The consistency of the data may also be investigated during the analysis.

#### IV. A CASE STUDY IN CHINA: SHANGHAI CHEMICALS

*Shanghai Chemicals* is selected in this research for a number of reasons. First, the economic, financial, and operational status of *Shanghai Chemicals* has been viewed as highly representative to most international joint venture corporations in China. Secondly, the chemical product industry (*Shanghai Chemicals* is one of a few large modernized chemicals plants newly developed in China) is one of the fundamental, fast growing, high-tech "backbone" industries which have huge market potential and significant impacts on the growth of China's economy. In addition, the location of the company -Shanghai, is the center for a remarkable surrounding economic area - a key economic development zone for the success of China's undergoing economic reform. Finally, the cooperation from company's top management in terms of data collection and participation in solution process has made this research project possible.

Prior to data collection, a specific workshop was organized for all the managers involved to explain the methodological approach of organizing all criteria and subcriteria into a chain of hierarchy in the proposed AHP model. Both advantages and potential issues of the approach were then thoroughly discussed with previous application case studies. Overall feedback from those managers about the proposed AHP model was very positive. Some suggestions by those managers were even adopted in the research, such as: starting with a small and simplified model - two levels with total 10 criteria/subcriteria only.

Four major performance criteria - *Productivity, Capital Flow, Profit Contribution, and Resource Consumption* are selected in this case study - applying the AHP model in evaluating the long-term overall performance of *Shanghai Chemicals*. Those four criteria were selected by a group of top managers within the company - based on a newly developed company's 5-year strategic plan (at the time). Each criterion is then disaggregated into two or more subcriteria. The four major criteria and their 10 subcriteria are then structured into a two-level hierarchy, as shown in Table 2. (**Note:** The degree of detail and the number of levels can certainly vary with the complexity of the evaluation, the amount of available resources, and the desire of decision makers.)

The required data for the proposed AHP model: (1) key criteria data of each group, and (2) estimated ratings about relative importance among criteria and subcriteria, were collected from the company over an eight-year period (1988 - 1995). The priority weights of each criterion are computed by using pairwise comparison between each criterion at a particular level, as shown in Table 3. Data analysis and matrix calculation are conducted by a mathematical software specialized in matrix computation, called **GAUSSIAN**. It provides the eigenvalues of a matrix. The software package of the AHP - *Expert Choice* is certainly recommended for larger real world problems (see Expert Choice [7]). The results of composite weights computation along with the corresponding "maximal eigenvalue" ( $\lambda_{\max}$ ) and "consistency ratios" (CR) are presented in Table 4.

**Table 2**  
Key performance criteria and subcriteria

Factor	Quantifiable
A:	<b>PRODUCTIVITY</b>
	A1 - Average Labor Productivity Growth
	A2 - Average Output/Salary Ratio
B:	<b>CAPITAL FLOW</b>
	B1 - Capital Turnover Ratio
	B2 - Inventory Turnover Ratio
C:	<b>PROFIT CONTRIBUTION</b>
	C1 - Sales/Profit Ratio
	C2 - Return On Total Assets
	C3 - Return On Investment
	C4 - Asset Appreciation Rate
D:	<b>RESOURCE CONSUMPTION</b>
	D1 - Output/per Resource Unit
	D2 - Output/per Ton of Coal Consumed

**Table 3**  
Priority Weights of Performance Criteria

## a) Overall relative priority weights of four criteria

Criteria	A	B	C	D	Priority Weight
A	1	3	2	7	0.4901
B	1/3	1	1/2	3	0.1619
C	1/2	2	1	5	0.2879
D	1/7	1/3	1/5	1	0.0601

## b) Relative priority weights of criterion A: Productivity

Criteria	A1	A2	Priority Weight
A1	1	1/7	0.1250
A2	7	1	0.8750

## c) Relative priority weights of criterion B: Capital Flow

Criteria	B1	B2	Priority Weight
B1	1	1/2	0.3333
B2	2	1	0.6667

## d) Relative priority weights of criterion C: Profit Contribution

Criteria	C1	C2	C3	C4	Priority Weight
C1	1	3	3	5	0.5204
C2	1/3	1	1	3	0.2010
C3	1/3	1	1	3	0.2010
C4	1/5	1/3	1/3	1	0.0706

## e) Relative priority weights of criterion D: Resource Consumption

Criteria	D1	D2	Priority Weight
D1	1	3	0.750
D2	1/3	1	0.250

Several managerial insights can be summarized from the results of Table 4 - regarding the relative importance of performance criteria (and subcriteria) under the priority consideration of the management. For example, *productivity* (criterion A), as expected, has been ranked as one of the most important considerations in firm's long-term strategic planning (as indicated by the highest overall composite priority weight of 0.4901), followed by *profit contribution* (criterion C) with an overall priority weight of 0.2879. The highest priority weight (criterion A) demonstrates that for most companies in China (a developing country) - improving productivity will continuously be one of most important strategic objectives in order to become competitive in global market.

Furthermore, between two productivity subcriteria, *average labor productivity growth* (A1) has been outweighed significantly by *average output/salary ratio* (A2) (an 1/7 ratio by 0.06/0.42), which actually reflects the fact that the recent trend of labor cost increase has caught up the attention of management. The second highest priority weight (criterion C) further reinforces the argument that at the current stage of China's economic reform, increasing profit and revenue will remain as one of major business objectives for top management - which partially can be contributed back to the long history of losing money for many Chinese companies under the *old* planning economy system. In addition, among four profit contribution (criterion C) subcriteria, *sales/profit ratio* (C1) has a 3:1 (or higher) ratios of the composite priority weights over another three subcriteria. It can be explained largely by the increased cost of marketing in recent years under China's current marketing system. That is, before the economic reform started in 1980s, there had been basically no market competition at all for large state-owned firms in China – as such, there was little (if any) marketing cost to be considered at the time.

**Table 4**  
Composite priorities of criteria and subcriteria

Criteria	A	B	C	D	$\lambda_{\max}$	CR	Composite Priority
	0.4901	0.1619	0.2879	0.0601	4.02	0.0071	
A	0.4901				2.0	0.0	0.4901
A1	0.1250						0.0613
A2	0.8750						0.4288
B		0.1619			2.0	0.0	0.1619
B1		0.3333					0.0540
B2		0.6667					0.1079
C			0.2879		4.04	0.0165	0.2879
C1			0.5204				0.1489
C2			0.2010				0.0579
C3			0.2010				0.0579
C4			0.0776				0.0223
D				0.0601	2.0	0.0	0.0601
D1				0.750			0.0451
D2				0.250			0.0150

It can also be noted that among all subcriteria, *inventory turnover ratio* (B2) and *overall resource consumption rate* (D1) have attracted the attention of the management with two very high individual subcriterion priority weights of 0.1079 and 0.0451. Keeping too much of inventories has been a long time managerial dilemma for companies in China. Under the *old* planning economy system, there was never enough financial pressure (or economic incentive) to force the management to resolve this

issue. Only after the starting of the national economic reform process, this problem became "realistic" to the management of most firms in China. That is, companies now must reduce their inventory levels in order to enhance their control of cash flow and be competitive in the marketplace. A higher rank of D1 (*overall resource consumption rate*) reflects the concerns of management on both the production materials cost reduction and the increasingly tighten raw materials supply market.

Finally, the relative importance among all subcriteria in the same criterion group can also be learned from Table 4. For example, from the proposed AHP model, the management of current *Shanghai Chemicals* believes that to further reduce their current inventory levels is twice important as to increase their current cash flow rate – as their long-term strategic objectives, as indicated by a 2:1 ratio of their priority weights between *inventory turnover ratio* (B2) and *capital turnover ratio* (B1) in Table 4. Table 4 also indicates consistent rankings among all criteria and subcriteria, as shown by that all CRs (Consistency Ratio) are less than 0.1 (.0165, 0.0071, 0, 0, 0).

The proposed AHP model is also used to compare the *relative* performance of the company and the overall trend over that eight-year period (1988-1995). All performance criteria are first determined through the same computing procedure for each year, as shown in Table 5. Applying (i.e., multiplying) by their composite priority weights (Table 4) to all performance measures under each year, the "*Overall Ranking*" of each year can now be determined, as the lowest of 2.17 (in 1989) and the highest of 2.63 (in 1995). Based on their "*Overall Ranking*", using the first year (1988) as the base values (1.00), the "*Relative Ranking*" of each year (which displays a relative change of each year from the base year) can then be calculated (as shown in Table 5). From Table 5, it can easily be seen that the company had the relatively *best* performance in 1995 and the *poorest* in 1989. The management of *Shanghai Chemicals* had investigated the underlying causes for the above performance differences and summarized reasonable explanations for those changes. For example, the decline of the overall performance from 1988 to 1990 had been attributed to the unstable market conditions of that transition period in China's economic reform process, a continuing national industry restructure adjustment - which fluctuated the overall demand of the chemistry industry, an accumulative surplus in the national labor market (externally), and many out-of-date equipment and insufficiently trained workers at the time. Specifically, the declined demand, for instance, was believed as the main cause for a 30% decrease in Return-On-Investment (C3: from 0.18 to 0.13), 17% reduction in Return-On-Total-Assets (C2: from 0.3 to 0.25), and a 6% decrease in Output Rate (D1: from 1.38 to 1.30). In contrast, all performance measures had been improved significantly in the next five years (from 1991 to 1995), as shown in Table 5 (e.g., Labor Productivity Growth - A1: from 2.2 to 5.10, Inventory Turnover Ratio - B2: from 5.50 to 6.00, and Return-On-Investment - C3: from 0.13 to 0.16), because after 1991, the national industry restructure reached its stable stage, the demand for the chemistry industry started to recover (externally), while a new leadership of the company was established at the beginning of 1991, major equipment was upgraded by a \$20 million technology project, over 90% of all company's employees were "updated" through a rotating training program, and perhaps more importantly, a new company-wide performance based rewarding and incentive system was developed and implemented by the new leadership

(internally). Similar explanations had been explored for each specific meaningful performance change in detail. Such comparison results can certainly be depicted through two-or three-dimension curves to showcase (or highlight) the dynamic changing in the firm's long-term overall performance to provide more managerial insights for the management.

**Table 5**  
Overall performance comparison of *Shanghai Chemicals*: 1988 - 1995

Criteria	Year							
	1988	1989	1990	1991	1992	1993	1994	1995
A								
A1	1.50	1.90	2.20	2.20	2.90	4.00	4.80	5.10
A2	3.00	2.80	2.70	3.00	2.80	2.70	2.77	3.10
B								
B1	3.20	2.60	2.50	2.00	2.20	2.50	2.00	2.20
B2	5.50	5.00	5.55	5.50	6.00	5.55	5.50	6.00
C								
C1	0.26	0.24	0.27	0.28	0.28	0.27	0.28	0.26
C2	0.30	0.28	0.28	0.25	0.28	0.28	0.25	0.28
C3	0.18	0.16	0.14	0.13	0.18	0.18	0.16	0.16
C4	0.20	0.16	0.20	0.14	0.18	0.20	0.18	0.16
D								
D1	1.38	1.33	1.36	1.30	1.38	1.34	1.30	1.38
D2	6.32	6.28	6.33	6.28	6.32	6.30	6.24	6.32
Overall	2.32	2.17	2.25	2.34	2.37	2.36	2.41	2.63
Relative Ranking								
Relative Ranking*	1.00	0.94	0.97	1.01	1.02	1.02	1.04	1.13

**Note:** Relative Ranking is the ranking comparing with Base-Year (1988).

## V. SUMMARY

This paper presents an AHP application - evaluating firm's long-term overall performance in China. The proposed AHP model is illustrated through a case study - the evaluation of *Shanghai Chemicals'* overall performance over an eight-year period (1988-1995).

With the cooperation from the company and local government agencies, all required data were collected successfully. Specific workshops were organized for the managers involved in the research. Feedback from those managers was then examined and integrated into the study. The result of this study shows that such an AHP application can assist the managers of international joint venture incorporations in

China to effectively evaluate firm's long-term overall performance in their strategic planning process - even under China's current complex economic and marketing conditions.

Several managerial implications can be learned from this research. First, the proposed AHP model can assist managers to identify all information sources for required input data. Under an organized hierarchical structure, the AHP model will prepare the managers in advance for their information need. Another implication is in relation to a more systematic evaluation about the qualitative oriented performance criteria. In practical problems, a difficult task for managers is to consistently evaluate and compare those qualitative factors. A common complaint is that it is unfair or impossible to ask an individual to offer a consistent judgement or comparison on those qualitative factors because an "absolute" subjective consistency is beyond the nature of human being. As such, in a practical sense, the proposed AHP model is attractive to managers because its pairwise comparison procedure will allow managers only to offer relative (rather than absolute) preference assessment, one at a time, on those qualitative factors. The procedure will then scale these relative comparisons uniquely to ensure the consistency of these values. In fact, a built-in inconsistency checking mechanism has been established within the AHP to identify all inconsistencies at very early stages of the solution process (see Saaty [23]).

The methodological approach of organizing all criteria and subcriteria into a chain of hierarchy in the proposed AHP model has also received positive confirmation from the practice. One advantage of such a hierarchical structure is to provide a framework in which it is critical to seek input about the criteria and subcriteria within the hierarchy from different levels of managers in the organization. In addition, the AHP hierarchical structure can easily be incorporated into an interactive solution procedure, which allows more active participation of the managers to be involved in the solution process. It has been reported that using the AHP procedure to estimate the initial "relative" weights or preferences about related criteria requires very little training for managers, and the use of software "*Expert Choice*" can even allow managers to make pairwise comparisons (and "what-if" analysis ) on the screen (while complex mathematical manipulations are performed by computers) (see Saaty [24]).

The flexibility to industrial uniqueness and the high acceptability to business managers have been addressed as other managerial implications from the proposed AHP model. Its high acceptability can be contributed to the fact that the managers are required to participate actively in the solution process. The flexibility to industrial uniqueness comes from the fundamental nature of hierarchical structure. Different industries often evaluate their long-term overall performance from different perspectives. Each industry may need a unique priority consideration in their long-term overall performance evaluation process. The application of the AHP model will allow industrial managers to structure their "uniqueness" into the priority weights computation to reflect their desired unique priority considerations.

This research is initiated by (an internal request from *Shanghai Chemicals*) the motivation to develop an analytical model that will stratify normally complex and numerous criteria and subcriteria into a hierarchy and help decision makers focus on key issues within a large-scaled problem. By organizing all criteria and subcriteria into

a chain of hierarchy in successive levels, the AHP model also offers the flexibility to match the preferences of dynamic managerial priority considerations. For example, as managers may have different subjective priority rankings over certain key criteria, the proposed AHP model will allow repeated calculations of the overall priority weights of all or partial criteria and subcriteria under different ranks. Similarly, as the subjective priority rankings of different criteria and subcriteria may be changed over time (reacting to either external or internal changes), it will be an easy task to recalculate their corresponding overall priority rankings based on changed preferences among concerned criteria and subcriteria, and as a result, to adjust company's related business plan or policy. Under either circumstance, the proposed AHP model will make the comparisons and evaluations of overall priority ranks among concerned criteria and subcriteria under complex differential subjective considerations.

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