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the logistics supplier selection of SGM with AHP method

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The logistics supplier selection of SGM with AHP method

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Thesis: **The logistics supplier selection of SGM with AHP method**

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In order to maintain competitive in the fierce automotive market, SGM Shanghai General Motor）is trying every possible method to improve its performance. In such a background, the top management level is considering to change the policy on the RDC(regional distribution center)/CC(consolidation center), which initially outsourced to 2 logistics suppliers. The 2 logistics suppliers will be screened and the better performer will be appreciated as the next contractor for both RDC and CC. This is the original intention of this thesis.

In the preparation of the thesis, the author has identified the automotive logistics situation of the current China, and then investigates the particular details in RDC/CC, for example: the similarity and difference in the operation, management, construction, etc.

The main achievement of this thesis is to use the BSC(balanced scorecards) model thinking to construct a unique supplier indicator tree to evaluate the suppliers' performance. Then with the Delphi method, the indicator tree will be examed and refined. At last AHP(analytic hierarchy process) method will be applied to calculate the relative weights to get the final results, which may become some reference and constructive ideas for the managers' decision on this matter.

Keywords: inbound logistics, outsource, supplier selection, AHP, indicator tree

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LIST OF ABBREVIATIONS

AHP	analytic hierarchy process
BSC	balanced scorecards
CC	consolidation center
KPI	key performance indication
NVOCC	non-vessel operating common carrier
PC&L	part conveyance and logistics
PCR	part conveyance request
PR	purchasing request
R&D	research and development
RDC	regional distribution center
SAIC	Shanghai automotive industry company
SGM	Shanghai General Motor Co.,Ltd
SUSC	supplier unbalanced scorecards

1. Introduction

1.1 Problem of the logistics provider selection

The logistics has become the hot point of the management area, which will bring the company with good quality and low cost. Good quality means the right delivery time, right delivery place, right delivery quantity and quality, which will add the value on the product to become a distinctive feature. The low cost means the company streamlines its supply chain to achieve the lean concept which will be more advantageous in the accounting aspect. Thus the logistics is both useful in competition strategies of price and differentiation.

SGM (Shanghai General Motor) has benefitted a lot from logistics. At the establishment of the SGM, SGM had its own PC&L department to carry on the duty of logistics function. With the business enlargement and the requirement on performance being higher and higher, the PC&L department started to outsource some logistics business to third party. Now SGM starts to integrate some logistics functions and reduce the number of the logistics providers for further improvement. These improvements can be reflected in 3 aspects:

1st, the logistics cost should be lower for the financial pressure.

The SGM's financial performance of last year was not so good: the profit was declining from USD 8 billion in 2002 to USD 4.9 billion last year. Even the Guangzhou Honda has gained USD 5 billion last year; SGM has to do something to reverse the poor performance trend, which the logistics also has to contribute its effort. The action of reducing the logistics suppliers is aimed for this. When SGM combines the RDC/CC business, the scale economy is functioning for the similarity of the two entities and the bargain power on the purchaser side will be stronger.

2nd, the management complexity will be reduced.

In the PC&L department, there has been more 300 staff, they have been tired

and bored with endless fighting calls with different logistics suppliers. The reduction of logistics suppliers will be an ease for them.

The different suppliers have different information systems, so the interfaces between the logistics suppliers and SGM will be simplified when the number of logistics suppliers decreased.

Some processing work will be saved for the decrease of the number of logistics suppliers, because some cargo will directly be shipped from RDC to CC, if there can be unitary logistics supplier, the transferring process for SGM will be only once rather than twice before.

3rd, the logistics performance will be improved.

For the 2 suppliers both have the strong will to win the bid, they must improve their current performance and may learn from each other to be more competitive. A quarrel between the suppliers must benefit the customer.

1.2 The research objective

Because the efficient and effective logistics performance is the key for SGM to maintain competitive in the furious market, the research of the tools and methods on how to select an appropriate logistics supplier is obviously more and more important. Now SGM decides to select single supplier to run the RDC&CC at the same time, it’s necessary to do some research to decide which one has better performance. With the backlogged experience and the reference of the other literatures, the research objectives are below:

Study the essence of logistics supplier management;

Identify the related indicators which are important to form the performance evaluation criteria;

Analyze the supplier's performance with the usage of AHP model.

1.3 The research method

The thesis mainly uses the AHP method to analyze the supplier's performance. The AHP method is a universally applicable method, which can be used in many strategy decisions. It breaks the final target into several tiers which compares the related indicators to figure put the relative weights to each indicator and the relative weights with respect to proximity to each indicator.

When the indicator tree is constructed, the BSC model is an important source of reference. The major framework of the indicator tree is borrowed and remedied from the BSC model, in which the author summarize the 19 indicators on the basis of the company’s usual practice. Then the indicator tree is perfected by Delphi method, which eliminates and combines some unimportant indicators.

1.4 structure of the Thesis

The structure of this thesis is as follows. Chapter 1 is the introduction of the thesis, including the background of problem, the research objectives, the research method and the structure of the thesis. Chapter 2 concentrates on the background and the theoretical models including: theories of the supplier management and the actual development situation in China, the introduction of SGM, its logistics needs, 2 existing logistics suppliers, Delphi model and AHP model. Chapter 3 illustrates the SUSC model, and how to set the indicators for evaluating the performance. Chapter 4 uses the AHP method to analyze the data and get the calculation result of the performance evaluation. At last, chapter 5 summarizes the conclusions drawn from the research.

2. Background and the theoretical models

2.1 The background of automotive logistics situation faced by SGM

2.1.1 The logistics management of car industry in China

Because the logistics market was relatively monopolized by government, supplier management experience was weak and cost consciousness of the logistics purchaser was very bad in the past. Getting into 2000s, the vehemence of market competition made each enterprise to know strategic meaning of supplier management, but actual operation in supplier management heads for another extremity: the customer tries very hard to depress the purchasing price and leaves the logistics supplier with no profits, even negative profits. Research and study has very realistic strategic meaning on how to develop the logistics supplier management style of Chinese state situation and cultural background.

2.1.2 SGM

SGM was established in 1996. With the help of the North America GM's management advantage of the product development, SGM become car producing base in China which has strong competency and achieves the proud sale accomplishment. Today the car manufacturing tycoons from every corner all over the world rush into China to grab and divide the biggest and most alluring car market on the earth, which makes the competition of cost-control get into white-hot degree. How to further strengthen supplier management, lower the cost of whole supply chain and adapt to new competition already become important topics for SGM's further achievement.

2.1.3 The logistics needs of SGM

SGM has 3 plants in China: Jinqiao Shanghai, Dongyue Shandong and Shenyang Liaoning which are separated by long distance. They all have the whole

vehicle manufacturing capacity and manufacture different types of cars, for example: the Jinqiao plant produces Buick, the Dongyue plant produces Chevrolet, the Shenyang plant produces the GL8. However, only Jinqiao and Dongyue plants have the power train plants which have the ability to produce the motor engines.

The major sources of logistics needs are shown in table 2.1:

Table 2.1-The major sources of logistics needs of SGM

The logistics type	The explanation
The oversea logistics	All the oversea imported parts need to be shipped to Shanghai RDC, including the parts which will later be transshipped to Dongyue and Shenyang.
The Power Train logistics	Because Shenyang Plant has no Power Train Plant, the engine of GL8 needs to be shipped from Shanghai.
The manufacturing logistics	Because SGM's Plants have no warehouse in the plant, all the inventory parts are transferred and stored into RDC, then will be shipped to SGM plants in JIT way.

Because this thesis is mainly referred to the inbound logistics, other types of logistics are not listed in above table.

2.1.4 RDC-CC

2.1.4.1 RDC (regional distribution center)

RDC (regional distribution center) is the supplier that provides the material distribution service only for SGM regular production & project under the direct management of PC&L, SGM. RDC should report directly to SGM RDC manager is authorized by PC&L. Its daily operation should follow SGM business purpose, target & demand, meet the requirement of SGM production plan, and be changed flexibly for adapting to SGM special requirement after getting SGM written approval. These

operations should be 24 hours and full scope.

Table 2.2-RDC service content

No.	Service Content
1	Parts storage and distribution to JinQiao North Plant& South Plant for W-car、L-car、H-car、C-car vehicle production
2	Parts storage and distribution to Jinqiao Power Train plant.
3	Consignment parts distribution to SGM supplier
4	New project parts storage and distribution
5	SGM appointed local parts storage and repacking for Jinqiao, Dongyue and Shenyang plants.
6	Parts storage and distribution to WG plant.

Currently, the operation of RDC is outsourced to Haitong.

2.1.4.2 CC (consolidation center)

CC (consolidation center) is the supplier that provides the material consolidation service only for SGM part sale under the direct management of PC&L, SGM. CC should report directly to SGM. CC manager is authorized by PC&L. Its daily operation should follow SGM business purpose, target & demand, meet the requirement of SGM production plan, and be changed flexibly for adapting to SGM special requirement after getting SGM written approval. These operations should be 24 hours and full scope.

Table 2.3-CC service content

No.	Service Content
1	“C” transportation type parts consolidation and shipping to SGM Dongyue, Dongyue Power Train, Shenyang plants
2	GL8 Press parts consolidation and shipping to SGM Shenyang plant
3	CAMI engine anti-rust packing, consolidation and shipping; Issue tracking file of shipped material
4	Assign operator to SGM plant exchange and check V-car engine support
5	Support local L-car engines that need be rework transportation and return to Dongyue Plant
6	Test parts consolidation and shipping

Currently the operation of CC is outsourced to Anji-tnt.

2.1.5 The logistics service supplier

2.1.5.1 Shanghai Haitong International Automotive Logistics co.ltd

Shanghai Haitong International Automotive Logistics co.ltd is a joint venture invested by SAIC (Shanghai automotive industry company) and Shanghai international port joint-stock company. This company has the certificates of the "NVOCC" and "first class freight forwarder". With the professional teams of strong logistics design and operation capacity, the company has the all-around logistics service functions, like international shipping, the custom clearance, the domestics multimodel transportation, warehousing and transshipping. The company has the integral logistics information system platform, the tailor-made service menu and the performance management based on KPI, so the company gains the certificate of ISO9001:2000. With the advantaged and unshared port resources, the company is specialized in the container shipping logistics for the automotive parts and the

whole-vehicle export and import logistics.

2.1.5.2 Anji-tnt automotive logistics co.ltd

Anji-tnt automotive logistics co.ltd is a joint venture invested by SAIC (Shanghai automotive industry company) and TNT Logistics Holdings B.V. The company has the certificate of ISO14001、OHSAS18001 from the BVQI. The company is a specialized third party logistics service provider, which majoring in the automotive logistics and related technique consultancy, design, management and training. It has 6 specialized son companies and 25 warehousing across the country with the operating area of more than 800000 square meters, so Anji-tnt has the born advantage in the domestic distribution.

2.2 The theoretical research models

2.2.1 Delphi model

The name "Delphi" derives from the Oracle of Delphi. The authors of the method were not happy with this name, because it implies "something oracular, something smacking a little of the occult", whereas in reality precisely that is involved. The Delphi method recognizes the value of expert opinion, experience and intuition and allows using the limited information available in these forms, when full scientific knowledge is lacking.

Delphi method (*http://en.wikipedia.org/wiki/Delphi_method*) uses a panel of carefully selected experts who answer a series of questionnaires. Questions are usually formulated as hypotheses and experts state the time when they think these hypotheses will be fulfilled. Each round of questioning is followed with the feedback on the preceding round of replies, usually presented anonymously. Thus the experts are encouraged to revise their earlier answers in light of the replies of other members of the group. It is believed that during this process the range of the answers will decrease and the group will converge towards the "correct" answer. After several rounds the process is complete and the median scores determine the final answers.

The following key characteristics （A.L.Harold and T.Murray 2007）of the Delphi method help the participants to focus on the issues at hand and separate Delphi from other methodologies:

a. Structuring of information flow

The initial contributions from the experts are collected in the form of answers to questionnaires and their comments to these answers. The panel director controls the interactions among the participants by processing the information and filtering out irrelevant content. This avoids the negative effects of face-to-face panel discussions and solves the usual problems of group dynamics.

b. Regular feedback

Participants comment on their own forecasts, the responses of others and on the progress of the panel as a whole. At any moment they can revise their earlier statements. While in regular group meetings participants tend to stick to previously stated opinions and often conform too much to group leader, the Delphi method prevents it.

c. Anonymity of the participants

Usually all participants maintain anonymity. Their identity is not revealed even after the completion of the final report. This stops them from dominating others in the process using their authority or personality, frees them to some extent from their personal biases, minimizes the "bandwagon effect" or "halo effect", allows them to freely express their opinions, and encourages open critique and admitting errors by revising earlier judgments.

2.2.2 AHP model

Analytic Hierarchy Process (AHP) was developed by Satty (Satty, 1980), in which the hierarchy of components of the decisions were used in decision making process. The AHP is essentially an interactive one where a decision-maker or group of decision-makers relay their preferences to the analyst and can debate or discuss

opinions and outcomes (Wendy Proctor, 2000). The AHP is based upon the construction of a series of “pair-wise comparison” matrices which compares all the criteria to one another. This is done to estimate a ranking or weighting of each of the criteria that describes the importance of decision making, into hierarchy structure. The elements at a particular hierarchy level are compared in pairs as described above. The criteria are broken down into a number of sub-criteria and the pair wise comparisons are repeated for each level of the hierarchy (Evangelos Triantaphyllou and Stuart, 1995). A pair wise comparison of J criteria (G1…Gj) to reflect the importance or weighting of each criteria in influencing the overall objective, involves constructing a j By j matrix (G) which shows the dominance of the criteria in the left hand side column with respect to each criteria in the top row, as shown below (D.Thirumalaivasan, 2001):

Table 2.4-the AHP pair wise comparison modal

	Criteria				
criteria	1	G12	G13	….	G1j
	1/ G12	1	G23	….	G2j
	1/ G13	1/ G23	1	….	G3j
	….	….	….	1	….
	1/ G1j	1/ G2j	1/ G3j	….	1

Source: D.Thirumalaivasan. *Aquifer Vulnerability Assessment using Analytic Hierarchy Process And GIS For Upper Palar Watershed*. Retrieved May 24, 2007 from the World Wide Web: http://www.crisp.nus.edu.sg/~acrs2001/pdf/267THIRU.PDF

The pair wise comparisons are translated from linguistic/verbal terms to numerical numbers using the fundamental Satty’s Scale for the comparative judgments, as shown in table 2.5:

Table 2.5-the importance rank

Numerical Values	Verbal Terms	Explanation
1	Equally important	Two elements have equal importance regarding the element in higher level
3	Moderately more important	Experience or judgment slightly favors one element
5	Strongly more important	Experience or judgment strongly favors one element
7	Very strongly more important	Dominance of one element proved in practice
9	Extremely more important	The highest order dominance of one element over another
2,4,6,8	Important Intermediate values	Compromise is needed

Source: Satty, T.L. *The Analytic Hierarchy Process.* McGraw-Hill International, New York, U.S.A., 1980.

The ranking of these factors in each sub-criterion is determined by raising the pair wise matrix to its power that is iteratively squared each time. The row sums are calculated and normalized.(A.T.Michael, 2007) The iteration is stopped when the difference between sums calculated in two successive iterations fall below a threshold value.

The reason for the author to select AHP as the primary method in this thesis:

1st, AHP is specialized in solving the multilevel and multi-goal problem. According to the analysis, this indicator system has 11 indicators and 3 levels, which

can form the foundation of the structure of AHP.

2nd, AHP can be both used with combining the quantitative and qualitative analysis. In this thesis, the weight of each indicator is measured by subjective qualitative analysis while the indicator performance is embodied by quantitative data.

3rd, AHP is easy to understand and accept for its breaking down the problem into indicators and sub-indicators to form a visible system.

4th, AHP is a mature method which starts from the 1970s, so there has been much experience for reference to overcome some defects for my first attempt.

5th, AHP shows good compatibility to well perform with other methods, like: Delphi method, fuzzy comprehensive evaluation, data envelopment analysis, etc, which will provide more technique support and make the analysis more convincing and scientific.

3. The construction of indicator system

3.1 The introduction of SUSC

The BSC method was an epoch-making tool for strategy management and performance evaluation invented by American famous management master R.S. Kaplan and famous consultant CEO D.P. Norton on the basis of summarizing the successful experience of 12 big enterprises' performance evaluation systems.

The BSC method is a strategic management tool and guidance thinking. In other words, when we set up the strategic development indicators for the companies, we should comprehensively take account of the balance between the financial indicators and non-financial indicators, rather than prefer the financial indicators.

When I apply the BSC into the supplier management, the method will be modified, because BSC is for the internal user to measure and improve the own company's performance in strategic management and while now in supplier management, it's a must for the author to hold a external position to measure the supplier which is aimed to improve the performance of purchaser in supplier management (A.Farooq, S.Gareth and S.Jim, 1997). BSC used in supplier management is different from before, which I call it SUSC (supplier unbalanced scorecard).

3.2 The three balances

The BSC reflect the balance in 3 aspects, however in which the SUSC is somewhat unbalanced:

The first balance is the balance between the short term and long term. In terms of strategic management for BSC, the company's goal is to gain the max profit; the company's development depends on the continuous income rather than the one-off

lottery bonus, for which BSC can reasonably adjust the relation between the long term action and short term action with the strategic vision to realize the sustainable development. In terms of supplier management for SUSC, the purchaser company was used to being keen to the one-off transactional deal with the suppliers, however, SGM's logistics expenditure is huge even if the potential number of logistics providers is large, so it's not a good idea to change the logistics provider frequently for the considerable transit cost. So it's meaningful to measure the long term performance of the supplier, not only the short term performance.

The second balance is the balance between the finance and non-finance. In terms of strategic management for BSC, although the profit is the final goal of the company, the finance indicators can be well achieved on the basis of the good performance of other indicators. In terms of supplier management for SUSC, this balance is also extremely important. It's well mentioned that the price is no longer the only criteria for selecting the supplier. It's necessary to take into account other elements, for example: quality, flexibility and simplicity.

The third balance is the balance between the indicators. In terms of strategic management for BSC, when weighing the 4 kinds of indicators, we should have no preferential bias which is derived from the short slab management method to maintain the sustainable growth. In terms of supplier management for SUSC, this balance has less value, because the research target has changed from the company to its suppliers, the 4 types of indicators which estimate suppliers' performance may have different kinds of importance for the purchaser.

3.3 The four parts

The BSC breaks down the traditional performance management method, which only focuses on the financial indicators, and consider the financial indicators only

effective for measuring the past. The company should invest in customers, suppliers, employees, personnel structure, R&D to maintain the power for development. On the basis of this recognition, BSC holds the idea that the company should view the performance from the below 4 parts: customer, business internal process, study and growth, finance.

All the 4 parts above in SUSC have the different research objectives. No longer should the research find out how to fix the strategy and improve the performance for the target company, while the research is how to measure the contribution of target supplier for the purchaser in these 4 parts.

In terms of the finance aspect, the value in strategic management means how the company performs in accounting? This is used to measure the level of asset operating efficiency, the cost control and sales revenue of the company. The financial indicators usually include: the rate of return on assets, liquidity ratio, quick ratio, receivables turnover, inventory turnover, total capital profit ratio, rate of return on sales, etc. Meanwhile, the financial value in supplier management means how can the suppliers save money for the purchaser? This is a challenge for the supplier, which means the revenue declines for supplier while the supplier has to do it for the total supply chain. The indicators usually include: the price declining rate of contract, the annual saving percentage, the rate in long term service contract, etc.

In terms of the customer aspect, the value in strategic management means how the customers view our company? Customer is God, whether the company can provide the products appreciated by the customers and improve the competency has become the key question for the sustainable development. The customer angle is the reflection from the quality, performance and service. The related indicators usually include: the customer satisfaction, the ability to obtain the old customer and attract the new customer, the ability to gain profit, the target market share. However, the customary value in supplier management means how can the supplier help to

improve the image of the purchaser in the eyes of purchaser's customers? In this thesis, RDC/CC is used for parts distribution and consolidation, so the logistics suppliers have little relation with the whole-vehicle logistics which will affect SGM's image in customers' eyes.

In terms of the business internal process, the value in strategic management means what are we good at? The BSC's business internal process evaluation focuses on those internal processes which will affect the customer satisfaction and realization of the financial goal. The BSC brings the renewal process into the business internal process, which demands the company to continuously develop the new products and service to meet the current and future customers' demands, which will finally create the value and boost the accounting performance for the company's future. The value of the business internal process of supplier management means how can the supplier help to improve the purchaser's business internal process? In this aspect, the supplier would like to ensure the JIT parts flow from the RDC/CC to the plants to meet the manufacturing and logistics needs, especially if the manufacturing plan changed. The related indicators mainly focus on the logistics stabilization and flexibility.

In terms of the study and growth aspect, the value in strategic management means whether we can maintain the advantages in the future. The company's growth mainly comes from 3 sources: talents, system and organizational structure, in which BSC will reveal the gap between current capacity and the demanding capacity for the breakthrough performance improvement. The value of supplier management in the study and growth aspect means how can the supplier help to improve the purchaser's personnel, system and organizational structure? What the supplier can improve in this aspect is rather passive, because the SGM is too strong as the core of the total supply chain that no logistics supplier can assert the influence on SGM. Suppliers should do everything as SGM's order, so the criteria would be the level of compliance.

3.4 Designing criteria

According to the above analysis, the author designed about 19 selection indicators for potential usage in mainly 3 parts: finance, business internal process and study and growth. The customer aspect is omitted for the irrelativeness.

Table 3.1-the initial indicator tree

parts	fields	Indicators
Finance	Cost control	Indicator A: the saving rate of contract price compared with the PR's(purchasing request) budget
		Indicator B: the saving rate of contract price compared with the average market open price
		Indicator C: the saving rate of price of per handling activity of this year compared with price of per handling activity of last year
		Indicator D: the saving rate of the final bid price compared with the first bid price
Business internal process	logistics stabilization	Indicator E: the rate of the correct physical account
		Indicator F: rate of inventory accuracy in system
		Indicator G: rate of rightness of storage
		Indicator H: rate of JIT delivery
		Indicator I: rate of streamline shut down
		Indicator J: rate of material damaged
		Indicator K: rate of PCR (part conveyance request) closed in time
	logistics flexibility	Indicator L: rate of completion of the enlarged PCRs
		Indicator M: rate of completion of the advanced PCR
		Indicator N: rate of completion of the additional PCR

		Indicator O: rate of completion of special cargo requirement
Study and growth	compliance	Indicator P: rate of IT system shut down
		Indicator Q: rate of late conformation report of PCR
		Indicator R: rate of error transit report on PCR.
		Indicator S: rate of right audit report

3.5 Delphi method

Because the indicator system which designed by the author himself is the primary system, these indicators are still not convincing, lack of empirical test and somehow redundant. In order to overcome these defects, the author decides to use the Delphi method to perfect the indicator system.

The Delphi technique (*http://www.iit.edu/~it/delphi.html)* is a method for obtaining forecasts from a panel of independent experts over two or more rounds. Experts are asked to predict quantities. After each round, an administrator provides an anonymous summary of the experts' forecasts and their reasons for them. When experts' forecasts have changed little between rounds, the process is stopped and the final round forecasts are combined by averaging. Delphi is based on well-researched principles and provides forecasts that are more accurate than those from unstructured groups (Rowe and Wright 1999, Rowe and Wright 2001).

3.5.1 The 1st step: selecting the panel experts

According the particularity of this study, the RDC&CC are under the direct supervision of the PC&L department, so the opinion of the PC&L is more important than others. At the same time, it's reasonable to expect than different departments will have different preferences on different subjects, so it's important to clarify the original purpose of this study for all the participants.

Then the author select 16 related experts as the panel member: 8 staff from PC&L department including 2 managers in charge of the RDC/CC; 3 staff from

purchasing department in charge of logistics purchasing; 4 staff from the manufacturing department in charge of the parts transit from the RDC/CC; 1 staff from the IT department.

3.5.2 The 2nd step: design the questionnaire

The author shows all the 19 indicators and 3 level of importance: very important, relatively important and not important. And ask the panelists to categorize 19 indicators into the 3 kinds of importance level and the indicators which are deemed as not important by over 75% panelists will be omitted or merged with other indicators, and their reasons are expected to follow. At the same time, the author gives a clear indication that if any indicator was considered inappropriate or redundant or necessary to be changed by the panelist, any related advice from the panelists will be highly appreciated. The questionnaire in the next round will be adjusted according to their advice.(A.Michael and Erio Ziglio, 2007)

Another advantage of the questionnaire is that the paper-to-paper communication can leave the panelist enough time for consideration and avoid some defects of face-to-face communication, like the emotional interference.

3.5.3 The 3rd step: the analysis of the first round response

After author emails the questionnaires to all the panelists, the response is very interesting and suggestive. Thanks to Engineer Lu in IT department and Manager Ye in PC&L department, some indicators can be merged together: Indicator L, Indicator M and Indicator N can be defined as single indicator named rate of completion of the special PCRs; Indicator F can replace Indicator E, because the Indicator F is measured on the basis of the Indicator E, if physical account is wrong, the inventory data in the information system must be wrong; Indicator G can be replaced by Indicator J, because nearly all incorrect stack is found after the material has been damaged.

According to statistics of the first round, there are Indicator B, Indicator D,

Indicator E, Indicator G, Indicator K and Indicator Q which are considered not important by some panelists, although some rates have not achieved 75%.

Table 3.2-the indicators which are ranked as not important

Indicator	The reason from some panelists
Indicator B	The market price is fluctuating all the time, it's difficult to define the average price; the contract between SGM and RDC/CC is usually long term service contract which is not related to the market price very much.
Indicator D	The first bid is usually tentative, which has not much reference value.
Indicator E	It can be replaced by Indicator F.
Indicator G	It can be replaced by Indicator J.
Indicator K	PCR is only paid by SGM after the PCR is shut down. If the PCR is not closed in time, there will be delayed payment for the supplier, which will have no negative impact on SGM.
Indicator Q	This indicator is nearly 100% all the time, so it nearly has no reference value.

3.5.4 The 4th step: prepare the second round questionnaire

This questionnaire is modified from the first round questionnaire, the detailed are as follow:

The indicator L/M/N can be merged as rate of completion of the special PCRs, which I call Indicator T;

Indicator F can replace Indicator E;

Indicator J can replace Indicator G;

Indicator T, Indicator F, Indicator J, Indicator B, Indicator D, Indicator K and Indicator Q are attached into the questionnaires with the above reasons.

3.5.5 The 5th step: the analysis of the first round response

After author emails the modified questionnaires to all the panelists, the response of the second time is generally consistent. The not important indicators and the merged indicators are supported by their coherence. The author thinks it's enough evidently to get the result and not necessary for further iteration, now the refined indicator system of 11 indicators is shown below:

Table 3.3-the refined indicator tree

parts	fields	Indicators
Finance	Cost control	Indicator A: the saving rate of contract price compared with the PR's(purchasing request) budget
		Indicator C: the saving rate of price of per handling activity of this year compared with price of per handling activity of last year
Business internal process	logistics stabilization	Indicator F: rate of inventory Accuracy in System
		Indicator H: rate of JIT delivery
		Indicator I: rate of streamline shut down
		Indicator J: rate of material damaged
	logistics flexibility	Indicator T: rate of completion of the special PCRs
		Indicator O: rate of completion of special cargo requirement
Study and growth	compliance	Indicator P: rate of IT system shut down
		Indicator R: rate of error transit report on PCR.
		Indicator S: rate of right audit report

4. The supplier's performance evaluation with AHP

4.1 The 1st step: designing the questionnaires

In this part, the author designs 6 pairewise comparison matrices for the indicators' relative weights according to Table 3.5:

Pairewise Comparison Matrices A which reflects the first tier including Finance, Business internal process, Study and growth;

Pairewise Comparison Matrices B which reflects the second tier of Business internal process including logistics stabilization, logistics flexibility;

Pairewise Comparison Matrices C which reflects the third tier of cost control including Indicator A and Indicator C;

Pairewise Comparison Matrices D which reflects the third tier of logistics stabilization including Indicator F, Indicator H, Indicator I and Indicator J;

Pairewise Comparison Matrices E which reflects the third tier of logistics flexibility including Indicator T and Indicator O;

Pairewise Comparison Matrices F which reflects the third tier of compliance including Indicator P, Indicator R and Indicator S.

Then the author designs the pairewise comparison matrices Y for relative weights with respect to proximity to each indicator.

Table 4.1- Pairewise comparison matrices Y

proximity to the Indicator X(X=A/C/F/H/I/J/T/O/P/R/S)	RDC	CC
RDC		
CC		

The questionnaire informants are asked to rank the importance level of each indicator by comparing with each other. The importance level can be seen in Table

2.5.

4.2 The 2nd step: distributing the questionnaires

The author selects 40 staff from the above 4 departments: purchasing/PC&L/manufacturing/IT, 10 staff per department for the email interview. The reason for doing so is that the AHP is a subjective method which has some inevitable disadvantages like the deviation by the preference of the informants: informants from one department probably will overweigh the indicators of this department. So the author balanced the number of informants among the departments to reduce the subjective deviation.

The author distributes the relevant Pairewise Comparison Matrices only to relevant department, except the Pairewise Comparison Matrices A (the first tier) is for all. For example, the Pairewise Comparison Matrices C is only distributed to purchasing department, because the purchasing department is the experts in cost control and their opinion on this question will be highly appreciated, while the staff from the other department will not be qualified to do this for their unacquaintance.

Because the ranking is rather time consuming, the author is just going to run the questionnaire ranking interviews for once. For minimizing the all kinds of deviation, the author will introduce how to evaluate the AHP-9-rank weight of indicators, explain how the author will use these questionnaires and the purpose for this study, provide some related data in the above Delphi method about deciding what indicators are very important and relatively important, and the process to perfect the indicator system, and hope them to consultant with the author when they can’t make decisions. The author believes this additional information will help to get the most precise result.

4.3 The 3rd step: the questionnaire analysis

Thanks to the cooperation of the informants in different departments and the

high emphasis of top managerial level, the questionnaires are retrieved successfully, total 40 questionnaires are obtained and no one is missing. This process costs about 2 weeks, during which the informants are seen very interested in the study and frequently send E-mails to ask what they still wonder about.

The author finds that the data in these questionnaires are relative inspiring: 1st, the data shows that the informants in one department almost have consensus of opinions, the abnormal value is a very few; 2nd, the different departments doesn't show much overestimate on their own importance and performance, which nevertheless exists in somehow extent.

Then the author calculates the arithmetic mean for all the figures from the 40 questionnaires in the new method:

The traditional method is to calculate the sum of all the figures in the same blank of all received valid questionnaires, and then the sum should be divided by the number of all received valid questionnaires to get the arithmetic mean.

But the value in traditional method is usually overestimated by those figures which are bigger than 1 in the occasion of the co-existence of figures bigger than 1 and smaller than 1.

So the author thinks that we can use the symmetrical value system to substitute the AHP-9-rank value system.

Table 4.2-the symmetrical value system

AHP-9-rank	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
symmetrical	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8

The symmetrical value system can avoid the overestimation problem in AHP-9-rank problem, because the figures smaller than 1 are translated into the negative value with the same symmetrical absolute value to have the same weight in the sum calculation.

After the sum of the symmetrical value is get, it also needs to be divided by the

number of the received valid questionnaires to get the symmetrical mean value, then the symmetrical mean value will be translated into the AHP-9-rank mean value according to table 4.2. It's worthy to mention that the means will be rounded up if it is not integer.

Next the author fills the AHP-9-rank mean of each indicator into the 6 Pairewise comparison matrices for the indicators' relative weights and 11 Pairewise comparison matrices for relative weights with respect to proximity to each indicator.

4.4 The 4th step: the data calculation

Suppose that the value function has the form (Robert Full .R, 2003):

$v(y) = \sum_{i=1}^{q} \omega_i y_i$

Define the weight ratio by:

$$\omega_{ij} = \frac{\omega_i}{\omega_j};$$

Note that, for any i, j, k indexes:

$$\omega_{ij} = \omega_{ji}^{-1}, \quad \omega_{ij} = \omega_{ik} * \omega_{kj}$$

Define the matrix of weight ratios as $W=[\omega_{ij}]_{q*q}$:

$$\begin{pmatrix} \frac{\omega_1}{\omega_1} & \frac{\omega_1}{\omega_2} & \cdots & \frac{\omega_1}{\omega_q} \\ \frac{\omega_2}{\omega_1} & \frac{\omega_2}{\omega_2} & \cdots & \frac{\omega_2}{\omega_q} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\omega_q}{\omega_1} & \frac{\omega_q}{\omega_2} & \cdots & \frac{\omega_q}{\omega_q} \end{pmatrix}$$

A matrix W is called consistent if its components satisfy the equalities $\omega_{ij} = \frac{\omega_i}{\omega_j}$, $\omega_{ij} = \omega_{ik} * \omega_{kj}$ for any i, j and k.

But these 2 requirements are not usually met at the same time, so we estimate or

elicit the weight ratio w_{ij} by a_{ij} and let $A=[a_{ij}]_{q*q}$ be the matrix of components $\{a_{ij}\}$.

Furthermore, as $\omega_{ij} = \omega_{ji}^{-1}$, only a_{ij}, j> i need to be assessed.

Since A is found as an approximate for W, when the consistency conditions are almost satisfied for A, one would expect that the normalized eigenvector corresponding to the maximum eigenvector of A, denoted by λ_{max}, will also be close to ω.

Theorem 1. The maximum eigenvalue, λ_{max}, of A is a positive real number (Walailak Atthirawong and Bart MacCarthy, 2002).

Let $\hat{\omega}$ be the normalized eigenvector corresponding to λ_{max} of A. Then $\hat{\omega}_i$> 0 for

all $1 \leq i \leq q$.

Theorem 2. The maximum eigenvalue of A satisfies the inequality CR $\leq$ 0.1.

$$CR = \frac{CI}{RI}$$

$$CI = (\lambda_{max} - q)/(q-1)$$

Table 4.3-Average random index (RI) based on matrix size

q	1	2	3	4	5	6	7	8	9
RI	0.0	0.0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Source: Saaty, T.L, 2000. *Fundamentals of Decision Making and Priority Theory*. 2nd ed. Pittsburgh,PA: RWS Publications.

Let's take the Pairewise Comparison Matrices A for example:

The Pairewise Comparison Matrices A finally comes up with the arithmetic mean of the total 40 questionnaires.

Table 4.4-Pairewise Comparison Matrices A

	Finance	Business internal process	Study and growth
Finance	1	1/3	4
Business internal process	3	1	8
Study and growth	1/4	1/8	1

Then the author calculates the priority of each indicator, which is the normalized geometric means of the rows.

The geometric means are computed as:

$m_1 = \sqrt[3]{1 \times 1/3 \times 4}$ =1.101

$m_2 = \sqrt[3]{3 \times 1 \times 8}$ =2.884

$m_3 = \sqrt[3]{\frac{1}{4} \times \frac{1}{8} \times 1}$ =0.314

$p_1 = \frac{m_1}{m_1+m_2+m_3}$ =0.256

$p_2 = \frac{m_2}{m_1+m_2+m_3}$ =0.671

$p_3 = \frac{m_3}{m_1+m_2+m_3}$ =0.073

p_1, p_2, p_3 are the relative priority for Finance, Business internal process, Study and growth.

Then the author will test whether the consistency condition is almost satisfied.

Let us consider the following matrix:

$$A = \begin{bmatrix} 1 & 1/3 & 4 \\ 3 & 1 & 8 \\ \frac{1}{4} & 1/8 & 1 \end{bmatrix}, P = \begin{bmatrix} 0.256 \\ 0.671 \\ 0.073 \end{bmatrix}$$

To find λ_{max} we solve det[A-λI]=0, that is:

$$\det\begin{bmatrix} 1-\lambda & 1/3 & 4 \\ 3 & 1-\lambda & 8 \\ 1/4 & 1/8 & 1-\lambda \end{bmatrix}=0$$

3(1 − λ)-(1 − λ)^3-8/12-12/8=0

At the beginning the author starts to think about to use the Excel spreadsheet to figure out the value of λ, but later the author dismisses this idea for:

1st, we only can get the unique-solution by Excel spreadsheet when it is possible for get one, but the λ_{max} should be retrieved by comparing all the values of λ (even some values should be imaginary numbers which is mission impossible for Excel spreadsheet calculation), so we need to figure out all the values of λ.

2nd, the Newton-Laphson iteration is usually limited by the Excel spreadsheet calculation capacity. When we use the SOLVER of Excel spreadsheet to calculate the equation in one unknown, should these equations in one unknown be limited to linear, quadratic and cubic equations. Any equation in one unknown of more-than-3rd-order will be beyond the capacity of Excel spreadsheet. However, this thesis has an equation of 4th order.

So the author starts to understand and know how to use the software of MATLAB with the help of my two best friends: Li Cheng who majors in mathematics in Shanghai Jiaotong University and Lv Siyuan who majors in mathematics in Zhejiang University.

MATLAB is a numerical computing environment and programming language. Created by The MathWorks, MATLAB allows easy matrix manipulation, plotting of

functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs in other languages. Although it specializes in numerical computing, an optional toolbox interfaces with the Maple symbolic engine, allowing it to be part of a full computer algebra system.

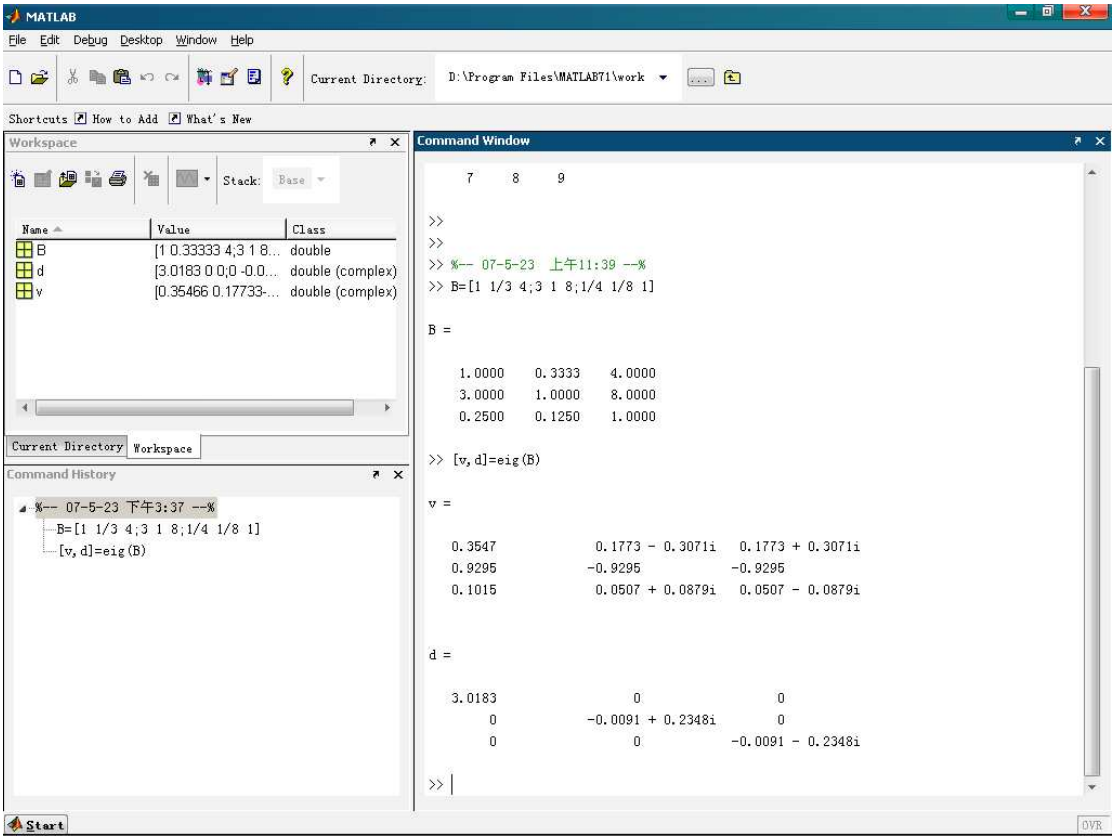

Figure 1-MATLAB for Pairewise Comparison Matrices A

With the help of MATLAB 7.1,λ= 3.0183, -0.0091 + 0.2348i, -0.0091 - 0.2348i

So λ_{max}=3.0183

CI = (3.0183- 3)/(3-1)=0.00915

RI=0.58

CR=$\frac{CI}{RI}=\frac{0.00915}{0.58}$=0.0158$\leq$ 0.1

So the Pairewise Comparison Matrices A is consistent and the priorities for

Finance, Business internal process, Study and growth will be acceptable.

With the same calculation method and process, the priorities of other pairewise comparison matrices and can be obtained. Luckily, all the pairewise comparison matrices are consistent and no further research for adjustment is needed. These pairewise comparison matrices are attached in the appendix of the thesis.

The relative weight (priority) table will show in table 4.5:

Table 4.5-the indicator tree with relative weight

parts	Fields	indicators
Finance (0.256)	Cost control (0.256)	Indicator A: the saving rate of contract price compared with the PR's(purchasing request) budget (0.192)
		Indicator C: the saving rate of price of per handling activity of this year compared with price of per handling activity of last year (0.064)
Business internal process (0.671)	logistics stabilization (0.537)	Indicator F: rate of inventory Accuracy in System (0.027)
		Indicator H: rate of JIT delivery (0.061)
		Indicator I: rate of streamline shut down (0.352)

		Indicator J: rate of material damaged (0.098)
	logistics flexibility (0.134)	Indicator T: rate of completion of the special PCRs (0.112)
		Indicator O: rate of completion of special cargo requirement (0.022)
Study and growth (0.073)	Compliance (0.073)	Indicator P: rate of IT system shut down (0.05)
		Indicator R: rate of error transit report on PCR. (0.015)
		Indicator S: rate of right audit report (0.009)

So ω_i= $\begin{pmatrix} 0.192 \\ 0.064 \\ 0.027 \\ 0.061 \\ 0.352 \\ 0.098 \\ 0.112 \\ 0.022 \\ 0.05 \\ 0.015 \\ 0.009 \end{pmatrix}$

The table of relative weights with respect to proximity to each indicator will show in table 4.6:

Table 4.6-the relative weights with respect to proximity to each indicator

Indicator	A	C	F	H	I	J	T	O	P	R	S
RDC	0.75	0.333	0.8	0.875	0.667	0.75	0.167	0.2	0.75	0.333	0.333
CC	0.25	0.667	0.2	0.125	0.333	0.25	0.833	0.8	0.25	0.667	0.667

So y_{RDC} =(0.75 0.333 0.8 0.875 0.667 0.75 0.167 0.2 0.75 0.333 0.333);

y_{CC} = (0.25 0.667 0.2 0.125 0.333 0.25 0.833 0.8 0.25 0.667 0.667)

According to the formula: $v(y) = \sum_{i=1}^{q} \omega_i y_i$

$$v(y_{RDC}) = (0.75\ 0.333\ 0.8\ 0.875\ 0.667\ 0.75\ 0.167\ 0.2\ 0.75\ 0.333\ 0.333) \times \begin{pmatrix} 0.192 \\ 0.064 \\ 0.027 \\ 0.061 \\ 0.352 \\ 0.098 \\ 0.112 \\ 0.022 \\ 0.05 \\ 0.016 \\ 0.009 \end{pmatrix} =$$

0.617

$$v(y_{CC}) = (0.25\ 0.667\ 0.2\ 0.125\ 0.333\ 0.25\ 0.833\ 0.8\ 0.25\ 0.667\ 0.667) \times \begin{pmatrix} 0.192 \\ 0.064 \\ 0.027 \\ 0.061 \\ 0.352 \\ 0.098 \\ 0.112 \\ 0.022 \\ 0.05 \\ 0.016 \\ 0.009 \end{pmatrix} = 0.385$$

4.5 The 5th step: the conclusion and the constructive advice

It's clear that the performance of RDC is better, so Haitong is more preferential to be chosen as the single supplier. From the table 4.5, we can clearly see that the indicator A (the saving rate of contract price compared with the PR's budget) and the indicator I (rate of streamline shut down) are dominant indicators, they together

occupy more than half weight of the total indicator tree. The RDC performs better than the CC both in indicator A and indicator I, which can be seen as the key successful elements to prevail against the CC. If the CC can gain better scores in indicator A and indicator I, will the situation be reversed certainly. So it’s obvious to consider indicator A and indicator I as key performance indicators for the inbound logistics provider, which can perform the guidance role for tentative and preparatory logistics supplier evaluation before the comprehensive evaluation.

5. The summary

Nowadays, the competition among the automotive manufacturer is heating up every day, all the companies are pursuing the methods to reduce the cost and improve the quality. In such environment, SGM is reconsidering its logistics framework, and starts to reduce the number of logistics number. The author is engaged in this research for the top managerial level, and hope to contribute to the right strategy, which is the purpose of this thesis.

The thesis first uses the BSC as the reference to structure the indicator system. The BSC method is powerful strategic decision tool, which measures the whole company in a comprehensive way; however, it doesn't fit the supplier management perfectly. So the author should change the viewpoint of the BSC from the customers' eye, which is considered as the biggest creative point of this thesis. Then this initial indicator system is perfected and refined by Delphi method with 2 rounds of questionnaire, next the author use the AHP method to decide the weight and performance of each indicator and summarize the final conclusion during which the author believes that the preparatory work is excellent done for all the calculation process is smoothly done.

The author hopes this thesis will be the milestone of evolution of SGM's logistics system. And the other research methods, hopefully the objective methods, can be applied on the basis of it.

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Appendix: indicator explanation, pairewise comparison matrices and questionnaires

Part A, The attached indicator explanation table below:

Indicators	Definition and Explanation
Indicator A	Indicator A=(budget- contract price)/ budget
Indicator B	Indicator B=(average market open price- contract price)/ average market open price
Indicator C	Indicator C=(price of per handling activity of last year- price of per handling activity of this year)/ price of per handling activity of last year
Indicator D	Indicator D=(the first bid price- the final bid price)/ the first bid price
Indicator E	Indicator E=the correct physical account times /the total physical account times
Indicator F	Indicator F=numbers of accurate inventory inputs into system/numbers of total inventory inputs into System
Indicator G	Indicator G=numbers of correct stack/ the number of total stack
Indicator H	Indicator H=number of JIT delivery/number of total delivery
Indicator I	Indicator I=the time of streamline shut down which are attributed by logistics error/ the time of streamline on duty
Indicator J	Indicator J= the amount of damaged materials/ the total materials
Indicator K	Indicator K=the number of PCRs closed in time/the total number of PCRs After a PCR is physically met, the RDC/CC should close this PCR in the information system.
Indicator L	Indicator L=the number of completed enlarged PCRs/ number of total

	enlarged PCRs Sometimes, the plants want more parts than normal, so they will order more in the next PCR, which is called enlarged PCR.
Indicator M	Indicator M=the number of completed advanced PCRs/ number of total advanced PCRs Sometimes, the plants want parts earlier than normal, so they will order the next PCR to be carrier on earlier, which is called advanced PCR.
Indicator N	Indicator M=the number of completed additional PCRs/ number of total additional PCRs Sometimes, the last PCR happens some accident which can't be finished, so the plants need new PCR to fill up, which is called additional PCR
Indicator O	Indicator O=the amount of completion of special cargo requirement/the amount of total special cargo requirement special cargo requirement means special cargo processing, like package, storage, transportation, etc
Indicator P	Indicator P=the time of IT system shut down/ the time of IT system on duty
Indicator Q	Indicator Q=the number of late conformation reports/ the number of total conformation reports After the RDC/CC receives the PCR, she should response with a conformation report in 15 minutes.
Indicator R	Indicator R=the number of error transit reports/ the number of total transit reports When the parts are transited from one place to another, the RDC/CC

	should give a transit report to SGM.
Indicator S	Indicator S=number of right audit reports/ number of total audit reports RDC/CC should do the audit reports every week for SGM. SGM will randomly check the audit report of RDC/CC. If the audit report is right, we call it right audit report.

Part B, The attached Pairewise Comparison Matrices below:

Pairewise Comparison Matrices B

	logistics stabilization	logistics flexibility	priority
logistics stabilization	1	4	0.8
logistics flexibility	1/4	1	0.2

Because P=2, it must be consistent.

Pairewise Comparison Matrices C

	Indicator A	Indicator C	priority
Indicator A	1	3	0.75
Indicator C	1/3	1	0.25

Because P=2, it must be consistent.

Pairewise Comparison Matrices D

	Indicator F	Indicator H	Indicator I	Indicator J	Priority

Indicator F	1	1/3	1/9	1/4	0.05
Indicator H	3	1	1/6	1/2	0.114
Indicator I	9	6	1	5	0.655
Indicator J	4	2	1/5	1	0.182

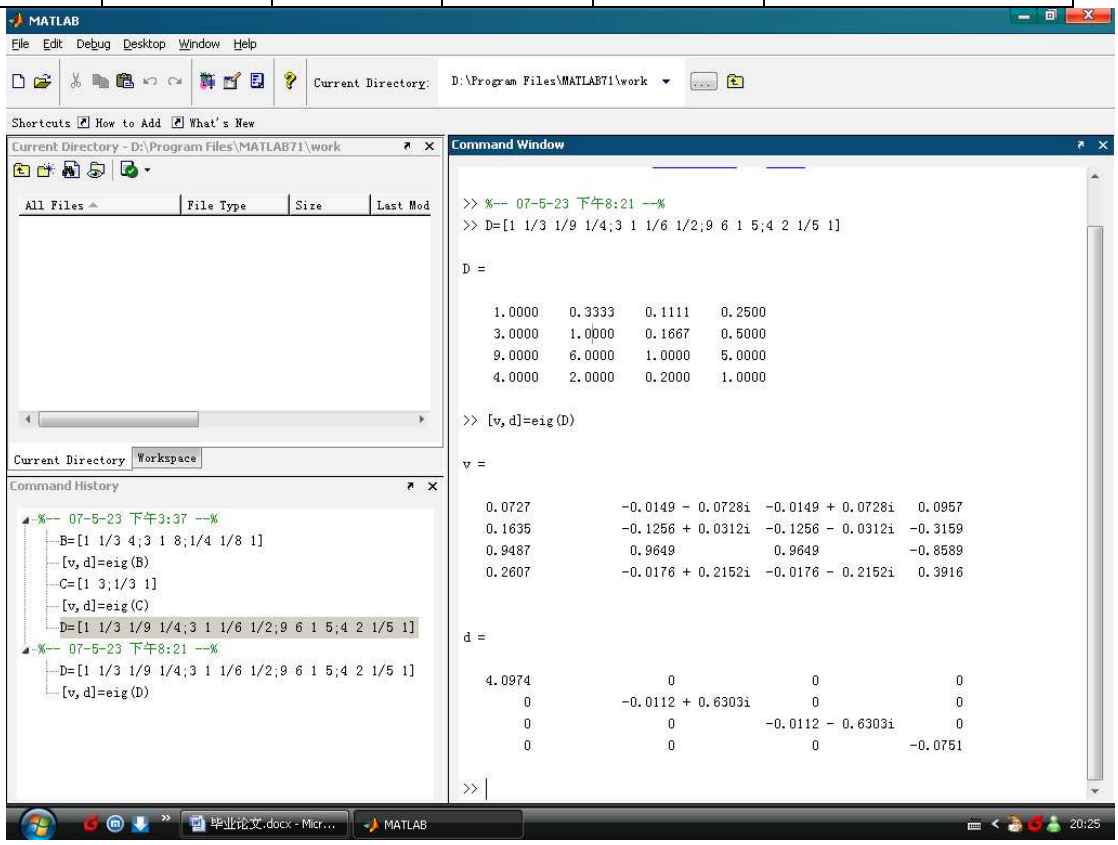

Figure 2-MATLAB for Pairewise Comparison Matrices D

λ_{max} =4.0974, CI=0.0325, RI= 0.9, CR=0.036≤ 0.1, so it must be consistent.

Pairewise Comparison Matrices E

	Indicator T	Indicator O	Priority
Indicator T	1	5	0.833
Indicator O	1/5	1	0.167

Because P=2, it must be consistent.

Pairewise Comparison Matrices F

	Indicator P	Indicator R	Indicator S	Priority
Indicator P	1	4	5	0.683
Indicator R	1/4	1	2	0.2
Indicator S	1/5	1/2	1	0.117

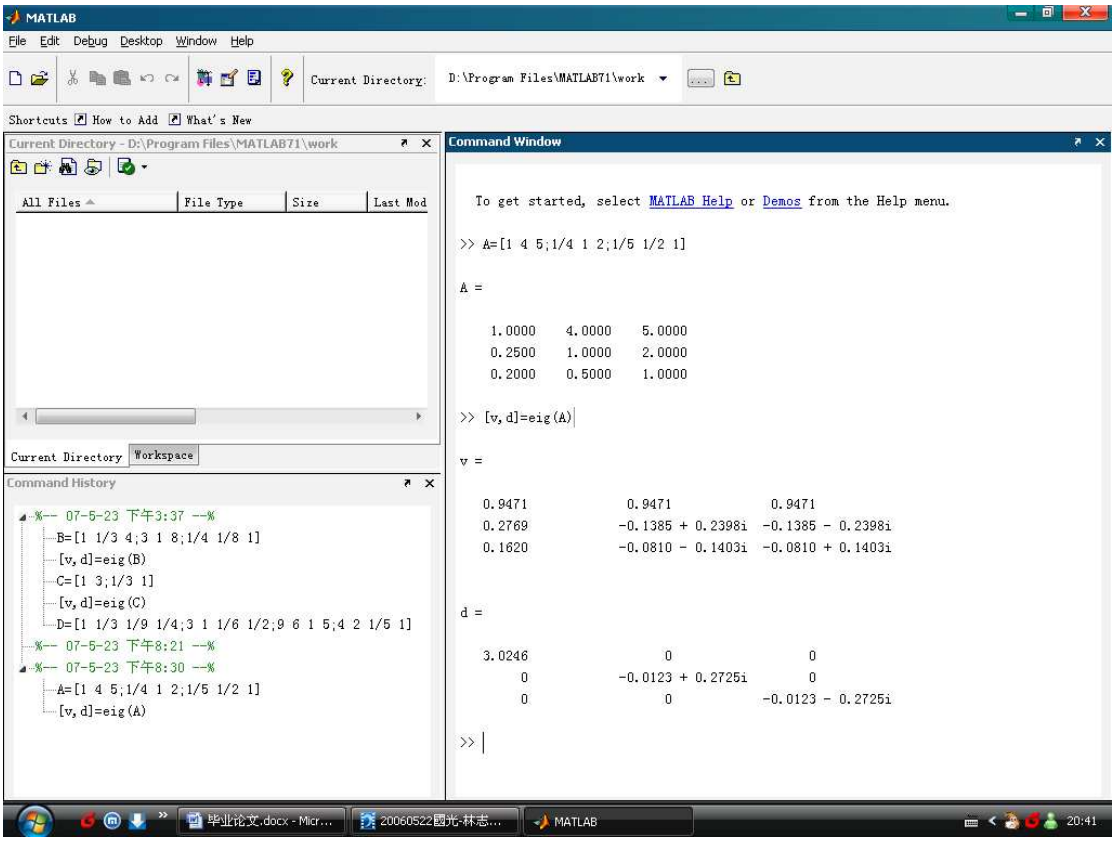

Figure 3-MATLAB for Pairewise Comparison Matrices F

$\lambda_{max} = 3.0246$, CI=0.0123, RI= 0.58, CR= 0.0212 $\leq$ 0.1, so it must be consistent.

Pairewise Comparison Matrices Y_A

Indicator A	RDC	CC	Priority

RDC	1	3	0.75
CC	1/3	1	0.25

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_C

Indicator C	RDC	CC	Priority
RDC	1	1/2	0.333
CC	2	1	0.667

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_F

Indicator F	RDC	CC	Priority
RDC	1	4	0.8
CC	1/4	1	0.2

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_H

Indicator H	RDC	CC	Priority
RDC	1	7	0.875
CC	1/7	1	0.125

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_I

Indicator I	RDC	CC	Priority
RDC	1	2	0.667
CC	1/2	1	0.333

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_J

Indicator J	RDC	CC	priority
RDC	1	3	0.75
CC	1/3	1	0.25

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_T

Indicator T	RDC	CC	Priority
RDC	1	1/5	0.167
CC	5	1	0.833

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_O

Indicator O	RDC	CC	Priority
RDC	1	1/4	0.2
CC	4	1	0.8

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_P

Indicator P	RDC	CC	Priority
RDC	1	3	0.75
CC	1/3	1	0.25

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_R

Indicator R	RDC	CC	Priority
RDC	1	1/2	0.333
CC	2	1	0.667

Because P=2, it must be consistent.

Pairewise Comparison Matrices Y_S

Indicator S	RDC	CC	priority
RDC	1	1/2	0.333
CC	2	1	0.667

Because P=2, it must be consistent.

Part C, The attached questionnaires below:

The questionnaire for first round of Delphi method

Ladies and gentlemen:

This questionnaire is designed for the research of RDC/CC performance evaluation. The coordinator has designed 19 indicators in 4 aspects (cost control, logistics stabilization, logistics flexibility and compliance) for the all-rounded performance of RDC/CC, but these 19 indicators are somehow redundant. So the coordinator hopes that all of you can rank 19 indicators into 3 levels of importance: very important (the 1^{st} rank), relatively important (the 2^{nd} rank) and not important (the 3^{rd} rank). In the blank "rank row", please enter the rank level, like: 1^{st}, 2^{nd}, 3^{rd}.

The indicators which are deemed as not important by over 75% panelists will be omitted or merged with other indicators. So please rank the indicators from an adiaphorous global view to avoid departmental preference.

If possible, the reasons why the indicators are ranked as not important and the suggestions about how to improve the indicator system are expected to follow at the bottom of the questionnaire.

aspects	indicators	Rank
Cost control	Indicator A: the saving rate of contract price compared with the PR's(purchasing request) budget	

	Indicator B: the saving rate of contract price compared with the average market open price	
	Indicator C: the saving rate of price of per handling activity of this year compared with price of per handling activity of last year	
	Indicator D: the saving rate of the final bid price compared with the first bid price	
logistics stabilization	Indicator E: the rate of the correct physical account	
	Indicator F: rate of inventory Accuracy in System	
	Indicator G: rate of rightness of storage	
	Indicator H: rate of JIT delivery	
	Indicator I: rate of streamline shut down	
	Indicator J: rate of material damaged	
	Indicator K: rate of PCR (part conveyance request) closed in time	
logistics flexibility	Indicator L: rate of completion of the enlarged PCRs	
	Indicator M: rate of completion of the advanced PCR	
	Indicator N: rate of completion of the additional PCR	
	Indicator O: rate of completion of special cargo requirement	
Complian	Indicator P: rate of IT system shut down	

ce	Indicator Q: rate of late conformation report of PCR	
	Indicator R: rate of error transit report on PCR.	
	Indicator S: rate of right audit report	

If you have any ideas or suggestions, please write here:

Thank you & Best Regards

Wang Jian

GP, Purchasing Department

Shanghai General Motors

The questionnaire for second round of Delphi method

Ladies and gentlemen:

Thanks for your active participation in the first round questionnaire research. We have achieved encouraging results. The reasons why the indicators are ranked as not important and the suggestions by different panelists about how to improve the indicator system are followed in the below table:

Indicator	The reason from some panelists
Indicator B	The market price is fluctuating all the time, it's difficult to define the average price; the contract between SGM and RDC/CC is usually long term service contract which is not related to the market price very much.
Indicator D	The first bid is usually tentative,

	which has not much reference value.
Indicator E	It can be replaced by Indicator F.
Indicator G	It can be replaced by Indicator J.
Indicator K	PCR is only paid by SGM after the PCR is shut down. If the PCR is not closed in time, there will be delayed payment for the supplier, which will have no negative impact on SGM.
Indicator Q	This indicator is nearly 100% all the time, so it nearly has no reference value.
Indicator L	They can be defined as single indicator named rate of completion of the special PCRs
Indicator M	
Indicator N	

According to the results of first round, the coordinator hopes that you will further refine the ranking of indicators in this second round. The requirements of second round is the same as the first round, and also if you have any idea or suggestion, please write down at the bottom of the questionnaire.

aspects	indicators	rank
Cost control	Indicator A: the saving rate of contract price compared with the PR's(purchasing request) budget	
	Indicator B: the saving rate of contract price compared with the average market open price	
	Indicator C: the saving rate of price of per handling activity of this year compared with price of per handling activity of last year	

	Indicator D: the saving rate of the final bid price compared with the first bid price	
logistics stabilization	Indicator E: the rate of the correct physical account	
	Indicator F: rate of inventory Accuracy in System	
	Indicator G: rate of rightness of storage	
	Indicator H: rate of JIT delivery	
	Indicator I: rate of streamline shut down	
	Indicator J: rate of material damaged	
	Indicator K: rate of PCR (part conveyance request) closed in time	
logistics flexibility	Indicator L: rate of completion of the special PCRs	
	Indicator O: rate of completion of special cargo requirement	
Compliance	Indicator P: rate of IT system shut down	
	Indicator Q: rate of late conformation report of PCR	
	Indicator R: rate of error transit report on PCR.	
	Indicator S: rate of right audit report	

If you have any ideas or suggestions, please write here:

Thank you & Best Regards

Wang Jian

GP, Purchasing Department

Shanghai General Motors

The questionnaire of AHP method for purchasing department

Ladies and gentlemen:

This questionnaire is designed for the research of RDC/CC performance evaluation. The coordinator has designed 11 indicators in 4 aspects (cost control, logistics stabilization, logistics flexibility and compliance) for the all-rounded performance of RDC/CC. The 11 indicators are well refined by the Delphi method that we have reduced the redundancy and made some constructive adjustment. The existing 11 indicators are believed to be effective and important.

The questionnaires will contain several tables with blanks for you to fill. The blank is the relative weight you should decide for one indicator compared with another. The coordinator hopes that all the informants will rank the relative weight of indicators and the relative weights with respect to proximity to each indicator according to the instruction of below table:

Numerical Values	Verbal Terms	Explanation
1	Equally important	Two elements have equal importance regarding the element in higher level
3	Moderately more important	Experience or judgment slightly favors one element
5	Strongly more important	Experience or judgment strongly favors one element
7	Very strongly more important	Dominance of one element proved in practice

9	Extremely more important	The highest order dominance of one element over another
2,4,6,8	Important Intermediate values	Compromise is needed

For example:

	apple
Banana	3

This means that banana is moderately more important than apple or the banana performs moderately better than the apple. It's worthy to mention that the relative weight for the apple compared with the banana must be 1/3, the reciprocal value of the relative weight for the banana compared with the apple.

However, in this case, different department will receive different questionnaires, which means that only the certain questionnaires will be distributed to related department.

So I hope all the informants will complete these questionnaires below smoothly. If you have any questions, please contact me. Thanks for your participation.

The relative weight of each indicator:

	Finance (How can the suppliers save money for the purchaser?)	Business internal process (How can the supplier help to improve the purchaser's business internal process?)	Study and growth (How can the supplier help to improve the purchaser's personnel, system and organizational structure)
Finance			

Business internal process			
Study and growth			

Finance(cost control)	Indicator A (the saving rate of contract price compared with the PR's budget)	Indicator C (the saving rate of price of per handling activity of this year compared with price of per handling activity of last year)
Indicator A:		
Indicator C:		

The relative weights with respect to proximity to each indicator:

Indicator A (the saving rate of contract price compared with the PR's budget)	RDC	CC
RDC		
CC		

Indicator C (the saving rate of price of per handling activity of this year compared with price of per handling activity of last year)	RDC	CC
RDC		
CC		

Thank you & Best Regards

Wang Jian

GP, Purchasing Department

Shanghai General Motors

The questionnaire of AHP method for PC&L department

Ladies and gentlemen:

This questionnaire is designed for the research of RDC/CC performance evaluation. The coordinator has designed 11 indicators in 4 aspects (cost control, logistics stabilization, logistics flexibility and compliance) for the all-rounded performance of RDC/CC. The 11 indicators are well refined by the Delphi method that we have reduced the redundancy and made some constructive adjustment. The existing 11 indicators are believed to be effective and important.

The questionnaires will contain several tables with blanks for you to fill. The blank is the relative weight you should decide for one indicator compared with another. The coordinator hopes that all the informants will rank the relative weight of indicators and the relative weights with respect to proximity to each indicator according to the instruction of below table:

Numerical Values	Verbal Terms	Explanation
1	Equally important	Two elements have equal importance regarding the element in higher level
3	Moderately more important	Experience or judgment slightly favors one element
5	Strongly more	Experience or judgment strongly

	important	favors one element
7	Very strongly more important	Dominance of one element proved in practice
9	Extremely more important	The highest order dominance of one element over another
2,4,6,8	Important Intermediate values	Compromise is needed

For example:

	apple
Banana	3

This means that banana is moderately more important than apple or the banana performs moderately better than the apple. It's worthy to mention that the relative weight for the apple compared with the banana must be 1/3, the reciprocal value of the relative weight for the banana compared with the apple.

However, in this case, different department will receive different questionnaires, which means that only the certain questionnaires will be distributed to related department.

So I hope all the informants will complete these questionnaires below smoothly. If you have any questions, please contact me. Thanks for your participation.

The relative weight of each indicator:

	Finance (How can the suppliers save money for the purchaser?)	Business internal process (How can the supplier help to improve the purchaser's business internal	Study and growth (How can the supplier help to improve the purchaser's personnel, system

		process?)	and organizational structure)
Finance			
Business internal process			
Study and growth			

Business internal process	logistics stabilization	logistics flexibility
logistics stabilization		
logistics flexibility		

logistics stabilization	Indicator F(rate of inventory Accuracy in System)	Indicator H (rate of JIT delivery)	Indicator I (rate of streamline shut down)	Indicator J (rate of material damaged)
Indicator F				
Indicator H				
Indicator I				
Indicator J				

logistics flexibility	Indicator T (rate of completion of the special PCRs)	Indicator O (rate of completion of special cargo requirement)
Indicator T		
Indicator O		

The relative weights with respect to proximity to each indicator:

Indicator F (rate of inventory Accuracy in System)	RDC	CC
RDC		
CC		

Indicator H (rate of JIT delivery)	RDC	CC
RDC		
CC		

Indicator I (rate of streamline shut down)	RDC	CC
RDC		
CC		

Indicator J (rate of material damaged)	RDC	CC
RDC		
CC		

Indicator T (rate of completion of the special PCRs)	RDC	CC
RDC		
CC		

Indicator O (rate of completion of special cargo requirement)	RDC	CC
RDC		
CC		

Thank you & Best Regards

Wang Jian

GP, Purchasing Department

Shanghai General Motors

The questionnaire of AHP method for manufacturing department

Ladies and gentlemen:

This questionnaire is designed for the research of RDC/CC performance evaluation. The coordinator has designed 11 indicators in 4 aspects (cost control, logistics stabilization, logistics flexibility and compliance) for the all-rounded performance of RDC/CC. The 11 indicators are well refined by the Delphi method that we have reduced the redundancy and made some constructive adjustment. The existing 11 indicators are believed to be effective and important.

The questionnaires will contain several tables with blanks for you to fill. The blank is the relative weight you should decide for one indicator compared with another. The coordinator hopes that all the informants will rank the relative weight of

indicators and the relative weights with respect to proximity to each indicator according to the instruction of below table:

Numerical Values	Verbal Terms	Explanation
1	Equally important	Two elements have equal importance regarding the element in higher level
3	Moderately more important	Experience or judgment slightly favors one element
5	Strongly more important	Experience or judgment strongly favors one element
7	Very strongly more important	Dominance of one element proved in practice
9	Extremely more important	The highest order dominance of one element over another
2,4,6,8	Important Intermediate values	Compromise is needed

For example:

	apple
Banana	3

This means that banana is moderately more important than apple or the banana performs moderately better than the apple. It's worthy to mention that the relative weight for the apple compared with the banana must be 1/3, the reciprocal value of the relative weight for the banana compared with the apple.

However, in this case, different department will receive different questionnaires, which means that only the certain questionnaires will be distributed to related

department.

So I hope all the informants will complete these questionnaires below smoothly. If you have any questions, please contact me. Thanks for your participation.

The relative weight of each indicator:

	Finance (How can the suppliers save money for the purchaser?)	Business internal process (How can the supplier help to improve the purchaser's business internal process?)	Study and growth (How can the supplier help to improve the purchaser's personnel, system and organizational structure)
Finance			
Business internal process			
Study and growth			

Business internal process	logistics stabilization	logistics flexibility
logistics stabilization		
logistics flexibility		

logistics stabilizati	Indicator F(rate of	Indicator H (rate of JIT	Indicator I (rate of streamline shut	Indicator J (rate of material

on	inventory Accuracy in System)	delivery)	down)	damaged)
Indicator F				
Indicator H				
Indicator I				
Indicator J				

logistics flexibility	Indicator T (rate of completion of the special PCRs)	Indicator O (rate of completion of special cargo requirement)
Indicator T		
Indicator O		

The relative weights with respect to proximity to each indicator:

Indicator F (rate of inventory Accuracy in System)	RDC	CC
RDC		
CC		

Indicator H (rate of JIT delivery)	RDC	CC
RDC		
CC		

Indicator I (rate of streamline shut down)	RDC	CC
RDC		
CC		

Indicator J (rate of material damaged)	RDC	CC
RDC		
CC		

Indicator T (rate of completion of the special PCRs)	RDC	CC
RDC		
CC		

Indicator O (rate of completion of special cargo requirement)	RDC	CC
RDC		
CC		

Thank you & Best Regards

Wang Jian

GP, Purchasing Department

Shanghai General Motors

The questionnaire of AHP method for IT department

Ladies and gentlemen:

This questionnaire is designed for the research of RDC/CC performance evaluation. The coordinator has designed 11 indicators in 4 aspects (cost control, logistics stabilization, logistics flexibility and compliance) for the all-rounded performance of RDC/CC. The 11 indicators are well refined by the Delphi method that we have reduced the redundancy and made some constructive adjustment. The existing 11 indicators are believed to be effective and important.

The questionnaires will contain several tables with blanks for you to fill. The blank is the relative weight you should decide for one indicator compared with another. The coordinator hopes that all the informants will rank the relative weight of indicators and the relative weights with respect to proximity to each indicator according to the instruction of below table:

Numerical Values	Verbal Terms	Explanation
1	Equally important	Two elements have equal importance regarding the element in higher level
3	Moderately more important	Experience or judgment slightly favors one element
5	Strongly more important	Experience or judgment strongly favors one element
7	Very strongly more important	Dominance of one element proved in practice
9	Extremely more important	The highest order dominance of one element over another
2,4,6,8	Important Intermediate values	Compromise is needed

For example:

	apple
Banana	3

This means that banana is moderately more important than apple or the banana performs moderately better than the apple. It's worthy to mention that the relative weight for the apple compared with the banana must be 1/3, the reciprocal value of the relative weight for the banana compared with the apple.

However, in this case, different department will receive different questionnaires, which means that only the certain questionnaires will be distributed to related department.

So I hope all the informants will complete these questionnaires below smoothly. If you have any questions, please contact me. Thanks for your participation.

The relative weight of each indicator:

	Finance (How can the suppliers save money for the purchaser?)	Business internal process (How can the supplier help to improve the purchaser's business internal process?)	Study and growth (How can the supplier help to improve the purchaser's personnel, system and organizational structure)
Finance			
Business internal process			
Study and growth			

Study and growth	Indicator P (rate of IT system shut down)	Indicator R (rate of error transit report on PCR)	Indicator S (rate of error transit report on PCR)
Indicator P			
Indicator R			
Indicator S			

The relative weights with respect to proximity to each indicator:

Indicator P (rate of IT system shut down)	RDC	CC
RDC		
CC		

Indicator R (rate of error transit report on PCR)	RDC	CC
RDC		
CC		

Indicator S (rate of error transit report on PCR)	RDC	CC
RDC		
CC		

Thank you & Best Regards

Wang Jian

GP, Purchasing Department

Shanghai General Motors