# MODELLING AND EVALUATION OF OPERATIONAL COMPETITIVENESS OF MANUFACTURING ENTERPRISES

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## 1 INTRODUCTION

With the fast growing economics, China will become the second largest economic entity in the world by 2010 according to Chinese economist's forecast. The Chinese manufacturing industries are more competitive than ever before in the global market. China is now a strong manufacturing country and Chinese economics has influenced the global market in many different areas. Everything seems to have been changed with the global economic downturn in which China prevails with its ongoing growth and huge market.

Chinese state-owned manufacturing enterprise (CSOME) is the most representative type of companies in China and most significant representative of Socialism with Chinese characteristics. CSOME produce majority of Chinese GDP (e.g. over 75% in 2007) and they are also majority portion of top 500 companies in China. As a fact the CSOME is the backbone and primary driving force of the growing Chinese economics even despite of the global economic downturn. Although the case studies are done for several subsidiaries of different industries which all belong to one large CSOME group, the results are commonly representative for majority since mostly they share very similar characteristics.

In this study we mainly focus on the integration of manufacturing strategy and transformational leadership for Chinese State-Owned Manufacturing Enterprises (CSOME), based on empirical studies in China. "China effect" has influenced business and manufacturing strategies globally in many different business areas (Takala et al., 2007a). We have brought the influence of "China effect" to study how it will impact the operational competitiveness of CSOME on top of their manufacturing strategy and transformational leadership. We promote a novel concept of overall competitiveness to evaluate performance of companies in global context by integrating the evaluation of manufacturing strategy and transformational leadership including technology level altogether using analytical models created in this paper.

The theoretical reference framework of this study starts from resource-based view of a firm for case study (Wernerfelt, 1984). Takala et al. (2002) have presented justification of multi-focused manufacturing strategies. Miles and Snow (1978) have defined four company groups which include prospector,

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analyzer, defender and reactor. According to Miles and Snow (1978), on the contrary to the three groups which are prospector, analyzer and defender, reactor does not lead to a consistent and stable organisation and therefore it is advised to change over to one of the other three groups. Based on this theory, Takala et al. (2007b) have introduced unique analytical model to evaluate global competitiveness rankings for manufacturing strategies in prospector, analyzer and defender groups according to the company's multi-criteria priority weights of Q(Quality), C(Cost), T(Time) and F(Flexibility). Such analytical models are used to gain insight into the influences and sensitivities of various parameters and processes on the alteration of manufacturing strategies by Takala et al. (2007c). In China, the most dynamic market, Liu et al. (2008) has first time applied such analytical models to analyze and improve operational competitiveness of one private middle-size Chinese manufacturing company by adjusting competitive priorities in manufacturing strategy. Liu, Si and Takala (2009) has compared the operational competitiveness strategies in China and other countries in a global context by utilizing same analytical models, in order to analyze different characteristics of manufacturing strategies in different markets and suggest how the companies can improve their operational competitiveness. But the adjustment of manufacturing strategy alone is not just enough to improve the overall competitiveness to develop the business. This is one important factor and there is another important and necessary factor to improve the overall competitiveness no matter in adversity or in prosperity, which can be even more decisive and that is leadership (Bass, 1985). Bass and Avolio (1994) provided evidence on the benefits and effectiveness of transformational leadership on leadership and training of leaders. Transformational leaders help their subordinates to learn and develop as individuals, by encouraging and motivating them with versatile repertoire of behavioural and decision making capability (Bass and Avolio, 1994; Bass, 1997). Takala et al. (2008a) introduced another unique analytical model to evaluate the level of outcome direction, leadership behaviour and resource allocation of transformational leadership. In this paper transformational leadership is further extended by adding technology level as part of resource allocation. The final idea in this paper is to create a new analytical model to integrate manufacturing strategy and transformational leadership including technology level together for more comprehensive evaluation of overall competitiveness to develop the business operations further. The study continues further in China with deeper insight analysis of overall competitiveness of CSOME and suggests how to improve the overall competitiveness. The related case study includes benchmarking and development of overall competitiveness of CSOME case CN_WG group in global context which emphasize more on the adjustment of its manufacturing strategy and transformational leadership to improve overall competitiveness in regional and global market.

The structure of this paper is as follow. Section 2 introduces research methodologies. Section 3 models the integration of manufacturing strategy and transformational leadership including technology level to evaluate overall competitiveness with case study. Section 4 discusses briefly the analysis results and proposes the future research areas. Section 5 draws the conclusion.

## 2 RESEARCH METHODOLOGIES

### 2.1 Analytic Hierarchy Process (AHP) method

Analytic Hierarchy Process (AHP) method (Saaty, 1980) is a multi-attribute decision instrument that allows considering quantitative, qualitative measures and making trade-offs. The AHP is used in this study to deal with the empirical part, which includes analyzing questionnaires and calculating weights of main criteria and sub-criteria. AHP is aimed at integrating different measures into single overall score for ranking decision alternatives with pair wise comparison of chosen attributes (Rangone, 1996). This utilizes pair wise comparison by interviewing the experts within the whole organization. The AHP based instruments (forms and questionnaires) have been used in our case studies for more than 20 years in successful analysis of case companies and proved to be reliable. Further more, some open questions are used in additional to the pair wise comparisons in the AHP questionnaires to add internal validity to the answers. The inconsistency ratio (icr) has been calculated to assure the reliability of pair wise comparison results. Only matrixes with inconsistency value of 0.10 or less, and 0.30 or less in smaller groups with competent informants, can be used for reliable decision-making. Otherwise the answers are considered as invalid and will not be used in the case study.

The procedures of utilizing the AHP are as follows in this paper. The first step is to establish the model of hierarchy structure for the goal. In this study, the hierarchy models are constructed for the evaluation of manufacturing strategy by Takala et al. (2002) and transformational leadership by Takala et al. (2005), which servers as theoretical framework of this study. The second step is the comparison of the alternatives and the criteria. They are pair wise compared with respect to each element of the next higher level. The last step is connecting the comparisons so that to get the priorities of the alternatives with respect to each criteria and the weights of each criteria with respect to the goal. The local priorities are then multiplied by the weights of the respective criterion. The results are summed up to get the overall priority of each alternative.

### 2.2 Data collection and analysis

The data of CSOME case CN_WG group has been collected by answering questionnaires from senior managers or directors of 15 different subsidiaries. The interviewees are normally decision makers and middle management groups in the

case companies, who have good knowledge about the operations of the case companies, and the number of informants is depended on the size of case company. From same case company the inconsistent results are left out. Firstly, the senior managers or directors were trained to understand every criteria of the questionnaire by email, telephone or interview. Secondly, after they finished the questionnaires, the answers were analyzed by AHP software. Thirdly, the discussion with managers or directors revealed the results and verified the reliabilities of the data further.

For studying the manufacturing strategy, competitiveness priorities are listed in the AHP questionnaires as main criteria consisting of quality, cost, delivery, and flexibility. The main criteria are typical items used in evaluating the competitiveness priorities in multi-focused manufacturing strategies (Takala et al., 2002). They are formed based on typical case studies and instruments used in interviews. The sub-criteria involve 19 criterions, such as low defect rate, low cost, fast delivery, broad product line, etc. The weights are statistically measured for further analysis with analytical model (Takala et al., 2007b).

For studying the transformational leadership, leadership profiles are empirically measured with the theoretical frame of reference by AHP questionnaires (Takala et al., 2005). Statistical tests are made to find out the logic in the leadership profiles to increase the accuracy in the profiles, and in parallel by induction analytical model is built and tested statistically to measure leadership skills by leadership indexes from resource utilizations to leadership behaviours and finally to outcome directions and outcomes. Analytical model is further used to measure the effectiveness of leadership actions within different areas of outcomes and try to find out the correlation between these outcomes and leadership indexes in a forecasting way (Takala et al., 2008b).

## 2.3 Research assumptions

(1) CSOME can have strong competitiveness of manufacturing strategy in prospectors under normal business situation and may change to analyzer or even defender under different business situation e.g. economic crisis.

(2) Strong competitive CSOME in manufacturing strategy do not necessarily have strong outcome index, leadership index, resource index in transformational leadership since government behaviour (national policies, macro control) normally plays a key role rather than leadership in the operations of CSOME.

(3) Overall competitiveness will be decided by both the level of manufacturing strategy and transformational leadership. For successful cases there should be positive relationship between manufacturing strategy index and total leadership index.

### 2.4 Case study and case company

The research is based on doing numerous case studies for CSOME to analyze with existing analytical models and to create new analytical models for further evaluation, therefore the selection of case company must be mostly representative, well performed and highly experienced in its operations. Among 10 major backbone industries of Chinese economics, iron and steel industry is ranked as No. 1. Case CN_WG group is the first giant iron and steel manufacturing enterprise established after the founding of the People's Republic of China and one of the backbone enterprises under the leadership of the central government and the state council. Case CN_WG group is ranked top 3 CSOME in iron and steel industry in China. It has a production scale of more than 30 million tons, with over 120 thousand employees and 123.7 billon RMB revenue in 2008. Its operational concept is taking quality-profitability development route to produce high quality and high value-added products, since quality factors and key principles of quality management are important for financial decision-making (Zgodavová, 2004). Its strategic goal is to enter top 500 enterprises in the world, and become a world first-class enterprise with powerful self-innovation capability and market competitiveness by the year of 2010.

## 3 EVALUATION AND INTEGRATION OF MANUFACTURING STRATEGY AND TRANSFORMATIONAL

In this study, we propose to evaluate overall competitiveness based on two core factors, i.e. manufacturing strategy and transformational leadership. Existing analytical models are examined and new analytical models are proposed to integrate the two core factors as a holistic model to evaluate overall competitiveness. Another factor, which is technology level, is proposed to be considered as part of resources of leadership.

### 3.1 Analytical models for manufacturing strategy

The analytical models for manufacturing strategy are used to calculate the operational competitiveness indexes of companies in the different groups, which are prospector, analyzer and defender. According to Takala (2002), the responsiveness, agility and leanness (RAL) holistic model supports the theory of the analytical models using four main criteria, i.e. quality, cost, time and flexibility. The analytical models are developed from our research group based on over 100 case company studies in over 10 countries worldwide, whose industrial branch varies from one to another and company size varies from big to small but they share one thing in common which is that they all compete in a highly dynamic business environment and therefore such analytical model has good transferability.

The Manufacturing Strategy Index (MSI) is modelled as function . In the analytical models (Takala et al., 2007), the equations to calculate weights of core factors are as follows.

$$Q\% = \frac{Q}{Q+C+T}(1); C\% = \frac{C}{Q+C+T}(2); T\% = \frac{T}{Q+C+T}(3);$$

$$F\% = \frac{F}{Q+C+T+F}(4);$$

The analytical models to calculate the operational competitiveness rankings in each group are given.

The analytical model for prospector group:

$$\phi \sim 1-\left(1-Q\%^{1/3}\right)(1-0.9*T\%)(1-0.9*C\%)*F\%^{1/3} \quad (5)$$

The analytical model for analyzer group:

$$\lambda \sim 1-(1-F\%)\left(ABS\left(\begin{matrix}(0.95*Q\%-0.285)*(0.95*T\%-0.285)*\\(0.95*C\%-0.285)\end{matrix}\right)\right)^{1/3} \quad (6)$$

The analytical model for defender group:

$$\varphi \sim 1-\left(1-C\%^{1/3}\right)(1-0.9*T\%)(1-0.9*Q\%)*F\%^{1/3} \quad (7)$$

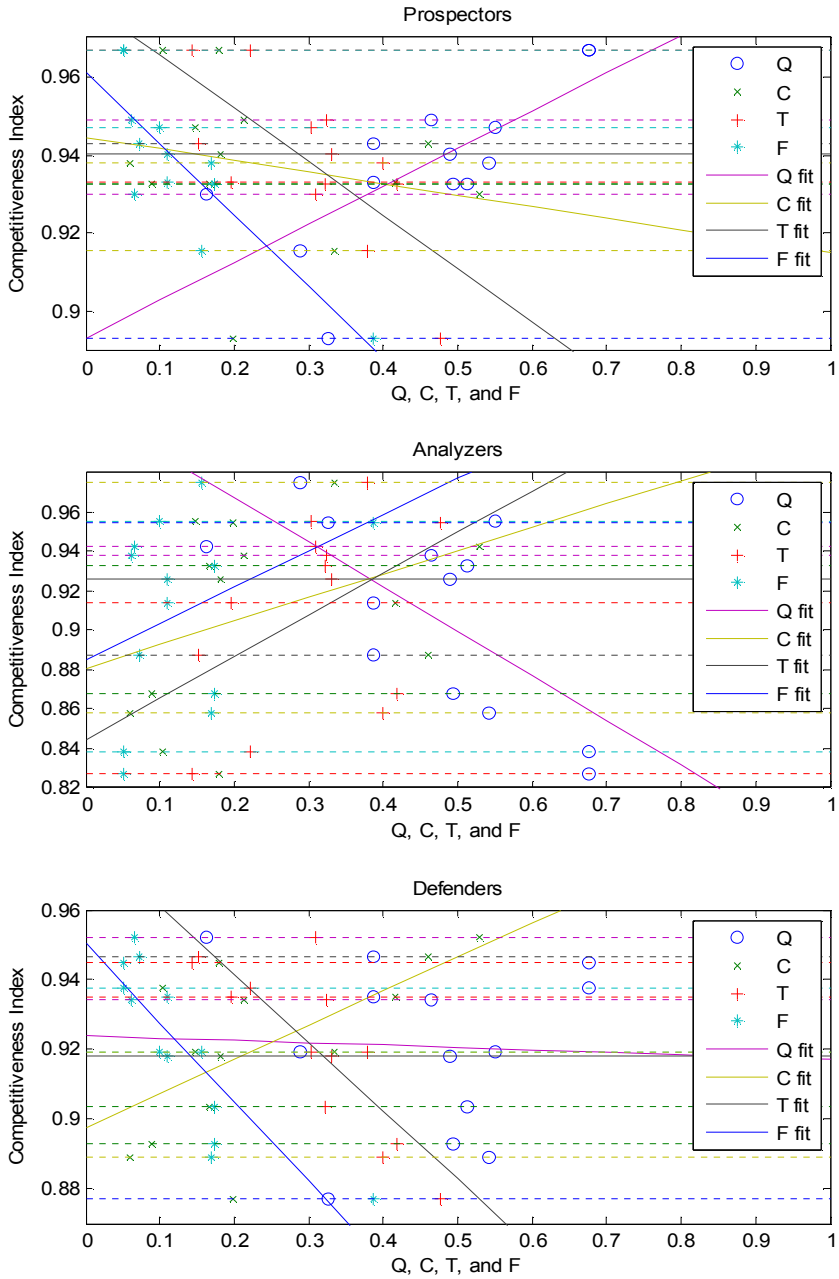


*Figure 1. Competitiveness indexes of 12 subsidiaries of case CN_WG in Prospector, Analyzer and Defender groups, solid horizontal lines are the median values*

*Table 1. Evaluation of manufacturing strategies of the subsidiaries of case CN_WG*

| | | | | | Prospector | | Analyzer | | Defender | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Subsidiaries** | **Quality** | **Cost** | **Time** | **Flexibility** | **Competitive index** | **Ranking** | **Competitive index** | **Ranking** | **Competitive index** | **Ranking** |
| CN_WG-1 | 0.4070 | 0.0740 | 0.3450 | 0.1740 | 0.9327 | | 0.8679 | | 0.8929 | |
| CN_WG-2 | 0.6410 | 0.1710 | 0.1370 | 0.0510 | 0.9669* | 8 | 0.8275 | | 0.9449 | |
| CN_WG-3 | 0.4940 | 0.1320 | 0.2730 | 0.1000 | 0.9470 | | 0.9556 | | 0.9194 | |
| CN_WG-4 | 0.4360 | 0.1990 | 0.3030 | 0.0620 | 0.9488 | | 0.9382 | | 0.9341 | |
| CN_WG-5 | 0.4510 | 0.0490 | 0.3320 | 0.1690 | 0.9381 | | 0.8583 | | 0.8892 | |
| CN_WG-6 | 0.3590 | 0.4280 | 0.1410 | 0.0720 | 0.9430 | | 0.8876 | | 0.9468 | |
| CN_WG-7 | 0.2000 | 0.1210 | 0.2920 | 0.3870 | 0.8933 | | 0.9546 | | 0.8772 | |
| CN_WG-8 | 0.4230 | 0.1370 | 0.2660 | 0.1740 | 0.9326 | | 0.9328 | | 0.9037 | |
| CN_WG-9 | 0.3450 | 0.3710 | 0.1750 | 0.1100 | 0.9332 | | 0.9140 | | 0.9349 | |
| CN_WG-10 | 0.6400 | 0.0980 | 0.2100 | 0.0520 | 0.9667* | 8 | 0.8383 | | 0.9378 | |
| CN_WG-11 | 0.1520 | 0.4930 | 0.2880 | 0.0670 | 0.9302 | | 0.9426 | | 0.9521* | 7 |
| CN_WG-12 | 0.2430 | 0.2810 | 0.3190 | 0.1570 | 0.9155 | | 0.9749* | 4 | 0.9192 | |
| Median of subsidiaries | 0.4348 | 0.1613 | 0.2939 | 0.1100 | 0.9401 | 38 | 0.9258 | 28 | 0.9181 | 32 |
| Mean of subsidiaries | 0.3993 | 0.2128 | 0.2567 | 0.1313 | 0.9336 | 43 | 0.9718 | 6 | 0.9181 | 32 |

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*Table 2. Evaluation of transformational leadership indexes of subsidiaries leaders of case CN_WG*

| Leaders | OI | OI (Prospectors) | OI (Analyzers) | OI (Defenders) | LI | RI | TLI | TLI (Prospectors) | TLI (Analyzers) | TLI (Defenders) |
|---|---|---|---|---|---|---|---|---|---|---|
| Leader-1 | 0.7732 | 0.9355 | 0.7908 | 0.9274 | 0.3235 | 0.3947 | 0.0987 | 0.1195 | 0.1010 | 0.1184 |
| Leader-2 | 0.6608 | 0.9149 | 0.8566 | 0.9424 | 0.0786 | 0.5386 | 0.0280 | 0.0387 | 0.0363 | 0.0399 |
| Leader-3 | 0.7667 | 0.9326 | 0.7788 | 0.9316 | 0.1747 | 0.1779 | 0.0238 | 0.0290 | 0.0242 | 0.0289 |
| Leader-4 | 0.8552 | 0.9328 | 0.8925 | 0.9226 | 0.1371 | 0.3024 | 0.0355 | 0.0387 | 0.0370 | 0.0383 |
| Leader-5 | 0.8657 | 0.9377 | 0.7874 | 0.9388 | 0.2366 | 0.6145 | 0.1259 | 0.1364 | 0.1145 | 0.1365 |
| Leader-6 | 0.7982 | 0.9329 | 0.7834 | 0.9337 | 0.1750 | 0.4750 | 0.0663 | 0.0775 | 0.0651 | 0.0776 |
| Leader-7 | 0.9167 | 0.9397 | 0.8404 | 0.9451 | 0.3420 | 0.3641 | 0.1141 | 0.1170 | 0.1046 | 0.1177 |
| Leader-8 | 0.9647 | 0.9580 | 0.7958 | 0.9561 | 0.2510 | 0.3401 | 0.0823 | 0.0818 | 0.0679 | 0.0816 |
| Leader-9 | 0.8677 | 0.9258 | 0.8520 | 0.9392 | 0.1974 | 0.4031 | 0.0690 | 0.0736 | 0.0678 | 0.0747 |
| Leader-10 | 0.8113 | 0.9236 | 0.8328 | 0.9383 | 0.1449 | 0.6027 | 0.0709 | 0.0807 | 0.0727 | 0.0820 |
| Leader-11 | 0.9698 | 0.9583 | 0.7739 | 0.9593 | 0.0391 | 0.4571 | 0.0173 | 0.0171 | 0.0138 | 0.0171 |
| Leader-12 | 0.8968 | 0.9380 | 0.7965 | 0.9427 | 0.2311 | 0.3231 | 0.0670 | 0.0700 | 0.0595 | 0.0704 |

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Table 1 shows the evaluation results of manufacturing strategies of 12 subsidiaries of case CN_WG. According to Liu et al. (2008) and Si et al. (2010), normalized median values and mean values can be reliably used to evaluate combined competitiveness ranking of an organization's manufacturing strategy based on individual values from its different departments or subsidiaries. Based on such theory, the competitiveness of case CN_WG is tested by calculating with median and mean values in Table 1. The top competitive subsidiaries, also the medians and the means of subsidiaries of case CN_WG in prospector, analyzer and defender groups are ranked in our global manufacturing strategies (GMSS) database. From the rankings it can be seen that case CN_WG is most competitive in analyzer group with mean value ranked 6th. The top competitive subsidiaries are marked with asterisks in Table 1. Case CN_WG-12 is most competitive among all subsidiaries, which has highest ranking 4th in analyzer group. The top competitive subsidiary in prospector group, case CN_WG-2 and CN_WG-10, both have nearly equivalent strong competitiveness which ranked 8th. The top competitive subsidiary in defender group, case CN_WG-11, has also strong competitiveness which ranked 7th. It can be seen that case CN_WG group has highly competitive subsidiaries in prospector, analyzer and defender groups, which indicates that it is a highly competitive group corporation and in overall it has strong competitiveness especially in analyzer group. This has proved research assumption (1).

## 3.2 Analytical models for transformational leadership

Takala et al. (2008a) have developed analytical models for the evaluations of leadership indexes and its outcomes of different parts of leadership. These models are outcome direction index (OI) by balancing the directions, leadership behaviour index (LI) by measuring deep leadership, and by measuring maximum of passive and/or controlling leadership and by measuring in different ways the utilization of the cornerstones of deep leadership, and resource allocation index (RI) by balancing utilization of human resources. Originally the Transformational Leadership Index (TLI) is modelled as function $f_{TLI}(OI, LI, RI)$. However, in this paper we propose that technology level index (TI) to be considered into transformational leadership as a special part of resources of leadership. Therefore the new proposal is to model Total Leadership Index (TLI) as function $f_{TLI}(OI, LI, RI, TI)$.

The theoretical frame of the analytical models is based on theory of Transformational Leadership (Bass 1997). A holistic but very simple model of a human being from resource allocations to behaviour and finally to outcome directions and outcomes has been built basing on psychic, social, functional, organizational and structural factors and put together according to the sand cone model (Takala et al., 2005) and participation objectives in leadership of an organization.

Sand cone model from operations management literature presents a model of cumulative layers of manufacturing performance dimensions (Takala et al., 2006). The model implies an idea that companies need to develop their performance in certain stages, in order to achieve higher levels of competitive performance. The prescriptive order of mutually supportive and enabling success factors is to proceed from quality, to delivery performance, then flexibility and finally to cost effectiveness. Financial results cannot be achieved if non-financial aspects of performance are improved first. In this manner, the often-competitive dimensions of performance need to be viewed as a whole, to think about performance and capabilities on a longer-term basis. The conceptual model with sand cone has similar basic ideas as the model of deep leadership (Nissinen 2001) in which the potential in professional skills and resources is transformed to outcomes of activities with the help and support of leadership process and behaviour.

The analytical models for evaluation of leadership are as follow.

Outcome Index: $OI = f_{OI}(EF, SA, EE)$

Leadership Index: $LI = f_{LI}(DL, PL, CL, IC, IM, IS, BT)$

Resource Index: $RI = f_{RI}(PT, PC, IT, OR, TI)$

Technology Index: $TI = f_{TI}(SH, CR, BS)$

**Outcome index (OI):**

Without classification: $1 - \max\left\{\left|\frac{1}{3} - EF\right|, \left|\frac{1}{3} - SA\right|, \left|\frac{1}{3} - EE\right|\right\}$ (8)

Prospector: $1 - (1 - EE^{1/3}) \cdot (1 - EF) \cdot (1 - SA) \cdot Std\{EE, SA, EF\}^{1/3}$ (9)

Analyzer: $1 - (1 - SA^{1/3}) \cdot (1 - Std\{EE, SA, EF\}^{1/3})$ (10)

Defender: $1 - (1 - EF^{1/3}) \cdot (1 - EE) \cdot (1 - SA) \cdot Std\{EE, SA, EF\}^{1/3}$ (11)

EF = Effectiveness

SA = Satisfaction

EE = Extra effort

**Leadership index (LI):**

$$DL \cdot (1 - \max\{PL, CL\}) \cdot \left(1 - \left|\frac{1}{4} - \max\{IC, IM, IS, BT\}\right|\right) \quad (12)$$

DL = deep leadership

PL = passive leadership

CL = controlling leadership

IC = individualized consideration

IM = inspirational motivation

IS = intellectual stimulation

BT = building trust and confidence

**Resource index (RI) integrating with Technology index (TI):**

$$\left(1 - PT \cdot (1 - TI)\right) \cdot \left(3 \cdot \min\{PC, IT, OR\} \cdot TI\right) \tag{13}$$

PT = people, technology, know how

PC = processes

IT = information systems

OR = organization (groups, teams)

$$TI = 1 - \max\left\{\left|SH_{optimal} - SH\right|, \left|CR_{optimal} - CR\right|, \left|BS_{optimal} - BS\right|\right\} \tag{14}$$

SH=Spearhead, CR=Core, BS=Basic

**Combined total leadership index (TLI):**

$$TLI = OI \cdot LI \cdot RI \tag{15}$$

In this paper we propose a brand new idea to model the effect of technology index (spearhead, core, and basic technology) to resource index. The definition is proposed as follows according to the principles how resource index has been built.

A. The excessive know how, meaning that caused by not the right technology belongs directly as an extra weight to the warehouse of know how (PT), and/or lowers weights in PC, IT or OR, lowering in both the cases the resource index RI in a linear manner.

B. The right technology, meaning that fitting to the manufacturing stages increases PC, IT or OR, and/or decreases the know how (PT) warehouse that caused by not the right technology, and increases in both the cases the resource index RI in a linear manner.

Definitions A and B with the expert opinions from the case companies and equation for modelling RI are used for the analysis. The weights of SH/CR/BS are collected by interviewing the experts especially how significant or how much effect they are or have to be for PT and min(PC, IT, OR) and then the effects of how TI affects RI is analyzed. The optimal weights of SH, SR, and BS are obtained theoretically from the chosen competitor and market benchmark with

some tolerance. Then the case company data are compared with the optimal values to get the differences for calculating TI. TI is defined to reflect how good the technology level allocation is by using 1 minus the worst deviation from the optimal weights of technology levels. The higher value of TI directly decrease PT caused by using not the right technology and increase min(PC, IT, OR), therefore increases RI eventually.

Table 2 shows the transformational leadership indexes of subsidiaries leaders of case CN_WG of the 12 leaders of their respective subsidiaries of case CN_WG. Figure 2 shows transformational leadership indexes (OI, LI, RI, and TLI) of subsidiaries leaders of case CN_WG. It can be seen that with different categories to calculate OI in prospectors, analyzers and defenders, the final results of TLI are not significantly different, therefore the analysis of TLI is considered without classification of prospectors, analyzers and defenders.

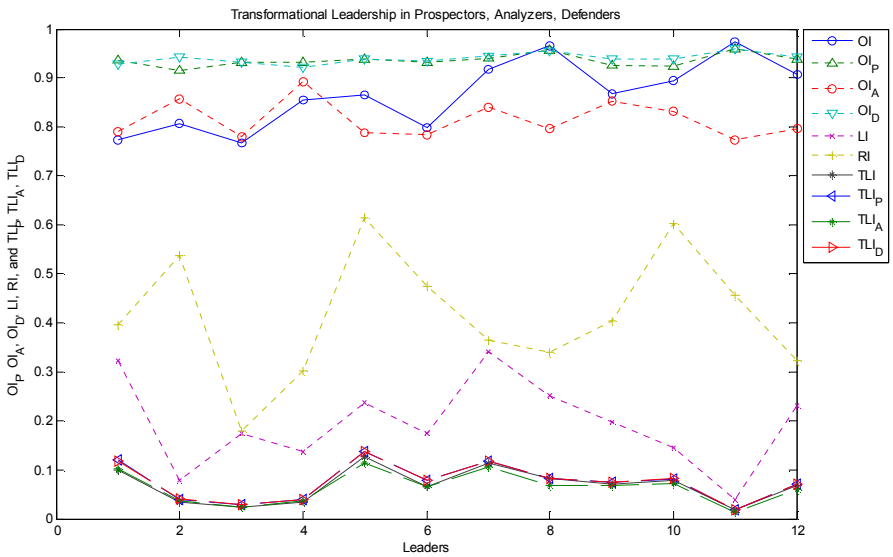


*Figure 2. Transformational leadership indexes of subsidiaries leaders of case CN_WG*

## 3.3 Evaluation of overall competitiveness

Manufacturing strategy and transformational leadership are integrated together to evaluate the overall competitiveness. Figure 3 plots the correlations between manufacturing strategy index (MSI) and total leadership index (TLI). It can be seen that MSI in all groups have positive relations with TLI especially the slope of MSI in analyzer group against TLI is highest, which also proves that CSOME is most competitive in analyzer group, and this is directly caused by the improvement of leadership. This has proved research assumption (2) and (3).

The overall competitiveness index (OCI) is proposed to be modelled as function:

$$OCI = f_{OCI}(f_{MSI}, f_{TLI}) = f_{MSI} \cdot f_{TLI} = MSI \cdot TLI$$

According to above analysis, the OCI can be modelled as reduced function:

$$OCI = f_{OCI}(f_{MSI}, f_{TLI}) = f_{MSI} \cdot f_{TLI} = MSI \cdot OI \cdot TI$$

This is because that the OI of transformational leadership is the key factor to direct the strategic goal of manufacturing strategy and MSI is the driving force of the company, taking the effects of TI into account in which TI are evaluated as approximately constant factors during certain period. In such cases, OI is more decisive to overall competitiveness but other factors like LI, RI, and TI can be influenced also by government macro control. In case CN_WG, since it's most competitive in analyzer group, the OC is evaluated based on MSI and OI in analyzer group. The 3-Dimentional plot of MSI, OI and OCI is shown in Figure 4. The rectangular region shows the potentials where the OCI can be developed.

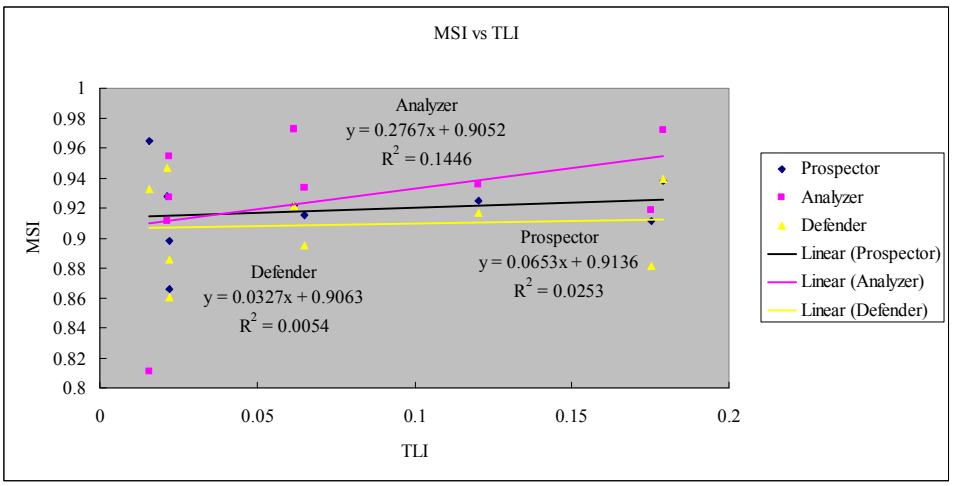


*Figure 3. MSI vs TLI*

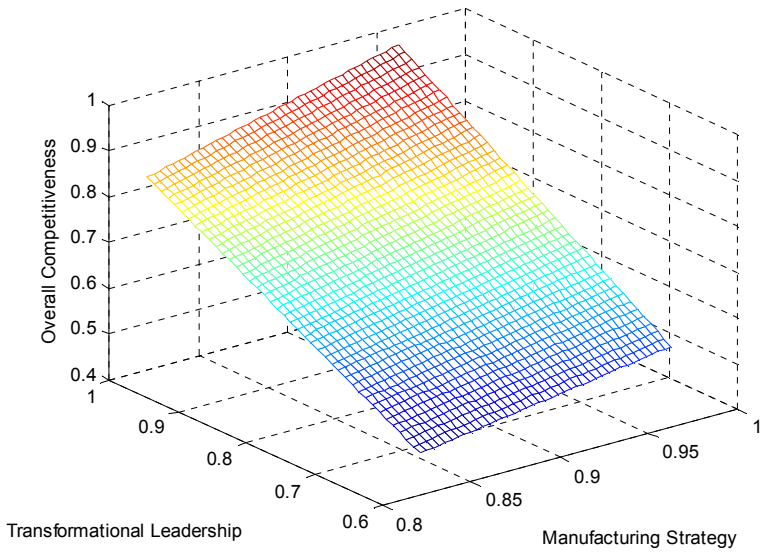


*Figure 4. 3-Dimentional plot of OCI evaluated based on MSI and OI*

## 4 DISCUSSION AND FUTURE RESEARCH

In this paper, the following has been done:

- case studies to management and decision making
- manufacturing strategy analysis: model as function $f_{MSI}(Q,C,T,F)$
- transformation leadership with technology level analysis: model as function $f_{TLI}(OI,LI,RI,TI)$
- overall competitiveness analysis by integration of manufacturing strategy and transformation leadership: model as function $f_{OCI}(f_{MSI},f_{TLI})$
- case studies and analysis of CSOME case CN_WG using analytical models

The experience learnt from this case study can become a model for companies in other countries.

In the future research, several ideas have been proposed as follow:

(1) For manufacturing strategy it will be everlasting and challenging work to calibrate the GMSS database in global context concerning more issues, such as different levels of cost, quality, time and flexibility, especially in technology level, as they all have important impact on competitiveness level of companies. The analytical models will be more intensively examined and calibrated by doing case studies with purpose to adapt to new business situation e.g. crisis and be

able to advise solutions based on the evaluation results obtained from analytical models. These may include:

- new measurement of customer behaviour through interview and case studies
- customer and market behaviour analysis under new situation
- how to change strategies according to different market needs and customer behaviour. Strategies should change according to new measurement of the differences, e.g. to overcome the currency depreciation, change of product line, change of supplier network, increase flexibility in certain area to gain new customer and new market (for example case Wärtsilä's high flexibility in service intensive business)
- simulate the operational performance with new adjusted strategies by utilizing analytical models
- forecast the effects of crisis and the effects of adjusted strategies
- other adjustments except strategies

(2) For transformational leadership, the OI value should probably be scaled to have more meaningful results. A brand new group, reactor, will be introduced. The definition and calculation of reactor group is worth to study in both theoretical and practical level. The actual modelling of TI as part of RI will be implemented. These give better simulation models to new business situations such as crisis.

(3) For overall competitiveness, the evaluation will be compared with more case studies with successful companies to verify its validity further.

(4) How government behaviour (national policies, macro control) will affect enterprises may also be taken into account, whether to put them into crisis (e.g. economical sanctions) or save them from crisis (local protection, government support for the CSOME). Since many large international orders are only based on bilateral government contracts, political reasons cannot be neglected and sometimes decisive. The analytical models can be further optimized according to different characteristics of markets behaviour and economical situation.

## 5 CONCLUSION

In this paper, a novel concept to model and evaluate overall competitiveness has been proposed by integrating manufacturing strategy and transformational leadership including technology level together. The empirical studies are focused to case companies in China especially Chinese State-Owned Manufacturing Enterprise (CSOME). From the case CN_WG group, a typical CSOME studied in this paper, some conclusions can be summarized as following: (1) the case CN_WG is a highly competitive group corporation and in overall it has strong competitiveness especially in analyzer group. (2) Leadership index (LI) has a most significant impact on deciding total leadership index of the case CN_WG.

Manufacturing strategy index (MSI) has a negative effect on total leadership index (TLI) in all groups. Leaders should take the resource of the company into account when deciding manufacturing strategy of the company, as RI has a significant negative effect on MSI. (3) Manufacturing strategy index (MSI) has significant relationship with outcome index (OI), which implies that the outcome direction of leadership will have an important effect on manufacturing strategies. The OI is the key factor to direct the strategic goal and MSI is the driving force of the company, therefore the OC is proposed to be evaluated based on MSI and OI.

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