Application of a quantification SWOT analytical method

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Abstract

In this paper we present a Quantified SWOT (Strengths, Weaknesses, Opportunities and Threats) analytical method which provides more detailed and quantified data for SWOT analysis. The Quantified SWOT analytical method adopts the concept of Multiple-Attribute Decision Making (MADM), which uses a multi-layer scheme to simplify complicated problems, and thus is able to perform SWOT analysis on several enterprises simultaneously. Container ports in East Asia are taken as a case study in this paper. Quantified SWOT analysis is used to assess the competing strength of each port and then suggest an adoptable competing strategy for each.

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1. Introduction

Strategic management has been widely used by all enterprises to withstand fierce market competition. The strategic management process consists of three stages: strategy formulation, strategy implementation, and strategy evaluation [1]. SWOT analysis of external opportunities and threats as well as the internal strengths and weaknesses of the enterprises is important for strategy formulation and development.

The purpose of the analysis of external opportunities and threats is to evaluate whether an enterprise can seize opportunities and avoid threats when facing an uncontrollable external environment, such as fluctuating prices, political destabilization, social transition, change in the rule of law, etc. The purpose of the analysis of internal strengths and weaknesses is to evaluate how an enterprise carries out its internal work, such as management, work efficiency, research and development, etc.

If used correctly, SWOT can provide a good basis for successful strategy formulation. A review of past documents on SWOT analysis reveals that most presented a literal description of the analysis and few conducted quantified analysis. As planning processes are often complicated by numerous criteria and interdependencies, it may be that utilization of SWOT is insufficient. A study by Hill and Westbrook [2] found that none of the 20 case companies prioritized individual SWOT factors, one grouped factors further into subcategories, and only three companies used

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SWOT analysis as an input for a new mission statement. In addition, the expression of individual factors was of a very
general nature and brief. Thus, it can be concluded that the result of SWOT analysis is too often only a superficial and
imprecise listing or an incomplete qualitative examination of internal and external factors [3].

Some related documents have put forward methods of quantified analysis, such as the following methods
generalized by David [1]: the External Factor Evaluation Matrix (EFE), Internal Factor Evaluation Matrix (IFE) and
Competitive Profile Matrix (CPM) methods. However, the following shortcomings are inevitable: (1) all the key
factors’ scores are measured subjectively (e.g., 1–4 points), so objective and quantified data (such as business volume)
is lacking; (2) non-uniformity may occur when answering the same question because the key factors’ weights are
scored subjectively by the evaluation group without a consistency test. Thus, Kurttila et al. [3] and Stewart et al.
[4] combined the Analytic Hierarchy Process (AHP) with SWOT to provide a new hybrid method for improving the
usability of SWOT analysis. Although a consistency test is used to ensure the weights are scored objectively by the
evaluation group, carrying out SWOT analysis comparison on several enterprises simultaneously is difficult.

Quantified SWOT in this study not only improves the above methods, but also develops them on the basis of
the Grand Strategy Matrix (GSM) [5]. Just as in the GSM, the enterprises are parked in the four quadrants of the
coordinate according to their categories (as shown in Fig. 1). However, there is a reversal in that the ordinate stands
for the external environment (opportunities, threats) while the abscissa stands for the internal environment (strengths,
weaknesses). The meaning of the four quadrants is as follows:

The first quadrant stands for the enterprises’ strengths and market opportunities. Enterprises in this quadrant can
use their strengths to adopt strategies, such as market penetration, market development, and product development to
form competitive strength. If the enterprise in the first quadrant has extra resources, forward, backward and horizontal
integration may be efficient strategies.

Enterprises in the second quadrant are those with market developing opportunities but on the weak side of
competition. The most urgent issue is to improve their weakness to intensify competitive strength. If they lack unique
competence, they may consider intensifying their competitive strength through joint venture or horizontal merger
strategies.

Enterprises in the third quadrant are of low competitive strength and facing threats from other competitors.
Defensive strategies, such as focusing on the most favored markets, can be adopted to avoid threats. Divestiture
or liquidation should be adopted if these strategies fail.

Enterprises in the fourth quadrant are those possessing competition strength but facing greater threats than
opportunities. Diversification or joint venture strategies should be adopted to reduce threats.

By Quantified SWOT analysis and revealing of the coordinates, enterprises can not only realize their position in
the competition but also have a reference for developing strategies. But only by the quantified comparison method

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**Fig. 1.** Quantified SWOT analysis and the strategic matrix. (Source: adapted from Christensen et al. [5].)
can the competition situation be shown on the four-quadrant coordinate, and the Quantified SWOT mentioned in this paper be used to solve this very problem.

2. Quantified SWOT analytical method

In this paper, the concept of MADM [6] is introduced into SWOT analysis to construct a quantified SWOT analytical method. Therefore, it is constructed according to the four factors of decision-making: alternatives, criteria, performance, and weight. Alternatives refer to objects to be compared with (e.g., company A and B, etc.). Criteria refer to the key factors of external assessment. Performance structure refers to weights of the key factors. Performance means the performance of the object put into comparison under the evaluation of all the key factors.

The Quantified SWOT analytical method consists of the following seven steps (see Fig. 2):

- **Step 1**: Decide what is to be compared, for example: enterprise A and B etc.
- **Step 2**: Research and draft the key factors of internal and external assessment to build a hierarchical structure.
- **Step 3**: Collect data, mainly to collect the objective and quantified performance (e.g., operating income) of the objects compared.
- **Step 4**: Questionnaire investigation which includes two parts: one to investigate the weights of key factors using the AHP method; and the other to investigate the subjective quality performance (e.g., service quality of the shop assistants) of the compared objects.

In this paper, weights of internal and external assessment are proposed to be the same. Weights of key factors are obtained by using the AHP method that was proposed by Saaty [7,8]. Its aim is to systemize complicated problems and to solve them at different levels and as regards different aspects. A proportion scale of 1, 2, . . . , 9 is used to show the comparison of all the weights to build a matrix; then the strength vector is found by eigenvalue solution which is often used in numerical analysis; finally, the relative weights of key factors can be obtained after the consistency test.

When using the AHP method to obtain the weights of criteria, the following steps are included:
Table 1
Average random consistency index (R.I.)

<table>
<thead>
<tr>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.I.</td>
<td>0.00</td>
<td>0.00</td>
<td>0.52</td>
<td>0.89</td>
<td>1.11</td>
<td>1.25</td>
<td>1.35</td>
<td>1.40</td>
<td>1.45</td>
<td>1.49</td>
</tr>
</tbody>
</table>

- Establishment of a pairwise comparison matrix 

In the hierarchy structure, factors of each level are marked as: $A_1, A_2, \ldots, A_n$. Based on the index of the upper level, weights of factors, $w_1, w_2, \ldots, w_n$ are to be determined. The relative importance of $a_i$ and $a_j$ is shown as $a_{ij}$, the pairwise comparison matrix of factors $A_1, A_2, \ldots, A_n$ as $A = [a_{ij}]$; while elements are shown as in formula (1):

$$A = \begin{bmatrix}
1 & a_{12} & \cdots & a_{1n} \\
1/a_{12} & 1 & \cdots & a_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
1/a_{1n} & 1/a_{2n} & \cdots & 1
\end{bmatrix}.$$  

(1)

In this matrix, the element $a_{ij} = 1/a_{ji}$ and thus, when $i = j$, $a_{ij} = 1$. The value of $w_i$ may vary from 1 to 9, and 1/1 indicates equal importance while 9/1 indicates extreme or absolute importance.

$$A = \begin{bmatrix}
w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\
w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\
\vdots & \vdots & \ddots & \vdots \\
w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n
\end{bmatrix}.$$  

(2)

- Calculate key factor weights.

Saaty [7,8] suggested that the largest eigenvalue $\lambda_{\text{max}}$ be:

$$w_i = \frac{1}{\lambda_{\text{max}}} \sum_{j=1}^{n} a_{ij} w_j$$  

(3)

$$\sum_{i=1}^{n} w_i = 1.$$  

(4)

If $A$ is a consistency matrix, eigenvector $w$ can be calculated by the formula (5):

$$(A - \lambda_{\text{max}} I) w = 0$$  

(5)

where $\lambda_{\text{max}}$ is the largest eigenvalue of matrix $A$; $w$ is the vector of weights; and $I$ is the identity matrix.

- Consistency test.

The consistency index of a matrix of comparisons is given by the formulas (6) and (7). The consistency ratio (C.R.) is obtained by comparing the C.I. with the appropriate one of the following set of numbers (see Table 1) each of which is an average random consistency index (R.I.) derived from a sample of randomly generated reciprocal matrices using the scale $1/9, 1/8, \ldots, 8, 9$. If it is not less than 0.10, study the problem and revise the judgments [8]

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

(6)

$$CI = (\lambda_{\text{max}} - n)/(n - 1).$$  

(7)

- Step 5: Normalize the performance. Performance of all the key factors includes quantified performance that is an actual statistic (e.g., business volume) and qualified performance that is a score of subjective scoring of the questionnaire (e.g., 1–5 points). The aim of normalization is to unify the scales of the key factors. Here is a suggested normalization method [9]:
(1) Benefit-criteria normalization (the higher the better)

\[ r_{ij} = \frac{p_{ij}}{\max_j p_{ij}}, \quad \forall j \]  

(8)

e.g.

\[ p_{11} = 2, \quad p_{12} = 4, \quad p_{13} = 5, \quad p_{14} = 3 \]

then

\[ r_{11} = \frac{p_{11}}{\max_j p_{1j}} = \frac{2}{5} = 0.4 \]

and similarly

\[ r_{12} = 0.8, \quad r_{13} = 1.0, \quad r_{14} = 0.6. \]

(2) Cost-criteria normalization (the lower the better)

\[ r_{ij} = \frac{\min_j p_{ij}}{p_{ij}}, \quad \forall j \]  

(9)

e.g.

\[ p_{11} = 2, \quad p_{12} = 4, \quad p_{13} = 5, \quad p_{14} = 3 \]

then

\[ r_{11} = \frac{\min_j p_{1j}}{p_{11}} = \frac{2}{2} = 1.0 \]

and similarly

\[ r_{12} = 0.5, \quad r_{13} = 0.4, \quad r_{14} = 0.67. \]

(3) Moderation-criteria normalization (the more moderate the better)

\[ r_{ij} = \frac{\min\{p_{ij}, p_0\}}{\max\{p_{ij}, p_0\}} \]  

where

\[ p_0 = \frac{1}{n} \sum_{j=1}^{n} p_{ij} \]

e.g.

\[ p_{11} = 2, \quad p_{12} = 4, \quad p_{13} = 5, \quad p_{14} = 3 \]

then

\[ p_0 = \frac{1}{4} \sum_{j=1}^{4} p_{ij} = \frac{1}{4} (2 + 4 + 5 + 3) = 3.5 \]

\[ r_{11} = \frac{\min\{p_{11}, p_0\}}{\max\{p_{11}, p_0\}} = \frac{\min\{2, 3.5\}}{\max\{2, 3.5\}} = \frac{2}{3.5} = 0.57 \]
and similarly
\[ r_{12} = 0.88, \quad r_{13} = 0.7, \quad r_{14} = 0.86. \]

- Step 6: Calculate the internal and external weight score of the comparing object separately (normalization of performance weights) and determine the benchmarking value.

It is suggested in this paper that the determination of the benchmarking value can be carried out using the following two approaches: (1) take the mean as the benchmarking value; or (2) take benchmarking enterprises as the benchmarking value. The first approach is recommended to make the calculation easier.

- Step 7: To calculate and compare the coordinate values of internal and external assessment and then show them on the four-quadrant coordinate.

Firstly, the internal and external scores of the compared enterprises should be added together and then the benchmarking value subtracted. The final value will be the coordinate value of the compared enterprise in the SWOT analysis matrix. The coordinate value will be within \(-1 \sim +1\). The enterprise possesses strengths and opportunities when the coordinate value is larger than the benchmarking value, but the enterprise is comparatively weak and faces threats when the coordinate value is smaller than the benchmarking value.

\[
IC_j = I_j - IB_j \quad j = 1, 2, \ldots, n \\
EC_j = E_j - EB_j \quad j = 1, 2, \ldots, n
\]

where
\[
IC_j: \text{ the internal assessment coordinate value of the } j\text{th enterprise.} \\
I_j: \text{ internal assessment score of the } j\text{th enterprise.} \\
IB: \text{ benchmarking value of the internal assessment.} \\
EC_j: \text{ the external assessment coordinate value of the } j\text{th enterprise.} \\
E_j: \text{ external assessment score of the } j\text{th enterprise.} \\
EB: \text{ benchmarking value of the external assessment.}
\]

\[-1 \leq IC_j \leq +1 \\
-1 \leq EC_j \leq +1.\]

By calculating the benchmarking value and coordinate value according to the above formulas, two groups of data can be obtained: one is the coordinate value used to compare the internal assessment of the enterprises; the other is the coordinate used to compare the external assessment of the enterprises. In order to show the comparison on the four-quadrant coordinate, the ordinate is prescribed to stand for the external environment (opportunities, threats) while the abscissa is prescribed to stand for the internal environment (strengths, weaknesses). Now each enterprise has a coordinate \((x, y)\), so its position in the competition can be clearly realized. This can help the enterprises assess themselves more effectively as well as the components and may be used as the foundation for policies of development.

### 3. An illustrative example

Container ports in East Asia are taken as a case study in this paper. Quantified SWOT analysis is used to assess the competing strength of each port and then suggest an adoptable competing strategy for each.

In recent years, due to the low cost of production, the business volumes of newly rising industrial countries, such as Taiwan, China and countries in Southeast Asia, are increasing rapidly. According to statistics provided by Cargo Systems [10] in August 2004 (see Table 2), the container handling volume of Shanghai port had reached 11,370 thousand TEU (Twenty-foot Equivalent Unit), a 32% increase over 2002, and its world ranking had changed from 4th place to 3rd. The progress of the Shenzhen port in 2003 was even more surprising. Its container handling volume had reached 10,650 thousand TEU, 40% more than that of the previous year. The Kaohsiung port of Taiwan was also doing well, its container handling volume in 2003 had reached 8844 thousand TEU, 4% more than that of the previous year, however, its world ranking had slid from the 5th to 6th place. The Keelung port of Taiwan had been declining between 1996 and 1999, but had been gradually bouncing back since 2000. In 2003, its container handling volume was 2000 thousand TEU, with a world ranking of 33rd. The container handling volume of Hong Kong maintained its 1st place in the world ranking. Due to the rapid growth of Shenzhen port, its growth had slowed down; the container
Table 2
Container ports in East Asia

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(1)</td>
<td>Hong Kong</td>
<td>China</td>
<td>20,450,000</td>
<td>19,144,000</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>(4)</td>
<td>Shanghai</td>
<td>China</td>
<td>11,370,000</td>
<td>8,611,890</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>(6)</td>
<td>Shenzhen</td>
<td>China</td>
<td>10,650,000</td>
<td>7,613,754</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>(5)</td>
<td>Kaohsiung</td>
<td>Taiwan</td>
<td>8,844,000</td>
<td>8,493,000</td>
<td>4</td>
</tr>
<tr>
<td>29</td>
<td>(36)</td>
<td>Xiamen</td>
<td>China</td>
<td>2,330,000</td>
<td>1,754,370</td>
<td>33</td>
</tr>
<tr>
<td>33</td>
<td>(31)</td>
<td>Keelung</td>
<td>Taiwan</td>
<td>2,000,001</td>
<td>1,918,598</td>
<td>4</td>
</tr>
<tr>
<td>60</td>
<td>(60)</td>
<td>Taichung</td>
<td>Taiwan</td>
<td>1,244,826</td>
<td>1,193,657</td>
<td>4</td>
</tr>
</tbody>
</table>


Table 3
Internal assessment score of ports in the East Asia area

<table>
<thead>
<tr>
<th>Internal assessment key factors</th>
<th>Unit</th>
<th>Polarity</th>
<th>Ports</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1 No. of deep-water berths</td>
<td>berths</td>
<td>+</td>
<td></td>
<td>1</td>
<td>6</td>
<td>18</td>
<td>16</td>
<td>10</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>I2 No. of container quay cranes</td>
<td>sets</td>
<td>+</td>
<td></td>
<td>28</td>
<td>13</td>
<td>62</td>
<td>67</td>
<td>37</td>
<td>13</td>
<td>57</td>
</tr>
<tr>
<td>I3 Container terminals area</td>
<td>ha</td>
<td>+</td>
<td></td>
<td>24</td>
<td>85</td>
<td>294</td>
<td>218</td>
<td>192</td>
<td>57</td>
<td>350</td>
</tr>
<tr>
<td>I4 External link transportation strength and weakness</td>
<td>5 scales</td>
<td>+</td>
<td>2.00</td>
<td>3.74</td>
<td>3.54</td>
<td>3.61</td>
<td>3.56</td>
<td>3.06</td>
<td>3.47</td>
<td></td>
</tr>
<tr>
<td>I5 Handled automation and information</td>
<td>5 scales</td>
<td>+</td>
<td>2.85</td>
<td>3.03</td>
<td>3.62</td>
<td>4.17</td>
<td>3.25</td>
<td>2.61</td>
<td>3.06</td>
<td></td>
</tr>
<tr>
<td>I6 No. of deep-water berths incoming/outgoing</td>
<td>5 scales</td>
<td>+</td>
<td>2.73</td>
<td>3.06</td>
<td>3.79</td>
<td>3.85</td>
<td>3.06</td>
<td>2.69</td>
<td>2.97</td>
<td></td>
</tr>
<tr>
<td>I7 Efficiency of handling containers</td>
<td>5 scales</td>
<td>+</td>
<td>2.94</td>
<td>2.97</td>
<td>3.79</td>
<td>4.00</td>
<td>3.35</td>
<td>2.68</td>
<td>3.10</td>
<td></td>
</tr>
<tr>
<td>I8 No. of containers handled</td>
<td>thousand TEU</td>
<td>+</td>
<td>2000</td>
<td>1245</td>
<td>8844</td>
<td>20,450</td>
<td>10,650</td>
<td>2330</td>
<td>11,370</td>
<td></td>
</tr>
<tr>
<td>I9 Operational liberalization</td>
<td>5 scales</td>
<td>+</td>
<td>2.88</td>
<td>3.21</td>
<td>3.57</td>
<td>4.22</td>
<td>2.81</td>
<td>2.38</td>
<td>2.78</td>
<td></td>
</tr>
<tr>
<td>I10 Port tariff</td>
<td>5 scales</td>
<td>–</td>
<td>3.10</td>
<td>2.91</td>
<td>2.88</td>
<td>3.24</td>
<td>2.30</td>
<td>1.93</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>I11 Integral investment plan</td>
<td>5 scales</td>
<td>+</td>
<td>2.56</td>
<td>3.12</td>
<td>3.66</td>
<td>3.56</td>
<td>3.56</td>
<td>2.97</td>
<td>3.50</td>
<td></td>
</tr>
<tr>
<td>I12 Efficiency of investment exploitation</td>
<td>5 scales</td>
<td>+</td>
<td>2.38</td>
<td>2.91</td>
<td>3.14</td>
<td>3.66</td>
<td>3.56</td>
<td>3.03</td>
<td>3.56</td>
<td></td>
</tr>
</tbody>
</table>

Polarity: '+' = benefit criteria, '-' = cost criteria.
Ports: A1 = Keelung, A2 = Taichung, A3 = Kaohsiung, A4 = Hong Kong, A5 = Shenzhen, A6 = Xiamen, A7 = Shanghai.

The handling volume of Hong Kong port in 2003 was 20,450 thousand TEU, 7% more than that of the previous year. From the growth and decline of the above ports, it is clear that an efficient competing strategy to confront the ever-changing competitive environment is very important for the above ports, and Quantified SWOT analysis would be an efficient method to use.

In this study, seven ports are chosen for SWOT analysis, A1–A7, respectively. In terms of the key factors for the analysis of the internal and external assessments, the AHP method is used to build the hierarchy framework chart (see Figs. 3 and 4). The key factors for analysis of the internal assessment are mainly related to hardware facility, work efficiency, operating and development. Detailed items are: number of deep-water berths (over 14M) (I1); number of container quay cranes (I2); container terminals area (I3); external link transportation strength and weakness (I4); handled automation and information (I5); efficiency of vessels incoming/outgoing (I6); efficiency of handling containers (I7); number of containers handled (I8); operational liberalization (I9); port tariff (I10); integral investment plan (I11); and efficiency of investment exploitation (I12); The key factors for analysis of the external assessment are mainly related to the political environment, economic environment, and geographic area. Detailed items are: efficiency of customs service (E1); political stability (E2); complete statute (E3); financial liberalization (E4); cargo source of the hinterland (E5); strength and weakness of geographic location (E6); and number of shipping lines and sailing (E7).
Table 4
External assessment score of ports in the East Asia area

<table>
<thead>
<tr>
<th>External assessment key factors</th>
<th>Unit</th>
<th>Polarity</th>
<th>Ports A₁</th>
<th>A₂</th>
<th>A₃</th>
<th>A₄</th>
<th>A₅</th>
<th>A₆</th>
<th>A₇</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency of customs service</td>
<td>5 scales</td>
<td>+</td>
<td>2.97</td>
<td>3.18</td>
<td>3.34</td>
<td>4.20</td>
<td>2.94</td>
<td>2.78</td>
<td>3.00</td>
</tr>
<tr>
<td>Political stability</td>
<td>5 scales</td>
<td>+</td>
<td>3.33</td>
<td>3.33</td>
<td>3.33</td>
<td>3.63</td>
<td>3.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Complete statute</td>
<td>5 scales</td>
<td>+</td>
<td>3.11</td>
<td>3.11</td>
<td>3.11</td>
<td>3.82</td>
<td>2.45</td>
<td>2.45</td>
<td>2.45</td>
</tr>
<tr>
<td>Financial liberalization</td>
<td>5 scales</td>
<td>+</td>
<td>3.48</td>
<td>3.48</td>
<td>3.48</td>
<td>4.34</td>
<td>2.82</td>
<td>2.82</td>
<td>2.82</td>
</tr>
<tr>
<td>Cargo source of the hinterland</td>
<td>5 scales</td>
<td>+</td>
<td>3.50</td>
<td>3.21</td>
<td>3.60</td>
<td>4.00</td>
<td>4.00</td>
<td>2.97</td>
<td>4.00</td>
</tr>
<tr>
<td>Strength and weakness of geographic location</td>
<td>5 scales</td>
<td>+</td>
<td>3.41</td>
<td>3.50</td>
<td>4.14</td>
<td>4.14</td>
<td>3.97</td>
<td>3.19</td>
<td>3.97</td>
</tr>
<tr>
<td>No. of shipping lines and sailing</td>
<td>5 scales</td>
<td>+</td>
<td>2.91</td>
<td>2.74</td>
<td>4.11</td>
<td>4.46</td>
<td>3.81</td>
<td>2.50</td>
<td>3.81</td>
</tr>
</tbody>
</table>

Polarity: ‘+’ = benefit criteria, ‘−’ = cost criteria.
Ports: A₁ = Keelung, A₂ = Taichung, A₃ = Kaohsiung, A₄ = Hong Kong, A₅ = Shenzhen, A₆ = Xiamen, A₇ = Shanghai.

Fig. 3. Hierarchy of analysis on internal assessment.

Now, the performance of the port as regards the key factors (see Tables 3 and 4) is discussed. Each performance contains two parts: quantified performance and qualified performance. Quantified performance is an actual statistic (e.g., container handling volume), while qualified performance is a questionnaire score, which is marked subjectively by experts and carriers ranging from 1 to 5 points (the higher the better). In order to unify the scale and direction of the key factors, normalization of key factors is inevitable (see Tables 5 and 6). The weights of key factors are obtained by using the AHP method on the questionnaire result, and then the total weight score can be obtained by multiplying the weights with key factor performance after normalization. Finally, the coordinate value of strengths (S), weaknesses (W), opportunities (O), threats (T) can be obtained by subtracting the benchmarking value from the total weight score.
Table 5
Internal assessment weighted average score of ports in the East Asia area

<table>
<thead>
<tr>
<th>Internal assessment key factors</th>
<th>Weight</th>
<th>Ports</th>
<th>A₁</th>
<th>A₂</th>
<th>A₃</th>
<th>A₄</th>
<th>A₅</th>
<th>A₆</th>
<th>A₇</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of deep-water berths</td>
<td>0.091</td>
<td>0.056</td>
<td>0.333</td>
<td>1.000</td>
<td>0.889</td>
<td>0.556</td>
<td>0.000</td>
<td>0.222</td>
<td></td>
</tr>
<tr>
<td>No. of container quay cranes</td>
<td>0.047</td>
<td>0.418</td>
<td>0.194</td>
<td>0.925</td>
<td>1.000</td>
<td>0.552</td>
<td>0.194</td>
<td>0.851</td>
<td></td>
</tr>
<tr>
<td>Container terminals area</td>
<td>0.048</td>
<td>0.069</td>
<td>0.243</td>
<td>0.840</td>
<td>0.623</td>
<td>0.549</td>
<td>0.163</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>External link transportation strength and weakness</td>
<td>0.041</td>
<td>0.535</td>
<td>1.000</td>
<td>0.948</td>
<td>0.967</td>
<td>0.954</td>
<td>0.820</td>
<td>0.929</td>
<td></td>
</tr>
<tr>
<td>Handled automation and information</td>
<td>0.123</td>
<td>0.684</td>
<td>0.726</td>
<td>0.867</td>
<td>1.000</td>
<td>0.779</td>
<td>0.626</td>
<td>0.736</td>
<td></td>
</tr>
<tr>
<td>No. of deep-water berths incoming/outgoing</td>
<td>0.126</td>
<td>0.708</td>
<td>0.794</td>
<td>0.983</td>
<td>1.000</td>
<td>0.795</td>
<td>0.698</td>
<td>0.771</td>
<td></td>
</tr>
<tr>
<td>Efficiency of handling containers</td>
<td>0.087</td>
<td>0.734</td>
<td>0.742</td>
<td>0.947</td>
<td>1.000</td>
<td>0.839</td>
<td>0.669</td>
<td>0.774</td>
<td></td>
</tr>
<tr>
<td>No. of containers handled</td>
<td>0.090</td>
<td>0.098</td>
<td>0.061</td>
<td>0.432</td>
<td>1.000</td>
<td>0.519</td>
<td>0.114</td>
<td>0.556</td>
<td></td>
</tr>
<tr>
<td>Operational liberalization</td>
<td>0.106</td>
<td>0.683</td>
<td>0.759</td>
<td>0.846</td>
<td>1.000</td>
<td>0.666</td>
<td>0.563</td>
<td>0.659</td>
<td></td>
</tr>
<tr>
<td>Port tariff</td>
<td>0.093</td>
<td>0.929</td>
<td>0.990</td>
<td>1.000</td>
<td>0.889</td>
<td>0.894</td>
<td>0.903</td>
<td>0.960</td>
<td></td>
</tr>
<tr>
<td>Integral investment plan</td>
<td>0.072</td>
<td>0.700</td>
<td>0.852</td>
<td>1.000</td>
<td>0.972</td>
<td>0.974</td>
<td>0.812</td>
<td>0.957</td>
<td></td>
</tr>
<tr>
<td>Efficiency of investment exploitation</td>
<td>0.076</td>
<td>0.651</td>
<td>0.796</td>
<td>0.859</td>
<td>1.000</td>
<td>0.974</td>
<td>0.829</td>
<td>0.974</td>
<td></td>
</tr>
<tr>
<td>Weighted average value</td>
<td>1.000</td>
<td>0.554</td>
<td>0.646</td>
<td>0.886</td>
<td>0.958</td>
<td>0.761</td>
<td>0.549</td>
<td>0.753</td>
<td></td>
</tr>
</tbody>
</table>

Polarity: ‘+’ = benefit criteria, ‘−’ = cost criteria.
 Ports: A₁ = Keelung, A₂ = Taichung, A₃ = Kaohsiung, A₄ = Hong Kong, A₅ = Shenzhen, A₆ = Xiamen, A₇ = Shanghai.

(see Table 7 and Fig. 5). Fig. 5 shows clearly the position of an enterprise in the competition and this can help ports choose their strategy for development.

As can be seen from Fig. 5, Hong Kong, Kaohsiung, Shanghai and Shenzhen ports are in the first quadrant, so have external opportunities for development and internal competing strength, thus are in the best position for facing competition. These ports could adopt an expansionistic strategy, such as market development, product development, to strengthen their competing strength. Though Shanghai and Shenzhen ports are in the first quadrant, there is a gap between them and Hong Kong and Kaohsiung ports. Take Shanghai port, for example, its competing strength is greatly affected by the low fairway depth. Shanghai port and Shenzhen port could enhance their competing strength by reinforcing their internal competing strength or by the help of a joint venture.
Table 6
External assessment weighted average score of ports in the East Asia area

<table>
<thead>
<tr>
<th>External assessment key factors</th>
<th>Weight</th>
<th>Ports</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 Efficiency of customs service</td>
<td>0.114</td>
<td>0.707</td>
<td>0.756</td>
<td>0.796</td>
<td>1.000</td>
<td>0.699</td>
<td>0.662</td>
<td>0.714</td>
<td></td>
</tr>
<tr>
<td>E2 Political stability</td>
<td>0.095</td>
<td>0.918</td>
<td>0.918</td>
<td>0.918</td>
<td>1.000</td>
<td>0.827</td>
<td>0.827</td>
<td>0.827</td>
<td></td>
</tr>
<tr>
<td>E3 Complete statute</td>
<td>0.068</td>
<td>0.813</td>
<td>0.813</td>
<td>0.813</td>
<td>1.000</td>
<td>0.641</td>
<td>0.641</td>
<td>0.641</td>
<td></td>
</tr>
<tr>
<td>E4 Financial liberalization</td>
<td>0.123</td>
<td>0.801</td>
<td>0.801</td>
<td>0.801</td>
<td>1.000</td>
<td>0.649</td>
<td>0.649</td>
<td>0.649</td>
<td></td>
</tr>
<tr>
<td>E5 Cargo source of the hinterland</td>
<td>0.290</td>
<td>0.875</td>
<td>0.801</td>
<td>0.900</td>
<td>1.000</td>
<td>1.000</td>
<td>0.742</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>E6 Strength and weakness of geographic location</td>
<td>0.154</td>
<td>0.824</td>
<td>0.845</td>
<td>1.000</td>
<td>1.000</td>
<td>0.958</td>
<td>0.769</td>
<td>0.958</td>
<td></td>
</tr>
<tr>
<td>E7 No. of shipping lines and sailing</td>
<td>0.156</td>
<td>0.653</td>
<td>0.614</td>
<td>0.923</td>
<td>1.000</td>
<td>0.855</td>
<td>0.561</td>
<td>0.855</td>
<td></td>
</tr>
<tr>
<td>Weighted average value</td>
<td>1.000</td>
<td>0.804</td>
<td>0.785</td>
<td>0.891</td>
<td>1.000</td>
<td>0.853</td>
<td>0.699</td>
<td>0.854</td>
<td></td>
</tr>
</tbody>
</table>

Polarity: ‘+’ = benefit criteria, ‘−’ = cost criteria.

Ports: A1 = Keelung, A2 = Taichung, A3 = Kaohsiung, A4 = Hong Kong, A5 = Shenzhen, A6 = Xiamen, A7 = Shanghai.

Table 7
Coordinate values of ports in the East Asia area under the SWOT analysis

<table>
<thead>
<tr>
<th>Ports</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
<th>Benchmarking value(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighted average value of internal assessment(^b)</td>
<td>0.554</td>
<td>0.646</td>
<td>0.886</td>
<td>0.958</td>
<td>0.760</td>
<td>0.549</td>
<td>0.753</td>
<td>0.729</td>
</tr>
<tr>
<td>Coordinate value of internal assessment</td>
<td>−0.175</td>
<td>−0.084</td>
<td>0.156</td>
<td>0.229</td>
<td>0.031</td>
<td>−0.181</td>
<td>0.024</td>
<td></td>
</tr>
<tr>
<td>Weighted average value of external assessment(^b)</td>
<td>0.804</td>
<td>0.785</td>
<td>0.891</td>
<td>1.000</td>
<td>0.853</td>
<td>0.699</td>
<td>0.854</td>
<td>0.841</td>
</tr>
<tr>
<td>Coordinate value of external assessment</td>
<td>−0.037</td>
<td>−0.055</td>
<td>0.050</td>
<td>0.159</td>
<td>0.012</td>
<td>−0.142</td>
<td>0.014</td>
<td></td>
</tr>
</tbody>
</table>

Ports: A1 = Keelung, A2 = Taichung, A3 = Kaohsiung, A4 = Hong Kong, A5 = Shenzhen, A6 = Xiamen, A7 = Shanghai.

\(^a\) Mean value.

Keelung, Taichung and Xiamen ports are in the third quadrant. Due to the challenge from Hong Kong and Kaohsiung ports, they face external threats. However, the difference between the external environment scores of the former and the latter group is not that large because ocean freight in East Asia is the most active. But Keelung, Taichung and Xiamen ports’ internal environment scores are much lower than those of Hong Kong port and Kaohsiung port. Therefore, they must not only enhance their external competing strength, but also carry out market segmentation to find the most profitable market to avoid threat.

If the research could be done many times, we could observe the changes of each port’s competitive position. Fig. 6 displays the results of Quantified SWOT analysis for the container ports in East Asia in 2000 and 2004. The most important change is the promotion of Shanghai port from the second quadrant to the first quadrant and Shenzhen port from the third quadrant to the first quadrant, showing that they have not only improved the internal competing strength, but also kept the external developing opportunities, thus gradually enhancing the competitive capacity. Therefore, Hong Kong and Kaohsiung ports will face strong competition from Shenzhen and Shanghai ports in the future.

4. Conclusions

SWOT analysis is very important in the process of strategy formulation. Analysis of external opportunities and threats is mainly to evaluate whether an enterprise can seize the opportunities and avoid the threats when facing an uncontrollable external environment. Analysis on internal strengths and weaknesses is mainly to evaluate how an enterprise carries out its internal work, such as management, work efficiency, research and development. SWOT
Fig. 5. Matrix of the ports in the East Asia area under the SWOT analysis.

Fig. 6. Matrix of the ports in the East Asia area under the SWOT analysis, 2000 and 2004. △ 2000, ■ 2004. Ports: A₁ = Keelung, A₂ = Taichung, A₃ = Kaohsiung, A₄ = Hong Kong, A₅ = Shenzhen, A₆ = Xiamen, A₇ = Shanghai.

analysis is able to help the enterprises evaluate their position in the competition and can be used as a foundation for the development of policies. In this study, a Quantified SWOT analysis pattern has been built which shows similarities to
the GSM concept. Therefore, the Quantified SWOT analysis could be combined with the GSM for strategy formulation and selection.

SWOT analysis of the main container port in East Asia was originally very complicated. However, it can be simplified and sorted using the Quantified SWOT analysis pattern. Further, the evaluation index in this paper includes a quantified and qualified index, thus, in addition to eliciting information about ports’ performance from international carriers, the ports are compared using actual statistics. Therefore, the result is relatively objective. In terms of the weights of the evaluation index, these are mainly obtained using the AHP method, and this is the function of the consistency test. As a consequence, inconsistencies are avoided when interviewees answer the questionnaire, and the weights are obtained precisely. In order to show ports’ positions in the competition, by benchmarking, the ordinate is prescribed to stand for the external environment (opportunities, threats) while the abscissa is prescribed to stand for the internal environment (strengths, weaknesses). From the coordinate value of the SWOT analysis of the ports their position in the competition can be clearly realized, and this helps enterprises learn about themselves as well as competitors and can be used as the foundation for developmental strategies.

References