**Table 1** Breakdown of Taiwan’s biotechnology industry from 2013 – 2014

Unit: NTD (100 million)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Industry** | **Applied biotechnology industry** | **Pharmaceutical industry** | **Medical device industry** | **Total** |
| **Year**  | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| **Revenue** | 782 | 822 | 824 | 832 | 1,163 | 1,232 | 2,769 | 2,886 |
| **Number of enterprises** | 490 | 500 | 350 | 350 | 761 | 781 | 1,601 | 1,631 |
| **Number of employees** | 17,540 | 18,340 | 19,000 | 19,000 | 35,040 | 36,429 | 71,580 | 73,769 |
| **Export value** | 299 | 312 | 196 | 197 | 484 | 513 | 979 | 1,022 |
| **Import value** | 495 | 500 | 992 | 999 | 605 | 615 | 2,092 | 2,114 |
| **Domestic sales: export sales** | 62:38 | 62:38 | 76:24 | 76:24 | 58:42 | 58:42 | 65:35 | 65:35 |
| **Demand of domestic market** | 978 | 1,010 | 1,620 | 1,634 | 1,284 | 1,334 | 3,882 | 3,978 |

**Data source**: Medical and Pharmaceutical Industry Technology and Development Center, Biotechnology and Pharmaceutical Industries Promotion Office, MOEA, 2015.

Figure 1 shows the research framework of the first stage. 

Fig. 1 First-stage hierarchy framework

**Tabl**e 2 Information about interviewed experts

|  |  |  |
| --- | --- | --- |
| **Interviewed company** | **Seniority** | **Title** |
| **Company A** | 28yrs | President |
| **Company B** | 25yrs | General manager |
| **Company C** | 25yrs | General manager |
| **Company D** | 25 yrs | General manager |
| **Company E** | 25yrs | Deputy general manager |
| **OrganizationF** | 18 yrs | Senior manager |
| **OrganizationG** | 15yrs | Senior manager |
| **UniversityH** | 20yrs | Dean |
| **Organization I** | 25yrs | Director |

The research framework proposed above is revised accordingly and presented as Figure 2.



Fig. 2 Second-stage hierarchy framework

**Table 3** Operative definitions of influential factors incluster cooperation in Taiwan’s biotechnology industry

|  |  |  |  |
| --- | --- | --- | --- |
| Influential factors in cluster cooperation in Taiwan’s biotechnology industry | 　Enterprise innovation ability  | Number of patents (intellectual property) | The number of patents for which an enterprise applies to improve the technical distribution. |
| R&D personnel qualities | Education and experience of relevant R&D personnel within an enterprise (Huang et al., 2010). |
| R&D environment | Software and hardware environments associated with R&D activities within an enterprise (Subramaniam and Youndt, 2005). |
| R&D network | Operation of tangible and intangible networks for R&D cooperation within and outside an enterprise (Drejer and Jorgensen, 2005). |
|  Government resource utilization | Talent training | Training (organized by the government) of the talent to promote industry development and reduce academy-industry disparities.  |
| Research technology transfer mechanism | Measures implemented by the government to smoothly transfer R&D achievements from universities and research institutes to enterprises for efficient application. |
| R&D incentive measures | Preferential measures implemented by the government to stimulate and promote industrial R&D (Bien et al., 2014). |
| Business incubation and counseling | Entrepreneurship incubation and business management counseling provided by the government to promote industrial development. |
| Regulatory counseling | Regulatory assistance provided by the government to help an enterprise meet requirements in different stages of biotechnology industrial development (Ernst and Young, 2016). |
| Business management ability | High-level business management team | Executive officers responsible for an enterprise’s overall business management (Downs and Velamuri, 2016). |
| Internationalization degree | Degree to which an enterprise is valued worldwide by people in the same business during the process between R&D and marketing (Feldman and Francis, 2014). |
| Intellectual property management flexibility | Flexibility of an enterprise’s management tomaximize the benefits of intellectual property (Su and Hung, 2009). |
| Financial improvement capacity | Capacity of an enterprise’s management to improve the financial system for sustainable development (Rosson and Mclarney, 2005). |
| Mutual trust | Corporate culture | Traits of an enterprise’s internal activities (Trippl et al., 2007). |
| Executive capacity | Capacity to negotiate operating standards and managerial agreement during cluster cooperation between enterprises (Edquist, 2005). |
| Cooperation network | Correlation between enterprises in cooperation (Todtling, F. and Lehnei, M., 2006). |

**Table 4** Evaluation measures

|  |  |  |
| --- | --- | --- |
| **Evaluation measure** | **Definition** | **Instructions** |
| **1** | Equally important | Contributions of two indicators are of equal importance – equally important. |
| **2** | Evaluation measure is between 1 and 3 | Compromised value is between the evaluation measures 1 and 3. |
| **3** | Slightly important | Slightly inclined toward a certain scheme based on experience and judgment – slightly important. |
| **4** | Evaluation measure is between 3 and 5 | Compromised value is between 3 and 5. |
| **5** | Very important | Fairly inclined toward a certain scheme based on experience and judgment – very important. |
| 6 | Evaluation measure is between 5 and 7 | Compromised value is between 5 and 7. |
| 7 | Extremely important | Strongly inclined toward a certain scheme in practice – extremely important. |
| 8 | Evaluation measure is between 7 and 9 | Compromised value is between 7 and 9. |
| 9 | Absolutely important | An indicator is sufficiently proved to be important – absolutely important. |

**Data source**: Zhengyuan Deng, Guoxiong Zeng (1989).

**Table 5** Summary of questionnaire collection

|  |  |  |
| --- | --- | --- |
| **Questionnaire information** | **Sample number** | **Percentage** |
| **Distributed questionnaires** | 25 | 100% |
| **Recovered questionnaires** | 21 | 84% |
| **Invalid questionnaires** | 1 | 4% |
| **Valid questionnaires** | 20 | 80% |

**Table 6** Service seniority of interviewed experts

|  |  |  |
| --- | --- | --- |
| **Service seniority** | **Sample number** | **Percentage** |
| **5-10 yrs** | 7 | 35% |
| **11-15 yrs** | 8 | 40% |
| **>15 yrs** | 5 | 25% |
| **Total** | 20 | 100% |

**Table 7** Expert titles

|  |  |
| --- | --- |
| **Affiliated enterprise or organization** | **Title** |
| **A Governmental industry-promotion organization 1** | Senior manager Yang |
| **B Governmental industry-incubation organization 2** | Manager Chen |
| **C Governmental organization 3** | Team leader Chung |
| **D Governmental organization 4** | Section chief Lin |
| **E Governmental organization 5** | Section chief Lin |
| **F Legal entity 1** | Manager Juan |
| **G Legal entity 2** | Manager Lin |
| **H Legal entity 3** | Deputy manager Gao |
| **I Legal entity 4** | Senior associate researcher Tsai |
| **J Legal entity 5** | Researcher Chiang |
| **K Biotech pharmaceutical factory 1** | Manager Gao |
| **L Biotech pharmaceutical factory 2** | Manager Gao |
| **M Biotech pharmaceutical factory 3** | Deputy manager Lai |
| **N Biotech pharmaceutical factory 4** | Deputy manager Shih |
| **O Biotech pharmaceutical factory 5** | Manager Chang |
| **P University professor 1****Q University professor 2****R University professor 3** | Professor Lan Professor Wu Professor Chen  |
| **S University professor 4** | Professor Hsu |
| **T University doctoral student 5** | Student Wang |

**Table 8** Weight analysis of each dimension using AHP

|  |  |  |  |
| --- | --- | --- | --- |
| **Primary dimension** | **Secondary dimension** | **Overall weight** | **Ranking** |
|  | Number of patents (intellectual property) | 0.086884 | 3 |
| **Enterprise innovation ability****0.428** | R&D personnel qualities | 0.171628 | 1 |
| R&D environment | 0.092448 | 2 |
|  | R&D network | 0.076612 | 5 |
|  | Talent training | 0.02511 | 15 |
| **Government resource utilization 0.155** | Research technology transfer mechanism | 0.0599 | 16 |
| R&D incentive measures | 0.036425 | 12 |
|  | Business incubation and counseling | 0.038905 | 11 |
|  | Regulatory counseling | 0.035185 | 14 |
|  | High-level business management team | 0.07367 | 6 |
| **Business management ability** | Internationalization degree | 0.053098 | 9 |
| Intellectual property management flexibility | 0.065608 | 7 |
| **0.278** | Financial improvement capacity | 0.085624 | 4 |
|  | Corporate culture | 0.041283 | 10 |
| **Mutual trust** | Executive capacity | 0.061438 | 8 |
| **0.139** | Cooperation network | 0.036279 | 13 |

**Table** 9 Pairwise comparison matrix of the primary dimensions

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Enterprise innovation ability** | **Government resource utilization** | **Business management ability** | **Mutual trust** | **Overall weight** | Ranking |
| **Enterprise innovation ability** | 1 | 3.217994 | 1.879443 | 2.131081 | 0.428 | 1 |
| **Government resource utilization** | 0.310753 | 1 | 0.577114 | 1.300954 | 0.155 | 3 |
| **Business management ability** | 0.532073 | 1.732761 | 1 | 2.557109 | 0.278 | 2 |
| **Mutual trust** | 0.469246 | 0.768667 | 0.391067 | 1 | 0.139 | 4 |

**Table 10** Pairwise comparison matrix of the secondary dimensions

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Number of patents (intellectual property)** | **R&D personnel qualities** | **R&D environment** | **R&D network** | **Hierarchical weight** | **Overall weight** | **Ranking** |
| **Number of patents (intellectual property)** | 1 | 0.66052301 | 1.0344285 | 0.793835014 | 0.203 | 0.086884 | 3 |
| **R&D personnel qualities** | 1.5139518 | 1 | 2.4555006 | 2.2790256 | 0.401 | 0.171628 | 1 |
| **R&D environment** | 0.966717371 | 0.407248933 | 1 | 1.7376689 | 0.216 | 0.092448 | 2 |
| **R&D network** | 1.2597076 | 0.438784014 | 0.575483626 | 1 | 0.179 | 0.076612 | 4 |

**Table 11** Pairwise comparison matrix of the secondary dimensions

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Talent****training** | **Research****Technology****Transfer****mechanism** | **R&D****Incentive****measures** | **Business incubation and counseling** | **Regulatory counseling** | **Hierarchical weight**  | **Overall weight**  | **Ranking** |
| **Talent training** | 1 | 1.1875085 | 0.866313528 | 0.61378609 | 0.639843776 | 0.162 | 0.02511 | 4 |
| **Research technology transfer mechanism** | 0.842099236 | 1 | 0.527325924 | 0.465059282 | 0.553954719 | 0.125 | 0.019375 | 5 |
| **R&D incentive measures** | 1.1543165 | 1.8963604 | 1 | 1.1125274 | 1.0646415 | 0.235 | 0.036425 | 2 |
| **Business incubation and counseling** | 1.6292321 | 2.1502635 | 0.898854266 | 1 | 1.1791476 | 0.251 | 0.038905 | 1 |
| **Regulatory counseling** | 1.5628815 | 1.8052017 | 0.939283317 | 0.84807025 | 1 | 0.227 | 0.035185 | 3 |

**Table 12** Pairwise comparison matrix of the secondary dimensions

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **High-level business management team** | **Internationalization degree** | **Intellectual property management flexibility** | **Financial improvement capacity** | **Hierarchical weight** | **Overall weight** | Ranking |
| **High-level business management team** | 1 | 1.1131557 | 1.3931514 | 0.869113505 | 0.265 | 0.07367 | 2 |
| **Internationalization degree** | 0.898346925 | 1 | 0.593114569 | 0.669416182 | 0.191 | 0.053098 | 4 |
| **Intellectual property management flexibility** | 0.717797075 | 1.6860149 | 1 | 0.670783893 | 0.236 | 0.065608 | 3 |
| **Financial improvement capacity** | 1.1505977 | 1.493839 | 1.4907931 | 1 | 0.308 | 0.085624 | 1 |

**Table 13** Pairwise comparison matrix of the secondary dimensions

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Corporate culture** | **Executive capacity** | **Cooperation network** | **Hierarchical weight** | **Overall weight** | **Ranking** |
| **Corporate culture** | 1 | 0.700519456 | 1.09284 | 0.297 | 0.041283 | 2 |
| **Executive capacity** | 1.4275121 | 1 | 1.7592499 | 0.442 | 0.061438 | 1 |
| **Cooperation network** | 0.915047033 | 0.568424077 | 1 | 0.261 | 0.036279 | 3 |