Table 1. Description of four programs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Program | Field | Number of Projects | Support Period | Funding |
| A | BT | 824 | 3-yr basis, Maximum 6 years | $85,000/yr for individual study  $170,000/yr for collaboration study |
| NT | 317 |
| B | BT | 239 | 3-yr basis, Maximum 9 years | $254,000/yr, only individual study |
| NT | 176 |
| C | BT | 36 | Maximum 9 years | $254,000 to $678,000/yr, only individual study |
| NT | 44 |
| D | BT | 283 | Maximum 7 years | $847,000 to $1,271,000/yr per group |
| NT | 127 |
| Total | BT | 1,382 |  | |
| NT | 664 |
| total | 2,046 |

Table 2. Major features of four programs

|  |  |
| --- | --- |
| Program | Major Features |
| A | - Increase the number of SCI paper  - Human resource development  - Cultivation of basic research capability in various areas including interdisciplinary area |
| B | - Strengthen of national science and technology competitiveness mainly through patent application  - Excellent paper quality  - Excavation and support of excellent laboratory in universities |
| C | - Cultivating next-generation researchers as a worldwide research leader  - Excellent paper quality |
| D | - Excellent paper quality  - Patent applications  - Human resource development with interdisciplinary ways |

Table 3. Input and output variables

|  |  |
| --- | --- |
| Variables | Descriptions |
| Input  (I1) Budget  (I2) Support period ratio | Total amount of funds allocated to a project  Ratio of support period overlapped with output measurement period |
| Output  (O1) SCI papers  (O2) Average IF  (O3) Applied patents  (O4) Proceeding papers  (O5) Graduate-level degrees | The number of SCI papers  Average Impact Factor of journal papers published  The number of applied patents  The number of domestic and international proceeding papers  The number of students graduated with master’s degree and doctoral degree |

Table 4. Statistics of input and output variables in BT and NT areas

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Area | Value | Budget  (I1) | Support period ratio (I2) | SCI papers (O1) | Average IF  (O2) | Applied patents  (O3) | Proceeding papers (O4) | Graduate-level degrees (O5) |
| BT | Max | 9509.1280 | 1 | 69 | 28.8530 | 30 | 281 | 54 |
| Min | 10.5880 | 0 | 1 | 0 | 0 | 0 | 0 |
| Average | 519.1192 | 0.8236 | 7.0753 | 3.6770 | 0.6585 | 19.8835 | 4.4233 |
| SD | 795.0267 | 0.2876 | 8.2675 | 2.5378 | 2.0059 | 25.4160 | 5.2003 |
| NT | Max | 7329.2750 | 1 | 173 | 17.6755 | 38 | 328 | 42 |
| Min | 15 | 0 | 1 | 0 | 0 | 0 | 0 |
| Average | 757.7223 | 0.8019 | 15.6913 | 2.9774 | 1.9473 | 39.4157 | 5.9262 |
| SD | 1172.5558 | 0.3143 | 19.3571 | 1.9283 | 4.3504 | 45.2354 | 6.0064 |

Table 5. Normalized average weights of output variables for programs in BT field

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Program | SCI papers  (O1) | Average IF  (O2) | Applied Patents  (O3) | Proceeding papers (O4) | Graduate-level degree (O5) |
| A | 0.0041 (2) | 0.0022 (4) | 0.0014 (5) | 0.0145 (1) | 0.0024 (3) |
| B | 0.0234 (2) | 0.0035 (5) | 0.007 (3) | 0.1004 (1) | 0.0049 (4) |
| C | 0.0254 (2) | 0.0046 (3) | 0.0043 (4) | 0.0514 (1) | 0.0035 (5) |
| D | 0.0211 (2) | 0.0032 (5) | 0.0042 (4) | 0.0957 (1) | 0.0088 (3) |

Table 6. Normalized average weights of output variables for programs in NT field

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Program | SCI papers  (O1) | Average IF  (O2) | Applied Patents  (O3) | Proceeding papers (O4) | Graduate-level degree (O5) |
| A | 0.0018 (2) | 0.0018 (3) | 0.0013 (5) | 0.0016 (4) | 0.0019 (1) |
| B | 0.0014 (2) | 0.0012 (5) | 0.0015 (1) | 0.0014 (3) | 0.0013 (4) |
| C | 0.0007 (4) | 0.0010 (2) | 0.0016 (1) | 0.0008 (3) | 0.0002 (5) |
| D | 0.0013 (4) | 0.0014 (3) | 0.0019 (1) | 0.0017 (2) | 0.0013 (5) |

Table 7. Comparison of program efficiency from BCC-O model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Program | Number of Projects in BT area | Average efficiency | Number of Projects in NT area | Average efficiency |
| A | 824 | 0.28202 | 317 | 0.3506 |
| B | 239 | 0.4375 | 176 | 0.5088 |
| C | 36 | 0.5232 | 44 | 0.6304 |
| D | 283 | 0.4678 | 127 | 0.6465 |
| Mann-Whitney U-test results : C, D > B > A | | | Mann-Whitney U-test results : D, C > B > A | |

χ2=251.226, df=3, p=0.000; χ2=168.233, df=3, p=0.000

Table 8. Correlation analysis among variables in the BT area

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Budget  (I1) | Support period ratio (I2) | SCI papers  (O1) | Average IF  (O2) | Applied patents  (O3) | Proceeding papers (O4) | Graduate-level degrees (O5) |
| Pearson  Statistics | Budget | 1 | -0.289 | 0.391 | 0.195 | 0.171 | 0.232 | 0.317 |
| Support period ratio | -0.289 | 1 | -0.084 | 0.035 | -0.089 | 0.019 | -0.039 |
| SCI papers | 0.391 | -0.084 | 1 | 0.009 | 0.411 | 0.604 | 0.476 |
| Average IF | 0.195 | 0.035 | 0.009 | 1 | -0.03 | -0.037 | -0.019 |
| Applied patents | 0.171 | -0.089 | 0.411 | -0.03 | 1 | 0.373 | 0.272 |
| Proceeding papers | 0.232 | 0.019 | 0.604 | -0.037 | 0.373 | 1 | 0.542 |
| Graduate-level degrees | 0.317 | -0.039 | 0.476 | -0.019 | 0.272 | 0.542 | 1 |
| P-value  (one-side) | Budget | - | 0 | 0 | 0 | 0 | 0 | 0 |
| Support period ratio | 0 | - | 0.001 | 0.095 | 0 | 0.235 | 0.072 |
| SCI papers | 0 | 0.001 | - | 0.363 | 0 | 0 | 0 |
| Average IF | 0 | 0.095 | 0.363 | - | 0.131 | 0.084 | 0.235 |
| Applied patents | 0 | 0 | 0 | 0.131 | - | 0 | 0 |
| Proceeding papers | 0 | 0.235 | 0 | 0.084 | 0 | - | 0 |
| Graduate-level degrees | 0 | 0.072 | 0 | 0.235 | 0 | 0 | - |

Table 9. Correlation analysis among variables in the NT area

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Budget  (I1) | Support period ratio (I2) | SCI papers  (O1) | Average IF  (O2) | Applied patents  (O3) | Proceeding papers (O4) | Graduate-level degrees (O5) |
| Pearson  Statistics | Budget | 1 | -0.338 | 0.491 | 0.131 | 0.359 | 0.308 | 0.269 |
| Support period ratio | -0.338 | 1 | -0.017 | 0.166 | -0.072 | 0.038 | -0.021 |
| SCI papers | 0.491 | -0.017 | 1 | 0.081 | 0.462 | 0.729 | 0.585 |
| Average IF | 0.131 | 0.166 | 0.081 | 1 | 0.001 | -0.033 | -0.055 |
| Applied patents | 0.359 | -0.072 | 0.462 | 0.001 | 1 | 0.425 | 0.467 |
| Proceeding papers | 0.308 | 0.038 | 0.729 | 0.033 | 0.425 | 1 | 0.612 |
| Graduate-level degrees | 0.269 | -0.021 | 0.585 | -0.055 | 0.467 | 0.612 | 1 |
| P-value  (one-side) | Budget | - | 0 | 0 | 0 | 0 | 0 | 0 |
| Support period ratio | 0 | - | 0.332 | 0 | 0.032 | 0.163 | 0.298 |
| SCI papers | 0 | 0.332 | - | 0.019 | 0 | 0 | 0 |
| Average IF | 0 | 0 | 0.019 | - | 0.494 | 0.2 | 0.077 |
| Applied patents | 0 | 0.032 | 0 | 0.494 | - | 0 | 0 |
| Proceeding papers | 0 | 0.163 | 0 | 0.2 | 0 | - | 0 |
| Graduate-level degrees | 0 | 0.298 | 0 | 0.077 | 0 | 0 | - |

Table 10. Projection for the entire BT projects

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Budget  (I1) | Support period ratio  (I2) | SCI Papers  (O1) | Average IF  (O2) | Applied patents  (O3) | Proceeding papers (O4) | Graduate-level degrees (O5) |
| Initial average | 519.12 | 0.82 | 7.08 | 3.68 | 0.66 | 19.88 | 4.42 |
| Projection’s average | 422.11 | 0.78 | 19.61 | 11.97 | 2.79 | 63.39 | 12.71 |
| Ratio (%) | 81.31 | 94.36 | 277.16 | 325.58 | 423.18 | 318.81 | 287.37 |

Table 11. Projection for the entire NT projects

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Budget  (I1) | Support period ratio  (I2) | SCI Papers  (O1) | Average IF  (O2) | Applied patents  (O3) | Proceeding papers (O4) | Graduate-level degrees (O5) |
| Initial average | 757.72 | 0.80 | 15.69 | 2.98 | 1.95 | 39.42 | 5.93 |
| Projection’s average | 638.12 | 0.72 | 38.97 | 7.30 | 5.70 | 107.10 | 14.26 |
| Ratio (%) | 84.22 | 89.20 | 248.32 | 245.10 | 292.57 | 271.71 | 240.62 |

Table 12. Project selection standard in Program B

|  |  |  |
| --- | --- | --- |
| Evaluation Criteria | | Points |
| Excellence of proposed research plan | Research contents and methods | 30 |
| Appropriateness of budget and support period | 10 |
| Utilization and expected effect | 10 |
| Capability of researcher | | 50 |
| Total | | 100 |