

# Perspectives from research on research- innovation interactions in Japan

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# Innovation Process Database for measuring “Science Economy”

- Science based industries (taxonomy of innovation a la Pavitt): involving “scientific findings” in industrial innovation process -> progressing by expanding frontier of scientific revolution (IT, life science, nano-tech)



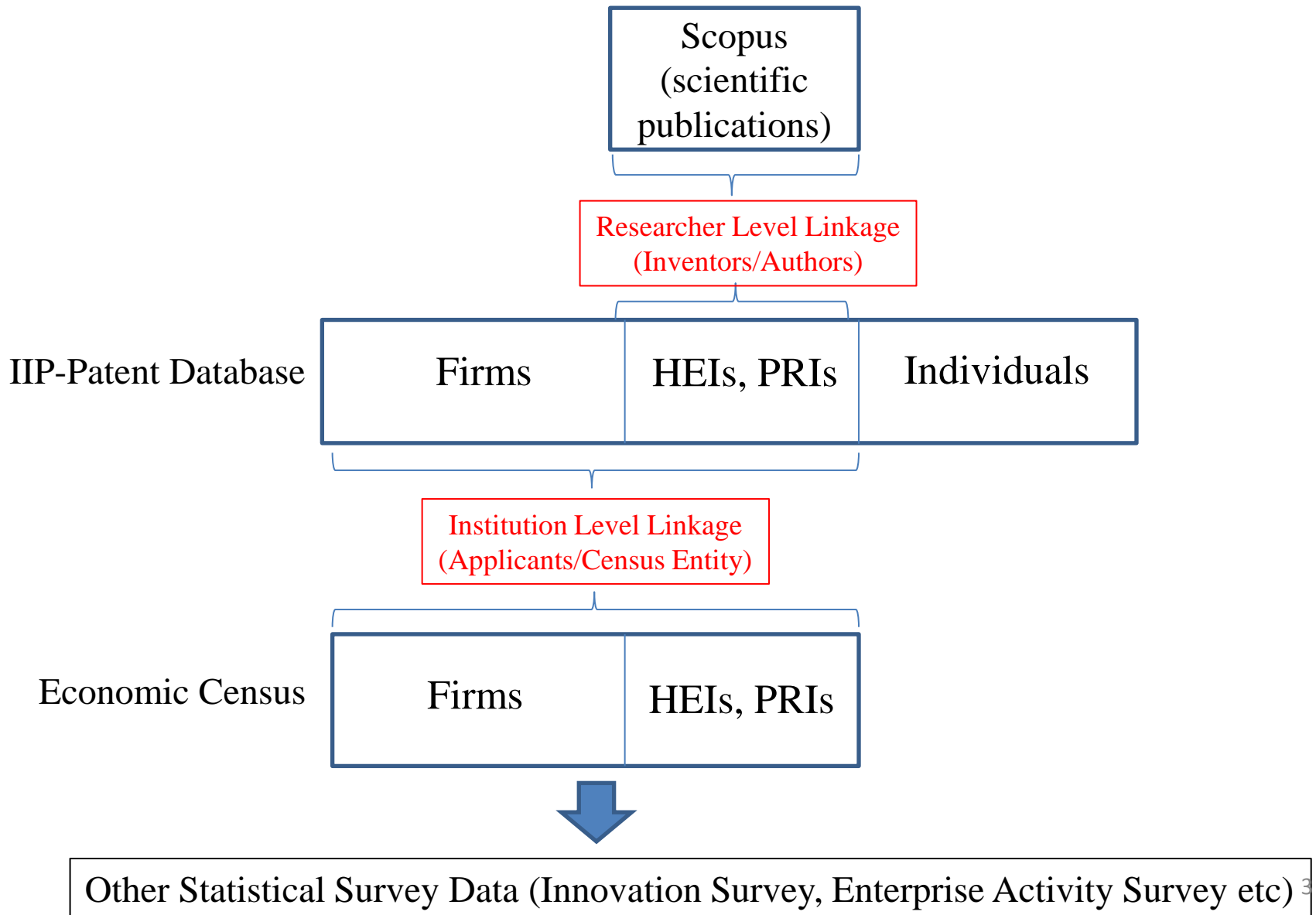
Science Linkage by NPL  
Citations by patents

- Science economy : Science base is not industry specific & not “science base (linear model)” but “science innovation interactions (interactive model)”

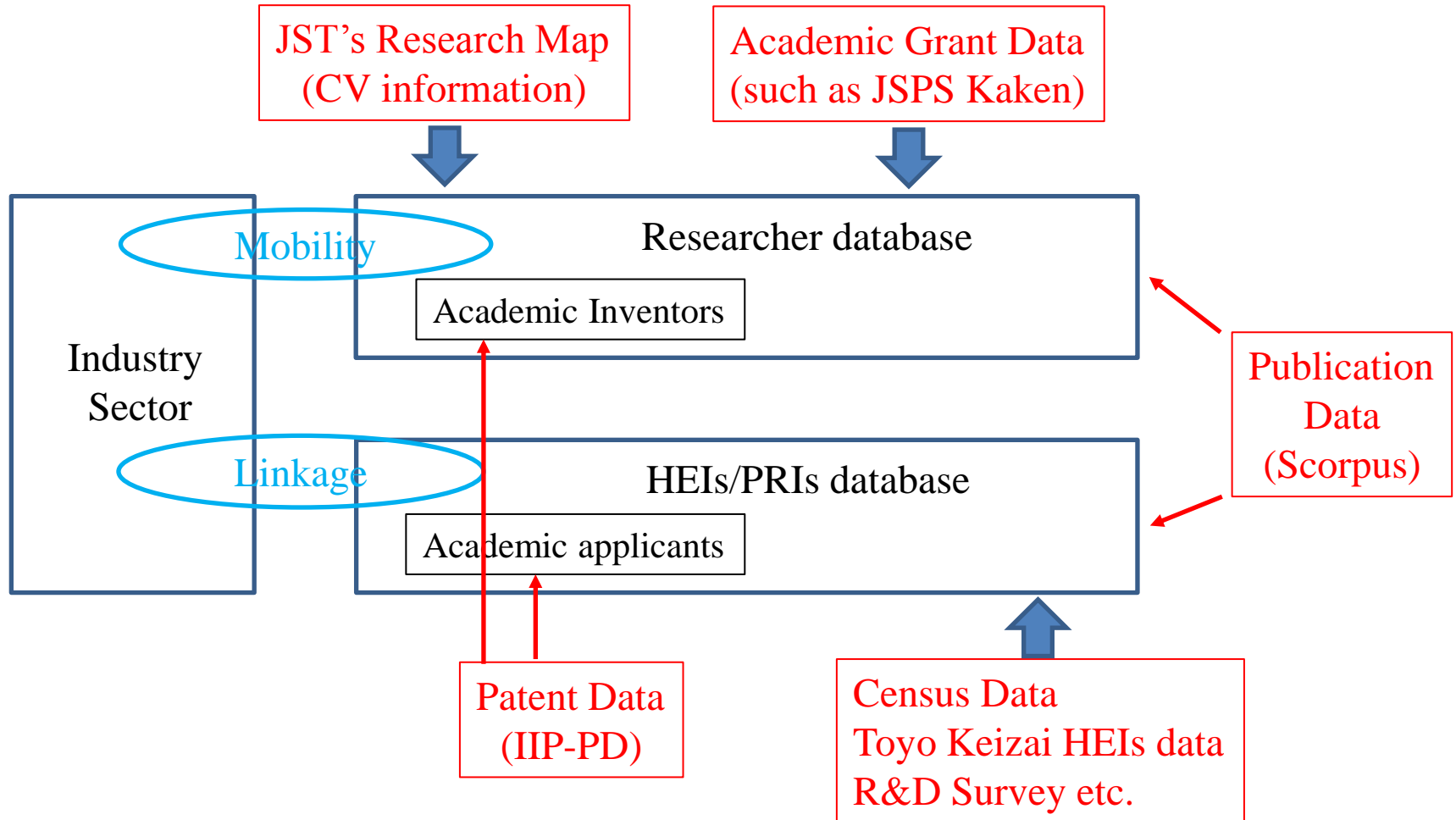


New database and indicators of science, technology and industry interactions

# Structure of Innovation Process Database



# HEIs/PRIs Parts



# Number of researchers by sector and inventor counts by Innovation Process DB (IPDB)

|                  | All dicipline |           | Only Natural Science |           | IPDB counts |
|------------------|---------------|-----------|----------------------|-----------|-------------|
|                  | FTE           | Headcount | FTE                  | Headcount | Headcount   |
| Total            | 866,920       | 926,671   | 753,374              | 810,614   |             |
| Private Firms    | 506,134       | 560,466   | 506,134              | 560,466   | 1,203,891   |
| Non profit organ | 8,842         | 10,567    | 7,892                | 9,468     |             |
| PRIs             | 30,373        | 34,067    | 28,712               | 31,620    | 10,810      |
|                  | National      |           | 2,499                | 2,112     | 2,249       |
|                  | Regional      |           | 12,431               | 9,100     | 10,972      |
|                  | Agency        |           | 19,137               | 17,500    | 18,399      |
| HEIs             | 321,571       | 321,571   | 218,528              | 218,528   | 38,750      |
|                  | National      | 145,374   | 145,374              | 115,403   | 115,403     |
|                  | Regional      | 23,595    | 23,595               | 17,957    | 17,957      |
|                  | Private       | 152,602   | 152,602              | 85,168    | 85,168      |

20,451  
Scopus Link

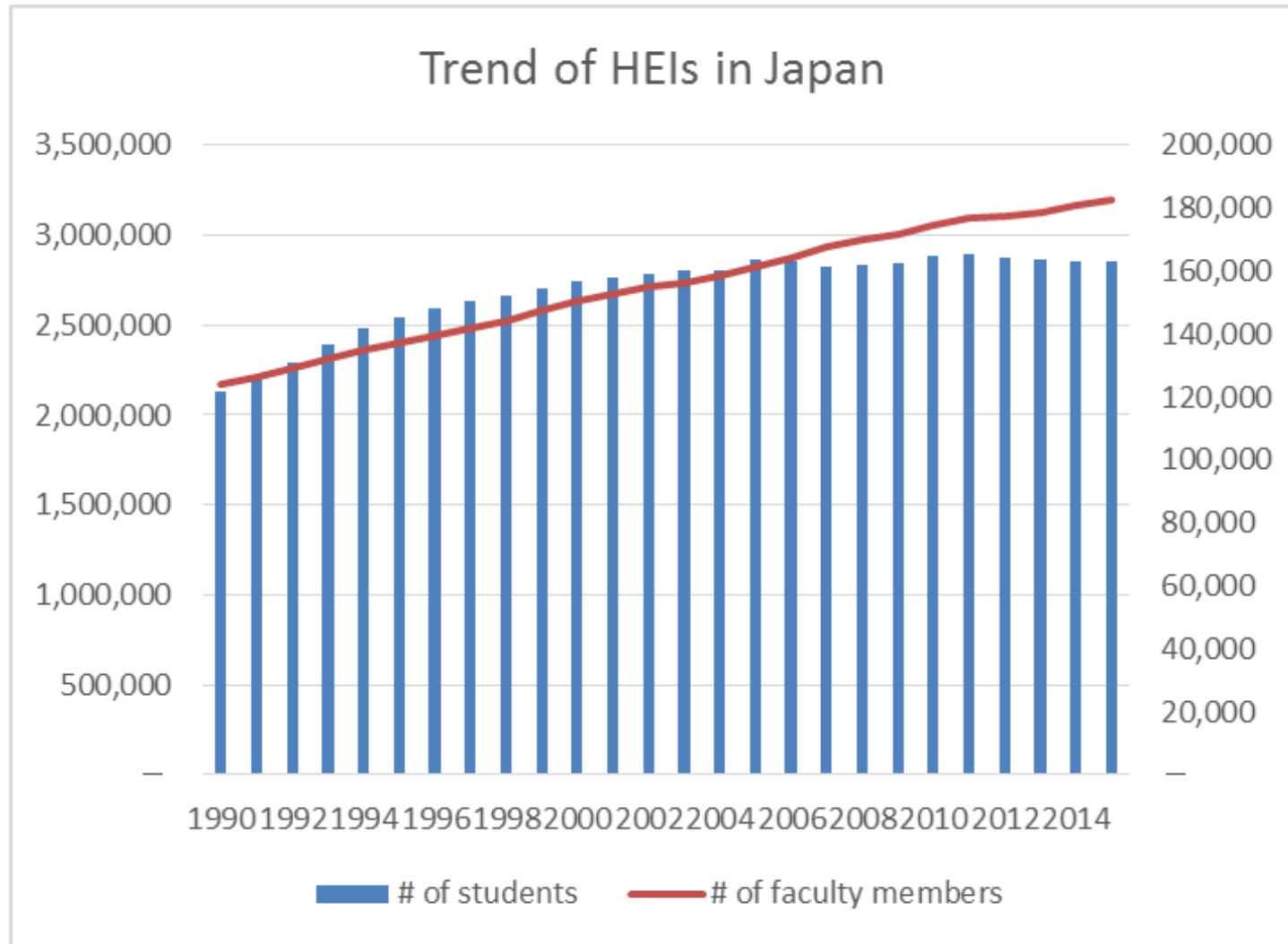
R&D Survey of Japan, 2015

# Structure of HEIs (2015)

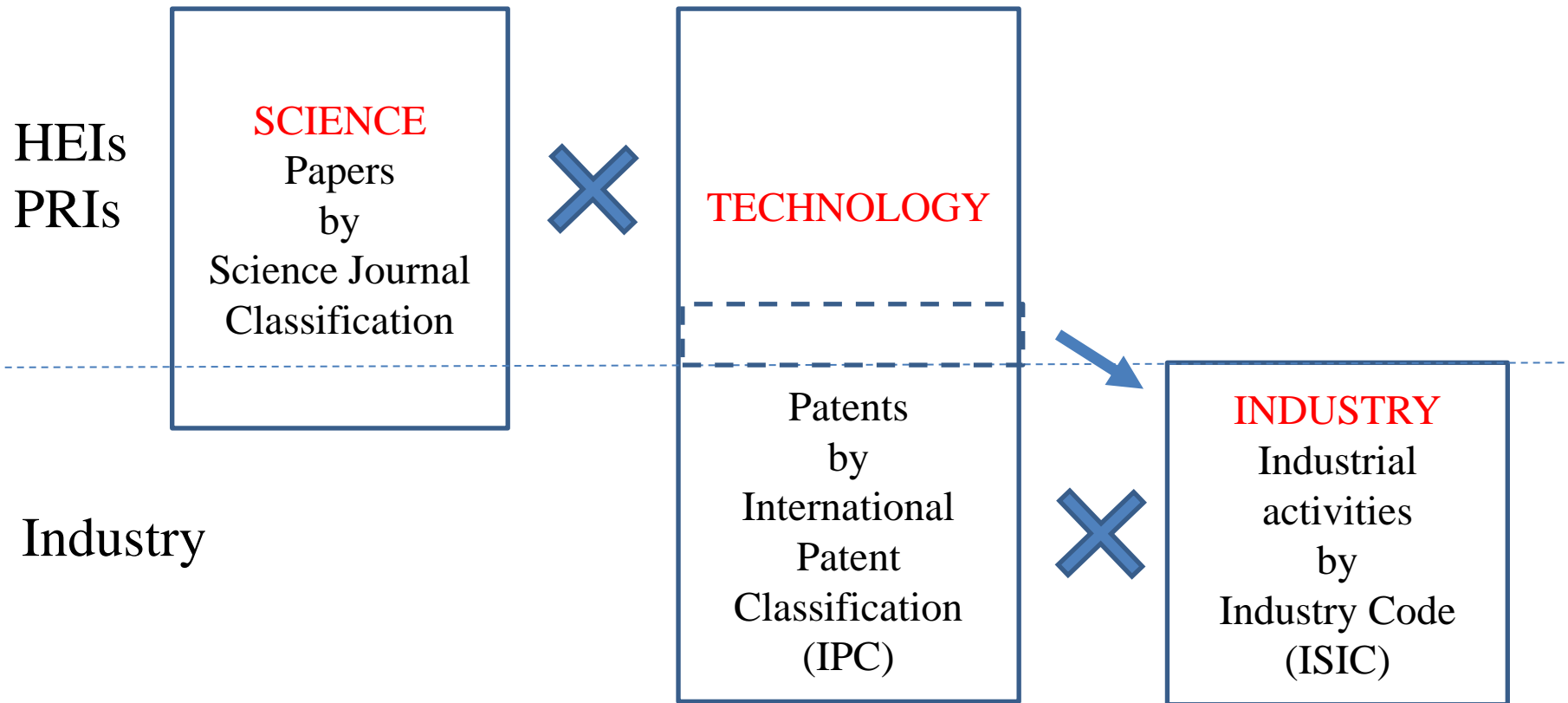
|          | #   | Students(A) | Graduate Students | Faculties (B) | A/B   | R&D Survey Researchers |
|----------|-----|-------------|-------------------|---------------|-------|------------------------|
| Naitonal | 86  | 610,802     | 150,091           | 64,684        | 9.44  | 145,374                |
| Regional | 89  | 148,766     | 15,974            | 13,126        | 11.33 | 23,595                 |
| Private  | 604 | 2,100,642   | 83,409            | 104,913       | 20.02 | 152,602                |
| Total    | 779 | 2,860,210   | 249,474           | 182,723       | 15.65 | 321,571                |

School Basic Survey, 2015

# Trend of HEIs in Japan



# Concept of STI indicators





# Preliminary Indicators (S-T part)

Original Data : # of research papers by science field “s” (Rs)  
# of patents by technology field “t” (Pt) for researcher “i”

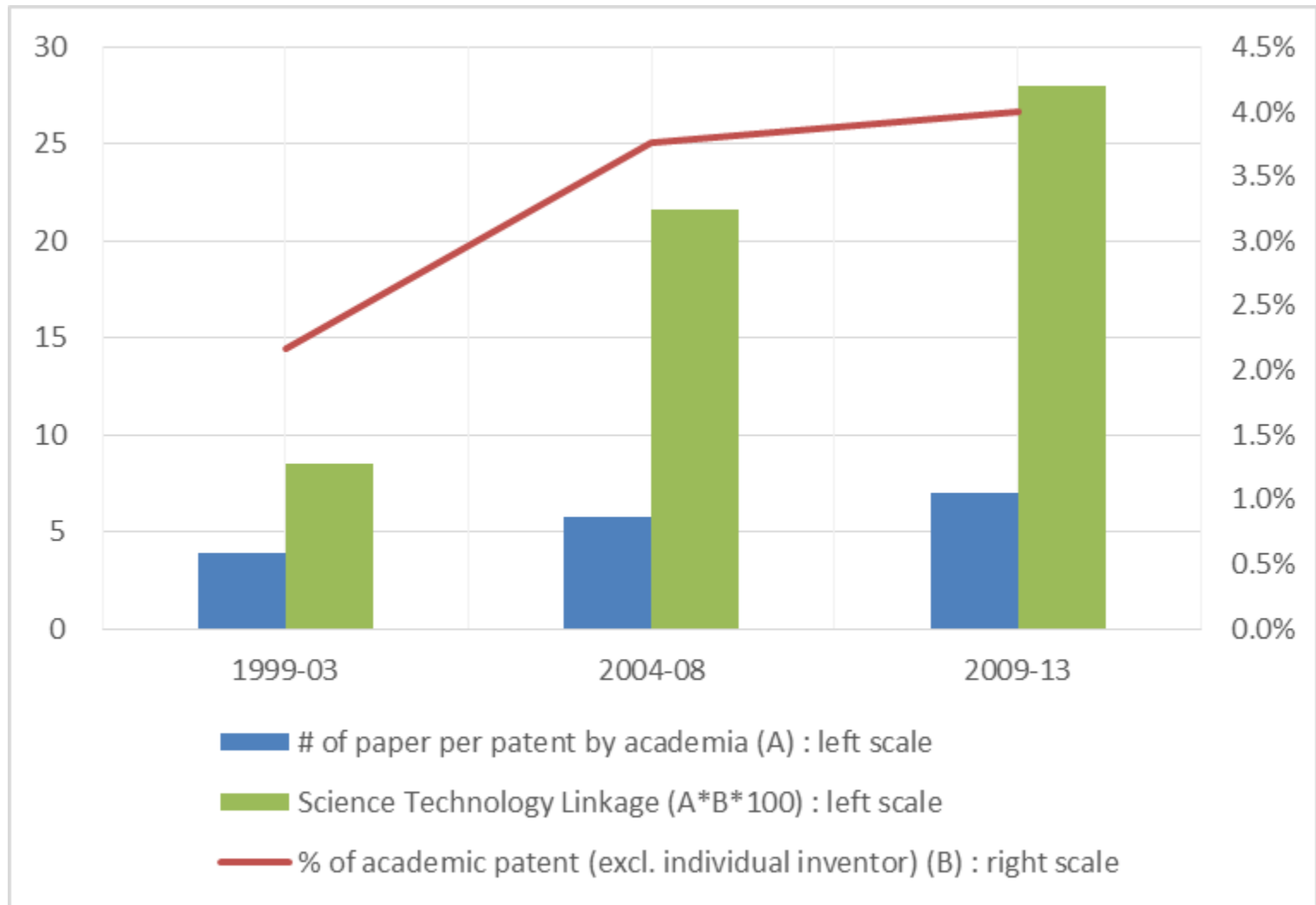
Step 1: Construct W matrix,  $W_{st}^{\text{Paper}} = \sum_i \left( R_{is} \times \frac{P_{it}}{\sum_t P_{it}} \right)$

Step 2: Normalize by patent counts of “i”  $L_t^{\text{Paper}} = \frac{\sum_s W_{st}^{\text{Paper}}}{\sum_{it} P_{it}}$

Step 3: S-T Linkage by technology class “t” is calculated by

$$SI_t = L_t^{\text{Paper}} * \text{Academic\_Share}_t$$

# Aggregated trend of S-T Linkage



# S-T Linkage by technology

|    |   | 2001   | 2006   | 2011   | NPL index |
|----|---|--------|--------|--------|-----------|
| 15 | Biotechnology                           | 132.05 | 304.30 | 511.41 | 138.43    |
| 22 | Micro-structural and nano-technology    | 56.94  | 131.64 | 138.18 |           |
| 14 | Organic fine chemistry                  | 27.38  | 73.04  | 110.21 | 69.06     |
| 16 | Pharmaceuticals                         | 23.63  | 52.90  | 87.77  | 83.71     |
| 13 | Medical technology                      | 17.18  | 44.86  | 71.28  |           |
| 20 | Materials, metallurgy                   | 18.05  | 44.80  | 53.91  | 20.20     |
| 11 | Analysis of biological materials        | 14.22  | 36.01  | 53.44  |           |
| 23 | Chemical engineering                    | 10.84  | 32.22  | 36.76  |           |
| 18 | Food chemistry                          | 10.99  | 25.86  | 29.28  | 42.39     |
| 10 | Measurement                             | 7.51   | 18.53  | 28.91  | 21.83     |
| 19 | Basic materials chemistry               | 8.59   | 17.73  | 24.51  |           |
| 21 | Surface technology, coating             | 11.04  | 18.80  | 24.14  |           |
| 8  | Semiconductors                          | 4.75   | 12.97  | 19.61  | 56.44     |
| 5  | Basic communication processes           | 2.50   | 8.59   | 18.81  |           |
| 17 | Macromolecular chemistry, polymers      | 7.18   | 18.12  | 16.77  |           |
| 29 | Other special machines                  | 5.87   | 17.07  | 14.68  |           |
| 24 | Environmental technology                | 5.90   | 14.88  | 13.91  |           |
| 12 | Control                                 | 2.46   | 10.60  | 13.17  |           |
| 7  | IT methods for management               | -      | 10.50  | 12.92  |           |
| 6  | Computer technology                     | 2.79   | 10.46  | 11.72  | 20.39     |
| 1  | Electrical machinery, apparatus, energy | 3.27   | 8.51   | 10.15  |           |
| 35 | Civil engineering                       | 1.90   | 5.18   | 9.54   |           |
| 9  | Optics                                  | 2.32   | 5.57   | 7.43   | 21.89     |
| 26 | Machine tools                           | 2.54   | 7.05   | 7.34   |           |
| 3  | Telecommunications                      | 1.24   | 3.37   | 6.15   | 17.89     |
| 27 | Engines, pumps, turbines                | 3.20   | 4.92   | 5.00   |           |
| 25 | Handling                                | 2.48   | 4.22   | 4.62   |           |
| 31 | Mechanical elements                     | 1.48   | 2.66   | 4.30   |           |
| 32 | Transport                               | 1.97   | 3.58   | 4.11   |           |
| 4  | Digital communication                   | 0.77   | 2.98   | 3.54   |           |
| 34 | Other consumer goods                    | 2.04   | 4.41   | 3.49   |           |
| 30 | Thermal processes and apparatus         | 1.31   | 3.97   | 3.12   |           |
| 2  | Audio-visual technology                 | 0.79   | 1.75   | 3.07   |           |
| 33 | Furniture, games                        | 1.62   | 2.37   | 2.01   |           |
| 28 | Textile and paper machines              | 0.77   | 1.10   | 1.49   |           |

NPL index: USPTO NPL citations per 100 patents (van Looy et. al)

# Comparison of L matrix (2001-2011)

|  | 1   | 2                      | 3                  | 4                     | 5                             | 6                   | 7                         | 8              | 9      | 10          | 11                               | 12      | 13                 | 14                     | 15            | 16              | 17                                 | 18             | 19                        | 20                    | 21                                     | 22                                  | 23                   | 24                       | 25       | 26            | 27                       | 28                         | 29                     | 30                              | 31                  | 32        | 33               | 34                   | 35                |      |
|--|---|------------------------|--------------------|-----------------------|-------------------------------|---------------------|---------------------------|----------------|--------|-------------|----------------------------------|---------|--------------------|------------------------|---------------|-----------------|------------------------------------|----------------|---------------------------|-----------------------|--|-------------------------------------|----------------------|--------------------------|----------|---------------|--------------------------|----------------------------|------------------------|---------------------------------|---------------------|-----------|------------------|----------------------|-------------------|------|
|  | mechanical machinery, automotive, aerospace | Auto-visual technology | Telecommunications | Digital communication | Basic communication processes | Computer technology | IT methods for management | Semiconductors | Optics | Measurement | Analysis of biological materials | Control | Medical technology | Organic fine chemistry | Biotechnology | Pharmaceuticals | Macromolecular chemistry, polymers | Food chemistry | Basic materials chemistry | Materials, metallurgy | Storage technology, and infrastructure | Chemical and aerospace technologies | Chemical engineering | Environmental technology | Handling | Machine tools | Engines, pumps, turbines | Textile and paper machines | Other special machines | Thermal processes and materials | Mechanical elements | Transport | Furniture, games | Other consumer goods | Civil engineering |      |
| Multidisciplinary                            | 0.01  | 0.00                   | 0.00               | 0.00                  | 0.02                          | 0.01                | 0.00                      | 0.02           | 0.01   | 0.01        | 0.02                             | 0.01    | 0.02               | 0.03                   | 0.11          | 0.02            | 0.01                               | 0.02           | 0.03                      | 0.02                  | 0.01                                   | 0.01                                | 0.01                 | 0.01                     | 0.03     | 0.00          | 0.03                     | 0.01                       | 0.04                   | 0.00                            | 0.00                | 0.01      | 0.01             | 0.01                 | 0.01              | 0.01 |
| Agricultural and Biological Sciences         | 0.03  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.03                | 0.00                      | 0.01           | 0.01   | 0.05        | 0.07                             | 0.03    | 0.07               | 0.16                   | 0.72          | 0.19            | 0.06                               | 1.81           | 0.38                      | 0.02                  | 0.01                                   | 0.01                                | 0.05                 | 0.12                     | 0.04     | 0.03          | 0.06                     | 0.04                       | 0.39                   | 0.04                            | 0.01                | 0.02      | 0.08             | 0.01                 | 0.07              |      |
| Arts and Humanities                          | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.00                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.00    | 0.00               | 0.00                   | 0.00          | 0.00            | 0.00                               | 0.00           | 0.00                      | 0.00                  | 0.01                                   | 0.00                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.00                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.00      | 0.00             | 0.00                 | 0.00              | 0.00 |
| Biochemistry, Genetics and Molecular Biology | 0.10  | 0.03                   | 0.02               | 0.03                  | 0.05                          | 0.19                | 0.00                      | 0.07           | 0.07   | 0.30        | 0.40                             | 0.18    | 0.93               | 1.22                   | 3.35          | 1.41            | 0.35                               | 1.13           | 0.42                      | 0.09                  | 0.13                                   | 0.20                                | 0.18                 | 0.20                     | 0.22     | 0.04          | 0.13                     | 0.12                       | 0.86                   | 0.04                            | 0.12                | 0.07      | 0.09             | 0.12                 | 0.12              |      |
| Business, Management and Accounting          | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.00                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.00    | 0.01               | 0.00                   | 0.02          | 0.00            | 0.00                               | 0.00           | 0.01                      | 0.00                  | 0.00                                   | 0.00                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.00                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.00      | 0.00             | 0.00                 | 0.00              | 0.00 |
| Chemical Engineering                         | 0.15  | 0.01                   | 0.00               | 0.00                  | 0.02                          | 0.04                | 0.00                      | 0.07           | 0.04   | 0.08        | 0.09                             | 0.05    | 0.28               | 0.20                   | 0.23          | 0.07            | 0.23                               | 0.14           | 0.33                      | 0.33                  | 0.18                                   | 0.18                                | 0.60                 | 0.29                     | 0.04     | 0.11          | 0.14                     | 0.12                       | 0.17                   | 0.25                            | 0.09                | 0.07      | 0.04             | 0.09                 | 0.04              |      |
| Chemistry                                    | 0.56  | 0.06                   | 0.01               | 0.01                  | 0.02                          | 0.06                | 0.00                      | 0.22           | 0.25   | 0.40        | 0.56                             | 0.03    | 0.20               | 1.86                   | 0.43          | 0.31            | 1.12                               | 0.25           | 0.98                      | 0.69                  | 0.57                                   | 0.71                                | 1.02                 | 0.44                     | 0.06     | 0.15          | 0.23                     | 0.34                       | 0.32                   | 0.16                            | 0.14                | 0.09      | 0.22             | 0.12                 | 0.11              |      |
| Computer Science                             | 0.05  | 0.10                   | 0.26               | 0.24                  | 0.45                          | 0.68                | 0.00                      | 0.04           | 0.08   | 0.09        | 0.03                             | 0.40    | 0.23               | 0.01                   | 0.03          | 0.00            | 0.02                               | 0.00           | 0.01                      | 0.01                  | 0.02                                   | 0.13                                | 0.02                 | 0.05                     | 0.74     | 0.02          | 0.04                     | 0.01                       | 0.02                   | 0.05                            | 0.10                | 0.19      | 0.63             | 0.24                 | 0.07              |      |
| Decision Sciences                            | 0.00  | 0.00                   | 0.00               | 0.01                  | 0.00                          | 0.01                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.01    | 0.00               | 0.00                   | 0.00          | 0.00            | 0.00                               | 0.00           | 0.00                      | 0.00                  | 0.00                                   | 0.00                                | 0.00                 | 0.00                     | 0.01     | 0.00          | 0.00                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.01      | 0.01             | 0.00                 | 0.01              | 0.00 |
| Earth and Planetary Sciences                 | 0.03  | 0.00                   | 0.03               | 0.01                  | 0.09                          | 0.03                | 0.00                      | 0.01           | 0.02   | 0.08        | 0.04                             | 0.02    | 0.02               | 0.01                   | 0.02          | 0.00            | 0.01                               | 0.01           | 0.04                      | 0.03                  | 0.04                                   | 0.02                                | 0.03                 | 0.08                     | 0.01     | 0.02          | 0.08                     | 0.00                       | 0.04                   | 0.03                            | 0.03                | 0.14      | 0.01             | 0.03                 | 0.13              |      |
| Economics, Econometrics and Finance          | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.00                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.00    | 0.00               | 0.00                   | 0.00          | 0.00            | 0.00                               | 0.00           | 0.00                      | 0.00                  | 0.00                                   | 0.00                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.00                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.00      | 0.00             | 0.00                 | 0.00              | 0.00 |
| Energy                                       | 0.12  | 0.01                   | 0.00               | 0.00                  | 0.02                          | 0.02                | 0.00                      | 0.04           | 0.02   | 0.04        | 0.04                             | 0.03    | 0.03               | 0.04                   | 0.01          | 0.00            | 0.03                               | 0.01           | 0.14                      | 0.12                  | 0.06                                   | 0.06                                | 0.13                 | 0.16                     | 0.03     | 0.04          | 0.49                     | 0.02                       | 0.06                   | 0.27                            | 0.08                | 0.02      | 0.00             | 0.05                 | 0.03              |      |
| Engineering                                  | 0.68  | 0.40                   | 0.68               | 0.39                  | 1.37                          | 0.74                | 0.00                      | 0.60           | 0.79   | 0.64        | 0.33                             | 0.89    | 0.96               | 0.06                   | 0.12          | 0.04            | 0.13                               | 0.02           | 0.30                      | 0.45                  | 0.51                                   | 0.76                                | 0.37                 | 0.33                     | 1.87     | 0.77          | 1.15                     | 0.12                       | 0.29                   | 0.73                            | 1.41                | 1.25      | 1.24             | 0.97                 | 0.61              |      |
| Environmental Science                        | 0.01  | 0.00                   | 0.01               | 0.01                  | 0.01                          | 0.01                | 0.00                      | 0.00           | 0.01   | 0.02        | 0.03                             | 0.01    | 0.01               | 0.03                   | 0.07          | 0.01            | 0.01                               | 0.03           | 0.06                      | 0.06                  | 0.03                                   | 0.02                                | 0.01                 | 0.06                     | 0.16     | 0.01          | 0.01                     | 0.05                       | 0.01                   | 0.05                            | 0.04                | 0.02      | 0.02             | 0.02                 | 0.04              |      |
| Immunology and Microbiology                  | 0.01  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.03                | 0.00                      | 0.02           | 0.01   | 0.05        | 0.07                             | 0.03    | 0.08               | 0.17                   | 0.83          | 0.29            | 0.03                               | 0.24           | 0.08                      | 0.01                  | 0.01                                   | 0.03                                | 0.09                 | 0.01                     | 0.00     | 0.01          | 0.02                     | 0.35                       | 0.01                   | 0.01                            | 0.00                | 0.00      | 0.00             | 0.07                 |                   |      |
| Materials Science                            | 0.93  | 0.20                   | 0.06               | 0.03                  | 0.31                          | 1.12                | 0.00                      | 1.22           | 0.59   | 0.41        | 0.44                             | 0.12    | 0.72               | 0.39                   | 0.18          | 0.11            | 1.47                               | 0.06           | 1.10                      | 2.90                  | 1.84                                   | 1.58                                | 0.73                 | 0.42                     | 0.16     | 1.11          | 0.46                     | 0.55                       | 0.79                   | 0.35                            | 0.52                | 0.10      | 0.67             | 0.15                 | 0.21              |      |
| Mathematics                                  | 0.01  | 0.01                   | 0.01               | 0.02                  | 0.04                          | 0.06                | 0.00                      | 0.01           | 0.01   | 0.01        | 0.01                             | 0.06    | 0.03               | 0.01                   | 0.01          | 0.00            | 0.01                               | 0.00           | 0.01                      | 0.01                  | 0.01                                   | 0.01                                | 0.00                 | 0.03                     | 0.00     | 0.02          | 0.00                     | 0.01                       | 0.01                   | 0.01                            | 0.01                | 0.07      | 0.08             | 0.01                 |                   |      |
| Medicine                                     | 0.15  | 0.05                   | 0.04               | 0.05                  | 0.05                          | 0.18                | 0.00                      | 0.10           | 0.08   | 0.20        | 0.22                             | 0.23    | 1.85               | 0.70                   | 1.78          | 1.42            | 0.12                               | 0.23           | 0.18                      | 0.07                  | 0.10                                   | 0.09                                | 0.07                 | 0.09                     | 0.22     | 0.04          | 0.11                     | 0.04                       | 0.67                   | 0.10                            | 0.14                | 0.25      | 0.11             | 0.15                 | 0.23              |      |
| Neuroscience                                 | 0.01  | 0.02                   | 0.01               | 0.01                  | 0.01                          | 0.05                | 0.00                      | 0.01           | 0.01   | 0.04        | 0.05                             | 0.05    | 0.24               | 0.14                   | 0.32          | 0.25            | 0.03                               | 0.05           | 0.01                      | 0.01                  | 0.02                                   | 0.02                                | 0.02                 | 0.02                     | 0.04     | 0.01          | 0.02                     | 0.01                       | 0.20                   | 0.01                            | 0.01                | 0.02      | 0.08             | 0.01                 | 0.01              |      |
| Nursing                                      | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.00                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.00    | 0.02               | 0.01                   | 0.01          | 0.01            | 0.00                               | 0.00           | 0.00                      | 0.00                  | 0.00                                   | 0.00                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.00                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.00      | 0.00             | 0.00                 | 0.00              |      |
| Pharmacology, Toxicology and Pharmaceutics   | 0.02  | 0.01                   | 0.00               | 0.00                  | 0.01                          | 0.02                | 0.00                      | 0.01           | 0.01   | 0.05        | 0.06                             | 0.01    | 0.13               | 0.48                   | 0.32          | 0.46            | 0.13                               | 0.16           | 0.07                      | 0.01                  | 0.01                                   | 0.02                                | 0.05                 | 0.02                     | 0.04     | 0.01          | 0.02                     | 0.02                       | 0.13                   | 0.01                            | 0.01                | 0.02      | 0.01             | 0.02                 |                   |      |
| Physics and Astronomy                        | 1.56  | 0.58                   | 0.24               | 0.10                  | 1.17                          | 0.34                | 0.00                      | 2.73           | 2.27   | 0.90        | 0.71                             | 0.23    | 0.69               | 0.26                   | 0.20          | 0.08            | 0.36                               | 0.13           | 1.09                      | 1.34                  | 2.57                                   | 1.83                                | 0.82                 | 0.78                     | 0.24     | 0.64          | 1.34                     | 0.33                       | 0.52                   | 0.59                            | 0.52                | 0.35      | 0.37             | 0.57                 | 0.19              |      |
| Psychology                                   | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.00                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.00    | 0.00               | 0.00                   | 0.01          | 0.01            | 0.00                               | 0.00           | 0.00                      | 0.00                  | 0.00                                   | 0.00                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.01                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.00      | 0.00             | 0.00                 | 0.00              |      |
| Social Sciences                              | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.01                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.01    | 0.00               | 0.00                   | 0.00          | 0.00            | 0.00                               | 0.00           | 0.00                      | 0.00                  | 0.00                                   | 0.00                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.00                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.00      | 0.00             | 0.00                 | 0.00              |      |
| Veterinary                                   | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.00                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.01                             | 0.00    | 0.01               | 0.00                   | 0.05          | 0.02            | 0.00                               | 0.04           | 0.01                      | 0.00                  | 0.00                                   | 0.00                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.00                     | 0.00                       | 0.02                   | 0.00                            | 0.00                | 0.00      | 0.01             | 0.00                 | 0.00              |      |
| Dentistry                                    | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.00                | 0.00                      | 0.00           | 0.00   | 0.01        | 0.01                             | 0.00    | 0.11               | 0.02                   | 0.04          | 0.05            | 0.00                               | 0.01           | 0.00                      | 0.00                  | 0.00                                   | 0.00                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.00                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.02      | 0.01             | 0.00                 | 0.00              |      |
| Health Professions                           | 0.00  | 0.00                   | 0.00               | 0.00                  | 0.00                          | 0.01                | 0.00                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.00    | 0.04               | 0.01                   | 0.01          | 0.01            | 0.00                               | 0.00           | 0.00                      | 0.01                  | 0.01                                   | 0.00                                | 0.00                 | 0.01                     | 0.01     | 0.00          | 0.01                     | 0.00                       | 0.01                   | 0.03                            | 0.01                | 0.00      | 0.03             | 0.00                 | 0.00              |      |
| Multidisciplinary                            | 0.02  | 0.01                   | 0.01               | 0.00                  | 0.04                          | 0.02                | 0.09                      | 0.04           | 0.03   | 0.05        | 0.06                             | 0.02    | 0.04               | 0.09                   | 0.26          | 0.10            | 0.03                               | 0.05           | 0.03                      | 0.05                  | 0.04                                   | 0.04                                | 0.04                 | 0.02                     | 0.01     | 0.01          | 0.04                     | 0.02                       | 0.09                   | 0.02                            | 0.02                | 0.01      | 0.00             | 0.01                 | 0.01              |      |
| Agricultural and Biological Sciences         | 0.02  | 0.01                   | 0.00               | 0.00                  | 0.03                          | 0.04                | 0.07                      | 0.01           | 0.02   | 0.09        | 0.13                             | 0.03    | 0.07               | 0.24                   | 1.02          | 0.25            | 0.06                               | 2.28           | 0.39                      | 0.04                  | 0.03                                   | 0.01                                | 0.07                 | 0.19                     | 0.03     | 0.04          | 0.09                     | 0.06                       | 0.94                   | 0.04                            | 0.01                | 0.08      | 0.06             | 0.06                 | 0.15              |      |
| Arts and Humanities                          | 0.00  | 0.01                   | 0.01               | 0.00                  | 0.01                          | 0.08                | 0.03                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.01    | 0.01               | 0.00                   | 0.01          | 0.01            | 0.00                               | 0.00           | 0.00                      | 0.00                  | 0.00                                   | 0.02                                | 0.00                 | 0.00                     | 0.00     | 0.00          | 0.00                     | 0.00                       | 0.00                   | 0.00                            | 0.00                | 0.01      | 0.01             | 0.02                 | 0.01              |      |
| Biochemistry, Genetics and Molecular Biology | 0.14  | 0.04                   | 0.02               | 0.02                  | 0.12                          | 0.21                | 0.44                      | 0.13           | 0.14   | 0.63        | 0.92                             | 0.31    | 1.09               | 1.85                   | 4.76          | 1.96            | 0.42                               | 1.64           | 0.53                      | 0.24                  | 0.26                                   | 0.40                                | 0.37                 | 0.37                     | 0.15     | 0.07          | 0.29                     | 0.20                       | 1.04                   | 0.07                            | 0.05                | 0.07      | 0.34             | 0.23                 | 0.11              |      |
| Business, Management and Accounting          | 0.00  | 0.00                   | 0.00               | 0.01                  | 0.00                          | 0.03                | 0.05                      | 0.00           | 0.00   | 0.00        | 0.00                             | 0.02    | 0.01               | 0.00                   | 0.01          | 0.00            | 0.00                               | 0.03           | 0.00                      | 0.00                  | 0.00                                   | 0.01                                | 0.00                 | 0.00                     | 0.01     | 0.01          | 0.00                     | 0.00                       | 0.01                   | 0.01                            | 0.00                | 0.00      | 0.03             | 0.00                 | 0.00              |      |
| Chemical Engineering                         | 0.27  | 0.02                   | 0.01               | 0.00                  | 0.05                          | 0.04                | 0.02                      | 0.14           | 0.11   | 0.22        | 0.27                             | 0.21    | 0.23               | 0.57                   | 0.48          | 0.13            | 0.51                               | 0.21           | 0.53                      | 0.56                  | 0.30                                   | 0.77                                | 0.99                 | 0.36                     | 0.05     | 0.10          | 0.26                     | 0.23                       | 0.31                   | 0.31                            | 0.12                | 0.09      | 0.10             | 0.05                 | 0.11              |      |
| Chemistry                                    | 0.95  | 0.06                   | 0.02               | 0.01                  | 0.11                          | 0.05                | 0.03                      | 0.47           | 0.42   | 0.51        | 0.71                             | 0.14    | 0.24               | 2.00                   | 0.82          | 0.44            | 1.57                               | 0.47           | 1.28                      | 1.43                  | 0.98                                   | 1.40                                | 1.62                 | 0.56                     | 0.05     | 0.20          | 0.52                     | 0.41                       | 0.68                   | 0.19                            | 0.10                | 0.01      | 0.11             | 0.06                 | 0.13              |      |
| Computer Science                             | 0.31  | 0.50                   | 1.08               | 1.05                  | 1.93                          | 3.13                | 2.84                      | 0.32           | 0.65   | 0.63        | 0.16                             | 2.49    | 1.09               | 0.05                   | 0.16          | 0.03            | 0.07                               | 0.04           | 0.17                      | 0.09                  | 0.14                                   | 0.74                                | 0.14                 | 0.09                     | 2.82     | 0.27          | 0.36                     | 0.12                       | 0.16                   | 0.19                            | 0.83                | 0.77      | 2.58             | 0.82                 | 0.66              |      |
| Decision Sciences                            |   |                        |                    |                       |                               |                     |                           |                |        |             |                                  |         |                    |                        |               |                 |                                    |                |                           |                       |  |                                     |                      |                          |          |               |                          |                            |                        |                                 |                     |           |                  |                      |                   |      |

# Research system reforms in Japan

## Centralization of strategy and macro control

- 1995: Science and Technology Basic Law : 1<sup>st</sup> Science and Technology Basic Plan (1996-2000). Now, 5<sup>th</sup> Plan (2016-2020) just started.
- 2001: CSTP (Committee of Science Technology Policy) and changed its name to CSTI (STP-ST and Innovation Policy)
- 2001: Ministry of education and S&T Agency merged into MEXT

## Decentralization of strategy implementation

- 2001: Incorporation of national research laboratories (PRIs)
- 2004: Incorporation of national universities

## Consistent Supports for U-I collaborations

- 1998: TLO promotion law
- 1999: Japanese Bayh-Dole Act
- 2001: 1000 university spin-outs plan
- 2005- : Various supports to university IP offices

# Summary of findings and Policy implications

- Growing trend of science and technology link
  - Institutional reforms in Japan's science system (incorporation of PRIs and national universities)
  - Scientification of industry (science economy)
- Inter-disciplinary science contributes to technological progress



- Linear model (I->U contract research)-> Interaction model of UI formations such as
  - Corporate research center inside university
  - University based entrepreneurship
- Bottom-up academic funding -> Issue specific centralized research programs (such as new energy system and IoT/AI)
- HEIs/PRIs as an innovation eco-system platform