The Economic and Non-economic Impacts of Bio-Industry: Methodologies and Implications for the Bio-industry in Korea

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Korea

I. Introduction

I. Introduction

- **Biotechnology: shaping current industries into entirely new ones In our world as well as in Korea**
- **Enormous expectations concerning the economic potential of biotechnology.**
- **Most researches: based on industry surveys with R&D, Firms' economic activities, target-oriented for forecasting**
- **2004 OECD Workshop on the Economic Impacts of Biotechnology**
  - **insightful methodological approaches to estimate the impacts**
  - **introduced some pioneering researches**
  - **wide range of defining bio-industries**
  - **economic impact would vary depending on the choice of modeling scheme**
- **We Introduce:**
  - **discussion on current Korean bio-industry statistics and measuring the economic impact of biotechnology and the bio-industry**
  - **a brief discussion of non-economic and social impacts of the bio-industry in Korea**
  - **estimate the economic impact of the bio-industry within the Korean economy by constructing a bio-industry augmented I-O Table**
  - **present the government's strategic plan for the future of bio-industry and expert opinions**
  - **some findings and implications for future research.**

II. Brief History of Bio-Industry in Korea: A Statistical View of Survey

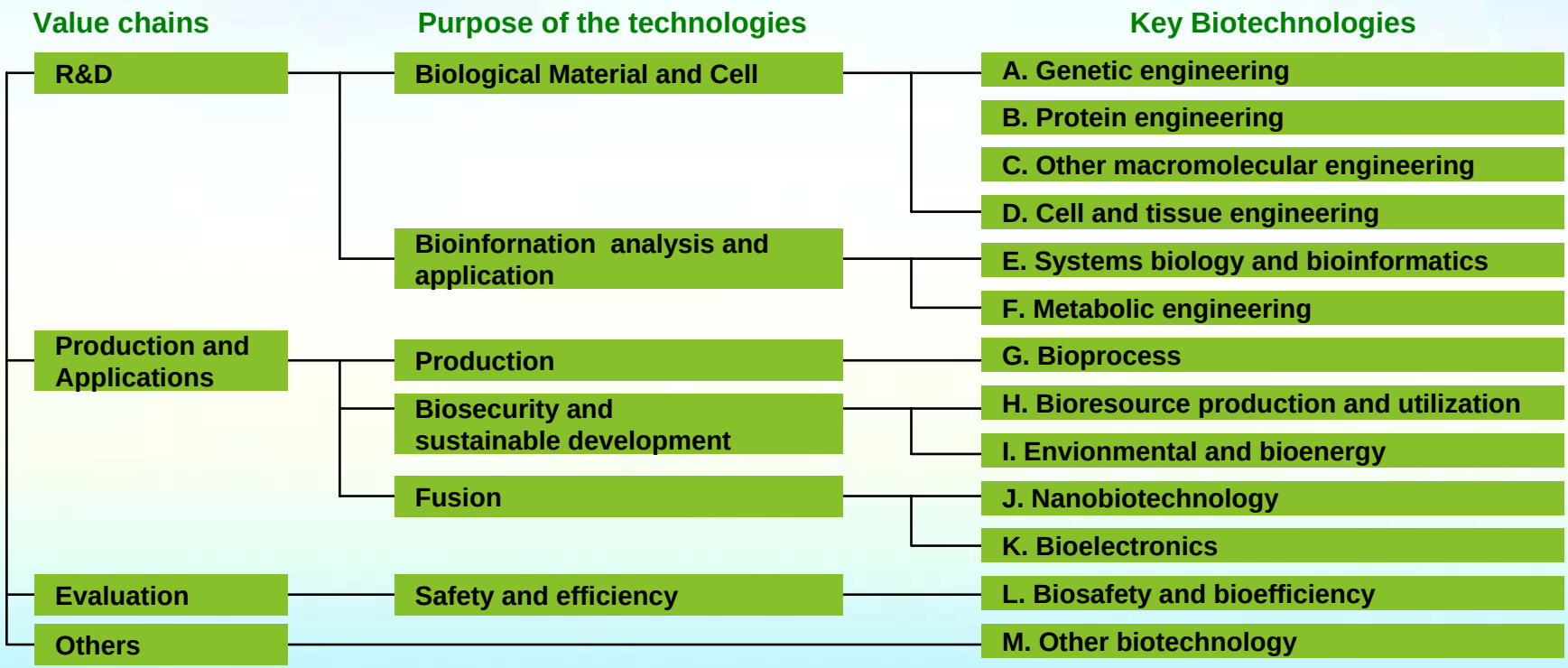
- **2.1. Classification of Bio-industry Statistics in Korea**
- **2.2. Brief History of the Korean Bio-industry**

II. Brief History of Bio-Industry in Korea: A Statistical View of Survey

2.1. Classification of Bio-industry Statistics in Korea

- Biotechnology Classification system of 13 categories
- Reflecting the status of the Korean Bio-industry
- Structure criteria: the main value-chains used & the object of the technology

Table 1. Structure of the biotechnology classification system in Korea

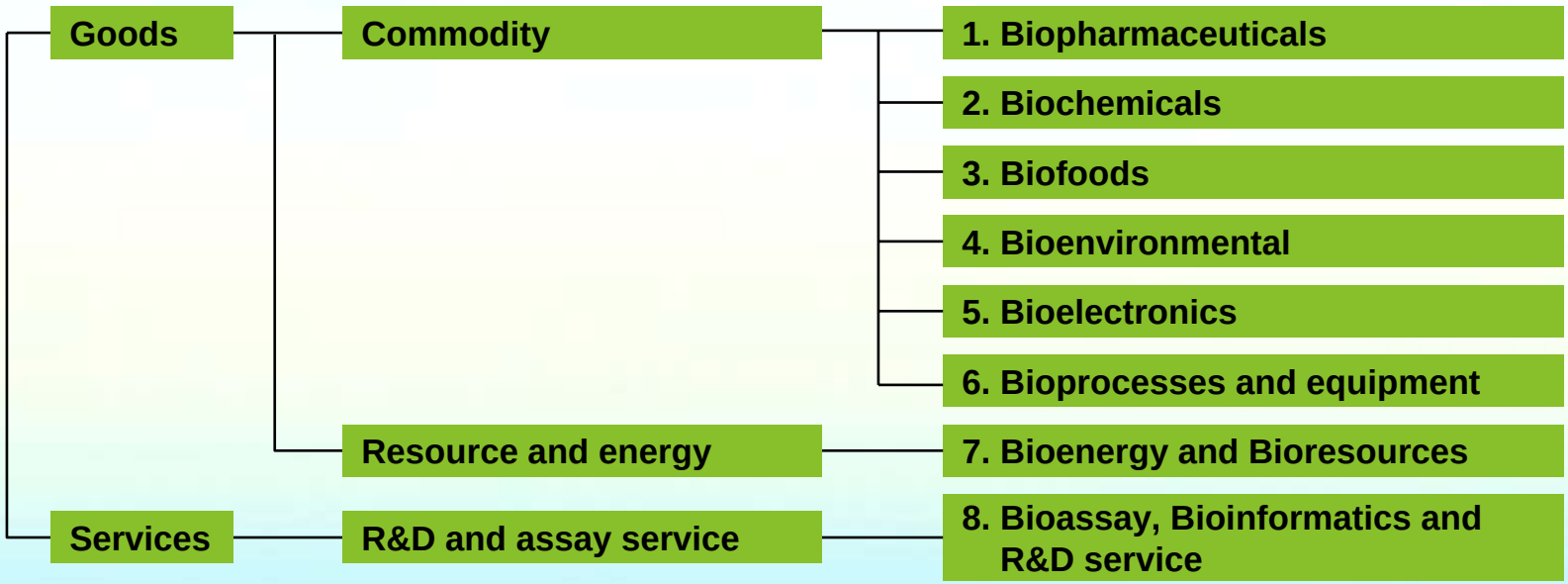


II. Brief History of Bio-Industry in Korea: A Statistical View of Survey

2.2. Brief History of the Korean Bio-industry

- Bio-industry Classification System of 8 categories
- Facilitate Analysis of the Bio-industry & the Economic Impact on the Various Industrial Sectors
- Structure Criteria: Goods & Services

Table 2. Structure of the bio-industry classification system in Korea



II. Brief History of Bio-Industry in Korea: A Statistical View of Survey

- **Korean Bio-industry has been growing rapidly**
  - CAGR 1999~2004: 22%
- **Major Driving Force**
  - Political Support from the Government
  - Entrepreneurship of R&D Oriented Company

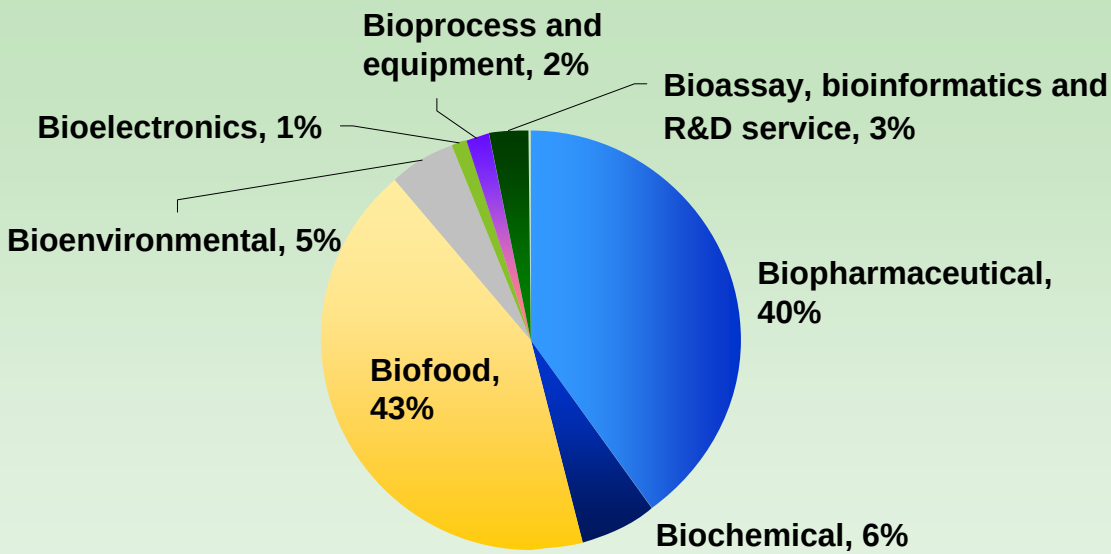
Table 3. Growth rate of the Korean bio-industry

Year	1999	2000	2001	2002	2003	2004	CAGR (99-04)
Biopharmaceuticals	30.02	4.94	28.47	-8.92	33.94	13.15	13.23
Biochemicals	-3.81	50.78	47.69	50.19	-11.18	42.51	33.46
Biofoods	-7.07	65.99	-10.72	91.03	3.40	14.91	27.46
Bioenvironmental	-33.44	41.62	138.88	45.56	-5.39	22.51	41.67
Bioelectronics	N/A	N/A	198.16	-10.80	-15.39	120.59	-
Bioprocesses and equipment	41.12	10.02	66.17	79.36	-37.61	5.79	16.70
Bioenergy and bioresources	N/A	N/A	N/A	N/A	-68.43	-33.85	N/A
Bioassay, bioinformatics and R&D service	N/A	180.05	707.85	-7.61	37.53	47.01	111.44
Total	11.37	29.19	18.27	35.73	9.81	16.39	21.52

II. Brief History of Bio-Industry in Korea: A Statistical View of Survey

- **The Annual Biotechnology Firm Survey by The Korean Ministry MOCIE**
  - In 2004, 640 Companies were active in the Korean Bio-industry
  - Almost 70% of Biotechnology Firm were small, less than 50 Employees
  - Production Share: Bio-food 43 %, Bio-Pharmaceutical 40 %
  - An Average of US $550,000 per firm on Biotechnology R&D

Figure 1. Biotechnology products by area of application in 2004



Source: KIET, 2006.

III. Economic Impact of Bio-industries in Korea

- **3.1. How to capture the Bio-industry in the perspective industrial structure**
- **3.2. The Economic Impacts of Bio-industry in Korea**
- **3.3. Forecast of total production in the Korean bio-industry: A strategic plan**
- **3.4 Non-economic Impacts of Bio-industries in Korea**

III. Economic Impact of Bio-industries in Korea

3.1. How to capture the Bio-industry in the perspective industrial structure

- **The economic impacts of biotechnology different according to measurement methods**

- **Should include substitution effects:**
  - **Increasingly using biotechnology to produce industrial substitutes for natural agricultural products manufactured in large quantities, new substances competing as viable substitutes**
  - **Older biotechnological techniques (e.g. fermentation) themselves benefiting from additional inputs from genetic engineering and new enzymatic processes**
  - **From the perspective of economic agencies, the impacts more significant in production processes such as reducing expenses on capital or running costs, more cost-effective products, increasing value-added, higher yields or lower input costs. As summing up the firm level changes in other industries derived from the bio-industry**
  - **the emergence of substitutes as production of intermediate inputs.**

III. Economic Impact of Bio-industries in Korea

- **Should include fabrication effects**
  - Referring to the altered proportion of value-added items of a sector's total purchases
  - Over time, a product of bio-relevant sectors such as Chemicals, Pharmaceuticals, Energy, and Foods depend more on bio-technology capital equipment and/or skilled labors
  - a KRW (Korean Won)'s worth of the product embodies proportionately less conventional, industrial inputs and proportionally more value-added inputs

- **Considering the effects, an input-output analysis a useful tool in capturing the overall impacts of the biotechnology industry**
  - a static input-output model is sufficient to determine the impact of new technologies on economy (Duchin and Lange, 1994)
  - In order to investigate the penetration of new technologies, a dynamic approach is required.

- **An optimal aggregation to include bio-industry as a separate sector also important**
  - may miss important information from over-aggregation within the bio-industry
  - may be violating the homogeneity hypothesis from under-aggregation

III. Economic Impact of Bio-industries in Korea

3.2. The Economic Impacts of Bio-industry in Korea

- To estimate the economic impact of the bio-industry on the Korean economy,
  - Construct an I-O framework with augmentation of separate bio-industries
  - Include the bio-industries as new sectors, based on the survey results.
  - Within the existing I-O of n sectors, create bio-industry sectors as n+1st to n+m sector.

$A_1 = A_{1a} + A_{1b}$, $Y_1 = Y_{1a} + Y_{1b}$, $VA_1 = VA_{1a} + VA_{1b}$

where,
A: intermediate transactions,
Y: final demand,
VA: Value-added
1: conventional sectors such as Chemicals, Pharmaceuticals, Energy, and Foods,
1a: conventional sectors – relevant bio-subsectors,
1b: relevant bio-subsectors

- To resolve the previous two questions, substitution and fabrication effects,
  - utilizes a survey of existing bio-firms in Korea and applies RAS to establish the Korea Bio-augmented I-O (KB I-O)

III. Economic Impact of Bio-industries in Korea

- **As in Table 4, the ratio of value-added (VA) in bio sectors:**
  - **generally much higher that those of conventional manufacturing and related industries, almost double the manufacturing total.**
  - **bio sectors, as new technology-oriented sectors, superior in the value chain.**
- **Wide variation in value structures within the bio-industry group**
  - **In Korea, bio-pharmaceuticals, as technology-oriented, the highest VA ratio.**
  - **Biochemical and bio-foods are currently similar in value structure to manufacturing industries.**
- **The output multiplier in bio-industries, as in Table 5:**
  - **The output multipliers for the bio- sectors ranged from 1.72 to 3.02, and slightly lower compared to other manufacturing industries.**
- **The impact coefficients (representing the backward linkage effect used to indicate demand-side interconnection of a particular sector to those sectors from which it purchases inputs)**
  - **The impact coefficients for bio sub-sectors are around 1, meaning average demand-side effects**

III. Economic Impact of Bio-industries in Korea

Table 4. Input Structure of the Bio-industry

(%)

Bio subsectors	Inter-mediate	Value-added					Gross output
		Sum	Wages	Operating revenue	Depreciation	Indirect tax (-subsidy)	
Bio-pharmaceuticals	39.5	60.5	20.9	16.6	26.2	17.6	0.0
Biochemical	62.0	38.0	11.3	17.8	16.7	3.5	0.0
Biofood	66.9	33.1	14.6	13.0	18.8	1.3	100.0
Bio-environment	66.2	33.8	16.9	8.1	20.5	5.2	100.0
Bio-electronics	49.2	50.8	7.9	37.9	11.7	1.2	100.0
Bioprocess and equipment	59.0	41.0	22.4	12.5	28.1	0.4	100.0
bio-energy and bio-resource	66.9	33.1	19.3	8.4	23.4	1.3	100.0
Bioassay, bioinformatics and R&D service	32.9	67.1	49.2	11.2	55.7	0.2	100.0
Bio-industry Total	54.4	45.6	18.1	14.6	22.9	8.1	100.0
Manufacturing Total	75.5	24.5	11.2	8.1	11.9	4.4	100.0
Service Total	41.6	58.4	23.3	24.8	26.7	6.9	100.0
Economy Total	59.7	40.3	17.1	15.7	18.9	5.7	100.0

Source: KIET, 2006.
Note: Extracted bio-industry from updated 2004 Korea Bio-industry augmented I-O table.

III. Economic Impact of Bio-industries in Korea

Table 5. Major Multipliers and Economic Impact Coefficients in Selected Industries

Industry	Output multiplier	Impact coefficients	Sensitivity coefficients
Agriculture	2.0577	0.8000	0.9660
Foods	2.8405	1.1043	0.8056
Chemicals	3.2683	1.2706	2.9404
Machinery	3.2596	1.2672	1.5236
Electric, Electronics	3.2363	1.2582	1.8706
Precision machinery	3.0872	1.2002	0.6325
Education and Health	1.5960	0.6205	0.7835
Bio-pharmaceuticals	1.8863	0.7333	0.4034
Biochemicals	2.6107	1.0149	0.3927
Biofoods	2.3478	0.9127	0.3919
Bio-environment	2.7649	1.0749	0.3901
Bio-electronics	1.8308	0.7117	0.3898
Bioprocess and equipment	2.7134	1.0549	0.3890
Bio-energy and bio-resources	3.0213	1.1745	0.3902
Bioassay, bioinformatics and R&D services	1.7287	0.6720	0.3896

Source: KIET, 2006.

III. Economic Impact of Bio-industries in Korea

- **The sensitivity coefficient (supply-side interconnection)**
  - Since the bio sectors in Korea are in a developing stage, their coefficients not as high as those of other industries.
  - More importantly, an optimal aggregation question, since a higher degree of disaggregation in a sector usually induces a lower sensitivity coefficient

- **Table 6 summarizes the estimates provided by the assumption that the final demand for Korean bio-industries has increased at a rate of 20 percent (reflecting recent growth rates and mid range of future growth targets)**
  - The economic activity of this 20 percent increase, or the 230 millions of US$ increase in final demand of bio products and services
  - generate close to 524 millions of US$ in the Korean economy
  - estimated 86 millions of US$ in wages and 29 millions of US$ in tax revenues
  - The total employment impact approximately 3,335 jobs to the national economy

III. Economic Impact of Bio-industries in Korea

Table 6. Summary of Economic Impacts of the Korean Bio-industry

(Unit: KRW, persons)

Industries	Total Sales	Value-added	Employment (persons)	wages	taxes	operational profits
Agriculture	20	12	8	1	2	9
Mining	670	420	315	117	63	224
Food	13	3	4	1	0	1
Textiles	33	8	28	5	1	1
Wood, Paper	127	33	56	23	6	3
Printing	95	26	76	17	4	3
Oil and Coal	429	103	8	36	21	41
Chemicals	215	51	58	18	10	21
Non-ferrous	25	8	9	4	2	2
Primary metals	188	43	23	16	8	17
Metal Products	71	17	40	6	3	7
Machinery	119	33	57	14	5	13
Electric, Electronics	93	25	28	11	4	10
Precision machinery	16	4	12	2	1	2
Transportation machine	59	12	18	8	3	1
Other Manufacturing	52	16	35	10	2	3
Electric utilities	90	38	16	8	15	15
Construction	67	29	80	19	2	7
Wholesale, Retail	122	34	447	53	7	41
Restaurant, Lodging	12	4	37	5	1	6
Transportation	116	87	127	19	3	21
Communications	102	79	33	17	3	18
Finance, Insurance	272	179	238	45	5	13
Real estate	181	85	163	33	18	18
Public administration	71	50	77	22	3	39
Education, health	35	28	78	2	5	12
Social services	49	26	158	23	4	10
Bio-pharmaceuticals	521	315	233	109	92	86
Biochemicals	1	0	1	0	0	0
Biofoods	1901	629	625	278	24	248
Bio-environment	95	32	83	16	5	8
Bio-electronics	6	3	5	0	0	2
Bioprocesses and equipment	74	31	107	17	0	9
bio-energy and bio-resource	2	1	10	0	0	0
Bioassay, bioinformatics and R&D	48	32	40	24	0	5
Sum (100 millions of KR won)	5992	2495	3335	981	324	918
Sum (billions of US$)	5.24	2.78	3335	0.86	0.28	0.80

Source: Authors' estimation, 2006.

Note: 1. As of 2004, 1 KR won/US $ is 1143.74

2. a 15 percent increase of bio final demand, approx. 263.8 billion won or $US2.3 billion.

III. Economic Impact of Bio-industries in Korea

Table 7. Summary of Economic Impacts of the Korean Bio-industry

	Total sales	Value-added	Employment	Wages	Taxes	Operational profits
Direct	232	91	1,104	39	11	31
Indirect and induced	292	127	2,231	47	18	49
Total	524	218	3,335	86	29	80

Note: millions of US dollar, persons

- **Table 7 summarizes the bio-industries' direct, indirect and induced economic impacts on the Korean economy**
  - **The total impact on employment was 3,335 jobs, with 1,104 direct jobs, and 2,231 indirect and induced jobs.**
  - **Other economic variables summarized as the same way.**

III. Economic Impact of Bio-industries in Korea

3.3. Forecast of total production in the Korean bio-industry: A strategic plan

Table 8. Strategic Plan for the Future of the Bio-industry in Korea

		2005	2016	Annual growth rate
Total production[1]	billions of Korea won	2,941	48,078	28.9
	billions of US dollar	2.9	46.9	
World Market[2]	billions of US dollar	910	3090	11.8
Government budget[1]	billions of Korea won	600	3250	16.6
	billions of US dollar	0.59	3.57	

Sources: 1. MOST, 2006. *The 2nd Bio-engineering Promotion Plan (A Proposal)*;
2. MOCIE, 2005. *A Vision for Bio-industry and Development Plan*.
Note: 1. in constant terms as of 2005
2. exchange rate, 1024.14 won per US dollar.

III. Economic Impact of Bio-industries in Korea

- **The Korean government estimates a total output of $US42.9 billion by 2016**
  - **a daunting task and would need 28.3 percent annual growth**
  - **Due to limited data available for analytical forecasting of the Korean bio-industry, attempt to incorporate additional sources such as a Delphi survey and Korean government policies**

- **As in Table 8, the forecast expects a target of $US 42.9 billion by 2016 under a long-term plan of continuous investment and R&D**
  - **These market sizes are possible but require intensive promotion of the Korean biotechnology industries.**

III. Economic Impact of Bio-industries in Korea

3.4 Non-economic Impacts of Bio-industries in Korea

- **Non-economic Impacts of Biotechnology through the Convergence & Linkage Process**
  - Human Health & Welfare
  - Innovation in the Other Technologies & Industries

- **Main areas**
  - Healthcare Strategy & related Impacts
  - IPR Impacts on Further Innovation
  - Co-evolution Impacts with Social Acceptance
  - Biotech-related Environmental Impacts: Bio-Safety, Bio-Security etc.

- **The Korean Government established infrastructures and laws related to bio-safety, bio-security, and bioethics.**

- **Still More Infrastructure and Societal “Software” needed for the ELSI of Biotech Field**

IV. Concluding remarks

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- **The main findings:**
  - According to the historical surveys in Korea, CAGR over the last 5 years = 22 %.
  - Major force behind the Korean bio-industry:
    the synergy created by enthusiastic governmental policy &
    the entrepreneurship of the research-oriented companies
- **Wide variations in value structures within the bio-industry**
  - Bio-pharmaceuticals, as a highly technology-oriented industry, the highest VA ratio
  - Bio-chemicals and bio-foods similar in value structure to that of manufacturing
  - Output multipliers for the bio-sectors ranged 1.72 ~ 3.02, slightly lower than other manufacturing industries.
  - Impact coefficients for bio sub-sectors are around 1, average demand-side effects
  - Sensitivity coefficients of supply-side interconnection are not high stemming from
    (1) by nature, (2) early stage of development, and/or
    (3) the higher degree of disaggregation in the bio-sectors.
- **A final demand of $US 2.3 billion**
  - generate close to $US 5.24 billion for the Korean Economy
  - includes an estimated $0.86 billion in wages, $0.28 billion in tax revenue
  - the total job impact is close to 3,335 jobs
- **For Non-economic impacts, further infra and societal 'software' needed**
- **Need more survey for accuracy of data, more sophisticated modeling**

Thank you