Economic Impact of Nanotechnology

Case Study on the LED Lights

Contents

Introduction

Motivation

- Quantitative analysis on the economic impact of nanotechnology is in demand with increasing effect of the technology on industries.
  - Nanotechnology is expected to be General Purpose Technology (GPT) in near future.
- Reliable index / statistics for monitoring the level of nanotechnology development is not set up.
  - Consensus on nanotechnology and stats on R&D investments is not built.
- Studies on economic effect of nanotechnology product are not enough.
  - Published stats are about technology level and patents.

Purpose of Analysis

- Case study on Nanotechnology product is performed with LED lights.
  - Economic benefit from substitution of LED lights for incumbent products will be analyzed quantitatively.
  - Analysis will be confined to domestic substitution market of Korea.
  * New/additional market with LED lights will not be considered.

- Effect of Nanotechnology on industry will be studied in economic terms.
  - Accumulation of case studies on economic effect of nanotechnology is essential.

- Only quantitative results is presented on this.
  - To obtain market data, analysis on value chain and participants of LED light market with interviews were performed.
  - Qualitative analysis is not introduced in this presentation.

Methodology

Methodology

- Few have attempted to address economic impact of new product based on nanotechnology
  - Establishment of reliable index on characteristics and development level of nanotechnology is “on the way”
  - Consensus on methodology for measuring economic impact of nanotechnology product is not built.
- General methodology of economic benefit assessment is utilized.
  - Economic benefit consists of consumer, producer's surplus and externality.

Economic Benefit

Economic Benefit =

Consumer's Surplus + Producer's Surplus + Externality

Overview of analysis

Case study guide of Oakdene Hollins for DEFRA (Nov. 2010)

- Comprehensive guide for measuring economic surplus of new product based on nanotechnology.
- Assumption on elasticity of demand essential to measure consumer's surplus is too strong.
- There is risk of overestimation by measuring the surplus regardless of technology categories. (Contribution of nanotechnology must be isolated from that of existing technology)

This analysis relies on methodology suggested by Oakdene Hollins with some improvements.

- Potential consumer survey is necessary to measure consumer's surplus of new product. This study leaves the WTP (willingness to pay) analysis for future research.
- Contribution ratio of nanotechnology in production of LED light is applied for measurement to avoid overestimation problem.

Economic Benefit of this case study

Economic Benefit in this study=

(Consumer's Surplus) + Producer's Surplus + Externality

*Periods : year 2011~2020 (10 periods)

*Market size : LED light substitution market

Producer's Surplus

Producer's Surplus

- Computation of producer's surplus is multiplication between unit margin and market size.
  - Difference between surplus with and without LED light substitution against incumbent products will be calculated.

Producer's Surplus

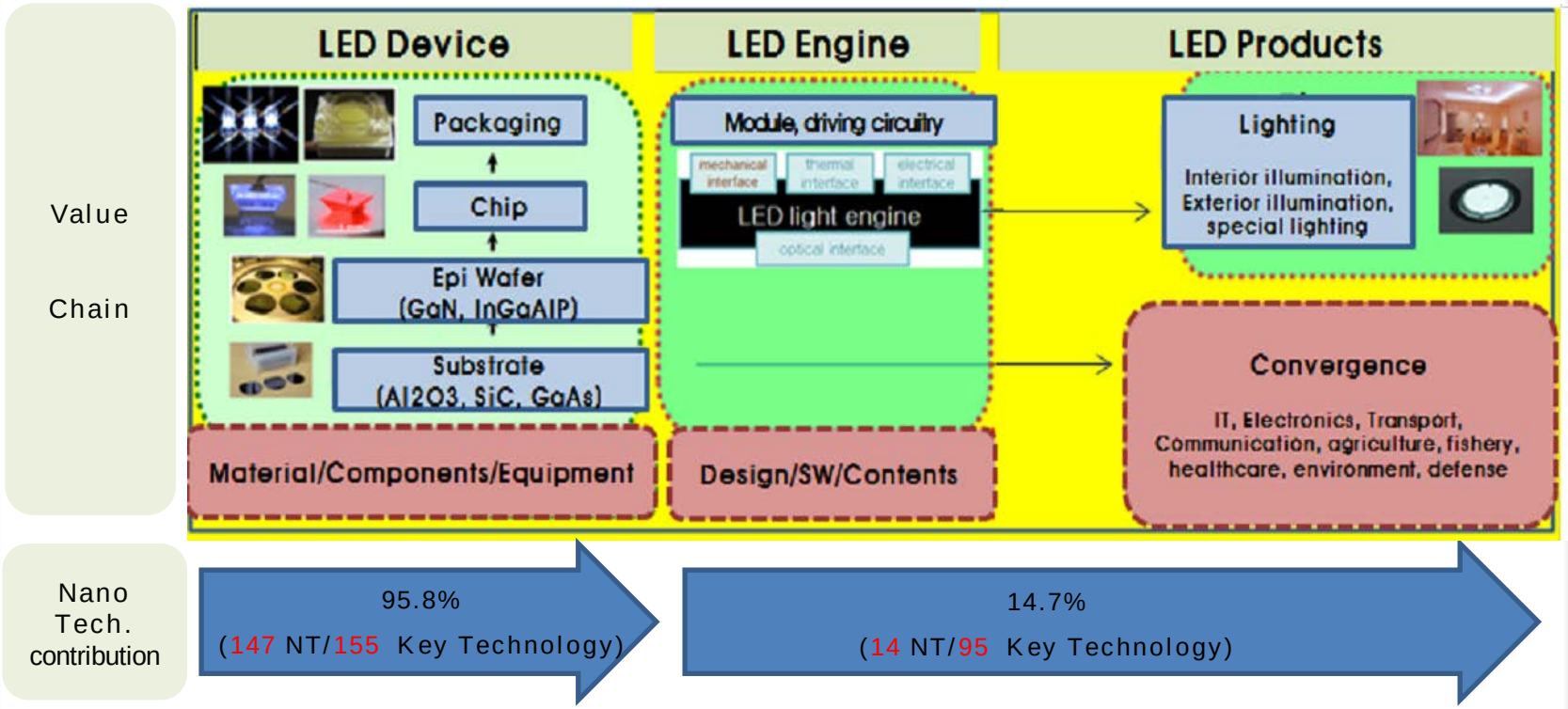
* Producer's Surplus=
[(unit price − unit cost) □ market size] □ Contribution ratio of Nanotechnology
* Producers's Surplus of LED light=
Surplus with LED substitution − Surplus without LED substitution

- Analysis relies on the data from KAPID(Korea Association for Photonics Industry Development).
  - Data for size & categories of Korean light market, LED substitution rate, expected price of LED and incumbent lights
- Incumbent market is consist of incandescent lamp, halogen lamp, Fluorescent lamp (FL), Compact Fluorescent lamp (CFL) and High Intensity Discharge lamp (HID).
  - Market coverage of these light sources is 95% in Korea market.

Contribution of Nanotechnology on Light Product

- Portion of nanotechnology in key technologies for LED lights production is estimated at 64.4%(=161 NT/250 key Tech.)
  - Technology Road Map prepared by cooperation of MKE (Ministry of Knowledge Economy), KIAT (Korea Institute for Advancement of Technology) and R&D experts is used.

Analysis on nanotechnology contribution in LED light product



Producer's Surplus

Substitution rates of LED light

Incumbent Product		Watt	2011	2013	2015	2017	2020
incandescent lamp		30	7%	21%	29%	34%	38%
		60	7%	43%	69%	82%	86%
		100	13%	56%	74%	82%	87%
Halogen lamp		20	6%	33%	53%	64%	72%
		50	8%	46%	74%	87%	92%
		100	7%	44%	70%	83%	88%
Fluorescent lamp		20	0%	12%	28%	39%	50%
		32	0%	3%	11%	27%	47%
CFL	FPL type	27	0%	17%	34%	36%	43%
		36	0%	18%	33%	39%	44%
		45	0%	41%	44%	44%	43%
	CFL	15	0%	8%	20%	34%	56%
		20	1%	9%	16%	25%	41%
		25	2%	17%	25%	34%	57%
HID		100	0%	17%	32%	41%	54%
		150	1%	7%	14%	27%	44%
		175	0%	3%	12%	30%	47%
		250	0%	1%	5%	17%	38%
		400	0%	2%	4%	17%	42%

Producer's Surplus

Analysis result on Producer's Surplus

Year	LED Light Product		Nanotechnology	
	Future Value	Present Value	Future Value	Present Value
2011	15.4	15.4	9.9	9.9
2012	33.3	31.6	21.4	20.4
2013	78.4	70.9	50.5	45.6
2014	45.9	39.5	29.6	25.4
2015	41.8	34.1	26.9	22.0
2016	52.1	40.5	33.6	26.1
2017	50.7	37.4	32.7	24.1
2018	53.6	37.6	34.5	24.2
2019	42.1	28.0	27.1	18.1
2020	21.2	13.4	13.6	8.6
Total	**434.6**	**348.5**	**279.9**	**224.4**

Exchange Rate=1100won/$ unit : million $

- Percent margin of LED lamp production = 26%
- Contribution of nanotechnology on LED light products = 64.4%
- annual inflation rate = 3.4%
- Annual interest rate = 5.2%

Ⅳ Externality

Externality

- Electricity saving is principal factor of externality.
  - Reduction of waste and carbon emission are not considered by lack of data.
  - 2 scenarios : with & without increase in electric rate

- Computation of Externality in economic term is multiplication between saved electricity and electric rate.
  - Data of Electricity Consumption of Lights, LED substitution ratio, Electricity Saving Ratio of LED, Electric Rate are requirements for calculation.

Externality

Externality=

Electricity Consumption of Lights X Substitution ratio of LED

□ Electricity Saving Ratio of LED □ Electric Rate

Externality

Electricity Saving Ratio of LED lights against incumbent products

Incumbent Product		Watt	2011	2013	2015	2017	2020
incandescent lamp		30	75%	84%	88%	91%	92%
		60	73%	83%	87%	90%	92%
		100	69%	80%	85%	89%	90%
Halogen lamp		20	74%	84%	87%	90%	91%
		50	71%	81%	85%	88%	90%
		100	67%	79%	84%	87%	89%
Fluorescent lamp		20	20%	42%	51%	59%	62%
		32	5%	32%	42%	51%	56%
CFL	FPL type	27	43%	60%	66%	72%	75%
		36	39%	57%	64%	70%	73%
		45	36%	55%	62%	68%	72%
	CFL	15	25%	47%	56%	64%	68%
		20	18%	42%	52%	60%	65%
		25	14%	39%	49%	58%	63%
HID		100	20%	43%	52%	59%	63%
		150	14%	38%	48%	56%	60%
		175	14%	38%	48%	56%	60%
		250	7%	33%	43%	52%	57%
		400	7%	33%	43%	52%	57%

Externality

Analysis result on Externality

Scenario 1; Electric rate is 100 (Korean won / kwh) for all periods

Year	Saved Electricity (Gwh)	By LED Light Product		By Nanotechnology	
		Future Value	Present Value	Future Value	Present Value
2011	860.0	78.2	78.2	50.3	50.3
2012	2746.0	249.6	237.3	160.8	152.8
2013	7328.2	666.2	602.0	429.0	387.7
2014	10506.5	955.1	820.4	615.1	528.3
2015	13945.7	1267.8	1035.1	816.5	666.6
2016	17323.3	1574.8	1222.2	1014.2	787.1
2017	20554.3	1868.6	1378.5	1203.4	887.8
2018	23549.9	2140.9	1501.4	1378.7	966.9
2019	26180.6	2380.1	1586.6	1532.8	1021.8
2020	28439.1	2585.4	1638.3	1665.0	1055.0
Total	151433.6	13766.7	10099.9	8865.7	6504.3

Exchange Rate=1100won/$ unit : million $

- Contribution of nanotechnology on LED light products = 64.4%
- annual inflation rate = 3.4%
- Annual interest rate = 5.2%

Externality

Analysis result on Externality

Scenario 2; Electric rate increase on 2015 by 10%

(110 Korean won / kwh)

Year	Saved Electricity (Gwh)	By LED Light Product		By Nanotechnology	
		Future Value	Present Value	Future Value	Present Value
2011	860.0	78.2	78.2	50.3	50.3
2012	2746.0	249.6	237.3	160.8	152.8
2013	7328.2	666.2	602.0	429.0	387.7
2014	10506.5	955.1	820.4	615.1	528.3
2015	13945.7	1394.6	1138.6	898.1	733.3
2016	17323.3	1732.3	1344.5	1115.6	865.8
2017	20554.3	2055.4	1516.4	1323.7	976.5
2018	23549.9	2355.0	1651.5	1516.6	1063.6
2019	26180.6	2618.1	1745.2	1686.0	1123.9
2020	28439.1	2843.9	1802.1	1831.5	1160.5
Total	**151433.6**	**14948.4**	**10936.1**	**9626.8**	**7042.9**

Exchange Rate=1100won/$ unit : million $

- Contribution of nanotechnology on LED light products = 64.4%
- annual inflation rate = 3.4%
- Annual interest rate = 5.2%

V Concluding Remarks

Summary of case study

Summary Table

Nanotechnology Application	- material, device, light engine
Effect of Nanotechnology on product	- performance improvement (electric saving, extended product life) - price increase (value addition)
Market size of LED lights (Korea)	- 150 million$('11) → 1.9 billion$('20)
Market share of LED lights(Korea)	- 4%('11) → 22%('15) → 60%('20)
Price ratio* (LED / incumbent light)	- 2.5~130 ('11) → 1.4~72 ('15) → 1.2~65 ('20)
Producer's surplus (2011~2020)	- by LED substitution : 350 million$ - by LED substitution * Nanotechnology contribution ratio : 224million$
Externality (2011~2020)	- by LED substitution 10.1 billion$ - by LED substitution * Nanotechnology contribution ratio : 6.5 billion$
Carbon reduction (2011~2020)	- 68,145,112 tCO2 - 442,943,226 euro(6.5 euro/tCO2, price of Dec 11)
Other effect	- Industry growth : expansion of LED application (example of display product) - Advance of industry structure (general product →higher value-added product) - promotion of technology innovation

* Min~Max value by incumbent light source

Contributions and Limitations

- Analysis on potential economic surplus of new product based on nanotechnology
  - Producer's surplus relied on market data analysis.
  - Consideration on contribution ratio of nanotechnology for product is made.
  - Externality from electricity saving has shown remarkable value.
  - Policy implementation for development & application of nanotechnology is required in consideration of externality dominance over producer's surplus.
- Ambiguities in boundaries of nanotechnology.
  - Scope of nanotechnology in production of LED lights is a hurdle for analysis.
  - This results rely on the technology scope from TRM. Assumption of same weight among technologies is limitation of this analysis to be addressed.
  - Nanotechnology product is not defined. Contribution of nanotechnology is to be identified for specific product.
- Contributions as a case study
  - Necessity for definition & classification of nanotechnology is ascertained.
  - Accumulation of case studies is necessary for Definition & Classification of nano-technology and product and Contribution of nanotechnology in production.


Thank you