

**PERFORMANCE ANALYSIS ON ‘NEW GROWTH ENGINE ACTION
PLAN’ IN KOREA**

By

LEE, Dongwoo

THESIS

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

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Professor Jinsoo LEE, Supervisor



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ABSTRACT

PERFORMANCE ANALYSIS ON ‘NEW GROWTH ENGINE ACTION PLAN’ IN KOREA

By

Dong Woo Lee

While actively fostering new growth engine as the next generation technology all over the world, Korea government also has been striving for economic development by promoting new growth engine industries by carrying out public R&D support since 2009. This study conducts performance analysis on ‘New Growth Engine Action Plan’ by concentrating on new growth engine firms’ growth in quantitative and qualitative aspects. It uses average sales growth rate and average added value growth rate analysis on Korean firms in 30 new growth engine sectors. First, this study finds that the average sales growth rate in most new growth engine sectors keeps decreasing after the policy implementation while the average added value growth rate sharply increases in the short-term, but decreases soon with a large deviation in the intermediate-term. This pattern accords with Schumpeterian theory Mark I, which explains that firms are hard to generate healthy revenue during the process of innovating the new technologies. In addition, the policy effect is most effective when the new growth engine sectors are in the early 1st stages of technology introduction by fully absorbing the R&D support. ‘New Growth Engine Action Plan’ can be regarded as a successful policy since it has clearly supported in improving the firm’s innovation capacity in qualitative aspect despite of the short-term effect.

I. Introduction

1.1 Background

In response to rapidly changing domestic and global industry environments, the Korean government is discovering and fostering new growth engines that will lead to new job creations. Under the belief that it is difficult to leap into the top ranks of the advanced countries only with the existing main industries such as heavy chemical, machinery, and shipbuilding, policy initiatives to foster new growth engines has been steadily progressed. The development of the growth engine industry is not a policy trend in Korea alone, but other advanced countries also compete to develop strategic industries in order to overcome the prolonged economic recession and declining productive population after the global financial crisis.

In 2009, the Ministry of Knowledge Economy¹ developed 17 new growth engines in three industries, which are green technology industry, high-tech convergence industry, and high value-added service industry, and announced ‘New Growth Engine Action Plan’² for systematic industry promotion. In the middle of losing national industrial competitiveness, ‘New Growth Engine Action Plan’ was expected to restore the economic downturn after the 2008 financial crisis by presenting technical strategy guidance, detailed promotion plan, workforce development plan, and small and medium enterprise support measures. The action plan has significance in clearly defining the role of public and private sectors. The government concentrated in improving investment environment by encouraging high-risk source technology development, improving law system, and developing pilot projects. The

¹ The Ministry of Knowledge Economy is reorganized as the Ministry of Trade, Industry and Energy in 2013.

² ‘New growth engine action plan’ was participated by 11 governmental departments in characteristics of interagency, but mainly led by the Ministry of Knowledge Economy.

private sector focused on expanding technology and facility investment by commercializing technology and creating new employment.

In case of green technology industry field, creation of initial market through source technology development and pilot projects was proposed as a promotion strategy by considering that the industry is still in early stage. High-tech convergence industry field proceeded promotion strategy and pilot projects that take product, technology and market into consideration comprehensively. High value-added service industry field proposed improvement of law system for attracting private sector investment as the main promotion strategy. The Korean government invested about 24.5 billion dollar on 17 new growth engines in three fields for five years (‘09~’13). Among the budget, 14.1 billion dollar (58%) is weighted toward research and development (R&D).

Category		Green Technology Industry	High-Tech Convergence Industry	High Value-added Service Industry	Total
Number of Project		79	62	89	200
Budget (Billion Dollar)	R&D	3.7	8.8	1.6	14.1
	Non R&D	3.0	3.4	3.9	10.4
	Total	6.7	12.2	5.5	24.5

Table 1. Number of Project and Budget for New Growth Engine Industries (Source: The Ministry of Knowledge Economy, 2009)

Category	Green Technology Industry	High-Tech Convergence Industry	High Value Service Industry
Technical Strategy	Renewable Energy	Communications Convergence	Health Care
Guidance	Carbon Reduction	IT Convergence	Education
Workforce Development Plan	Water Treatment	Robot Application	Green Finance
	LED Application	New Material/Nano	Software
SME Support Measures	Green Transportation	Bio/Medical	MICE/Tour
	Green City	High Value Food	-

Table 2. 17 New Growth Engine Action Plan Classifications (Source: The Ministry of Knowledge Economy, 2009)

According to the Ministry of Knowledge Economy (2012), 432 billion dollars of production, 37 billion dollars of facility investment, and 56 billion dollars of export were achieved from 2009 to 2011. Moreover, it is announced that secondary battery in green technology industry occupied the world market, and LED in high-tech convergence industry rocketed to the second place in the world market with fivefold sales growth during the policy implementation period. However, most of the new growth engines were still in the early stage of industrialization, and the development of related industries such as facility and equipment was insufficient since the strategy focused on finished products during the period.

Moreover, the government concentrated on green technology and high-tech convergence industries rather than high-value added service industry during the implementation period. Although green technology industry is still in early growth phase, it is expected to become a strategic field with high growth potential in the mid-long term. In case of high-tech convergence industry, the market size and growth potential is recognized as the most promising, and the government invested about 50%(12.2 billion dollar) of the total budget.

1.2 Purpose of Study

The ultimate goal of ‘New Growth Engine Action Plan’ is identifying and fostering promising industries which can create a virtuous circle of industrial ecosystem through complete support. Accordingly, since the policy is centred on fostering the entire industry ecosystem unlike other national projects which focus on R&D investment, it is necessary to analyze the performance in the distinguished aspect, not only by the quantitative performance. On the other hand, exiting literature related to the development of growth engine industry is concentrated to the policy direction or proposal, and lack of post evaluation.

National assembly budget office(2010) evaluates R&D business performance in new growth engine sectors by analyzing SCI dissertations and patents increases, but does not deal with the overall growth of the industry and institutional framework of policy.

Jang(2012) analyzes the performance of 17 new growth engine sectors by comparing the increase or decrease in 5 specific parts, which are production, export, facility investment, private R&D investment, and employment, during the implementation period. Jang argues that new growth engine sectors such as LED application, green transportation, and IT convergence, which are related to the existing main industries, achieved high economic performance. However, the study is limited to only focusing on the general quantitative aspects and policy delivery system.

Jang(2014) estimates the funding effect toward new growth engine industries based on the survey, but fails to confirm a significant correlation between the funding and growth of the firms in the industry. However, the study finds out the phenomenon that new entrants' growth rate is lower as the market is more mature.

Since some sectors' production, investment and exports account for the largest portion of all 17 new growth engines, there is little risk to understand the actual performance and policy effect, only judging by the fragmentary quantitative achievements. In other words, the performance analysis on 'New Growth Engine Action Plan' should be focused on whether the domestic new growth engine industries are developing with potential to become a frontier in the promising markets rather than short-term economic results.

Therefore, in order to diagnose the original intent of the policy, which is promoting new growth engines that will lead the future Korean economy, this study aims to analyze the policy effect on 30 respective new growth engine fields³ in both quantitative and qualitative

³ The Ministry of Knowledge Economy selected total 62 new growth engine fields in 13 sectors by excluding 4 sectors, which are healthcare, education, green finance, and MICE/tour in 'New

aspects by utilizing the firm growth index from EUROSTAT-OECD Business Demography Statistics manual. The firm growth index is measured by sales and added value. The index is suitable for the policy performance analysis by measuring the efficiency how the firms make the best use of government support in the short-term.

Industry	Sector	Field	Industry	Sector	Field	
Green Technology	Renewable Energy	Solar Energy	High-Tech Convergence	Communications Convergence	Convergence Network	
		Fuel Cell			Wireless Communications	
		Waste Bio			DTV	
		IPTV				
	Carbon Reduction	Carbon Reduction		IT Convergence	Sensor Network	
	Water Treatment	Smart Waterworks			System Semiconductor	
		Replacement Water			Display	
		Water Environment				
	LED Application	LED Application		Robot Application	Life/Edu Robot	
	Green Transportation	Green Transportation			Cleaner Production	
	Green City	U-City			Safety/Medical Robot	
					New Materials /Nano	New Materials/Nano
					Bio/ Medical	Bio Medicine
		ITS				Bio Resources
	GIS		Advanced Medical Care			
	Eco-friendly House					
High Value Service	Software	Game		High Value Food	High Value Food	
		Contents/SW		-		

Table 3. 30 New Growth Engine Fields Categorization

Growth Engine Detailed Promotion Plan'(2009). This study performs analysis on readjusted 30 fields, which is available for the practical analysis.

II. Literature Review

2.1 Firm Growth Theory

Research on entry, growth and exit of firms is a key topic in economics, and it is mainly explained in industrial organization. The theory of growth dynamics of a firm is based on Viner's long-run cost function (Viner 1932, Lucas 1978). The U-shaped long-run cost function depends on the increase of the production scale, and average cost declines as fixed cost declines (economies of scale). Beyond the time of declining fixed cost, however, production increases proportionally as scale increases (constant returns to scale). When the size of a firm grows more, due to the increase in administrative costs such as communication cost and bureaucracy, average cost increases (diseconomies of scale). In the early stage of a firm's establishment, since the uncertainty of the cost function prediction and fluctuation in production is large, the growth in production is considered to increase the management efficiency, and firms tend to grow their business rapidly in the early stage (Jovanovic 1982). On the other hand, firms with low production size growth are likely to be eliminated soon. As a result of the combination of growth dynamics, a simulated inverse relationship is derived.

While the theory of growth dynamics of a firm focuses on the firm size and its costs, Schumpeterian theory is based on the relationship between the firm size and its technology capability. Schumpeter suggests that the larger the firm size, a firm is more easily able to fund in technology innovation in order to cope with the uncertainty in technology innovation, and he predicts the positive correlation between technology innovation and firm size (Schumpeter 1942). Mansfield (1962) expands the Schumpeterian theory by arguing that even a small sized firm can succeed in productivity and profitability improvements through active R&D. However, the greater the market's dominance, the less innovation effort will be made, and the business growth becomes slow. Schumpeterian theory becomes structuralized into two stages by the technological development stage. Schumpeter Mark 1 underlines

creative destruction which is led by the new entrants with the active technological innovation. New entrants which possess innovative capacity in the market break down conventional production, distribution and organization systems (Breschi and Malerba, 1997). Contrastively, Schumpeter Mark 2 emphasizes creative accumulation which is that existing giant firms in the market contribute in the high standard of living by providing new products and services more cheaply through continuous R&D (Malerba and Orsenigo, 1995).

2.2 Technology Innovation, R&D and Firm Growth

Firms' R&D endeavours are essential for technological innovation and growth (Romer, 1989). Stam and Wennberg (2009) argue that R&D effect on innovative start-ups is important specifically during the first 6 years of the firm's life course. The study explains that the initial R&D activity of high-tech firm increases levels of inter-firm alliances, contributes largely in exploiting the external knowledge, and encourages new product development in long term.

Griffith et al. (2004) maintains that there is strong a correlation between firm's productivity growth and R&D investment. Empirically using a panel of industries across OECD countries, the study finds out that R&D is economically crucial for technological innovation which leads to the productivity growth. Wieser (2001) argues that firm's R&D activity and productivity growth have a significantly positive relationship with the statistical evidences, but rate of return to R&D remains stationary around at 12% unlike expectation. Griliches (1979), and Coe and Helpman (1995) also support the idea that R&D invest is one of significant factors in productivity development by finding out that R&D capital stocks affect largely on increase in total factor productivity(TFP), which estimates the efficiency and growth in productivity.

On the other hand, Winters and Stam (2007) find no evidence for whether R&D innovation of young and small firms has a positive effect on firm's value creation, estimated by sales growth. Freel and Robson (2004) even argue that there is a negative relationship between firm's R&D activity and growth in productivity or sales although product innovation and employment growth have positive relationship to each other. Accordingly, direct influence on firm's growth by enhancing R&D activity is still on debate and not clear yet. (Davidsson et al. 2007)

Westhead and Storey (1997) state that innovative small firms with highly sophisticated technologies are more likely to show low-growth or even experience early exit from the market than less technologically sophisticated firms due to constrained finance. Goodacre and Tonks (1995) also argue that investors are reluctant to finance on highly sophisticated technology firms due to lack of evidences and difficulty in making decision whether the technology can make profits in the market in the future. Bloom and Van Reenen (2002) maintain that firm in the high-tech market with uncertainty experience the lag between innovation and its transformation to commercialization, and investors tend to hesitate in financing the high-tech frontiers. Thus, external financing for highly innovative firms is strongly recommended in order to keep a firm to strive for the advanced technology and to survive in the market simultaneously (Storey and Tether, 1998).

2.3 R&D Policy Effect

Becker (2015) argues that a government supporting in R&D investment is critical for increasing private R&D investment by providing a funding at the time of scarce resources in the early stage of a firm. According to Feldman and Kelley (2006), government R&D subsidized firms are more likely to receive funds from other sources such as ventures and universities, and grab more opportunities in participating into the joint research. Other forms

of public policies such as tax credits and providing high-skilled human capital also stimulate private R&D. Minniti and Venturini (2014, 2017) find out that labour productivity growth rate increases by 0.4% per year when R&D tax credit for US manufacturing industries increases by 10%, and tax credit is a significant R&D policy tool in long term. However, they argue that other R&D policy tools like R&D subsidy have only temporary effects on the business growth. According to Reinkowski et al. (2010), firms which receive R&D subsidy from government shows 3.7% higher R&D intensity than non-subsidized firms, and the subsidy effect is more significant to small and medium sized enterprises (SMEs) with more patent applications.

Czarnitzki and Delanote (2015) also argue that the effect of government R&D subsidy is maximized when independent high-tech young firms are subsidized with more patent production outputs, so that R&D subsidy policy should selectively target on SMEs with high technology capacity. Grilli and Murtinu (2012) maintain that providing selective R&D subsidies on new technology based firms outperforms other types of R&D policy by evaluating and comparing the firm performances when government implements selective or automatic subsidies on technology based or general firms. Wakelin (2001) supports the above argument by finding out that the rate of return to R&D is much higher for innovative firms than non-innovative firms in UK manufacturing firms by utilizing Cobb-Douglas production function in growth rate form. Wanzenbock et al (2013) also argues the importance of the selective R&D policy, but the study finds out that R&D subsidy has more positive influence on technologically specialized firms with less R&D experience rather than a firm with high R&D resources. However, indiscreet selective R&D policy may fall into the pitfall of crowding effect, and small firms in low technology sectors are likely to lose opportunities for government subsidy although the firms have promising idea (Gonzalez and Pazo, 2008).

2.4 Firm Growth Indicators: Sales Growth and Added Value Growth

Sales growth of a firm through innovation play is considered as the most important factor for firm's growth since it accounts for expanding the market share quantitatively. On the contrary, added value is the source of a firm's wages and profits, and it is generated only when the investment exceeds the capital cost with excess earning rate. A firm with high added value is recognized as a robust firm which is able to hold a dominant position in long term amid the consistent competition. Therefore, a firm's added value growth can be considered as a qualitative indicator for the firm growth.

Coad and Rao (2008) study the influence of R&D activity on the sales growth of US manufacturing firms. They argue that strong innovation activity has a positive impact on sales growth, but only applicable to the fast-growing incumbent firms. Geroski and Machin (1992) argue that firms with active innovation experience sharp increase in sales growth, but the effect is short-lived. They also find that R&D activity influences more on profit margin growth rather than sales growth. Other studies also highlight innovation's significantly positive effect on sales growth by using various methods such as OLS regression model and survey data (Geroski and Toker, 1996 and Roper, 1997). However, some studies fail to find strong linkage between sales growth and R&D innovation. Bottazzi et al. (2001) find no significant relationship between innovation and sales growth at the worldwide pharmaceutical sector.

Utilizing VAIC(Value Added Intellectual Coefficient)⁴ method which measures a firm's value added efficiency according to Pulic (2000), Chen et al. (2005) argue that increase in R&D expenditure has a positive effect on creation of added value, which becomes the standard of the firm's future financial performance. Tsang et al. (2008) also find out that

⁴ VAIC = CEE (Capital Employed Efficiency) + HCE (Human Capital Efficiency) + SCE (Structural Capital Efficiency)

the impact of R&D on added value of Singapore firms in newly industrialized economy is significantly positive, but firms owned by foreign firms are more highly influenced compared to the pure domestic firms. The study argues that R&D effect on added value is different by type of R&D, technological level of firms and firm's ownership structure.

There have been many efforts to evaluate 'New Growth Engine Action Plan' with various research methods. However, most previous performance evaluation researches have limitations in generally focusing on the short-term quantitative outcomes after the policy implementation. The study tries to have significance in meeting the true policy objective, promoting new promising industries with sufficient capacity in the global market, by comparing the performances before and after the policy implementation in both quantitative and qualitative aspects.

Title	Author	Year	Research Method
Performance Analysis in The Future Engine Growth	National Assembly Budget Office	2010	Analyzing the number of SCI dissertations and the number of patents
Evaluation on New Growth Engine Industry	KIET	2010	Evaluating statistical indicators and expert opinions
Performance and Development Direction of New Growth Engine Policy in the Aspect of Industrial Field	Jang	2012	Analyzing production, export, facility, R&D and employment
Expansion of Korean New Growth Engine Firms	National IT Industry Promotion Agency	2012	Conducting survey on person interested and experts
An Evaluation of Korea's Policy for Creating Growth Engines and its Future Developmental Challenges	Jang	2014	Conducting survey on person interested and experts

Table 4. Previous Researches on 'New Growth Engine Action Plan'

III. Research Method

3.1 Data

This study analyzes 31 brands which belong to 13 sectors. The data is derived from the Korea Enterprise Data Base by keyword extraction. Through filtering the redundant and extraneous firms in the fields, about 1,800 firms in new growth engine industry are derived. Then, the study excludes the firms which have non-continuous financial data by missing and also the firms which make entry or exit to the market in the middle of the study period (2007 to 2014)⁵ in order to analyze the efficiency about the policy continuity. Accordingly, the study analyzes the total number of 1,145 firms.

The details about the number of firms are shown in the table below, and the range is variant by the fields from the maximum number of 211 firms (Fuel Cell) to the minimum number of 9 firms (Life/Edu Robot).

Field	Numbers	Field	Numbers	Field	Numbers
Solar Energy	126	ITS	13	Life/Edu Robot	9
Fuel Cell	204	GIS	33	Cleaner Production	13
Waste Bio	39	Eco-friendly House	23	Safety/Medical Robot	11
Carbon Reduction	24	Convergence Network	16	New Materials/Nano	26
Smart Waterworks	17	Wireless	37	Bio Medicine	72
Replacement Water	19	DTV	23	Bio Resources	14
Water Environment	28	IPTV	14	Advanced Medical Care	20
LED Application	107	Sensor Network	19	High Value Food	39
Green Transportation	49	Semiconductor	32	Game	16
U-City	10	Display	21	Contents/SW	71

Table 5. Number of Firms Analyzed in Each Field

⁵ The study period is limited from 2007 to 2014 in order to compare the pre & poster policy effect by setting the policy implementation year, 2009, as a reference year.

3.2 Method

In this study, the firm growth index from EUROSTAT-OECD Business Demography Statistics manual is utilized. The manual is expanded from Mapping Firm Growth around the World, which is the OECD's EIP sub-project. The project is jointly conducted by NESTA (National Endowment for Science, Technology and the Arts) from UK and FORA research institute from Denmark.

EUROSTAT-OECD Business Demography Statistics is generally utilized in analyzing the performance of high growth firms. Krosiakova et al. (2015) analyze dynamics of gazelle enterprise in Czech Republic is analyzed by using two criteria, employment and turnover growth rate, and finds out that gazelle firms in service sector overwhelms those in manufacturing sector during 2006-2011. Sarmiento et al. (2014) also describe enterprise dynamics for high growth firms in Portugal for the period, 1990-2007, and argue that gazelle firms in service and commerce sectors are growing faster than those in manufacturing and construction sectors. Yoon Y. H. (2010) analyzes the sub-sectors in mining and manufacturing industries in Korea during 2002-2006 by utilizing three criteria which are sales, employment and added value, and argues that high growth firm ratio is higher as the size of employment is less.

The firm growth index is measured by sales and added value. Sales growth is an important criterion that judges whether a firm makes quantitative performance clearly. If the sales growth rate is high, a firm is very likely to succeed in the long run. Supergrowers, which have sales growth rate of more than 60% at the time of exceeding 100 million dollars in sales, are eight times more likely to exceed one billion dollar in revenue than firms with sales growth rate below 20% at the same time.⁶ On the other hand, added value growth is a

⁶ McKinsey&Company (2014). *Grow Fast or Die Slow*

significant pointer which indicates a firm's qualitative performance by being utilized in estimating production efficiency.⁷

When measuring annual average growth in sales and added value, it is not necessary to measure changes in every consecutive year. The base year 't' goes toward the past period. For example, it measures from t-3 to t in order to measure growth for three years. The average growth rates for sales and added value are as follows.

$$\text{Firm } j\text{'s average sales growth} = \sqrt{\frac{\text{sales}_{j,t}}{\text{sales}_{j,t-i}}} - 1, \quad i = 3,5$$

$$\text{Firm } j\text{'s average added value growth} = \sqrt{\frac{\text{added value}_{j,t}}{\text{added value}_{j,t-i}}} - 1, \quad i = 3,5$$

In addition, as shown in Table 5, growth of the firms is measured by using 3 growth segments in this study. The first segment, which is from 2006 to 2009, measures the growth of the pre- policy implementation. The second segment, which is from 2009 to 2012, measures the short-term effect of the policy. The third segment, which is from 2009 to 2014, measures the intermediate-term effect of the policy. Through dividing the study period into the 3 segments by setting 2009, 'New Growth Engine Action Plan' implementation year, as the base year, the study facilitates in comparing the policy effect before and after the implementation, and also how long the effect is maintained.

Segment	1 st	2 nd	3 rd
Year / i	2006-2009 / 3	2009-2012 / 3	2009-2014 / 5
Characteristic	It measures the growth of the firms in new growth engine fields before the policy implementation.	It assesses the short-term effect of the policy by measuring the firm growth for 3 years.	It assesses the intermediate-term effect of the policy by measuring the firm growth for 5 years.

Table 6. 3 Segments within the Study Period (2007-2014)

⁷ Labor Productivity = Added Value / Number of Employees, and Capital Productivity = Added Value / Total Capital

Accordingly, the growth calculation method of this study is as follows.

- i) Calculate the sales growth rate and added value growth rate of each firm in the belonging fields by the 3 segments
- ii) Calculate the average of the firms' sales growth rate and added value growth rate in the belong fields to estimate the sales growth rate and added value growth rate of the fields by the 3 segments.
- iii) Analyze the trend of the growth rate variation of each field, and figure out the overall performance in the belonging sector.

IV. Results

Utilizing EUROSTAT-OECD Business Demography Statistics, the study calculates each 30 sectors' average sales growth rate and average added value growth rate for 3 segments ('06~'09, '09~'12 and '09~'14).

The study examines the trend of sales and added value growth rates on the basis of the policy implementation, and finds out any particular points for the new growth engine sectors. In addition, the study tries to search the common trends according to the new growth engine sectors' technology levels.

Technology Level	Green Technology	High-Tech Convergence	High Value Service
Industrialization 3 rd Stage	Solar Energy ITS	Wireless Communications DTV IPTV System Semiconductor Display Bio Medicines	-
Industrialization 2 nd Stage	Fuel Cell Waste Bio Green Transportation	Sensor Network Cleaner Production Robot Advanced Medical Care High Value Food	Game
Industrialization 1 st Stage	Carbon Reduction Eco-friendly House	Bio Resources	Contents/SW
Technology Introduction 2 nd Stage	Smart Waterworks Replacement Water Water Environment U-City	Convergence Network New Mateirals/Nano	-
Technology Introduction 1 st Stage	LED Application GIS	Life/Edu Robot Safety/Medical Robot	-

Table 7. Evaluation on New Growth Engine Sector Technology Level (Jang, 2014, edited by the author)

4.1 Sector Result Analysis

1) Solar Energy

Average sales growth rate in solar energy keeps decreasing after the policy implementation. The 2nd segment, which is 3 years after the policy implementation, decreased by 6.82% and the 3rd segment, which is 5 years after the policy implementation, decreased by 11.02% compared to the average sales growth rate in the 1st segment.

On the other hand, average added value growth rate increases by 5.44% in the 2nd segment, but decreases by 3.29% in the 3rd segment compared to the average added value growth rate in the 1st segment.

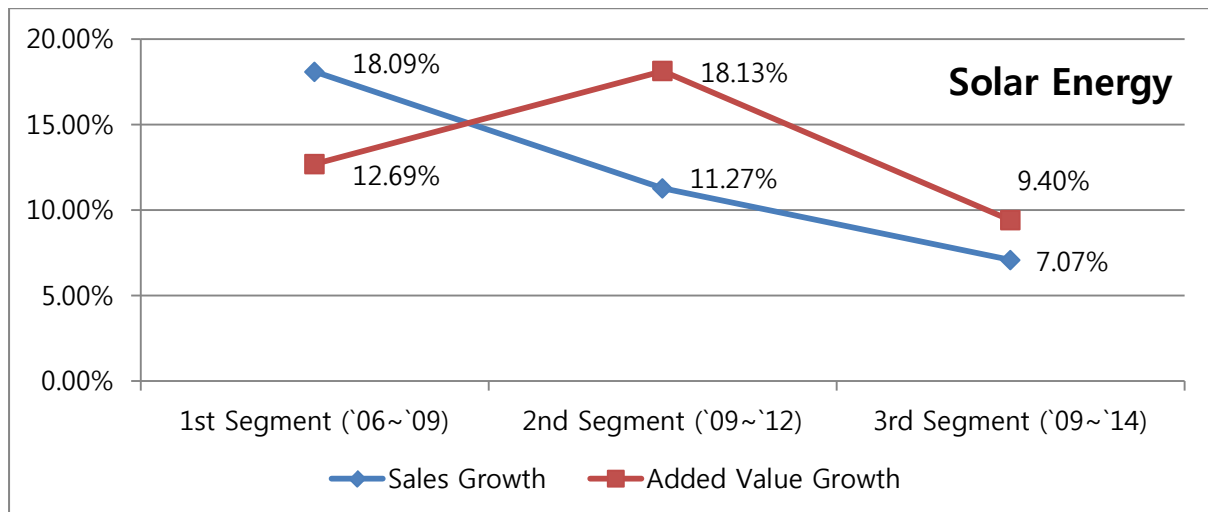


Figure 1. Solar Energy : Sales Growth Rate and Added Value Growth Rate

Solar Energy (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	18.09	11.27	7.07
Added Value Growth Rate	12.69	18.13	9.40

Table 8. Solar Energy : Sales Growth Rate and Added Value Growth Rate

Although the quantitative performance decreased after the policy implementation, the sector's performance in the qualitative aspect increases right after the policy implantation with sharply increased added value growth rate. However, the positive effect on the added

value growth rate only continues by the short-term, and turned back to the 9.40% in the 3rd segment. It indicates that policy effect on solar energy sector was temporary and only effective during the first 3 years.

2) Fuel Cell

Average sales growth rate in fuel cell keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreased by 10.53% and decreased by 16.54% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate slightly increases by 2.15% in the 2nd segment, but sharply decreases by 9.8% in the 3rd segment compared to the 1st segment.

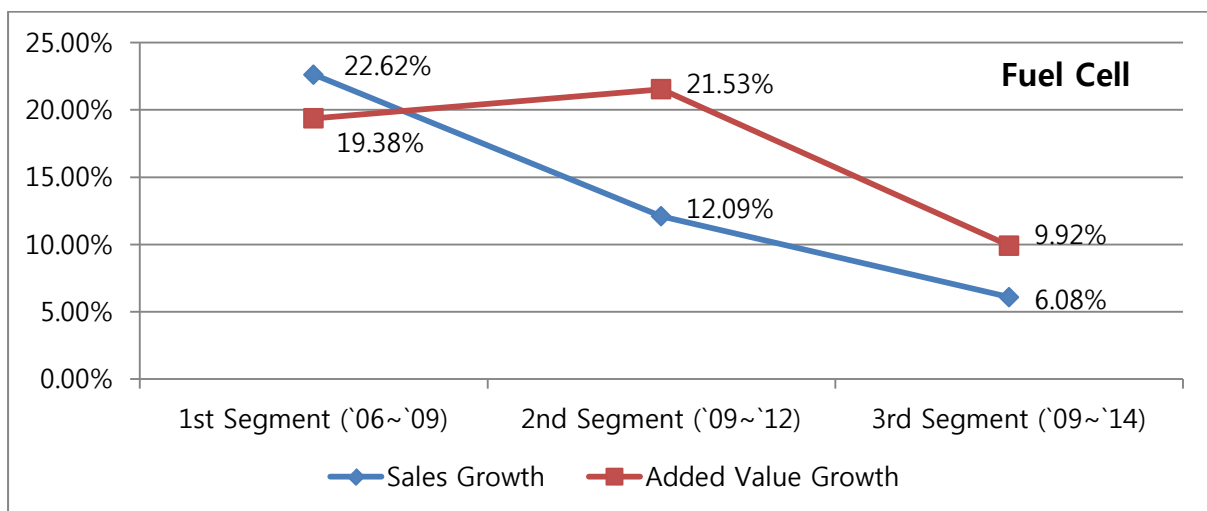


Figure 2. Fuel Cell : Sales Growth Rate and Added Value Growth Rate

Fuel Cell (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	22.62	12.09	6.08
Added Value Growth Rate	19.38	21.53	9.92

Table 9. Fuel Cell : Sales Growth Rate and Added Value Growth Rate

The policy impact on fuel cell sector is considered somewhat unsatisfactory since the performance on both the quantitative and qualitative aspects drops largely by the 3rd segment

despite of slight increase in average added value growth rate in the 2nd segment. It indicates that fuel cell sector did not receive a beneficiary effect by the policy implementation since the sector already possesses the first rank in the global market share.

3) Waste Bio

Average sales growth rate in waste bio drastically decreases after the policy implementation. The average sales growth rate in the 2nd segment decreases by 10.11% and also decreases by 16.14% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate suddenly increases by 8.68% in the 2nd segment, but decreases by 7.27% again in the 3rd segment compared to the 1st segment.

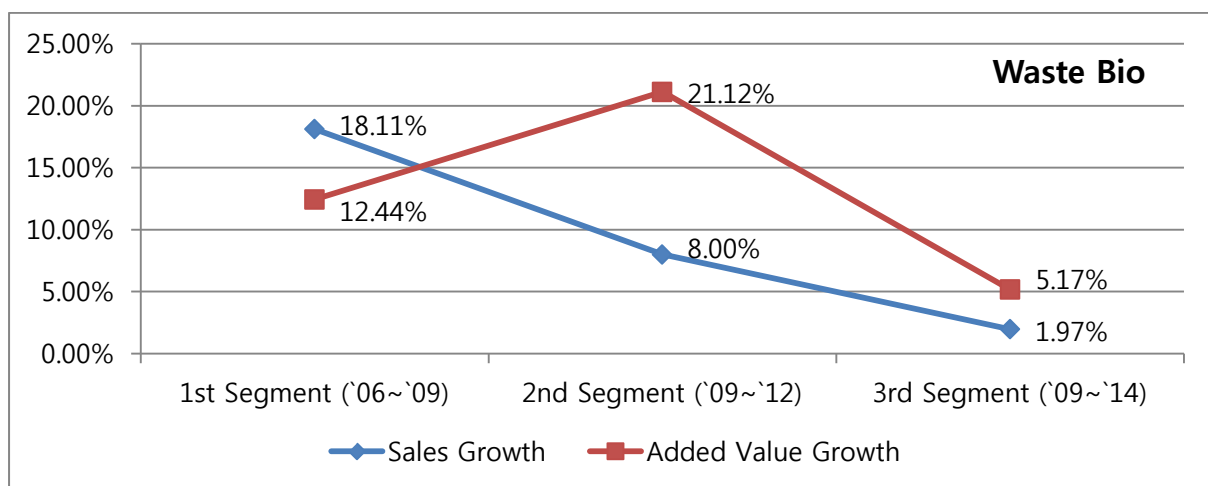


Figure 3. Waste Bio : Sales Growth Rate and Added Value Growth Rate

Waste Bio (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	18.11	8.00	1.97
Added Value Growth Rate	12.44	21.12	5.17

Table 10. Waste Bio : Sales Growth Rate and Added Value Growth Rate

The policy impact on waste bio sector was only effect in the short-term. The added value growth rate peaked to 21.12% until the 2nd segment, but sharply dropped to 5.17%, and

even the sales growth rate barely recorded the positive in the 3rd segment. Therefore, the policy is considered to fail in promoting waste bio sector in the long-term.

4) Carbon Reduction

Average sales growth rate in carbon reduction increases slightly in the 2nd segment, but decreases by 8.88% in the 3rd segment compared to the 1st segment.

On the other hand, average added value growth rate sharply increases by 37.56% in the 2nd segment and also increases by 10.09% again in the 3rd segment compared to the 1st segment.

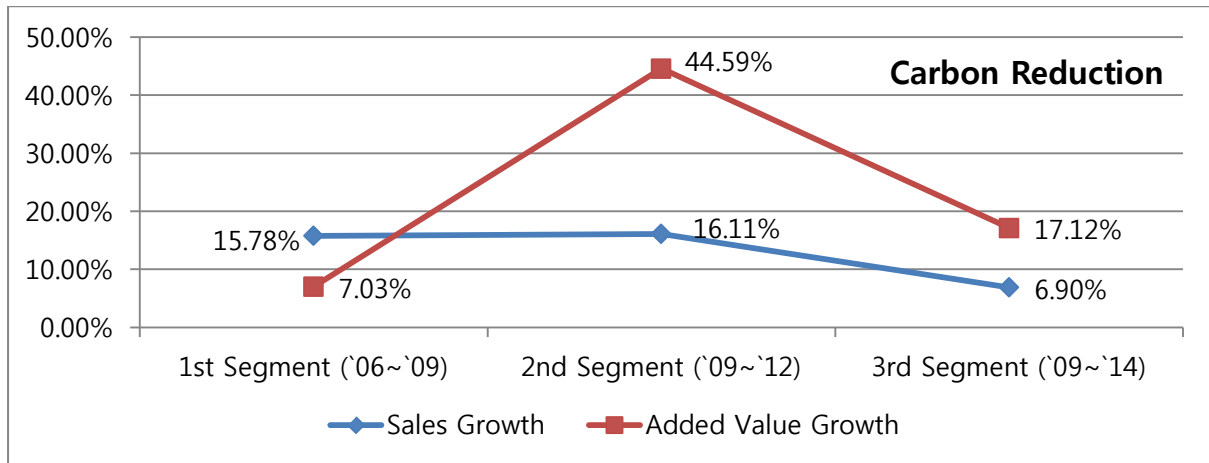


Figure 4. Carbon Reduction : Sales Growth Rate and Added Value Growth Rate

Carbon Reduction (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	15.78	16.11	6.90
Added Value Growth Rate	7.03	44.59	17.12

Table 11. Carbon Reduction : Sales Growth Rate and Added Value Growth Rate

The policy effect on carbon reduction sector is considered successful with largely increased added value growth rate. Moreover, the effect is continuous until the 3rd segment by recording high added value growth rate of 17.12%. Decrease in sales growth rate can be explained as a transitional phenomenon in positive way.

5) Smart Waterworks

Average sales growth rate in smart waterworks keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreases by 10.32% and also decreases by 14.04% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate slightly increases by 3.86% in the 2nd segment, but soon decreases by 7.6% in the 3rd segment compared to the 1st segment.

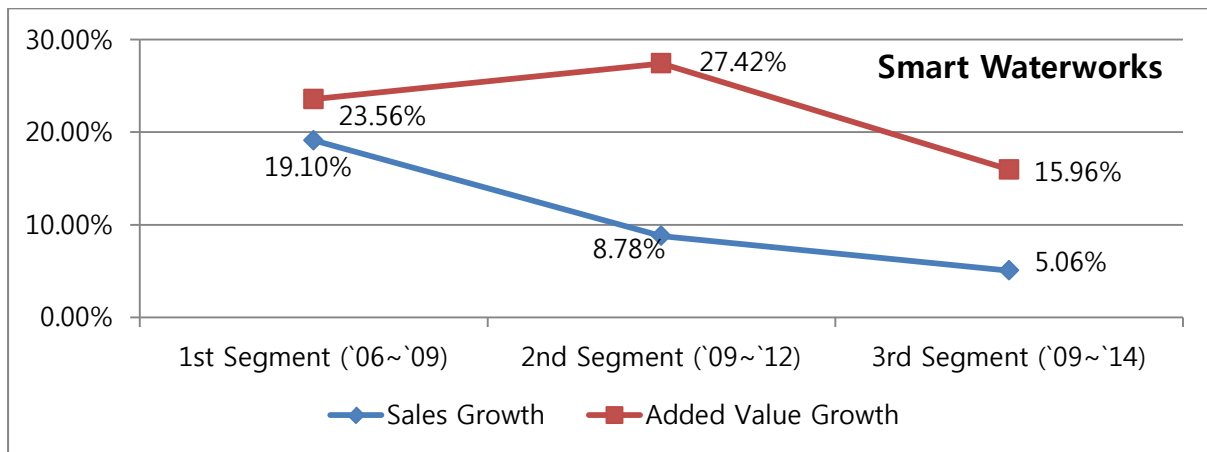


Figure 5. Smart Waterworks : Sales Growth Rate and Added Value Growth Rate

Smart Waterworks (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	19.10	8.78	5.06
Added Value Growth Rate	23.56	27.42	15.96

Table 12. Smart Waterworks : Sales Growth Rate and Added Value Growth Rate

Although the quantitative performance decreased after the policy implementation, the sector's performance in the qualitative aspect increased after the policy implantation, but the positive effect on the added value growth rate only continued by the short-term. However, the points that high added value growth rate of 15.96% and little decrease in sales growth rate in the 3rd segment are considered somewhat positive, and the sector has a possibility in growing continuously in long-term.

6) Replacement Water

Both the average sales growth rate and average added value growth rate in replacement water sector decreases sharply after the policy implementation. The average added value growth rate in the 3rd segment even transforms to the negative value.

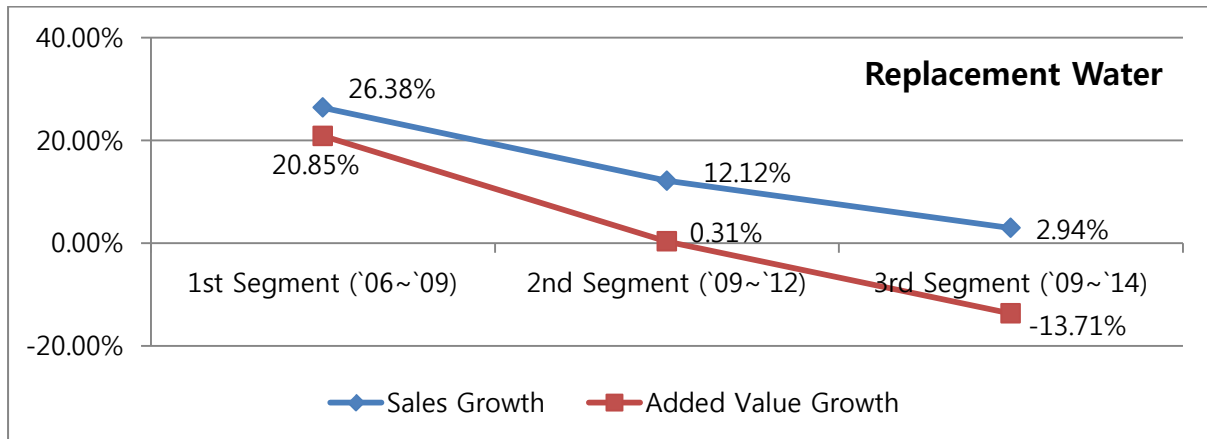


Figure 6. Replacement Water : Sales Growth Rate and Added Value Growth Rate

Replacement Water (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	26.38	12.12	2.94
Added Value Growth Rate	20.85	0.31	-13.71

Table 13. Replacement Water : Sales Growth Rate and Added Value Growth Rate

While the sales growth rate and added value growth rate before the policy implementation are high over 20%, the sector experiences a terrible decline after the policy implementation. The biggest problem is that average added value growth rate turns to the negative value in the 3rd segment by recording -13.71%. It indicates that the policy completely failed to support or revive replacement water sector, regarded as a twilight sector.

7) Water Environment

Both the average sales growth rate and average added value growth rate in water environment sector also decreased after the policy implementation. The average sales growth

rate in the 2nd segment sharply declines by 16.87% and the average added value growth rate in the 3rd segment decreases by 9.86% in the 3rd segment compared to the 1st segment.

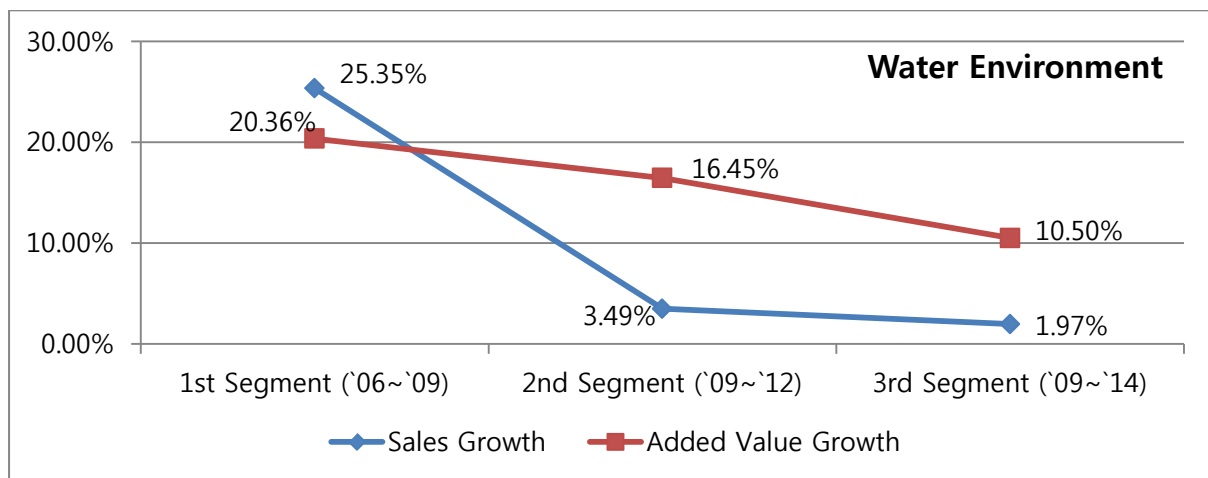


Figure 7. Water Environment : Sales Growth Rate and Added Value Growth Rate

Water Environment (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	25.35	3.49	1.97
Added Value Growth Rate	20.36	16.45	10.50

Table 14. Water Environment : Sales Growth Rate and Added Value Growth Rate

Like replacement water sector, while the sales growth rate and added value growth rate before the policy implementation are over 20%, the sector's sales growth rate sharply decreases after the policy implementation. The policy is considered to fail in supporting water environment sector, which is also can be seen as a twilight sector.

8) LED Application

Average sales growth rate in LED application sector keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreases by 6.18% and also decreases by 11.24% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate increases by 6.57% in the 2nd segment, and also slightly increases by 1.83% in the 3rd segment compared to the 1st segment.

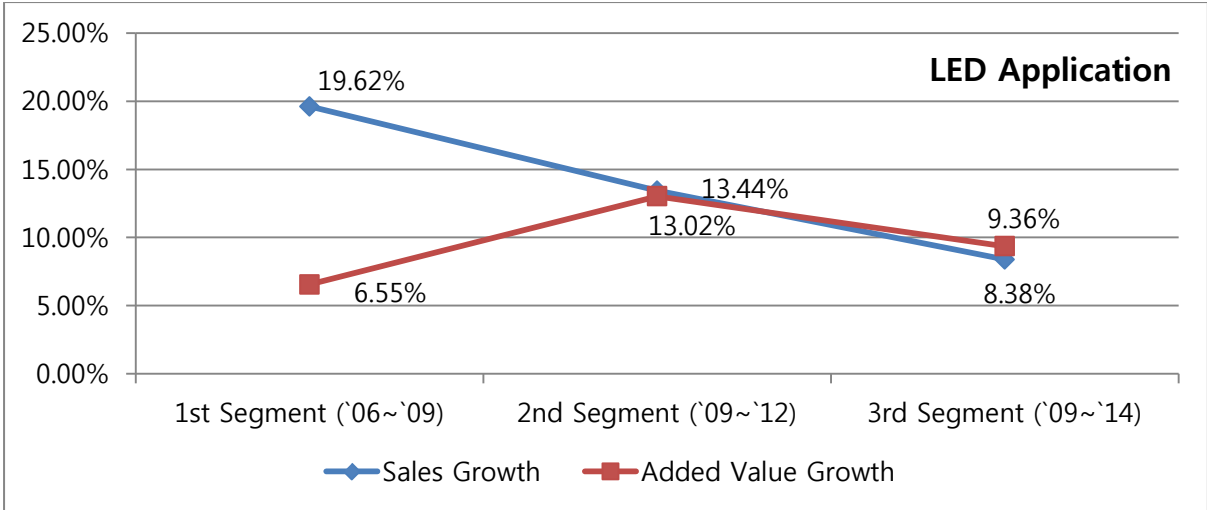


Figure 8. LED Application : Sales Growth Rate and Added Value Growth Rate

LED Application (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	19.62	13.44	8.38
Added Value Growth Rate	6.55	13.02	9.36

Table 15. LED Application : Sales Growth Rate and Added Value Growth Rate

Although the quantitative performance decreased after the policy implementation, the sector's performance in the qualitative aspect increased after the policy implantation. If the sector overcomes the transition phase wisely by enhancing more in the quantitative aspect by expanding R&D, the sector may develop to the promising sector. It indicates that policy effect is positive in LED application sector with increased added value growth rate.

9) Green Transportation

Average sales growth rate in green transportation sector keeps decreasing after the policy implementation. The average sales growth rate in the 3rd segment decreases by 8.4% when compared to the 1st segment.

On the other hand, average added value growth rate sharply increases by 12.31% in the 2nd segment, but decreases by 5.62% in the 3rd segment when compared to the 1st segment.

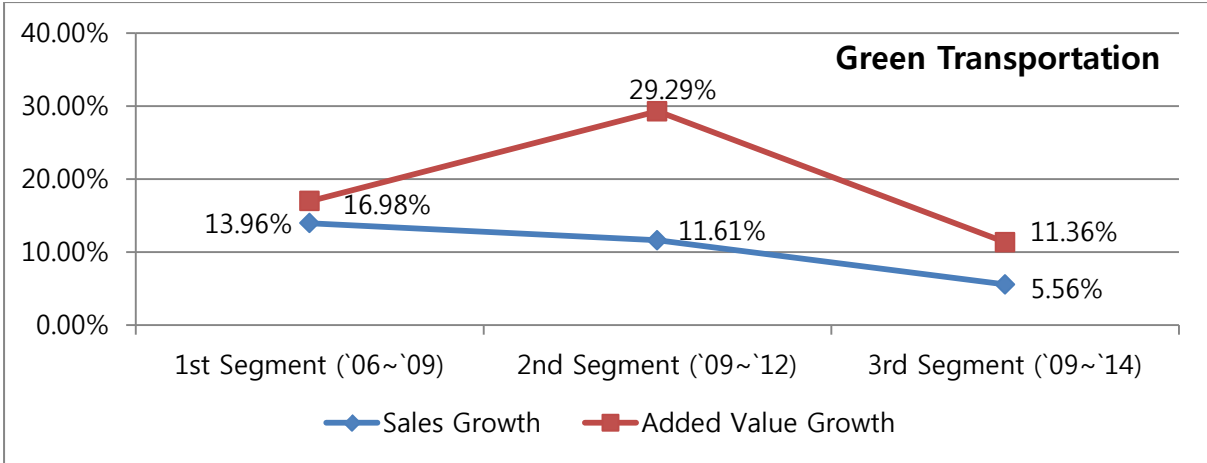


Figure 9. Green Transportation : Sales Growth Rate and Added Value Growth Rate

Green Transportation (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	13.96	11.61	5.56
Added Value Growth Rate	16.98	29.29	11.36

Table 16. Green Transportation : Sales Growth Rate and Added Value Growth Rate

Although the quantitative performance decreased after the policy implementation, the sector’s performance in the qualitative aspect increased largely right after the policy implantation. However, the positive effect on the added value growth rate only continued by the short-term since the added value growth rate turned back to 11.36% in the 3rd segment. It indicates that positive policy effect on green transportation sector was temporary, but the sector is still promising with high added value growth rate.

10) U-City

Both the average sales growth rate and average added value growth rate in U-City sector decreases sharply after the policy implementation. Both growth rates barely maintain positive values of 0.15% and 0.23% in the 3rd segment.

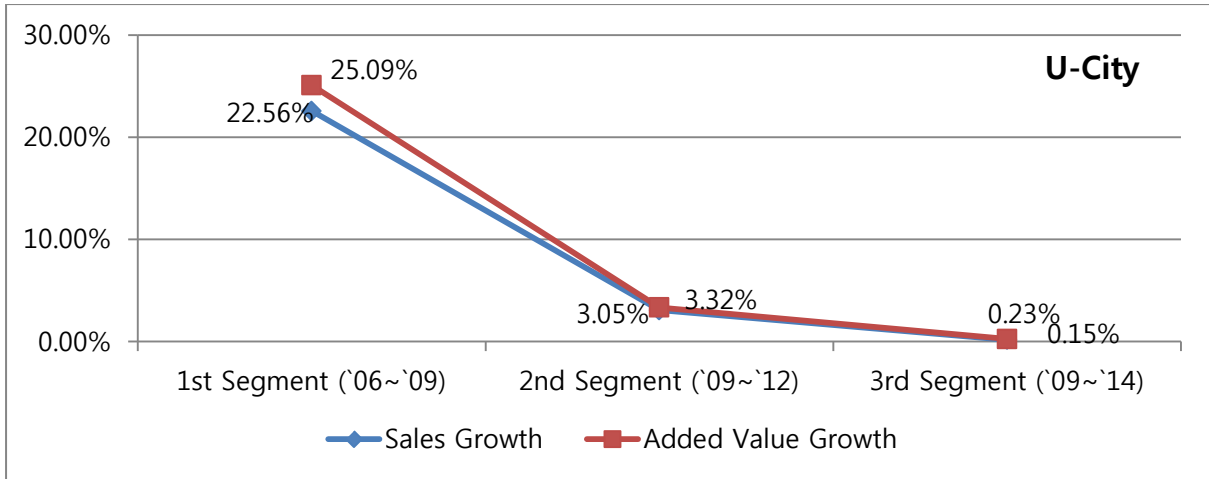


Figure 10. U-City : Sales Growth Rate and Added Value Growth Rate

U-City (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	22.56	3.05	0.15
Added Value Growth Rate	25.09	3.32	0.23

Table 17. U-City : Sales Growth Rate and Added Value Growth Rate

While the sales growth rate and added value growth rate before the policy implementation exceeds over 20%, the sector experiences a terrible decline right after the policy implementation by approaching to nearly 0%. It indicates that the policy completely failed to support or revive U-City sector, considered as a declining sector.

11) ITS

Average sales growth rate in ITS sector slightly decreases after the policy implementation. The average sales growth rate in the 2nd segment decreases by 2.74% and also decreases by 5.83% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate increases by 4.49% in the 2nd segment, and also slightly increases by 1.97% in the 3rd segment compared to the 1st segment.

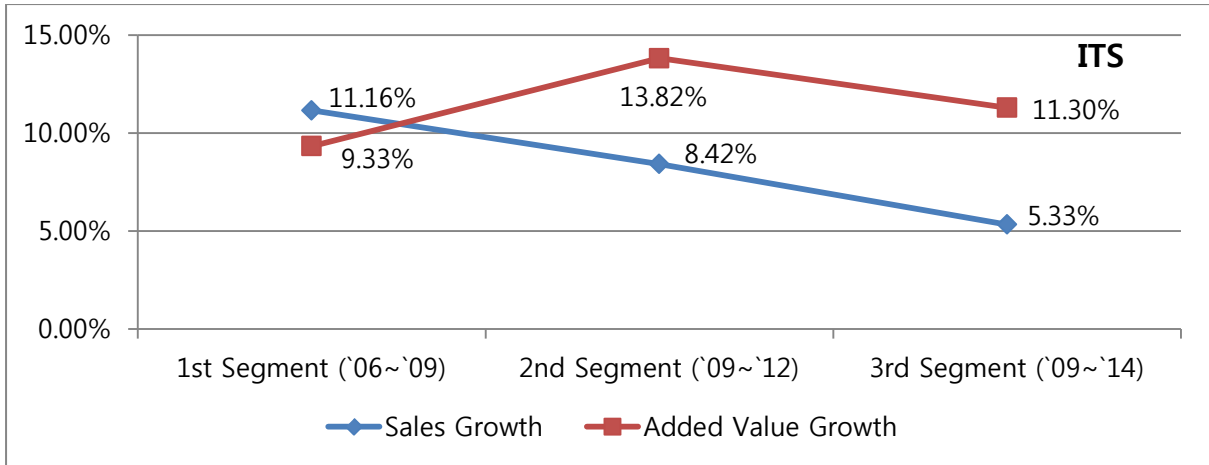


Figure 11. ITS : Sales Growth Rate and Added Value Growth Rate

ITS (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	11.16	8.42	5.33
Added Value Growth Rate	9.33	13.82	11.30

Table 18. ITS : Sales Growth Rate and Added Value Growth Rate

Although the quantitative performance decreased after the policy implementation, the sector's performance in the qualitative aspect increased after the policy implantation. It indicates that policy is successful in supporting ITS sector with continuous increased added value growth rate.

12) GIS

Average sales growth rate in ITS sector keeps decreasing after the policy implementation. The average sales growth rate in the 3rd segment decreases by 15.82% when compared to the 1st segment.

On the other hand, average added value growth rate increases by 11.7% in the 2nd segment, but decreases by 19.02% in the 3rd segment compared to the 1st segment.

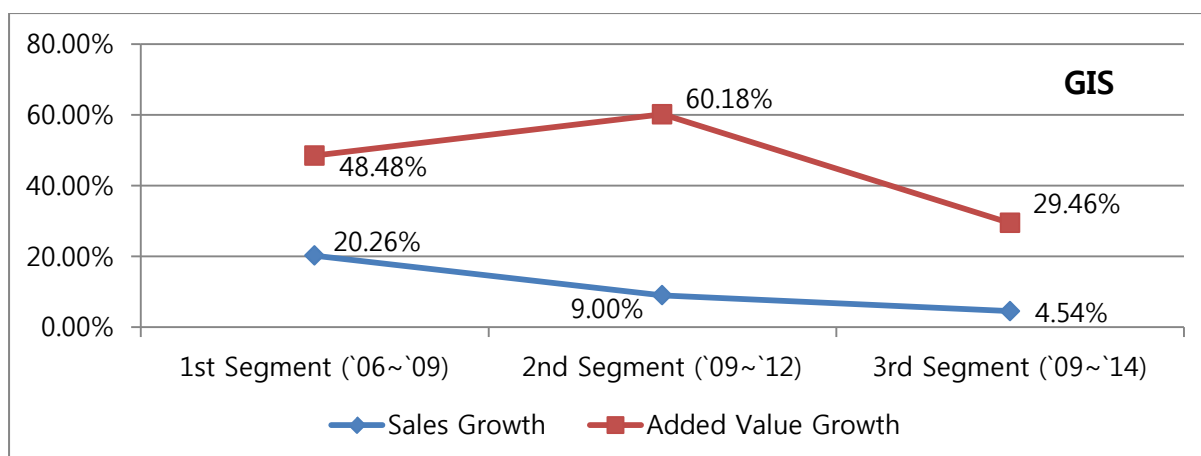


Figure 12. GIS : Sales Growth Rate and Added Value Growth Rate

GIS (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	20.26	9.00	4.54
Added Value Growth Rate	48.48	60.18	29.46

Table 19. GIS : Sales Growth Rate and Added Value Growth Rate

GIS sector has a characteristic of very high added value growth rate. Although the quantitative performance decreased after the policy implementation, the sector's performance in added value growth rate increased to 60.18% in the 2nd segment and still maintains the high growth rate of 29.46% by the 3rd segment. It indicates that policy effect on GIS sector is somewhat positive, and the sector can be classified as a promising sector.

13) Eco-friendly House

Average sales growth rate in eco-friendly house sector keeps decreasing after the policy implementation. The average sales growth rate in the 3rd segment decreases by 5.36% when compared to the 1st segment.

On the other hand, average added value growth rate increases largely by 17.3% in the 2nd segment, and also by 7.82% in the 3rd segment compared to the 1st segment.

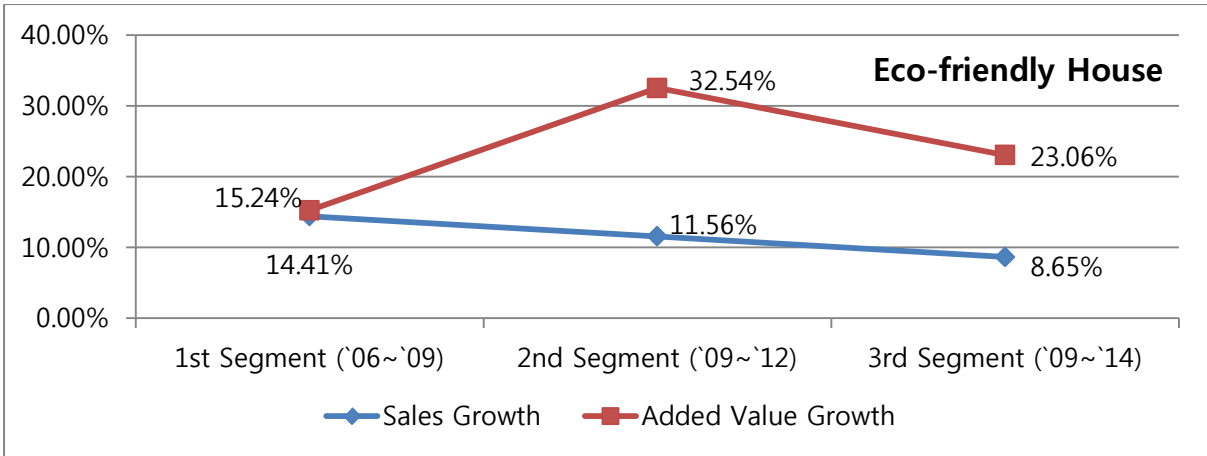


Figure 13. Eco-friendly House : Sales Growth Rate and Added Value Growth Rate

Eco-friendly House (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	14.41	11.56	8.65
Added Value Growth Rate	15.24	32.54	23.06

Table 20. Eco-friendly House : Sales Growth Rate and Added Value Growth Rate

Although the sales growth rate slightly decreased after the policy implementation, the added value growth rate sharply increased in the 2nd segment and also kept high growth rate of 23.06% by the 3rd segment. It indicates that policy impact on eco-friendly house sector is successful by supporting well in the qualitative aspect.

14) Convergence Network

Average sales growth rate in convergence network sector slightly decreases after the policy implementation. The average sales growth rate in the 3rd segment decreases by 4.1% when compared to the 1st segment.

On the other hand, average added value growth rate increases by 3.82% in the 2nd segment, but goes back to around 14% again in the 3rd segment.

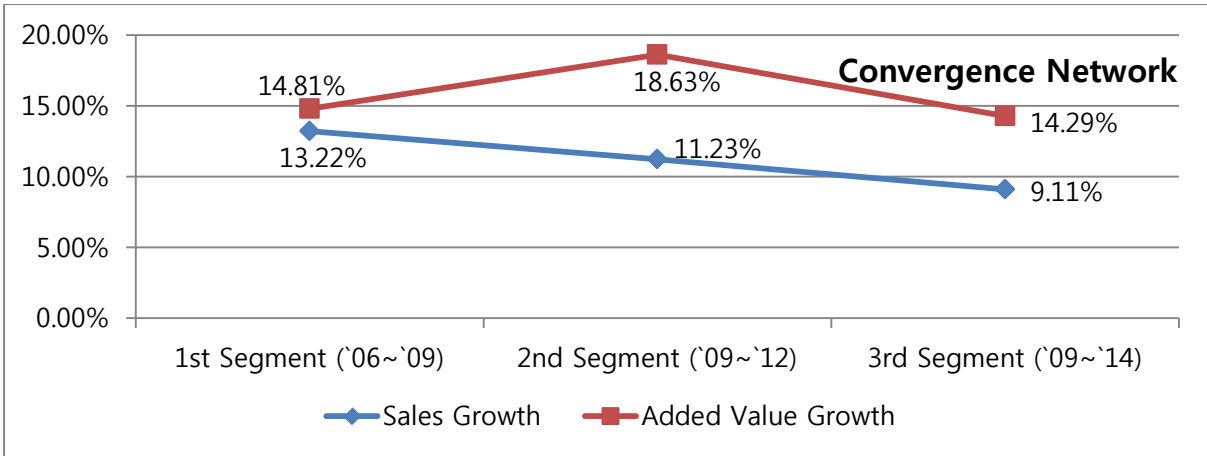


Figure 14. Convergence Network : Sales Growth Rate and Added Value Growth Rate

Convergence Network (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	13.22	11.23	9.11
Added Value Growth Rate	14.81	18.63	14.29

Table 21. Convergence Network : Sales Growth Rate and Added Value Growth Rate

The growth rates of convergence network segment shows stability compared to other sectors since sales growth rate decreases in only small amount and added value growth rate gap also does not deviate from only 4%. It indicates that policy impact is steady, and makes a synergy effect with the stable market.

15) Wireless Communications

Average sales growth rate in wireless communications sector keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreases by 3.36% and also decreases by 10.24% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate tremendously increases by 20.61% in the 2nd segment, and also increases by 6.56% in the 3rd segment compared to the 1st segment.

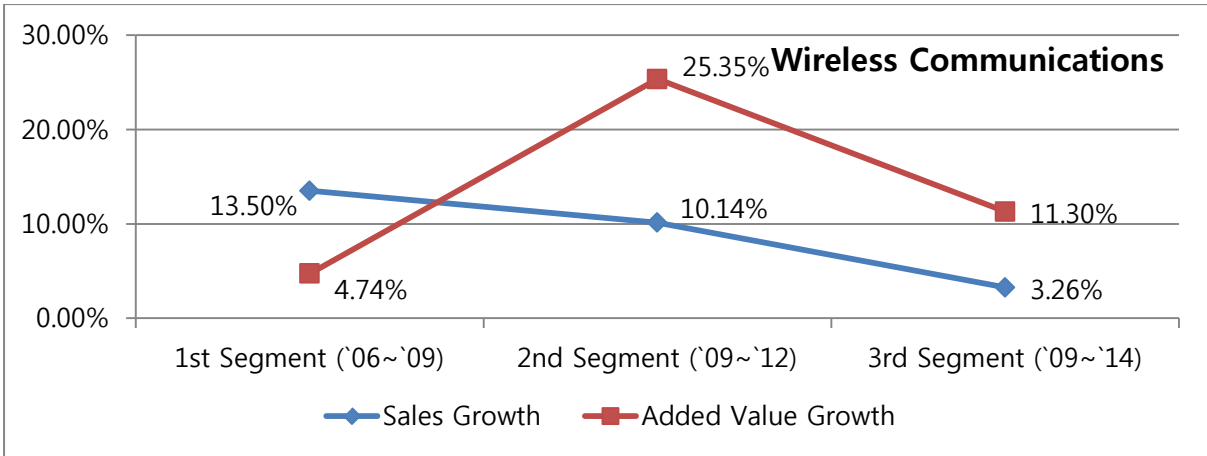


Figure 15. Wireless Communications : Sales Growth Rate and Added Value Growth Rate

Wireless Communications(%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	13.50	10.14	3.26
Added Value Growth Rate	4.74	25.35	11.30

Table 22. Wireless Communications : Sales Growth Rate and Added Value Growth Rate

Although the sales growth rate decreased quite much after the policy implementation, the sector's performance in the added value growth rate highly increased after the policy implantation. Especially, the sector achieves in 20.61% increase in added value growth rate during the first 3 years from the policy implementation. It indicates that policy is particularly successful in supporting wireless communications sector in qualitative aspect, and the sector may be considered as the most promising sector afterward.

16) DTV

Average sales growth rate in DTV sector keeps decreasing after the policy implementation. The average sales growth rate in the 3rd segment decreases by 8.91% when compared to the 1st segment. On the other hand, average added value growth rate slightly increases by 3.67% in the 2nd segment, but soon decrease by 1.38% in the 3rd segment compared to the 1st segment.

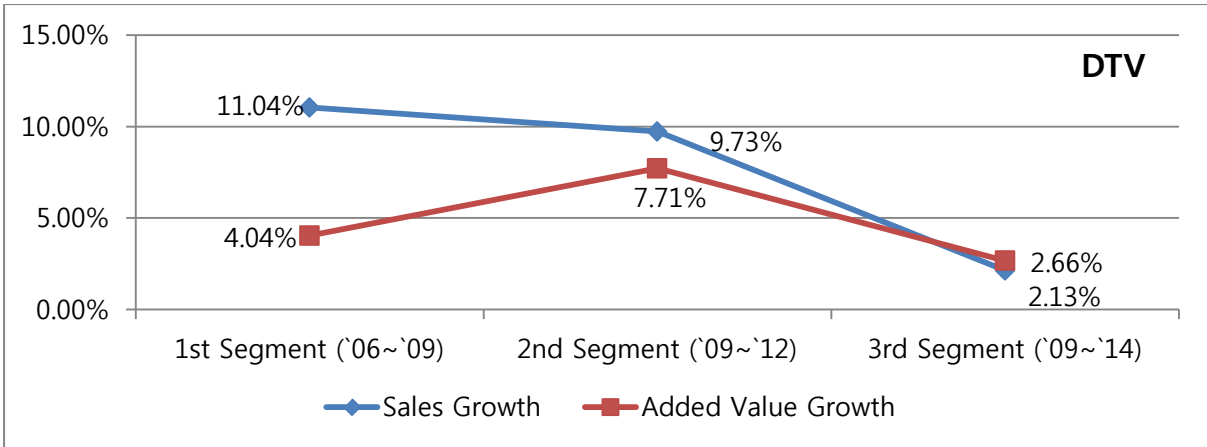


Figure 16. DTV : Sales Growth Rate and Added Value Growth Rate

DTV (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	11.04	9.73	2.13
Added Value Growth Rate	4.04	7.71	2.66

Table 23. DTV : Sales Growth Rate and Added Value Growth Rate

Both the sales growth rate and added value growth rate in the 3rd segment ends around at 2%. Furthermore, the differential of the rates before and after the policy implementation is small. It indicates that there was no significant policy effect at DTV sector in both the quantitative and qualitative ways.

17) IPTV

Average sales growth rate in wireless communications sector keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreases by 9.46% and also decreases by 6.85% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate tremendously increases by 23.05% in the 2nd segment, but soon decreases by 1.88% in the 3rd segment compared to the 1st segment.

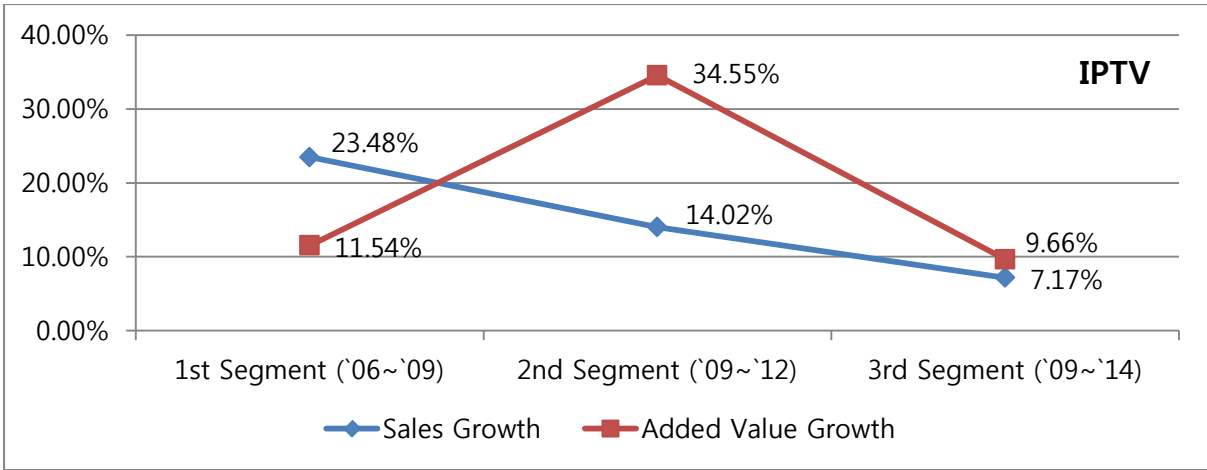


Figure 17. IPTV : Sales Growth Rate and Added Value Growth Rate

IPTV (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	23.48	14.02	7.17
Added Value Growth Rate	11.54	34.55	9.66

Table 24. IPTV : Sales Growth Rate and Added Value Growth Rate

Although the sales growth rate decreased much after the policy implementation, the sector's performance in the added value growth rate highly increased temporarily after the policy implantation. Especially, the sector achieves in 23.05% increase in the added value growth rate during the first 3 years from the policy implementation. However, the outstanding effect only lasts in the short-term and the growth rate largely drops in case of the 3rd segment. It indicates that the policy impact was only twilight in IPTV sector.

18) Sensor Network

Average sales growth rate in sensor network sector keeps decreasing after the policy implementation. The average sales growth rate in the 3rd segment decreases by 5.6% when compared to the 1st segment. On the other hand, average added value growth rate slightly increases by 3.64% in the 2nd segment, but largely drops by 12.79% in the 3rd segment compared to the 1st segment

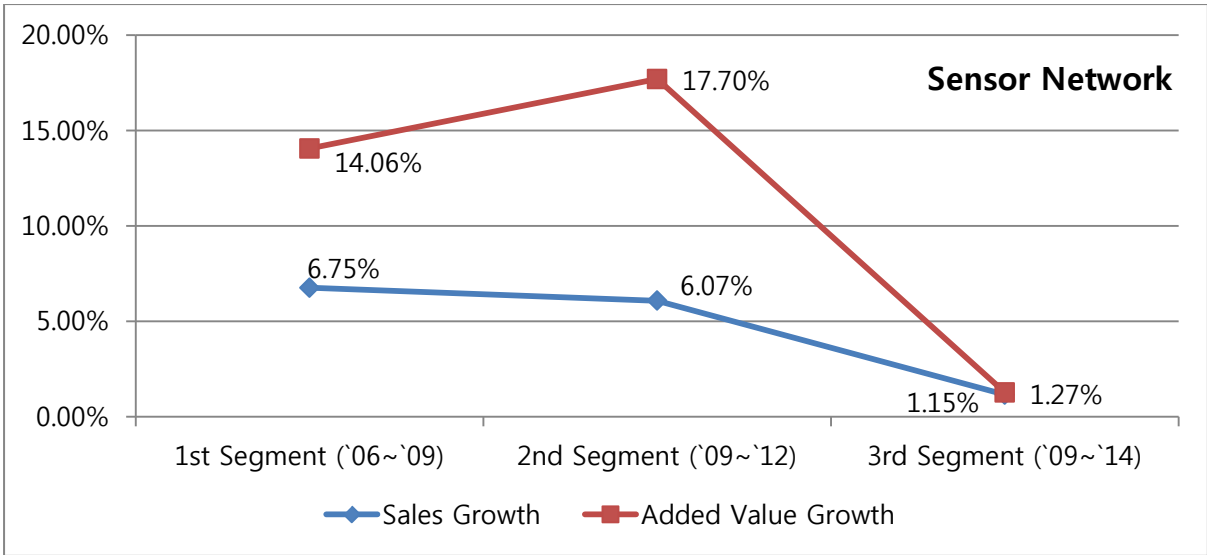


Figure 18. Sensor Network : Sales Growth Rate and Added Value Growth Rate

Sensor Network (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	6.75	6.07	1.15
Added Value Growth Rate	14.06	17.70	1.27

Table 25. Sensor Network : Sales Growth Rate and Added Value Growth Rate

Both the sales growth rate and added value growth rate in the 3rd segment ends around at 1%. Although the added value growth rate slightly increased in the 2nd segment, it plunges to the bottom in the 3rd segment. It indicates that the policy effect was short-lived and even may have a negative effect on the sector in both the quantitative and qualitative ways.

19) System Semiconductor

Average sales growth rate in system semiconductor sector slightly increases after the policy implementation. The average sales growth rate in the 2nd segment increases by 4.52% and increases little by 0.61% in the 3rd segment when compared to the 1st segment.

Average added value growth rate also keeps increasing after the policy implementation. It increases by 1.51% in the 2nd segment, and also increases by 7.24% in the 3rd segment compared to the 1st segment

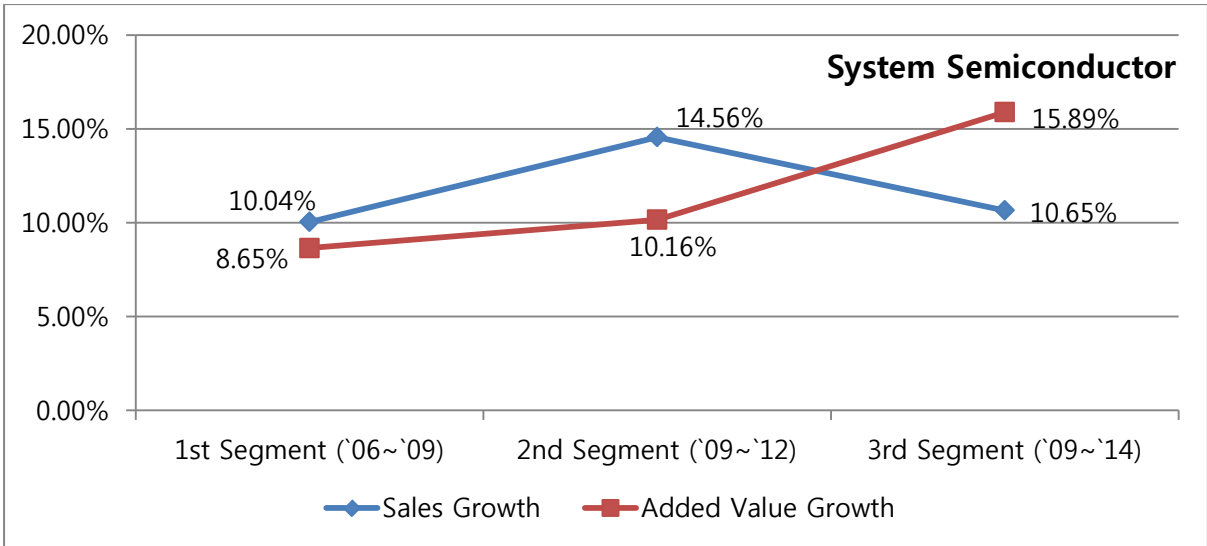


Figure 19. System Semiconductor : Sales Growth Rate and Added Value Growth Rate

System Semiconductor (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	10.04	14.56	10.65
Added Value Growth Rate	8.65	10.16	15.89

Table 26. System Semiconductor : Sales Growth Rate and Added Value Growth Rate

System semiconductor sector has a characteristic in that both the average sales growth rate and average added value growth rate increased after the policy implementation. It indicates that the policy was perfectly suitable in system semiconductor sector by promoting the performances in both quantitative and qualitative ways.

20) Display

Average sales growth rate in system semiconductor sector slightly decreases after the policy implementation. The average sales growth rate in the 2nd segment decreases by 5.97% when compared to the 1st segment.

Average added value growth rate also keeps decreasing after the policy implementation. It decreases by 6.8% in the 3rd segment compared to the 1st segment

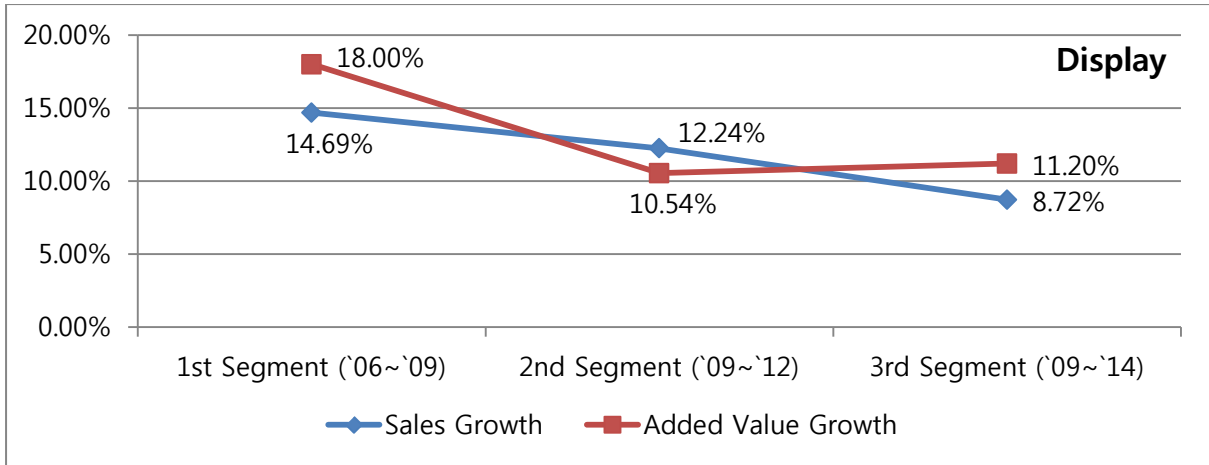


Figure 20. Display : Sales Growth Rate and Added Value Growth Rate

Display (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	14.69	12.24	8.72
Added Value Growth Rate	18.00	10.54	11.20

Table 27. Display : Sales Growth Rate and Added Value Growth Rate

Display sector has a characteristic in that both the average sales growth rate and average added value growth rate decreased after the policy implementation. It indicates that the policy failed to make any significant effect on display sector, which already leads the global market with outstanding competitiveness.

21) Life/Edu Robot

Average sales growth rate in life/edu robot sector keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment slightly decreases by 2.53% and also decreases by 8.57% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate sharply increases by 24.34% in the 2nd segment, but soon decreases by 1.47% in the 3rd segment compared to the 1st segment.

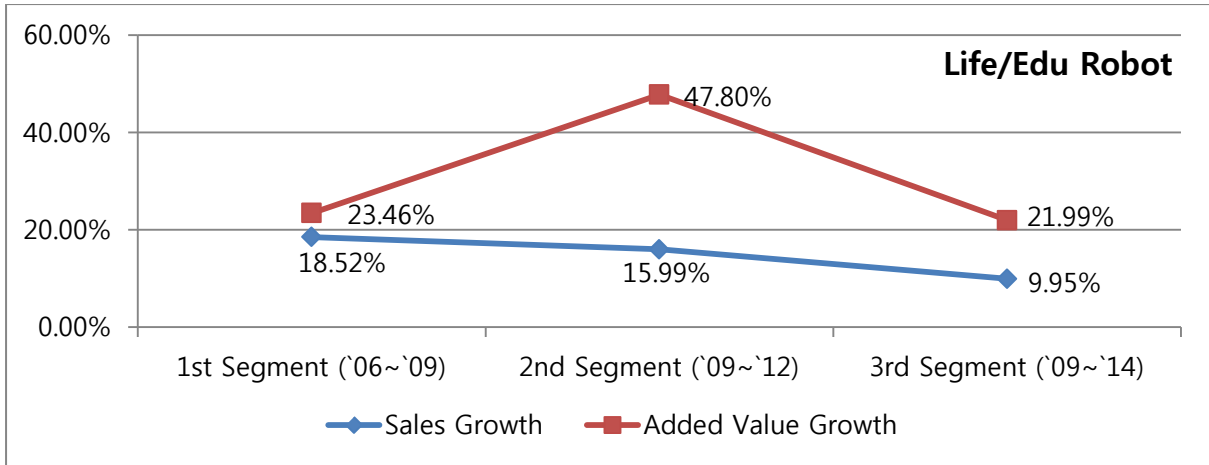


Figure 21. Life/Edu Robot : Sales Growth Rate and Added Value Growth Rate

Display (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	18.52	15.99	9.95
Added Value Growth Rate	23.46	47.80	21.99

Table 28. Life/Edu Robot : Sales Growth Rate and Added Value Growth Rate

Although the sales growth rate decreased much after the policy implementation, the sector's performance in the added value growth rate highly increased temporarily after the policy implantation. Especially, the sector achieves in 24.34% increase in the added value growth rate during the first 3 years from the policy implementation. Despite of slight decrease in added value growth rate in the 3rd segment, since it still records high rate of 21.99%, the policy effect is considered as successful in qualitative aspect.

22) Cleaner Production Robot

Average sales growth rate in cleaner production robot sector largely increases in the 2nd segment by 16.69% and also increases by 1.91% in the 3rd segment when compared to the 1st segment.

Average added value growth rate follows the same pattern. It sharply increases by 13.09% in the 2nd segment, but soon decreases by 0.52% in the 3rd segment compared to the 1st segment.

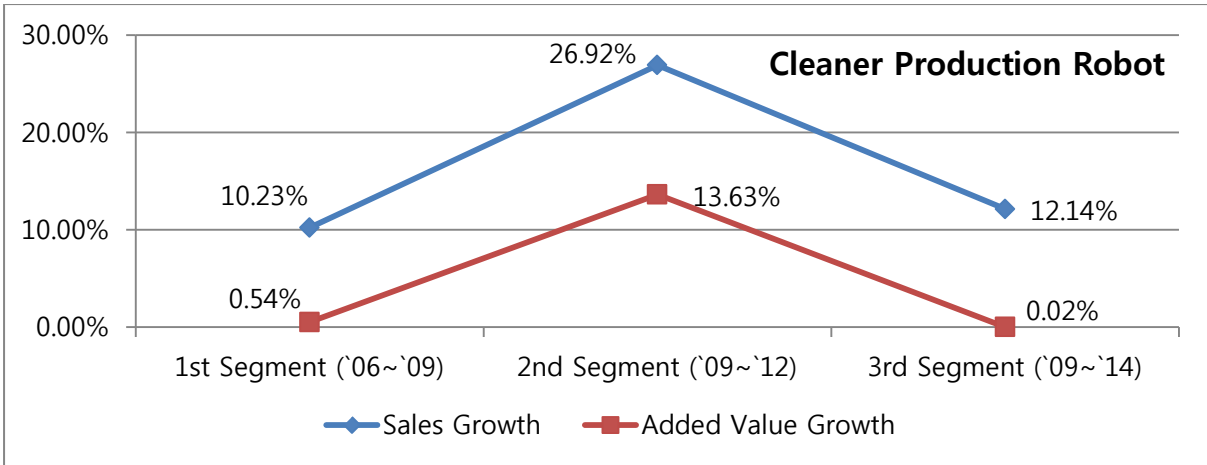


Figure 22. Cleaner Production Robot : Sales Growth Rate and Added Value Growth Rate

Cleaner Production Robot (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	18.52	15.99	9.95
Added Value Growth Rate	23.46	47.80	21.99

Table 29. Cleaner Production Robot : Sales Growth Rate and Added Value Growth Rate

Cleaner production robot sector has a characteristic in that sales growth rate and added value growth rate have a common trend. Both rates increase sharply in the first 3 years from the policy implementation, but the effect do not last until the 3rd segment with large decline again. The pattern indicates that the policy somewhat achieved in quantitative way with increasing sales, but fails to have steady effect in the qualitative aspect.

23) Safety/Medical Robot

Average sales growth rate in cleaner production robot sector largely increases in the 2nd segment by 30.27% and also increases by 11.6% in the 3rd segment when compared to the 1st segment.

Average added value growth rate follows the same pattern. It sharply increases by 46.54% in the 2nd segment, but soon decreases by 17.82% in the 3rd segment compared to the 1st segment.

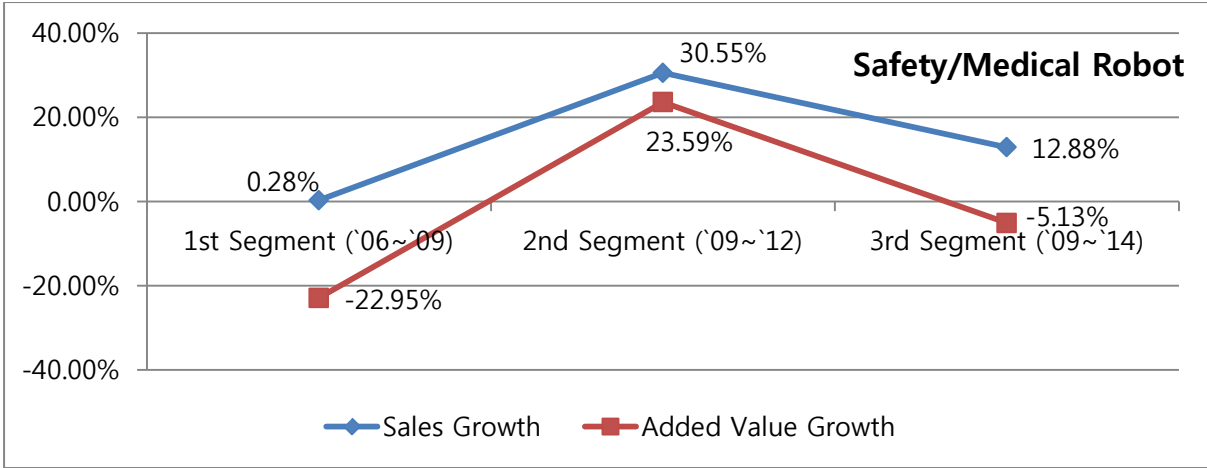


Figure 23. Safety/Medical Robot : Sales Growth Rate and Added Value Growth Rate

Safety/Medical Robot (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	18.52	15.99	9.95
Added Value Growth Rate	23.46	47.80	21.99

Table 30. Safety/Medical Robot : Sales Growth Rate and Added Value Growth Rate

Safety/Medical robot sector has a characteristic in that sales growth rate and added value growth rate have a common trend like cleaner production robot sector. Both rates increase sharply in the first 3 years from the policy implementation, and maintain the large positive effect until the 5 years after the policy implementation. It indicates that the policy was quite suitable for safety/medical robot sector by achieving its ultimate goal which is developing the next generation promising sector in both quantitative and qualitative aspects.

24) New Materials/Nano

Average sales growth rate in new materials/nano sector keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreases by 7.99% and also decreases by 13.03% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate increases by 6.47% in the 2nd segment, but soon decreases by 2.33% in the 3rd segment compared to the 1st segment.

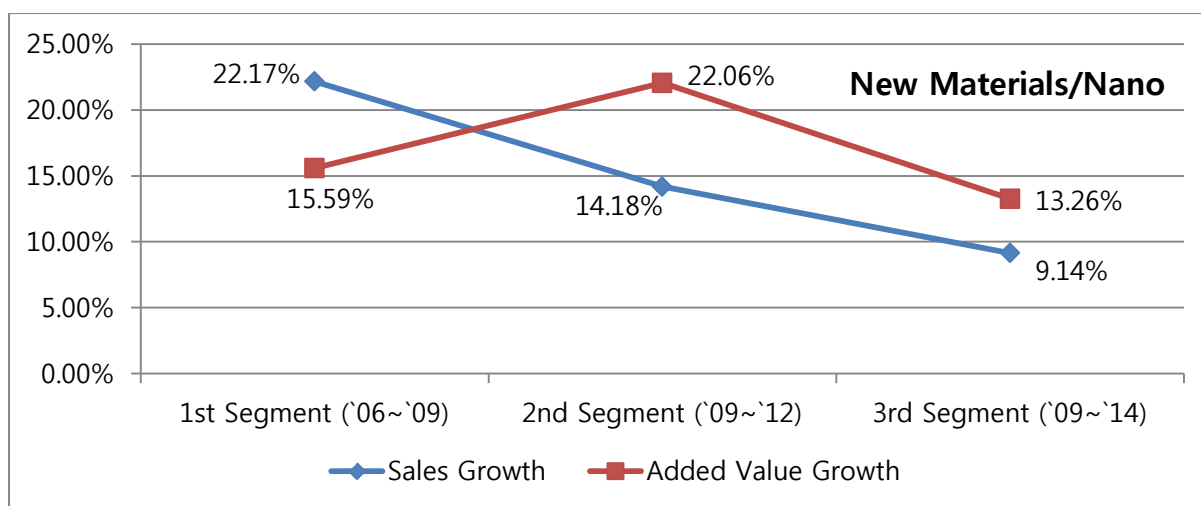


Figure 24. New Materials/Nano : Sales Growth Rate and Added Value Growth Rate

New Materials/Nano (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	22.17	14.18	9.14
Added Value Growth Rate	15.59	22.06	13.26

Table 31. New Materials/Nano : Sales Growth Rate and Added Value Growth Rate

Although the sales growth rate decreased much after the policy implementation, the sector's performance in the added value growth rate increases temporarily after the policy implantation. The added value growth rate decreases in the 3rd segment, but since it still maintains high growth rate over 10%, it is considered that new materials/nano sector received a positive effect from the policy implementation.

25) Bio Medicines

Average sales growth rate in new materials/nano sector keeps decreasing after the policy implementation. The average sales growth rate in the 3rd segment decreases by 10.51% when compared to the 1st segment.

On the other hand, average added value growth rate increases by 4.53% in the 2nd segment, but soon decreases by 8.52% in the 3rd segment compared to the 1st segment.

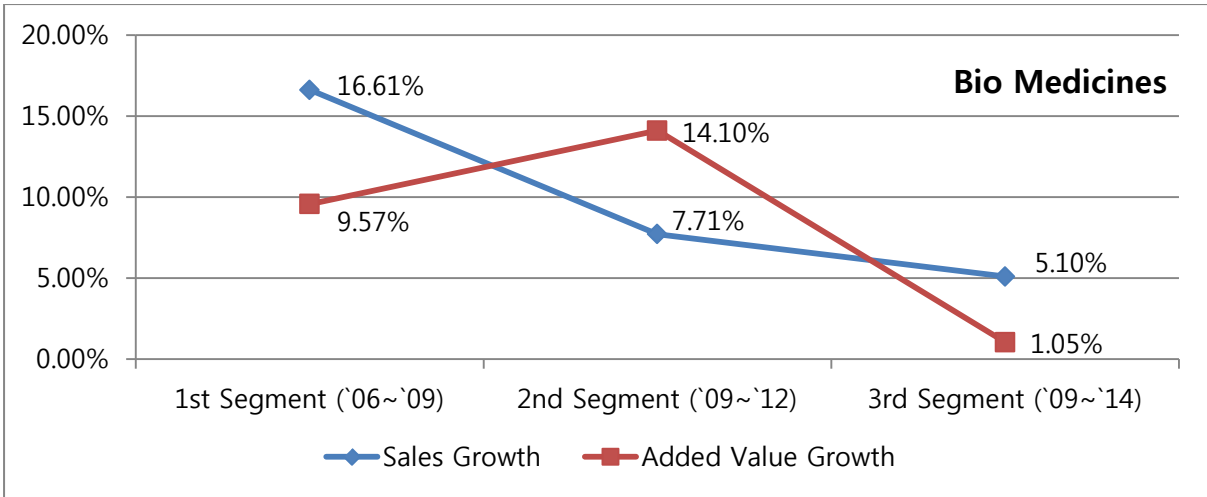


Figure 25. Bio Medicines : Sales Growth Rate and Added Value Growth Rate

Bio Medicines (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	16.61	7.71	5.10
Added Value Growth Rate	9.57	14.10	1.05

Table 32. Bio Medicines : Sales Growth Rate and Added Value Growth Rate

Both the sales growth rate and added value growth rate in the 3rd segment decreases largely and especially the added value growth rate ends at 1.05%. Although the added value growth rate slightly increased in the 2nd segment, it plunges to the bottom in the 3rd segment. It indicates that the policy effect was short-lived and failed to make a positive performance in the qualitative aspect.

26) Bio Resources

Both the average sales growth rate and average added value growth rate in bio resources sector decreases sharply after the policy implementation. Both growth rates barely maintain 2.67% in the 3rd segment.

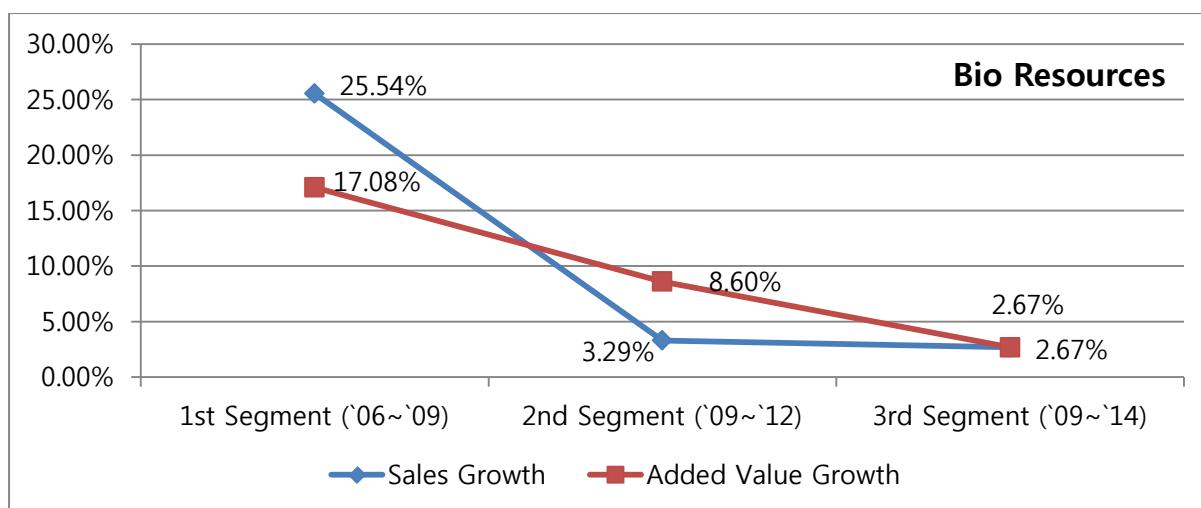


Figure 26. Bio Resources : Sales Growth Rate and Added Value Growth Rate

Bio Resources (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	25.54	3.29	2.67
Added Value Growth Rate	17.08	8.60	2.67

Table 33. Bio Resources : Sales Growth Rate and Added Value Growth Rate

While the sales growth rate and added value growth rate before the policy implementation are around 20%, the sector experiences a sharp decline right after the policy implementation. It indicates that the policy completely failed to support or revive bio resources sector, considered as a declining sector.

27) Advanced Medical Care

Average sales growth rate in advanced medical care sector keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreases by 6.13% and also decreases by 13.81% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate increases slightly by 0.72% in the 2nd segment, but soon decreases by 13.78% in the 3rd segment compared to the 1st segment.

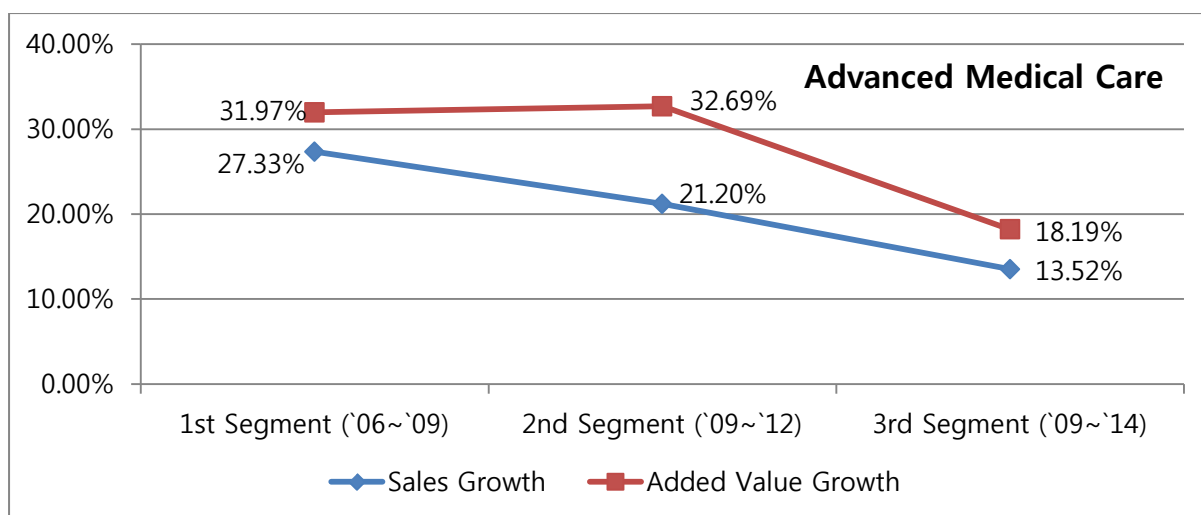


Figure 27. Advanced Medical Care : Sales Growth Rate and Added Value Growth Rate

Advanced Medical Care (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	27.33	21.20	13.52
Added Value Growth Rate	31.97	32.69	18.19

Table 34. Advanced Medical Care : Sales Growth Rate and Added Value Growth Rate

Although the sales growth rate decreased much after the policy implementation, the sector's performance in the added value growth rate is favourable since it maintains high growth rate 18.19% in the 3rd segment. It indicates that policy was somewhat successful for advanced medical care sector by supporting the sector not to decline largely in the qualitative aspect.

28) High Value Food

Average sales growth rate in advanced medical care sector keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreases by 12.03% and also decreases by 16.29% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate increases by 3.84% in the 2nd segment, but soon decreases by 5.09% in the 3rd segment compared to the 1st segment.

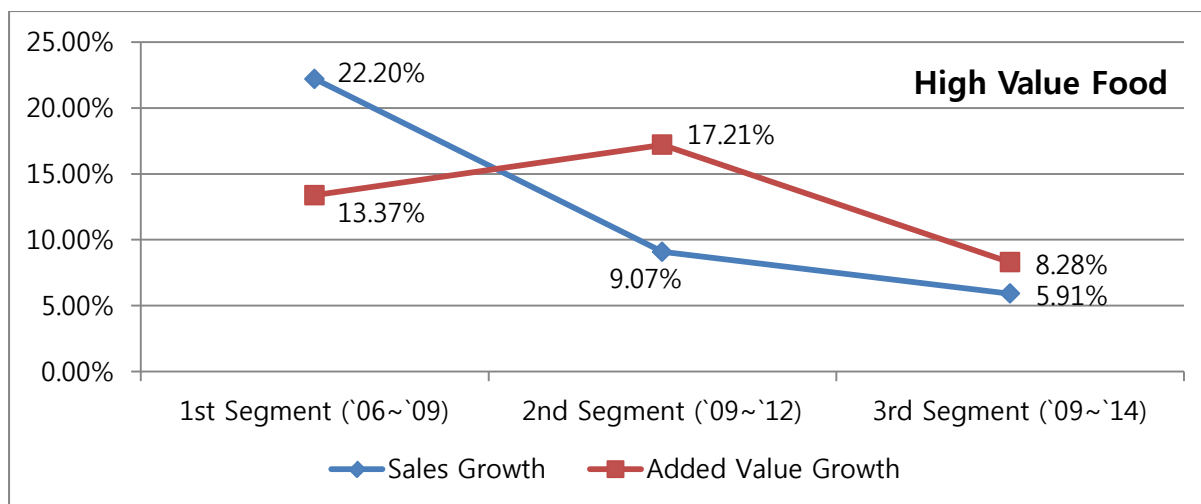


Figure 28. High Value Food : Sales Growth Rate and Added Value Growth Rate

High Value Food (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	22.20	9.07	5.91
Added Value Growth Rate	13.37	17.21	8.28

Table 35. High Value Food : Sales Growth Rate and Added Value Growth Rate

Although the sales growth rate decreased much after the policy implementation, the sector's performance in the added value growth rate increases temporarily after the policy implantation. However, the policy effect on high value food sector was short-lived and failed to make a positive performance both in the quantitative and qualitative aspects.

29) Game

Both average sales growth and added value growth rates decrease drastically after the policy implementation. The average sales growth rate in the 3rd segment decreases by 28.13% and average added value growth rate in the 3rd segment decreases by 47.58%.

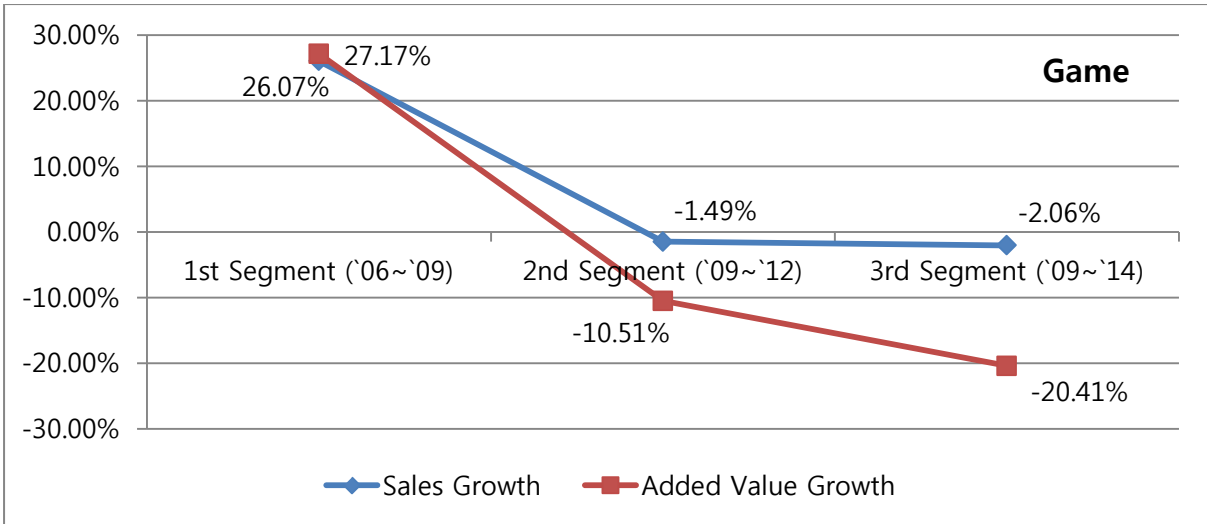


Figure 29. Game : Sales Growth Rate and Added Value Growth Rate

Game (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	26.07	-1.49	-2.06
Added Value Growth Rate	27.17	-10.51	-20.41

Table 36. Game : Sales Growth Rate and Added Value Growth Rate

Game sector has a characteristic in that both rates transformed to the negative values with terrible declines. It indicates that the policy completely failed to support game sector or even the sector may received a negative influences.

30) Contents/SW

Average sales growth rate in contents/SW sector keeps decreasing after the policy implementation. The average sales growth rate in the 2nd segment decreases by 16.66% and also decreases by 19.83% in the 3rd segment when compared to the 1st segment.

On the other hand, average added value growth rate increases by 5.75% in the 2nd segment, but soon decreases by 7.56% in the 3rd segment compared to the 1st segment.

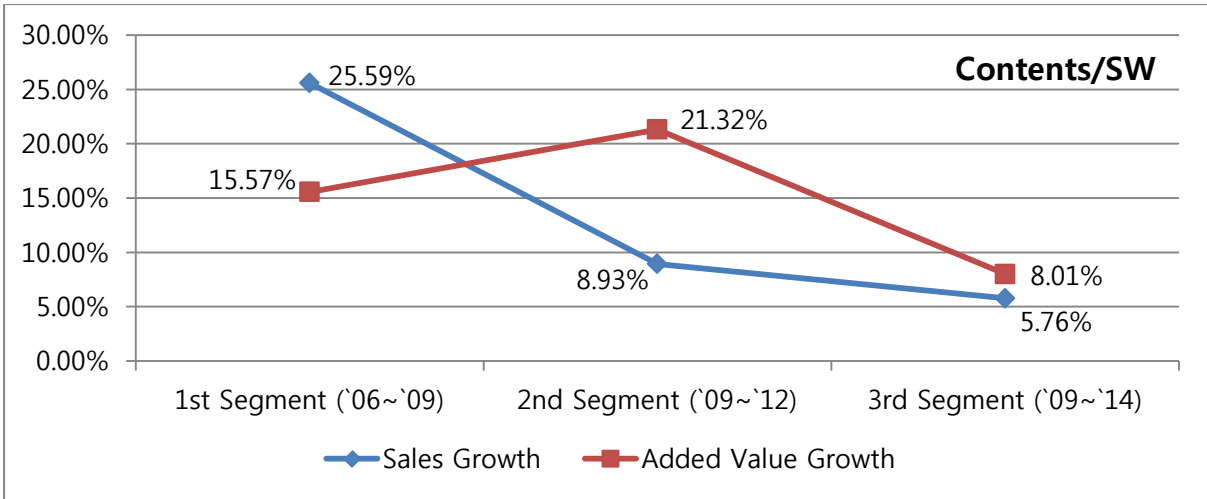


Figure 30. Contents/SW : Sales Growth Rate and Added Value Growth Rate

Contents/SW (%)	1 st segment ('06~'09)	2 nd Segment ('09~'12)	3 rd Segment ('09~'14)
Sales Growth Rate	25.59	8.93	5.76
Added Value Growth Rate	15.57	21.32	8.01

Table 37. Contents/SW : Sales Growth Rate and Added Value Growth Rate

Although the sales growth rate decreased much after the policy implementation, the sector's performance in the added value growth rate increases temporarily after the policy implantation. However, the policy effect on contents/SW sector was short-lived and failed to make a positive performance both in the quantitative and qualitative aspects.

4.2 Overall Result Analysis

There are some overall characteristics of the growth rates trend in the sector results. First, the average sales growth rate generally keeps decreasing after the policy implementation in the most sectors. It corresponds to Schumpeterian theory's one of firm growth stages, Mark I. According to Schumpeterian Mark I, firms in the early stage market challenges in earning excess profits by creating new opportunities through the technology innovation. If the challenge is successful, the balance of the existing system becomes broken and newly structuralized (Nelson and Winter, 1982). During the restructuring process, existing products become replaced by new products so that the period of time to earn revenue from a particular opportunity becomes limited, and sales growth rate must be reduced during the transition period. Thus, it is very important for firms to have the ability to develop next-generation new products as fast as possible while firms are making profits with the existing products not to lose the opportunity for recovering R&D cost. Among the 30 sectors, only safety/medical robot sector's average sales growth rate increased after the policy implementation. It indicates that the sector is in the very early stage of the market, and not ready to challenge for the next level through new technology innovation yet.

Secondly, the average added value growth rate in the most sectors rapidly increases in the 2nd segment, during the 3 years after the policy implementation, and then decrease in the 3rd segment, during the 5 years after the policy implantation. Among the 30 sectors, 24 sectors have the following trend patterns. It indicates that the practical policy effect on new growth engine sectors was generally short-lived, and failed to make long-lasting effect. This point also accord with Schumpeterian theory. Imbalance during that process is called creative destruction because it creates added value and promotes economic development (Winter 1984). However, firms in Schumpeterian competitions system may disappear after the twilight effect with new opportunity or may advance to the next stage through the driving

force of imbalance. (Winter, 1971). The sectors of replacement water, U-City, and bio resources experience terrible declines in both average sales growth and added value growth rates after the policy implementation. Both rates in these sectors end at the value around 0% in the 3rd segment. It indicates that those sectors are declining or twilight sectors at least in domestic situation, and even the policy fails in supporting their technology innovation for the next growth stage. Display sector also shows decreased added value growth rate after the policy implementation, but the case is different with the declining sectors. Domestic display sector is already one of the main businesses which take first place in the global market. Display sector has been led by conglomerate firms such as LG display and Samsung display. Since the conglomerate firms already have their own systemized R&D strategies, it is considered that the policy could not make any significant effect on display sector.

On the other hand, some sectors such as carbon reduction, eco-friendly house and system semiconductor achieve outstanding performance in both quantitative and qualitative aspects with increased sales and added value growth rates. The average added value growth rate records 44.59% in the 2nd segment and 17.12% in the 3rd segment and that is significantly higher than added value growth rate in the 1st segment, 7.03%. Moreover, average sales growth rate in carbon reduction sector also slightly increases in the 2nd segment. It indicates that policy effect on carbon reduction sector was completely successful. Eco-friendly house sector also receives a large benefit from the policy implementation by achieving high qualitative performance with continuously increased added value growth rate during the policy term. In addition, system semiconductor sector exceptionally displays the result that added value growth rate in the 3rd segment (15.89%) is much higher than that in the 2nd segment (10.16%). It indicates that policy was successful in providing positive long-term effect for system semiconductor sector with outstanding qualitative performance and quantitative outcome as well.

The policy effect is also variant by sectors' technology levels. Each 30 sectors are classified into the five technology levels, which are Industrialization stages of 1st (4 sectors), 2nd (8 sectors), 3rd (8 sectors) and technology introduction stages of 1st (4 sectors) and 2nd (6 sectors).⁸

Technology Level	Average Sales Growth Rate (%)			Average Added Value Growth Rate (%)		
	1 st Segment (`06~`09)	2 nd Segment (`09~`12)	3 rd Segment (`09~`14)	1 st Segment (`06~`09)	2 nd Segment (`09~`12)	3 rd Segment (`09~`14)
Industrialization 3 rd Stage	14.83	11.01	6.18	9.82	16.79	9.06
Industrialization 2 nd Stage	18.41	11.68	5.53	16.99	17.83	4.23
Industrialization 1 st Stage	20.33	9.97	5.99	13.73	26.76	12.71
Technology Intro. 2 nd Stage	21.46	8.81	4.73	20.04	19.53	6.76
Technology Intro. 1 st Stage	14.67	17.24	8.94	13.88	36.15	13.92

Table 38. Average Sales Growth and Added Value Growth Rates by Technology Levels

In the aspect of average sales growth rate, most technology level stages have a common trend of decreasing after the policy implementation except the technology introduction 1st stage. It indicates that firms still have a capacity yet in making profits with the existing products at the very early stage of the market while getting ready to start R&D activity for the next-generation products. In industrialization 3rd stage, average sales growth rate decreases in small amount compared to other technology level stages since the sectors in that stage has entered to the maturity period with stability in firm operation.

⁸ Refer to the table 7 in this study for more details.

In the aspect of average added value growth rate, technology introduction 1st stage and industrialization 1st stage are considered as the most beneficiary sectors compared to the sectors in other technology levels. The sectors in the two technology levels achieve high performance in added value growth rate right after the policy implementation. Moreover, the growth rates in the 3rd segment stay over 10% unlike the other technology levels which experience rapid drops. It indicates that sectors in the 1st stages are more likely to fully absorb the R&D policy effects with the higher development possibility in the growing markets.

On the other hand, sectors in the 2nd stages in technology introduction and industrialization fail to receive positive policy impact in both the quantitative and qualitative aspects. This result may be derived from the firm's incapability in performing the effective R&D activities or the short-term effect of the R&D policy which fails to support the sectors due to lack of sustainable development strategies.

It can be judged that, however, 'New Growth Engine Action Plan' was clearly successful in achieving its prescribed goal, identifying and fostering promising industries qualitatively with deliberate R&D policy.

4.3 Implications

Although the government's 'New Growth Engine Action Plan' generally had positive impacts on supporting R&D activities of the promising firms which struggle at the next-generation high-tech markets, the policy displayed some limitations that the policy effect was short-lived and the policy fails to provide each tailored strategies for the sectors in the different technology levels.

Due to frequent changes in the selection of new growth engines and lack of implementation system, it is difficult to establish a continuous policy linkage and to develop and implement the long-term strategy for government R&D investment. Especially from

2013 to 2016, the government has selected or changed new growth engine sectors seven times for the recent 3 years. Accordingly, transitioning to the long-term performance based new growth engine promotion with the steady support for the sectors with continuity is necessary in order to break from the short-term based performance.

First, following the acquisition of key technologies through R&D support, the government needs to strengthen the full cycle support for the early industrialization of new growth engine sectors with the additional ecosystem functions, such as pilot production, sequential investment linkage, and human resources. For example, U.S. provides follow-up support for technological development by expanding the government's R&D support to the pilot test production phase, which is 8 out of 10 phases in Manufacturing Readiness Level (MRL)

Secondly, it is necessary to select new growth engine items and allocate R&D investment based on the sector's ability for the economic ripple effect and job creations. Currently selected new growth engine items are too much concentrated in the sectors in ICT industry, but the key players in those sectors have struggled in leading the sustainable innovation due to the characteristic of ICT technology, the short life cycle. Therefore, giving more opportunities on manufacturing or service industries through the R&D policy needs to be considered.

Third, since the absorptive capacity for the government R&D investment differs according to the technological levels in each growing sector, it is necessary to establish a direction for the tailored R&D support for each stage of industrialization. For example, for the sectors that already secures the core technologies, the government needs to mainly support the stage of mass production such as R&D commercialization, pilot projects, and legal mitigation.

V. Conclusion

R&D policy on new growth engine business has recently become the limelight globally. Korean government's 'New Growth Engine Action Plan' also has strived to develop prospective industries which will make influential economic profits in the future. However, the previous researches or evaluations on 'New Growth Engine Action Plan' mainly focus on the short-term quantitative outcomes, and neglect to conduct performance analysis on the policy's ultimate goal, identifying and fostering promising industries qualitatively for the next-generations. Thus, the significance of this study is that it analyzes the policy performance both quantitatively and qualitatively, and the sectors' sustainability in future growth through comparison of the performances before and after the policy implementation by utilizing suitable indicators, average sales growth rate and average added value growth rate.

In accordance with Schumpeterian theory Mark I (creative destruction) about firm's growth, the average sales growth rate in most new growth engine sectors keeps decreasing after the policy implementation because the firms are hard to generate healthy revenue during the process of restructuring the production system and innovating to the new technologies. Furthermore, the average added value growth rate in most sectors sharply increases in the short-term, 3 years after the policy implementation, but tends to decrease soon with a large deviation in the intermediate or long-term, 5 years after the policy implementation. This pattern also follows Schumpeterian competitions system, which explains that firms may disappear after the twilight effect or may advance to the next stage depending on firms' technology innovation capability.

The policy effect is also different by new growth engine sectors' technology levels. The result displays that the policy was most effective with sharp increase in the average added value growth rates when the sectors are in the early 1st stages of technology

introduction and industrialization by fully absorbing the R&D support from the government in the growing markets. On the other hand, the policy effect was insignificant in the 2nd stages of technology introduction and industrialization due to the firm's innovation incapability to advance to the next stage or short-lived policy effect without sustainable development strategies. However, 'New Growth Engine Action Plan' can be regarded as a successful policy since it has clearly supported in improving the firm's innovation capacity in qualitative aspect despite of the short-term effect.

In order to enhance the positive impact on R&D policy for new growth engine businesses, transitioning to the long-term performance based promotion strategy is necessary from the short-term based performance evaluation. First, the government should strengthen the full cycle support for the early industrialization of the firms beside R&D subsidy like pilot production, sequential investment linkage and human resources. Second, the government needs to carefully select new growth engine sectors which can make influential economic ripple effect and job creations. Third, the government needs to apply customized R&D support for each stage of industrialization due to the different absorptive capacity for the government R&D investment by the technology levels.

APPENDICES

Appendix A. Average Sales Growth Rate by Sector

Average Sales Growth Rate			
Sector	1st Segment ('06~'09)	2nd Segment ('09~'12)	3rd Segment ('09~'14)
Solar Energy	0.180904744	0.112715724	0.070734633
Fuel Cell	0.2261554	0.120916253	0.060819979
Waste/Bio	0.18113355	0.080000631	0.019681595
Carbon Reduction	0.157777832	0.161064089	0.068960372
Smart Waterworks	0.190968567	0.08781553	0.050551708
Replace Water	0.263824295	0.121206118	0.029440115
Water Environment	0.253494841	0.034912354	0.019659047
LED Application	0.196168295	0.134395668	0.083810903
Green Transportation	0.13962142	0.116116028	0.055570858
U-City	0.22559274	0.030547286	0.001540052
ITS	0.111556676	0.084176986	0.053271497
GIS	0.202566018	0.090005095	0.045381096
Eco House	0.144081172	0.115554742	0.086521634
Convergence Network	0.13222988	0.112343594	0.09105356
Wireless Communication	0.135036274	0.101351674	0.032584708
DTV	0.11039933	0.097267757	0.02125142
IPTV	0.234757687	0.140189588	0.071675853
Sensor Network	0.067535958	0.060697879	0.011455589
Semi Conductor	0.100409704	0.145639461	0.106521932
Display	0.146860283	0.122441279	0.087244178
Life/Edu Robot	0.185248019	0.159860236	0.099545591
Clean Production Robot	0.102258622	0.269188182	0.12136288
Social Safety Robot	0.002797992	0.305483193	0.128826756
New Materials/Nano	0.221695888	0.141789049	0.091418589
Bio Medicines	0.1661434	0.077115051	0.050981243
Bio Resources	0.255408365	0.032949468	0.02670294
Advanced Medical System	0.273285215	0.211986574	0.135161436
High Value Added Food	0.22203524	0.090729151	0.059078984
Game	0.260741993	-0.01492348	-0.020592256
Contents/SW	0.25586168	0.089333837	0.057608782

Appendix B. Average Added Value Growth Rate by Sector

Average Added Value Growth Rate			
Sector	1st Segment ('06~'09)	2nd Segment ('09~'12)	3rd Segment ('09~'14)
Solar Energy	0.126874346	0.181284246	0.093995668
Fuel Cell	0.193758849	0.215301006	0.099151932
Waste/Bio	0.124446774	0.211249005	0.051740901
Carbon Reduction	0.070300047	0.445870504	0.171193193
Smart Waterworks	0.235627344	0.274249862	0.159568302
Replace Water	0.208501319	0.003086628	-0.137066891
Water Environment	0.20359633	0.16454905	0.105029437
LED Application	0.065480317	0.130210706	0.093625636
Green Transportation	0.169829494	0.292852629	0.113559902
U-City	0.250929751	0.323219653	0.002265554
ITS	0.09330923	0.13822773	0.112969448
GIS	0.484837194	0.601755111	0.294627438
Eco House	0.152437567	0.325393238	0.230588734
Convergence Network	0.148071718	0.186293421	0.14290118
Wireless Communication	0.047413124	0.253451284	0.113038416
DTV	0.040359972	0.077141553	0.026603444
IPTV	0.115437493	0.345463342	0.096563533
Sensor Network	0.140569948	0.177010827	0.012665337
Semi Conductor	0.086459571	0.101592864	0.158911951
Display	0.179998994	0.105415533	0.112014046
Life/Edu Robot	0.234553139	0.478025833	0.21991756
Clean Production Robot	0.00537661	0.136321278	0.000237686
Social Safety Robot	-0.229484487	0.235942464	-0.051269389
New Materials/Nano	0.155924487	0.220556181	0.132617304
Bio Medicines	0.095723784	0.141022857	0.010468886
Bio Resources	0.170802294	0.085953961	0.026717456
Advanced Medical System	0.319738523	0.326898205	0.181934077
High Value Added Food	0.133723618	0.172106081	0.082822115
Game	0.27170153	-0.10509662	-0.204107046
Contents/SW	0.155711208	0.213207657	0.080090862

Appendix C. Average Sales Growth Rate by Technology Level

Average Sales Growth Rate			
Technology Level	1st Segment (`06~`09)	2nd Segment (`09~`12)	3rd Segment (`09~`14)
Solar Energy	0.180904744	0.112715724	0.070734633
ITS	0.111556676	0.084176986	0.053271497
Wireless	0.135036274	0.101351674	0.032584708
DTV	0.11039933	0.097267757	0.02125142
IPTV	0.234757687	0.140189588	0.071675853
Semi Conductor	0.100409704	0.145639461	0.106521932
Display	0.146860283	0.122441279	0.087244178
Bio Medicines	0.1661434	0.077115051	0.050981243
Industrialization 3rd	0.148258512	0.11011219	0.061783183
Fuel Cell	0.2261554	0.120916253	0.060819979
Waste/Bio	0.18113355	0.080000631	0.019681595
Green Transportation	0.13962142	0.116116028	0.055570858
Sensor Network	0.067535958	0.060697879	0.011455589
Clean Production Robot	0.102258622	0.269188182	0.12136288
Advanced Medical System	0.273285215	0.211986574	0.135161436
High Value Added Food	0.22203524	0.090729151	0.059078984
Game	0.260741993	-0.01492348	-0.020592256
Industrialization 2nd	0.184095925	0.116838902	0.055317383
Carbon Reduction	0.157777832	0.161064089	0.068960372
Eco House	0.144081172	0.115554742	0.086521634
Bio Resources	0.255408365	0.032949468	0.02670294
Contents/SW	0.25586168	0.089333837	0.057608782
Industrialization 1st	0.203282262	0.099725534	0.059948432
Smart Waterworks	0.190968567	0.08781553	0.050551708
Replace Water	0.263824295	0.121206118	0.029440115
Water Environment	0.253494841	0.034912354	0.019659047
U-City	0.22559274	0.030547286	0.001540052
Convergence Network	0.13222988	0.112343594	0.09105356
New Materials/Nano	0.221695888	0.141789049	0.091418589
Tech. Intro. 2nd	0.214634369	0.088102322	0.047277179
LED Application	0.196168295	0.134395668	0.083810903
GIS	0.202566018	0.090005095	0.045381096
Life/Edu Robot	0.185248019	0.159860236	0.099545591
Social Safety Robot	0.002797992	0.305483193	0.128826756
Tech. Intro. 1st	0.146695081	0.172436048	0.089391087

Appendix D. Average Added Value Growth Rate by Technology Level

Average Added Value Growth Rate			
Technology Level	1st Segment ('06~'09)	2nd Segment ('09~'12)	3rd Segment ('09~'14)
Solar Energy	0.112715724	0.070734633	0.126874346
ITS	0.080000631	0.019681595	0.124446774
Wireless	0.211986574	0.135161436	0.319738523
DTV	0.090729151	0.059078984	0.133723618
IPTV	-0.01492348	-0.020592256	0.27170153
Semi Conductor	0.161064089	0.068960372	0.070300047
Display	0.115554742	0.086521634	0.152437567
Bio Medicines	0.121206118	0.029440115	0.208501319
Industrialization 3rd	0.109791694	0.056123314	0.175965465
Fuel Cell	0.084176986	0.053271497	0.09330923
Waste/Bio	0.101351674	0.032584708	0.047413124
Green Transportation	0.11011219	0.061783183	0.098197064
Sensor Network	0.116838902	0.055317383	0.169893168
Clean Production Robot	0.089333837	0.057608782	0.155711208
Advanced Medical System	0.030547286	0.001540052	0.250929751
High Value Added Food	0.112343594	0.09105356	0.148071718
Game	0.141789049	0.091418589	0.155924487
Industrialization 2nd	0.09831169	0.055572219	0.139931219
Carbon Reduction	0.097267757	0.02125142	0.040359972
Eco House	0.060697879	0.011455589	0.140569948
Bio Resources	0.034912354	0.019659047	0.20359633
Contents/SW	0.088102322	0.047277179	0.200441825
Industrialization 1st	0.070245078	0.024910809	0.146242018
Smart Waterworks	0.140189588	0.071675853	0.115437493
Replace Water	0.145639461	0.106521932	0.086459571
Water Environment	0.122441279	0.087244178	0.179998994
U-City	0.120916253	0.060819979	0.193758849
Convergence Network	0.269188182	0.12136288	0.00537661
New Mateirals/Nano	0.08781553	0.050551708	0.235627344
Tech. Intro. 2nd	0.147698382	0.083029422	0.13610981
LED Application	0.077115051	0.050981243	0.095723784
GIS	0.116116028	0.055570858	0.169829494
Life/Edu Robot	0.032949468	0.02670294	0.170802294
Social Safety Robot	0.099725534	0.059948432	0.137312779
Tech. Intro. 1st	0.08147652	0.048300868	0.143417087

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