THE ECONOMIC EFFECTS OF STANDARDS IN KOREA:
THE EFFECTS OF NATIONAL STANDARDS ON MACROECONOMIC GROWTH

By

KO, Sangjin

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

MASTER OF PUBLIC POLICY

2015

THE ECONOMIC EFFECTS OF STANDARDS IN KOREA:

THE EFFECTS OF NATIONAL STANDARDS ON MACROECONOMIC GROWTH

By

KO, Sangjin

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

MASTER OF PUBLIC POLICY

2015

Professor Ju-Ho Lee

THE ECONOMIC EFFECTS OF STANDARDS IN KOREA:

THE EFFECTS OF NATIONAL STANDARDS ON MACROECONOMIC GROWTH

By

KO, Sangjin

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

MASTER OF PUBLIC POLICY

Committee in charge:

Professor Ju Ho LEE, Supervisor ________________

Professor Jin Soo LEE ________________

Professor Ji Sun BAEK ________________

Approval as of December, 2015

ABSTRACT

THE ECONOMIC EFFECTS OF STANDARDS IN KOREA :

THE EFFECTS OF NATIONAL STANDARDS ON MACROECONOMIC GROWTH

By

Sangjin KO

Since 1960s, Korean national standards have been developed to improve quality of products, ensuring their safety and providing criteria for testing to import and export products. However, there have been few studies on the economic effects of the standards, especially in Korea. This study tries to find the macro economic effects of national standards in Korea by using Cobb-Douglas production function and time-series regression analysis with related factors such as national standards, patents, and imported technology.

The result shows that there is statistically significant evidence that increasing national standards have had positive impacts on Korea economic growth from 1970 to 2012 by 0.0589% at a 1% significance level. Considering the industrialization period, from 1970 to 1990, standards had significant positive effects on economic growth in Korea. This statistical analysis indicated that national standards have an important role during the industrialization period, however, patents became more important for economic growth after 1990.

Overall, this study shows that standards have been an important role as stimulus for technical progress affecting economic growth during the Korean economic development. And the weight of each factors' contribution have been changed from standards to patents as the structure of Korean industries have been changed.

ACKNOWLEDGEMENT

Firstly, I would like to express special gratitude to my thesis supervisor, Professor Ju Ho LEE. His guidance and advices allowed me to build a sense of academic research. In addition, both his compliments and criticism stimulated me to navigate through tough challenges and ultimately find the finish this thesis. I also would like to sincerely thank my second supervisor, Professor Jin Su LEE. Through his lectures and comments, I was able to gain confidence in econometric analysis and to complete the quantitative analyses.

Also, I cannot fail to thank Mr. Dong Geun CHOI of Korean Standards Association. Through the integrated statistics of national standards, he provided me the important data with practical recommendation for research. Without his assistance, I would not have been able to conduct the analyses for this thesis.

Lastly and most importantly, I would like to thank my family for their support and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

There are many different definition of a “Standard.” Commonly, it means the common characteristics of products, services and anything around our lives. When it comes to public policy area, its boundary is limited to documents that define scientific and technical criteria, standards, guidelines, regulations for testing, certifying, and other official activities. Officially, ISO (International Organization for Standardization)[1] defines a standard as “A document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose.”[2] Following this definition, standards are useful and important tools especially for development in manufacturing industries. Therefore, Korean government has invested considerable budget to promote standardization activities and develop national standards.

In the 1960s, the Korean government made concerted efforts to recover and develop the economy by supporting national industries. To achieve this purpose, a lot of supportive government policies were applied such as investing huge budgets in building national infrastructure projects, supporting many promotional events to increase the quality of products, and so on. As one of the economic supporting policies, the national standards system called KS(Korean Industrial Standards) was established based on the Industrial Standardization Act of 1962.

The development of national standards has proceeded in line with industrial development. In

[1] ISO(International Organization for Standardization) is an independent, non-governmental membership organization and the world’s largest developer of voluntary International Standards. It consist of 162 member countries, 19,500 International Standards (2014).

[2] “What is a standard,” ISO(International Organization for Standardization), accessed June 26, 2015, http://www.iso.org/iso/home/standards.htm.

the 1960s, Korean industries began to increase productivities and expand the market by exporting products. However, Korean suffered quality issues in the initial stage of industrialization because foreign countries required internationally competitive products. Therefore, government had invested to establish of national standards to be used in regulations, manufacturing products, testing and inspection of products.

With this government's full support, 300 national standards were introduced in 1962, and since this time many national standards (KS) have been established, revised, withdrawn leading to 20,519 standards at the end of 2014.[3] At the same time, the Korean economy rapidly developed as seen in GDP growth from 2,794.8 billion won (KRW)[4] in 1970 to 1,485,078 billion won in 2014.[5]

Some quantitative empirical studies have shown the relationship between Korean economic growth and national standards in Korea. However, compared to foreign studies, there is a lack of studies about the economic impacts of standards in Korea. Although patents are mostly considered as a key factor for technical progress and having a significant effect on economic development in Korea, there are few studies on standards and its economic effects. There are prior national studies related to national standards, however, these are usually conducted to analyze the contribution of national standards in time-series, and so do not consider the type of standards and change in architecture of Korean industries. In addition, most prior studies the effects of national standards are focused on case studies without macroeconomic analysis.

---

[3] The statistics of the Korean industrial standard, KATS(Korean Association for Technology and Science) under Ministry of Trade, Industry, and Energy, January 2015.

[4] Exchange rate(USD/KRW) is 1 USD = 1,194 KRW as of Sep 27, 2015.

[5] Gross domestic product and expenditure, KOSIS(Korean Statistical Information Service) Homepage, accessed Sep 14, 2015, http://kosis.kr/statHtml/statHtml.do?orgId=301&tblId=DT_102Y003&conn_path=I3.

Therefore, this thesis was intended to analyze and present the relationship between Korean economic growth and the increase of national standards. Therefore this research used quantitative analysis to show how the introduction of national standards and patents has contributed to the Korean economy. In addition, thesis attempted to determine if standards have a more significant impact on the economy than patents especially during the developing and industrialization period(1970~ 1990) in Korea.

This thesis consists of 6 parts, which are 1. Introduction; 2. Background; 3. Literature Review; 4. Methodology; 5. Result; 6. Conclusion. In the second part, “Background”, the classification and characteristics of standards are briefly described. And representative research papers about the effects of standards are reviewed in third part, “Literature Review.” Then, in the next part, “Methodology”, the hypothesis, model, and data characteristics are specifically explained. And it ends with a brief summary of the results, implications, and limitations of the research in following “Result” and “Conclusion” parts.

2. Background

It is hard to classify the types of "Standards" because it has a wide range of meanings and usages in various fields with different purpose, and there are different criteria for classification of standards based on sectors, key actors and targets of enactment, scope of application, and binding force. In this paper, common classifications of standards are introduced to understand what standards are and what types of standards have been established. Two classifications are referred to, classification of standards by sectors[6] and classification of standards based on the economic effects. [7]

2.1 Classification of standards by sectors

The most comprehensive classification by sectors includes and "science and technology standards" and "humanities and society standards." The structure of the type of standards by sector is illustrated in Figure1.

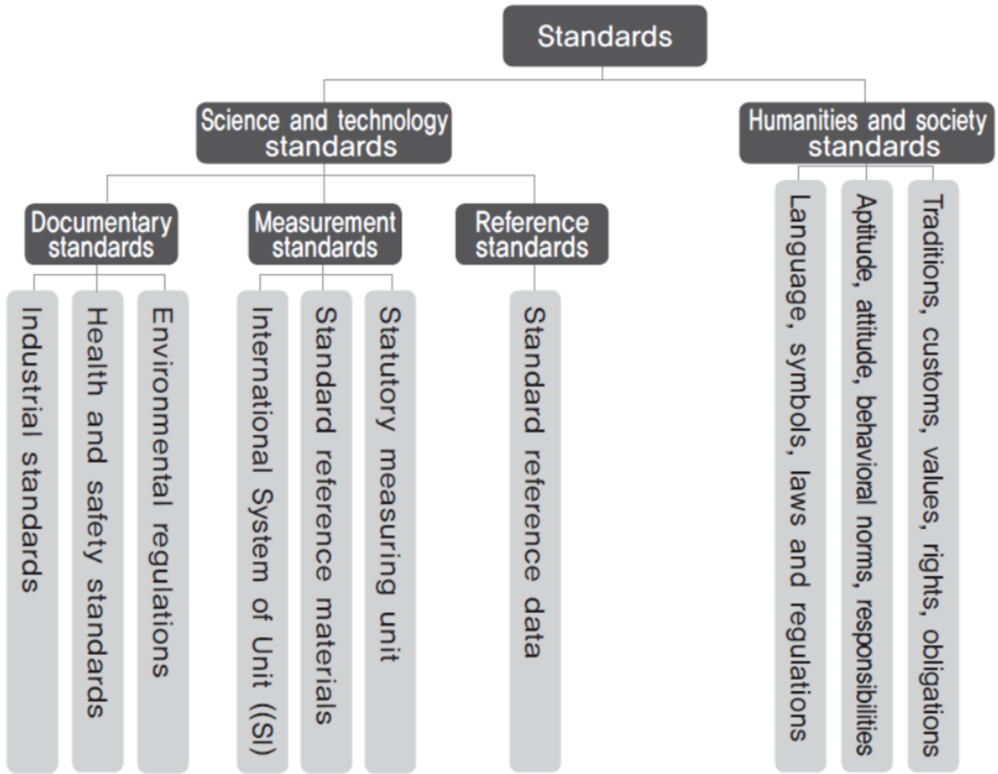
"Science and technology standards" consists of documentary standards, measurement standards, and reference standards. Documentary standards mean documented regulations, specifications, terminologies, symbol and signs which are applied to enhance the overall understanding, safety, effectiveness, and economic efficiency in all sectors. The sectors contains a variety of economic activities such as production, distribution, consumption, transport, communication, service, education, construction, and even people's daily lives.

---

[6] "Types and Functions of Standards," Future Society and Standards, KSA(Korean Standards Association), 6nd ed., March 2015.

[7] Blind, K. and A. Jungmittag, "The impact of patents and standards on macroeconomic growth: a panel approach covering four countries and twelve sectors," Journal of Productivity Analysis, July 2008.

<Fig1> Types of Standards by Sector



(Source : Future Society and Standards, KSA, 2015)

Measurement standards are used as the criteria that are used for measuring the time, volume, length, temperature, and so on. Also, fundamental materials and units derived from basic units required for measuring specific units are also included in this type. Measurement standards include seven base units of International System of Unit(SI), two derived units and statutory measuring units, which include international system of unit, standard reference materials, and statutory measuring unit. There are examples of measurement standards shown below in Table1.

<Tab1> Examples of measurement standards

Category	Examples
Base units	meter (m), a unit of length; kilogram (kg), a unit of weight; second (s), a unit of time; ampere (A), a unit of electric current; kelvin (K), a unit of thermodynamics temperature; mol, a unit of measuring matter; candela (cd), a unit of luminous intensity.
Derived units	radian (rad), a unit of plane angle; steradian (sr), a unit of solid angle; hertz (Hz), the unit of frequency; newton (N), a unit of force; pascal (Pa), a unit pressure; watt (W), a unit of electric power. meter per second (m/s), a unit of speed; meter per second squared (m/s2), a unit of acceleration.
Statutory measuring units	7 SI(meter (m), kilogram (kg), second(s), ampere (A), kelvin (K), mol, candela (cd)), kilo (k) ; meaning multiplication by a thousand), milli (m) ; meaning one-thousandth); denier (D) ; a unit of measurement for the fineness of silk or nylon or rayon, grain (gr) ; a unit of measurement of mass that is nominally based upon the mass of a single seed of a cereal

(Source : Future Society and Standards, KSA, 2015)

Reference standards refer to quantitative information measurements associated with measureable physical or chemical property such as physical and chemical constants including the Avogadro constant or gravitational constant, observed data, statistical data like demographic statistics, and so on. Those data are usually gathered and provided by relevant standardization organization for wider use in all sectors.

“Humanities and society standards” are divided into language, signs, laws and regulations, aptitude, behavioral norms, obligations, and so on. When it comes to “Standards” used in this paper, it indicates “Science and technology standards” that is the documentary standards used in industries for economic activities.

2.2 Classification of standards based on the economic effects

Considering the economic effects of standards, standards can be divided into three types, which are compatibility and interface standards, minimum quality and safety standards, and variety-reducing standards.

Compatibility and interface standards provide connectivity or compatibility between different products, components, or services, which are mostly found in network and computer industries. For example, people usually like to buy an IBM PC rather than an Apple PC because most components of IBM PC are widely exchanged by IBM providing its standards for increasing compatibility. This is called network effects of network externalities. That effect is not only for customers, but also for producers by reducing switching costs. If there were no standards or interface for components consisting of end-products, producers would suffer from the switching cost for different configuration, specification, and so on. However, it indicates that the market can be locked into inferior products, designs, or functions since producers and customers are reluctant to switch to something better.

Minimum quality and safety standards ensure the quality and safety of products or services for customers. Because of the information asymmetries between producers and customers, it is hard for a buyer to make decisions. Standards provide enough information to the buyer so that buyers are able to choose high quality products and services. Also, safety standards especially related to electricity, electrical appliances, water, gas and all products related to people's lives, restrict negative external effects that could damage health and the environment. However, there is also disadvantage of minimum quality and safety standards, it could be too high a quality requirement or restrictive standards hinder the development of the market.

Variety reducing standards limit some specific characteristics such as size, designs, and quality levels. By decreasing the variety and reducing the manufacturing production cost for number of various different products, economies of scale can be exploited by mass sourcing of input materials and mass production. Customers can enjoy lower costs of the products or services. On the other hand, variety reduction standards could restrict innovation since lager scale production tends to promote more capital-intensive process causing small but potentially innovative companies to be excluded from the market. Also, customers may lose utility from the reduction of a wide range of alternatives.

Standards may not match exactly and exclusively into a single category, because standards fulfill multiple characteristics and have different economic effects. Commonly, most standards have many characteristics among different sectors and has both positive impacts and negative impacts as shown in Table2.

<Tab2> Types of standards and their impacts on growth

Types	Positive impacts	Negative impacts
Compatibility and interface standards	Physical networks based on compatibility standards are the basis for most service industries	Restricted diffusion in case of proprietary standards
Minimum quality and safety standards	Foster development of new markets and high quality segments of existing markets, which are decisive sources for growth Safety standards are means to restrict negative externalities damaging health& the environment	Misuse by small groups of suppliers in order to raise rivals' costs and allows them to behave like monopolists Restrictive quality and safety standards hinder the development of markets

Variety-reducing standards	Foster the exploitation of economies of scale A necessary condition for the development of new technologies and markets in order to reach critical masses attractive for entering companies and customers	Restrict the choices for customers Foster concentration within a market to a smaller number of suppliers misusing their market power on the other hand

(Source : Blind, K. and A. Jungmittag (2008))

3. Literature Review

There have been a number of quantitative studies for analyzing the relationship between macroeconomic growth and standards. Jungmittag(1999)[8], Blind Knut(2004)[9], Choe HoChull(2005)[10], and AFNOR[11](2009)[12], researched the effects of standards as one of the important variables affecting economic growth. Also there were several national research programs about the economic effects of national standards for each county conducted by ISO in 2012 as shown in Table 3.[13] Those studies commonly used Cobb-Douglas production function to analyze the economy and employed quantitative methods to draw significance level regarding the effect of standards on economic growth. Recent studies including Blind and Jungmittag(2008)[14] in Germany and Choi HyunKyung(2011)[15] in Korea estimated the economic benefits of standards that contribute to an aggregate value (GDP[16]) in four countries in Europe and in Korea respectively.

---

8 Jungmittag, A., K. Blind and H. Grupp, " Innovation, standardization and the longterm production function: a co-integration approach for Germany 1960-96," Zeitschrift f¨ur Wirtschafts- und Sozialwissenschaften, 1999.

9 Knut Blind, "The Economics of Standards: Theory, Evidence, Policy", Edward Elgar, July 2004.

10 HoChull Choe, "The economic effects of standardization in Korean manufacturing industry," MA, School of IT Business, 2005.

11 AFNOR(Association Francaise de Normalisation) is the French representative within European and international standards organizations, which works to the benefit of the innovation, performance and sustainable development of companies and civil society

12 "The Economic Impact of Standardization – Technological Change, Standards Growth in France", Hakima Miotti, AFNOR Group, June 2009.

13 "National impact," What's the bottom line, published by ISO, 2012.

14 Blind, K. and A. Jungmittag, "The impact of patents and standards on macroeconomic growth: a panel approach covering four countries and twelve sectors," Journal of Productivity Analysis, July 2008.

15 HyunKyung Choi, "The economic impact and implication of standards," KIET(Korea Institute for Industrial Economics & Trade), May 2011.

16 Gross Domestic Product

<Tab3> Macroeconomic studies on the contribution of standards to national economic growth

Country	Contribution
France	up to 0.81 %, or almost 25 % of GDP growth
New Zealand	1.0 % or NZD 2.4 billion increase in GDP
Canada	17 % of the labor productivity growth rate About 9 % of the growth rate in economic output (GDP)
Australia	0.17 % increase in productivity across the economy
Germany	1 % of GDP in Germany(greater contribution than patents or licenses)
United Kingdom	GBP 2.5 billion to the economy 13 % of the growth in labor productivity

(Source : What's the bottom line, ISO, 2012)

3.1 Foreign study on the economic effects of standards

Blind and Jungmittag(2008) adopted the result of Jungmittag(1999) and developed the research by analyzing the standards and patents that significantly contribute to economic growth as one of the important factor affecting technological progress. The scope of the research included the U.K., Germany, France, and Italy in time-series dating from 1990 to 2001 for 12 categorized industries. Since countries in the Euro zone sharing regional standards, European standards are applied for this research, including international standards and each countries' standards, in order to analyze the economic effects for each country.

This paper applies a simple growth model, the Cobb-Douglas production function, which explains that aggregate values consist of the three factors of neutral technological change, capital, and labor input. It assumes that technological progress is derived from innovative activity and the role of domestic diffusion of technology, such as patens and standards. The

OLS regression is used to draw estimations of each of the factors affecting economic growth. Capital, labor, patent, and standards are independent variables, and GDP is dependent variable in the OLS regression model.

The result is that both standards and patents are significant and the coefficient of standards is 0.079, which is lower than the patent value of 0.105 and is around 20% higher than the standards' elasticity. The estimation results for each country, indicate that four countries show different results with different coefficients and significance. On the other hand, the estimation for individual industries shows a rough pattern with significant impacts of standards in the sectors which have low and medium R&D and technology intensity such as metals and metal products and manufacturing fields.

3.2 National study on the economic effects of standards

Choi HyunKyung(2011) applied the research method of Blind Knut(2004) to the Korean economy. Therefore, this paper adds one more independent variable affecting technological progress, which is the payment of technology licenses from abroad, and shows how standards, patents, and technology license payment significantly contribute to economic growth in Korea. The scope of the research is bounded in Korea and in a time-series dating from 1970 to 2008. Since the scope of the study is limited to the national economy, only national standards, Korean Standards(KS) are considered.

In the same manner as Blind and Jungmittag(2008), this paper also applies Cobb-Douglas production function, which includes neutral technological change, capital, and labor input. Different from prior studies, it assumes technological progress is not only affected by standards and patents, but also by the import of technology from abroad. Therefore, The OLS regression model is composed of growth rate of capital, labor, patent, standards, and payment of technology from abroad as independent variables, and growth rate of labor productivity as the dependent variable.

The results shows that both standards and payment for technology license are significant, with 1% increase in the effects of standards contributing to 0.14~10.16% increase in labor productivity with 0.05~0.09% attributed to importing foreign technology. It indicates that the contribution of national standards in Korea is approximately 0.8% of GDP. However, national patents is not significant different from prior studies in other countries.

4. Methodology

This part, the hypothesis of this paper, explains the analysis of the macroeconomic effects of standards and to compare with the impact of patents. In addition to the applied model that is adopted from prior studies such as Blind Knut(2004) , Blind and Jungmittag(2008) and Choi HyunKyung(2011). Also, the used dependent and independent variables and data characteristics are specifically illustrated.

4.1 Hypothesis

The literature review about prior researches into the economic effects of standards raised two research questions. The first question is about the empirical results of the effects of standards in Korea such as “Has national standards have an impact on economic growth in Korea’s history?” and “How significantly has it been affected?” And the second one is about the different impacts of standards and patents such as “Compare to patents that are usually considered as a key factor for technology innovation, which one has affected more for economic growth between patents and standards?” and “Are there any differences before and after industrialization period?” Two hypothesizes are formulated from these questions for this study as below.

- Thesis 1 : The national standard in Korea has a significant impact on macroeconomic growth during Korean economic development period from 1970 to 2012.

- Thesis 2 : Standards has a more significant impact than patents on economic growth especially during Korean’s industrialization period from 1970 to 1990.

In thesis 2, it supposed that national standards contribute to the growth of manufacturing and construction industries during the industrialization period because a fundamental function of the standards are to improve productivity and ensure minimum quality and safety of products including construction materials. To set the period of industrialization, the statistics of Korea regarding annual output growth by sector are referred to, showing that before 1990, annual output growth in manufacturing and construction field was over 10%. [17] And Kim JinWoong(2008) [18] states that there was huge change of the industrial structure in Korea after 1990 with a rapid increase in ICT industry in which R&D and patents might be considered as important factors.

<Tab4> Annual output growth by sector(1960-2009)

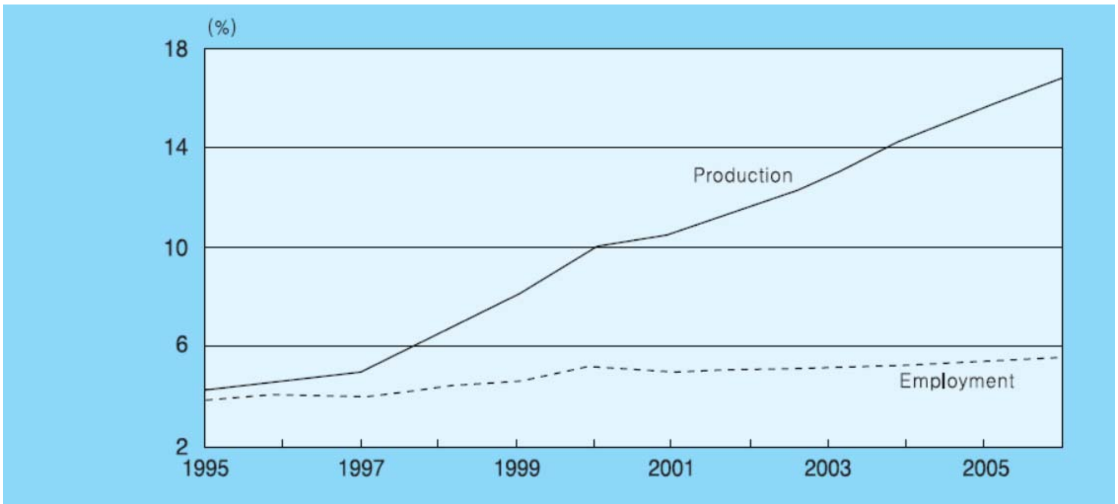
Sector	1960-1970	1970-1980	1980-1990	1990-2000	2000-2009
Manufacturing	16.8	15.8	12.2	8.4	5.4
Construction	-	10.1	9.7	1.4	2.6
Agriculture, forestry and fishing	4.4	1.6	3.5	1.9	1.8
Mining	-	4.7	-0.2	-1.3	-0.3
Services	8.4	9.0	9.7	6.5	3.9

(Source : https://www.kdevelopedia.org/Development-Overview)

[17] "Development Overview," K-Developedia Homepage, accessed by July 29, 2015, https://www.kdevelopedia.org/Development-Overview/all/rapid-changes-industrial-structure--22.do?fldRoot=TP_IND&subCategory=TP_IND_GE#.Vgo5cBHoteU

[18] JinWoong Kim, "Determinants of change of the industrial structure," KIET(Korea Institute for Industrial Economics & Trade), KIET Industrial Economic Review:vol. 13(no. 2), 2008.

<Fig2>Industrial Structure in Korea – ICT Industry(1995-2005)



Source : Bank of Korea, Korea National Statistical Office.
Note : Each share is a ratio out of the non-agricultural sector.

(Source : Kim JinWoong(2008), quoted statistics of BOK)

4.2 Model

This thesis adopts the economic growth model commonly used in Jungmittag(1999), Blind Knut(2004) Blind and Jungmittag(2008), and Choi HyunKyung(2011) which was initially derived from Cobb-Douglas production function as below.

$$Y(t) = A(t)[F(K(t), L(t))] \quad (1)$$

In this equation, Y is the aggregated value added, A is neutral technological change and K, L are measures of capital and labor input and t is time. Jungmittag(1999) and Blind Knut(2004) indicate that technological change can be distinguished by technical progress in domestic and import patent, which are effective standards, domestic patents, and payment for technology licenses. Therefore, national standards, effective standards, and imported technology are applied affecting technological change, Y(t) giving the general equation came in linear in logarithm form as below.

$$y(t) = \alpha \cdot k(t) + \beta \cdot l(t) + \gamma \cdot std(t) + \delta \cdot pat(t) + \varepsilon \cdot lex(t) + u(t) \tag{2}$$

where y(t) is added value at time t(= annual GDP in Korea), k(t) is capital at time t(=annual consumption of fixed capital in Korea), l(t) is labor input at time t (= annual compensation of employees in Korea), std(t) is standards at time t(=effective national standards), pat(t) is patents at time t(=effective domestic patents), lex(t) is imported technology at time t (=expenditure for payment of foreign licenses), u(t) is error term, and t is time(1970-2012). Finally, considering hypothesis2 that is focusing on industrialization period(1970-1990), data restriction that there are no data about the volume of imported technology between 1970-1980 , economic situation that there was Korean economic crisis in late 1997, three equations varying duration and variables affecting technological progress are denoted as below.

$$y(t) = \alpha \cdot k(t) + \beta \cdot l(t) + \gamma \cdot std(t) + \delta \cdot pat(t) + \varepsilon \cdot lex(t) + u(t) \tag{3}$$

where t is from 1980 to 2012, except for 1998

$$y(t) = \alpha \cdot k(t) + \beta \cdot l(t) + \gamma \cdot std(t) + \delta \cdot pat(t) + u(t) \tag{4}$$

where t is from 1970 to 1990

$$y(t) = \alpha \cdot k(t) + \beta \cdot l(t) + \gamma \cdot std(t) + \delta \cdot pat(t) + u(t) \tag{5}$$

where t is from 1991 to 2012, except for 1998

4.3 Data and Data Characteristics

The term of this research is from 1970 to 2012, so time series data for y(t), l(t), k(t), std(t), pat(t), and lex(t) are extracted from KOSIS[19], KIPO[20], Choi DongGeun(2013)[21] and MSIFP[22].

The statistics about annual GDP, annual consumption of fixed capital, and annual compensation of employees in Korea is extracted from "National gross domestic production and expenditure[23]" served by KOSIS. And the data of effective national standards in Korea is gathered from Choi DongGeun(2013) providing various types and time series data about Korean Standards(KS). In terms of effective domestic patents, the statistics of registered data in Korea is obtained from "Patents and utility models grants by industry[24]" provided by KIPO. Lastly, annual expenditure for payment for foreign licenses in Korea is excerpted from "Surveys on Korean Trade Statistics in Technology[25]" from the statistics from MSIFP.

Considering the Korean economic crisis in late 1997, the statistics from 1970 to 2012 except for 1998 are selected in this analysis to remove any external effect. The economic trend in Korea is illustrated in Figure 3 as below.

---

[19] Korean Statistical Information Service

[20] Korean Intellectual Property Office

[21] DongGeun Choi, "Characteristics and implication of the Korean Standard (KS) viewed from statistics," KSA Policy Study 003, KSA(Korean Standards Association), July 2013.

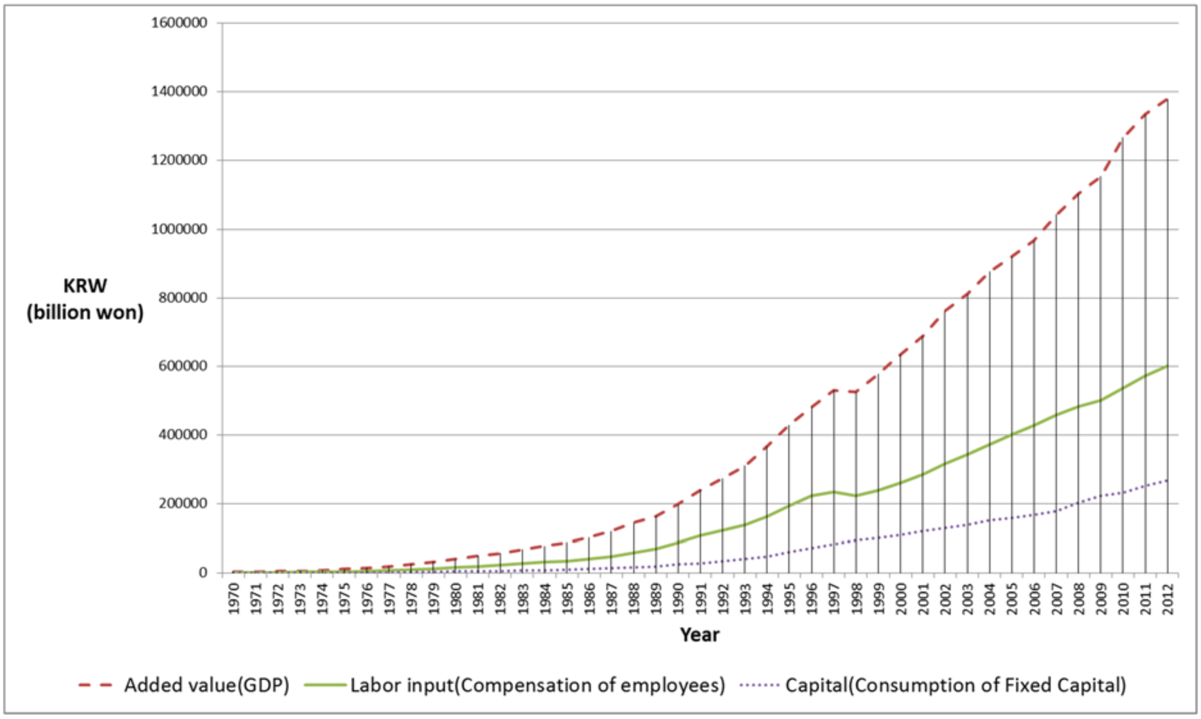
[22] Ministry of Science, ICT and Future Planning

[23] "National gross domestic production and expenditure," KOSIS(Korean Statistical Information Service) Homepage, accessed by June 29, 2015, http://kosis.kr.

[24] "Patents and utility models grants by industry ," KIPO(Korean Intellectual Property Office) Homepage, accessed by June 24, 2015, http://www.kipo.go.kr.

[25] "Surveys on Korean Trade Statistics in Technology," KOSIS(Korean Statistical Information Service) Homepage, accessed by June 29, 2015, http://kosis.kr.

<Fig3> The economic trend in Korea(1970-2012)



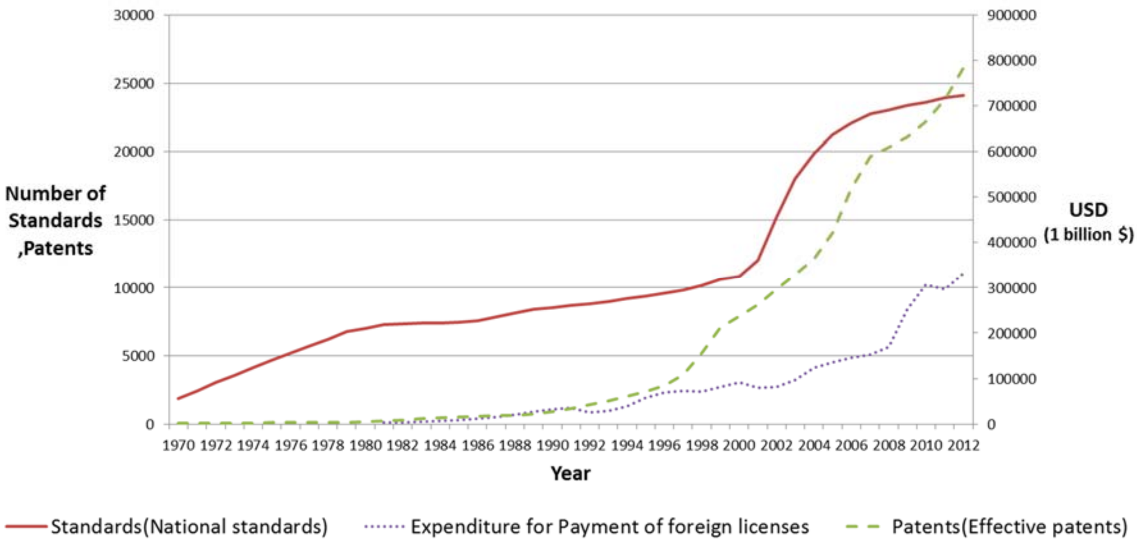
And the effective domestic patents are calculated according to the below equation (6), in accordance with the average durability of patents of about 8.84 year[26]. It assumes that registered patents are cancelled after 9 years.

pat(t) = the number of registered patents(t) –the number of registered patents(t-9) (6)

The data trends include the number of national standards, effective domestic patents, and expenditure of payment for foreign licenses are shown in Figure4. I shows that there are common pattern of steady increases in the number of standards, the number of effective domestic patents, and expenditure for imported technology.

[26] "The trend of patents in Korea," Korea Institute of Patent Information, 2004.

<Fig4> The trend of standards, patents, imported technology in Korea(1970-2012)



The data summary includes log-transformed variables as presented in Table 5. There are 42 observations, except for expenditure for payment of foreign technology. It contains 31 time-series data from 1980 to 2012 except for 1998 since there is no statistics about imported technology before 1980.

<Tab5> The Summary of the data

Variable	Observations	Mean	Std. Dev.	Min	Max
Year	42	1990.833	12.66051	1970	2012
GDP	42	413541	439486.4	2794.8	1377457
Labor Input	42	177814.9	190041.1	939.8	599308.5
Capital Input	42	69535.19	82441.92	175.8	267390
Standards	42	11024.33	6849.659	1846	24129
Patents	42	173352.4	242200.1	2449	784360
Imported Tech	31	3020.635	3144.12	107.1	11052
Ln(Y)	42	11.87185	1.874741	7.935516	14.13575
Ln(L)	42	10.95893	1.972362	6.845667	13.30353
Ln(K)	42	9.752479	2.220646	5.169347	12.49646
Ln(Std)	42	9.11725	0.643288	7.520776	10.09117
Ln(Pat)	42	10.54354	2.041343	7.803435	13.57262
Ln(Lex)	31	7.354199	1.333649	4.673763	9.310367

5. Result

The results of the OLS regressions are explained in Table 6, Table 7, and Table 8. Table6 shows the result for long period 30 years from 1970 to 2012 and shows the impact of each variable on the economic growth in Korea. Table 7 and Table 8 show the result of regressions for short periods divided into two parts that are for 1970 - 1990 and for 1991 - 2012 and observes the differences before and after of industrialization in Korea.

<Tab6> The result of OLS regression for long period (over 30 years)

	Dependent Variable : GDP			
Independent Variables	(1) 1981-2012	(2) 1981-2012	(3) 1981-2012	(4) 1970-2012
Labor input	0.533***	0.595***	0.602***	0.469***
	(0.0356)	(0.0536)	(0.0538)	(0.0531)
Capital input	0.367***	0.279***	0.249***	0.432***
	(0.0317)	(0.0655)	(0.0707)	(0.0538)
Standards	0.0201	-0.00906	-0.0207	0.0589***
	(0.0129)	(0.0229)	(0.0252)	(0.0157)
Patents		0.0371	0.0494*	-0.0233**
		(0.0244)	(0.0268)	(0.00863)
Imported Tech			0.0127	
			(0.0115)	
Constant	2.272***	2.331***	2.447***	2.226***
	(0.144)	(0.146)	(0.180)	(0.182)
Observations	31	31	31	42
R-squared	1.000	1.000	1.000	1.000

Note: The quantities in parentheses below the estimates are the standard errors. ***, **, * indicating significance at, or below, 1, 5, 10 percent respectively.

When standards and patents are considered as independent variables for technical progress as shown in the result (1) and (2) in Table 6, only labor input and capital input have significant impacts on economic growth, and both standards and standards are not significant. However, when all variables including standards, patents, and imported technology are considered at the same time, patents are also correlated with economic growth by 0.0494% at 10% significance level besides labor input and capital input.

To observe the correlation over a long period of time, additional OLS regressions with 42 observations from 1970 to 2012 is applied in the result (4) in Table 6. In contrast to the prior equation with 30 observations, this shows that both standards and patents are significant for economic growth. Increasing the number of national standards significantly affects the growth of GDP in Korea by 0.0589% at 1% significance level. On the other hand, domestic patents have a slightly negative impact by -0.023% at 5% significance level. It indicates that at the initial stage of economic development period from 1970 to 2012 in Korea, standards gave more contributions to economic growth than patents.

<Tab7> The result of OLS regression for short period (industrialization period)

Dependent Variable : GDP			
Independent Variables	(1) 1970-1990	(2) 1970-1990	(3) 1970-1990
Labor input	0.557***	0.422***	0.390**
	(0.111)	(0.107)	(0.140)
Capital input	0.314***	0.517***	0.567***
	(0.103)	(0.103)	(0.172)
Standards	0.139***		-0.0392
	(0.0373)		(0.106)
Patents		-0.0765***	-0.0951*
		(0.0172)	(0.0534)
Constant	1.436***	2.969***	3.374***
	(0.325)	(0.252)	(1.130)
Observations	21	21	21
R-squared	1.000	1.000	1.000

Note: The quantities in parentheses below the estimates are the standard errors. ***, **, * indicating significance at, or below, 1, 5, 10 percent respectively.

In Table 7 shows the results of regressions for 1970 - 1990 which is the assumed industrialization period in Korea. When standards or patents are only considered as an independent variable for technical progress as shown in the result (1) and (2) in Table 7, both variables are significant with different co-efficient values. The standards have a positive relation with increase of GDP by 0.0139% at 1% significance level. In contrast, patents have a negative correlation of 0.0765% at 1% significance level. In the case when both standards and patents are applied as shown in the result (3) of Table 7, only labor input and capital input have significantly positive impacts on economic growth with negative impact of 0.0951% at 10% significance level.

<Tab8> The result of OLS regression for short period (after industrialization)

Dependent Variable : GDP			
Independent Variables	(1) 1991-2012	(2) 1991-2012	(3) 1991-2012
Labor input	0.481***	0.572***	0.567***
	(0.0715)	(0.0516)	(0.0975)
Capital input	0.393***	0.280***	0.285***
	(0.0463)	(0.0528)	(0.0964)
Standards	0.0420		0.00265
	(0.0252)		(0.0397)
Patents		0.0447**	0.0429
		(0.0205)	(0.0339)
Constant	2.412***	2.428***	2.431***
	(0.234)	(0.218)	(0.231)
Observations	21	21	21
R-squared	0.999	0.999	0.999

Note: The quantities in parentheses below the estimates are the standard errors. ***, **, * indicating significance at, or below, 1, 5, 10 percent respectively.

To compare the results of regression for the industrialization period, the same equation for after 1991 is applied and the results are shown in Table 8. The result (1) and (3) in Table 8 explain that standards are not related to GDP. Notably, in (2) patents significantly affect increase of GDP by 0.0447% at 5% significance level. That shows patents became a key factor of the technology progress and had an impact on the market and economic growth because the ICT industry rapidly expanded and technology became more and more important for ICT businesses. However, there is also no correlation between both standards and patents and economic growth in the result (3) of Table 8, when both variables are applied together.

6. Conclusion

Through the analyze of the OLS regressions with independent variables including labor input, capital input, national standards, domestic patents, and imported technology, there are two main findings stating the effects of standards on economic growth in Korea and the differences of impacts of standards and patents as an key factor affecting Korean economy.

Firstly, national standards in Korea had a positive impact on economic growth by 0.0589% at 1% significance level during the economic development period from 1970 to 2012. It shows that the national standards, KS, played an important role for Korean economic growth as a stimulus for increasing quality of products and expanding markets by providing fundamental information to industries. National standards provides fundamental information to industries for helping increase of productivity, quality safety and compatibility among components consisting products by serving common requirements so that the volume of the markets could be expanded.

Secondly, national standards had an important role for Korean economic growth at the initial stage of economic development, which is the industrialization period in Korea. Assuming that standards only affected technical progress except for other variables such as domestic patents, imported technology and so on, standards have a significant impact on increase of GDP by 0.0139% at 1% significance level during the period 1970 to 1990. It indicates that national standards was more importantly used in the manufacturing industry that had rapidly increased in industrialization period in Korea because the national standards provide required information for producing qualified products and services and also the criteria for testing exported goods.

Lastly, after the industrialization period in Korea, domestic patents in Korea became a key factor affect economic development compared to standards. Patents have significantly increased GDP by 0.0447% at 5% significance level when only patents are considered as an independent variable for stimulating technical progress. This shows the key factor inducing technical progress and economic growth have been changed from standards to patens as the structure or Korea industries have been changed from focusing the manufacturing industry to the ICT industry.

However, when standards and patents are applied together, both variables have no correlation with economic growth as shown in Table 7 and Table 8. There are two possibilities for this result. The first one is because of a lack of observation about both standards and patents regarding the Central limit theorem require at least 30 observations for having normal distribution. As shown in the result (4) in Table 6, with 40 observations from 1970 to 2012, there is higher positive impact of standards on growth of GDP compared to patents. The second one is the multicollinearity problem between standards and patents. Both of them are derived from new technology, products, services, etc. and stimulate technical progress.

There are some limitations of this study, which are a lack of data, biased data and causality problem. Only 42 observations during the economic development in Korea and 31 observations about imported technology are applied. Also, the statistics of effective domestic patents are assumed so it could be biased because there is no accumulated statistics for effective domestic patents. Plus, there is a possibility of reverse causality between dependent and independent variables, which mean the national standards and patent might have grown because of the economic growth.

For further study on the economic effects of standards in Korea, more observations by quarters or by sectors could be applied for getting over 40 observations. And other omitted independent variables such as the number of registered new technologies and products could be considered. Also, in-depth analysis for solving causality between standards and economic growth would be required.

APPENDIX A. Statistics of Gross Domestic Production in Korean

- Unit : Billion won(KRW)

- Source : "National gross domestic production and expenditure," KOSIS(Korean Statistical Information Service)

Year	Gross Domestic Production	Compensation of Employees	Consumption of Fixed Capital
1970	2,794.8	939.8	175.8
1971	3,433.3	1,158.5	228.2
1972	4,259.8	1,407.3	290.5
1973	5,513.5	1,841.2	407.7
1974	7,879.9	2,493.8	578.0
1975	10,505.1	3,363.8	789.8
1976	14,413.2	4,737.4	1,091.7
1977	18,520.3	6,404.0	1,453.7
1978	25,023.1	9,141.7	1,896.4
1979	32,218.9	12,256.5	2,635.4
1980	39,471.3	15,452.1	3,740.7
1981	49,324.0	19,127.5	4,753.5
1982	56,858.6	22,304.0	5,907.7
1983	67,509.2	27,017.1	7,106.4
1984	77,855.6	31,116.1	7,941.0
1985	87,239.6	34,528.6	9,233.6
1986	101,840.2	40,085.9	11,066.7
1987	120,204.9	48,069.4	13,547.8
1988	144,073.4	59,159.4	16,673.3
1989	163,518.0	70,335.2	19,166.2
1990	197,712.3	86,290.9	24,057.1
1991	238,877.2	107,421.5	27,972.4
1992	273,267.4	122,094.2	34,329.3

1993	310,073.7	138,498.5	39,841.4
1994	366,054.2	162,395.9	46,004.1
1995	428,927.1	193,564.1	60,348.3
1996	481,140.8	221,867.7	70,835.8
1997	530,347.1	234,806.6	81,787.2
1998	524,476.8	223,393.6	94,297.9
1999	576,872.8	237,609.2	99,429.1
2000	635,184.6	260,585.3	108,657.0
2001	688,164.9	285,669.6	119,653.7
2002	761,938.9	315,333.5	128,173.5
2003	810,915.3	343,475.7	138,835.7
2004	876,033.1	372,207.9	150,833.7
2005	919,797.3	401,449.9	158,964.4
2006	966,054.6	426,142.2	167,364.1
2007	1,043,257.8	457,914.0	178,020.1
2008	1,104,492.2	483,000.6	203,033.6
2009	1,151,707.8	500,935.3	221,748.3
2010	1,265,308.0	536,350.3	232,133.2
2011	1,332,681.0	570,366.6	252,381.9
2012	1,377,456.7	599,308.5	267,390.0

APPENDIX B. Statistics of Korean Standards (KS)

- Unit : The number of Korean Standards

- Source : "Characteristics and implication of the Korean Standard (KS) viewed from statistics," KSA Policy Study 003, KSA(Korean Standards Association), July 2013

Year	Establishment	Revision	Confirmation	Withdrawal	Settlement
1970	159	154	297	4	1,846
1971	593	97	339	13	2,426
1972	619	298	353	11	3,034
1973	537	196	411	13	3,558
1974	561	319	928	13	4,106
1975	605	334	815	13	4,698
1976	523	339	831	26	5,195
1977	506	421	1,369	17	5,684
1978	544	538	1,207	42	6,186
1979	600	563	1,320	34	6,752
1980	327	632	1,722	50	7,029
1981	325	536	1,469	86	7,268
1982	140	765	1,557	93	7,315
1983	165	535	6	64	7,416
1984	120	378	-	123	7,413
1985	101	459	1,650	39	7,475
1986	183	753	1,405	72	7,586
1987	394	734	1,555	147	7,833
1988	359	338	472	76	8,116
1989	331	245	285	47	8,400
1990	368	549	1,388	216	8,552
1991	207	552	1,454	73	8,686

1992	200	626	1,665	102	8,784
1993	222	574	686	31	8,975
1994	242	355	608	32	9,185
1995	309	670	1,496	126	9,368
1996	310	740	1,228	72	9,606
1997	375	1081	1,273	130	9,851
1998	419	444	927	77	10,193
1999	448	598	686	45	10,596
2000	290	427	1,456	41	10,845
2001	1,343	1,426	1,554	182	12,006
2002	3,616	1,810	1,108	446	15,176
2003	3,142	1,518	600	304	18,014
2004	1,988	1,029	702	137	19,865
2005	1,656	1,092	735	270	21,251
2006	995	1,694	2,059	188	22,058
2007	916	2,558	3,351	214	22,760
2008	483	1,891	3,042	181	23,062
2009	567	1,508	2,323	257	23,372
2010	361	984	2,488	111	23,622
2011	411	1,050	3,441	110	23,923
2012	525	1,518	4,681	319	24,129

APPENDIX C. Statistics of Domestic Patents in Korea

- Unit : The number of domestic patents in Korea

- Source : "Patents and utility models grants by industry ," KIPO(Korean Intellectual Property Office)

Year	Registered Domestic Patents	Pending Domestic patents	Effective Domestic Patents*
1970	266	1,846	2,449
1971	229	1,906	2,579
1972	218	1,995	2,574
1973	199	2,398	2,560
1974	322	4,455	2,594
1975	442	2,914	2,780
1976	479	3,261	2,831
1977	274	3,139	2,746
1978	427	4,015	2,856
1979	1,419	4,722	4,009
1980	1,632	5,070	5,412
1981	1,808	5,303	7,002
1982	2,609	5,924	9,412
1983	2,433	6,394	11,523
1984	2,365	8,633	13,446
1985	2,268	10,587	15,235
1986	1,894	12,759	16,855
1987	2,330	17,062	18,758
1988	2,174	20,051	19,513
1989	3,972	23,315	21,853
1990	7,762	25,820	27,807
1991	8,690	28,132	33,888

1992	10,502	31,073	41,957
1993	11,446	36,491	51,038
1994	11,683	45,712	60,453
1995	12,512	78,499	71,071
1996	16,516	90,326	85,257
1997	24,579	92,734	107,662
1998	52,900	75,188	156,590
1999	62,635	80,642	211,463
2000	34,956	102,010	237,729
2001	34,675	104,612	261,902
2002	45,298	106,136	295,754
2003	44,165	118,652	328,236
2004	49,068	140,115	364,792
2005	73,512	160,921	421,788
2006	120,790	166,189	517,999
2007	123,705	172,469	588,804
2008	83,523	170,632	609,692
2009	56,732	163,523	631,468
2010	68,843	170,101	665,636
2011	94,720	178,924	715,058
2012	113,467	188,915	784,360

(Note : “Effective domestic patents” is calculated under assumption that registered patents are cancelled after 9 years, which is pat(t) = the number of registered patents(t) –the number of registered patents(t-9).)

APPENDIX D. Statistics of Expenditure of Payment on Foreign Technology

- Unit : Million dollar (USD)
- Source : "Surveys on Korean Trade Statistics in Technology," KOSIS(Korean Statistical Information Service)

Year	the amount of export (A)	the amount of import(B)	Balance of Trade(A-B)	Trade Volume(A+B)	Balance of Trade-Ratio(A/B)
1981	11.8	107.1	-95.3	118.9	0.11
1982	18.2	115.7	-97.5	133.9	0.16
1983	18.9	149.5	-130.6	168.4	0.13
1984	16.9	213.2	-196.3	230.1	0.08
1985	11.3	295.5	-284.2	306.8	0.04
1986	11.7	411	-399.3	422.7	0.03
1987	9.1	523.7	-514.6	532.8	0.02
1988	8.9	676.3	-667.4	685.2	0.01
1989	10.5	888.6	-878.1	899.1	0.01
1990	21.8	1,087.00	-1,065.20	1,108.80	0.02
1991	35.2	1,183.80	-1,148.60	1,219.00	0.03
1992	32.5	850.6	-818.1	883.1	0.04
1993	45.1	946.4	-901.3	991.5	0.05
1994	110.9	1,276.60	-1,165.70	1,387.50	0.09
1995	112.4	1,947.00	-1,834.60	2,059.40	0.06
1996	108.5	2,297.20	-2,188.70	2,405.70	0.05
1997	162.9	2,414.60	-2,251.70	2,577.50	0.07
1998	140.9	2,386.50	-2,245.60	2,527.40	0.06
1999	193.3	2,685.80	-2,492.50	2,879.10	0.07
2000	201	3,062.80	-2,861.80	3,263.80	0.07
2001	619.1	2,642.70	-2,023.60	3,261.80	0.23
2002	638.1	2,721.50	-2,083.30	3,359.60	0.23

2003	816.2	3,236.50	-2,420.30	4,052.70	0.25
2004	1,416.40	4,147.50	-2,731.10	5,563.90	0.34
2005	1,624.90	4,524.10	-2,900.20	6,150.00	0.36
2006	1,897.00	4,838.00	-2,941.00	6,734.00	0.39
2007	2,178.00	5,103.00	-2,925.00	7,282.00	0.43
2008	2,530.00	5,670.00	-3,140.00	8,200.00	0.45
2009	3,582.00	8,438.00	-4,856.00	12,020.00	0.42
2010	3,345.00	10,234.00	-6,889.00	13,579.00	0.33
2011	4,032.00	9,900.00	-5,868.00	13,933.00	0.41
2012	5,311.00	11,052.00	-5,741.00	16,363.00	0.48

REFERENCE

1. ″What is a standard.” ISO(International Organization for Standardization). Accessed June 26, 2015. http://www.iso.org/iso/home/standards.htm.

2. The statistics of the Korean industrial standard. KATS(Korean Association for Technology and Science) under Ministry of Trade, Industry, and Energy, January 2015.

3. National total production and expenditure. KOSIS(Korean Statistical Information Service) Homepage. Accessed June 14, 2015.
http://kosis.kr/statHtml/statHtml.do?orgId=301&tblId=DT_102Y003&conn_path=I3.

4. Jungmittag A, Blind K and Grupp H. “ Innovation, standardization and the longterm production function: a co-integration approach for Germany 1960-96.” Zeitschrift f¨ur Wirtschafts- und Sozialwissenschaften, 1999.

5. Blind Knut. "The Economics of Standards: Theory, Evidence, Policy." Edward Elgar, July 2004.

6. Blind K and Jungmittag A. “The impact of patents and standards on macroeconomic growth: a panel approach covering four countries and twelve sectors.” Journal of Productivity Analysis, July 2007.

7. “The Economic Impact of Standardization : Technological Change, Standards Growth in France.” AFNOR Group, June 2009.

8. “National impact.” What’s the bottome line, published by ISO, July 2012.

9. Choe HoChull. “The economic effects of standardization in Korean manufacturing industry.” MA, School of IT Business, 2005.

10. Choi HyunKyung. “The economic impact and implication of standards.” KIET(Korea Institute for Industrial Economics & Trade), May 2011.

11. “Types and Functions of Standards.” Future Society and Standards, KSA(Korean Standards Association), 6nd ed., March 2015.

12. ″Development Overview.” K-Developedia Homepage. Accessed by July 29, 2015. https://www.kdevelopedia.org/Development-Overview.

13. Kim Jin Woong. "Determinants of change of the industrial structure. " KIET(Korea Institute for Industrial Economics & Trade), KIET Industrial Economic Review:vol. 13(no. 2), 2008.

14. “National gross domestic production and expenditure.” KOSIS(Korean Statistical Information Service) Homepage. Accessed by June 29, 2015. http://kosis.kr.

15. Choi DongGeun. “Characteristics and implication of the Korean Standard (KS) viewed from statistics.” KSA Policy Study 003, KSA(Korean Standards Association), July 2013.

16. “Patents and utility models grants by industry .” KIPO(Korean Intellectual Property Office) Homepage. Accessed by June 24, 2015. http://www.kipo.go.kr.

17. “Surveys on Korean Trade Statistics in Technology.” KOSIS(Korean Statistical Information Service) Homepage. Accessed by June 29, 2015. http://kosis.kr.