The Effects and Implication of Green Public Procurement with Economy-wide Perspective

Yeo, Yeong-jun[1], SHIN, Ki-yoon[1], Jeong-dong Lee[1]

[1] Technology Management, Economics and Policy Program, Seoul National University, Gwanak-gu, Seoul 151-742, Republic of Korea; E-Mails: yyj913@snu.ac.kr (Y.Y.); kiryoon92@snu.ac.kr (K.S); jeongdonglee@gmail.com (J.L.)

Abstract: Nowadays, with increasing interests of demand-side innovation policy, there is needs for investigating public procurement policy aiming to strengthen the industrial competitiveness by expanding new markets with innovative activities. Public Procurement is regarded as the most effective policy for stimulating innovation in relevant sectors. Under this background, each countries in OECD spends about 15~20% of its GDP on public procurement, and most of the demands in industry and technology sector such as energy, environment, health, construction is stimulated by public procurement. Especially, in order to achieve both mitigating climate change and economic revitalization, the share of green public procurement which is public procurement for green products in total public procurement is enlarging among developed countries.

Despite of the amount of public procurement, and policy significance and effectiveness, there is few study on the effects of public procurement for innovation and the macroeconomic analysis from public procurement. In addition, some empirical studies which investigated policy impact of green public procurement are also limited in partial equilibrium perspectives, and they did not show the integrated and macro-economic impact of public procurement. Therefore, with previous literature reviews, this study presents general equilibrium perspectives which can analyze environmental, economic, and social benefits from public procurement simultaneously. Based on the conceptual framework from the previous literatures, further study will present empirical results of the impacts of green public procurement quantitatively by computable general equilibrium model. From this study, it is expected to contribute for validation of the potential policy as well as present conceptual framework for the macroeconomic impact of public procurement policy.

Keywords: Green public procurement, innovation policy, policy impact, general equilibrium

---

1. Introduction

Nowadays, there is increasing interest on demand-side innovation policy which can impact on market demand among developed countries such as EU countries, USA, and Japan, and it is different from previous policy framework which focused on supply-side innovation policy.

This means that while previous policy framework regarded the policy only for support of technology innovation and development, new policy framework targets not only technology innovation but also creation and escalation of market for the innovation. With this change of innovation policy framework, the interest on public procurement which is the representative policy tool for demand-side innovation policy is growing. According to OECD (2015), the amount of spending for public procurement in each country was about 18% of its GDP at average in 2012. Korea spends relatively small amount for public procurement compared to other OECD countries, but Korean government tries to achieve innovation goal with public procurement with cooperation among National Science and Technology Committee and other government agencies (Sung, 2011).

Especially, in order to accomplish two goals which are mitigating climate change and sustainable economic growth simultaneously, the importance of green public procurement (GPP) which is public procurement of green product and technology is growing among developed countries. Green industry has significant technological and economic uncertainty because commercialization and technology innovation is difficult due to huge amount of sunk cost. For this reason, developed countries which have experienced the success of IT, BT, and NT by public lead process try to innovate and develop GT with active intervention of public sector, and GPP is one of the most effective tool for them (Mazzucato, 2015). The share of GPP of total public procurement is higher than 20% in major EU developed countries, and the UK, especially, spends 75% of public procurement as GPP (PwC and Ecofys, 2009).

Despite the amount, importance, and effectiveness of public procurement, there is few study on the macroeconomic and innovation impact of public procurement. In addition, some empirical studies which tried to investigate the policy impact of GPP are limited in environmental impact, or microeconomic impact based on partial equilibrium framework. Therefore, this study presents the fact that GPP has macroeconomic impacts with various paths and analyzes these impacts with general equilibrium perspectives simultaneously.

The organization of this study is as follows. Chapter 2 describes the current status of public procurement and GPP, and also presents the role and importance of public procurement as innovation policy. Chapter 3 discusses the various paths of macroeconomic impact of GPP, and suggests the general equilibrium perspectives in order to analyze these paths synthetically. Finally, Chapter 4 concludes this study and suggests the implication for further studies.

2. Current Status of Public Procurement and Green Public Procurement

2.1. Current status and role of public procurement

Public procurement refers to the procurement of necessary resources by government, and the public concern should be considered on the procurement process different from the private market (Sung, 2011). Generally, public procurement is done for products and industries which have potential economic and social benefits when it diffused but have difficulty in creation of market due to the low technological competitiveness (Edquist et al., 2015; Edler and

Georghiou, 2007; Lee et al., 2011). Public procurement also mainly aims environment protection, sustainable growth, and improvement of quality of life. Moreover, especially among EU countries, public procurement is implemented as the way to achieve both stimulating economic growth and solving social problems1 simultaneously (European Commission, 2013; 2015; OECD, 2011; Choi et al., 2011; McCrudden, 2004). According to OECD (2014), each OECD country spends the amount of 18% of its GDP for public procurement on average, and public procurement has significant proportion of total demand in energy, environment, health care, and construction sectors.

Public procurement is evaluated as the most direct and effective demand-side policy to stimulate innovation among the other innovation policies (Edquist et al., 2015; Uyarra et al., 2014; Choi et al., 2011; Edler and Georghiou, 2007; Marron, 2004). According to Edler and Georghiou (2007), supply-side innovation policy focuses on improvement of innovation capacity by circulation of knowledge, capital, and labor force among industries, and includes R&D program by public research institutions, R&D subsidy, and program of human resources education. On the other hand, demand-side innovation policy specifies the demand, induces the reaction of the entities of innovation, and, as a result, instills the willingness to innovate of these entities. Regulation, public procurement, and standardization can be included in demand-side innovation policy. From this categorization of innovation policies, there were some empirical studies that compared the innovation result between supply-side policy and demand-side policy (Mowery and Rosenberg, 1979; Rothwell and Zegveld, 1981; Rothwell, 1984; Geroski, 1990; BDL, 2003; Edler, 2006; Borras and Edquist, 2003).

Most of the previous literature which compared the effectiveness between two policy tools commonly asserted that public procurement which is the demand-side innovation policy is more effective tool for stimulating innovation than other supply-side innovation policy tools. For instance, Rothwell and Zegveld (1981) and Geroski (1990) insisted that public procurement stimulates innovation more than R&D subsidy and tax grants in the long run. In addition, Palmberg (2004; 2005) studied commercialized innovation projects from 1984 to 1998 in the world, and concluded that about 48% of the successful commercialized projects was due to the public procurement empirically. The empirical study from BDL (2003) also investigated that new demand is the most crucial factor for induction of innovation by the survey from several innovative firms. For Korean case, Choi et al. (2014) addressed that the growth rate of technology development grows more sustainably in public procurement for small and middle entrepreneurs than in tax grants for ones.

These various previous studies drew the common result that public procurement, or demand-side policy tools, is the more effective way to stimulate innovation than supply-side policy tools from empirical analysis and case studies. This is because supply-side innovation

[1] For example, Lead Market Initiative by EU focuses on creation and escalation of lead market for new products and services which can solve social problem when it diffuses and increase sustainable employment and growth simultaneously, especially in public health, energy, sustainable production, and safety sectors.

policy only induces the development of new technology, products and services with focus on technology suppliers, so the long run effects such as technology diffusion and learning process is limited. Moreover, supply-side innovation policy tools reduce the private R&D spending, so there is a risk for private sectors to crowd-out the R&D investment (Aschhoff and Sofka, 2008). On the contrary, public procurement induces innovation by specifying new demand. In the early stage of industry and market, potential suppliers have a problem of asymmetric information of potential demand due to the significantly high market uncertainty and small and scattered early demand (Moors et al., 2003; Smits, 2002; Edler and Georghiou, 2007). In this situation, public procurement can reduce or even remove the market uncertainty of potential suppliers by specifying demand, and promote more interaction among suppliers and buyers and network effects. In other words, public procurement provides the chance to the potential suppliers to earn profit from innovation, and, as a result, it stimulates the interaction between technology suppliers and users (Edquist et al., 2015; Edler and Georghiou, 2007; Aschhoff and Sofka, 2008; Edquist, 1998; Geroski, 1990).

Therefore, public procurement, or demand-side innovation policy, can enlarge the depth and width of the innovation policy with consideration of demand and users as entities of innovation newly (Choi et al., 2011). Because of the increasing government spending, the limitation of existed supply-side innovation policy[2] and the analysis of innovation effects of public procurement, public procurement has increasing portion in innovation policy among several countries nowadays.

2.2. Green public procurement and the role of government

In the case that certain technology can give numerous benefits for users and solve social problem but do not have enough demand to create the market, the intervention of government is needed for specifying demand and creating new demand. From this perspective, public procurement can change the social demand for market demand, and sustainable growth and mitigating climate change are the examples. Actually, most of the demand in energy, environment, health care, and construction sectors consist of public demand by public procurement, and, especially in energy and environment sectors, GPP has significant portions of the demand (Kahlenborn et al., 2010; PwC and Ecofys, 2009).

Developed countries are now focusing on green revolution[3] with two purposes which are mitigating climate change and economic revitalization by developing green industries, followed by world-wide understanding of seriousness of climate change (Mazzcato, 2015;

[2] Choi et al., (2011) emphasized that there is a limitation to continue to implement supply-side innovation policy, and the marginal productivity can also be decreased.

[3] From United Kingdom where research group of financial, energy, and environment experts suggested "green new deal" policy to the government, UNEP addressed the concept of "green economy", and Center for American Progress (CAP) also proposed "green recovery" strategy (Ministry of Government Legislation (Korea), 2012)

Marron, 2003). The policy strategy which aims decoupling of economic growth and environment damage from usage of resources, and stimulating economic growth with environment-friendly way is called "win-win" strategy (UNEP, 2011; Marron, 2003). Departed from previous "win-lose" situation between economic growth and environment impact, developed countries implement both supply-side and demand-side innovation policy in order to accomplish both innovation with environment-friendly and energy efficient technology and economic growth with foster green industries. Therefore, each country actively enforces not only supply-side policy such as R&D support policy for green energy technology development, but also public procurement policy for the products which are energy efficient and environment-friendly.

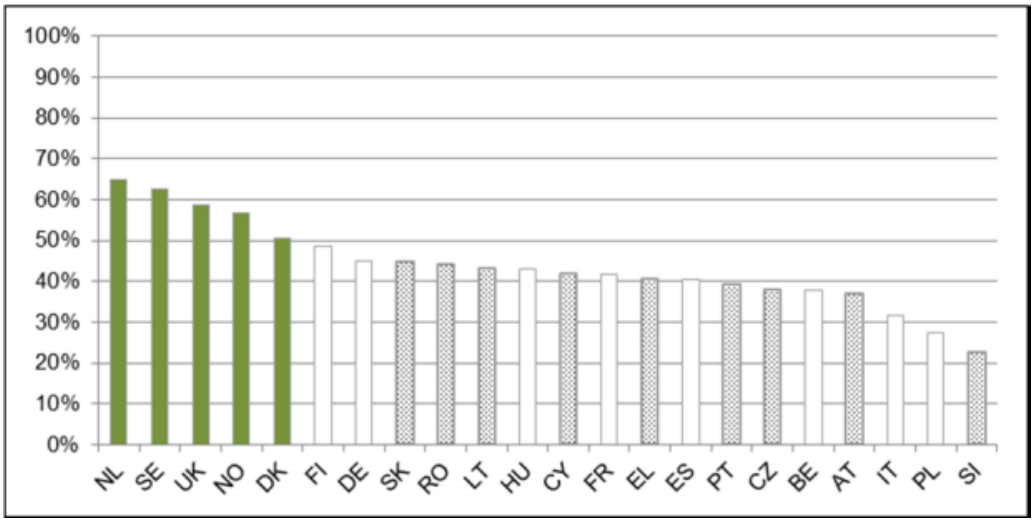

Figure 1. GPP share of European countries in total public procurement
(Source: Kahlenborn et al., 2010)

In order to achieve the expansion of green industry and following sustainable development, it is required to change the energy system fundamentally. Green technology is still infant, so market and technology uncertainty exists substantially. Therefore, potential suppliers suffers from the problems of asymmetric information for expected market demand (Edler and Georghiou, 2007). In addition, energy industry has significant sunk costs in development and production, and relatively high path dependency to the existing technology (Mazzucato, 2015; Lovio et al., 2011; Lafferty, 2009). Consequently, the speed of technology transition to green energy technology is very slow due to significant learning and adjustment costs, so there is a tendency that the creation of demand is delayed (Choi et al., 2011; Edler and Georghiou, 2007). With these distinctive characteristics of energy industry, it is concluded that the public sector should provide strong signal of specified demand to the supply parts of energy industry by creating and escalating demand.

From this perspective, European Union focuses on creation of lead market for new products and services with "Lead Market Initiative", especially in public health, energy, and sustainable

production sectors (European Commission, 2011; 2007; Uyarra and Flanagan, 2009). United Kingdom and other European countries are implementing public procurement for green products and services which is cost-saving (DTI, 2006).[4] In case of United States, the government started to intervene for GPP, which is the federal and state government specify the green standard such as energy efficiency ratio, and bio-based products for 95% of total public procurement (UNEP, 2013; ISEAL, 2013; Conway, 2012; Lee et al., 2011; Kim et al., 2010).[5] Japan enacted the Law on Promoting Green Purchasing[6] in 2000, and supports the diffusion of GPP with the effort of creating Green purchasing network which promotes the demand of green products. U.K., U.S., and Japan are actively doing public procurement in order to promote green technology which is new potential driving-force of economic growth and can be utilized for mitigating climate change.

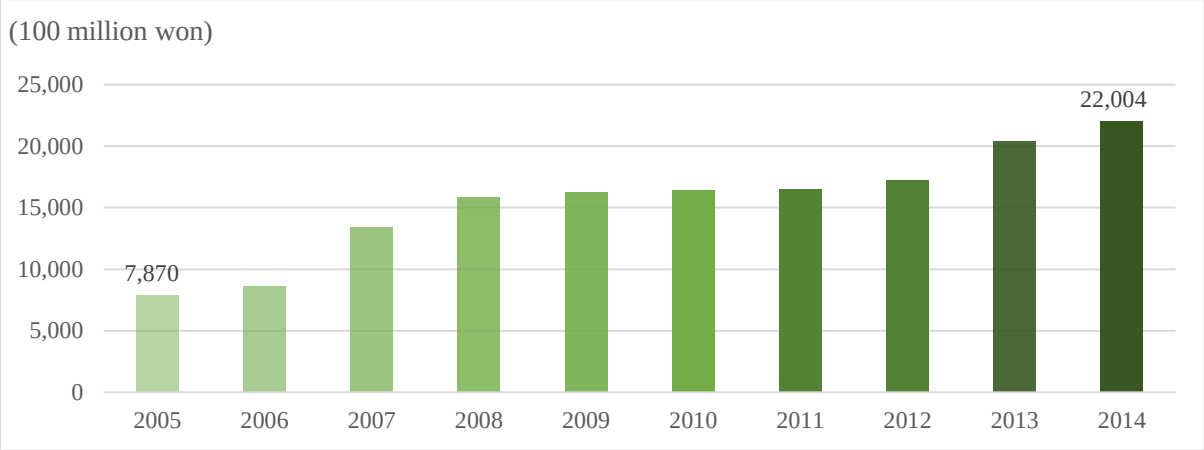

Figure 2. Trends of GPP level in Korea (2005-2014)
(Source: Ministry of Environment, 2015)

In addition, Korea have also stressed out government's role as large-scale purchasers in the market economy. In this context, Korea established laws for green purchasing entitled as the Act on Promotion of Purchase of Green Products in 2005. Under this scheme, Korean government has supported sustainable public procurement start-up phase. From 2005, the

[4] Not only Lead Market Initiative, GPP of EU started with "Integrated Product Policy" in 2003 and embodied by "Public Procurement for a Better Environment" in 2008 as one of the policies from "EU Sustainable Development Strategy" in 2006. EU recommends to follow the criteria for environment protection by each sectors for the EU countries. The relative codes of EU's GPP is Eco Label, Energy Star, Environmental Management System (EMAS), and Energy Performance of Buildings Directive.

[5] United States is implementing 7 GPP programs (6 mandatory, and 1 voluntary), which are procurement of recycled products, procurement of energy efficient products, procurement of the vehicles with alternative fuels, procurement of bio-based products, regulation of environment pollution and toxic substances, and procurement of environment-friendly products.

[6] Japan made the green/environment standards for 19 industry sectors with 246 products types and specified that public agencies should buy the qualified products by this law.

purchase level from the governments towards green products has increased drastically as shown in the <Figure 2>. It is also found that a significant share of the public purchase comes from the green public procurement with an average share of 55% in all government agencies' purchase in 2014 (Ministry of Environment, 2015).

However, there are some critics for the effectiveness of GPP, some economists assert that the government intervention by public procurement could hinder efficiency of the market, so they insists that the role of government should be limited (Mazzucato, 2015; Brenton et al., 2011; Hindley et al., 2007). Moreover, with the perspectives that GPP is the part of environment policy, some experts addressed that direct environment regulation such as cap and trade system and carbon tax is more effective tool for reduction of CO2 emission and mitigating climate change than GPP (Hindley et al., 2007; Aschhoff and Sofka, 2008).

The reason why there is a debate of the potential effectiveness of GPP and there was not deeper analysis for it is absence of the combinational analysis framework for analyzing the impact of GPP. The main purposes of GPP are mitigating climate change by enhancing social environment effect, securing industry competitiveness by stimulating innovation in existing and new industries, and increasing the effectiveness of government spending and social welfare by diffusion of green products (European Commission, 2012; 2011; Yoon et al., 2009). In other words, GPP has indirect and direct impacts on the whole economic system with various paths. However, most of the previous researches which tried to analyze the impact of GPP were limited on partial equilibrium perspectives and for case studies. From this perspective and framework, it is difficult to analyze combinational impact of economy and society of GPP because policy spillover effects among industry and economic players cannot be examined properly. Therefore, next chapter will suggest proper framework for analysis of macro-economic impact of GPP with addressing the several paths of GPP impact by combinational and integrational perspectives.

3. Macro-economic impact of GPP

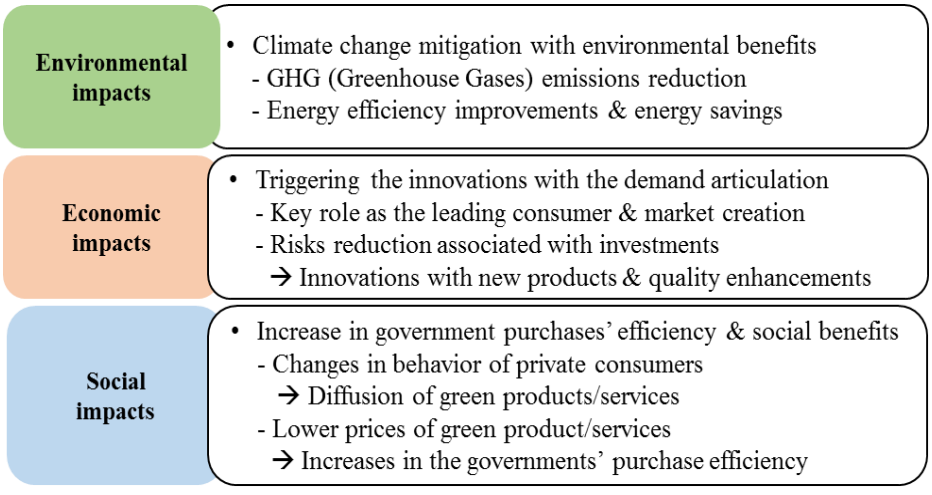

Figure 3. GPP's potential effects in three dimensions (Environmental, Economic, and Social effects)

As mentioned before, GPP has environmental and social purpose of mitigating climate change and economic purpose of stimulating innovation by enough securement of demand. These purposes of GPP can be depicted as <Figure 3>. Environmental impacts of GPP are energy savings by development of energy efficiency and reduction of greenhouse gases. Economic impacts are market creation and escalation, reduction of market uncertainty and risk of potential suppliers by specifying demand, and appearance of new products and quality improvement by stimulating innovation. Social impacts are increasing social welfare by improvement of quality and price reduction and enhancement the effectiveness of government spending. This chapter addresses these impacts of GPP from several cases and analyzing results, and provides conceptual framework which can combine these impacts.

3.1. Climate change mitigation and energy efficiency improvements effects

Environmental impacts of GPP consists of main purposes and expected effects of GPP in most of countries. Several empirical showed that GPP influences in reduction of greenhouse gases and energy consumption, and restraint of toxic substances.

Greenhouse gases, or CO2, is known for the main reason of climate change followed by global warming, and they are mainly emitted from energy generation by fossil fuels and transportation sectors. Therefore, many countries have policies of GPP such as strategic procurement of renewable energy and procurement for transportation without fossil fuels. In the case of Korea, it was investigated that 543 thousand tons of CO2 was reduced by public procurement of energy efficient products.7 In Europe, Slovenia take the policy called “GPP National Action Plan” in 2009, and set an objective which make 100% of procurement of product and service in energy sector as GPP. In addition, Slovenia regulated that the vehicles with Euro 5 emission standards only can be sold in the country. As a result, the amount of CO2 emission per vehicle in Slovenia reduced from 45g/km to 3g/km in 2011 (European Commission, 2012).

In addition, GPP has an effect of reducing energy consumption with the procurement of energy efficient products by public sector. From late 1970s, there was an interest on energy efficient products in order to get cost-savings, and the government tried to reduce the demand of energy by stimulating consumption of energy efficient product with policy tools (Gillingham et al., 2009). Each country including Korea has its own standards of energy efficiency for the products, and GPP is implemented as the government preferentially buy the products with high levels of energy efficiency. Lee et al. (2013) analyzed that the economic impact of energy saving by preferential procurement for energy efficient products in 75 product types was 149.8 billion Korean won. In Spain, the city of Badalona conducted the GPP policy for public schools from stationary to IT products. Especially, the city changed the paper of the public schools to

[7] Korea Environmental Industry and Technology Institute (KEITI) measured the amount of CO2 reduction, cited from “Environmental and Economic Benefit Analysis of Green Products” (KOECO, 2007)

recycled paper, and it experienced the reduction of energy consumption by 2,048kWh per year (European Commission, 2012).

These environmental impacts reveal that GPP has positive impacts for mitigating climate change as an environment policy. Moreover, in the long run, by changing energy system into environment-friendly way, improvement of social welfare and quality of life can be achieved.

Many previous researches present the environmental impacts as a direct impact of GPP. Environmental impacts of GPP are the reduction of greenhouse gases, curtailing energy consumption by enhancement of energy efficiency, and the decrease of toxic substances. However, most of ex-post empirical studies and policy assessment reports only investigate the benefit and cost of GPP partially, without consideration of the reaction of other economic players and interaction between industries. Therefore, in order to analyze macro-economic impacts of GPP generally, the effects of GPP by changing behavior of several economic entities and markets with various paths should also be considered.

3.2. Government as a lead consumer and market creation and escalation

GPP can create and escalate the market because the public sector take a role of lead consumer in green products and services. The effects of market creation and escalation by public sector can be divided into three stages (Edquist et al., 2015). First stage is market creation, which the public sector makes a contract of procurement green technology not yet commercialized preferentially. Second stage is that the public sector procures green products or services which were commercialized but were not have enough demand in large quantities, which is market escalation stage. Final stage is market consolidation, which is the public sector stimulate the competition between suppliers when the green products or services have enough market to entry and exit. <Figure 4> depicts this flow of impact on market of GPP.

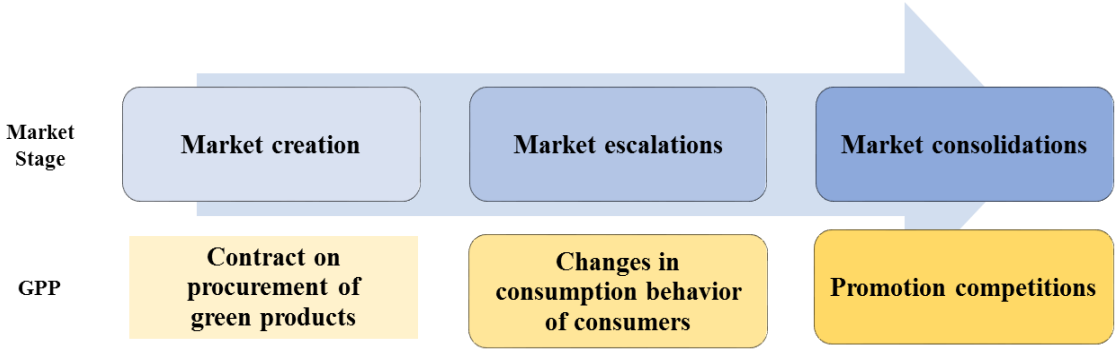

Figure 4. GPP's effects in terms of market stages

First of all, public sector reduce and eliminate market and technological uncertainty by specification of the demand of green technology and products. Thanks to the public sector, potential suppliers can escalate their pre-commercialization R&D and commercialization process (Edquist et al., 2015; Edler and Georghiou, 2007). Edquist (1996; 2015) mentioned

that public procurement for innovation stimulates not only the development of new technology but also the diffusion of technology. In addition, he strengthened that public procurement is an important policy tools for adjustment and absorption of new technology into the market properly. Bauer et al. (2009) investigated the 31 cases of GPP from Denmark and Sweden, and concluded that GPP let green products become a standard and achieve more demand by creation of the markets. In other words, when the technology is in early stage, GPP remove market uncertainty and make potential suppliers enter the new market, which is the impact of market creation (Bauer et al., 2009; Marron, 2003; van Calster, 2002).

Moreover, government utilizes GPP in order to give signal to public sectors to change their demand more into the green products (OGC, 2003; Marron, 2003; OECD, 2000). Kunzlik (2003) studied various certification systems of green products and GPP policies in EU, NAFTA, Australia and New Zealand. From the study, he insisted that the governments did a role of lead consumers in new markets for the green technology and products in most of the cases, and found that GPP and certification systems of green products induced the private demand into greener products. In sum, GPP can change the behavior of consumers into greener way. Consumers in many countries, especially in Europe, U.S. and Japan, started to change their consumption pattern for the green products, and this lead the market escalation of the green products (Payen et al., 2013).8 By market creation and escalation thanks to GPP, the prices of green products and services decrease, and the market expand further because the consumption pattern of private sectors change into environment-friendly way (Korkmaz, 2012). In conclusion, government can stimulate demand and expand the market of its own standard green products and technology by GPP with stimulating R&D.

Followed by market creation and escalation, size and structure of the market are also changed. After the stage of market escalation, the number of potential suppliers which are willing to participate in GPP contracts increases. By increasing number of entrants, competition in the market is stimulated, and the price of green products and services goes down and the quality of them is enhanced (Uyarra and Flanagan, 2009; OFT, 2004). In addition, OFT (2004) addressed that the competition in lowering price is intensified if there is high homogeneity among the potential suppliers for GPP contracts, and the competition of the quality is increased in the case of high heterogeneity among the suppliers. Therefore, by the formation of the market for green products, intensity of the competition influences on the market power of suppliers, and, as a result, affects the decision-making of them in terms of investment and innovation (Uyarra and Flanagan, 2009; OFT, 2004; OGC, 2003).

[8] In the countries which the governments are actively implementing GPP such as Europe, U.S., and Japan, the consumers are changing their awareness and behavior of buying the green products. For example, 80% of the consumers in Europe responded that they consider the environmental impact of the goods and services when they buy something. 95% of U.S. consumers also said that they can buy the green products. In addition, 90% of Japanese consumers replied that they buy the green products when they face the non-green products with same price and functions.

Brannlund et al. (2009) and Bergman et al. (2005) suggested that competition benefits such as the intra-industry innovation and specialization can be achieved by public procurement, not by in-house production and supply. Empirical result was found in the case of the preferential procurement of energy saving technology in Italian public administrative building construction, and European Commission (2012) argued that 27% of cost saving was achieved by stimulating competition by that procurement in about 5000 administrative buildings.

In conclusion, GPP creates the market by preferential procurement for green technology, escalates it by stimulating private "green" demand and innovation activities of suppliers, and consolidate it by promoting competition of the green products. From this flow, developers of green technology can successfully commercialize their technology into the products, producers of the green products and services can run their business with stable demand, and the consumers can get benefits from quality enhancement and price reduction by competition.

3.3. Investment induction, emergence of new products by innovation, and quality enhancement

The main goals of GPP are the emergence of new products and the enhancement of quality of the products by innovation, and the improvement of competitiveness of green industry. As mentioned before, GPP eliminate the market and technology uncertainty for green technology and industry. Public procurement is important for the technology in early stage because it allow the technology to have enough demand for commercialization, and the government does a role of lead consumer in order to mitigate market risk for the technology (Choi et al., 2011; Uyarra and Flanagan, 2009; Edler and Georghiou, 2007; Marron, 2003). Therefore, GPP reduce the uncertainty across whole stage of production from development of new technology to diffusion of the products by specifying the information on demand for the industry, and it leads more innovation activity of suppliers and investment for the production (Geroski, 1990). While R&D subsidy which focuses on supply-side only stimulates technology development and diffuse the capacity of technology innovation, public procurement increases the production capacity of private sectors as well as what R&D subsidy does (Heo, 2011).

Public procurement, which is the demand-side innovation policy, help the private sector discover and develop the market for new products and new technology, with the role of the public sector as testing-ground of the innovative products (Rothwell, 1994; ECWG, 2005). Marron (2003) insisted that GPP influence much more in the early stage of production cycle, which is the development of new products and services. With respect to the fact that green industry is in the early stage yet and has high path dependency to the existing technology, Marron's argument is appropriate. Actually, Westling (2000) mentioned that several inventions such as energy saving copy machine, and energy efficient bulb and television was leaded by GPP before. In addition, because GPP contracts usually include green or environment standards for the procured products or services, suppliers who already have relating technology increase

their investment on product and technology development, and it leads incremental innovation (Edquist and Zabala, 2012; Hommen and Rolfstam, 2009).

However, when the risk in the commercialization is very high or the related markets are not formulated well, the effect followed by emergence of new products and product innovation is very limited (Marron, 2003). In this case, public procurement can solve these barriers. DTI (2007) and Bauer et al. (2009) stressed that GPP can mitigate the risk and uncertainty from demonstration stage to scale up stage in the case that commercialization is delayed due to high market uncertainty despite the existence of environment-friendly and energy efficient production technology. (Figure 5)

Bauer et al. (2009) presented the example of Sweden, which is Sweden government procured bio-fuel taxi vehicles. By this GPP policy, vehicle production firms such as Volvo can face reduced risk for technology investment, and they increased investment and diffused more bio-fuel vehicles, Bauer et al. mentioned. Moreover, IISD (2012) addressed the case of Toronto, Canada. IISD insisted that the project called "LightSavers" which has a goal of diffusion of LED lights in order to mitigate climate change and improve air condition results in successful diffusion of LED lights with active participation of not only big companies but also small and middle-sized entrepreneurs (SMEs). IISD investigated the reason why SMEs actively participated in the project, and concluded that it is because they can share and reduce the risk for commercialization. In sum, GPP stimulate investment in the pre-commercialization and commercialization stage by giving the signal to the private sector of reducing potential risk which private firms face "valley of death" in the process of commercialization of green products and technology.

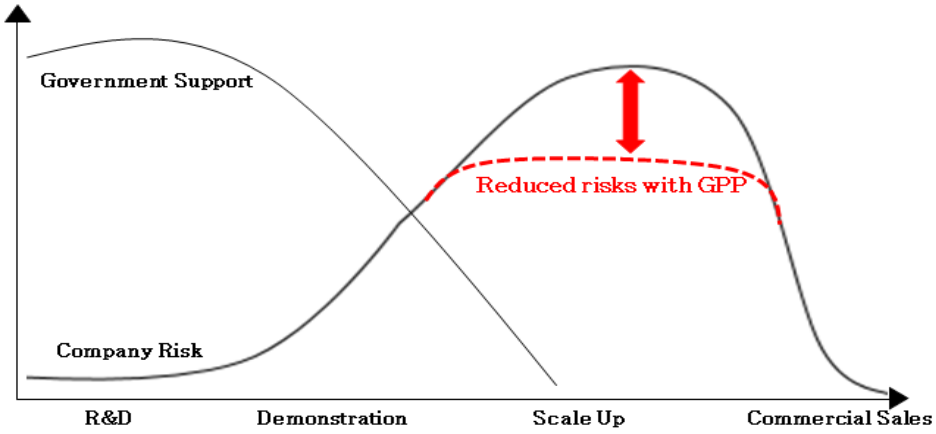

Figure 5. Risk profile from the GPP
(Source: Bauer et. al., 2009)

In addition, public procurement for new technology accelerate technology diffusion in the private sector because the government guarantees enough demand for the market for the private firms. As a result, with integrational impacts which are risk reduction in the commercialization stage and behavior change of private consumers, the markets for green products and services

expand more and more. Suppliers increase investment for facilities in order to enhance production capacity, and this leads to economies of scale and learning by doing (Rolfstam, 2009; Edler and Georghiou, 2007; Marron, 2003). By positive impact of economies of scale and learning by doing, diffusion of the products and services are accelerated, and the production cost of the suppliers is also reduced. Thanks to the cost reduction, the private consumers can experience lower prices than before, and this leads enhancement of social welfare. <Figure 6> shows the impacts of risk reduction of investment and stimulation of innovation.

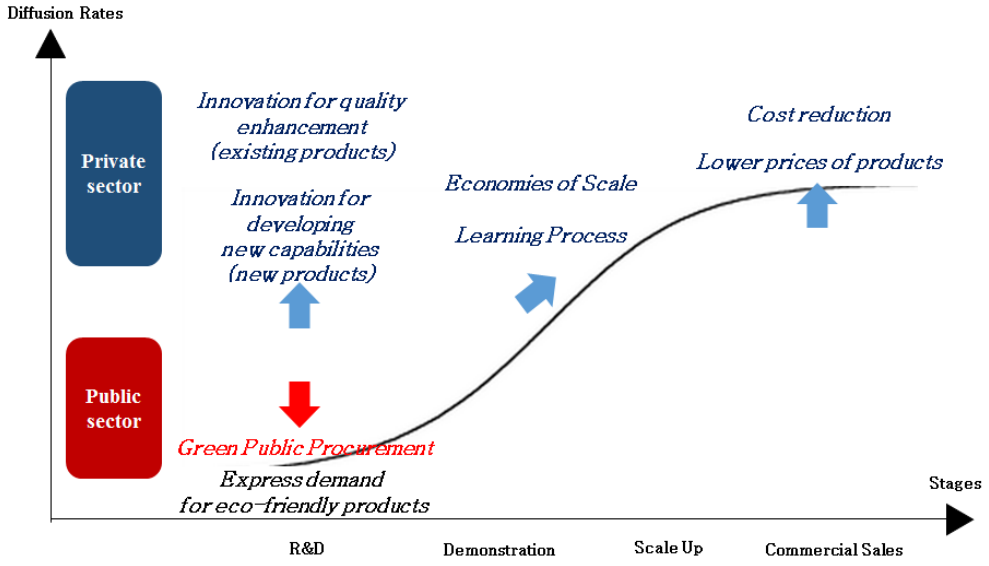

Figure 6. Effects of GPP in terms of innovation stages

3.4. Potential Economy-wide effects of GPP

As discussed above, although GPP could have indirect and direct effects on the economy in terms of environmental, economic, and social perspectives, previous literature give us bounded information in understanding potential effects of the GPP. This is because most studies on the GPP are limited to a specific cases based on the theoretical or conceptual level, and analyzing its effect with partial equilibrium perspectives.

When considering its expected benefits as mentioned by the European Commission (2013), including environmental factors (having benefits from the climate change mitigation and improvements of the energy efficiency, etc.), economic factors (creating new markets by providing market signal to potential suppliers with incentives for developing green products and services with related innovative activities), and social factors (having benefits from the reduced utility costs, and raising efficiency in the governments' purchase), the partial equilibrium perspective could give us wrong (bounded) policy implications in evaluating the effects of GPP. Based on the discussions as described above, in this section we propose a causal

loop diagram, which can be useful to trace the impact pathway of the GPP. It is represented in the <Figure 7> as below.

As described above, the GPP's main effects could appear in various pathways, including the environmental, economic, and social factors. Environmental effects can be brought about with energy savings from the improvements in energy efficiency, and climate change mitigation through wide-spread green products/services. Economic effects can be expected to arise, as a consequence of new market creation (especially for green products/services), risks reduction associated with (potential) suppliers' physical investments and innovative activities with demand articulation, and higher social welfares resulting in lower prices and better qualities of green product/services. In addition to those effects, it is expected to have higher social benefits arising from positive effects on economic and environmental factors, and higher efficiency in government's purchase as social effects.

For example, the pathway from GPP's implementation to risks reduction in suppliers of green industries with demand articulation is presented in <Figure 7> (Choi, et al., 2011; Uyarra and Flanagan, 2009; Edler and Georghiou, 2007; Marron, 2003). This effects could have impacts on the decision making process of the suppliers associated with physical investments and innovative activities. As a result, it can trigger the development of new products or services with higher R&D investments, or enhancement of existing products' quality through incremental innovations (Edquist and Zabala, 2012; Hommen and Rolfstam, 2009). It can also have effects on the energy consumption structure of those suppliers when they produce products and services, along with the innovation-related factors. Furthermore, each firm (supplier)'s knowledge stock can be accumulated through higher R&D investments on the green products and energy efficient technologies, leading to changes in industry-level knowledge stocks and spillover effects among industries (Adams, 1990; Terleckyj, 1980). Through these multi-level pathways, the spillover effects could influence each supplier's productivity. This multi-level pathways from risks reduction from the demand articulation to increases in productivity of suppliers are presented in <Figure 7> with circle lines.

With large procurement by the public sector, greener products will become the standard, and the market for the greener products can achieve more demand as mention by the Bauer et al. (2009). As the public sector acts as the leading consumer, and let private consumers buy more greener products, green markets of econ-friendly products/services will be expanded. Along with this market expansion effect, GPP policies may will influence the physical investments level by (potential) suppliers. With lower market risks and uncertainties, suppliers would increase the physical investment levels, and this could bring about learning by doing and economies of scale in those suppliers. With enhanced production/technology capabilities, suppliers' market power can be changed with changes in their cost structures, product portfolios, and products/services' quality. As a result, with combinations of those effects, the industrial competitiveness could be determined in the long-run perspective. This pathway can also be presented in the <Figure 6> with square lines.

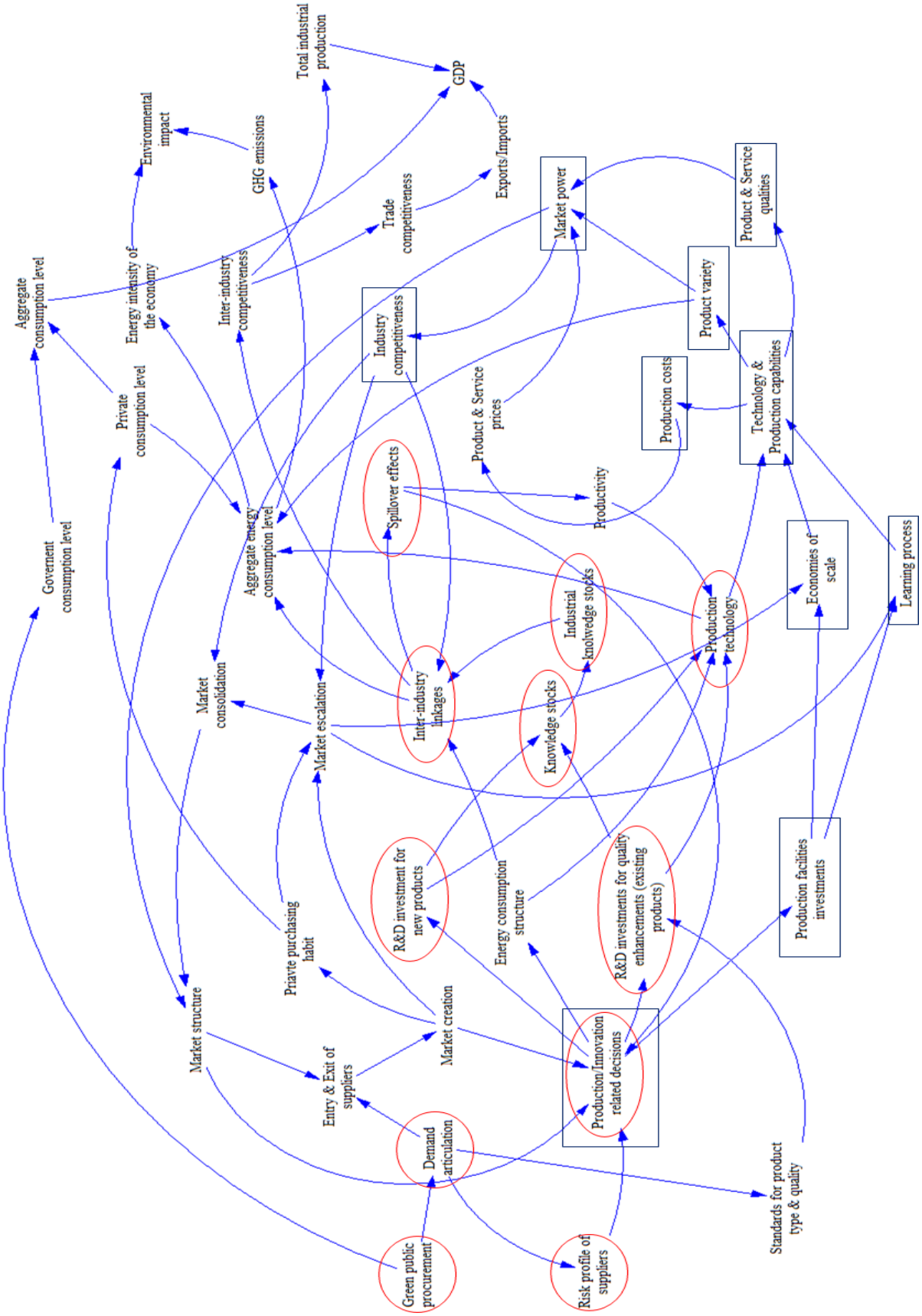

Figure 7. Summary of Potential Economy-wide Effects of GPP

Changes in each industry's competitiveness also can influence the relative competitiveness within industries, based on the degree of interaction among industries. Ultimately, this could lead to total production levels in the economy and trade competitiveness in foreign markets, which determines the economic effects. As discussed above, GPP could lead to multiple potential pathways which could have effects on the economic performance in the economy, when considering the interaction between the economic agents, and linkages between production and consumption sides.

Furthermore, it can also be seen that if the energy consumption structure is moved toward low carbon energy sources with GPP policy, this can have impacts on the production technology of (potential) suppliers and industry-level energy consumption level as mentioned by Ramer (2011), Schumacher (2007), and Ian Sue Wing (2006). In the long-term perspective, this can influence on the energy intensity and GHG emissions level in the economy. Therefore, as discussed in this section, we could summarize and propose multiple potential effects of GPP with economy-wide perspective, based on the previous literature related to GPP's effects, which were limited to partial equilibrium perspectives.

4. Conclusion

Recently, the governments of several developed countries try to change their policy framework from supply-side innovation policy to demand-side innovation policy which can influence on market demand. Especially, in order to attain mitigating climate change and achieve sustainable growth simultaneously, the significance of green public procurement (GPP) is stressed among developed countries. However, despite the fact that the amount of public procurement is relatively large, and public procurement has high effectiveness for support industries and markets, there is few researches on the impact of public procurement for innovation and macro-economy. This study investigated the previous studies which tried to analyze the policy impact of GPP, addressed that these studies were limited on the partial equilibrium perspectives, and insisted that the studies with partial equilibrium analysis cannot draw integrational and macro-economic impact of public procurement. In addition, this study presented the main policy impact of GPP with various paths, and proposed the analyzing framework in order to investigate the macro-economic impact of GPP properly.

In sum, the impact of GPP can be categorized into three, which are environmental impact, economic impact, and social impact. Energy savings from enhancing energy efficiency and reduction of CO2 emissions are some of the environmental impacts of GPP. Economic impacts of GPP are shown as market creation and escalation, reduction of market uncertainty and risk by specifying demand, and emergence of new products and development of quality of existed products by innovation. In addition, GPP has social impacts which are increasing social welfare by price reduction and enhancement of quality, and improvement of the effectiveness of government spending. Moreover, this study deepened and broadened the debate on the impact

of GPP with suggestion of the causal loop where these impacts of GPP can be checked synthetically.

Further study will investigate these various causal relationships regarding GPP quantitatively and simultaneously with computable general equilibrium (CGE) model. From macro-economic and general equilibrium perspectives with CGE model, it is possible to understand the environmental, economic, and social impacts of GPP synthetically and debate on the policy impact of GPP much more deeply.

Reference

(1) in Korean

1. Kim, Gihwan (2010), "Development of the Products with Minimum Standard of Public Procurement", Public Procurement Service (PPS) (Korea), Korea Association of Procurement and Supply Management

2, Sung, Jieun (2011), "Demand-side Innovation policy: Concepts and Cases", 「STEPI Issues and Policy 2011」, Vol.28, pp1-15.

3. Lee, Sanghun, Kim, Byeongeon, Kim, Jaehyeon, Lee, Dahoon, and Lee, Jeonghwan (2013), "Improvement of Public Procurement System regarding Environmental Factors", Public Procurement Service (PPS) (Korea). Korea Institute of Procurement.

4. Choi, Yangrak, Song, Wijin, Sung, Jieun, and Lee, Seokmin (2011), "Analysis of Demand-side Science and Technology Innovation Policy", National Science and Technology Commission (Korea).

5. Heo, Changsoo (2011), "Comparison of Public Procurement for Innovation of Major Countires", 「FIK Issue Paper」, Vol.185, pp1-26.

6. Ministry of Environment (2015), "The Amount of Procurement by Public Agency was 2.2 trillion Korean Won", Press Release of Ministry of Environment.

(2) in English

7. Ashhoff, B. and Sofka, W. (2009), "Innovation on Demand – Can Public Procurement Drive Market Success of Innovations?", Research Policy, Vol.38, No.8, pp1235-1247.

8. Bauer, B., Christensen, J., and Christensen, K. (2010), 「Benefits of green public procurement」, Nordic Council of Ministers.

9. Brannlund, R., Lundberg, S., and Marklund, P. O. (2009), 「Assessment of green public procurement as a policy tool: cost-efficiency and competition considerations」, Umea University.

10. Conway, D. M. (2012). 「Sustainable procurement policies and practices at the state and local government level」, GREENING LOCAL GOVERNMENT,

11. DTI. (2006).「Bridging the gap between envirionmental necessity and economic opportunity」. DTI: Department of Trade and Industry.

12. Edler, J. and Georghiou, L. (2007), "Public procurement and innovation – Resurrecting the demand side", Research Policy, Vol.36, No.7, pp949-963.

13. Edquist, C. (1996),「Government technology procurement as an instrument of technology policy」, Springer Netherlands.

14. Edquist, C., Vonortas, N. S., Zabala-Iturriagagoitia, J. M., & Edler, J. (2015).「Public Procurement for Innovation」. Cheltenham: Edward Elgar Publishing.

15. Edquist, C., and Zabala, J. M. (2012). "Public Procurement for Innovation as mission-oriented innovation policy". Research Policy, Vol.41, No.7. pp1757-1769.

16. Edquist, C., & Zabala-Iturriagagoitia, J. M. (2015). "Pre-commercial procurement: a demand or supply policy instrument in relation to innovation?". R&D Management, Vol.45. No.2, pp147-160.

17. European Commission (2011),「Buying Green: A handbook on green public procurement」. European Commission.

18. European Commission (2012),「Green Public Procurement: A collection of Good Practices」. European Commission.

19. Geroski, P. A. (1990), "Procurement policy as a tool of industrial policy", International Review of Applied Economics, Vol.4, No.2, pp182-198.

20. Gillinghamm K., Newell, R. G., and Palmer, K. (2009), "Energy efficiency economics and policy", Annual Review of Resource Economics, Vol.1, No.1, pp597-620.

21. Hommen, L., & Rolfstam, M. (2009). "Public procurement and innovation: towards a taxonomy". Journal of Public Procurement, Vol.9, No.1. pp17-56.

22. IISD (2012).「Procurement, Innovation and Green Growtht」. Minister for the Environment, Denmark.

23. ISEAL (2013).「Buying Tomorrow: Sustainable public procurement and the use of standards as a mechanisms to scale-up implementation」. ISEAL Alliance.

24. Kahlenborn, W. Moser. C. Frijdal, J., and Essig. M. (2003).「Strategic Use of Public Procurement in Europe」, European Commission.

25. Kunzlik, P. (2003).「International procurement regimes and the scope for the inclusion of environmental factors in public procurement: The Environmental Performance of Public Procurement」, OECD.

26. Lafferty, W. M. (2009).「Promoting sustainable electricity in Europe: Challenging the path dependence of dominant energy systems」. Edward Elgar Publishing.

27. Lovio, R., Mickwitz, P., & Heiskanen, E. (2011). 「Path dependence, path creation and creative destruction in the evolution of energy systems」. Edward Elgar Publishing.

28. Marron. D. (2003). “Greener public purchasing as an environmental policy instrument”. OECD Journal on Budgeting. Vol.3. No.4. pp72-105.

29. McCrudden, C. (2004). “Using public procurement to achieve social outcomes”. Natural resources forum. Vol.28. No.4, pp257-267.

30. OECD (2000), 「Greener Public Purchasing: Issues and Practical Soultions」, OECD.

31. OECD (2015), “Size of public procurement”, in Government at a Glance 2015, OECD

32. OFT (2004), 「Assessing the impact of public sector procurement on competition」, OFT: Office of Fair Trading.

33. Parikka-Alhola, K. (2008), “Promoting environmentally sound furniture by green public procurement”, Ecological Economics, Vol.68, No.1, pp472-485.

34. Payne. C., and Weber. A. (2013). 「Energy-efficient public procurement: Best practice in program delivery」, Environmental Energy Technologies Division.

35. PwC, PricewaterhouseCoopers. and Ecofys, Utrecht Netherlands. (2009), 「Collection of statistical information on Green Public Procurement in the EU」, United Nations.

36. Rolfstam, M. (2009). “Public procurement as an innovation policy tool: the role of institutions”. Science and Public Policy, Vol.36. No.5, pp349-360.

37. Rolfstam, M. (2015). “Public procurement of innovation for a better world: a consolidation or a new beginning?. Innovation”. The European Journal of Social Science Research, Vol.28. No.3, pp211-219.

38. UNEP (2011). 「Sustainable public procurement: A global review」, UNEP: United Nations Environment Programme.

39. UNEP (2011). 「Decoupling natural resource use and environmental impacts from economic growth」, UNEP: United Nations Environment Programme.

40. Uyarra, E., & Flanagan, K. (2010). “Understanding the innovation impacts of public procurement”. European Planning Studies, Vol.18, No.1. pp123-143.