Extending the Efficient and Responsive Supply Chains Framework to the Green Context

Sunhee Youn
Department of Information, Operations and Technology Management
College of Business Administration
The University of Toledo
Toledo, Ohio, USA 43606
younsh365@gmail.com

Ma Ga (Mark) Yang
Department of Information, Operations and Technology Management
College of Business Administration
The University of Toledo
Toledo, Ohio, USA 43606
myang5@rockets.utoledo.edu

James Jungbae Roh
Department of Management and Entrepreneurship
William G. Rohrer College of Business
Rowan University, 201 Mullica Hill Road, Glassboro, NJ 08028, USA
Tel: 856-256-5430, Fax: 856-256-4439
roh@rowan.edu

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Send Correspondence to:

Ma Ga (Mark) Yang
Department of Information, Operations and Technology Management
College of Business Administration
The University of Toledo
Toledo, Ohio, USA 43606
(419) 530-2907
myang5@rockets.utoledo.edu

SHORT BIOGRAPHICAL INFORMATION

Dr. SunHee Youn is a Lecturer at the Hongik University of Seoul, Korea. As a recipient of Young Scholar Award from Korean government she is currently a post-doctoral researcher at the University of Toledo. She is a recipient of Korea Young Scholar's Award. Her research interest is in the area of supply chain management. Her articles have been published (accepted) in *International Journal of Business Excellence, International Journal of Logistics and Systems Management, International Journal of Services Operations and Management, Journal of Korea Production and Operations Management Society* and *Journal of the Korean Society for Quality Management.*

Ma Ga (Mark) Yang is a Ph.D. candidate of Manufacturing and Technology Management at the University of Toledo, USA. He holds an MBA from the University of Toledo and a BA from Hankuk University of Foreign Studies in Seoul, Korea. He is a recipient of 2010 APICS Plossl Doctoral Dissertation Award. His articles have been published in *International Journal of Production Economics* and *International Journal of Service Operations Management* and accepted for *International Journal of Business Excellence*. His research interests are in sustainable supply chains, environmental management, lean manufacturing, green supply chain management, and the impact of information technology in the supply chain.

Dr. James Jungbae Roh is Assistant Professor of Operations Management at Rowan University, Glassboro, NJ, USA. Dr. Roh received his PhD in Manufacturing Management and Engineering, his MBA in management information systems, and his MA in Economics from the University of Toledo, and his BA from Dongguk University, Seoul, Korea. His research interests center on the interface of supply chain strategy, sustainability, and technology management. His articles have been published in or accepted for *Information and Management, International Journal of Production Research, International Journal of Production Economics, Journal of Enterprise Information Management, European Journal of Innovation Management, International Journal of Services and Operations Management,* and *Research in International Business and Finance*.

Extending the Efficient and Responsive Supply Chains Framework to the Green Context

Abstract

Purpose – The purpose of this paper is to develop research frameworks for two types of green supply chains based on Fisher's (1997) seminal work. In spite of Fisher's contribution to the literature, his study has rarely been extended into green supply chain contexts, except in a few conceptual arguments. The current study explores how Fisher's perspective of efficient versus responsive supply chains can be a stepping stone to the development of two green supply chains: eco-efficient and eco-responsive supply chains.
Design/methodology/approach – Toward the above end, a case methodology is employed (Yin, 2004). Two Korean global companies, Pohang Iron and Steel Company (POSCO) and Samsung Electronics (SEC), are selected to explore eco-efficient and eco-responsive supply chains. POSCO (steel products) is selected to enable us to understand how efficient and eco-efficient supply chains work. SEC (mobile phone products) is chosen to understand responsive and eco-responsive supply chains.
Findings – Our findings suggest that (1) POSCO tends to stress process technology innovation as a means to address green pressures, while SEC accentuates the green product strategy; (2) while an eco-efficient supply chain focuses on keeping to an environmental standard across the supply chains, an eco-responsive supply chain centers on the collaboration of suppliers and distributors in greening the supply chain; and (3) SEC takes more initiatives to educate and encourage consumers to engage in recycling activities than POSCO does.
Originality/value – Few studies have examined the green supply chain using the perspective of Fisher's framework (efficient vs. responsive supply chains). By addressing the timely topic, this study fills a research gap in green supply chain literature.

Keywords Comparative study, Efficient supply chain, Eco-efficient supply chain, Responsive supply chain, Eco-responsive supply chain, POSCO, SEC
Paper type Research paper

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Introduction

Over the past decade, firms' ability to meet 'green' demands has become an essential dimension of competition in the global business world (Krugman, 2010). In supply chain contexts, the management of 'green' issues can take place in several ways. In terms of production, the basis of going 'green' is to optimize the production of goods and services while minimizing waste and scrap (Hong et al., 2009; Yang et al., 2011). Firms can make their supply chain 'greener' by embedding modularity into the product design, using more environmentally friendly materials, and increasing the recyclability of products (Sroufe, 2003; Montabon et al., 2007). Changing customer management into a symbiotic relationship is also key in meeting customers' evolving preferences for just-in-time. Evidently, firms can design their supply chains to be greener and thus to fit in with the diverse needs derived from managing internal operations, suppliers, and customers.

One useful framework for understanding supply chains is Fisher (1997)'s seminal work, which argues the perspective of efficient versus responsive supply chains. Fisher's study indicates that the nature of products' demand patterns determines the type of supply chain. The efficient supply chain (ESC) becomes important where products run with low profit margins, low product variety, and a stable demand forecast. On the contrary, the responsive supply chain (RSC) becomes relevant where products show high profit margins, high product variety, and volatile demand, requiring quick adaptation to constantly changing customer preferences.

Since the release of Fisher's framework, scholars have examined the differences between the two supply chains (Christopher and Towill, 2000; Aitken et al., 2002; Randall et al., 2003) and extended this framework to different contexts (Lee, 2002; Quak and de Koster, 2007). Yet, it still needs to be expanded to the context of the green supply chain. Filling the void in this line of

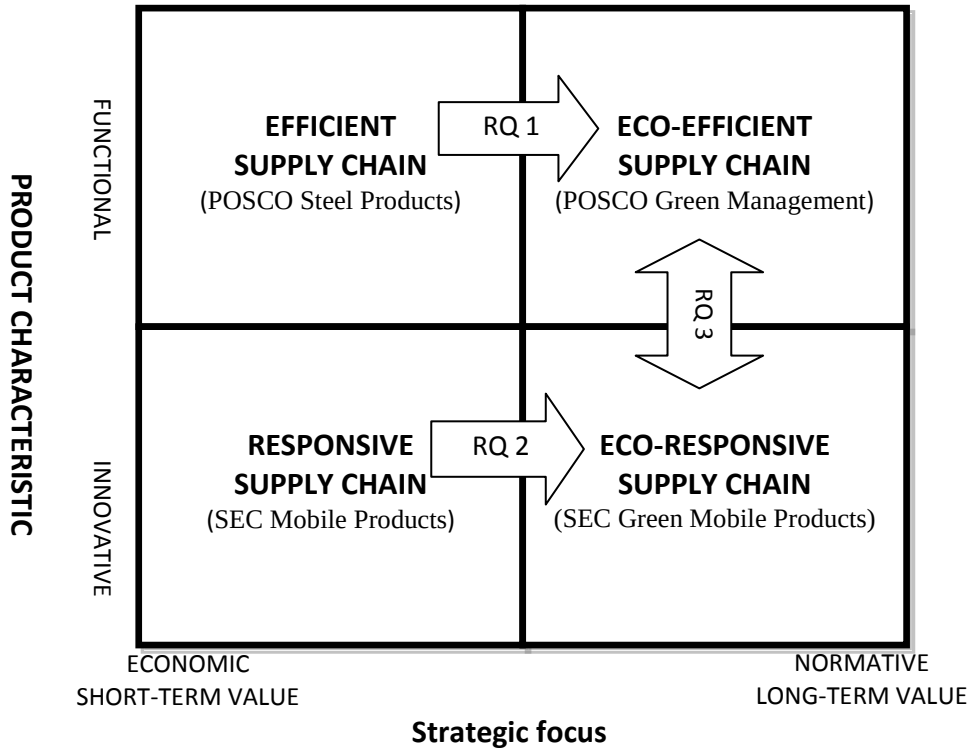
research, this study is intended to examine the following research questions: first, how can the ESC be extended into the eco-efficient supply chain (EESC)? Second, how can the RSC be extended into the eco-responsive supply chain (ERSC)? Third, are there any differences between these two supply chains? The next section provides a research model and sampling method. Following this are two cases, Pohang Iron and Steel Company (POSCO) and Samsung Electronics (SEC), that explore the evolutionary paths among ESC, EESC, RSC, and ERSC. Finally, the findings and implications drawn from the cases are discussed.

Research design

Research Model

Figure 1 portrays the proposed research model. Two guiding parameters are product characteristics and strategic focus. Firms design their green supply chain based on existing capabilities and core products. *Product characteristics* can be either efficient or innovative, and the corresponding supply chains are either ESC or RSC, respectively (Fisher, 1997). These propositions lead us to predict that there will generally be two types of green supply chains: EESC or ERSC. *Strategic focus* is another determining factor in whether or not firms implement the green supply chain. What motivates firms to implement green supply chains is primarily a normative long-term value.

Figure 1. Proposed Research Model



Sampling

To further explore the research framework, we use a qualitative method of enquiry to describe, explain, and examine how ESC and RSC are extended into EESC and ERSC and how they are different (Yin, 2004). Toward this end, we have selected two Korean firms, POSCO and SEC.

First, POSCO and SEC display a clear distinction between ESC and RSC. POSCO has been recognized as one of the most efficient steel companies in the world, in regard to cost efficiency and superior productivity (Bremner and Moon, 2004). SEC has positioned itself as the top mobile phone provider in the U.S.A., offering a variety of innovative mobile products meeting global market standards. The two producers' excellent track records of efficiency and responsiveness in their respective industries over the years provide credentials for investigation.

Second, the product characteristics and strategic focus of POSCO and SEC correspond with the research framework. In regard to product characteristics, POSCO's products are functional,

typified by a long life cycle and a low profit margin. POSCO's supply chain reveals the pattern of an ESC, including low-cost operations and relatively low prices (Sohal and Ferme, 1996). SEC's mobile products compete by using innovation, characterized by a short life cycle and a high profit margin. SEC implements an RSC, with emphasis on innovation and responsiveness. As for strategic focus, POSCO and SEC have embarked on greening the products, process, and supply chain considerably. POSCO strives to reduce CO_2 emissions and enhance energy efficiency, thus implementing an EESC. SEC invests in developing green mobile phones to address customers' environmental and social concerns, thus implementing an ERSC. Table 1 compares POSCO with SEC in terms of major product and market characteristics.

Table 1. Comparison between functional and innovation products: Cases of POSCO and SEC (Adapted from Fisher, 1997)

Product characteristics	**Functional**	**Innovative**
Cases	**POSCO**	**SEC**
Product type	Functional products (Steel products)	Innovative products (Mobile phone products)
Demand stability	Predictable and stable	Unpredictable and unstable
Product Life cycle	Long (10-20 years)	Short (1-2 years)
Product variety	Relatively Low (Hot rolled steel, steel plate, wire rod, cold rolled steel, galvanized steel, electrical galvanized steel, electrical steel, stainless steel, titanium steel)	Relatively High (several hundred products)
Profit margin	Relatively Low	Relatively High

POSCO – Efficient Supply Chain

General Background

POSCO began with intensive governmental support in 1968. Steel production started in 1972 with the aim of establishing self-sufficiency in steel in South Korea and boosting its international

competitiveness. POSCO operates two main plants with different strategic foci. The plant at Kwangyang produces a small variety of steel products in large volumes, while the plant at Pohang produces a wide variety of products in small volumes (Sohal and Ferme, 1996). Currently, POSCO produces high-quality steel products at low cost, using the most modern facilities and advanced technologies, and has a sales turnover of about $12.5 billion.

Efficient Supply Chain (ESC)

POSCO's supply chain has reduced costs by streamlining the processes. POSCO has developed a world-class ESC with collaborative supplier activities, process innovation, and the launching of the steel-n.com website (www.steel-n.com).

First, collaborative activities with suppliers. POSCO has developed collaborative activities with its numerous small-and medium-sized (SME) suppliers. POSCO promotes supplier partnership by implementing a benefit sharing system. Some examples of this are as follows: to compensate according to performance; to grant long-term contract rights; and to offer joint patent benefits. POSCO also supports suppliers with technology and financial resources. The Techno Partnership program, for example, has provided technical services to suppliers, and POSCO has extended loans to suppliers affected by the global financial crisis. Finally, it actively offers education/training programs to key suppliers' families to nurture them and improve their wellbeing.

Second, operational excellence. In 1999, POSCO initiated a 'process innovation (PI)' to streamline all the operations of the company (Lee and Lee, 2009). The hallmark of the PI is POSPIA (POSCO + Utopia), an integrated enterprise resource planning (ERP) system, which

links all parts of the business practices of POSCO. This PI system enables all the scattered functions of purchasing, sales, production, equipment, finance, HR, and technology to operate just-in-time and allows speedy quality decision-making. POSPIA also enables POSCO to network with various plants and customers to facilitate the placement of orders online. Valuable data on the status of production, orders, and delivery allowed the company to achieve seamless coordination, to reduce budget lead-time from 110 days to 30 days, to improve on-time deliveries from 74 to 97%, and to save costs by $17 per ton (Lee and Lee, 2009).

Third, e-business capability. The intended functions of e-business via www.steel-n.com are to enable qualified corporate customers to purchase POSCO's products online (e-Sale) and to allow potential suppliers to create electronic bidding and exchange transaction documents and information (e-Procurement). POSCO streamlined the supply chain processes by allowing small- and medium-sized customers to directly contact the company, removing intermediaries (e.g., wholesalers and retailers) and unnecessary costs.

POSCO- Eco-Efficient Supply Chain

With the accelerating level of world greenhouse gas (GHS) regulations, the demand for carbon reduction, and the international campaign for green growth, green issues have made it more necessary for companies in Korea to consider environmental concerns than ever before. Due to its high rate of carbon emission, the steel industry needs tighter international collaboration in dealing with GHG emissions. This has forced POSCO to accept the greater need for adopting green management in the supply chains.

Mounting public expectations also caused POSCO to take actions toward green management. For example, the Chinese steel companies Baosteel Group, Jiangsu Shagang, and Ansteel

emerged as mega-steel producers through strategic merger and acquisition. Customers' preferences for eco-friendly products and the high costs of raw materials and energy pose considerable challenges to POSCO in the securing of raw materials (Kleindorfer et al., 2005). Finally, competition in the domestic market will intensify as new domestic steel producers appear in the years to come.

POSCO's effort to green its supply chain involves a continuation of the use of its knowledge and skills developed from ESC practices: thus we term it the development of an "eco-efficient supply chain." To pursue EESC, POSCO implements green purchasing practices, internal environmental operations management, and green logistics/customer-related practices (see Figure 2).

Green purchasing.

POSCO's pursuit of greening its supply chain began when it joined and supported a government-initiated voluntary program in 2005. Since then, POSCO has played a leading role among 30 other top Korean companies (POSCO Sustainability report, 2006). Along the way, the establishment of an environmentally friendly purchasing team in 2006 (Anonymous, 2010) became a milestone in POSCO's green purchasing efforts (POSCO Sustainability report, 2006). First, POSCO set out its green purchase guidelines with a classification into 6 categories: "Environmental" items (GP1), "Good Recycled" items (GP2), "Energy Saving" items (GP3), "Harmful Materials" (GP4), items involving "Less Waste" (GP5), and "Others" (GP6) (POSCO Sustainability report, 2006). In 2006, POSCO extended its green purchase practices into the supply chain to promote green purchasing activities with suppliers. Second, in monitoring and assessing its suppliers, POSCO took into consideration environmental aspects such as the

environmental impact of the materials that the company uses. POSCO encourages suppliers to comply with green purchasing initiatives, while restricting its use of uncooperative suppliers or those causing serious environmental problems (POSCO Sustainability report, 2006).

Internal environmental operations management

POSCO's internal environmental operations management involves three areas: (1) eco-friendly products; (2) process innovation through FINEX; and (3) 3R (Reduce, Reuse, and Recycle) practices.

First, eco-friendly products. POSCO's strong environmental orientation is manifested in eco-friendly products that aim to (1) minimize pollutant emission and energy consumption in the production process; (2) reduce its damaging impact on people and the environment throughout the period of use of its products; and (3) promote the recycling of various types of waste. As of 2009, POSCO has made 231 eco-friendly products in total, accounting for 76% of the total products that POSCO has developed.

Second, process innovation (FINEX). FINEX is the world's first commercialized innovative steel process, developed by POSCO in 2007. The FINEX process employs innovative technologies and produces pig iron directly using iron ore and non-coking coal instead of processing the ore through the sintering and coke-making that had been essential to the conventional blast furnace method (Lee, 2010). POSCO realized two vital benefits through FINEX. First, FINEX significantly lowered equipment and material costs in comparison with the traditional blast furnace process, because it removed the need for preliminary raw material processing. Second, because of the elimination of sintering and coke-making, emissions of sulfur

oxides (SOx) and nitrogen oxides (NOx) were reduced by 3% and 1%, respectively. Furthermore, FINEX achieved high energy efficiency and air pollution reduction by the use of pure oxygen (SOx 19%, NOx 10%, Dust 52% level compared to the blast furnace) (Lee and Lee, 2009).

Third, 3R (Reduce, Reuse, and Recycle) practices. In order to reduce carbon emission, POSCO focused closely on making improvements in the following areas: air quality, emission reduction, water recycling, and recycling of byproducts (POSCO Sustainability Report, 2006; Lee, 2010). To generate a cleaner atmosphere, POSCO built a large silo, an environmentally friendly raw material storage facility (POSCO Sustainability Report, 2006). POSCO also actively participated in the 'Chemical Discharge Reduction 30/50 Program', which is committed to the extensive reduction of emissions (POSCO Sustainability Report, 2009). For instance, POSCO strives to cut the carbon emissions from the production of crude steel by 9% by 2020 (Park, 2010). In terms of recycling, POSCO reuses 98% of water, utilizing water management and recent techniques. As a result, a ton of steel is produced with just a small amount of water up to 3.8 cubic meters of water (Lee, 2010). POSCO is also highly involved in recycling byproducts (slag, dust, sludge, and other waste materials) created by steelworking: 100% of the slag is recycled as material for cement-making and the aggregate for road and engineering works, while dust and sludge and other byproducts are recycled as raw materials for steel and for the steel process (Lee, 2010).

Logistics/Customer-related practices

As POSCO seeks to serve customers with a green orientation, it has reduced socially emitted GHG for three distinct customer groups: those involved with automobiles, electronics, and cement (POSCO sustainability report, 2009). POSCO has developed CO_2 reduction technologies

for low-carbon use. The strategy is to create "energy efficient steel", which provides high grade steel that improves the energy efficiency of the products used in automobiles, electric motors, and other items. In addition to supplying these products, POSCO uses blast furnace slag as an ingredient for cement, lowering CO_2 emissions in the broader society (POSCO Sustainability Report 2009).

First, POSCO offers high-strength steel sheets for automobiles that are thinner than normal steel sheets but have the same strength, while they lighten the weight of cars and consequently improve fuel efficiency. Second, POSCO produces high-end electrical steel sheets with high energy efficiency. The high-end electrical steel sheets have high energy efficiency due to their low core loss and high magnetic flux density. Third, POSCO encourages the use of a steel byproduct, slag, as the cement clinker, reducing the use of limestone and CO_2 emissions. In 2008, POSCO reduced indirect GHG emissions by 5.91 million tons with 7.48 million tons of granulated slag.

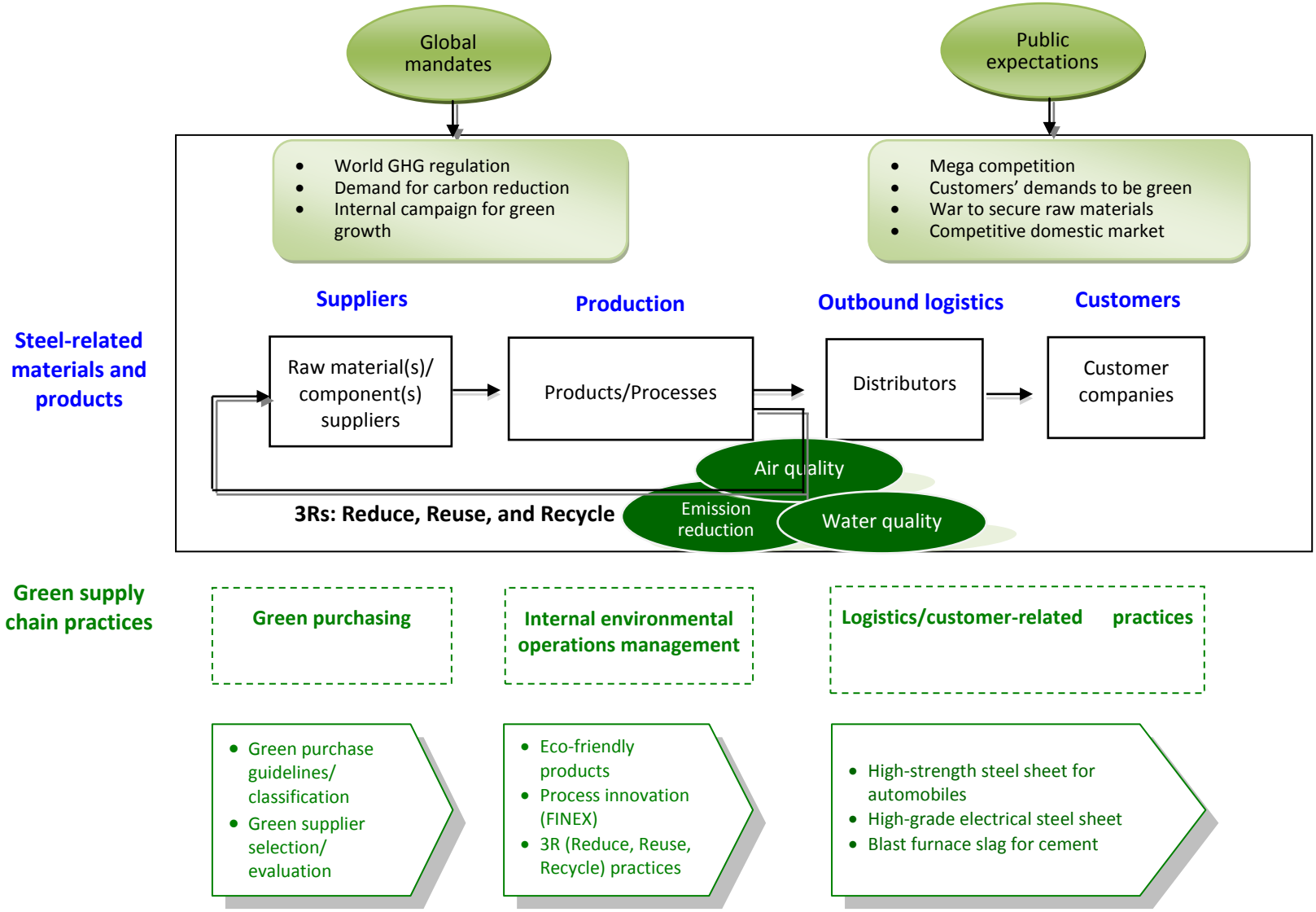
Implications for an *Eco-efficient supply chain*

POSCO's EESC places a great deal of emphasis on reducing CO_2 emissions. POSCO has constantly developed innovative breakthrough technologies including FINEX, an environmentally friendly iron-making technology. 3R (Reduce, Reuse, and Recycle) has been at the core of POSCO's endeavor to go green. It has enabled POSCO to achieve a high rate of energy efficiency. Another course of action POSCO has taken to increase energy efficiency is the development of eco-friendly products. The motivation for such a strategic shift was not to be responsive to changing customers' needs but to reduce pollutants. POSCO's substantial

investment in internal environmental operations management is yet to permeate into greening distribution and marketing initiatives.

Another important aspect of POSCO's EESC is its superior supply chain leadership. POSCO has exerted powerful leadership in initiation, coordination, and management of its supply chain partners. For instance, in 2009, POSCO initiated the 'POSCO green growth committee,' with the intention that it should become a global green growth leader (Anonymous, 2010). Under this leadership, POSCO has clarified four major areas: developing low carbon technologies, responding to climate change, creating renewable energy, and fostering new green businesses. POSCO's leadership has been derived from its strong emphasis on internal environmental operations management, which has been the core capability of POSCO. The powerful, well-constructed internal operations have enabled POSCO to influence suppliers and customers to become greener. First of all, POSCO has been able to pursue aggressive green purchasing initiatives, such as green purchasing guidelines, with its suppliers. POSCO has also mandated suppliers to adopt important environmental management practices such as ISO 14001, which has enabled POSCO to effectively manage and control the suppliers. Second, POSCO has been able to provide tailored energy-efficient products to the target customer segments (those dealing with automobiles, electric motors, and cement), through which it has gained support from customers. Its strong leadership has enabled POSCO to work together with its supply chain partners to green its supply chains.

Figure 2. POSCO's Green Supply Chain Management Framework
(Adapted from Kleindorfer et al., 2005; POSCO Sustainability Report, 2006, 2009)



Samsung Mobile–Responsive Supply Chain

General Background

Samsung Electronics Corp., Ltd. (SEC) is a leading company producing dynamic random access memory (DRAM) devices, static random access memory (SRAM) devices, and other advanced digital integrated circuits. With the core capability of making the semiconductor, SEC became one of the top mobile phone providers in the U.S.A. As of 2008, SEC reached 22.4% of the market share based on the shipment of mobile handsets to the U.S.A., unseating Motorola, the leading company up to that time.

Responsive Supply Chain

SEC's supply chain contains characteristics of RSC, for it focuses on meeting customers' changing needs by offering innovative products using collaborative supplier management. SEC's strength lies in making robust and impressive hardware features, and SEC aims at mid- and high-end products that yield higher margins than functional products. In order to achieve these goals, SEC implements the newest technologies, collaborates with suppliers, and streamlines supply chains.

First, partner collaboration. SEC recognizes partnership as the source of global competitiveness. SEC's understanding expressed in its annual report for 2010 shows that SEC regards partnership as the basis and extension of continuous innovation and improvement in its products and processes. This realization has led the company to emphasize responsible partnership with suppliers. For example, SEC offers various education programs for its vendors that center around innovation in collaboration. It opened collaboration innovation schools in Tianjin, Suzhou, and Huizhou in China. An executive advisory group consisting of 10 SEC executives is another

means to support suppliers in making congruent decisions on production, technology, and innovation. The executives travel to designated suppliers and share experience, knowledge, and insights with them. In 2009 alone, members of the executive advisor group made around 500 visits to their partners and assisted in improving innovation initiatives. SEC also extends financial support, loans or grants, to qualified suppliers that exhibit a good potential and collaboration opportunities.

Second, production innovation. To proactively deal with volatility in consumer demand, SEC offers a platform where partners come in and innovate together with SEC in terms of products and processes. It crafted an open innovation scheme in 2009 and has encouraged its partners to put forth ground-breaking ideas and progressive technologies in a wide variety of areas, from software to chip design to solar cells. Successfully completed projects have been added to SEC's new products. SEC plans to expand the scale and scope of such open collaboration with partners. Open innovation with partners also stretches into the sphere of cost innovation. SEC undertook with suppliers 135 projects in 2009 and 110 projects in 2010 that were intended to disseminate cost-saving management tools such as group value engineering and six sigma, and these tools improved quality, productivity, and supply chain management.

Third, supplier synchronization. To tackle oscillating customer demand, SEC has supported its suppliers by laying down a technological infrastructure that connects the company's frontend information flows to the upstream supply chains. Through an enterprise resource planning (ERP) system, SEC provides suppliers with standard business process templates that homogenize each stage of operations from order placement to dispensation. For example, SEC shared process improvement templates with 30 companies in China in 2010 and also installed ERP for 13

partners in China and 11 in Mexico that did not have ERP up and running. SEC's annual report for 2010 shows that such synchronization with suppliers helped it to improve inventory turnovers, inventories accuracy, and workforce productivity.

Samsung Green Mobile – An eco-responsive supply chain

SEC's mobile products (hereafter 'Samsung Mobile') have placed an emphasis on supply chain responsibility in environmental management. Mobile phones have become smaller than ever before, thanks to innovations in technology. These innovations, however, have had environmental consequences: it takes more fossil fuels and larger amounts of water to make the chips smaller. It is reported that one two-gram chip consumes 32 liters of water, 72 grams of chemicals, and 1.6 kilos of fossil fuels, and that one mobile handset usually requires 12 chips (Wilde-Ramsing and Haan, 2006). One handset uses materials up to 800 times its own weight. In contrast to the car manufacturing industry, which consumes fossil fuels about twice the size of the car, the mobile phone industry adds a substantial amount of toxic substances and pollutant materials to the environment. This is an issue that the supply chain in the mobile phone industry faces as a whole. SEC strives to develop an environmentally friendly product that minimizes its impact on the environment through the whole process from the procurement of raw materials, production, transportation, use, and end-of-life disposal. SEC pursues this initiative by adding 'environment' to function, price, quality, and design as an essential element in product development.

Samsung Green Mobile (Overview)

Realizing the significant impacts of mobile phones on the environment, the mobile phone industry has begun to focus strongly on greening its products. Following that trend, SEC has

developed eco-friendly phones that could be as popular as others are today. For example, the W510 is a green cell phone that SEC launched in 2008 both in Korea and in China. It is made of corn-based bio-plastic rather than toxic petroleum-based plastic. Besides, SEC applied sustainable product design by using a water-soluble coating and avoiding the use of any heavy metals such as lead, mercury, and cadmium (Shapiro, 2010). Samsung F268, another environmentally friendly mobile phone introduced in 2008, used no brominated flame retardant and strictly complied with the Energy Star standards of the U.S. Environmental Protection Agency and the U.S. Department of Energy (Samsung Electronics, 2008). Most lately, SEC offered the Blue Earth Phone, which uses a built-in solar panel for power generation, recycled water bottles for plastics, and a charging system that does not give off any toxic chemicals such as beryllium, phthalates, and brominated flame retardants (Billings, 2009). SEC also strives to increase eco-friendly packaging across its products (Chang, 2010).

e-HMS (Environmental Hazardous Substances Management System)

e-HMS is an internal information system that enables SEC to promptly and systematically manage hazardous materials in every ingredient of the product that comes from partnering firms. Through this system small and large suppliers alike communicate better with SEC, in regard to the way they use all the raw materials. SEC integrates this e-HMS with a product design system and purchasing system, and does not allow the use of parts without prior approval at the development and purchasing stages. In the development stage, SEC monitors whether or not a part complies with the environment management rules. If it does not comply, SEC does not endorse the part. Also, through the hazardousness management system, SEC builds the process of development, purchase, quality management for every product unit.

Green procurement practices

SEC has paid attention to environmental issues by creating and imposing supply chain responsibility and environment certification programs in its supply chains. It developed a code of conduct for suppliers that encompass safety requirements, fair business practices, human rights, and pollutant emissions (Sodhi and Lee, 2007). A third-party organization conducts a rigorous audit of first-tier suppliers and ensures that these suppliers comply with the code of conduct. It grants certification to suppliers that meet the standards. For example, SEC has established a green procurement certification system to screen suppliers and encourage green practices in the supply chain. In 2001, it initiated an eco-partnership program, a part of the green procurement system, in which suppliers attain certification when their components satisfy various environmental regulations in design and quality. SEC scrutinizes suppliers' environmental performance in manufacturing processes and production composition, and grants suppliers certification.

Green Product Design and Production System

In response to the need to green the production system, SEC started to embed high environmental standards in its production system. At the product design phase, one of the major initiatives was to implant an eco-design process into the product design components, to maximize resource and energy efficiency and to minimize pollutants (Pratt, 2008). SEC inserted a quality certification process that monitors whether the eco-design principle holds in its products. To make recycling more feasible, for example, SEC endeavors to simplify product design and reduce the number of parts per product. SEC's efforts to green the production system include using soy-ink on images, text, and warranty cards (Samsung Electronics, 2008).

Another green product strategy is to increase energy use efficiency in electronics products. In 2010, SEC started mass-production of a four gigabit, 30-nanometer class DDR3 Dram whose high-density memory consumes much less power than previous versions of memory chips. For mobile devices, SEC now uses a 40-nanometer class LPDDR2. The 'Green Memory'[1] is compressed twice the density of its predecessors and as a result consumes 35% less energy and makes more eco-friendly design possible. SEC partners with influential suppliers such as AMD, Cisco Systems, Fujitsu, Hewlett-Packard, and Microsoft to promote its green initiatives and its aim of generating greater awareness and increased application of green memory. The green initiative is expected to embrace all of the component products, from memory to LCD panels, and reduce power requirements significantly in a range of consumer devices.

Recently, SEC announced an ambitious initiative, called 'Planet First', which aims to accelerate the process of making the company more environmentally friendly by 2013. It invested $865 million to lower GHG emissions by 31% and to achieve 16% higher energy saving in production and process (Haider, 2010). It also reported that indirect carbon emissions had decreased by 9.6 million tons and third-party organizations have examined 39 global manufacturing sites to verify the status of greenhouse emissions (Haider, 2010).

Green awareness marketing campaigns

SEC is aggressively pushing for green campaigns in the United States. It has launched various programs to promote the importance of mobile phone recycling and to educate students to realize the impact of phone recycling on the planet. For example, it embarked on the Hey Monday program, where students receive $50,000 to make the school more environmentally friendly. The

[1] For details, refer to information available at http://www.samsung.com/greenmemory.

March to a Million program aimed to increase consumers' awareness of the importance of mobile phone recycling and of convenient ways to recycle. In 2010, SEC also started the Mobile Take-Back program to enhance students', their peers', and their families' awareness of the social and environmental impact of the green movement. These community campaigns acknowledge that only 10% of mobile phones come back to manufacturers for recycling, and thus the campaigns encourage consumers to reutilize or recycle their cell phones. In 2009, SEC also embarked on a recycling program in the San Francisco Bay Area. In all, 7 million students took part in the program, for it came at a time of economic austerity and helped students and the community to benefit from electronics recycling.

Implications for eco-responsive supply chain

Samsung Mobile's supply chains consist of three main suppliers: original equipment manufacturers (OEMs), Electronic Manufacturing Services (EMSs), and original design manufacturers (ODMs). While OEMs principally design and build products in their brand, EMSs and ODMs are contract manufacturers that extend their manufacturing and supply chain capabilities from designing to manufacturing to delivery. Component manufacturers supply parts of a handset to the OEM or EMS, being the sub-tiers of the mobile industry supply chains.

In 2005, the mobile industry outsourced overall 30% of manufacturing to other countries, which is relatively low compared to that of the laptop assembly industry, which outsourced 80% of production to other countries (Wilde-Ramsing and Haan, 2006). The major reasons why the mobile industry shows a comparatively lower rate of outsourcing are the lower degree of standardization, the variety of design platforms, and the complexity of products due to ongoing technological innovation in the industry. ODMs have only a limited capacity to proficiently deal with all the different platforms, and as a result it is more difficult to outsource production to

other suppliers. SEC outsourced no production to other countries in 2005. It was a strategic decision, taken in response to the latest customer preferences and changes in the mobile phone.

SEC's efforts to make the supply chain green are essentially three-fold. First, SEC endeavors to minimize the use of environmentally harmful materials. Examples include using plastics made from corn and enhancing energy consumption efficiency through green memory and solar panel power. In the supply chain context, SEC has implemented green certification programs, in which suppliers need to undergo an extensive audit. The e-HMS system oversees the process from product design to purchasing to the procurement system and ensures that supply chain partners meet the environmental standards and improve their environmental performance.

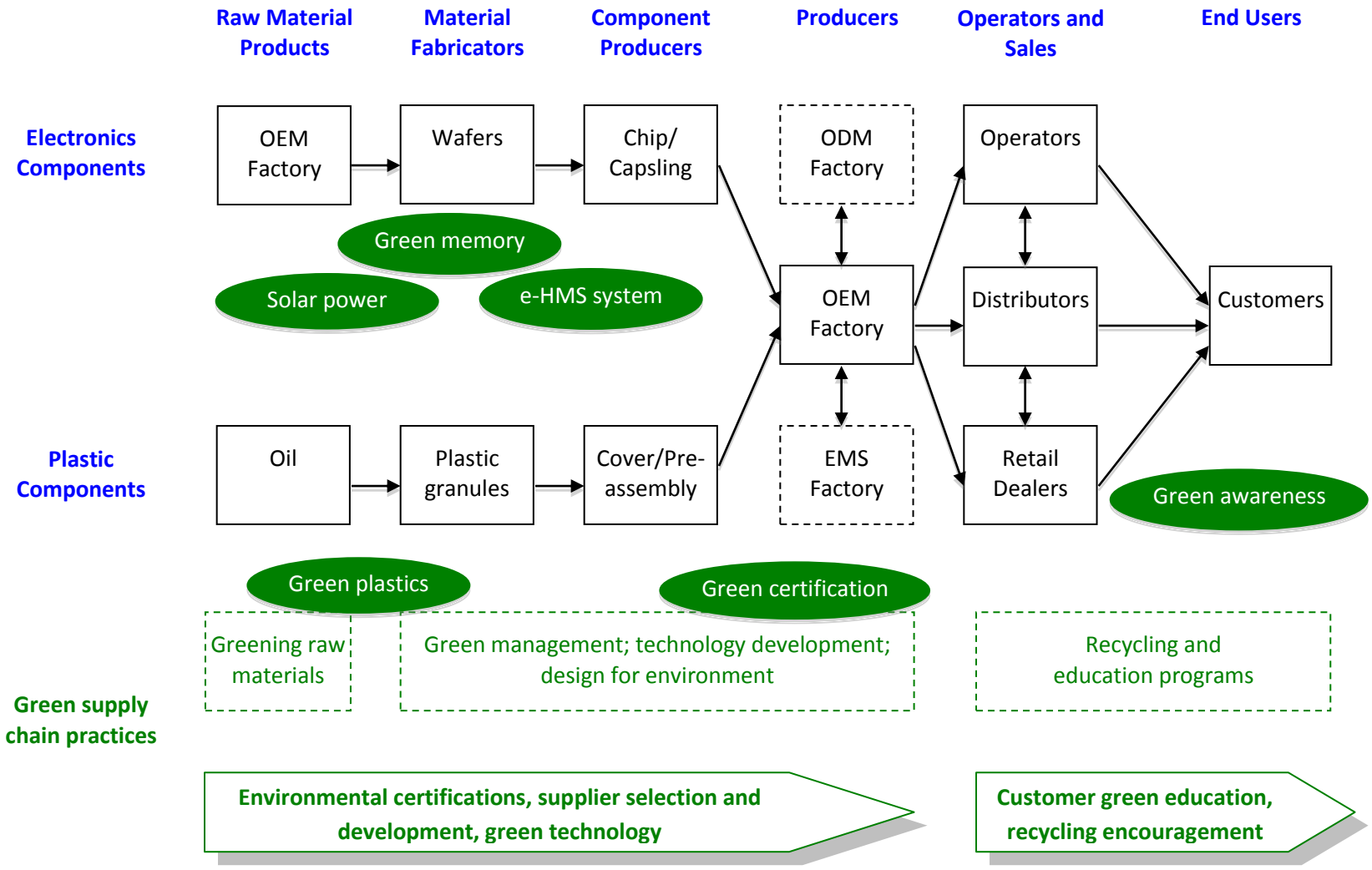
Second, SEC has striven to increase the recyclability of its products. Given the low volume of recycled phones and the short product life cycle of cell phones, it is imperative for SEC to enhance the feasibility of recycling. Toward this aim, SEC attempts to address recyclability from the product design stage by using more modular designs and enhancing remanufacturability. On the frontend, SEC works with consumers and runs education programs for students and communities to increase their awareness of the significance of cell phone recycling.

Third, SEC runs supplier selection and development programs. Due to the fast-phased technological changes, competition, and customer preference variations, the company needs to responsively develop cell phones and deliver them to customers. Cutting the lead time and sharing demand information concurrently is key to reducing the bullwhip effect in the supply chain. Furthermore, embarking on multiple new products development requires the firm to collaborate with core ODMs and EMSs and to foster innovative and cutting-edge handsets. Since the environmental performance of the mobile phone often depends on the quality of the supplier's capability, the firm needs a mechanism that encourages suppliers not only to follow

the environmental regulations but also to innovate on the green front. By offering various certifications, programs, and audits, SEC attempts to advance environmental innovation and improve performance.

Figure 3 shows a simplified version of the supply chain structure and the green management practices of Samsung Mobile. With regard to suppliers' parts, the firm is pursuing various technological innovations to increase the energy efficiency and recyclability of handsets. Green memory, green plastics, and e-HMS systems are examples of these innovations. While the firm implements various certification programs to cultivate the supplier's capability, the firm also carries out major customer awareness drives.

Figure 3. Samsung Mobile Supply Chain Structure and Green Management Practices
(Adapted from Olhager et al., 2002; Catalan and Kotzab, 2003)



Discussions & Implications

One of the important research questions that this research investigates is the differences in the type of green supply chain practices depending on the characteristics of the products involved. Based on the findings provided in the previous section, we propose the following similarities and differences between EESC and ERSC.

The two supply chains share common features in green management. Both POSCO and SEC pursue the reduction of pollutants and toxic emissions in production from raw materials to manufacturing to logistics. Consequently, they not only abide by the environmental regulations but also exceed the expectations and introduce innovative ways to make the product and process greener. When it comes to specifics, however, we find that the companies place different emphases on green management.

First, POSCO tends to stress technological innovation in the green process to address green pressures, whereas SEC accentuates the green product strategy. POSCO implemented FINEX, an innovative steel process technology that drastically lowered both greenhouse gas emissions and production cost. Functional product usually aims at economy of scale and there is less need for customization and innovative product design. Thus, the primary concern is to reduce the level of the environmentally detrimental effects coming out of the production process. In contrast, Samsung Mobile faces high uncertainty in demand due to competition and customers' preference changes. The technology convergence frequently taking place in the mobile phone industry widens the horizon of competition to other fields, posing threats to the company. Consequently, the firm has focused on product innovation in order to outcompete other firms. With respect to the environmentally friendly product, the firm has endeavored to embed innovative environmental features into cell phones as manifested in green memory, the solar-powered panel,

and plastics recycled from corn. Although SEC strives to lessen the amount of GHG emissions and pollutants, offering environmentally friendly and innovative products carries more weight in earning a market share in the industry.

Second, while EESC stresses keeping to the environmental standard across the supply chains, ERSC centers on the collaboration of suppliers and distributors in greening the supply chain (Blackburn et al., 2004; Gyöngyi, 2005). POSCO, for example, works with its raw material suppliers to meet the international environment protocols and apply the regulations consistently. POSCO strives to meet the industry standards and the environmental regulations. Samsung Mobile, however, attempts not only to place the components under the control of environmental regulations but also to encourage its suppliers to suggest innovations in the ways of improving environmental performance. Because there are limited numbers of EMSs and ODMs that proficiently tackle today's customers' needs, SEC has only a handful of suppliers with which to build long-term collaborative relationships. Suppliers perceive earning environmental certification from SEC as a useful accomplishment and they make efforts to attain such certification. It is an important priority for Samsung Mobile to continually screen qualified and potential suppliers and develop their capability to meet the need for groundbreaking design and steady improvement in handset functions.

Third, the extent of reverse logistics differs between the companies. It seems that Samsung Mobile takes more initiatives to educate consumers and encourage them to recycle handsets than POSCO does. SEC's efforts are due, in part, to the low awareness of mobile phone recyclability. Another reason for SEC's efforts is that in the mobile phone industry customer and community drive green management. SEC perceives more pressure from its customers than POSCO does. SEC's strategy is to improve its image as a socially responsible company in order to attract high-

end customers. In the case of POSCO, however, its environmental goals are governed by its interest in improving the process technology and by the regulatory pressure to conform to environmental regulations. The drive for customer awareness is a less conspicuous issue in POSCO. Generalizing at the EESC and ERSC level, the findings of this study make it clear that cultivating customers' knowledge of and aptitude in green management is more important to ERSC companies. The rationale behind the disparity is two-fold. First, innovative products face a shorter product life cycle on account of frequent leaps in technology development. Second, the customer plays a hefty role in recycling the products. Table 2 provides a summary of the comparisons between ESC, EESC, RSC, and ERSC.

Table 2. Summary of the comparisons among efficient, eco-efficient, responsive, and eco-responsive supply chains

	Efficient Supply chain	**Eco-efficient supply chain**	**Responsive supply chain**	**Eco-responsive supply chain**
Definition	To minimize cost through efficient coordination of material flows and manufacturing processes	To achieve waste and pollution reduction with fewer resources	To respond to market demands through shortened product design and supplier collaboration	To deliver environmentally friendly products to customers speedily
Value priority	To supply predictable demand efficiently at the lowest possible cost	To pursue zero-waste/ pollution goals at minimal cost	To respond quickly to unpredictable demand in order to minimize stock-outs, forced markdowns, and obsolete inventory	To seek value premium and satisfying environmentally oriented customer demand
Practices	Lean practices	Pollution reduction practices, 3R (Reduce, Reuse, and Recycle) practices	Agile practices	Eco-design or design for environment practices
Manufacturing focus	To maintain high average utilization rate	To reduce pollutants	To deploy excess buffer capacity	To achieve recyclability, remanufacturability, modularity, design innovation
Supplier selection	To select primarily for cost and quality	To select for keeping to the environmental	To select primarily for speed,	To select for supplier involvement in early

priorities		regulations	flexibility, and quality	product design phase, environmental certification.
Product design priorities	To maximize performance and minimize cost	To decrease use of environmentally harmful material	To use modular design in order to postpone product differentiation	To use recycled materials, aim for energy efficiency
Logistic/ marketing	Forward logistics	Reverse logistics	Customer management	Customer awareness program

Conclusion

Green supply chains will play a pivotal role in business in the future. In this globalized business landscape, it is inevitable that firms will work with dispersed suppliers around the world. As the scope of supply chains broadens and becomes more complicated, firms face challenges in managing supplier relationships and in achieving sustainability compliance across the supply chains. For example, the recent sticky pedal recall by Toyota was largely attributed to mismanagement of supplier quality. Thus, it is important for the focal firms to maintain and increase supplier quality and reduce pollutant material in the production and distribution process.

This study has endeavored to examine two types of supply chains based on Fisher's seminal work (1997). The study shows that two types of green supply chains are in the process of development contingent on the prior supply chain types. The basic research purpose was to look for the evolution of supply chains from ESC to EESC and from RSC to ERSC. The case studies of POSCO and SEC proffer preliminary evidence of such evolution in progress. While both companies pursue the minimizing of environmental pollutants in their manufacturing and delivery processes and the adoption of socially responsible practices, they place different emphases on specific practices. POSCO invests a great deal of its resources in improving the production process, and environmental regulations primarily drive the company to pursue

environmental excellence. Samsung Mobile, however, emphasizes innovation in product design and features to make them more environmentally friendly, and the main goal behind the emphasis is the consumer and social quest for greener business. A significant portion of Samsung Mobile's efforts pertains to enhancing customer awareness of mobile handset recycling.

As the emphasis of EESC and ERSC differs in green practices, performance measures will carry different weights depending on the type of supply chains. EESC should pursue process innovation, and ERSC should seek product innovation, supplier collaboration, and consumer education. To the authors' best knowledge, this is the first attempt to distinguish between EESC and ERSC. Future research should look at the similarities and dissimilarities between these two types of supply chains in more depth and in different contexts. In addition, it will be interesting to see what kind of changes the difference in the supply chains causes in management and performance outcomes.

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