The Impact of Product Variety in The Supply Chain: An Integrative Review and Future Research Direction

제품다양성이 공급사슬에 미치는 영향: 종합리뷰 및 미래연구방향

Youngah Kim(김영아)*

In recent decades, product variety has increased dramatically in most industries. Rapidly evolving technologies, global competition, and sophisticated customers have contributed to an increase in product variety in many industries. In this paper, I study the impact of product variety on several businesses in the supply chain through literature review. By study of literature, this paper presents the benefits and drawbacks of increasing product variety on functions performed in several departments, such as engineering, manufacturing, purchasing, logistics and marketing. It provides a brief overview of the various techniques like modularity, component sharing, and platform-based development, which are helpful in reducing the costs, when designing for variety. It also provides a brief overview of order processing, purchased component/part variety, which are helpful in reducing the purchasing costs, and customer satisfaction, market advantage, market share, competitive advantage and demand forecast, which are useful in impact of product variety on marketing. Future research directions are discussed.

Keywords: product variety, supply chain, platform-based development

I. Introduction

In recent decades, product variety has increased dramatically in most industries. Rapidly evolving technologies, global competition, and sophisticated customers have contributed to an increase in product variety in many industries. Companies are increasing variety in their products to gain more market share and to be competitive in the market where customers' preferences to products change rapidly and customers would

* Research Fellow, The Institute for Industrial Policy Studies(queenmkt@hanmail.net)

like to buy just what they need or want. In the U.S. automotive market, the number of models offered increased from 84 in 1972 to 142 models in 1989(Fisher et al. 1996). In the packaged-goods industry, the number of new products introduced doubled from 12,000 in 1986 to 24,000 in 1996(Thonemann and Bradley 2002). The number of products available in large supermarkets has increased from on the order of 1000 in the 1950s to 30,000 in a modern supermarkets(Safeway Annual Report 1997). Similar developments can be found in most other industries, such as computer hardware, software, and telecommunication industries. By increasing product variety in style, function, package, size, and so on, it may be possible to satisfy customers more, resulting in enhanced competitiveness and more market share in the market.

Even though increasing product variety might have a potential to increase sales, it has its share of drawbacks so that it might not be profitable. Simply increasing variety does not guarantee an increase in long run profits, and can worsen firm's competitiveness. This makes variety management a crucial dimension of successful business practice. Increasing product variety might have strong impact on a firm's business. More product variety may increase the manufacturing costs and complexity. Increasing product variety causes higher complexity of demand forecasting and matching of supply with demand in the supply chain (Whang and Lee 1998; Ulrich and Randall 2001). Therefore, companies increasing variety in their product lines should also understand the impact of product variety on all relevant costs and the various functions performed by its engineering, manufacturing, purchasing, logistics, and marketing departments. The literature on product variety has been focused on such issues as its importance within the competitive strategy(Kekre and Srinivasan 1990; Uzemeri and Sanderson 1995), its impact in operation performance(MacDuffine et at. 1996; Perkins 1994; Yeh and Chu 1991) and the use of flexibility for dealing with product and part variety in operations and strategy(Chen et al. 1992; Slack 1987). In recent years, companies have started to recognize that a trade off exists between product variety and supply-chain performance. Some firms have sought to optimize the number of products they offer, trading off the benefits of a larger product portfolio for lower supply chain performance. In the absence of a quantitative model for the effect of product variety on supply chain performance, these companies have mainly relied on qualitative judgment. Thonemann and Bradley(2002) developed a model for analyzing the effect of product variety on supply chain performance for a supply chain with single manufacturer and multiple retailers. Ramdas and Ulich(2003) discussed key issues on variety creation decisions and variety implementation decisions. Previous research indicated the impact of product

variety on businesses functions fragmentally. Until now, the research mostly focused on the impact of product variety on individual functional areas or in only one industry.

This study introduces a framework for the management of product variety in the supply chain. This framework is based on literature review. It aims to describe the elements involved in the process of dealing with product variety needs within the strategic and operational levels in supply chain. In this paper, I discuss the key issue factors in product variety, and review the literature in several business functions, e.g. design and engineering, manufacturing, purchasing, logistics and marketing. I focus exclusively on product variety from the firm's perspective, as opposed to the individual consumer's perspective, market-equilibrium or social optimality perspective.

Thus, it is timely to extensively study the impact of product variety on various businesses. This research will show a comprehensive list of past research appeared in the literature, the positive or negative impacts of product variety on various business functions, and finally, will discuss the directions for future research.

II. Definitions and Drivers of Product Variety

There are several definitions of product variety available in the literature. Ulrich and Randall(2001) defined product variety as the number of different versions of a product offered by a firm at a single point in time. Fisher et al.(1999) stated that product variety can be defined in two dimensions: the breadth of the products that a firm offers at a given time and the rate at which the firm replaces existing products with new products. Martin(1999) defined two types of variety: spatial variety and generational variety, Spatial variety indicates the variety that a company offers the marketplace at a point in time, and generational variety means variety across future generations of products.

Increasing product and part variety is one of the most distinctive characteristics of industrial competition today(Frey 1994; Lee and Tang 1997). Its increasing role as determinant of operations strategy and performance has been noted by a series of studies(Gerwin 1993, Mc Cutcheon et al. 1994; Milgrom and Roberts 1990). Kekre and Srinivasan(1990)'s survey of 1,400 business units suggested that broadening product lines have a positive impact in competitiveness and that firms in many businesses have to increase their product variety to remain competitive. However, some companies have realized that they might have underestimated the cost of product variety and consequently offer too much product variety. Thus, some firms have reduced the number of products they offer to improve supply-chain performance.

Procter & Gamble recently reduced the number of variants of Head and Shoulders dandruff shampoo from 22 to 15(The drive for simplicity, The Financial Times, August 11, 1998). Ford reduced the number of models in its Taurus product line by 30% from 1988 to 1995(Thonemann and Bradley 2002). Both companies accomplished the reduction in product variety without adversely affecting sales.

Many different authors seem to agree that the external dynamics of industrial firms has increased over the last decade or so. Some speak of increased competition and the need for more market-focused organizations, whereas others discuss technological pressured on firms. It seems to have become accepted that whereas firms in the 1960s and prior could rely on stable(expanding) market conditions and customer emphasis on price alone, today markets are less than stable and emphasis is on price, quality, delivery, innovation, and so on. There seems to agree that an entirely new competitive situation has arisen. This is nicely summarized by D'Aveni(1994) under the concept of hypercompetition. This is a competitive situation where the key competitive success factor is the ability to constantly develop new product, processes or services, providing the customer with increased functionality and performance. It seems fair to say that the pressure for innovation and reinventing the firm is greater than ever. The corresponding need for strategic changes and organizational adjustment serves to challenge several established notions of strategic management-not least traditional ideas regarding product variety.

Managing product variety requires decision making at different organization levels, over different time horizons, within and across functional and organizational boundaries, before and after product launch. Variety-related decisions can be viewed as focusing on how to create variety in a product line, and on managing a firm's processes and supply chain to implement variety(Ramdas 2002). The question is how much variety should be offered. To optimize product variety, the benefits of product variety have to be assessed relative to the cost of product variety. The manufacturer produces products on a shared resource with limited capacity and the effect of changeovers from one product to the next on supply-chain cost is due primarily to setup time rather than setup cost. The expected lead time and the retailer's costs are concave increasing in product variety, and that they increase at a rate that is asymptotically linear. Thus, if setup times are significant, the cost of product variety is substantially greater than that suggested by the risk-pooling literature for perfectly flexible manufacturing processes, where the cost increases proportionally to the square root of product variety.

Offering consumers some product variety is essential for success in today's business environment. Customers' evaluations of product quality and choice level and their expressions

of satisfaction are critical decision to the level of product variety. Customer satisfaction undeniably has come to be an important cornerstone of customer-oriented business practices for firms that operate in diverse industries and global markets. Satisfaction ratings are viewed as means to strategic ends, such as repurchase behavior and customer retention, that directly affect a firm's profits and overall performance.

The characteristics of customers' preferences are the antecedents to and main drivers of the response to markets' offers, including individually customized offers. The emerging consensus among researchers of customer decision making is that buyers often do not have well-defined preferences that can be retrieved and they construct their preference when face with the need to make decisions. It is noteworthy that the conclusion that preferences tend to be unstable and susceptible to various influences does not apply equally to all preference levels. In particular, much of the research supporting the notion that preferences are constructed and susceptible to a variety of seemingly irrelevant influences has involved options with different attribute values that were in the same product category.

How to variety management, and the decision themes introduced above, fit within the broader context of the firm's long-term objectives? In a rational approach, firms should strive to balance the revenue and cost impact of variety decisions, in order to maximize long-term profits. In my view, variety creation and variety implementation decisions impact revenues via two important criteria that mold customers' perceptions about a firm's products: differentiation and variety. The term differentiation is used in the strategy literature, to describe how a firm's products are distinct from those of competitors, along either price or non-price dimensions. Thus even a single product firm can be highly differentiated in the marketplace. In contrast, I define variety as describing how a firm's products are perceived as distinct from one another. A firm's variety creation and variety implementation decisions enable it to attain a certain degree of synergy among its products. Synergies may accrue from sharing of underlying product or process technologies, product function, components, production or distribution processes, or knowledge about the needs of a customer segment. They enable the firm to realize economies of scale in design, production, distribution and after-sales support: these in turn drive costs. Variety implementation decisions determine a firm's responsiveness to demand uncertainty. For example, reducing lead-time by locating production geographically close to demand or by increasing manufacturing flexibility, increases responsiveness.

Collecting decisions across the multiple academic perspectives mentioned in 〈Table 2-1〉 helps us not only integrate these perspectives but also identify interdependencies among these decisions.

〈Table 2-1〉 Comparative of Product Perspective in Marketing, Organizations, Engineering Design, and Operations Management(Krishnan and Ulich 2001)

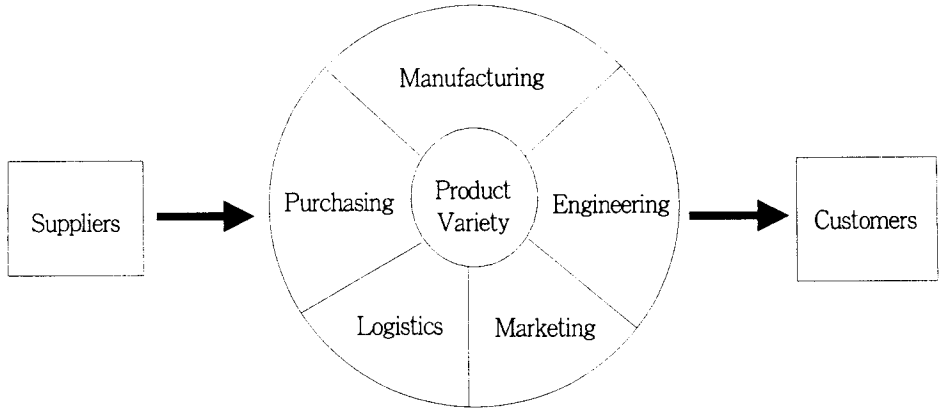
	Marketing	Organization	Engineering Design	Operations Management
Perspective on Product	a bundle of attributes	an artifact resulting from an organizational process	a complex assembly of interacting components	A sequence of development and/or production process steps
Typical Performance Metrics	Market share Consumer utility	Project success	Form and function Technical performance innovativeness	Total cost Lead time Service level
Dominant Representational Paradigm	Customer utility as a function of product attributes	No dominant paradigm Organizational network sometimes used	Geometric models Parametric models of technical performance	Process flow diagram Parametric models of process performance

Ⅲ. The Impact of Product Variety on Business in The Supply Chain

Supply chain is such a broad notion that it can be approach from many different perspectives: purchasing and supply, logistics and transportation, industrial organization, marketing, strategic management, and many others(Croom et al. 2000). Some of the pioneering works viewing SCM(Supply Chain Management) as management approach are from Jones and Riley (1985), Houlihan(1985). These authors recognize that there is a continuous chain of functional areas through which materials flow and that extends from suppliers to final distributors.

Product variety management in the supply chain has been topic of a large number of research papers(Hayes and Wheelwright 1984, Miller and Vollmann 1985, Kekre and Srinivasan 1990, Child et al. 1991, Yeh and Chu 1991, McCutcheon et al. 1994, Kotteaku et al. 1995, Anderson 1995, Tang and Yam 1996, Fisher et al. 1996, Jina et al. 1997, Prasad 1998, Fisher and Ittner 1999, Flynn and Flynn 1999, Ahlstroom and Westbrook 1999, Alford et al. 2000, Ulrich and Randall 2001, Froza and Salvador 2002, Thonemann and Bradley 2002). In this view, I find it useful to discuss the research framework on the impact of product variety on business in the supply chain. This framework aims to describe the elements involved in the process of dealing with product

〈Figure 3-1〉 Business Function Affected by Product Variety



variety needs within the strategic and operational levels in supply chain. I discuss the key issue factors in product variety from the firm's perspective, and review the literature in several business functions, e.g. design and engineering, manufacturing, purchasing, logistics and marketing. This chapter will show a comprehensive list of past research appeared in the literature, the positive or negative impacts of product variety on various business functions.

Several functions in a firm have directly related to product variety, as illustrated in 〈Figure 3-1〉. A marketing department in a firm usually plays a main role to determine what customers want and need. However, the degree of product variety in a product line should be a cross-functional decision and further company's strategic decision because it will directly affect the company's sales. In this section, the impact of product variety on the various functions will be thoroughly investigated through literature review.

3.1 Engineering

Increasing variety increases the design workload connected to the development of numerous new product variants(Forza and Salvador 2002). When designing for variety, introducing modular architecture increases flexibility in design and manufacturing through separation of subparts of products(Fujita 2002). By pursuing modularity in the design of product family architecture, the negative impact of product variety on operational performance can be reduced(Forza et al. 2002).

Modular product design is the best way for achieving product variety. Modular approach enables to offer a great range of end products, while reducing the variety of components (McCutcheon et al. 1994; Alford et al. 2000). A competitive company must consider product families and generations and seek commonality between parts and subsystems(McDermott and Stock 1994). Modularity in product design

plays an important role in many activities: product cost, DFM/DFA, manufacturing cycle (flow) time, product flexibility, supplier capabilities, supply chain management issues, serviceability, and multi-generation product platform planning(Ishii 1998).

The challenge is to introduce the high degree of product variety, while retaining low unit costs which have been achieved through mass production with a few standardized products. Investments in new products include the costs of product development and production, and each new component has to be designed and tested, and requires investment in tooling(Fisher et al. 1999). An alternative way to reduce the unit costs is to share more common components among the variants of a product. Firms can offer high variety in the market by component sharing while retaining low variety in their operations(Ramdas et al. 2003).

To manage the complexity of offering greater product variety, firms in many industries are considering platform-based product development (Krishnan and Gupta 2001). Platforms, in their most general sense, are intellectual and material assets shared across a family of products. The advantages of using platform-based product development are reduced fixed cost of developing individual product variant, greater degree of reuse, better architecture, lower unit variable cost, quicker development of product variants, and increase in the optimal quality level of the product targeted by the high-end segment. However, the product platforms are not appropriate for all product and market conditions, and product-planning decisions are strongly impacted by the presence of platforms over design of low-end variants and under design of high-end products. Their results confirm that the platform-based development approach is more profitable than independent development of products. The impacts of product variety on various engineering operations are presented in 〈Table 3-1〉.

3.2 Manufacturing

Increasing product variety increases the costs and complexity in manufacturing(Alford et al. 2000). As product variety increases, the per-

〈Table 3-1〉 Impact of Product variety on Engineering

Index	Impact	Research
Design Complexity	I	Forza and Salvador 2001
R &D cost	I	Yeh and Chu 1991
Unit cost of product	I	Hayes and Wheelwright 1984
Engineering/ model changes	I	Yeh and Chu 1991; Fisher et al. 1995

* I-Increases

formance of the firm's internal operations decreases due to higher direct manufacturing costs, manufacturing overhead, delivery times, and inventory levels(Forza, et al. 2002). Increasing the variety level also generates a range of difficulties in ensuring operational efficiency(McCutcheon et al. 1994; Ahlstroom and Westbrook 1999). A broader product line with corresponding low volumes for each item in the line can result in higher unit costs, mainly because of increases in overhead expenses(Hayes and Wheelright 1984), and higher direct labor and material costs(Abbegglen and Stalk 1985). Especially, if setup times are significant, the effect of product variety on cost is substantially greater than that suggested by the risk-pooling literature for perfectly flexible manufacturing processes(Thonemann and Bradley 2002). However, using flexible tooling and filtering can reduce increase in setup costs arising due to increase in variety(Fisher et al. 1996).

Banker et al.(1990) studied an auto component manufacturer and observed that product complexity had a significant impact on the cost of supervision, quality control, and tool maintenance. In contradiction, research done by Fisher et al.(1996) in the automotive plant showed that the product complexity does not have a negative impact on quality and labor productivity, but there is a statistically significant negative effect of parts complexity on productivity. Using data from the U.S. bicycle industry, Ulrich and Randall(2001) showed how product variety can be matched with a supply chain structure. Increasing product variety within a supply chain increases both production costs(Stalk and Hout 1990; Cooper 1990) and market mediation costs(Fisher 1996).

Yeh and Chu(1991) showed that broadening product lines increases firm's power to compete, but it also causes the firm to lose its cost advantage. On the other hand, the results of Kekre and Srinivasan(1990) showed that product variety has a small significantly favorable impact on direct costs and manufacturing costs. Using modern production technology and sophisticated operations management will only cause slight increase in these costs(Tang and Yam 1996; Kekre and Srinivasan 1990). Jaikumar(1986) observed that simply procuring flexible manufacturing systems is no panacea for handling the complexity arising from product variety. Management has an important role in making the entire production system flexible both by insuring that production scheduling, equipment setup, and maintenance policies support the effective utilization of flexible tooling, and by training workers in multiple skills so they can handle the demands of higher variety. Modularity can be a solution to the growing complexity in assembly processes cost(Baldwin and Clark 1997).

Martin and Ishii(1996) developed a model that helps in understanding the true costs associated with providing variety. They tried to capture the indirect costs through the measure-

ment of three indices: commonality, differentiation point, and set-up cost. Martin and Ishii(1997) developed qualitative and quantitative tools, which will help engineers in developing products with minimum costs. With increase in variety, assembly line task balancing becomes problematic, and parts planning and production scheduling systems becomes complex(Fisher et al. 1996).

A recurring theme in popular management press is that marketing and manufacturing have conflicting objectives(Crittenden et al. 1993). In contradiction to the common theme, Gupta and Srinivasan(1998) showed that it is not always true that marketing benefits from increase in product variety, whereas manufacturing pays the price due to higher production costs. To optimize product variety, the benefits of product variety have to be assessed compared with all the relevant costs. Focusing on make-to-order environment and using queuing models, Gupta and Srinivasan(1998) derived conditions under which an increase in product variety improves both individual product performance and system performance.

Jina et al.(1997) studied how lean manufacturing can be applied to high-variety and low-volume segments. Study in an automotive assembly plant by Fisher et al.(1996) provided partial support of the hypothesis that lean production plants are capable of handling higher levels of product variety with less adverse effect on labor productivity than traditional mass production plants.

Keeping the system as common as possible and postponing the commitment to variety requirements, commonly known as "late point differentiation or postponement," have been proven effective for appliances(Ishii et al. 1995) and computer peripherals(Lee and Tang 1997), and many other industries. Using postponement increases flexibility and also improves the forecast accuracy for the demand of final products in the distant future(Whang and Lee 1998). Forza et al.(2002) provided empirical insights into the relationships among the type of modularity, product variety, and component sourcing decisions. They suggested that the appropriate type of modularity is component swapping modularity when product variety level is low, and production volume is high, whereas if the product variety level is high, and production volume is low, then the appropriate type of modularity is combinatorial modularity. They also showed how modularity is helpful in limiting the negative implications of product variety on operational performance. In 〈Table 3-2〉, the various manufacturing operations that are impacted by increase in product variety are summarized.

To product produces in small batch sizes, some companies have reduced setup times in recent years. In car manufacturing, for instance, Toyota developed a die-change technique that dramatically reduced setup technique allows a die change every few hours(Womack, Jones

〈Table 3-2〉 Impact of Product Variety on Manufacturing

Index		Impact	Research
Labor Productivity (due to Product Complexity)		NNI	Fisher et al. 1996
Quality	Total Quality	IS	Yeh and Chu 1991
	Quality Control Cost	I	Banker et al. 1990
	Quality problems and rework	I	Fisher et al. 1995
	Quality(due to product complexity)	NNI	Fisher et al. 1996
Manufacturing Costs		I	Anderson 1995; Child et al. 1991; Fisher and Ittner 1999; Flynn and Flynn 1999; Forza and Salvador 2002; Kotteaku et al. 1995; Miller and Vollmann 1985; Prasad 1998; Yeh and Chu 1991; Tang and Yam 1996; Alford et al. 2000; Thonemann and Bradley 2002
		FI	Kekre and Srinivasan 1990
		SI	Tang and Yam 1996
Production Costs		I	Stalk and Hout 1990; Cooper 1990; Fisher et al. 1995; Bayus et al. 2003
Set up costs		I	Fisher and Ittner 1999
Manufacturing Flexibility		I	Silveira 1998
Process variety		I	Yeh and Chu 1991
Part Variety		I	Yeh and Chu 1991
Manufacturing Complexity		I	Alford et al. 2000; Yeh and Chu 1991
Direct Labor costs		I	Abegglen and Stalk 1985
Supervision effort		I	Yeh and Chu 1991; Fisher et al. 1995
Scheduling Complexity		I	Yeh and Chu 1991; Fisher et al. 1995
Material costs		I	Abegglen and Stalk 1985; Tang and Yam 1996
Part Complexity/Productivity (due to Product Complexity)		NI	Fisher et al. 1996
Overhead costs		I	Stalk 1988; Fisher et al. 1995; Tam and Yang 1996; Hayes and Wheelright 1984; Fisher and Ittner 1999

* I-Increases; D-Decreases; IS-In significant; SI-Slight increase; FI-Favorable impact; NI-Negative impact; NNI-No negative impact; LNI-Little negative impact

and Ross 1990). Conversely, production runs in traditional automobile parts stamping plants can last days.

For the manufacturer, whose objective is to minimize expected lead time, setup-time reductions are attractive if the size of the setup time, the manufacturer might decided that an additional small decrease in setup time is not worth a certain investment. However, even small reductions in set up time might be attractive to the retailer, especially when the current setup time is small. Thus, if the performance of the supply chain in total is to be considered, then the manufacturer must consider the effect of its actions outside of its own facility. Expected lead time and cost at the retailers can be reduced the unit manufacturing time. Reductions in unit manufacturing time can be achieved by several means, e.g. by installing faster or additional equipment, or by assigning additional workers to the manufacturing process.

3.3 Purchasing

Increase in variety increases the purchasing costs(Ulrich and Randall 2001). The increase in purchasing overhead costs might not be significant when e-purchasing is used as opposed to using traditional purchasing processes. The increases in purchasing costs are mainly attributed to the increase in variety and reduction in volumes of purchased parts and components (Fisher et al. 1999). As product variety increases, the volume is split among multiple products and the quantity discounts in purchasing are unattainable(Ulrich and Randall 2001). Forza et al.(2002) stated that suppliers may experience diseconomies due to component variety, with potential negative impact on component prices, delivery times, and component inventory levels (Krishnan and Gupta 2001; McCutcheon et al. 1994). In high variety and low volume manufacturing, it is difficult to develop the most profitable partnership with the supplier, in terms of delivery quantity, frequency, and price(Jina et al. 1997). Carr and Pearson(2002) revealed that the purchasing/supplier involvement has a positive impact on strategic purchasing, and this purchasing has a positive impact on a firm's financial performance. The impacts of product variety on various purchasing operations are presented in 〈Table 3-3〉.

〈Table 3-3〉 Impact of Product Variety on Purchasing

Index	Impact	Research
Purchasing Costs	I	Ulrich and Randall, 2001
Order Processing	I	Forza and Salvador, 2002
Purchased Component/Part Variety	I	Fisher et al., 1999

* I-Increases

3.4 Logistics

Increasing variety has impact on various logistics operations and costs. Variety incurs many indirect costs, such as raw material costs, work-in-process, finished goods, and post-sales service inventories, and logistics costs that are difficult to capture, and are often neglected when making the decision about introducing variety(Martin and Ishii 1996). Due to the uncertainty in forecasting demands, a firm offering more variants usually tends to carry more finished goods inventory than a firm with less variants.

Increase in variety increases the inventory levels and inventory costs(Ittner and Fisher 1999; Thonemann and Bradley 2002). The introduction of new products increases the number of SKU(stock-keeping units)'s over product life cycle. Increasing variety also increases the inventories of purchased and semi-finished parts(Forza and Salvador 2001). Benjaafar et al.(2002) examined the effect of product variety on inventory-related costs, and showed that total cost increases linearly with the number of products. In contradiction to the above general perception, Rajagopalan and Swaminathan(2001), using a mathematical programming model, show that if the plant has the ability to acquire additional capacity, increasing product variety may not result in excessive inventory, and the total inventory costs are insignificant. Er and MacCarthy (2003) also asserted that increasing variety alone does not have a significant impact on the average of total inventory. They stated that the average of total inventory is affected highly by the uncertainty in supply delivery time.

Increasing variety increases the inventories of purchased and semi-finished parts(Forza and Salvador 2002). Er and MacCarthy(2003) suggested that the negative impact of variety driven material variation in the supply chain can be reduced through standardization of materials, and by arranging service level agreement between manufacturer and buyer. Communizing raw material parts also reduces the part count. This allows the supplier to deliver higher volumes with fewer part numbers(Jina et al. 1997). The impacts of product variety on various logistics operations are presented in 〈Table 3-4〉.

Cost can be reduced by consolidating retailers. As an extreme example of retailer consolidation, Egghead, the computer store closed all of its retail outlets in 1998(Business Wire 1998). Egghead now offers its 25,000 computer products exclusively via the Internet, which is equivalent to moving to a supply chain with a single retailer. The cost is concave increasing in the number of retailers and thus the benefit of reducing the number of retailers is convex increasing in the number of retailer reduced (Thonemann and Bradley 2002).

〈Table 3-4〉 Impact of Product Variety on Logistics

Index	Impact	Research
Work-in-process inventory	I	Yeh and Chu 1991
Finished goods inventory	I	Yeh and Chu 1991;Ulrich and Randall 2001
Inventory costs	I	Fisher and Ittner 1999; Martin and Ishii 1996; Thonemann and Bradley 2002; Benjaafar et al. 2002
	IS	Rajagopalan and Swaminathan 2001
Purchased Parts inventory/ Parts inventory	I	Forza and Salvador 2002; Jina et al. 1997
Inventory levels	I	Anderson 1995; Child et al. 1991; Fisher and Ittner 1999; Flynn and Flynn 1999; Forza and Salvador 2002; Kotteaku et al. 1995; Miller and Vollmann 1985; Prasad 1998; Fisher et al. 1995; Yeh and Chu 1991
	IS	Er and MacCarthy 2003
Delivery time	I	Anderson 1995; Child et al. 1991; Fisher and Ittner 1999; Flynn and Flynn 1999; Forza and Salvador 2002; Kotteaku et al. 1995; Miller and Vollmann 1985; Prasad 1998
Component Inventory	I	Krishnan and Gupta 2001; McCutcheon 1994
Material inventory/handling/ costs	I	Yeh and Chu 1991; Fisher et al. 1995; Abegglen and Stalk 1985
Market Mediation Costs	I	Fisher et al. 1996

* I- Increases; IS-In significant;

3.5 Marketing

Market structures have often been determined by means of perceptual mapping, but these maps offer only a snapshot of structure at a particular moment in time. Buyer perceptions of product quality change because of changes in the environment of product variety. Enhancing complements may suggest quality improvements, thus making current customers less satisfied; augmenting complements may add new criteria by which buyers can judge quality.

Consumers are the ultimate source for demand for product variety, as each individual has preference for different product variants(Ho and Tang 1998). Companies try to satisfy these demands by offering a wide range of products. Multi product firms offer a variety of choices in a single product category to capture the surplus of consumers who may have hetero-

geneous quality valuations, tastes or budget constraints(Hui 2003).

Many companies expand their brands by introducing more products to compete for higher market share. Hui(2003) stated that setting aside manufacturing costs, Bayus et al. (2003) found that product line extension (new product introduction) increases PC firms' profitability through reductions in selling, general and administrative(SG&A) expenses, and other marketing and advertising costs. Even though initially increasing variety improves sales and profits, the law of diminishing returns means the benefits do not keep pace(Child et al. 1991). In the case of mature firms, increase in variety does not increase the total demand, but firms increase variety to retain market share (Rajagopalan and Swaminathan 2001).

Offering products which do not satisfy the customer needs, might not increase the market share but might adversely affect the costs. Marketers have to be careful in assessing the customer's needs since increasing product variety increases the costs and complexity in manufacturing(Alford et al. 2000). Higher product variety also evokes the complexity of demand forecasting and matching of supply with demand in the supply chain. Thus, companies must assess the level of variety at which the customer's will find the offerings attractive, and the level of complexity that will keep the costs low(Jiao et al. 1998). Martin and Ishii(1996) develop a tool that helps product managers in estimating the cost of introducing variety into their product line. This tool will help managers to maximize the market coverage while maintaining required profit margins. Various marketing operations that are impacted by product variety are presented in 〈Table 3-5〉. The notations used in this table are described below the table.

〈Table 3-5〉 Impact of Product Variety on Marketing

Index	Impact	Research
Customer Satisfaction	I	Kekere & Srinivasan 1990; Yeh and Chu 1991; Khan 1998.
Market Advantage/ Market Share	I	Tang and Yam 1996; Kekere & Srinivasan 1990; Bayus et al. 2003
Competitive Advantage	I	Tang and Yam 1996; Martin et al. 1998; Yeh and Chu 1991
Profitability	I	Bayus et al. 2003
Demand Forecast Uncertainity/Complexity	I	Whang and Lee 1998; Ulrich and Randall 2001; Er and MacCarthy 2003; Fisher et al. 1995

* I- Increases

Ⅳ. Conclusion and Future Research Directions

4.1 Concluding Remarks

Increasing product variety has become an important strategy to increase market share, sales, and profits. This paper presents a comprehensive review on the impact of product variety on various business operations and some directions for future research. The thorough literature review reveals that past research studied the impact of product variety on businesses functions fragmentally, and mostly focused on the impact of product variety on individual functional areas or in only one industry. Thus, it should be cautious to use the research findings from a particular industry for other industries, and benefits shown in one business function through product variety may be diminished by increased costs or inefficiency in other functions that will be caused by the product variety. Before increasing the variety in their product lines, companies should also take into consideration all the relevant functions and operations effected by higher product variety. As mentioned in the above sections, increasing variety has significant positive as well as negative impacts on the manufacturing, inventory, engineering, and purchasing costs, and on the manufacturing and forecasting complexity. Therefore, companies should carefully assess both benefits and detriments from offering product variety throughout all relevant functions.

4.2 Future Research Directions

In this paper, I study the impact of product variety on several businesses in the supply chain through literature review. By study of literature, this paper presents the benefits and drawbacks of increasing product variety on functions performed in several departments, such as engineering, manufacturing, purchasing, logistics and marketing. It provides a brief overview of the various techniques like modularity, component sharing, and platform based development, which are helpful in reducing the costs, when designing for variety. It also provides a brief overview of order processing, purchased component/part variety, which are helpful in reducing the purchasing costs, and customer satisfaction, market advantage, market share, competitive advantage and demand forecast, which are useful in impact of product variety on marketing. Most of the research focused on designing for product variety and the impact on manufacturing, engineering, marketing costs due to variety. Not much work has been done on how product variety affects various logistics costs; specifically, transportation costs, warehousing costs, and packaging costs.

Future research can focus on integrated study of purchasing, supplier involvement in increasing

variety. Some theories of this research could further be researched in several industries. Some theories were developed by collected data in a single industry. For example, most of the research on the impact of product variety on quality has been done in the auto industry. Some research on the impact of product variety on inventory costs and production costs revealed conflicting findings. Fisher et al. (1996) found through their study in the automotive assembly plant that product complexity occurring variety has no negative impact on the quality of products, whereas Banker et al.(1990) showed through their research in auto component manufacturer that product complexity has significant impact on quality control costs. Fisher et al.(1995) revealed through their field research in the auto industry that increasing product variety results in quality problems and rework. The general perception is that increasing variety increases the inventory costs, but Rajagopalan and Swaminathan(2001) showed that if the plant has the ability to acquire additional capacity, increasing product variety may not result in excessive inventory, and the total inventory costs are insignificant. Future research can focus on integrated demonstration study of logistics, purchasing, supplier involvement in increasing variety through several industries.

In addition, future research can provide a framework for managerial decisions about product variety. Variety decisions can be viewed as variety-creation decisions that determine the amount, type, and timing of end-product variety, and variety-implementation decisions, which focus on the design and operation of internal processes and a supply chain to support a firm's variety-creation strategy. Managing product variety requires decision making at different organizational levels, over different time horizon, within and across functional and organizational boundaries, before and after product launch. Variety decisions are driven by a combination of inertia, historical precedent, ad hoc criteria, and rational decision-making. We can develop variety-related decisions dimensions. For example, dimensions of variety, product innovation, product architecture and organization, degree of customization, timing, process capabilities, point of variegation, temporary decisions and so on. According to future research, we can have insight to problems faced in practice. Specially, we can focus two perspectives about product variety: firm's perspective and individual customer's perspective. Product variety from the firm's perspective, as opposed to the individual consumers' perspective, is market-equilibrium or social optimality perspective. We may seek to provide an integrative framework for product variety management based on these key decision themes, to discuss the research on variety using this framework, and to identify untapped areas for future research.

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제품다양성이 공급사슬에 미치는 영향: 종합리뷰 및 미래연구방향

김 영 아*

국문초록

최근 몇 년 동안, 빠르게 진보하는 기술, 국제적 경쟁, 성숙된 소비자들의 출현 등으로 많은 산업분야에서 제품 다양성은 급격하게 증가되어왔다. 기업들은 자사가 생산 또는 판매하는 제품의 다양성을 확보함으로써 고객만족이 증대하고, 이러한 결과로 자사의 시장점유율과 수익률을 증가시키고자 노력한다. 본 연구는 선행된 제품다양성에 관한 문헌연구를 전반적으로 검토하여, 공급사슬상의 기업 및 사업부 내 제품다양성 효과를 밝히고 미래연구 방향을 제시하는데 연구 목표가 있다. 즉, 본 연구는 먼저, 문헌연구에 대한 재검토를 통해서 제품 다양성 수준을 제품설계, 생산, 구매, 물류, 마케팅과 같은 각각의 공급사슬 기능별 단위들로 구분하여 정리하고, 이러한 공급사슬 각 부문에서 수행된 기능들에 대한 제품 다양성의 긍정적, 부정적 영향들을 밝히고자 한다. 또한, 다양성을 위한 제품 설계 할 때, 모듈방식, 부품공유와 같은 제품생산 비용절감에 도움이 되는 요인들, 주문 처리과정, 구매부품 다양성 정도와 같은 구매비용절감에 관련된 요인들, 시장 점유, 고객만족, 경쟁적 우위, 수요예측과 같은 마케팅 관점에서의 제품다양성에 관한 요인들을 분류 제시하고자 한다. 끝으로, 미래연구 방향에 대해서 논의한다.

핵심개념: 제품다양성, 공급사슬, 플렛폼기반 개발

* 경영학 박사, 산업정책연구원 연구원