The Potential for MFCA Spread in Supply Chains Through Information Sharing

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Material Flow Cost Accounting (MFCA) has been published as ISO 14051 and introduced to a number of Japanese companies. This paper investigates the smooth expansion of MFCA to Supply Chains between both Buyer and Suppliers. Our purpose is achieved by questionnaire research (QR). According to the results of our QR, although the requirements of the introduction of MFCA are information sharing and cooperative Kaizen, some assemblers, except automobile companies, have yet to implement this tool. Some case studies of the introduction of MFCA to companies illustrates the use of MFCA information to Kaizen. Additionally, We investigated that the Assembler (machinery, electrical appliances, transportation equipment, and precision equipment) to determine where it would be simplest to introduce MFCA to a supply chain, and to determine which aspects of MFCA should be emphasized. The electrical-appliance companies had a stronger environmental awareness.

Keywords: MFCA (Material Flow Cost Accounting), Questionnaire Research, Japanese Company, Environmental Management

1. Introduction

The business community has come to regard the environment more seriously than ever in recent years. Many companies are seeking to reduce their environmental footprint, particularly their greenhouse gas emissions, while also pursuing profits.

Material Flow Cost Accounting (MFCA) is an environmental management tech-

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nique that increases resource efficiency, thus allowing a company to reduce both its environmental footprint and its costs. In Japan, there are more than 300 examples of this tool in practice, and society's awareness of it has grown following its publication as a standard in September 2011 as ISO 14051. Thus far, MFCA has been adopted at the individual company level as an environmental management accounting technique, but its scope is growing, due to its adoption throughout supply chains (METI 2010, pp 69–77).

Our intent in this paper is to study how existing supply chains can be transformed into environmentally oriented supply chains through the use of MFCA, to reduce resource use and contribute to a low-carbon society. In particular, our goal in this paper is to identify types of industries amenable to the smooth introduction of MFCA as a step towards the development of environmentally oriented supply chains. We should point out that when we discuss this development, our assessment is not confined to a single company's reduction of resource use and CO2 emissions. It also encompasses the upstream and downstream companies, with reference to supply chains in which these companies share information on material loss and CO2 emissions to attain the primary goal of reducing CO2 emissions and resource use (Kokubu et al, 2012). Because MFCA aims to reduce resource use directly, it can also help lower CO2 emissions by reducing energy losses, but it does not take CO2 as a unit of measure directly. Even so, by linking carbon-footprint concepts to MFCA, it is possible to assess CO2-emission reductions that are tied to reductions in the material losses of processes, which information companies can then use as a new form of business information regarding CO2 reduction (Kokubu et al 2012, 2013; Nakajima and Oka 2013).

This paper will first provide an overview of MFCA and consider the factors involved in introducing it; next, we will discuss those industries which are ready to introduce MFCA, on the basis of a questionnaire in February 2012 conducted as a survey of publicly listed companies. Finally, this paper's implications and unresolved issues will be examined.

2. An overview of MFCA: factors in its introduction

1. What it means to introduce MFCA to a Supply Chain

Products or production line processes are the focus of MFCA analysis: this tool aims to visualize material losses in terms of material quantities and to assess the costs of material losses using manufacturing-cost information. MFCA analysis is used as a management technique to increase resource efficiency. Cutting material

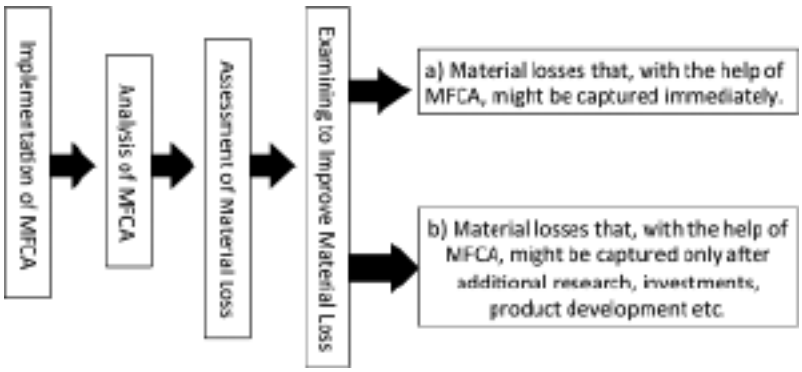

Figure 1. Classification of Material Loss
Nakajima and Kimura (2012) p. 16

losses reduces both costs and environmental footprints, and contributes to building a low-carbon supply chain by reducing the volume of input materials and energy used. Seen in this light, MFCA can be considered an environmental-management accounting method.

In past research, material losses made visible through MFCA have been classified into two categories, as shown in Figure 1.

As shown in Figure 1, material losses made visible through MFCA can be classified as either a) capable of being quickly reduced or improved through on-the-spot changes on the factory floor, or b) requiring long-term study. Although there may be any number of conceivable measures to reduce material losses, those in the latter industry often require cooperation outside the manufacturing department, which renders quick fixes impossible. For example, when a problem has been discovered that can only be fixed with a change in manufacturing processes and a change in product design, several internal functions - such as manufacturing technology, product development, and R&D - must cooperate together to address the issue. Additionally, material losses can be cut in many cases with the cooperation of suppliers outside the company. Cases which require the cooperation of suppliers will be driven by the company's purchasing department.

To increase resource efficiency throughout the supply chain and to achieve a low-carbon supply chain, the buyer firm, having discovered issues through MFCA, must cooperate with the supplier and, together, they must address the issues individually. The next section considers the factors needed to introduce MFCA to a supply chain.

3. Supplier-driven inter-organizational cost management

Previous research that looks at Japanese business and discusses the supply chain in the buyer-supplier relationship includes Asanuma (1984, 1997), who discusses the relationship between product (or component) manufacturers which are assemblers and their suppliers in Japan's automotive and electronic parts industries. Asanuma (1997), for example, emphasizes the longstanding and robust networks between buyers and suppliers as a source of strength for certain product (or component) manufacturers in Japan.

There is also previous research which focuses on inter-organizational cost management among Japanese companies, including Cusumano and Takeishi (1991), Sako (1992), and Carr and Ng (1995). In Cusumano and Takeishi (1991), a questionnaire surveying US and Japanese automakers showed that Japanese companies were more likely to propose improvements to their suppliers. Sako (1992) used a questionnaire study administered to suppliers in the UK and Japan and found that Japanese businesses built closer relationships between organizations and with greater trust. Additionally, Carr and Ng (1995) studied the collaboration between Japanese automakers in the UK and their suppliers, observing that information sharing and trust are important for inter-organizational cost reductions. Further, Shank and Govindarajan (1993) emphasized the importance of relationships with suppliers in their discussion of the utility of value-chain analysis from the perspective of managerial accounting.

This research considers the role that the relationship between buyer and supplier plays in inter-organizational cost management from the perspective of target costing (Carr and Ng, 1995). If we also consider target costing as one of the methods in the introduction of MFCA to the factory floor, then it is important to consider previous research on target costing in terms of the buyer-supplier relationship. Morofuji (1999), Lee and Monden (2000), and others discuss the importance of information sharing between buyer and supplier. This factor plays an important role in the collaboration between buyer and supplier.

Morofuji (1999) describes how carmakers, which assemble finished products, present performance requirements and price expectations to the manufacturers that supply their components; the component manufacturers produce suitable designs, taking into account their own manufacturing conditions, and are able to meet multiple targets simultaneously. From their questionnaire, Lee and Monden (2000) show that when finished-goods manufacturers and component manufacturers both share in the risks and profits, they tend to share information well

between them.[1] Previous research(Car and Ng, 2001; Morofuji, 1999; Lee and Monden, 2000) highlights that in inter-organizational cost management at least, which includes target costing, information sharing is likely to play an important role in the collaboration between assemblers and suppliers.

A common element in previous research is the attention given to assemblers. For example, a buyer that is a manufacturer of building materials will purchase raw materials and perform almost all the processing in-house to complete the finished goods. In the supply chains described here, however, the close collaboration and trust relationship discussed in the research above assumes that the buyer is an assembler, as with carmakers and component manufacturers.

As previously mentioned, MFCA is a method for discovering material loss from the perspective of resource efficiency. Further, while MFCA is applicable to any company that handles materials, companies that handle processing in-house will be able to make more internal improvements than an assembler due to the effects of cutting the material losses that have been made visible. This means that among companies introducing MFCA, non-assemblers will experience greater effects in terms of resource efficiency at the individual company level. However, as we have seen, where collaboration with suppliers is possible, the assembler can initiate sharing those issues made visible through MFCA, thereby improving resource efficiency across the supply chain as a whole through Kaizen activities.

As is the case with many new methods, MFCA may meet with resistance when introduced to the factory floor. This is because, in almost all cases, measuring and totalling physical-quantity information per stage of production in processes requires the performance of a new task in addition to the routine work. In companies that are already engaged in inter-organizational information sharing and collaborative kaizen activities, the implementation of MFCA may be smoother than in those companies that are not. Because MFCA can lead to both a smaller environmental footprint and lower costs, the assembler and supplier that collaborate to solve these issues can share the profits gained from cost reductions between them.

In this paper, we consider it desirable that the assembler would have already laid the groundwork with its suppliers for information sharing and collaborative kaizen activities in order to achieve a smooth and straightforward introduction of MFCA to the supply chain. Accordingly, the next section will analyse the current

1）Lee and Monden (2008) distinguish between approved plan auto parts manufacturers and lent plan auto parts manufacturers in their QR.

state of affairs among assemblers, as revealed through a questionnaire.

4. Questionnaire results and observations

1. Overview of questionnaires

Questionnaires in Japan targeting assemblers on the subject of managerial accounting include those of Lee and Monden (2000) (as mentioned in Section 3) and Sakaguchi (2003). Sakaguchi (2003) aimed to clarify the buyer-supplier relationship in Japan and, much like Lee and Monden (2000), took as its subjects, publicly traded companies in the fields of machinery, electrical appliances, transport equipment and precision equipment. According to the findings of the questionnaire used in Sakaguchi (2003), while assemblers in Japan were familiar with their suppliers' production processes, manufacturing facilities, quality-control systems and quality-related information, their level of understanding was insufficient with regard to information on cost.

Questionnaires of Japanese companies on the subject of low-carbon supply chains include that of Kajiwara and Kokubu (2012). Their questionnaire showed how the style and quality of business relationships between buyer and supplier, and departmental targets in the purchasing department, affected the pursuit of low-carbon supply-chain management. Kajiwara and Kokubu (2012) make an important contribution by identifying the determining factors of low-carbon supply chain management.

Our goal in this paper is to identify the industries that are amenable to the smooth introduction of MFCA to the supply chain, and the characteristics that favor this method. We conducted a questionnaire that would let us examine, among other factors, whether assemblers were better equipped to introduce MFCA than non-assemblers.

We sent the questionnaire to publicly listed manufacturers (1,561). Following the example of Lee and Monden (2000) and Sakaguchi (2003), we treated responses from businesses in the fields of machinery, electrical appliances, transport equipment and precision equipment as those of "assemblers." We sent questionnaire forms by mail to purchasing officers (in purchasing departments, materials departments, etc.)

We sent our questionnaire forms on February 4, 2012, with a response deadline of February 29, 2012 . We had a response rate of 22.8% (356 responses). Figure 2 below shows the breakdown by industry among respondents. Figure 3 shows that we did not discover any non-response bias between responding and non-

Figure 2. Category of industry and companies

Category of industry	Number of responses		Number of mailings	
	Number	Ratio	Number	Ratio
Transportation Equipment	26	7.3%	104	6.6%
Non-Ferrous Metals	8	2.2%	38	2.4%
Electric Appliances	73	20.5%	283	18.1%
Electric Power & Gas	3	0.8%	22	1.4%
Iron & Steel	9	2.5%	54	3.5%
Textiles & Apparel	7	2.0%	58	3.7%
Oil and Coal Products	2	0.6%	13	0.8%
Precision Instruments	15	4.2%	50	3.2%
Foods	19	5.3%	131	8.4%
Metal Products	24	6.7%	94	6.0%
Machinery	70	19.7%	236	15.1%
Chemicals	54	15.2%	210	13.4%
Pharmaceuticals	7	2.0%	56	3.6%
Pulp & Paper	5	1.4%	24	1.5%
Other Products	19	5.3%	107	6.9%
Rubber Products	6	1.7%	19	1.2%
Glass & Ceramics Products	9	2.5%	64	4.1%
Total	356	100.0%	1563	100.0%

Figure 3. Test of the difference between the average values related to the company size (sales) of the respondent and non-respondent companies

Listed company of the first section of TSE	Replied			No replied			
	Average	SD	Median	Average	SD	Median	t value
Sales	353,409	1,055,892	96,768	352,992	1,054,020	74,981	1.384

Listed Company of the second section of TSE and the section of another stock exchange	Replied			No replied			
	Average	SD	Median	Average	SD	Median	t value
Sales	17,486	21,540	11,807	17,640	21,576	11,478	0.737

responding companies, and for this reason, we treated all the responses as subjects for analysis and consideration.

The next section firstly shows responses to our questions concerning how purchasing departments determine the most important criteria when choosing a supplier, in order to ascertain their views of problems and issues; next, we examine trends in information sharing and collaboration with suppliers. Finally, we analyse the results to identify which trends emerge in different assembly

industries, and consider differences in their amenability to more widespread MFCA.

2. Ranking of criteria when choosing suppliers

Figure 4 shows the results of a question regarding the most important criteria when choosing suppliers. Respondents were asked to select their highest priority from among the choices of environmentalism, delivery time, price and quality. As shown in Figure 4, quality is most important for assemblers and non-assemblers, but there is a difference with regard to this choice of more than 14% between the two, indicating that assemblers do not value quality as highly as non-assemblers do. Among assemblers, 36% valued price more highly than quality when choosing suppliers.

Next, we asked whether buyers, when either updating an existing product or developing a new product, communicated their requirements and negotiated only on price with the suppliers of externally produced components and materials, or whether they involved their suppliers in defining the design and other requirements. As Figure 5 illustrates, 69.1% of assemblers and 62.1% of non-assemblers involved the suppliers in defining requirements.

From Figures 4 and 5, we can see that buyers prioritise quality when choosing

Figure 4. Priority Criterion for Selecting Supplier

	Assembler		Non-assembler	
	Number	Rate [%]	Number	Rate [%]
Environment	3	1.7	1	0.6
Delivery Time	8	4.5	5	3.0
Price	64	36.0	40	23.8
Quality	103	57.9	122	72.6
Total	178	100.0	168	100.0

Figure 5. The Factor of Negotiation on New Product Development/Model Change

	Assembler		Non-Assembler	
	Number	Rate [%]	Number	Rate [%]
Only Price	54	30.9	61	37.9
Participation in Requirement Definition	121	69.1	100	62.1
Total	175	100.0	161	100.0

suppliers, and when developing new products or updating existing ones, they not only negotiate on price, but also involve suppliers in defining requirements such as product design. However, while the results show that assemblers and non-assemblers both place the highest priority on quality, there is some difference in their numbers, and there are a number of assemblers that are more price-sensitive than non-assemblers. In addition, there were more assemblers who involve their suppliers in defining requirements than there were assemblers who prioritise quality. These facts suggest that, rather than being more price-oriented, several assemblers bring suppliers in to define requirements when developing new products or updating existing ones. In other words, for those assemblers, prioritizing price may not be a matter of "you get what you pay for," but a matter of getting something better for less.

When introducing MFCA into a supply chain, a price-sensitive assembler may be better positioned to achieve a smooth rollout than other assemblers, in reference to the fact that, as previously mentioned, MFCA is a method for achieving both a smaller environmental footprint and lower costs. Some companies that have already introduced MFCA did so primarily to reduce costs. In that sense, price-sensitive assemblers could be expected to collaborate more enthusiastically with suppliers to introduce MFCA.

We split assemblers into two groups: those with a strong price preference ("price-focused assemblers") and others ("non-price-focused assemblers"), as shown in Figure 6. We considered whether these groups involved their suppliers in defining requirements when developing new products or updating existing ones. Our goal here was to determine whether price-focused assemblers simply set a target cost and entered into negotiations, or rather, they involved their suppliers in defining requirements when developing new products or updating existing ones, and collaborated while negotiating prices.

Figure 6. The Negotiation by Price Focused Assembler/Non-Price Focused Assembler

		Assembler		Total
		Price Focused	Non Price Focused	
Only Price	Number	16	36	52
	Rate	25.8	33.3	30.6
Participation to Requirement Definition	Number	46	72	118
	Rate	74.2	66.7	69.4
Total	Number	62	108	170
	Rate	100.0	100.0	100.0

Figure 6 shows that price-focused assemblers more often involve suppliers in defining requirements. In other words, price-focused assemblers, despite higher price sensitivity, do not compel suppliers to meet their procurement price; we can infer, instead, that they take opportunities to discuss product-design requirements. In Figures 7 and 8 below, we looked at how respondents viewed the competitive advantage conferred by their own supply chains.

When we asked about buyers' supply chains as a competitive advantage, assemblers as a whole responded that their greatest advantage lay in their ability to coordinate delivery times. Price-focused assemblers cited this 56.3% of the time, and non-price-focused assemblers cited it 53.8% of the time, or roughly the same proportion. In contrast, there were areas where there was a relatively strong distinction between the two groups: on quality uniformity, price competitiveness, and shared ownership of issues with suppliers. The non-price-focused assemblers, which responded that they prioritized quality over price when choosing suppliers, more often cited quality uniformity than did price-focused assemblers. In addition, unsurprisingly, price-focused assemblers more often cited price competitiveness than did non-price-focused assemblers. Finally, 10% more price-focused than non-price-focused assemblers cited shared ownership of issues with suppliers as a strength. Hence, it is possible that price-focused assemblers create opportunities to collaborate with suppliers in order to keep procurement prices down.

Figure 7. Competitive Advantage in SC (Multiple Answers Allowed)

	Assembler		Non Assembler	
	Number	Rate [%]	Number	Rate [%]
Technological Development Competitiveness	34	18.6	35	21.0
Price Competitiveness	62	33.9	68	40.7
Delivery Time Competitiveness	104	56.8	76	45.5
Stable Quality	82	44.8	97	58.1
Attention for Environment	13	7.1	8	4.8
Sharing Problems	45	24.6	39	23.4
No Fitness	18	9.8	16	9.6
Others	3	1.6	3	1.8
Total	183	100.0	167	100.0

Figure 8. Competitive Advantage in SC by Price Focused Assembler/ Non-Price Focused Assembler (Multiple Answers Allowed)

		Assembler		Total
		Price Focused	Non-Price Focused	
Technological Development Competitiveness	Number	9	25	34
	Rate	14.1	21.0	18.6
Price Competitiveness	Number	25	34	59
	Rate	39.1	28.6	32.2
Delivery Time Competitiveness	Number	36	64	100
	Rate	56.3	53.8	54.6
Stable Quality	Number	24	56	80
	Rate	37.5	47.1	43.7
Attention for Environment	Number	6	7	13
	Rate	9.4	5.9	7.1
Sharing Problems	Number	20	23	43
	Rate	31.3	19.3	23.5
No Fitness	Number	5	13	18
	Rate	7.8	10.9	9.8
Others	Number	2	0	2
	Rate	3.1	0.0	1.1
Total Responce Company	Number	64	114	178
	Rate	100.0	95.8	97.3

3. Trends in information sharing and cooperation

As mentioned in Section 3, this paper investigates how assemblers and suppliers share information and collaborate. In this section, we asked whether buyers had material yield rate, and whether they worked with suppliers to improve those material yields. Below, we will explain why it is important to be aware of material yields when introducing MFCA to a supply chain.

In theory, MFCA information in a supply chain could be used as management information to cut material losses in all companies throughout the supply chain (including one's own company) and could, therefore, be expected to produce cost-saving effects beyond what could be achieved within one company (METI, 2010). Contrarily, however, if a company relies on a reduction in material loss upstream, it will also expect lower purchasing costs from the supplier. This decrease in costs could be predicted by estimating the magnitude of the known material loss and the potential improvement. Realistically, a supplier would not want to share its own material losses with its assembler customer, so the benefits

of sharing information under MFCA would not materialize.

However, our questionnaire results show that there are buyers who already have material yield rate. We can infer from this that the aforementioned resistance of suppliers to sharing information on material losses is relatively low. Furthermore, cutting material losses and costs as much as possible, by sharing information on material losses and collaborating with the buyer, could be seen as a way to establish price competitiveness over competing suppliers who are unwilling to share information on material losses. Beyond this, such sharing could be expected to increase order volumes and produce economies of scale, which could lead to greater profitability for the supplier.

Present-day collaborations between buyer and supplier involve sharing information on target costing and other design-phase costs; however, it appears that information on material losses in mass production, as used in MFCA, is not yet being shared. As such, when introducing MFCA, it is desirable that the buyer has material yield rate and. In addition,a management platform should be promoted that more effectively establishes a cooperative relationship: MFCA should be effective in yielding profits under these conditions.

Figure 9 shows the extent to which both assemblers and non-assemblers have knowledge of material yield figures, indicating that assemblers are aware more often than non-assemblers. More than half of assemblers have this information. Figure 10 shows the results to our question which asks whether buyers work with suppliers to improve material yields rate. Indeed, more than half of assemblers do, at about double the rate for non-assemblers. It can be said that assemblers build closer relationships than non-assemblers with suppliers.

Figures 11 and 12 show the differences between price-focused and non-price-focused assemblers. These tables highlight the fact that the former have material yield rate more often than the latter. However, we understand from Figure 12 that price-sensitive assemblers are only slightly more likely to work with suppliers to improve material yields.

Figure 9. Information Sharing of Material Yield Rate in Suppliers

	Assembler		Non Assembler	
	Number	Rate [%]	Number	Rate [%]
Known	92	51.1	54	32.9
Unknown	88	48.9	110	67.1
Total	180	100.0	164	100.0

Figure 10. Cooperative Activity for Reduction of Suppliers Material Yield Rate

	Assembler		Non Assembler	
	Number	Rate [%]	Number	Rate [%]
Conducted	91	50.3	43	25.9
Un-conducted	90	49.7	123	74.1
Total	181	100.0	166	100.0

Figure 11. Information Sharing of Material Yield Rate in Suppliers by Price Focused Assembler/ Non-Price Focused Assembler

		Assembler		Total
		Price Focused	Non-Price Focused	
Known	Number	38	50	88
	Rate	59.4	45.0	50.3
Unknown	Number	26	61	87
	Rate	40.6	55.0	49.7
Total	Number	64	111	175
	Rate	100.0	100.0	100.0

Figure 12. Cooperative Activity for Reduction of Suppliers Material Yield Rate by Price Focused Assembler/ Non-Price Focused Assembler

		Assembler		Total
		Price Focused	Non-Price Focused	
Conducted	Number	33	54	87
	Rate	51.6	48.2	49.4
Un-conducted	Number	31	58	89
	Rate	48.4	51.8	50.6
Total	Number	64	112	176
	Rate	100.0	100.0	100.0

4. Trends by industry

In this section, we categorize assemblers the same way that Lee and Monden (2000) and Sakaguchi (2003) have done — machinery, electrical appliances, transportation equipment and precision equipment — to look at trends in each of these categories. We consider the effects that the introduction of MFCA can have on each of these categories, and examine approaches for the more widespread adoption of MFCA.

Figure 13 shows the highest-priority criterion when choosing suppliers in each

Figure13. Priority Criteria for Selecting Supplier by Industry of Assembler

	Machinery		Electric Appliances		Transport Equipment		Precision Equipment	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Environment	1	1.4	2	2.8	0	0.0	0	0.0
Delivery Time	4	5.8	3	4.2	0	0.0	1	7.7
Price	28	40.6	26	36.1	7	29.2	3	23.1
Quality	36	52.2	41	56.9	17	70.8	9	69.2
Total	69	100.0	72	100.0	24	100.0	13	100.0

industrial category. In Figure 4, which breaks this down into assemblers and non-assemblers, the latter picked quality 57.9% of the time. In Figure 13, we see a relatively wide spread for quality as the top criterion among these four industrial categories. While this was a very strong criterion in the transportation-equipment industry (70.8%), it was considerably less so in the machinery industry (52.2%), where it ranked the lowest of the four. Machinery was also the industrial category where price was ranked highest.

Figure 14 divides companies into categories to identify which firms involve their suppliers in defining requirements when developing new products or updating existing ones. As discussed above, target costing has been widely adopted in the automotive industry, and there is an emphasis on collaboration and information sharing between buyer and supplier (Morofuji, 1000; Lee and Monden, 2000). Following the model of Figure 5, we see that 84.0% of companies in the transportation-equipment industry involve suppliers in defining requirements, giving them the closest relationships of the four categories. The rate for the electrical equipment category (where target costing is also widely used) was 63.8%, lower than the machinery category (71.6%). It is not clear how widely target costing is used

Figure 14. The Factor of Negotiation on New Product Development/Model Change by Industry of Assembler

	Machinery		Electric Appliances		Transport Equipment		Precision Equipment	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Only Price	19	28.4	25	36.2	4	16.0	6	42.9
Participation to Requirement Definition	48	71.6	44	63.8	21	84.0	8	57.1
Total	67	100.0	69	100.0	25	100.0	14	100.0

in the machinery category, but sufficient opportunities exist for buyers and suppliers to discuss designs and other requirements when developing new products or updating existing ones.

Figure 15 (below) shows how companies in each of these categories perceive their competitive advantage. This figure shows that respondents in all categories most often selected their ability to coordinate deliveries as their greatest competitive advantage, and this tendency was the most pronounced in the machinery category. Companies in the machinery category appear to have a higher regard for their own supply chains than do companies in other categories: they also ranked quality and price competitiveness higher than did other companies. In contrast, they ranked environmentalism and shared ownership of issues lower on the scale: in fact, it seems that almost none of the companies paid attention to environmentalism. Companies in the electrical equipment category were second to the machinery category in their ranking of delivery coordination. Further, despite relatively small numbers in absolute terms, companies in this category ranked environmentalism higher than did any of the other categories, along with quality uniformity and shared ownership of issues. This may be related to the close contact consumers have with electrical appliances. It is possible that electrical-appliance makers are actively involved in building an environmentally oriented supply chain that involves suppliers. Transportation equipment companies also rank delivery coordination highest, but not as highly as do machinery and electrical appliance makers; the one area that transportation-equipment companies

Figure 15. Competitive Advantage in SC by Industry of Assembler (Multiple Answers Allowed)

	Machinery		Electric Appliances		Transport Equipment		Precision Equipment	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Technological Development Competitiveness	9	12.9	16	21.9	5	19.2	4	28.6
Price Competitiveness	29	41.4	23	31.5	8	30.8	2	14.3
Delivery Time Competitiveness	44	62.9	43	58.9	13	50.0	4	28.6
Stable Quality	35	50.0	30	41.1	10	38.5	7	50.0
Attention to the Environment	2	2.9	9	12.3	2	7.7	0	0.0
Sharing Problems	15	21.4	15	20.5	10	38.5	5	35.7
No Fitness	4	5.7	6	8.2	5	19.2	3	21.4
Total	70	—	73	—	26	—	14	—

view as a strong suit relative to the other three categories is their shared ownership of issues with suppliers. It is possible that transportation equipment companies have a shared sense of ownership that leads them to collaborate on finding solutions and improvements. As discussed below, this can also be inferred from their knowledge of material yield information and their inclination toward improvements. Precision equipment makers view their uniformity of quality as a competitive advantage rather than their timing coordination that ranks third, following shared ownership of issues. Considering the nature of precision equipment, it is no surprise that uniformity of quality would be especially important in procurement.

Next, we will look at the extent to which companies in each category have knowledge of material yields and collaborate on Kaizen activities. Figure 16 shows that companies in the transportation equipment category most often have knowledge of material yields, followed by electrical appliance companies. In both categories, more than half the companies reported that they were aware of their suppliers' material yields — 76% for transportation equipment companies.

Figure 17 similarly shows that companies in the transportation equipment and electrical appliance categories collaborate to improve yields. We should take special note of the fact that in both of these categories, more companies collaborate on kaizen activities than those who are aware of yield figures. Conversely, companies in the machinery and precision equipment categories responded with low numbers in both cases, and even fewer collaborate on kaizen activities than are aware of material yield figures.

Figure 18 cross-tabulates yield knowledge and collaboration and shows that companies that have yield knowledge collaborate with suppliers, whereas those that do not have yield knowledge do not collaborate. Among firms in the transportation equipment and electrical appliance categories, companies that do have that knowledge and collaborate, added to those that do not have that knowledge and do not collaborate, total more than 85%, accounting for the majority. As can be expected from the transportation equipment industry, where target costing is already widely used, 75% of companies have yield information and collaborate, not only creating an opportunity for suppliers to define requirements, but also sharing information and working together. Of the companies that do not have yield knowledge and do not collaborate, a certain number are in the precision equipment, machinery, and electrical appliance categories. Companies that have yield information but do not collaborate, or that do not have yield information but do collaborate, are scarce in all four categories, which may suggest that setting up

Figure 16. Information Sharing of Material Yield Rate in Suppliers by Industry of Assembler

	Machinery		Electric Appliances		Transport Equipment		Precision Equipment	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Known	31	44.3	38	52.8	19	76.0	4	30.8
Unknown	39	55.7	34	47.2	6	24.0	9	69.2
Total	70	100.0	72	100.0	25	100.0	13	100.0

Figure 17. Cooperative Activity for Reduction of Suppliers Material Yield Rate by Industry of Assembler

	Machinery		Electric Appliances		Transport Equipment		Precision Equipment	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Conducted	27	38.6	41	56.2	21	87.5	2	14.3
Un-conducted	43	61.4	32	43.8	3	12.5	12	85.7
Total	70	100.0	73	100.0	24	100.0	14	100.0

Figure 18. Cross Table of Information Sharing and Cooperative Activity Relevant to Material Yield Rate by Industry of Assembler

	Machinery		Electric Appliances		Transport Equipment		Precision Equipment	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate
Known/Conducted	21	30.0	34	47.2	18	75.0	2	15.4
Known/Un-conducted	10	14.3	4	5.6	0	0.0	2	15.4
Unknown/ Un-conducted	33	47.1	28	38.9	3	12.5	9	69.2
Unknown/conducted	6	8.6	6	8.3	3	12.5	0	0.0
Total	70	100.0	72	100.0	24	100.0	13	100.0

a system to collect yield information which promotes collaboration between buyer and supplier.

6. Conclusion

In this paper, we have considered assemblers as being in a favorable position to effectively introduce MFCA to their supply chains. The reason is that, compared to non-assemblers, assemblers handle a large number of parts, and in introducing MFCA to the supply chain in which they are at the centre, it should

be possible to reveal material losses beyond what could be achieved by introducing MFCA to one company in isolation. We categorized responses to our questionnaire form as assembler and non-assembler and examined the results.

First, to study the relationships between assemblers and their suppliers, we looked into the criteria that assemblers used when selecting suppliers. The results showed that, compared to non-assemblers, assemblers treated quality as the highest-priority decision-making criterion, but did not emphasize quality as highly as non-assemblers. What they did emphasize more than non-assemblers was price. Assemblers were also more likely than non-assemblers to involve suppliers in defining requirements when developing a new product or updating an existing one, rather than simply negotiating over procurement price. In short, while assemblers are more price sensitive than non-assemblers, they also frequently seek out the opinions of suppliers to define factors such as requirements or design as part of the pricing negotiation.

Second, we categorized assemblers on the basis of whether they were price-focused or non-price-focused and examined the results. We found that more price-focused than non-price-focused assemblers, when assessing their own supply chains, were more price competitive and felt a higher degree of shared ownership of issues with their suppliers. Having a higher degree of shared ownership with suppliers may indicate that they are already sharing information with suppliers. When we looked into the assemblers' knowledge of material yields and the collaborative efforts to improve them, it became clear that price-sensitive assemblers and those with a stronger sense of shared ownership with suppliers were sharing information. However, collaborative efforts with suppliers were only marginally more common among price-sensitive assemblers than among non-price-focused assemblers. In short, even though there is more information sharing and shared ownership of issues with suppliers among price-focused assemblers than among other companies in the same industry, it appears that some companies have not reached the level of joint kaizen activities. In fact, the priority of price competitiveness for price-focused assemblers is relatively high, compared to non-price-focused assemblers, but fails to reach 40% even among that group. This may signify that some price-focused assemblers feel a need to lower procurement prices further. To lay the groundwork for a smooth introduction of MFCA to the supply chain, it may be desirable to start by approaching those price-focused assemblers that have yield information.

Third, we divided assemblers into four industrial categories (machinery, electrical appliances, transportation equipment, and precision equipment) and exam-

ined the results. Of the four industrial categories, we found that transportation-equipment companies most often use target costing, which can be viewed as a tendency to maintain a closer relationship with suppliers. We also found that companies in this group involved suppliers in defining requirements such as designs when developing new products or updating existing ones (84.0%), they had knowledge of their suppliers' yields, and they worked with their suppliers to improve yields (75.0%). As indicated by earlier studies (Morofuji, 1999; Lee and Monden, 2000), companies that have introduced target costing emphasize information sharing and collaboration; in the light of this fact, it seems likely that they have built relationships of trust.

We also found that fewer companies in the machinery and precision equipment groups had knowledge of material yields than did companies in the transportation-equipment and electrical-appliance groups, and that there was an even more pronounced trend away from collaborating with suppliers on kaizen activities among them. Companies in the machinery and precision-equipment groups that are not satisfied with their suppliers' material yields could use MFCA as a method to reduce costs with suppliers. Additionally, we found that companies in all the groups except for transportation equipment that did not have knowledge of material yields tended not to collaborate with suppliers on kaizen activities. If we consider that many of those companies that do have knowledge of material yields will also work to improve yields, then having a system in place for discovering material yields might naturally lead to buyers working to improve suppliers' material yields. For assembler companies, it may be the case that their suppliers have aconsiderable margins to improve their material yields. If the buyer has knowledge of material yields, then there is some likelihood that MFCA would be useful as a tool to improve yields. For that reason, it is important for the buyer to find a way to obtain material-yield information in order to introduce MFCA to the supply chain.

We also looked at how companies in each of the industrial categories perceived their own competitive advantage and found little difference in absolute numbers, but we did observe that electrical-appliance companies had a stronger environmental awareness. Because electrical appliances are especially close to the end consumer, some electrical-appliance manufacturers are working enthusiastically to reduce their environmental footprints. Kokubu and Shinohara(2012) pointed to Panasonic as the most advanced company in terms of its environmentally oriented supply chain. It is possible that other companies in the industry will, in future, become more environmentally oriented; indeed, emphasizing the fact that

MFCA can reduce the environmental footprint of electrical appliances might help to popularize the implementation of MFCA.

We cross-tabulated price-oriented and non-price-oriented assemblers with the four industrial categories of machinery, electrical appliances, transportation equipment, and precision equipment to determine where it would be simplest to introduce MFCA to a supply chain, and to determine which aspects of MFCA should be emphasized. We are still in the process of analyzing the details of the supply chains in each industrial category, and more work remains to be done. For example, we were unable to clearly identify companies in which delivery coordination is a problem, but if we were able to identify companies (supply chains) that needed to improve their productivity per unit time, it might be possible to tackle those issues by introducing MFCA and TOC (Theory of Constraints) at the same time (Tobita et al, 2013).

Finally, in future, we intend to perform face-to-face interviews with questionnaire respondents. The continuation of these surveys will allow us to ascertain the precise factors needed to for the smooth introduction of MFCA into an environmentally oriented supply chain.

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