12-2014

Managing Value in Supply Chains: Case Studies on the Sourcing Hub Concept

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A firm's raw material sourcing knowledge can be a strategic resource. This article explores how firms can capture and use this knowledge. It examines the sourcing experiences of four firms in four different countries in the automotive industry and identifies the raw material sourcing knowledge-related parameters. Synthesizing the findings from these case studies, it proposes the concept of the sourcing hub—a collaborative center involving the firm, its suppliers, and raw material suppliers—which can effectively capture and deploy the raw material sourcing knowledge for managing value in upstream sourcing. (Keywords: Case Study, Sourcing, Supply Chain, Sourcing Hub)

Outsourcing can improve the flexibility to respond to changes in demand and technology (and thus spur innovation) and may also help in avoiding inefficiencies in coordination and design.[1] However, for products and components in which raw material is a large part of the cost, there may be value for a buyer in managing the upstream raw material (RM) supply chain of the component/product differently from the manufacturing part of the component. We examine this issue by detailing the sourcing practices of four automotive firms in four different countries. We focus on the complex supply network upstream from a buyer, consisting of its direct suppliers and raw material suppliers, and how managing RM complexity within this network can be valuable.

We studied four firms: DMV in Germany, TMV in India, TDV in South Korea (these three firms are automotive OEMs), and BKI in France (BKI is an automotive brakes supplier). (Firm names are pseudonyms for confidentiality reason.)[2]

The authors thank Kishore Sengupta for his helpful comments on earlier drafts of this manuscript. The extensive travel involved in this work was generously supported by the INSEAD Alumni Fund, and the Judge School of Business at the University of Cambridge, UK, where Anupam was a visiting scholar in the summer of 2007.

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In our research, we found that there often are only a few RM upstream suppliers but a large number of direct suppliers to an OEM. The RM suppliers supply to a large number of tier 1 or tier 2 suppliers in different quantities. For automotive OEMs, RM suppliers could include suppliers of steel, aluminum, plastics, rubber, copper, and other RMs to suppliers of these OEMs (see Figure 1). Our studies indicate that buyer OEMs (focal firms) have a lot of information about their 1st tier (or direct) suppliers and have relationships with them, but this relationship and information is not always deployed for the 2nd tier (or indirect) suppliers, such as RM suppliers.

Our empirical findings provide insights into a new type of structure in the supply chain that, although present in practice at a few firms, is rarely currently captured in the academic and practitioner literature. This structure entails deploying what we call a *sourcing hub* (Figure 1). The sourcing hub is an in-house group initiated and deployed by the OEM and is focused on developing relationships with an OEM's suppliers and RM suppliers in order to develop deeper RM sourcing knowledge.

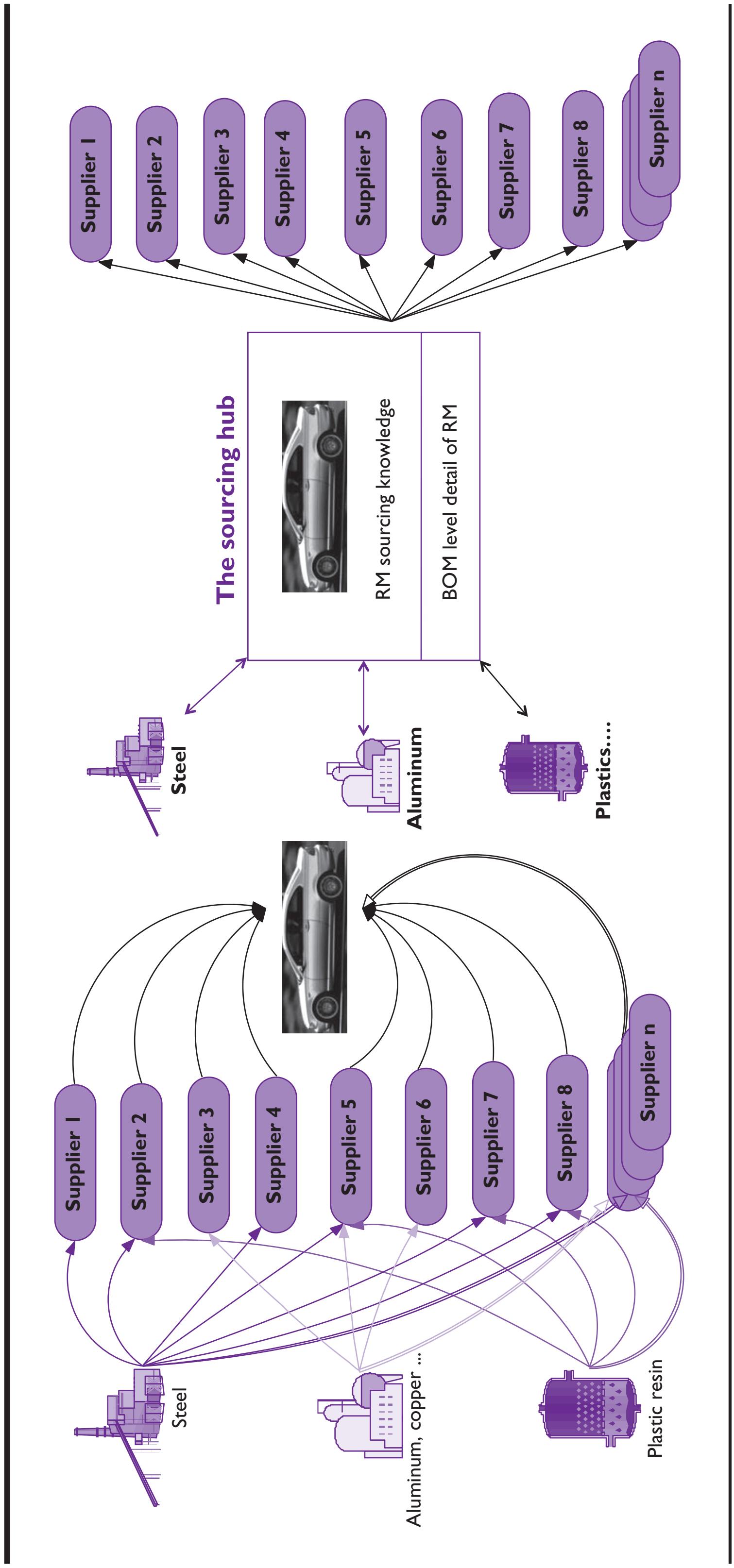
When we enquired as to the total volume of aluminum being bought by our case study firm DMV, we were told by its managers, "We do not know much about aluminum volumes. We don't need this information since this is not our core competence." DMV is the biggest indirect buyer of aluminum in Germany: it buys aluminum components from suppliers who purchase the required aluminum from aluminum suppliers. Yet DMV has no direct relationship with the primary aluminum suppliers in Germany. The same situation is also true for TMV in India. TMV is the biggest indirect buyer of primary aluminum in India. However, TMV does not have any relationship with the Indian aluminum producer that has a >50% market share of aluminum in India (and TMV was its biggest buyer). Both of these Indian firms have existed for more than 50 years, yet they have never had a direct relationship with each other.

Increased attention on developing relationships with a firm's suppliers' suppliers can add value by influencing sourcing knowledge and sourcing costs. A way to focus such attention is to enable the collection and use of micro-level knowledge of the raw material being sourced by the buyer firm (including quantities, grades, processes, sources, technical linkages with components, and prices). We found that three of the firms in our study (TMV, DMV, and BKI) did not have a process in place to develop and use such RM knowledge, while the fourth (TDV) did. As a result of our study, two of these three firms (TMV and DMV) are proceeding with deploying processes to use the RM-related knowledge in their upstream sourcing via a sourcing hub, while the one remaining firm is still considering the adoption of such processes.

RM Sourcing and the Sourcing Hub

To get to know more about the sourcing of a particular RM (say aluminum), we had to get the details of this raw material from the Bill of Materials (BOM). A BOM includes information about the raw materials, components, and

FIGURE 1. The left panel shows the prevalent supplier network of most auto OEMs. The right panel shows the proposed structure of the Sourcing hub



assemblies, as well as their respective quantities to manufacture an end product. Studying the BOM was the only way to find out answers to questions such as: Which current products of the OEM require a particular RM? What quantities of this RM are needed at the firm level? What is the quality (or grade) of the most important RMs needed at the firm level? Which processes must exist at the RM supplier for supplying these RMs? Only after this information was collated could we map out *who* was supplying *how much* RM of *which quality* at *what cost* by querying the appropriate people in the supply chain. The collation at the level of the BOM could indicate which suppliers and which RMs were important elements of the upstream RM sourcing. For example, at TMV, we had to review the BOM, the cost details, and the accompanying drawings for over 500 different components that had aluminum as a RM. This exercise helped detail the amount of RM used in a particular vehicle, the RM used by a particular supplier, and the total RM buying for a firm. This was an exhaustive and very time-consuming exercise (Table 1 and Table 2 detail such an analysis for TMV, India) that resulted in developing knowledge of firm-level RM procurement, and helped to map out strategically important relationships in the upstream RM chain.

We learned two things: BOM-based RM sourcing knowledge is not widespread, and acquiring it is not a shallow, quick fix exercise. In three of the four firms we studied, the BOM-level details of RM were not readily available, nor used in day-to-day decisions by the sourcing or design engineers and managers. Developing relationships with a firm's RM suppliers needs BOM-based detailing of RM. Processes such as BOM-based RM detailing, and subsequent development of relationships with RM suppliers, can be better deployed in a firm's sourcing structure via a sourcing hub.

The Sourcing Hub

What exactly is a sourcing hub, and what happens there? The sourcing hub is an upstream entity in supply chains, focused on developing collaborative relationships with an OEM's suppliers and suppliers' RM suppliers. The hub can be deployed as a physical department or organizational unit within an OEM's organizational structure. This department or organizational unit can be separate from the normal sourcing or purchasing department, since the specific focus is on developing collaborative relationships with RM suppliers.

The sourcing hub focuses on managing sourcing knowledge and sourcing costs by:

- gathering inputs from the design and technical departments for developing BOM-based RM details of the sourced components;
- utilizing the BOM-based RM details to help suppliers procure inputs at lower costs, or even directly procuring inputs for them;
- detailing the upstream RM sourcing network, including all suppliers' suppliers (firms who affect an OEM's business, even if they are not direct suppliers to the OEM);
- Sharing information with suppliers and suppliers' suppliers about RM supplies, about current and immediate future production, about market demand,

and about new products (this helps suppliers and RM suppliers align their production by reducing uncertainties); and

- collaborating with the design and technical departments for sharing knowledge on available technologies and RM available from RM suppliers in order to help improve design and development of current and new products.

How can a sourcing hub structure help firms? Our hypothesis is that in many supply chain scenarios, RM-related knowledge generated at the sourcing hub can help in lowering RM costs, reducing RM-related complexity in design (such as using fewer grades of RM) and thereby aid in developing better products, enabling better decisions in production planning and other day-to-day operations by reducing RM-related uncertainty. The RM-related knowledge can also be an input to strategic decisions such as entering new markets by developing products suited to these markets. A lack of relationships with RM suppliers may deplete the availability and use of RM-related sourcing knowledge, and this may decrease the value that firms can harness from their supply chain.

Deploying Sourcing Knowledge via the Sourcing Hub

Knowledge at a firm level has been defined as a set of capabilities resulting from activities and cooperation within the firm. It is easier to transfer within the firm than across firms or in the market, and it constitutes the ownership advantage of the firm.[3] We define the RM sourcing knowledge of a firm as the collective set of capabilities, information, details of production (such as designs, processes, and prices), decisions, and other technical details required for procuring the required RM inputs for a firm. Knowledge transfer depends on the characteristics of knowledge—tacit knowledge is personal, context specific, and therefore hard to formalize and communicate, whereas explicit or codifiable knowledge is transmittable in formal and systematic language.[4]

RM sourcing knowledge at the sourcing hub can help create value in many ways. First, such knowledge helps decrease the manufacturing complexity related to sourced components.[5] A production system is complex if: it consists of numerous elements; and those elements interact with each other in many ways.[6] RM sourcing knowledge and processes deployed at the sourcing hub can affect both of these aspects of manufacturing for OEMs. TDV sourcing engineers told us, "If a new material grade has to be established for a new component, the process is longer, since TDV and the steel supplier need to agree on the new requirement and its price, as well as supplies. Additional IT work is also involved. Since the additional work is cumbersome, there is therefore an inherent pushback to any frivolous increase in the number of basic RM grades being used. This process helps us use a fewer number of grades of RM." When managers know more about RM, then they can deploy simplified sourcing by reducing the number of grades of RM used. The reduction of complexity in designing new solutions has also been analyzed in the literature on variety reduction programs, value engineering, value analysis, and target cost techniques.[7] This aspect is also related to the literature about early involvement of suppliers[8] and concurrent engineering.

RM-related knowledge also interacts with process design and quality parameters related to sourcing. When OEM designers have more information about the

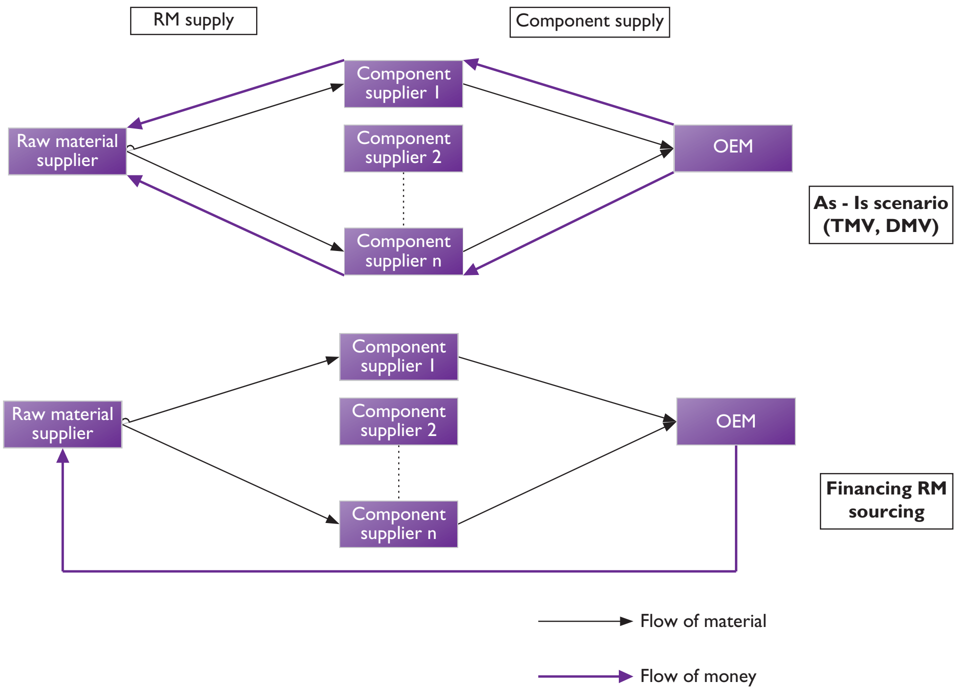
RM, they are able to better predict the problems in a new product development cycle, and thereby develop more robust products.[9] Further, our studies show that an OEM's sourcing engineers develop process parameters for sourced components, and also help design and approve the dies, jigs, and fixtures for new components being developed with suppliers. These engineers fix the process parameters in alignment with the RM grades being procured. Knowledge of RM helps deploy robust manufacturing processes at the suppliers and also helps reduce the time taken for new component development, since the sourcing engineers can quickly settle the parameters using their RM knowledge.[10] Thus, RM sourcing knowledge helps reduce manufacturing design-, quality-, and time-related complexity.

Second, better RM sourcing knowledge at the sourcing hub can help reduce the costs of sourcing. There are two ways in which RM knowledge affects sourcing costs: by cost control at the design stage of components;[11] and by exploiting the differential cost of capital between the OEM and its suppliers. TDV design engineers told us, "The component level RM details provide transparency on the material grades being purchased. We can choose from the existing steel grades when we are developing the design for a new component. This helps the design process, since detailed RM-related information for all components developed in the past is available, along with the price impacts. As a designer, we can see which specific steel grade should be used since it can be sourced much more easily from our steel supplier. If we choose another steel grade, the component cost may be higher." This quote indicates that it is helpful if the design and sourcing departments collaborate, since the quality of a new steel grade could affect the transactional cost of RM purchased. Moreover, the quality of the RM could not only affect the transactional cost in the RM purchase phase, but also affect the life cycle cost of the designed component.

The cost of capital effect is different. TMV India sources its debt internationally and its weighted average cost of capital is lower than that of its suppliers. There is a difference of more than 3% between the cost of capital of TMV and most of its suppliers. Therefore, if RM purchasing is done with TMV capital, it may result in a lower cost to TMV than purchasing done with the supplier's capital. Figure 2 shows this scenario schematically. When the OEM finances RM purchases, savings may be accrued in cases where its suppliers borrow money at a higher cost.[12] This effect is different from purchasing contracts, and arises when the suppliers are small and cannot access the same financial markets that the OEM can.[13]

Finally, RM sourcing knowledge can also help reduce the information asymmetry between the two ends of the supply chain, the buyer OEM and the RM supplier, and therefore reduce the mismatch of supply and demand. Mismatch can result in two kinds of costs. First, firms can experience high inventories when supply outstrips demand. Second, if supplies are not at hand, sales are lost and customers are dissatisfied. Such customers may aggravate the costs by spreading negative information by word of mouth. Mismatch can be reduced by improving coordination and cooperation between buyers and suppliers. Improving coordination can take the form of sharing information about capacity and demand with suppliers,[14] and working with suppliers.[15] Such improvement is not easy: it needs extensive internal effort on the part of a buyer, and the willingness to share information along

FIGURE 2. Financing RM Sourcing via a Sourcing Hub



the supply chain.[16] However, it can help mitigate the mismatch in supply and demand[17] and lower the purchasing costs of a buyer.[18] Information sharing can also help develop reciprocal commitment on RM availability and target pricing of the components and end products, thus enhancing supply chain performance.[19]

Several empirical studies have focused on RM in supply chains. Signorelli and Heskett discuss how Benetton buys yarn for their subcontracted manufacturing.[20] Barnes and Morris study the product pipeline at an automotive firm, its first-tier supplier, its second-tier supplier, and its RM supplier, and they explore how raw material flows along this supply chain.[21] Ellram and Billington document how an automaker facilitates RM supply to its machine shop contractor, which helps build price stability between the automaker and the contractor.[22] What we propose is that the RM supply chain is linked to the knowledge residing within a firm, and that a better management of this knowledge can help firms create value.

Methods

Our research design involves four case studies. Case studies are suitable for empirical development of testable theories.[23] Yin points out that a case study involves direct observation and systematic interviewing as its two principal components. It is a tool for building theory from practice. "Case studies, like experiments, are generalizable to theoretical propositions and not populations or universes.

A case study, like an experiment, does not constitute a 'sample' and the investigator's goal is to expand and generalize theories (analytical generalization) and not to enumerate frequencies (statistical generalization)."[24] Meredith agrees, and notes that case study research has advantages of relevance, understanding, and exploratory depth. He cautions however that such research takes time, and the researchers need to exercise research controls and triangulations to tease out testable hypotheses from their observations.[25] We use comparative case studies to develop testable theoretical propositions on upstream relationships in supply chains, we use specific research questions, and we use similar study variables in all case studies.

We had two specific research questions: First, how can a firm capture and build on its RM sourcing knowledge? Second, can a firm create more value by building relationships with its RM suppliers? We approached firms, studied their upstream sourcing relationships, and explored how these firms were creating value by working with their suppliers and suppliers' suppliers. We refrained from making any additional a-priori propositions, and focused on developing the same during data collection so as to have a rich understanding of the cases in all their complexity. Our unit of analysis was the upstream sourcing of a firm: we focused on a firm's 1st tier suppliers and the RM suppliers (2nd tier suppliers).

Our four-year long study of these four firms involved extensive travel to four countries. We spent a lot of time onsite at each of these firms observing the day-to-day operations, interviewing managers, and documenting the sourcing network. The semi-structured interviews were conducted with the purchasing, design, and materials engineers of the four firms, as well as with the managers and operations executives of the direct suppliers and the RM suppliers to these firms. (Interviewee list is available from the authors. The semi-structured interview instrument is in the Appendix).

We found that precise details of RM sourcing were not easily available: the buyers had rich data on their suppliers, however, there was scant data about the second tier (the suppliers' suppliers) at three out of the four research sites. We talked to the suppliers at length to elicit this information, also bringing in people from the buyer side: people who had worked with these suppliers for a long time. We tried to document the source and usage of RM at each of these sites, and adopted three variables for our within-case and cross-case comparisons.

BOM-Based RM Sourcing Knowledge

At every research site, we studied the basic bill of material (BOM) details of all components for all suppliers for a particular RM. We also explored how knowledge is (or could be) collated, replicated, and used at the buyer end. For example, we studied the effect of RM sourcing on design processes (in terms of RM choices available to the designers) and sourcing processes (in terms of time required for development of tools, jigs, and fixtures for components). This required a very long and detailed exercise, because:

- There were differences in condition of supply between various plants of an OEM. While one plant procured casting x, in another, casting x and machining y were tiered together to make combined component z, which was the procured component. These differences were due to plant-level decisions, supplier changes, or even engineering changes over time, and they needed to be homogenized. In many cases, the way in which the final purchase price of the sourced component was arrived at also differed by location, due to differences in tool-and-die development help given by the buyers to 1st tier suppliers.

- At three of the research sites, there was no perceived need by the firm for systematic tracking of RM-related information for any supplier. Therefore, some of the basic information about RM had to be ascertained by onsite physical verification, such as the (actual and gross)[26] weight of the RM used for a bought component.

Over time, we learned to iron out these challenges and detail the factors affecting RM sourcing knowledge at each site.

RM Sourcing Network

In all our case studies, we tried to detail all the suppliers for a buyer, but only for a single RM. This helped us map a subset of the sourcing network of a firm: the sourcing network of a single RM. Specifically, we measured the number of suppliers and the number of RM suppliers that are supplying to the OEM buyer. In three of our case studies, we focused on components being developed from aluminum. This enabled us to probe deeper into the effect of aluminum-related components on sourcing knowledge and costs for these firms. We compare the findings of these three studies to the steel supply chain of the fourth firm, TDV. Our choice of this variable was inspired by the studies of Nishiguchi, who explains how supply chain structures affect the costs and relationships within.[27]

Sourcing Costs and Financing of RM

In all our case studies, we focused on the BOM-based component-level detailing as our primary tool to measure upstream sourcing costs. Our choice of BOM based detailing was also influenced by the detailed studies of Asanuma,[28] who explains how in the Japanese automotive industry, auto assemblers evaluate their suppliers with rigor and precision via component costs. We also studied the cost of financing the RM sourcing for all firms in our study as well as the difference in financing costs of the firms and their suppliers. This helped us understand the flow of money in the upstream supply chain, as well as in generalizing how firms can run their supply chains at the least cost.

Case Profiles

We first describe in short the four case studies.

TMV, India

TMV is the world's fifth largest medium and heavy truck manufacturer and the second largest heavy bus manufacturer. Aluminum components bought by TMV include cylinder heads, inlet manifolds, gearbox and transaxle housings, cylinder head covers, and air intake pipes. The suppliers supply either gravity die casting or pressure die casting components. The gravity casting process is suitable for mass production and mechanical parts, where precision and small tolerances are required (such as a cylinder head for an automobile engine). The pressure die casting process is used for most other parts, which do not require close tolerances, such as alloy wheels.

Why is this difference important? The aluminum needed for a casting can be derived from two different sources. Firms can either use pure ingots from a primary aluminum producer or recycled aluminum scrap. The gravity die process needs pure ingots for maintaining close tolerances, and the pressure die process can use the scrap as input. Therefore, for aluminum, only gravity die casting-based components provide an OEM with a direct link to the RM producer. The pressure die based components follow a much more complex RM chain, and studying them has to take into account the remanufacturing supply chain.

The RM supply chain for TMV's gravity die-based suppliers is shown in the left panel in Figure 3. The four suppliers (including the in-house foundry) deal directly with the primary aluminum producer for their input of virgin aluminum ingots. The ingots are sent to an alloy maker, where they are melted with other metals (like silicon and zinc) to form an alloy used for casting components. The alloy maker sends the alloyed ingots to the component suppliers. The suppliers pay the primary aluminum supplier for the virgin ingots and the alloy maker for the conversion.

The pressure die casting supply chain (right panel in Figure 3) is very different. The alloy makers depend on major aluminum reprocessing centers such as recycled beverage can plants for recycled aluminum in addition to virgin aluminum. Virgin aluminum is needed to correct the percentages of added metals, such as zinc; however, the total amount of virgin aluminum in PDC alloys is only around 15-20%. The pressure die casting suppliers pay the alloy maker for the complete alloy.

The resulting sourcing network for primary aluminum for TMV (gravity die-based suppliers only) is shown in Figure 4. Tables 1 and 2 show how BOM-level detailing leads to such figures. For its yearly production, TMV buys components that need approximately 10,000 tons of virgin aluminum and 15,000 tons of recycled aluminum.

DMV, Germany

DMV is a European auto giant and is one of the world's ten biggest car manufacturers. It has 14 plants worldwide, with six main plants in Germany. The firm operates a joint venture in China and a contract manufacturing site in Austria. In 2007, DMV's annual consumption of virgin aluminum, including what is used in its in-house foundry, was 47,000 tons. The PDC-based sourcing of recycled aluminum, including alloy wheels, was close to 100,000 tons.

DMV has six gravity die casting-based aluminum component suppliers (including the in-house foundry) and 24 pressure die casting-based suppliers that are supplied by Germany's three main aluminum suppliers. The sourcing network is shown in Figure 5.

FIGURE 3. The left panel shows the RM supply chain for GDC-based aluminum components. The right panel shows the RM supply chain for PDC-based aluminum components

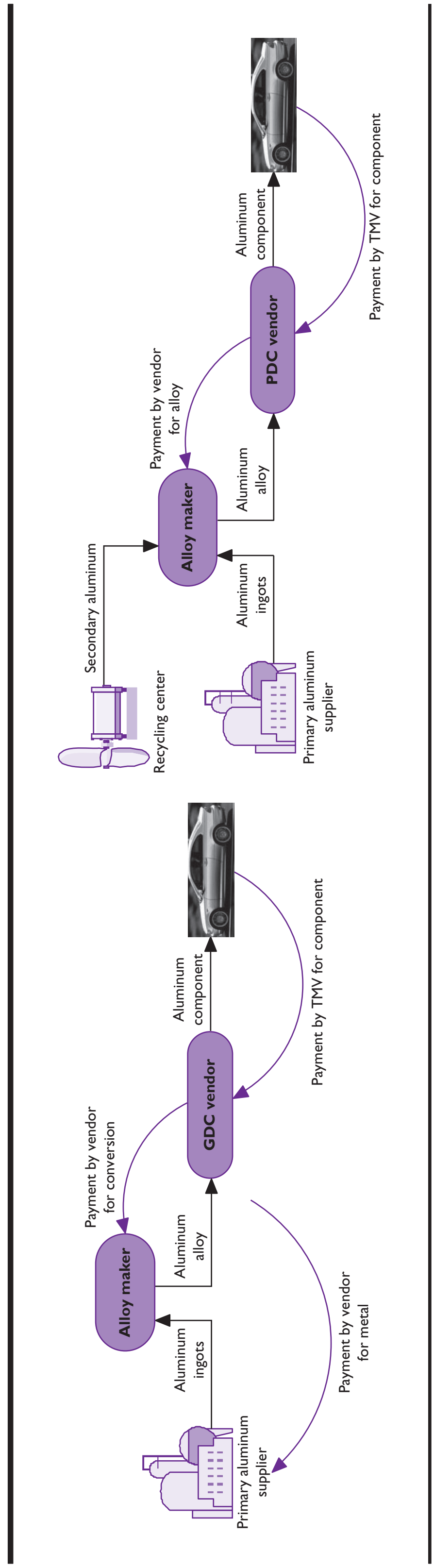


FIGURE 4. Overall Aluminum Sourcing Network of TMV–*One* Primary Aluminum Supplier

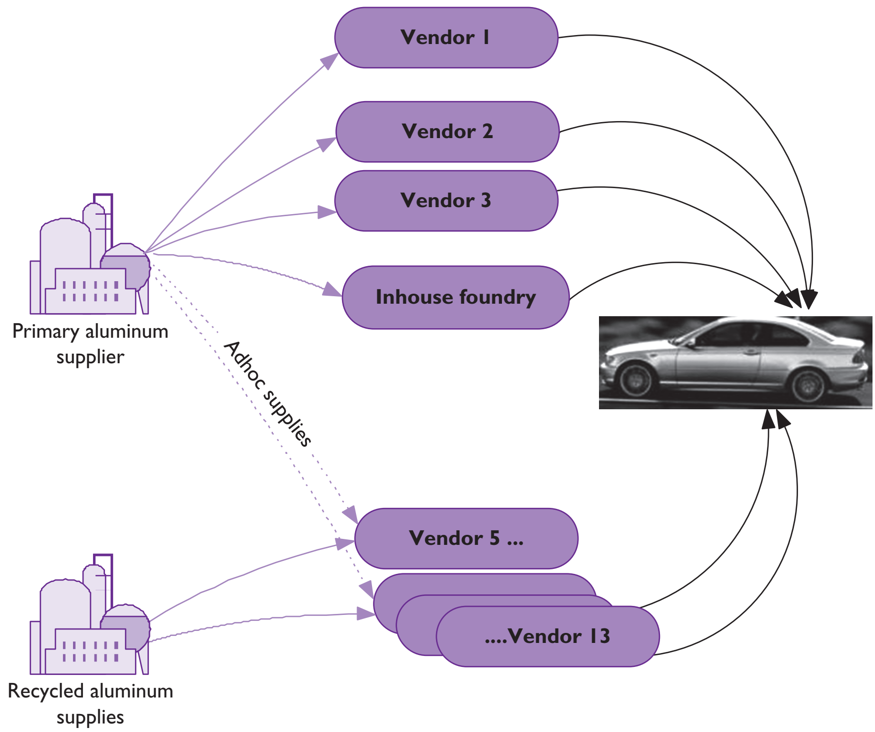


TABLE 1. BOM-Based RM Details, Mapped onto Final Products

	Aluminum Input Weights per Vehicle (Kgs)		
Vehicle Category	**GDC**	**PDC**	**Total Weight**
Heavy Truck	5.287	8.778	14.065
Medium Truck 1	5.287	7.964	13.251
Medium Truck 2	2.777	7.964	10.741
Low End Truck 1	7.003	8.529	15.532
Low End Truck 2	4.832	8.529	13.361
9 Ton Truck	2.014	1.352	8.744
Bus	2.143	6.099	8.242
7 Ton Truck	3.570	6.252	9.822
7 Ton Truck 2	3.773	6.099	9.872

DMV suppliers, including the in-house foundry, buy from all three of Germany's major aluminum suppliers. DMV's sourcing network of aluminum is dependent on the technology used by the suppliers for RM. In Germany, the aluminum component suppliers use molten aluminum as input (unlike in India). The aluminum sourcing network is linked via this technology choice of molten aluminum.

TABLE 2. Business Turnover and Technology Base of Aluminum Component suppliers. Such detailing helps map the RM sourcing network and indicates financing opportunities

Supplier #	Turnover ('000 Euros)	Technology
1	10483	PDC
2	5163	GDC
3	4126	GDC
4	2182	GDC
5	1709	PDC
6	1481	PDC
7	1287	PDC
8	813	PDC
9	636	PDC
10	613	PDC
11	363	PDC
12	337	PDC
Inhouse Foundry	7500	GDC

A high volume of production is needed to ensure that the molten aluminum process is viable. More importantly, molten aluminum cannot be transported further than 200 km without undesirable temperature drop; therefore, it is imperative for component suppliers to be physically located close to the RM suppliers. For DMV, most component suppliers, including the in-house foundry, are within a 200 km radius of the molten aluminum supplier plants. Therefore, the foundries, smelters, and transportation providers of DMV are enmeshed in long-standing customer relationships within the delivery system that has high switching costs. Production and all the associated processes of DMV aluminum supply are structured around this delivery model.

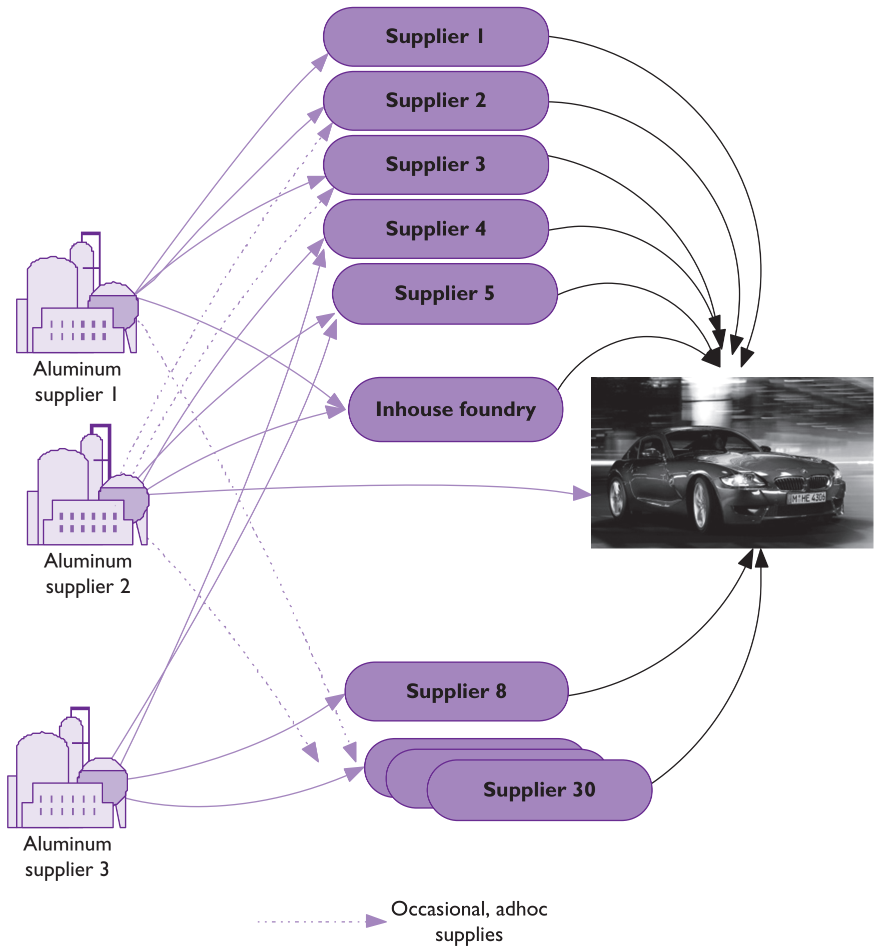
BKI, France

BKI is an automotive and railway safety systems supplier. The company also produces door systems for rail vehicles and torsional dampers. The firm is a major supplier of brakes to truck and bus manufacturers and its clients are OEMs such as Volvo, Scania, Mann, and Mercedes Benz. The plant in France, where we carried out our case study, produces compressors and actuators.

BKI was the only supplier in our study. In addition to the details of RM sourcing knowledge, BKI also provided the opportunity for us to study two additional aspects of upstream sourcing. First, we could study how relationships with RM suppliers were developed at a tier 1 component supplier in the automotive industry. Second, since tier 1 suppliers supply to many OEMs, we could study how such multi-customer supply is related to the RM sourcing network. For most of its sourced components, the BKI plant had historically developed its own suppliers, and therefore a plant-level study was appropriate for exploring the sourcing network.

At BKI, for its compressor and actuator business, aluminum parts are supplied by 15 tier 2 suppliers. Of these, six are gravity die-based foundries, and the

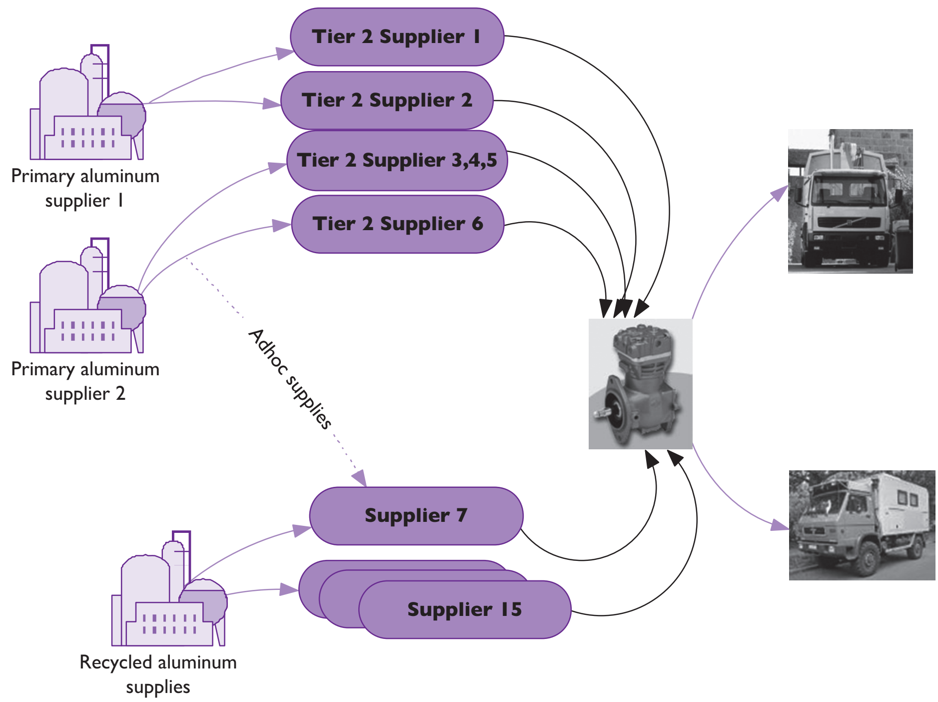
FIGURE 5. Aluminum Sourcing Network of DMV–*Two* Primary Aluminum Suppliers



rest are pressure die-based foundries. One single foundry, which buys its RM from one primary aluminum supplier, is the dominant supplier of gravity die-based components to BKI. (See Figure 6.)

We also studied how BKI's RM sourcing network was related to BKI's customers. We found that at BKI, it is possible to distinguish not only the finished products and categorize a brake system as a Volvo or a Scania brake, but also, at the subcomponent level, it is possible to differentiate the castings/forgings and related RM that are to be utilized for Volvo or Scania brakes. The RM sourcing for different OEMs are fungible. Why so? For most auto suppliers, components are developed at different times for different models. Consider OEM A and supplier BKI who come together for developing brakes for a new truck. For their new truck, A's development engineers sit with BKI's manufacturing engineers to develop detailed specifications for the brake, which will go into the truck that A wants to produce (call it Z). As plans develop, the brake system for Z is broken

FIGURE 6. Aluminum Sourcing Network of BKI–Two Primary aluminum suppliers supply to this supplier, who supplies to many OEMs (none of which have relationships with the Primary RM suppliers)



into component-level details that are used for detailed drawings. Usually, BKI takes over at this point, and starts the process of developing the Z brake system. The component drawings, arising out of specifications for Z, are unique to Z. Next, BKI generates new part numbers and a detailed BOM for the Z brake system. The BOM will have some small components that are common to other brake systems (for the same or another OEM); however, the sizes and specifications of material, the forgings, castings, and machining tolerances, will be specific to Z. This pattern is repeated when A develops a variant ("New Z"). Different brakes will be needed for A's different trucks, requiring fresh development by BKI, and culminating in specific bills of materials for A's specific truck models.

Thus, at BKI, BOMs for customer-specific, model-specific products are available. Even when the OEM has platform developments, blurring the model-level details at component level, there is little commonality in components used by different OEMs. This material information can be used in developing the design and cost details for each supplier at an OEM.

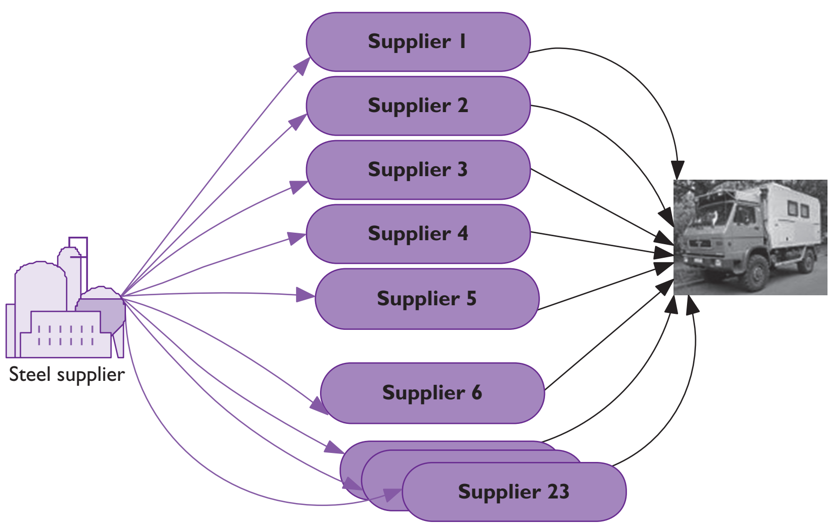
TDV, South Korea

TDV is the second largest commercial vehicle manufacturer in South Korea. This case study is different from the other three. In our earlier cases, we studied the current practices and explored how the RM sourcing network affects sourcing knowledge and costs. TDV has already established relationships with its RM supplier. At TDV, we could study these processes, their deployment, and associated contingencies.

TDV has 23 suppliers for its steel components. It purchases steel from a single supplier, and supplies the same to all its suppliers. It has a direct agreement with the steel supplier on RM prices, and manages the logistics and other related transactions. TDV and the steel supplier agree on required volumes, and the steel supplier then allocates the TDV production quantity for six months. The production plan of TDV is simultaneously transmitted to its component suppliers. The component suppliers submit a request for supply of materials to TDV. All these requests are consolidated by TDV and passed on to the local distributor of the steel supplier, a coil center. The coil center stores the steel coils, and performs slitting and shearing operations. The suppliers receive the RM directly from the coil center, but it is paid for by TDV. TDV also aggregates and takes care of the scrap (resultant waste of RM at the component suppliers). This transaction helps track RM inventory for TDV. (See Figure 7.)

TDV buys around 95% of its input steel directly from its steel supplier. These purchases are centered on the grades of steel that are used in most of its components and are aligned with the choice of specific grades selected for component design. TDV manages all transactions for direct steel procurement. The in-house computer systems have the BOM-based details of the RM required for each component. The system also has the details of the current pricing between TDV and the steel supplier for various grades of steel. TDCV's costing process exemplifies an important element of its RM practices. TDCV's suppliers do not

FIGURE 7. Steel Supply Network of TDV, Korea–*One* primary RM supplier, supplies via a sourcing hub



make any profit from RM materials, even when they buy the materials themselves. The costing process incentivizes TDCV to do the RM buying. A representative costing sheet is shown in Table 3. On this component, the profit element (the amount of KW 1589, row 4, column 7) is not calculated on the raw material, irrespective of whether TDCV is supplying the raw material or not. The costing process supports the overall strategy of RM sourcing by adding value via reduction in double marginalization on RM.

Analysis

In developing theory from our case studies, it is necessary to define the boundary conditions of our propositions. We limit the scope of our propositions to manufacturing firms: that have an assembly process; that source from many suppliers; and that have a significant proportion of RM costs in the total cost of goods sold. These boundary conditions are consistent with our sample and our within-case and across-case analyses. We also limit the scope of the propositions to suppliers to these manufacturing firms who either supply only to the focal manufacturing firms or have a fungible RM chain for each of their buyers.

Within- and Cross-Case Analyses

The four case studies help us understand how a firm can enhance its RM sourcing knowledge by detailing out its upstream sourcing and thereby influence its sourcing costs by direct procurement and by influencing the financial flows in its sourcing. Table 4 summarizes the case study variables for the four cases. In the table, we have indicated the level of the first variable (BOM-based RM sourcing knowledge) along three dimensions. First, we have indicated the level of RM sourcing knowledge of a particular firm in comparison to that of TDV. We have taken the RM sourcing knowledge level at TDV as "High" and then indicated the levels of other firms. Second, we have indicated the position of RM sourcing knowledge in the supply chain: does the knowledge reside within the buyer firm, or not? Third, we have indicated the nature of the RM sourcing knowledge using the categorization of Nonaka (tacit/explicit).[29] For the second variable (RM sourcing structure), we have indicated the number of direct suppliers and the number of RM suppliers for that firm for a particular RM. For the third variable, we have indicated the level of involvement of the buyer firm in RM sourcing costs, including financing the RM (direct procurement of RM).

Analyzing BOM-Based RM Sourcing Knowledge-Related Differences

In three of these four firms, the BOM-level details of RM were not available to the sourcing or design engineers. At TMV, whenever TMV decides to source a new component, the design engineer develops the drawings, and the sourcing engineer then details the BOM and associated manufacturing processes necessary to manufacture the new component. Over the course of time, the sourcing engineer develops tacit knowledge about RM and upstream sourcing simply by being involved in BOM-based sourcing for a lot of components. However, since there is no systematic process deployed to collate the component-level

TABLE 3. A Representative Costing Sheet from TDV. Such costing sheets, developed at a component level, are linked online in TDV's web based system for material-related changes. Note that the profit of 15% is calculated not on the raw material, but only on the labor, factory and administrative overheads. This sheet is an example of how, irrespective of volume, direct RM supply can save costs via reduction in double marginalization on RM (*continued on next page*)

Costing sheet adapted from TDV Korea										
Part number	**xxx111**		**Vendor**	**M/s Precision**		**Prepared by KJH**				
Vehicle	**MCV**									
Part name	**Exhaust pipe**									
Account	**Factory cost**				**Administrative (20%)**	**Profits (15%)**	**Inventory (1%)**	**Depreciation**	**Royalty**	**Final Price**
	Material	**Labor**	**Factory**	**TOTAL**						
COST	**32606.3**	**6374**	**2455**	**41435**	**1766**	**1589**	**326**	**0**	**0**	**45115.9**
	No	**Subpart**	**RM**	**Specs**	**Unit**	**Quantity (a)**	**Unit Cost (b)**	**Price (c) = (a)*(b)**	**Scrap (d)**	**Matl cost (c)-(d)**
Material Costs	1	Flange	ss41	151*151	kg	2.19	730	1599	290	1309
	2	Pipe	sa1d	600mm	kg	2.64	1376	3633	275	3358
	3	Connector	sa1c	340*340*2EA	kg	3.46	1150	3979	481	3498
	4	Bellows	sus304		EA	1	22600	22600		22600
	5	Flange	ss41	151*151	Kg	1.46	637	930	163	767
		Paint	Silver		DM2	29.87	36	1075		1075
							Total Material Costs			32606

TABLE 3. A Representative Costing Sheet from TDV. Such costing sheets, developed at a component level, are linked online in TDV's web based system for material-related changes. Note that the profit of 15% is calculated not on the raw material, but only on the labor, factory and administrative overheads. This sheet is an example of how, irrespective of volume, direct RM supply can save costs via reduction in double marginalization on RM (*continued from previous page*)

	No	Partname	Process	Machine		Work time		Labor cost	Factory Expenses	
				Name	Specs	staff	M/c hour	@6800	Rate	Costs
Factory and Labor Costs	1	Flange	shearing	Sh m/c	10t	4	0.001	27	2514	3
			BL	Press	250t	2	0.0097	132	5570	54
			Pi-1st	Press	250t	1	0.0097	66	5570	54
			Pi-2nd	Press	250t	1	0.0097	66	5570	54
			Restrike	Press	250t	1	0.0097	66	5570	54
	2	Pipe	cutting	saw	10t	2	0.0167	227	1270	21
			Grinding	grinder		1	0.0083	56	–	0
			BE	cnc	100s	1	0.05	340	23758	1188
			Cut-1st	saw	10t	1	0.025	170	1270	32
			Cut-2nd	saw	10t	1	0.025	170	1270	32
	3	Connector	shearing	Sh m/c	10t	4	0.0111	302	2514	28
	4	Flange								
	5	Assembly				Data Suppressed for confidentiality.				
					TOTAL			6374		2455

TABLE 4. Within-Case Analysis (*continued on next page*)

Firms	BOM Based RM Sourcing Knowledge	Sourcing Structure of RM	Sourcing Costs and Financing of RM
TMV	During NPD, design engineers developed the drawings, and the sourcing engineers detail the BOM and associated manufacturing processes necessary. Implicit knowledge developed by doing BOM based sourcing for a lot of components. No systematic process deployed to collate component-level RM information. Knowledge not developed into explicit knowledge or used by other sourcing engineers or design engineers.	Aluminum Chain: TMV had 1 RM supplier, a group of 'recycled aluminum' suppliers, and 13 component suppliers. No direct relationship with the RM supplier - component suppliers deal RM directly. The inhouse foundry of TMV sourced the RM directly with the same RM supplier.	There was a significant difference of 3% in the cost of capital of TMV and that of its suppliers. No financing of upstream RM purchasing. Some suppliers were using pressure die casting while others were using gravity die casting, and their costs were different owing to the technology differences in sourcing of inputs for the RM supplier.
DMV	Unlike TMV, the RM and associated manufacturing processes were not detailed by DMV during the new component development process. The suppliers usually did the BOM based detailing of a component. Therefore, tacit knowledge of RM was with the component suppliers, and not with inhouse sourcing engineers. However, RM information existed on the final drawings developed by the suppliers, and submitted to DMV for approval, but there was no systematic process deployed to collate this component-level RM information, either at DMV or at the suppliers.	Aluminum Chain: 3 RM suppliers supply virgin as well as recycled aluminum to DMV as well as to its 29 component suppliers. No direct relationship with RM suppliers, except for inhouse foundry (Foundry sourced from 2 RM suppliers). RM suppliers located geographically close to RM suppliers.	There was about 1% difference in cost of capital of DMV and its suppliers. DMV did not participate in financing of its suppliers, who all were paying the RM suppliers directly. The firm did have an inhouse foundry, which was its information source for RM sourcing.
BKI	BKI also did not have a process for detailing or using the RM sourcing knowledge. The RM information existed on the drawings. Like TMV, a one-off detailing was done while developing a new component, but there was no systematic process deployed to collate this component-level RM information. RM information was also not available on the computer systems, and therefore was not available to the sourcing engineers or designers.	Aluminum chain: 2 primary RM suppliers and 15 tier 2 suppliers - tier 2 for OEM. BKI does not source any aluminum directly, and does not control the prices or supplies of its RM. Additionally, although BKI is Tier 1 supplier, yet there is no process deployed at BKI, with any of its OEM customers, that focuses on collation or usage of BOM based RM sourcing knowledge.	Insignificant difference in the cost of capital of BKI compared to that of its suppliers. No financing of any part of RM sourcing. No direct sourcing of RM from any RM supplier. No process deployed for financing RM sourcing.

TABLE 4. Within-Case Analysis (*continued from previous page*)

Firms	BOM Based RM Sourcing Knowledge	Sourcing Structure of RM	Sourcing Costs and Financing of RM
TDV	A systematic process deployed to assimilate and utilize BOM based RM sourcing knowledge. BOM-level RM of each component on shared knowledge base, and is updated with the details of RM of each new component that is developed. Design engineers use for developing new components. Preferable choice of current grades of RM. Sourcing engineers use for settlement of sourcing contracts, component-level prices, and payments to RM supplier.	Steel Chain: Single RM supplier, and 23 component suppliers. TDV controls the RM supply to its component suppliers. It buys RM from RM supplier, pays it directly, and manages the associated processes of RM inventory, scrap and delivery along with the RM supplier. The component suppliers do not buy the RM for TDV supplies.	There is about 1% difference in the cost of capital of TDV compared to that of its suppliers. However, the pricing of RM by the RM supplier to TDV is about 7% lower than the pricing to TDV's component suppliers. The RM supplier attributed this price difference to lower variation in demand of RM from TDV (main effect), and to higher volumes.

RM information, this knowledge is not developed into explicit knowledge or used by other sourcing engineers or design engineers beyond this initial component development phase. Unlike TMV, the RM and associated manufacturing processes are not detailed by DMV during the new component development process. The suppliers usually do the BOM-based detailing of a component. Therefore, tacit knowledge of RM is with the component suppliers and not with the OEM. While RM information exists on the final drawings developed by the suppliers (and these drawings are submitted to DMV), there is no systematic process deployed to collate this component-level RM information at DMV. The supplier firm BKI also does not have a process for detailing or using the RM sourcing knowledge. Like TMV, a one-off detailing is done while developing a new component, but there is no systematic process deployed to collate this component-level RM information. Unlike TMV, RM information was also not in the computer systems, and therefore was not available to the sourcing engineers, even though the information existed on the component drawings (like DMV). It is interesting to note that there was no process deployed at any of BKI's OEM customers that focused on collation or usage of BOM-based RM sourcing knowledge.

The RM sourcing knowledge at TDV is driven by an extremely detailed BOM-based RM database. This database gave exactly the same information, which we had to cull from BOM-level drawings at TMV, DMV, and BKI. This RM database supports design process in two ways: it helps lower the cost of new components being designed; and it helps lessen the number of new grades of steel to be procured, thus reducing the overall complexity.

RM sourcing knowledge is also important for TDV's sourcing processes. The sourcing engineers fix the process parameters in alignment with the steel grades being procured. This practice at TDV is completely different from that at TMV or DMV, where even though suppliers' inputs go into the process parameters of the component, there is hardly any input from the RM supplier, or any use of an explicit RM database in the new product development cycle. On the other hand, for TDV, the RM database helps reduce the time taken for new product development: the tooling and jigs/fixture development is faster, since sourcing engineers and suppliers need to design and develop manufacturing parameters for a lesser number of RM.

The TMV, DMV, and BKI cases show us that RM sourcing knowledge does not exist in an explicit form in these firms as opposed to TDV. The detailing of RM needs a thorough understanding of RM, of RM-related manufacturing processes, and of technical dependencies in RM sourcing network (such as gravity and pressure die casting processes for aluminum). Such knowledge is usually held by individuals in sourcing and design functions, and can be categorized as tacit knowledge. The BKI case shows us that such knowledge is OEM specific, and each OEM will need to deploy processes to harness this knowledge, thus it may not be possible to quickly replicate this knowledge. A focused effort from the firm is needed to externalize this tacit knowledge and convert it to explicit knowledge.[30] An example of such explicit knowledge is the RM database at TDV. This explicit knowledge can then be shared easily (the RM database is shared across the sourcing and design engineers of TDV) and also used to reduce complexity of design, sourcing, and manufacturing.

At TMV, our continuing studies show how BOM-based RM sourcing knowledge drives complexity reduction. As the gravity die casting sourcing network was mapped out, sourcing engineers went back to their designer counterparts and had discussions about a reduction in the number of grades of aluminum being put on the engineering drawings. In many cases, design engineers were optimizing the design of even small components on an individual basis. In this case, we saw how the combining different competencies along the NPD process can be useful. The BOM-based RM sourcing knowledge could reduce the ineffective complexity of using special RM. This is similar to managing early supplier involvement, in this case 2nd tier (RM) supplier and sourcing hub competencies that help the NPD process to be more efficient.[31] This process helped in eliminating a number of grades of aluminum. We are still studying the direct effects of this reduction in RM grades on the time taken for new component development.

Analyzing RM Sourcing Structure and Cost-Related Differences

The aluminum chain of TMV has 1 RM supplier, a group of 'recycled aluminum' suppliers, and 13 component suppliers. TMV does not have a direct relationship with the RM supplier. The firm has no control over the RM prices or RM supplies of its component suppliers; the component suppliers are dealing with the RM directly. The in-house foundry of TMV sources the RM directly, and this is a potential source of information regarding RM supplier for TMV. There is a significant difference of 3% in the cost of capital of TMV and that of its suppliers. However, TMV does not finance RM purchasing nor does it participate in any financial transactions with its RM suppliers.

DMV's aluminum chain has 2 main RM suppliers and 1 ad hoc RM supplier. All RM suppliers supply virgin as well as recycled aluminum to DMV as well as to its 29 component suppliers. The firm does not have a direct relationship with its RM suppliers, except for its in-house foundry, which sources RM from 2 RM suppliers out of 3. Many of the component suppliers source molten aluminum from the RM suppliers, and to facilitate the RM supplies, are located geographically close to RM suppliers. DMV does not control RM pricing or RM supplies for its component suppliers. There is a difference of about 1% in the cost of the capital of DMV and its suppliers. Like TMV, DMV also does not participate in the financing of its suppliers, who all were paying the RM suppliers directly. The firm does have an in-house foundry, which was its information source for RM sourcing.

The aluminum chain of BKI comprises of 2 primary RM suppliers and 15 tier 2 suppliers—tier 2 for OEM. BKI does not source any aluminum directly. There was little to no difference in the cost of the capital of BKI compared to that of its suppliers. BKI did not finance any part of its RM sourcing, and it did not source RM directly from any RM supplier.

TDV's steel chain has a single RM supplier and 23 component suppliers. TDV controls the RM supply to its component suppliers. It buys RM from a RM supplier, pays it directly, and manages the associated processes of RM inventory, scrap, and delivery along with the RM supplier. The component suppliers do not buy the RM for TDV supplies. For TDV, there was a difference of about 1% in the cost of capital of TDV compared to that of its suppliers. TDV buys the RM needed for most of its products directly, and thus finances its RM sourcing chain.

Two factors related to sourcing costs are interesting for our discussion. The first factor relates to direct RM costs. TDV aggregates and buys steel as a single buyer from the steel supplier. TDV's suppliers told us, "If we buy steel from the steel supplier ourselves, our purchase price would be higher than the price obtained via TDV." We cross-checked these price differences with the steel supplier and found that there is indeed a difference of 7% between the supply prices of steel to OEMs and to other buyers. Moreover, the steel supply to TDV suppliers and other purchasers was on an immediate cash basis, whereas TDV enjoys 60 days payment terms. These pricing differences lead us to believe that TDV benefits by working together with the RM supplier.

At first glance, this seemed to be the standard volume-purchasing benefit. However, we wondered if there was something we were missing. TDV is a truck manufacturer and is a smaller firm compared to GM-Daewoo or Hyundai, who produce cars in high volumes. If the volume purchasing argument was correct, we would expect to find the price of steel to TDV to be much higher than the price of steel to Hyundai. However, we found differences of only around 1% in steel prices between OEMs based on volumes of purchases (compared to 7% difference between OEM and non-OEM customers). Low volumes bought by TDV did not really matter much.

The steel supplier executives, in repeated enquiries and detailed discussions, emphasized the aspect of long-term relationships and managing demand uncertainty over price premiums. They told us, "Volumes are not the main thing. Relationship with a component supplier is usually short term in nature. Our pricing is related to relationships with the customers, and we differentiate between OEMs and other second tier customers. Volumes are important, but relationships override everything else. Of course, this means that TDV buys only from us!" Upon being questioned further as to why volumes would not affect their input costs, they replied, "You see, costs are not dependent on individual customer volumes after a base level. As long as firms procure standard products from us, our costs are really the same for TDV as for Hyundai. Costs reduce by having a detailed plan and leveled production. That only comes from our OEM customers, because their plans do not vary too much for the next two months." Essentially, the RM supplier argument seemed to be that the reduced costs emanating from lower variation in demand override the losses due to reduced prices to OEMs. The RM demand from the OEM has a lower variation since the demand is pooled over all its component suppliers, and also employs a longer time frame. Due to both these effects, demand is less volatile.

Our experience (in three firms for over four years) shows that it takes time to develop the BOM-based RM sourcing details, making a shareable database, and using it for reducing complexity and cost of manufacturing and sourcing. Such sourcing knowledge is a strategic resource for a firm, a rare and valuable entity that has a high imitation cost.[32] Once a firm develops the BOM-based RM sourcing knowledge for all its procurement, it can take strategic decisions on establishing partnerships with RM suppliers. The development and sharing of such a database helps convert the tacit knowledge residing at the suppliers and the in-house sourcing engineers and designers into explicit RM sourcing knowledge. This knowledge can help reduce complexity in sourcing (since there are fewer RM grades to source) and component manufacturing (since there are fewer process changes, and correspondingly fewer quality-related inspection and control considerations, both at the supplier and at the OEM level). Combining the above arguments about reduction in uncertainty with those of complexity reduction, we can propose:

> **Proposition A:** As uncertainty increases, developing BOM-based sourcing details of RM by working with RM suppliers for components sourced from 1st tier suppliers can help decrease design-, sourcing-, and manufacturing-related complexity for the focal firms, the 1st tier suppliers, and the RM supplier.

We postulate that negotiations with a single RM supplier can result in cost reductions due to the differential purchasing arrangements at the supplier level. Since the suppliers are dealing one-on-one with the RM supplier, direct purchasing can result in cost reduction—the RM prices may be brought down to the lowest among the prevailing prices. This effect is dependent on the number of RM suppliers as well as the value of the RM being contracted. The lower the number of RM suppliers, and the higher the value of RM being contracted, the higher the potential for savings. The above argument is counterintuitive: more RM suppliers should lead to competition for supplies of RM, and therefore there should be very little possibility of savings. The steel supplier's comments on relationships, however, lead us to the argument advanced earlier. Figure 1 allows us more insight into this argument. When there are only a few RM suppliers, they have more power over the pricing of the RM, while negotiating with the multiple component suppliers. However, when the relationships are developed with the OEM, there are two distinct differences that emerge. First, the savings from higher volumes can offset the losses due to the elimination of higher prices to component suppliers (or price discrimination by the RM supplier). Second, and perhaps more importantly, the risk-pooling effect from aggregation of RM can provide benefits to the RM supplier.

The development of relationships by the OEM with the RM supplier changes the structure of the upstream supply chain. For the RM supplier, such a relationship is long-term in nature and provides more stable production and delivery schedules. The RM supplier values this reduction in uncertainty as more valuable than the higher revenue coming from differential prices negotiated with the component suppliers. Therefore, our case studies confirm the theory that managing upstream relationships (especially with RM suppliers) can help reduce the bullwhip effect.[33] For the RM supplier, the incremental revenue from the component supplier is uncertain not only because of higher uncertainty in individual component production, but also because the component supplier can switch to an alternate RM provider much more readily than an OEM, since the contracts are usually short term and involve lesser volumes. Integrating the above arguments concerning the RM supplies and the sourcing structure, and the consequences for the resulting component-level pricing, we can say:

> **Proposition B:** As the number of RM suppliers decreases and the RM content in the cost of goods sold increases, the opportunity for value addition in upstream supply chain increases as a result of: direct purchasing of RM; sharing demand information

with 1st tier and RM suppliers; and production related information for the focal firms, the 1st tier suppliers, and the RM supplier.

Note that Proposition B is based on the assumption of a monopolistic RM supplier. This assumption (and real life setting of TDV) is not general. In many industries (such as apparel and food), there is a large RM supply base, and therefore they may be very low margins for the RM suppliers, putting a downward pressure on the RM prices. Therefore, the opportunity from managing the RM sourcing may be more beneficial in those industries where buyers have to contract with monopolistic (or oligopolistic) RM suppliers. Highly competitive RM scenarios present a barrier to the adoption of RM sourcing practices such as the sourcing hub.

Our two propositions can be used to analyze how TDV established its sourcing hub. TDV forged relationships with a single steel supplier and bought RM supplies for a large number of (mostly small) component suppliers. Many of these suppliers (some of whom we visited) have 40-70% of their business with TDV. TDV detailed out, at a BOM level, the RM grade, size, and weight required for every single component, and then used these details to manage day-to-day sourcing operations, including RM usage, inventory, and scrap. The relationship with the steel supplier also helped reduce complexities in the design and sourcing. All of these processes need a specific focus, and are quite distinct from the day-to-day operations in a typical sourcing department (e.g., at TMV or DMV). A sourcing hub structure can help align many of the processes described above.

Discussion

Our objective in this article was to explore how managers can strike a balance between the two seemingly contrasting views of managing the sourcing of a firm. On the one hand, there is the complexity perspective, according to which firms should gain visibility over their supply network and attempt to gain some form of control over it.[34] On the other hand, there is the outsourcing/simplification perspective, according to which managing the network is complex and unrelated to the core focus of the firm.[35] We propose that a possible way to strike a balance between these two perspectives is the sourcing hub. Our sample of four cases is appropriate for exploring this contrast, because we have two firms (BKI and DMV) that are in the process of considering the implementation of a sourcing hub, one firm that is now implementing the sourcing hub concept (TMV), and one firm that has already implemented it (TDV). (See Table 5.)

Deploying the Sourcing Hub

In its sourcing hub, TDV manages complete transactions for RM sourcing via an online web-based system. The hub has sourcing individuals working full-time on the related transactions, including logistics and negotiations. The hub also has the support of other departments such as finance, IT, and others who are working part time in the hub. The web-based system has BOM-level details of the RM required for each component, as well as the details of current pricing between TDV and the steel supplier for various grades of steel. These feed directly into the costing sheets for each component.

TABLE 5. Cross-Case Comparisons

Variables	TMV	DMV	BKI	TDV
BOM-Based	Medium	Low	Low	High
RM Sourcing	Exists within TMV	Exists with suppliers	Exists within BKI	Exists within TDV
Knowledge	Tacit	Tacit	Tacit	Explicit
RM Sourcing	1 RM supplier	3 RM suppliers	2 RM suppliers	1 RM supplier
Structure	13 direct suppliers	29 direct suppliers	15 direct suppliers	23 direct suppliers
RM Sourcing Costs	Nil	Nil	Nil	High

The sourcing hub is not a trivial way of organizing the upstream sourcing. There are many complexities. The buyer needs to invest in upstream sourcing relationships with RM suppliers. Firms in some other industries (such as the electronics jobbing industry) have a similar structure. Firms like Flextronics and Jabil act as supply chain integrators by pooling manufacturing for a lot of their buyers. However, the sourcing hub structure is very different from the typical jobbing in the electronics industry. It is focused on how a single firm can gain knowledge about its upstream sourcing; the suppliers still focus on design and development of components, but there may be value in exercising a hybrid control on the RM element of components.

At TDV, a lot of information is shared between the firm, the suppliers, and the RM supplier. TDV manages this information at the sourcing hub; the suppliers do not share information with the RM supplier. The specific information includes details of production plans for the coming months, including new models, changes in drawings, production schedules, the quantity of components required for the supplier, and the RM required (for the RM supplier). The web-based information is accessible online, and is usually modified twice a month to update information about the future. TDV works on a frozen production schedule for two months and a tentative third-month schedule with its component suppliers. With the RM supplier, TDV agrees on required yearly volumes, with fixed volumes for six months. Thus, the RM supplier and TDV enter into a slightly longer-term contract than the intermediate suppliers. If the market demand changes, TDV does not modify the immediate month or the next month's production schedules, but makes changes in the third month's plans. This helps bring stability in component supplies.

At TMV, where the implementation is going on, the sourcing hub engineers are currently aligning all the RM suppliers (aluminum and other inputs), drawing up longer-term contracts and developing processes for physical supply and tracking of RM at the suppliers. The input RM, and all the scrap and offcuts generated during the production process, also need to be tracked, and these processes are being mapped and slowly deployed. While the firm had initial apprehensions about whether the suppliers will align with the OEM, these have been replaced with enthusiasm: the suppliers are readily coopting with the firm. There are, of course, some concerns, and many a time these concerns are not what we would find in purchasing literature. As one of the aluminum component suppliers of TMV told us, "The sourcing hub concept is fine for us. We really do not add value via purchasing. So, it is fine if TMV buys the raw material. Indeed, for aluminum, TMV would have a much better pull with Hindalco or Balco. [These are Aluminum suppliers.] And I can really see the improvement due to less number of grades of aluminum that are coming in my shop. [The word "shop" is used in manufacturing parlance to denote a manufacturing plant.] It is also heartening to see these engineers setting up process parameters with my people. My concern is slightly unorthodox. When I buy the raw material, my turnover goes up. So, in the eyes of my community, my business is bigger. Now that a significant portion of my buying is going away, my business will become smaller!"

What are the costs of setting up a sourcing hub? We have observed that there are two types of costs in setting up the sourcing hub: startup and ongoing. The startup cost relates to the detailing of raw material at the component level and establishing a material database so that the raw material supply is streamlined. The raw material level details at the component bill of material level are normally not a part of the day-to-day operations at other OEMs. In order to develop such a database, the OEM has to collate accurate raw material information, such as grades, weights, and sources of material for each component. This is not easy, but once in place, the database is an invaluable source for raw material-related knowledge. The ongoing cost consists of managing the sourcing hub: developing periodic (frequently monthly) schedules, linking supply with the payment cycle to the raw material and component suppliers, and auditing the inventory. Our study of the TDV sourcing hub shows that its ongoing costs are insignificant compared to its cost savings. TDV manages the sourcing hub (for a single raw material, for a single country) with just two full-time employees and part-time support from one person in the finance department.

What is the extent of savings that can accrue to an OEM from managing its RM sourcing? The exact answer depends on the relationship between the RM and the fixed costs of the OEM and the suppliers. Our empirical research shows that direct RM purchasing and collaborative sourcing at the sourcing hub lead to savings of 3%-6% on the costs of RM for the OEM. This is a huge benefit, considering that RM costs amount to over 50% of the cost of goods sold for automotive OEMs, and the margins on the auto products are very low.[36]

Practical Considerations

As the TMV and TDV case studies show, deploying a sourcing hub is not easy. When a supplier is responsible for the entire component, the responsibility includes that for the RM used. However, when the customer OEM becomes responsible for the RM part of the component, this responsibility is shared. It is possible that a direct relationship with the RM supplier may help improve the upstream sourcing and design processes, but it is also possible that the component suppliers shift the blame of quality of manufacturing to the customers. Thus, there is a possible conflict of interest that can arise when the sourcing hub is operating. This is also an interesting area for future research.

Next, the operational issue of delivery can arise. It is not easy to physically keep track of the RM being used. The component suppliers, the RM supplier, and the OEM need careful monitoring for the delivery of RM. It is possible that the component supplier can point towards constraints in RM supply for its failure of the delivery of components. This issue came up in the sourcing hub deployment at TMV (which did not have any relationships with its RM suppliers when our study started). A TMV manager summarized the situation as follows: "See, till now they [the component suppliers] could not blame me for not supplying components on time to TMV factories. Now, they would have a lever, and can say that TMV did not supply the RM on time, and therefore there are delivery issues." The same argument can be advanced for quality: the supplier can say that the quality defect is due to bad RM. These operational issues are real, they represent possible roadblocks when the OEM deploys processes for deploying the sourcing hub, and they need to be managed proactively. At TMV, where the sourcing hub is being implemented, these issues are being managed by deploying additional processes such as online RM inventory monitoring.

Third, the transaction costs for deploying the sourcing hub are not trivial. Many of the activities (RM database development, RM tracking) are one-time investments to start the sourcing hub processes; however, some additional work will be needed every time a new component is developed. This cost is specifically relevant when there are reasons to switch the RM supplier. In this case, the investments that the buyer firm makes in developing the sourcing hub may need to be repeated every time the RM supplier changes, and the sourcing hub may show a reduction in value. Therefore, if the RM suppliers may change very dynamically–an example may be the change of sourcing patterns for memory chips in the IT industry (the supplier concentrations changed from Japan to China to Korea)—then sourcing hubs may not provide value.

A sourcing hub is quite different from e-procurement platforms (e.g., www.exiros.com) or third-party purchasing groups. The fundamental difference with third-party solutions or purchasing groups is in two areas. First, the level of detailed analysis that is required to generate BOM-based RM requirements necessitates an in-house group. These details, in most cases, would be too valuable for any focal firm to divulge to a third party. Therefore, the efficacy of such a third-party arrangement is unstable. Second, the core idea of sourcing hub is to develop deeper relationships with the RM suppliers, so that RM knowledge can be created and then used in streamlining current operations, reducing complexity, and developing new products. Such value-added processes cannot be deployed via outsourced knowledge.

Conclusion: Building a Better Supply Chain with the Sourcing Hub

We studied four firms in four countries in the automotive industry, focusing on sourcing relationships of OEMs with their suppliers as well as with suppliers' suppliers, and explored these via BOM-level knowledge and RM details for the entire sourcing for a single raw material, supplemented with interviews of suppliers, RM suppliers, and buyers for all firms. Our research suggests two lessons for managers. First, in those industries where RM forms an important part of the product value, and RM suppliers are an important part of the value chain, developing relationships with RM suppliers via a sourcing hub can provide higher value to firms. Second, these relationships can be improved by developing BOM-based sourcing details of RM for components sourced from all suppliers. This can help decrease design-, sourcing-, and manufacturing-related complexity, and these benefits can increase with rising uncertainty in business scenarios. While our research focuses only on automotive firms, a further research step will be to generalize the insights from the case studies to firms for whom the raw material is an important part of supply chain.

Our research explores the effect of the supply chain partners at the periphery of the firm: partners who may not supply directly to the firm, but may affect the knowledge of the firm and its operations, including factors such as design complexities and costs. We propose a specific supply chain structure to capture value from supply chains. This is the upstream entity, the sourcing hub, which helps in many ways. It facilitates generation and use of RM sourcing knowledge by helping develop collaborative relations with RM suppliers. Building a relationship with RM suppliers encourages the sharing of demand, production, and design information. The sharing of information leads to improved sourcing processes and reduction in complexity of new product development, which helps drive down the costs of inputs. Our work suggests that managers may have systematically underestimated the value that they can add by developing and preserving knowledge in their upstream sourcing. A specific way to develop this rich knowledge about RM sourcing is the sourcing hub.

APPENDIX
Semi-Structured Interview Instrument

OEM/Supplier/Supplier's supplier

Firm: ___________________

Name:_________________

Date: ___/____/____ Title: _________________

(Staple visiting card!)

Step 1: Introduction and Context

Introduce research. Specifically emphasize that the confidentiality agreements are in place, emphasis on numbers or names are only to authenticate responses and build up a database. Also, neutrality and trust are essential to this research. Emphasize automotive industrial experience and INSEAD.

Step 2: Ask open ended questions

(a) BOM-based RM sourcing knowledge

- How is the BOM created? Who has access to BOM?
- How are raw materials determined for BOM?
- What are the raw materials that you deal with in production/assembly of components?
- Do raw material suppliers supply direct to your line?

- If raw material is of different quality, does it affect the production process? How?
- Let us talk about the design of components. If raw material is of different quality, does it affect the design process? How?

(b) RM Sourcing network

- Can you tell us who are the major suppliers of these raw materials? (probe existing and potential suppliers both)
- How long have you worked with raw material supplier/s?

(c) Sourcing costs and financing

- Are you involved in pricing (if yes, probe price of RM)
- What specific pricing decisions depend on RM supply?
- Would RM supply be different if your buyer bought RM?
- Probe Working Capital, see records.

Step 3: Closure and Reassurance

- Reassure for confidentiality
- Answer queries. Thank for time, make sure future email and phone contact is confirmed and agreed to.

Notes

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California Management Review, Vol. 56, No. 2, pp. 23–54. ISSN 0008-1256, eISSN 2162-8564. DOI: 10.1525/cmr.2014.56.2.23.