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The Cost Effects of Component Commonality: A Literature Review Through a Management-Accounting Lens

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In this paper I review the component commonality literature through a management-accounting lens, focusing on the cost effects of an increase in the use of the same version of a component across multiple products. The bulk of this literature is of a theoretical nature, for example, analytical models, programming models, or conjectures based on casual observations of practice. Some of this literature purports, especially in introductions to the topic, that cost generally decreases with increasing commonality. However, based on a review of the theoretical literature using an activity-based costing framework and distinguishing between cost-driver and cost-rate effects, I conclude that the cost picture is more subtle. In other words, it is too early to make any general statement about the effect of increasing commonality on total costs. Moving to the limited empirical literature on the topic, consisting of case studies (sometimes combined with simulation) and empirical research on larger data sets, the conclusion that there is even more room for future research becomes evident.

Key words: component commonality; unique versus common components; new product development; activity-based costing
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1. Introduction

In recent years, many firms have experienced the need to offer more product variety because of increased competition and more demanding customers. Component commonality, the use of the same version of a component across multiple products (Fisher et al. 1999), is increasingly considered as a way to offer high variety while retaining low variety in operations, and thus to lower costs (e.g., Swaminathan 2001).

Component commonality has mainly been studied by operations-management (OM) researchers. An overview of this literature is presented in §3. Surprisingly few management-accounting researchers have studied this issue. However, the management-accounting literature has looked at the costs of complexity and identified the number of components as an important determinant of the complexity of both products and processes. A big opportunity for cost reduction arises when products are first designed (Cooper and Kaplan 1998), because a substantial part of the manufacturing costs gets determined during product design and development stages (Blanchard 1978, Michaels and Wood 1989).

Traditional standard costing systems, focusing on direct material cost and allocating overhead via a direct-material burden rate, send a message to the designer or engineer to reduce the cost of the purchased materials to incur lower overhead costs. Product designers thus increase the number of components by shopping around for the lowest price solution for each product, instead of using a common but more expensive component on a set of products to decrease the amount of overhead allocated to their product. Several case studies (e.g., Banker et al. 1990, Cooper and Turney 1990), however, report an "unease" with this practice when both designers and managers realized that product costs were systematically distorted. Traditional accounting systems favored an approach with lots of unique and inexpensive components, because products were not punished with the costs of the complexity. Some papers examined the cost drivers of manufacturing overhead in larger-scale research settings and came to the same conclusions (Foster and Gupta 1990, Banker and Johnston 1993, Banker et al. 1995). Firms started shifting to activity-based costing (ABC) systems that enable product designers to ensure that the products will consume fewer process drivers, creating the possibility of manufacturing products with low indirect and support costs (Kaplan and Cooper 1997). New cost drivers, such as the number of different components, became important. This cost driver sends a clear message to designers to increase the use of common components. Also, if the component-sustaining costs are divided over the products in which the component is used, the designers are encouraged to use the common component that is already purchased and used in high volumes in even more new products. This leads to a decrease in another new cost driver—the number of suppliers—because less shopping around is necessary to find the lowest cost supplier for each unique component.

Component commonality has not only been identified as a way to obtain end-product variety with low component variety and low cost, but also as a risk-decreasing strategy in a stochastic-demand environment because by pooling risk the total volume of the common component can be forecasted more accurately (Baker et al. 1986).

In the OM literature, three research streams on component commonality have developed. The earliest papers, written in the early 1970s, looked at the effect of commonality on inventory levels, and thus on inventory costs, and the decrease in demand uncertainty through risk pooling. This stream has developed well into the 1990s, considering more and more complex inventory-holding situations. A second stream of research, originating in the early 1990s, examines a variety of other costs influenced by component commonality. This stream, implicitly or explicitly, assumes that the components are invisible to the customer or do not affect the quality of the end product as perceived by the customer. A very recent third stream of literature, with roots in the marketing literature (e.g., Green and Krieger 1985), has studied the ability of products to attract new customers and their potential to cause demand substitution (i.e., cannibalization). This stream assumes that the revenue side is no longer independent of component commonality and tries to include revenue and cost aspects in the commonality decision. Robertson and Ulrich (1998) differentiate between external (as in Stream 3) and internal (as in Stream 2) commonality and emphasize that increasing internal commonality does not necessarily lead to cannibalization of demand. For example, if commonality is introduced in the internal electrical wiring of cars, the customer will not notice. However, if commonality is introduced across the dashboards for several classes of cars, cannibalization of demand may occur (Kim and Chhajed 2000, 2001; Ramdas and Sawhney 2001; Ulrich and Ellison 1999; Krishnan and Gupta 2001; Desai et al. 2001).

This article reviews the component commonality literature through a management-accounting lens, focusing on the cost effects of an increase in the use of the same version of a component across multiple products. The bulk of this literature is of a theoretical nature. Some of this literature purports, especially in their introductions to the topic, that cost is generally decreasing with increasing commonality (e.g., Desai et al. 2001, p. 38; Duray et al. 2000, p. 608; also acknowledged by Nobelius and Sundgren 2002, p. 60). However, based on a review of the theoretical literature using an ABC framework (that distinguishes between cost-driver and cost-rate effects and that clarifies at which level in the ABC hierarchy costs become variable), the conclusion reached is that the cost picture is more subtle. In other words, it is too early to make any general statement about the effect of increasing commonality on total costs. Also, there seem to be conflicting views on the sign of the effect of some specific costs. Moving to the empirical literature on the topic, that consists of case studies (sometimes combined with simulation) and empirical research on larger data sets, the conclusion is that there is even more room for future research.

Three recent reviews cover broader research areas, of which component commonality is a subsection. Krishnan and Ulrich (2001) present a very broad review of research in product development using marketing, organizational, engineering-design, and operations-management perspectives. They do not use an accounting perspective. Ramdas (2003) presents a review of variety management from the perspective of the problems faced by practitioners, identifying gaps in research knowledge. Again, this review is much broader because commonality is discussed as just one of the ways to implement a variety strategy. Ramdas (2003) calls for further research in improving the estimation of costs and how they interact with the demand side. Swaminathan and Lee (2004) review design for postponement and cover both process as well as product factors. One of the latter is component standardization (cf. their §5).

The rest of this paper is structured as follows. Section 2 presents the ABC framework I use to classify all the cost effects documented in the literature, distinguishing between a cost-driver use effect and a cost-rate effect and different levels in the ABC hierarchy. Section 3 then goes on to review the existing literature within this framework and present insights into how the various costs identified in the literature behave under increasing commonality. The last section concludes the discussion.

2. The ABC Framework

Using ABC, the objective function of optimization models that determine the optimal level of component commonality is written as a summation of cost rates multiplied by cost-driver use over all ABC hierarchical levels. Or, expressed in mathematical notation

$$\min_N \sum_{j\in N} p_j \times q_j + \sum_{l\in H} \sum_{c\in C_l} a_{cj} \times d_{cj}$$

with

N set of components, index j

H set of ABC hierarchical levels, index l

C_l set of activities performed on ABC hierarchical level l, index c

p_j price per unit of component j

q_j quantity of component j purchased in units

a_{cj} cost rate per activity c, which may depend on the choice of component j

d_{cj} cost-driver use expressed in units of activity c driver performed, which may depend on the choice of component j.

This paper uses a five-level ABC hierarchy to classify all the cost effects identified in the literature: supplier (s), component (i), order (o), batch (b), and unit (u) level.[1] The hierarchical level at which a particular cost is classified indicates when this cost becomes variable.

Costs on the supplier level are incurred whenever a supplier is selected. They include, for example, negotiating and managing costs. Whenever the supplier is not selected (a choice that could be expressed by a binary decision variable in the optimization model), these costs are not incurred. In ABC terminology, these supplier negotiating and managing costs are variable at the supplier level in the ABC hierarchy.[2] Costs on the component level are incurred whenever a particular component is selected. Examples are component-specific R&D, the writing of component specifications, and component testing costs. Costs on the order level are incurred each time an order is placed and include, for example, ordering and invoicing costs. Costs on the batch level are incurred each time a batch is delivered or brought to the production line (e.g., inspection and set-up costs). Costs on the unit level are the costs that are traditionally called variable costs and that are incurred per unit (e.g., price and inventory-holding costs).

Within each hierarchical level, several activities are performed. The cost of these activities is determined by multiplying their cost-rate with their cost-driver use. For example, the total set-up cost on the batch

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[1] This hierarchy was selected to include the link with supply chain management issues such as supplier selection (Degraeve et al. 2000) and early supplier involvement in new product development (Wynstra et al. 2003). Benton and Krajewski (1990), Ulrich and Ellison (1999), and Salvador et al. (2002) indicate how these issues are intertwined with the component commonality decision. Novak and Eppinger (2001) suggest that greater coordination of the purchasing function and the product development function could improve firm performance. However, component commonality research that focused on a more internal view of the firm (e.g., to determine the degree of commonality in product design without making the link to supply chain management issues) could use one of the more traditional ABC hierarchies (e.g., facility, product line, product, batch, and unit level).

[2] Cooper and Kaplan (1998), who are usually thought to be the "inventors" of ABC, coined the term "hierarchy." In the early literature, the examples used indeed had a typical pyramid shape in terms of the number of cost drivers on each level, and therefore the term hierarchy was reflecting practice. Recently, however, research has indicated that the hierarchy is case specific, and we can now find examples of ABC systems in which the hierarchy does not necessarily have the pyramid shape, for example, in this paper. If the reader therefore finds this accounting terminology confusing, we would suggest just thinking about it in terms of "levels at which costs become variable."

level is calculated by multiplying the set-up cost rate (the cost of one set-up in terms of its consumption of resources, such as an engineer's time) by the number of set-ups needed (i.e., the cost-driver use).[3]

An important caveat: Applying ABC assumes that the costs are linear (or step linear) with the cost drivers. Research in the accounting area (e.g., Noreen 1991, Bromwich 1997, Maher and Marais 1998), however, has shown that the conditions under which any costing system in general—and ABC in particular—provides accurate costs are rather stringent and, in some cases, hard to meet, especially when resources are provided on a joint and indivisible basis. Noreen (1991) established three conditions under which ABC provides valid product costs: (1) total costs can be separated into cost pools,[4] each of which depends solely on one activity (separability), (2) the cost in each cost pool must be strictly proportional to the level of activity in that cost pool (linearity), and (3) activity drivers assigned to individual products can be simply summed to arrive at total activity. Noreen and Soderstrom (1994) empirically test the linearity assumption for different categories of overheads and conclude that it is often not met. I acknowledge these possible problems with any application of a costing system and with ABC in particular. However, I argue that the use of ABC is already a leap forward as it approximates the linearity of the cost functions much better than the traditional volume-related approaches by using a cost hierarchy in which costs become variable at different levels. With ABC, the linearity assumption is solely required to hold on each level in the hierarchy; that is, cost should behave in a linear way with the selected cost driver for that particular hierarchical level. Ittner et al. (1997) have shown that the costing hierarchy is case specific. In theory, one can extend the number of hierarchical levels for a particular costing system to reflect the underlying production technology and thus define linear relationships on each level in the hierarchy. In practice, a compromise needs to be reached between the complexity of the costing system in terms of the number of cost drivers and hierarchical levels and the loss in accuracy resulting from the approximation by linear relationships.

3. Summarizing the Cost Effects of Commonality Identified in the OM Literature

Table 1 summarizes the results reported in the OM literature on the cost effects of commonality, classified using our five-level ABC hierarchy. On each level in the hierarchy, I distinguish between the effects on cost rate (a_{cj}) and on cost-driver use (d_{cj}). In the table, references to papers in normal print indicate results from theoretical papers; bold type refers to empirical results.

3.1. Discussion of Unit-Level Effects

The description begins with the unit-level (u) cost effects, where component commonality research originated. On the unit level, the effects on driver use (number of units) and cost rates are split into a price effect, an inventory effect, and a backlog effect. Note that the signs ("+" or "−") of these effects are often contradictory.

Rutenberg (1971) first studied the problem of commonality of subassemblies. He models it in a dynamic programming model as the balance between the disutility of refusing to provide each customer product with an item fitting its exact requirements and economies of scale achieved in producing and inventorying each item. He derives the optimal depth of the product line. Dogramaci (1979) researches the reduction in the standard error of demand forecasts and the implications on inventory systems of component commonality. Collier (1981) develops an analytical index to measure component commonality and simulates the effect of demand uncertainty on safety stock under several degrees of component commonality (1982). He concludes that safety stock decreases when

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[3] By presenting the effects on cost-driver use separately, Hillier's (2000) concern about comparing a one-off saving on the purchase price of safety stock with a higher component price to be paid in all periods can be overcome. Indeed, cost-driver use d_{cj} clarifies how often these recurring costs have to be taken into account in multiple time period models.

[4] A cost pool is a grouping of individual cost items. In practice, cost pools can range from the very broad (such as a companywide, total-cost pool for telephones and fax machines) to the very narrow (such as the cost of operating a car used by a traveling salesperson). A homogeneous cost pool is one in which all the activities whose costs are included in the pool have the same or a similar cause-and-effect relationship between the cost driver and the costs of the activity (Horngren et al. 1999).

Table 1 Effect of Increasing Component Commonality on ABC Hierarchical Levels

Commonality increase	Driver	Cost-rate a_{cj}	Driver use d_{cj}
Supplier level (*s*)	Number of suppliers	*Increase* (Benton and Krajewski 1990, **Salvador et al. 2002**)	*Decrease* (Gupta and Krishnan 1999, Perera et al. 1999)
Component level (*i*)	Number of components	*Increase* (Gupta and Krishnan 1999, **Ulrich et al. 1993**, Ho and Li 1997, Lee and Tang 1997, **Ramdas and Sawhney 2001**)	*Decrease* (**Fisher et al. 1999**, **Thonemann and Brandeau 2000**, **Ramdas and Sawhney 2001**, Desai et al. 2001)
Order level (*o*)	Number of orders	*Constant*	*Decrease* (Hillier 2002)
Batch level (*b*)	Number of batches	*Increase* (**Thonemann and Brandeau 2000**, Vakharia et al. 1996) *or decrease* (Maimon et al. 1993, Collier 1981, Tallon 1989, Perera et al. 1999, Lee and Tang 1997)	*Decrease* (Tallon 1989, **Thonemann and Brandeau 2000**, Perera et al. 1999)
Unit level (*u*)			
1. Price	Number of units bought	*Increase* (**Gupta and Krishnan 1999**, Fisher et al. 1999, Ulrich 1995, Hillier 2002) *or decrease* (Perera et al. 1999, Ulrich 1995, Fisher et al. 1999)	*Constant or increase*
2. Inventory holding	Number of units held in inventory	*Increase* (Ho and Li 1997) *or decrease* (Perera et al. 1999)	*Decrease* (Collier 1982; Baker et al. 1986; **Thonemann and Brandeau 2000**; Dogramaci 1979; Hillier 2000, 2002; Lee and Tang 1997; Vakharia et al. 1996)
3. Backlog	Number of backlog orders	*Constant*	*Decrease* (Benton and Krajewski 1990, Perera et al. 1999, Lee and Tang 1997)

component commonality increases. His simulation evidence is criticized by McClain et al. (1984) for being an invalid test and based on very restrictive assumptions. Guerrero (1985) researches the effect of component commonality on work-in-process inventories under various production-planning systems, such as make-to-stock, make-to-order, and assemble-to-order systems. Tallon (1989) studies different production-scheduling techniques in the assemble-to-order production environment under commonality. Baker et al. (1986) and Gerchak et al. (1988) model the relationship between safety stock and service level and provide mixed results about the effect of component commonality on the stock of common components versus the stock of unique components. Benton and Krajewski (1990) introduce the concept of supply-side uncertainty in a manufacturing environment. They demonstrate that, in certain manufacturing environments, commonality reduces order backlogs but increases total inventories and creates an environment that is very sensitive to vendor quality problems. The parameters studied are still very much at the inventory level, as the only effect of quality problems considered is a stock-out for the component. No intuitive reasoning is provided to explain these results relating to the increase in total inventory level. This is strange in a context where most papers show a decrease in inventory level, as less safety stock is needed since the same component is used in several products. Bagchi and Gutierrez (1992) and Eynan and Rosenblatt (1996) determine optimal levels of component commonality to minimize inventory costs. Eynan and Rosenblatt (1997) demonstrate that keeping a product structure with unique components alongside one with a common component is advantageous with respect to purchasing price, under a specified service level. Hillier (2000) develops a multiperiod model minimizing production, holding, and shortage costs. He indicates that the savings of component commonality achieved in previous literature is often not obtained in a multiperiod context, as savings on the purchase price of safety stock occur only once as a one-off freeing up of working capital, whereas a higher price for the common component of higher functionality is incurred in every time period. Extending this model, Hillier (2002) concludes that a strategy of using the common part only as backup stock when one or more of the unique parts' stock-out may still be worthwhile, even if the common part is significantly more expensive than the unique part. Mirchandani and Mishra (2002) contribute to this literature by introducing product-specific service levels.

From this first research stream (i.e., concentrating on inventory levels), we also learn about the effects on inventory costs and backlog costs. The cost driver of *inventory costs*—the number of units held in inventory—decreases in a stochastic environment where safety stock is held to absorb unpredicted shocks in demand. As mentioned earlier, several researchers (e.g., Collier 1982, Baker et al. 1986, Thonemann and Brandeau 2000) have shown that, through risk pooling, less overall safety-stock investment is necessary, as the component can be used for several products and the accuracy of demand forecasts increases (Dogramaci 1979). Benton and Krajewski's (1990) finding that an environment with high component commonality is more sensitive to supply uncertainty because of the reliance on these components should, however, be noted. The effect on the cost of one unit in inventory is unclear. Ho and Li (1997) show that the probability for an engineering change increases when component commonality increases, which, in its turn, results in higher obsolescence costs as part of the inventory-holding cost rate. Perera et al. (1999), however, reason that the use of common components among products and product generations will result in decreasing obsolescence costs as the degree of interchangeability between products increases. Also, more or less working capital can be tied up in inventory, depending on the unit price of an item held in stock.

While the *backlog* cost rate (e.g., cost of customer dissatisfaction and replanning of the production process when orders remain unfulfilled for some time) will remain the same, the use of backlog orders (cost-driver use) will decrease (Benton and Krajewski 1990, Perera et al. 1999) as the availability of backup spare components increases.

The effect on *price* is not clear. The overall number of units of the components to be bought (cost-driver use) will usually remain the same; although one could think of situations where the number of units increases. For example, two common 1-Ohm resistors could replace one 2-Ohm resistor. Contradicting assertions have been made with regard to price rate. Some reason that prices will decrease as higher quantity discounts from a supplier can be reached for a common component (Perera et al. 1999). Others (Gupta and Krishnan 1999, Fisher et al. 1999) stress the fact that the common component will be more expensive than the unique one because its functionality needs to be higher to work in more than one end product and thus has excess capability. Ulrich (1995) presents the two sides of the argument. On one hand, higher component volume may attract several competing suppliers who exert price pressure on one another. On the other hand, the excess capability issue is at play.

3.2. Discussion of Higher-Level Effects

The second research stream (i.e., concentrating also on noninventory effects) presents insights relating to a wider variety of cost types (moving upward in our discussion of Table 1). Ulrich et al. (1993) present a case study on the design of a Polaroid camera in which they consider the trade-off between lower unit costs and longer product-development time, which may have a negative impact on product revenues. Maimon et al. (1993) demonstrate that component commonality creates significant reductions in set-up time and so leads to more efficient scheduling. Vakharia et al. (1996) investigate the impact of increasing commonality on the workload of the shop floor and find negative effects. Ho and Li (1997) show that the higher the component commonality in a multilevel product structure, the higher the probability of an engineering change to redesign components. They suggest that future research should not only look at the decrease in inventory-holding costs, as is done in the first research stream, but also take the increase in engineering change costs into account in a "total cost" function. Swaminathan and Tayur (1998) study the issue of modular design, which has several similarities to the component commonality problem. They consider a production environment in which partial modules of an end product, the so-called "vanilla boxes," are made to stock and the end product is then assembled to order, once the demand is realized. They introduce a two-stage integer program with recourse where, in the first stage, the configuration of vanilla boxes and their inventory level are chosen under different demand scenarios, each assigned a probability of occurrence. In the second stage, once demand occurs, the vanilla boxes are allocated to the different products under the constraint of limited assembly capacity. The parameters are stock-out costs, inventory-holding costs, and assembly time. Gupta and Krishnan (1999) research integrated component and supplier selection to minimize the sum of design costs, procurement costs, and price. They assert that integrating supplier capabilities and costs in the design decision results in a reduction of the number of unique suppliers. Product design and the costs of the procuring activity are predicted to decrease, while price is increasing because of the replacement of a lower functionality component with a higher functionality one in some products. The supplier-selection part of their methodology, however, turns out to be unimportant in the case studied, as procurement costs are nearly equal for all suppliers and the firm already worked with the minimal set of suppliers proposed. Perera et al. (1999) discuss how component standardization decreases various costs in different phases of the life cycle. They develop arguments for a decrease in product-development, material, facility, production, distribution, maintenance, and disposal costs by using more component commonality within products, among products, and among product generations. In this way, they come to an extensive list of cost decreases due to component commonality. The disadvantages of excess functionality and customer dissatisfaction are treated very shortly. For most of their claims they present no analytical model or empirical evidence. They indicate that future research needs to address the quantification of all these benefits, on top of the already frequently studied benefits in inventory. Fisher et al. (1999) report on the design of an effective component-sharing strategy in the automotive braking system industry. They consider the trade-offs between product-development costs, the unit variable cost in production where economies of scale and excess functionality have opposite signs, and what they call "system" costs. Examples of "system costs" are purchasing costs, spare parts inventory, distribution, and after-sale support. Thonemann and Brandeau (2000) use mathematical programming to determine the optimal level of component commonality that minimizes production, inventory-holding, set-up, and complexity costs, using data from a wire-harness design problem. They argue, as in the management-accounting literature, that complexity costs will decrease when fewer variants have to be processed by the indirect functions of a company.

3.2.1. Discussion of Batch-Level Effects. The OM literature has documented that decreasing the variety of components results in a decrease in cost drivers on the batch level (d_{cj} $\forall c \in C_b$) such as the number of batches (Tallon 1989, Thonemann and Brandeau 2000, Perera et al. 1999), the number of set-ups (in most organizations typically done per batch) (Tallon 1989, Thonemann and Brandeau 2000, Perera et al. 1999), and the number of inspections (again, typically done per batch)[5] (Perera et al. 1999). The literature, however, presents some mixed evidence about the batch-level cost rate (a_{cj} $\forall c \in C_b$). Some researchers document an increase in what I classify as batch-level rate. They argue that more handling will be required because the component is no longer unique to the product it is used in (Thonemann and Brandeau 2000). Vakharia et al. (1996) find an increase in shop-floor system disruption. Others argue that the batch-level costs will decrease. Arguments presented here are the ease of scheduling activities (Benton and Krajewski 1990), a decrease in set-up time as fewer different components are used (Maimon et al. 1993, Collier 1981), a decrease in shop congestion (Tallon 1989), a lower labor cost rate as fewer multiskilled laborers are required (Perera et al. 1999), and the possibilities for automation (Perera et al. 1999).

3.2.2. Discussion of Order-Level Effects. Hillier (2002) has established that, on the order level, there will be a decrease in the number of orders (d_{cj} $\forall c \in C_o$) from suppliers because of larger order sizes and fewer types of components ordered. The literature does not speak about the order cost rate (a_{cj} $\forall c \in C_o$). In my view, this will remain the same because the ordering technique or time spent on one order (which are the

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[5] As discussed in §2, although the ABC hierarchy presented here is most commonly used and summarizes the effects identified in the literature adequately, it should be checked on a case-by-case basis before applying it to a practical costing system design problem. Should, for example, in a particular (uncommon) case the number of set-ups or number of inspections *not* vary with the number of batches, an additional hierarchical level (e.g., set-up level) can be included.

factors that would influence the order cost rate) is not influenced by component commonality.

3.2.3. Discussion of Component-Level Effects. On the component level, increasing component commonality results in a decreasing use of the driver ($d_{cj}\ \forall c \in C_i$), the number of components, as component commonality assumes that the variety of components decreases. Fewer components will need to be designed and tested or provided with tools (Fisher et al. 1999, Thonemann and Brandeau 2000). "System costs" (Fisher et al. 1999) and "complexity costs" (Thonemann and Brandeau 2000) will decrease as a result of the cost-driver decrease. These authors do not, however, define these terms. Gupta and Krishnan (1999) and Perera et al. (1999) argue that, as development costs for a common component, such as designing and testing, are higher (because it has to fit exactly into multiple products) the component-level cost rate ($a_{cj}\ \forall c \in C_i$) will increase. Perera et al. (1999) add that by replacing duplicate R&D efforts on functionally similar components with a single development effort, the overall cost of development of the common component (i.e., cost rate multiplied by cost driver) will be smaller than the sum of the development costs of the unique components it replaces. Ho and Li (1997) assert that there will be an increase in engineering costs. Also, Ulrich et al. (1993) argue that the product-development time will increase because complex parts typically require tooling with larger lead times.

3.2.4. Discussion of Supplier-Level Effects. Gupta and Krishnan (1999) and Perera et al. (1999) have established that, on the supplier level, increasing component commonality will result in a reduced use of its cost driver ($d_{cj}\ \forall c \in C_s$), the number of suppliers, as fewer different components can be bought from fewer suppliers. Benton and Krajewski (1990) advocate a close collaborative relationship with vendors to avoid the deleterious effects of poor vendor performance they identify in a setting with high commonality. This would obviously increase the cost rate ($a_{cj}\ \forall c \in C_s$) of working with the supplier. Also, Salvador et al. (2002) provide case-study evidence that relationships with suppliers are more intense and involve joint actions on R&D under combinatorial modularity. The literature on early supplier involvement in new product development (e.g., Wynstra et al. 2003) extensively discusses how to manage joint R&D.

Multiplying the number of cost drivers by their respective cost rates and adding them up over all levels of the ABC hierarchy gives the total cost of a given level of component commonality. Table 1 shows that overall cost-driver use will decrease with increasing commonality in most cases. However, it is not obvious how the cost rates for several of the hierarchical levels will behave because research has presented contradictory evidence, especially on the batch and unit level. On supplier and component level, however, it is clear that increases in the cost rates are to be expected. Thus, while for some cost categories even the sign of the relationship between component commonality and cost is unclear, the slope of the relationships between component commonality and both cost and driver use is definitely unknown. All of this is true for the theoretical literature summarized in this section.

The empirical evidence on the cost effect of increasing commonality leaves even more room for future research. Reference to conjectured cost effects for which empirical support has been found are in bold in Table 1. Empirical work finds support for the supplier-level cost rate increasing (Salvador et al. 2002), the number of components decreasing—which is fairly obvious, as this happens in commonality by definition (Fisher et al. 1999, Thonemann and Brandeau 2000, Ramdas and Sawhney 2001)—the component-level cost rate increasing (longer product-development lead time, Ulrich et al. 1993), the batch-level cost rate increasing (increasing material handling, Thonemann and Brandeau 2000), the batch-level cost-driver use decreasing (fewer set-ups, Thonemann and Brandeau 2000), price increasing (Gupta and Krishnan 1999), and the number of units held in inventory decreasing (Thonemann and Brandeau 2000). I observe important gaps in our empirical knowledge[6] of the effect of increasing commonality

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[6] More empirical work on component commonality exists than presented in the table (e.g., Ulrich and Ellisson 1999), but these papers do not have specific results on the cost effects of commonality and are therefore not included in the table. Sometimes empirical papers do not find evidence for some of their hypotheses and will therefore not be in bold in the table for these predictions either (e.g., Gupta and Krishnan 1999 do not find that the number of suppliers decreases).

on the cost (both rate and driver aspect) on batch level and price, the cost rate on component level, the number of suppliers, and the decreasing use of backlogs.

4. Conclusion and Future Research

In this paper, I looked at the OM component commonality literature through a management-accounting lens. I presented a review of the OM literature and reconciled it with management-accounting literature on cost drivers and cost of complexity. ABC was introduced as a framework to classify the effects of an increase in component commonality on costs identified in the existing literature. From Table 1 we can see that even theoretical research is not clear on what the effect is on all the cost levels in the hierarchy. Contradictory assertions have been made, especially on the batch and unit level. Cost rates on the supplier and component levels are predicted and shown to increase. Empirical research is rather limited in volume, leaving lots of further research to be carried out. It is therefore too early to make any general statement on the effect of increasing commonality on total costs.

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