SUPPLY CHAIN OUTSOURCING

ANDY A. TSAY
OMIS Department, Leavey School of Business, Santa Clara University, Santa Clara, California

This article focuses on the outsourcing of manufacturing/production/assembly, procurement/sourcing, logistics, and product design/development. The first three in the list are traditionally considered to be the major supply chain functions, to which we add the fourth to acknowledge that design decisions strongly preordain the supply base and the manufacturing processes. Also, in modern practice, the insource-versus-outsource decisions for design and manufacturing are often intertwined. Alternatively this scope can be viewed as the endeavor of stewarding a product from concept to market, and then operating the resulting supply chain.

Since the outsourcing of a supply chain activity is a special instance of business process outsourcing (BPO), readers should first review the BPO article in this encyclopedia (see ***Business Process Outsourcing***). Similar to that entry, this article is intended to serve as a tutorial, and will not provide a comprehensive review of the research literature. The BPO article ends with a high-level assessment of extant operations research and management science (ORMS) research on general outsourcing that applies to supply chain outsourcing research as well.

We will discuss the outsourcing of each of the stated activities, with the caveat that they do not segment cleanly into distinct and sequential steps. Because of cross-functional coordination issues, the resolution of the insource-versus-outsource quandary for each activity depends on how the others are conducted. Further, the service providers are increasingly blending these into a package deal for their customers.

Supply chain outsourcing is of tremendous interest in the business community. While the potential benefits are alluring, the magnitude of the risks is illustrated by recent high-profile crises faced by Cisco [1], Boeing [2], Mattel [3], and Menu Foods [4]. Most of those included offshoring as well, but the problems could be attributed primarily to the incentive conflicts and loss of visibility symptomatic of delegation to external providers of services.

OUTSOURCING OF MANUFACTURING

For many, outsourcing in the supply chain setting first brings to mind the treatment of manufacturing/production/assembly. The most basic form is the purchase of a standard material from an outside party, for which the proper control processes are generally well-understood and efficient. The need for managerial concern grows when the buyer obtains more complex manufacturing services from a service provider, such as when a brand owner engages a contract manufacturer to produce a noncommodity product using nonstandard processes.

The following terms are used by practitioners to characterize the key players in such settings:

OEM: *o*riginal *e*quipment *m*anufacturer
OBM: *o*riginal (or *o*wn) *b*rand *m*anufacturer
CM: *c*ontract *m*anufacturer

The acronym OEM has classically referred to a party that makes and sells a branded product, but (somewhat anachronistically) continues to be applied to the brand owner even if the "M" is performed by another party. However, such a firm may decide "to OEM" a component, which means that the procured part will retain the supplier's brand identity. In this usage, the term *OEM* refers to the supplier. Emerging from the electronics industry around 2004 [5], the OBM label is used to affirm that the brand owner is also performing the manufacturing. A CM manufactures products that ultimately

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bear another party's brand, and traditionally does not own the intellectual property of the design.

This article will frame outsourcing's consequences from the OEM's perspective, since the OEM controls the decision of whether to outsource in the first place. Supply chain outsourcing inherits the motives for general outsourcing (see ***Business Process Outsourcing***), but here the OEM's highest priorities are typically to avoid ownership of the factory workforce, assets and infrastructure, and to tap into specialized expertise that can quickly ramp to a cost-efficient and robust stream of supply. The increasing availability of a competent CM segment serving virtually every product category makes this possible. This is a boon to start-ups which may lack the capital for funding internal production (or elements of design, logistics, etc.). The lowering of these entry barriers has profoundly affected the competitive dynamics in many industries.

The general risks also persist, especially for the sourcing of complex or nonstandard manufacturing services rather than manufactured product. Context-specific concerns include the CM's counterfeiting the product, stealing proprietary processes, or simply not following the expected procedures. Even without deliberate malfeasance, coordination problems arise from inserting company boundaries between manufacturing and other key OEM functions such as product design or sales/marketing.

The coordination between design and manufacturing that is required to generate manufacturable designs (i.e., design for manufacturability, DFM; see ***Design for Manufacturing and Assembly***) and accurate bills-of-materials is already elusive when the two functions are under the same roof. Separating into different companies only adds additional obstacles, such as incompatibilities in data formats, materials nomenclature, or part-numbering conventions.

OEM sales and marketing managers can struggle to monitor quality and manufacturing status when the manufacturing has been outsourced, particularly when products are spread across multiple CMs. These managers face frustrations trying to respond to end-customer questions like "Where is my order and when will it ship?" or "Can I still change the configuration?" [6].

These points make apparent that the performance of any outsourcing strategy will depend on the needs for flow of information along partners in the resulting extended enterprise. This underlies the argument that product architecture drives supply chain architecture. A "modular" architecture includes a one-to-one mapping from functional elements to components, and specifies decoupled interfaces between components. An "integral" architecture includes a complex (non–one-to-one) mapping from functional elements to components and/or coupled interfaces between components [7]. Because decomposability reduces the need for communication, the writing of detailed specifications, and iteration in designing the parts for which each party is responsible, modular products (e.g., personal computers) tend to be built (and designed) by modular supply chains (heavy outsourcing; many suppliers for each component) while integral products (e.g., high-performance automobiles) tend to come from integral supply chains (little outsourcing; vertically integrated industry) [8]. In short, the supply chains can be "mix and match" only to the extent that the product components (and the associated business processes and IT platforms) are "plug and play."

A vast body of practitioner literature weighs in on the insource-versus-outsource question for manufacturing, and provides operational advice on engaging a CM. A recurring topic therein is the hidden costs of coordination. The need for cross-functional integration between design and manufacturing calls for CM involvement very early in the OEM's product design timeline, or even outsourcing design and manufacturing as a bundle to qualified CMs [9]. The consequences of the latter approach will be discussed in the section titled "Outsourcing of Product Design/Development." Information technology, in areas such as enterprise resource planning (ERP) or product life-cycle management (PLM), can also enhance the coordination across chasms created by outsourcing. Of course, technical connectivity can provide only limited benefit without compatible

data formats and business processes. These are the goals of standards such as the Partner-Interface-Protocol (PIPs) framework of RosettaNet (www.rosettanet.org) or the programs of the Voluntary Inter-Industry Commerce Solutions (VICS) consortium (www.vics.org) that include collaborative planning, forecasting, and replenishment (CPFR). These require a willingness to share information with partners and, to reiterate a recurring theme, nontrivial investments of human and financial resources.

For these reasons and others, insourcing of manufacturing remains a legitimate strategy. OEMs in various industries have affirmed their commitment to this approach [10,11].

OUTSOURCING OF PRODUCT DESIGN/DEVELOPMENT

While typically not as asset-intensive as manufacturing, maintaining superior product design capability can also be imposingly expensive, especially in the specialized human capital. The coordination difficulties noted earlier may also motivate the outsourcing of design in a way that reintegrates it with outsourced manufacturing activities. [Although theoretically possible, there is no evidence that any OEMs are outsourcing significant amounts of design while retaining manufacturing in-house [9].] Consequently, design outsourcing is a growing trend in many industries [12].

The term *design* can be applied to a vast range of activities, from generation of product concepts all the way to the creation of very precise schematics of product configuration. These pieces can be further subdivided, and any of the segments are candidates for outsourcing. Some firms even outsource the pursuit of breakthrough innovation (R&D) to specific organizations or to the open community. This could be broadened to consider innovation in processes or business models, not just designs of specific products. To invoke a recurring theme, design outsourcing is not a binary decision. Of course, a firm should be incessantly wary about outsourcing design activities that might fall among its core competences. Indeed, in early 2009, amidst a broad economic crisis that had many of its rivals conducting massive layoffs, Apple Inc. was aggressively hiring specialized chip designers to work on key technologies. This reflected Apple's desire to get critical new features to market quickly while sharing fewer details about its technology plans with external chip suppliers [13].

Design outsourcing faces the challenges of services procurement explained in the article on BPO (see ***Business Process Outsourcing***). Communication and coordination across-company boundaries are particularly difficult because even though design can be performed much more systematically than most people think, it is still inherently a creative activity that entails working with ideas that are not fully developed, with many interdependencies among decisions. Further, the staff asked to liaison with the design service providers often, at least initially, lack the appropriate background and organizational support for the increased emphasis on project and relationship management [12,14].

Yet the stakes are high, especially for the many design decisions that have implications for manufacturing and supply chain management [9]. Among other impacts, design decisions strongly constrain the choice of materials, suppliers, and manufacturing processes. The folk wisdom is that roughly 70% or more of a product's life-cycle costs (manufacturing, supply chain, quality) are preordained at the design stage. (That design decisions are important is not in dispute, but the concrete evidence for this numeric rule of thumb is apocryphal. As Barton *et al*. [15] note, "Where authors support it by reference to published work, the references are to authors who themselves provide no substantive proof to support their claims. These referenced authors assert it themselves or quote a study by, or give a quote from, a major corporation. Examples of such corporations are Boeing, British Aerospace, General Electric, Rolls-Royce, Westinghouse, and Ford. With the exception of Rolls-Royce, the studies reportedly carried out by these major corporations cannot be easily traced as they are inadequately referenced, for example, as '. . .a Boeing

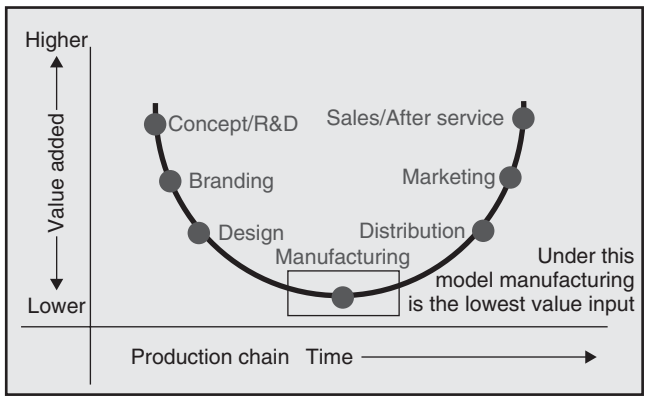

Figure 1. Smile Curve (*Source*: Version from http://www.madeintaiwan.tv/blog/?p=10).

study of turbine engines. . .' or '. . .according to General Motors' executives. . .". Regarding Rolls-Royce, Barton *et al*. [15] emphasize that the widely quoted original study [16] actually concludes that good design decisions can reduce 80% of "*unnecessary*" costs rather than of total costs.)

In principle, one way to maximize the coordination between design and manufacturing decisions in an outsourced supply chain is to entrust both activities to the same service provider. The following two paradigms for such joint outsourcing have arisen in a variety of industries:

CDM: *c*ontract (or custom or collaborative) *d*esign and *m*anufacturing
ODM: *o*riginal (or *o*wn) *d*esign *m*anufacturing (er)

The primary difference between CDM and ODM is in the ownership of the intellectual property (IP) in the product design. In the CDM model, the IP fully belongs to the OEM, whereas an ODM owns the product IP and is entitled to use it to create its own brands, products for other OEMs, generics, or white-box products. Additionally, ODMs take on inventory liability, while in the CDM model, the OEM generally owns the inventory. In these senses, a CDM is primarily a service company whereas an ODM is primarily a product company.

The historical evolution of both CDM and ODM reflect the reality that, in many industries and for many product types, manufacturing excellence has become a commodity. This is the notion that underlies the "(Stan Shih) Smile Curve," attributed to the founder of Acer who proposed it in 1992 [17]. One version of the framework appears in Fig. 1.

The Smile Curve originally addressed what semiconductor and electronic CMs (mostly Taiwan-based) experienced in the 1990's, a phenomenon which persists in many industries today: the lion's share of the wealth in the value chain seems to gravitate to the activities upstream and downstream of the manufacturing segment, so that the profitability of a traditional CM will be squeezed from both sides. This contributes another entry to the previous section's list of OEM motives for outsourcing manufacturing, but here it conveys why the pure-play CM business model, even with its focus, economies of scale, and risk-pooling, seems so often to be a transient form on the way to either CDM or ODM.

Indeed, some traditional CMs have added CDM or ODM services in search of a sustainable means of differentiation, one able to command higher margins. CMs are thus able to enhance their manufacturing competitiveness by generating designs that are efficiently manufacturable.

CDM is less dramatic a transformation for a CM, so the documentation of this phenomenon seems to focus more on the ODM form. The majority of written coverage of ODM has been in the press surrounding the electronics industry. There the ODMs grew out of the motherboard companies in Taiwan, who moved into computer systems, especially notebook computers. A resulting misconception is that this organizational

format is unique to electronics. In fact, the model appeared earlier in bicycle manufacturing and possibly elsewhere. Apparel ODMs reside in various parts of Asia, especially Hong Kong and Korea.

OEMs are increasing their usage of both models. This suggests that the motives for manufacturing outsourcing are compelling, but that design and manufacturing need to go together. Beyond that the OEM still must choose a specific model, neither of which dominates the other.

An OEM benefits from the turnkey aspect of either solution, as CDM and ODM service providers both allow an OEM to tap into a supply chain possessing many of the benefits of vertical integration. An ODM provides a virtually complete product off-the-shelf to fill out an OEM's product portfolio, a fast solution that allows the OEM to reduce in-house R&D expense but with only limited customizability. However, the ODM needs to supply multiple OEMs to recover the cost of R&D for a platform and to mitigate the inventory risk. As noted, ownership of the IP entitles the ODM to supply the OEM's direct competitors, as well as to become a competitor itself via white-box or own-brand products.

This raises the ultimate question for the OEM, which is how to differentiate its brand when its ODM-supplied product is technically equivalent to many others on the market. ODMs are very protective of the identities of their clients for this reason, lest end-consumers start to view their products as a commodity. For mobile computers, a category which is predominantly supplied by Asian ODMs, OEMs such as Hewlett-Packard pursue differentiation through the industrial design of the chassis, the software bundle, and after-sale support.

ODMs have both the motivation (as indicated by the Smile Curve) and the prerogative to become OBMs. Indeed, the evolutionary path from CM to ODM to OBM is well-documented for firms in late-industrializing economies such as Taiwan, Korea, Singapore, and Malaysia [18,19]. Firms that started as CMs offering cheap labor learned design skills and market insights from sophisticated customers who needed to transfer this knowledge to preserve DFM. Eventually these ODMs aspired to develop their own brands to increase their control and financial returns.

If an OEM does not design or manufacture, what competitive capabilities does it retain that are so hard for ODMs to learn or obtain? Earlier, the Taiwanese electronics ODMs had only limited success achieving sustained global brand awareness, forcing them to compete on price. Challenges include the need to develop sophisticated distribution channels with infrastructure for functions such as handling returns, offering credit, and providing warranty service, and the marketing expertise that provides the deep customer knowledge critical to the conception of attractive products. However in some cases, a CM or ODM can obtain these rapidly through an acquisition. In any event, an OEM outsourcing design to its manufacturing partner should proceed under the assumption that this partner will eventually become a direct competitor.

OUTSOURCING OF PROCUREMENT

Procurement already implies outsourcing, in that some good or service is being purchased from outside a firm. The buying firm has another outsourcing decision to make beyond that, regarding whether management of the procurement activity itself should also be entrusted to an outside party.

The outside party can be a focused procurement specialist, to which some apply the label "procurement service provider" (PSP). These offer not only capacity and expertise, but also assets such as supplier databases and technology for conducting reverse auctions.

Alternatively, the magnitude of the financial impact may present a valid business case for integrating the manufacturing and direct materials decisions. This approach can prevent myopic actions such as choosing the cheaper component in ignorance of the detrimental impact on assembly cost. "Turnkey" engagement of a CM, in which the CM is entirely responsible for providing the end product to the OEM, ostensibly produces tight integration with the least overhead

while retaining the benefits of manufacturing outsourcing.

CMs have financial incentives to take over the OEM's procurement of direct materials, for which they typically earn a percentage markup over the cost of materials. In addition, because financial analysts sometimes base certain metrics on revenue, the ability to count the flow of materials as revenue can elevate a CM's public stature. In the electronics sector, for example, materials can represent 75–80% of a CM's revenue. At the same time, competition has pressured the margins that CMs can earn solely by manufacturing. Some CMs now view direct manufacturing as a loss leader for driving business through the profit center that direct procurement has become.

A strategic view of procurement understands that control of the buying decision is a precious asset. The livelihood of any seller depends on making buyers happy, and sophisticated or large-scale buyers may be able to extract strategically significant treatment from suppliers. This preferential treatment can take the form of low prices (either straightforwardly or indirectly through rebates and other subsidies), short lead times, liberal return privileges, forgiveness of occasional contract noncompliance, assurance of supply in times of scarcity, influence over technology road-maps, technical support, and so forth. Thus, something more profound than markup on materials changes hands when an OEM outsources procurement; the OEM may cede control of the preferential treatment as well.

OEMs have a variety of options for retaining control of procurement while still outsourcing manufacturing. Between turnkey outsourcing, which exposes the OEM to a long list of hazards, and full insourcing of procurement, in which the OEM foregoes the potential benefits of outsourcing, are a number of procurement models that seek a compromise by incorporating various preventive and reactive business controls. Amaral *et al*. [20] summarizes the strengths and weaknesses of a number of such approaches:

In-House

With in-house procurement, OEMs buy directly from suppliers, managing storage and transit to CMs. In electronics, OEMs began with this approach when they first outsourced production by providing prepackaged part kits to CMs for overflow assembly work. The OEM completely controls procurement in this way, which minimizes outsourcing risks.

Such control is costly. In-house procurement requires fully staffed organizations, highly integrated information systems, and distributed sites for planning, executing, and managing the inbound supply chain from suppliers to CMs. OEMs must stay abreast of technical developments and in contact with potential suppliers around the world. They must also maintain inventory storage locations (hubs) near the various CM assembly sites.

Turnkey

In the turnkey model, the CM negotiates with and buys directly from suppliers. Thus, the OEM can keep procurement overhead low while leveraging the CM's buying power and ability to break bulk, which can be a boon for small OEMs. Also the CM can pool the demand uncertainty of multiple OEMs to reduce the safety stocks. In principle, this efficiency should translate into low costs and high availability for the OEM.

The turnkey model carries many hazards, including forfeiture by the OEM of preferential treatment and loss of visibility into true procurement and material costs. For large OEMs and for noncommodity parts, the CM's procurement leverage will probably be weaker than the OEM's.

Turnkey with Audits

With this approach, the OEM retains the advantages of the turnkey model but adds auditing to detect errors and deter fraud, partially mitigating several hazards of pure turnkey. The OEM may perform the audits itself or rely on a specialist firm.

Through audits, OEMs can discover only a fraction of possible problems, may not gain full recovery of damages, and often lose the time value of money. They still forfeit preferential treatment and lose visibility into true procurement and material costs, while bearing the auditing expenses. When OEMs

believe they have greater procurement leverage than their CMs, they often choose from among the following procurement models.

Supplier Rebates

When OEMs believe they can negotiate superior prices and effectively monitor and collect private rebates from suppliers, they can obtain the same partial risk mitigation as they do with audits, because the information technology systems for tracking and collecting rebates essentially perform ongoing audits. In addition, suppliers can safely offer the OEM preferential pricing without revealing their prices to CMs and other OEMs. That is, this scheme achieves "price masking."

The primary disadvantages of supplier rebates are the cost to the OEM for tracking and processing rebates and the costs to suppliers of negotiating prices separately with the CM and the OEM. Smaller OEMs and suppliers might find the administrative burden of the rebate scheme to be prohibitive. The CM is still ultimately the one paying the suppliers, and may use this role to enhance its own procurement leverage.

Buy–Sell

In the buy–sell model, the OEM buys directly from the supplier at a private price and immediately resells to the CM at a higher price. This achieves price masking and the benefits of maintaining direct OEM–supplier relationships. Once the buy–sell transaction is complete, the supplier delivers the materials directly to the CM.

The primary disadvantages for OEMs are the overhead required to manage procurement and any investment in systems and processes to enable buy–sell execution. In addition to maintaining supplier relationships, the OEMs must replicate the channel functions of a materials reseller.

Consignment

Consignment is an arrangement in which OEMs buy and own the inventory, which the CMs store. OEMs often use this model for parts that are unique, slow moving, proprietary, or scarce. OEMs can thus mask prices and establish inventory buffers above those prescribed by the CMs' standard policies. With consignment, OEMs are responsible for most of the procurement activities, reducing various risks but adding overhead costs.

An OEM need not limit itself to just one of these approaches, and many leading firms have developed the ability to execute many of them simultaneously. At the time of publication of Ref. 21, HP used buy–sell for strategic commodities (high value or coming from key suppliers), that is, the 20% of parts representing about half of its production spending. For the next 50% of parts, HP used audits (to verify pricing) and rebates (to mask pricing). HP allowed CMs to procure the remaining commodity parts in turnkey fashion.

OUTSOURCING OF LOGISTICS

Logistics, which many traditionalists view as the core activity of supply chain management, has a long history of outsourcing. A strong motive comes from the asset intensiveness of logistics (e.g., infrastructure for transportation, handling, storage, and increasingly, IT for real-time, global tracking at the individual package level of detail). At the same time, a strong enabler for the existence of logistics service providers is the fungibility of these assets across many customer and material categories. The value proposition of these service providers also includes an inventory dimension. Cycle stocks will decrease to the extent that clients feel relief from the need to completely fill containers or vehicles, greater delivery reliability reduces the need for safety stock, and pipeline inventories will be lower if the transit times are shorter. Service providers with an international footprint offer critical expertise in moving products through disparate physical, legal, and regulatory environments.

As with the broad supply chain functions discussed earlier, logistics can be divided into specialized elements, with labels such

as "freight forwarding," "inbound logistics," "warehousing," "outbound logistics" (distribution), "service logistics" (for spare parts), and "reverse logistics." All of these, as well as their smaller subtasks, are candidates for outsourcing. Some providers now offer nontraditional services such as light manufacturing, after-sale repair, packaging of products into store displays, and even financing of inventory.

Key terms for identifying the providers of logistics services are

3PL third-*p*arty *l*ogistics provider
4PL fourth-*p*arty *l*ogistics provider
LLP *l*ead *l*ogistics *p*rovider

Lynch notes that "3PL" was first used in the early 1970s to identify intermodal marketing companies (IMCs) in transportation contracts [22]. Prior to that, transportation contracts involved only the shipper and the carrier. As intermediaries that accepted shipments from shippers and tendered them to rail carriers, IMCs became the third party to these contracts. Since then, the definition has broadened to refer to any company that offers a logistics service. "4PL" is generally attributed to Accenture, which registered it as a trademark in 1996 (while still known as Andersen Consulting). Accenture described the 4PL as an integrator, but today some consultants, software companies, and even 3PLs lay claim to being a 4PL. A 4PL can be thought to serve the function of general contractor. "LLP" is favored by some as a term with greater transparency than 4PL. Lynch [22] advocates using the following definitions.

3PL

According to the Council of Supply Chain Management Professionals, 3PL is a firm which provides multiple logistic services for use by customers. Preferably, these services are integrated, or "bundled" together by the provider. These firms facilitate the movement of parts and materials from suppliers to manufacturers, and finished products from manufacturers to distributors and retailers. Among the services which they provide are transportation, warehousing, cross-docking, inventory management, packaging, and freight forwarding.

4PL

According to Accenture, 4PL is a supply chain integrator that assembles and manages the resources, capabilities, and technology of its own organization with those of complementary service providers to deliver a comprehensive supply chain solution.

LLP

Lynch defines LLP as a party that serves as the client's primary supply chain management provider, defining processes, and managing the provision and integration of logistic services through its own organization and those of its subcontractors [22].

As with the other forms of supply chain outsourcing, a large body of practitioner literature provides advice on how to make the insource-versus-outsource decision for logistics and then how best to engage the service provider. In terms of the degree of difficulty of managing the outsourced relationship, logistics is comparable to design in being purely a service, but is comparable to manufacturing in the availability of relatively straightforward metrics such as delivery times and error rates.

THE OEM'S ROLE IN THE SUPPLY CHAIN OF THE FUTURE

In a world in which the ability to outsource nearly all supply chain functions have some joking that OEM must be an acronym for "Outsource Everything but Marketing," one must wonder whether the OEM should still be considered the lead actor in the resulting ecosystem of codependent partners [23]. Some OEMs may evolve to a business model based on performing as supply chain "orchestrator" or "integrator," such as the role played by the venerable Li & Fung or, increasingly in some of its electronics segments, Hewlett-Packard [24]. This resembles the function of the 4PL/LLP in logistics, but with a comprehensive scope.

Success in this role requires a core competence in managing complexity and designing mechanisms to contain transactions costs and moral hazards. As autocratic fiat does not exist in such extended enterprises, supply chain management takes on a political flavor in which negotiation and relationship-building prowess are the critical determinants of success [25]. How power, and hence profitability, will distribute across these supply chains will provide rich substrate for business research for years to come.

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