

SUPPLYCHAIN

MANAGEMENT REVIEW®



The Supply Chain Game Plan

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A Portfolio Approach to

In today's volatile economy, one supply chain design is probably not enough. What's really needed is a portfolio of supply chains that at once enables you to be cost effective and yet agile and highly responsive in situations where those competencies are called for. The case study here on HP's Inkjet Printer Supply Chain spotlights a successful portfolio approach in action.

By Thomas Olavson, Hau Lee and Gavin DeNyse

Our supply chains operate in a volatile world. Starting in 2007, oil prices climbed from \$60 to \$145 per barrel within 18 months only to crash back to \$40 shortly after the peak. As a result, fuel surcharges for airfreight went on a rollercoaster ride up to as high as 50 percent of the base rate and back down to close to zero within a two year period. In a six-month period starting in late 2008, the Chinese Yuan strengthened in value against the Mexican peso by more than 50 percent, only to fall back close to its original value within a year of the peak. When considering alternatives like manufacturing a product in Mexico vs. air shipping it from China to North America, shifts in macroeconomic factors can mean the difference between winning and losing in the marketplace.

In such a volatile environment, it is unwise to use a one-size-fits-all approach to supply chain design. While offshoring or nearshoring manufacturing, building in

as much speed in to your supply chain as possible, and postponement all have their place, they are not universal best practices. To illustrate, while the Hewlett-Packard case study on postponement continues to be taught in many business schools, HP actually has discontinued the use of postponement for many of its printer platforms. HP has adapted its supply chain to the realities of a maturing product category.

Clearly, supply chains need to be adaptable to cope with changing environments defined by economic factors like oil prices, exchange rates, labor rates and tax policies; competitive forces; and the maturity of product categories as product characteristics and business strategies evolve. In describing "The Triple-A Supply Chain," Hau Lee stressed the importance of alignment, agility, and adaptability for world-class supply chain performance.¹ Agile supply chains respond quickly to short-term changes in supply and demand. Adaptable supply chains adjust supply chain design to accommodate market changes. Aligned supply chains establish incentives for supply chain partners to improve performance of the entire chain.

But how often should a business adapt its supply chain design and ramp up an entirely new supply chain? How do we know which new design will be best? Does agility mean that the supply chain should serve all cus-

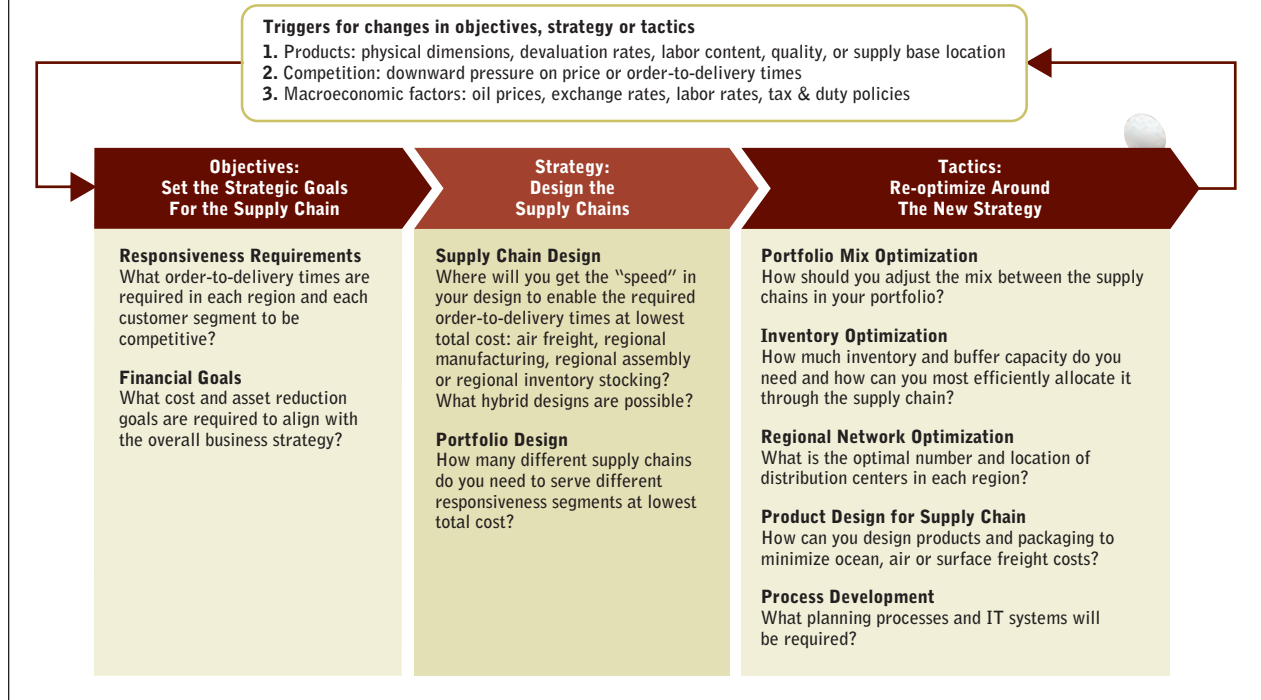
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Supply Chain DESIGN



EXHIBIT 1

A Framework for Supply Chain Design



tomer segments with a highly responsive, short order-to-delivery model? Is there still some way to capture benefits of lower cost, more efficient supply chain designs?

In this article, we demonstrate how companies can respond to these challenges through the use of *portfolios* of supply chains. Portfolios allow companies to reap the benefits of low cost, lean supply chains while still remaining agile and responsive where they need to be. Portfolios also allow supply chains to adapt over both the long-term and short-term, with or without changing supply chain designs. In the short-term, portfolios allow companies to re-optimize tactics to shift the mix between supply chains to adjust to macroeconomic volatility and new competitive threats to both price and responsiveness. In the long-term, portfolios allow companies to gradually phase in and out supply chain designs to adapt to long-term market trends, business strategy shifts, and maturing product categories. Not all companies will have the scale to afford to have multiple supply chains for the same product category. But for companies like HP that have scale, operate globally, and serve customers through a variety of sales channels, they can gain significant competitive advantage through the use of supply chain portfolios.

At its heart, supply chain design involves tradeoffs

between cost and customer responsiveness. Just as a stock portfolio will have more efficient overall tradeoffs between risk and return by diversifying across multiple asset classes, supply chains will have more efficient overall tradeoffs between cost and responsiveness by having multiple supply chains.

A Framework for Supply Chain Portfolios

Exhibit 1 shows a framework for designing and managing supply chain portfolios. There is a sequence and hierarchy at work here. Strategic objectives are at the top of the hierarchy and are typically either set by top management or dictated by the marketplace. Strategic objectives align supply chain strategy with business strategy and the realities of the competitive environment. Once those goals are understood, supply chain strategists can design an appropriate portfolio of supply chains to meet the required responsiveness levels for various customer segments at minimal total cost.

A small number of top-notch analytical strategists, often as part of a centralized supply chain strategy and modeling team, are needed to periodically re-visit questions of supply chain design. Once supply chains are set, tactics can be optimized. Tactics are re-optimized more

The best design will vary depending on product characteristics

like inventory devaluation rate, labor content, and physical weight and bulkiness.



frequently than supply chain design, and are at least as important as strategy in achieving the best possible trade-off between responsiveness and cost. For instance, as part of optimizing the mix between supply chains, during each lifecycle products need to be mapped to an appropriate supply chain within the portfolio. Re-optimizing tactics will involve many more people each doing their part from across functional, business unit, and regional supply chain organizations.

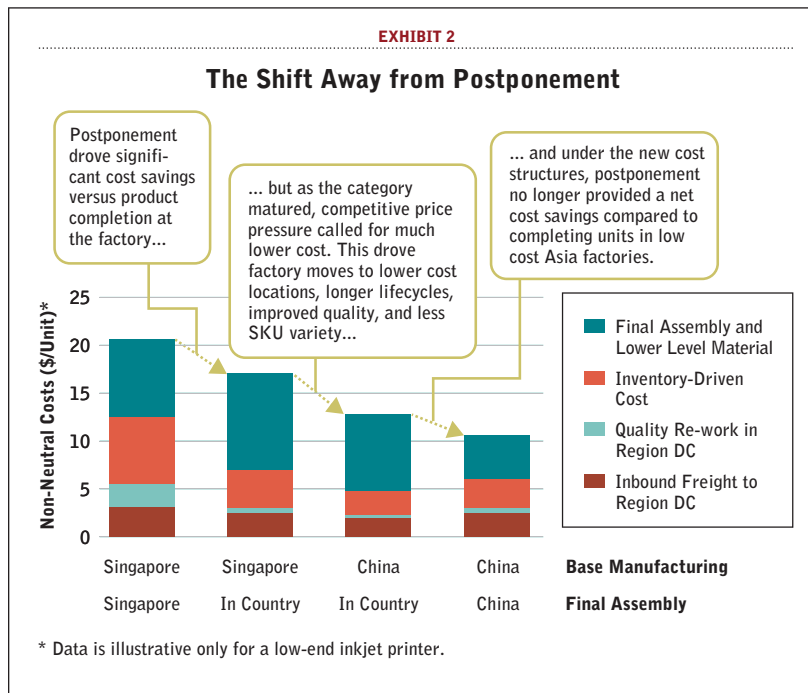
Case Study: HP's Inkjet Printer Supply Chain

The evolution of HP's inkjet printer supply chain exemplifies the importance of adapting supply chain design over time, and demonstrates how supply chain portfolios

can allow that adaptation to occur in a seamless manner.

The inkjet printer story is an example of adaptable supply chain strategy based on changing customer requirements, product characteristics, and most importantly financial goals set at the executive board level. In the 1990s in its printer business, HP pioneered the use in the high tech industry of a supply chain design with late point differentiation, or "postponement". In postponement, the task of differentiating a product for a specific customer segment is postponed until the latest possible point in a supply network. Through modular product design and manufacturing processes, printer "engines" can be manufactured in low cost factories in Asia, while the final assembly and packaging of those engines into differentiated SKUs can be done in regional postponement centers that are closer to the true customer demand. For example, a German and a French SKU may be built from a common printer engine that is held in inventory until close to the time of a customer order when the actual demand mix between the SKUs is known. HP saved hundreds of millions of dollars over the years by using postponement to deliver customized products quickly and at a low cost. However, in recent years HP has largely shifted away from postponement to minimize the regional manufacturing and distribution costs in the supply chain.

Exhibit 2 illustrates the value of the original postponement strategy and the subsequent shift from final assembly out of the region and into the worldwide factory. The stacked bars represent the costs of alternative designs. The bars focus only on the relevant costs that drive *incremental* differences between alternatives in the decision. We call these the "non-neutral" costs. For the sake of simplicity in the case in Exhibit 2, we exclude the base unit manufacturing cost and the outbound surface freight cost, since all these supply chains relied on low cost manufacturing in Asia and fulfilled orders from a network of distribution centers in each region. The non-neutral costs are those from final assembly (in the factory or in the region), the international freight cost (bulk engine or finished unit shipped by ocean), quality and re-work costs in the region (more costly without regional postponement centers to handle quality or NPI problems), and inventory-driven costs.



When comparing alternatives on cost, all alternatives should include the same assumption for customer order-to-delivery time and service level. We have done so here. The postponement alternative will require lower inventory safety stocks, since SKU level forecast error can be risk-pooled and filled from base unit engine inventory in the regional product completion centers. Inventory-driven costs include not only the more tangible costs of financing and warehousing, but also the less predictable and less tangible costs of devaluation, excess and obsolescence, channel price protection or price markdowns due to excess.²

In the inkjet story depicted in Exhibit 2, we show the effectiveness of two alternatives in the mid-1990s and ten years later. During this time, the printer product has matured, resulting in five key customer and product differences that alter the cost structure:

1. Inventory-driven cost rates are lower, since devaluation rates are lower, lifecycles are longer, and the customer demand and market size are more predictable.

2. Fewer SKUs are needed in mature markets with more well defined and consolidated customer segments; therefore, the inventory risk-pooling benefits from postponement are reduced. The problem of forecasting the right mix of SKUs in the region at the China factory lead time is less severe.

3. Product quality is more stable, so the re-work costs are lower. The ability to re-work quality issues in the regions used to be a key advantage of the postponement design, especially during new product introduction for new technologies. Now, the regional re-work capabilities are seen as an enabler of poor build quality or NPI

Companies will have more efficient overall tradeoffs

between cost and responsiveness by having multiple supply chains.



schedule slips that simply can't be tolerated in a mature product category while staying profitable.

4. The printer has become smaller and is thus less costly to ship in finished goods form through international freight. A low-end inkjet printer today is about one-third the size of one from the 1990s, and packaging has been optimized to maximize the number of finished units that can fit into a pallet.

5. Manufacturing costs are much lower with low cost offshore manufacturing. HP's inkjet manufacturing operations started in the U.S. close to the R&D base in the 1980s, moved offshore to Singapore in the 1990s, and then migrated to China and other low cost Asia countries. With each step, the direct labor costs were cut by more than half. With the change in cost structure over time, doing product completion steps in high cost regional postponement centers in the U.S. or Europe became more expensive relative to doing product completion in low cost factories.

These product and customer differences impacting cost structure were also driven by shifting financial goals. The financial goals in a high-growth market where capturing market share is imperative are fundamentally different than in a mature market where profitability and free cash flow are the focus. The financial goals were the fundamental driver to initiate programs to offshore manufacturing, improve quality, reduce SKUs, and reduce product and packaging size.

Consequently, more and more of the product lines shifted away from postponement to "low touch" models where factories supplied finished goods inventory to regional distribution centers. As with the postponement strategy that preceded it, the value of this new low touch

EXHIBIT 3

HP's Portfolio Today: Two or More Supply Chains

	A Fast Supply Chain	A Low Cost Supply Chain
Inkjet Printers, Late 90's	Postponement Worldwide Manufacturing; In-Country Assembly; In-Country Order Fulfillment; Build-to-Stock	Low Touch Worldwide Manufacturing and Assembly; In-Country Order Fulfillment; Build-to-Stock
Inkjet Printers, Today	Low Touch Worldwide Manufacturing And Assembly; In-Country Order Fulfillment; Build-to-Stock	International Direct Ship-Ocean Worldwide Manufacturing, Assembly; Ocean Freight, Build-to-Customer Commit
Notebook PCs	International Direct Ship-Air Worldwide Manufacturing Assembly, and Order Fulfillment; Air Freight; Configure-to-Order	Ocean Worldwide Manufacturing and Assembly; Ocean Freight, Build-to-Customer Commit
Desktop PCs	Regional Manufacturing In-Region Manufacturing, Assembly and Fulfillment; Build-to-Order	Worldwide Manufacturing Worldwide Manufacturing, Assembly; Build-to-Customer Commit

strategy is in the hundreds of millions of dollars order of magnitude. Still, postponement has its place in the high-end of HP's laserjet printer portfolio where product quality is less stable, variety required to compete in the marketplace is greater, and product availability to capture share in growing markets is still the top priority. The laserjet supply chain portfolio looks much like the inkjet supply chain portfolio five years ago, with a mix of postponement and low touch. But for inkjet printers, postponement has been phased out of the portfolio, replaced by the low touch model.

So what does the inkjet supply chain portfolio look like today? As shown in Exhibit 3, many of HP's business have a portfolio of at least two supply chains, with a relatively responsive supply chain and a supply chain optimized for cost. To respond to ever greater cost pressures, a new, even lower cost supply chain design has been added to the inkjet supply chain—"international direct ship-ocean."

Strategic Objectives: Setting the Design Requirements

A starting point for designing supply chain portfolios is to understand the strategic objectives that the supply chain should serve. Broadly, the objectives are of two types: (1) customer responsiveness levels required to be competitive in different customer segments and sales channels, and (2) financial goals for cost, inventory and asset reduction required to serve the overall business strategy set at the top levels of the company.

Customer responsiveness requirements

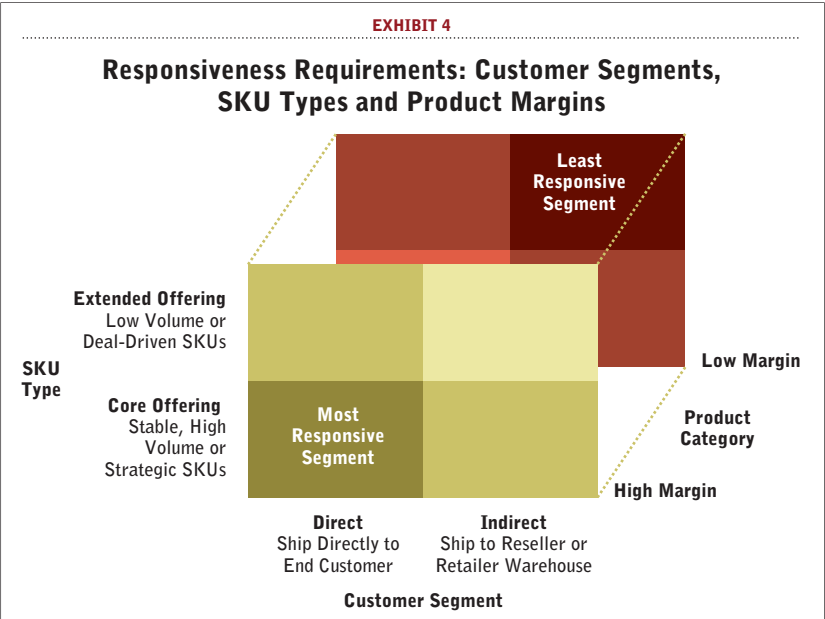
There is a continuum of tradeoffs between responsiveness and cost for a given product—and designing a supply chain for a single point on that continuum would likely leave the business uncompetitive on delivery time in some channels and uncompetitive on cost in other channels. For example, enterprise customers who prefer ordering from a manufacturer directly may require greater responsiveness than retail or distribution partners who engage with the manufacturer on collaborative forecasting and planning processes. Responsiveness requirements should start with the customer and competitive landscape in mind. More than

one supply chain will often be needed in global businesses with diverse product categories, channels, customer segments and fierce competitive pressure.

Segmenting customer demand into different OTD time requirements allows supply chain designers to match the distribution of delivery time requirements with a portfolio of supply chains optimized for cost at each responsiveness level. This enables competitive delivery across a range of regions, channels and customer segments without overinvesting in speed in any one segment. Portfolios of supply chains geared towards low and high responsiveness segments also allow a business to adapt supply chains quickly when a competitor enters a channel and applies pressure on either price (favoring a low cost supply chain) or delivery time (favoring a fast supply chain).

Exhibit 4 provides a starting point for segmenting products and customers by responsiveness needs. Distinctions can be made both by product category and customer type. Serving channel partners does often not require the same level of responsiveness (short OTD) as serving enterprise customers directly. In many cases, the additional downstream inventory stocked in a channel partner's distribution center is another reason why responsiveness can be set lower (in exchange for lower cost) with channel customers.

The other dimension for segmenting responsiveness is product value, which can vary across high and low margin product categories or within a product category across different types of SKUs. High value products are those product categories with high gross margins where



stockouts are most costly, and therefore service levels and service times are more favorable to the customer. For example, in the printer business, different supply chain designs may be appropriate for the high margin ink supplies category (where the closest substitute product may be a non-HP product) vs. the lower margin printer hardware category (where a different HP printer may be an acceptable substitute to one that is out of stock). Within a product category, a business may further distinguish between higher value “core” SKUs and lower value “extended offering” SKUs. Enterprise customers and channel partners expect high volume “core” SKUs to be in stock with short delivery time. Yet they may be more willing to accept longer delivery times on SKUs that are less popular or have customized configurations that they may request over standard configurations.

Financial goals

Financial goals also are driven by competitive factors. In growing markets where priorities are around capturing market share and growing revenue, financial goals may serve to reinforce customer responsiveness goals. They

financial goals necessary to grow a business profitably (early in the lifecycle) or to ensure that a mature business stays profitable (late in the lifecycle) are different. Furthermore, mature businesses have the added pressure of needing to generate enough cash to feed investments in growth businesses.

Supply Chain Design and Decision Quality

Key to executing the approach we have described is having a proven technique for the supply chain design process, a method for determining which designs are right for your business (the portfolio), and a project governance structure to ensure decision quality.

Supply chain design

To frame a set of decisions and options used to construct strategies, we often use a technique from the practice of decision analysis called a strategy table. Exhibit 5 is a simple, generic strategy table for supply chain design where we have listed five fundamental strategic decision levers that are linked to form a supply chain design.

Choices for each decision lever are linked to develop a supply chain design.

Most customer order-to-delivery time requirements are shorter than what would result from choosing the absolute lowest cost supply chain. The design objective is to minimize the total supply chain cost subject to meeting the OTD requirement. The best design will vary depending on

EXHIBIT 5					
Strategy Table for SC Design					
(One Option Chosen From Each Column)					
	Manufacturing Location	International Freight Mode	Final Assembly Location	Order Fulfillment Location	Inventory Stocking Model
Fast but High Cost Option	In Country (e.g., US)	Air	In Country	In Country Factory/DC	Build-to-Stock
Intermediate Option	In Region (e.g., Mexico)	Truck /Rail	In Region	In Region Factory/DC	Configure-to-Order
Slow and Low Cost Option	Worldwide (e.g., China)	Ocean	Worldwide	Worldwide Factory/DC	Build-to-Order/ Customer Commit

may also support the ability to quickly customize the product to a different version (postponement) in order to capture and identify new growing market trends. This tilts the supply chain design to favor responsiveness over cost, maximizing revenue growth. Especially in the early portion of the market creation, amortizing fixed costs over as much volume as possible can be critical, and a responsive supply chain can help. As product categories mature, pressure to reduce costs (supply chain cost as % of revenue) or working capital (days of inventory) becomes increasingly important. Mature markets will tend to have well understood customer profiles, so responding quickly to customer demand or product variation is less important than being cost competitive.

Based on where the product is in its lifecycle, the

product characteristics like inventory devaluation rate, labor content, and physical weight and bulkiness. The key insights in supply chain design come from realizing *which* lever will provide the most cost-efficient source for speed. Speed can come from manufacturing close to the customer, shipping by air, or doing final assembly and/or inventory stocking close to the customer.

For example, consider the supply chain portfolios for inkjet printers, notebook PCs, and desktop PCs. Exhibit 3 summarizes a “fast” supply chain used in each business. They are all different, and each gets its “speed” from a different source. For printers, getting speed from manufacturing in the region or shipping by air would come at a high cost premium to shipping by ocean from Asia. So inventory safety stocks are used in customer

segments and SKU types where short OTD is required. For notebooks, inventory devaluation rates are high, so holding safety stocks of inventory in the region is not a good option. However, notebooks are relatively lightweight and compact, so shipping by air from Asia is attractive relative to manufacturing in the region close to the customer. Desktops, however, are bulkier than notebooks, tipping the balance towards regional manufacturing for customer segments and SKU types where higher responsiveness is required. Hybrid options may also be possible, where a more costly regional manufacturing or postponement supply chain is used only as a buffer to fill upside demand or used only at product introduction and end of life when forecast error and its costs are higher.

Portfolio Design

The number of supply chains that are right for a given business will depend on a number of factors: How widely do the customer requirements vary across segments? How great is the cost difference between the best supply chain for the shortest OTD segment and the best supply chain for the longest OTD segment? Is there a strategic shift underway to migrate towards a lower cost supply chain structure, where multiple supply chains will be needed during the transformation? Are there economic risks, like oil prices, exchange rates, or new competitors that could be effectively hedged with a second supply chain? What fixed costs are associated with maintaining multiple supply chains, and what is the breakeven volume where the variable cost benefits of adding a supply chain outweigh the fixed and investment costs?

To begin to understand these questions, we recommend using rough cut analysis to construct an “efficient frontier” of supply chains. The efficient frontier maps cost/unit as a function of the responsiveness requirement (OTD). For each OTD, estimate the cost of the supply chain that minimizes the cost to meet that OTD. There will likely be multiple designs represented on the efficient frontier—for example, for notebook PCs, points to the left of the curve would represent the air ship supply chain and points to the right of the curve would represent the ocean ship supply chain. Once we understand the magnitude of the cost differences as we move across the efficient frontier, and how the supply chain designs are materially different, then we are in a better position to decide how many supply chains should be included in the portfolio.

Decision quality in supply chain design

Perhaps the most important dimension of decision quality to emphasize is the importance of building commit-

ment to action. This does not happen just by having a good strategy and a good analysis. Rather, it is a process of organizational change management that starts by involving up front all of the key stakeholders and decision makers and going through the analysis and design journey together. By collecting data inputs, issues and ideas from all affected groups throughout the process, trust and confidence is built as a foundation for building alignment and commitment to a decision. An essential element to building commitment to action is having a clear project governance structure. In such a structure, a core team who can be trusted with impartial analysis iterates back and forth with a steering team of decision makers representing all of the key stakeholders. Ideally, the core team is led by a neutral, data-driven, centralized team of analytic consultants, such as HP’s Strategic Planning and Modeling team. At its heart, supply chain design is a strategic decision. Accordingly, it is just as important to include best practices from strategic decision-making as it is to include best practices from supply chain management.

Implementation of new supply chain designs should not be underestimated. New supply chains may be designed in a matter of months, but implementing, optimizing, and re-optimizing the supply chains takes years. The time and investment required to build a new supply chain emphasizes not only the importance of doing supply chain design well, but also the importance of designing portfolios of supply chains. Portfolios buy us time to implement long-term strategic shifts in our supply chains with minimal disruption, and they build in future options and flexibility for dealing with the unexpected. In short, portfolios enable us to meet diverse customer requirements at lowest cost, align to strategic shifts in business strategy, and deal with unexpected changes in the marketplace—all hallmarks of world-class supply chain performance. ☐☐

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End Notes:

- 1 H. Lee, “The Triple-A Supply Chain,” *Harvard Business Review*, October 2004.
- 2 For more information, see Callioni et al., “Inventory-Driven Costs,” *Harvard Business Review*, March 2005.

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