Enterprise Strategy: Leveraging the Dynamics and Behaviors in a Supply Chain for Operational Excellence

by

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Submitted to the Sloan School of Management
and to the Department of Mechanical Engineering
in Partial Fulfillment of the Requirements for the Degrees of

Master of Business Administration
and
Master of Science in Mechanical Engineering

in conjunction with the
Leaders for Manufacturing Program
at the
Massachusetts Institute of Technology
June, 2003

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Abstract

With dozens of tools and strategies being cast around the business world, the complexity in managing supply chain operations and architecting strategies to manage the chain dynamics can seem overwhelming. In response, much of today's supply chain strategy literature focuses on how to improve the collaboration, speed and flexibility in a value chain. These attributes are generally touted as essential for lasting operational success. While the intent is clear for many companies to develop these attributes, the behaviors and capabilities required to successfully achieve the goal is less clear. This research contends that in order to drive truly lasting change and improvement, this complexity can be simplified by identifying and understanding the basic behaviors that govern successful operations. Because these behaviors drive all of the processes, structures and tools that are enacted in the operation, tremendous improvements can be gained by developing and evolving these capabilities in your enterprise.

From this mindset, this research presents a framework for developing the complex business operations for a leading high-tech firm to achieve a heightened level of performance. The work proposes three behaviors that are essential for operational excellence in complex systems: informed process-thinking, skillful learning, and a balanced sensitivity response to market signals. First, an understanding of the market and industry dynamics is established. Second, the ideal behaviors are explored for an organization given those dynamics. Third, several tactics are presented, rooted in their application at a leading high-tech firm. Lastly, recognizing that this form of 'Enterprise Thinking' has relevance beyond the scope of supply chain operations, a brief reflection is offered for how it relates to other challenges facing the world.

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Acknowledgements

Dedicated to my parents,
Louis and Cecelia Rassey,
I will forever be grateful for your support and encouragement.

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I respectfully acknowledge and thank the Leaders for Manufacturing Program (LFM) for its generous support of my studies, for the research conducted in this thesis, and for their generosity in giving me the opportunity to join an amazing partnership.

I also acknowledge and thank Adam J. King, my supervisor at Intel, for his consistent and thoughtful support and insights. Additionally, I thank Intel Corporation and the gracious employees who contributed steadily and selflessly to helping this work evolve, including Jeff Tripaldi, Dave McCloskey, Jen Rigoni and many others.

I also thank Professors Dan Whitney, Charles Fine, Debbie Nightingale and Steve Graves for their constructive ideas and support throughout this journey. Additionally, I am indebted to Professor Shoji Shiba for his guidance and instruction early in my time at MIT, particularly his coaching on the art of 'seeing the invisible' in the world and using images to relay back what you have seen.

I also am indebted to the research and insights of many leaders in industry and academia whose inspiration served as the foundation for various sections of this thesis. Specifically, I thank Professor Charles Fine of MIT for his research and instruction in supply chain dynamics and the bullwhip effect which are at the core of Part 1. Similarly, the instruction of Michael Hammer around his well-known process engineering work was important in articulating the process-thinking behaviors explored in Part 2. Also in Part 2, the work of Professors Stephen Spear and Kent Bowen of Harvard Business School are central to the attempt at understanding operational excellence and the nature of learning and improvement in complex organizations. More specifically, I thank Stephen for his instruction and guidance in 2003 which was invaluable in building a deeper understanding of these subjects.

I am also indebted to the commitment, assistance and contributions from many of my LFM colleagues. Particularly, I express great appreciation and thanks to Brian and Ted for their steady encouragement and support, for their commitment to excellence, and for their dedication to learning and growing with the highest character and integrity. Their contributions serve an important part throughout the thesis, particularly in building an understanding of operational sensitivity and lean operations in Part 3. I also thank Brian for his willingness to face adversity and stand tall and true through the end of difficult storms. Additionally, I thank Wes for the privilege of working closely with him to launch our research and to learn and grow together at Intel. I also thank Jamie, a respected advisor and colleague whose support and encouragement has been very important on my journey to LFM and throughout my time in this community.

Finally, and most importantly, I would like to acknowledge my wonderful family, without whom none of my successes would have been possible, including Rob, Jen, Karen, Mary, Pete, Ann, Geraldine, Victoria, and many others.

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To the reader: for any ideas or insights of value you find from this work, I am indebted and thankful to so many people who have given their time and energy to the work. Should errors be found, I take full responsibility, express my genuine regret and would welcome your feedback.

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Much of today's supply chain strategy literature focuses on how to improve the collaboration, speed and flexibility in a value chain. These attributes are generally touted as essential for lasting supply chain operational success. While the intent is clear for many companies to develop these attributes, the behaviors and capabilities required to successfully achieve the goal is less clear. This research presents a framework for developing the business operations for a leading high-tech firm to achieve a heightened level of performance. The work was chartered out of the business operations group at Intel Corporation seeking to better navigate the supply-demand dynamics of the semiconductor industry. The key themes explored center around understanding enterprise dynamics, process-thinking, and enterprise learning.

The findings are presented in three parts:

Part 1: Business Dynamics – Drivers for Enterprise Thinking

- This section develops a basic understanding of the supply chain and business dynamics of the high-tech industry (specifically microprocessors) and how those dynamics relate to the trend towards collaborative supply chain operations. It also presents an overview of the specific supply chain and operations processes which served as the basis for the research, followed by an overview of the 'levers' supply chain groups can take to better balance supply and demand.

Part 2: Enterprise Thinking – Process-Focus, Learning Across Boundaries & Balanced Sensitivity

- This section translates the understanding of the dynamics of an environment into a recommended behavior and thought pattern for complex business operations. With a convergence around the importance of fast, collaborative and flexible operational capabilities, supply chain organizations are presented with a multitude of possible 'levers' to balance supply with demand in this dynamic environment. Ranging from dynamic pricing to vendor-managed inventory, the list of possible tools is endless. Rather than focusing on any specific lever, this research explores *how we should go about pulling whichever lever we choose* in an effective way that brings about lasting improvement. With this understanding of the underlying principles and behaviors that bring about success, operations leaders can more effectively choose, design and implement any one of the possible tactics. Without establishing this behavioral foundation, however, it may not matter which tool is chosen as it runs the risk of not getting off the ground or meeting its full potential.

Part 3: Enterprise Design – Mechanisms and Management Practices

- This section presents various tools and tactics an organization can use to develop the desired behaviors and capabilities in its supply chain and business operations. It focuses on work done with Intel's business operations group in an effort to understand how the firm can respond and effectively navigate such a complex operations environment. While much of the focus is on Intel, the intent is to develop lessons that are broadly applicable to complex operations environments of any sort.

The first three parts are then synthesized into a simple model to guide individuals and organizations in achieving excellence in complex business operations through capability development. Lastly, recognizing that 'Enterprise Thinking' has relevance beyond the scope of supply chain operations, the epilogue explores how it can be applied or related to other challenges facing the world.

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Stated another way... we will take a journey together. We will endeavor to understand and navigate the complex world of business operations as we seek 'operational success'. We will explore the behaviors needed to succeed... and explore some tools to help us on our way.

Over the course of our journey, we will take a ride on the back of bull to understand the dynamics of supply chains, hear the wisdom of an ancient Greek philosopher to figure out how fast we should go, listen to the 'fathers of flight' on how to soar through the skies, take lessons from a superhero on how we should behave.... and... in the end, float above it all to see what we have learned about ourselves and the world.

PART 1: BUSINESS DYNAMICS – DRIVERS FOR ENTERPRISE THINKING

"Sometimes volatility ripples through the chain… sometimes it roars. Knowing what to expect pays big dividends."

Charles Fine, Author & Professor – Massachusetts Institute of Technology

PART 1: BUSINESS DYNAMICS – DRIVERS FOR ENTERPRISE THINKING

The dynamics of the microprocessor industry, and more generally the dynamics of high-tech industries, are filled with remarkable complexity. For decades, significant research and energy has been dedicated to building an understanding of these dynamics and how to best navigate a business or value chain through them. For a company seeking to understand how to develop effective supply chain strategies, a thorough understanding of these dynamics and how they map into their day-to-day decisions is an essential capability, yet often undervalued and superficially understood.

While this research focuses on the dynamics in the semiconductor industry, it is intended to serve as an example of how to more broadly understand market dynamics and map them into supply chain behaviors for any complex supply chain.

Part 1 summarizes several key frameworks and ideas that can help one understand the significant challenges associated with matching supply with demand. First, a brief overview of the market and company in which the research was conducted is presented. Second, the dynamics resulting from supply and demand processes are analyzed using the body of knowledge surrounding the 'Bullwhip Effect'. Third, the broader dynamics of the high-tech industry are characterized relative to how they impact supply chain requirements, or more broadly, business operations requirements. In total, this assessment of the supply chain dynamics in the semiconductor industry paints a picture for how alignment and collaboration are important pieces in a company's operating capability, and just as importantly, in the collective capability of the value chain.

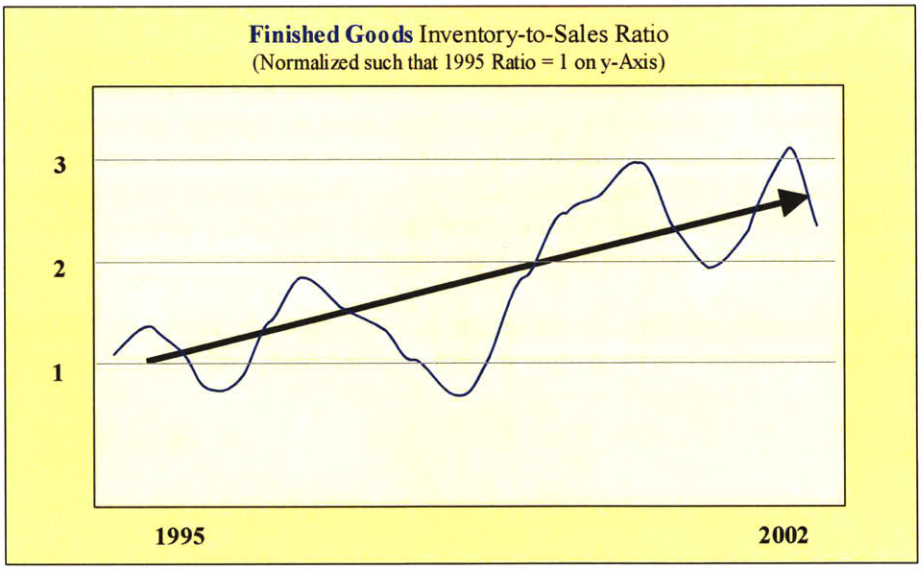
1.1 COMPANY HISTORY & INTRODUCTION

Since 1971 when Intel Corporation introduced the world's first microprocessor, it has developed technology and products that have enabled the computing and Internet revolution that has changed the world. Today, Intel is one of the world's leading suppliers in the computing and communications industry, providing the building blocks of computers, servers and networking and communications products [14].

As its products, customers and markets have grown and diversified, Intel's supply chain has evolved into a complex network of people and companies that span the globe. While this growth has brought tremendous success and opportunity, it comes at a price of increased complexity in day-to-day operations and long-term strategy. Today, Intel is aggressively searching to improve the process of matching supply with demand in its supply chain.

At present, in Intel's quest for improvement, dozens of projects are under way to tackle pieces of the supply chain opportunities and challenges. From information systems to inventory staging strategies, Intel is investing seriously in improving its supply chain capabilities. For all of its effort in the past and present, much opportunity and need still exists for further operational improvements. For example, while many companies and industries experienced a reduction in inventory as a percent of sales, Intel has seen a steady climb as shown in Figure 1.

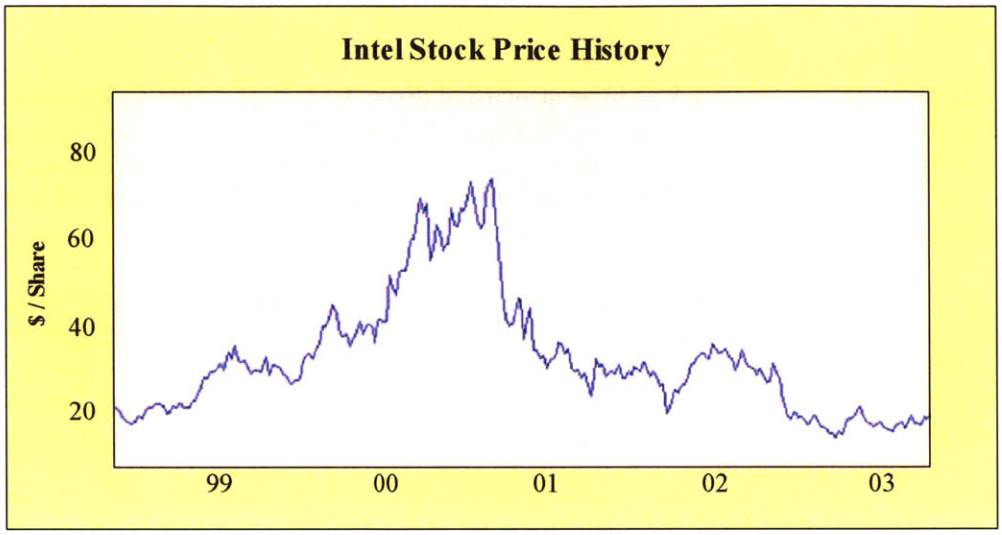
Figure 1: Intel's Inventory Increasing Over Time



Many factors contributed to Intel's upward inventory trend, including geographic complexity of the supply chain and customer base, institution of different inventory staging models with customers, and sku proliferation to name a few [26]. While some might argue these forces are unavoidable, one is compelled to ask why many other industries have overcome these forces and achieved different results. Why inventory-to-sales is only one simple metric, it makes the point that further opportunities exist for improvements in Intel's supply chain strategies to make a significant impact in the company's performance.

Combining the increasingly complex demands on the supply chain with the overall market challenges, Intel has seen some difficult times in overall financial performance, along with much of the high-tech industry, since the "bubble" burst in 2000 [14].

Figure 2: The 2000 'Bubble Burst' on Wall Street - - Waiting for Recovery



Nonetheless, most agree that the market is on the verge of a recovery and Intel is working diligently to prepare for the upturn. In this preparation, supply chain capability will be an essential determinant in whatever success or failure is found [13]. While Intel has dozens of groups within the corporation that are intimately involved with pieces of the supply chain operations, the Microprocessor Marketing and Business Planning Group (MMBP) has a central role in coordinating much of the supply-demand activities. Serving as the basis for this research, their specific role and an assessment of Intel's supply chain processes are explored at the end of Part 1 and again in Part 3.

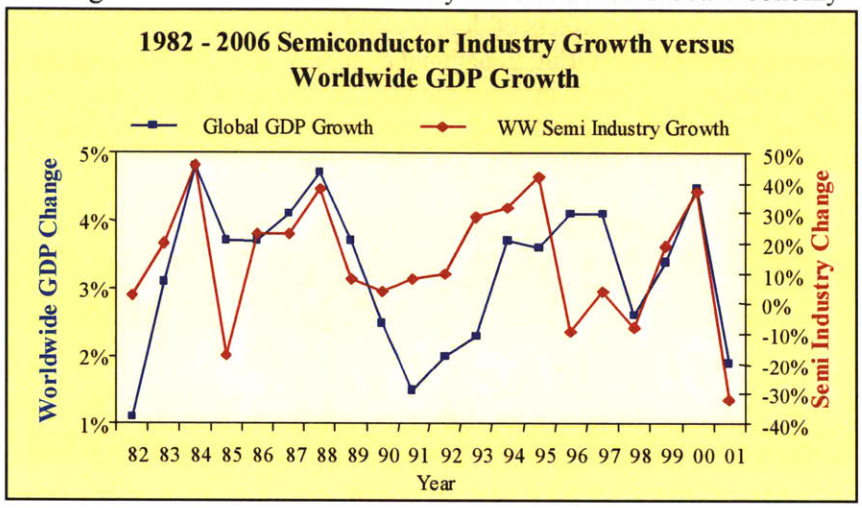
For now, let us turn to understanding the market forces and dynamics confronting MMBP which are making supply chain operations an even more integral and necessary competency for global competition.

1.2 DYNAMICS OF SUPPLY & DEMAND PROCESSES – "THE BULLWHIP"

Volatility – "Is it Random & Like the Weather?"

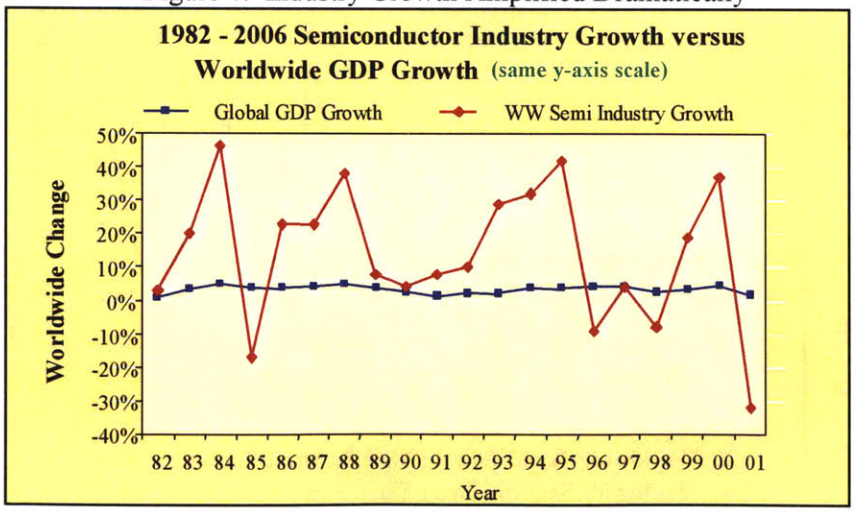
Looking at the history of the semiconductor industry, one notes that the industry growth follows a similar pattern as the macroeconomic cycle as reflected by global GDP growth [22].

Figure 3: Semiconductor Industry in Period with Global Economy



To say that the industry "goes up and down" with the economy does not offer a very meaningful insight. In fact, because the statement seems so obvious, many executives across industries explain away much of their industry volatility by extrapolation: "because the macro-economy oscillates, my industry oscillates; we are forced to go along for the ride and try to do the best we can to weather the storms… this volatility is like the weather". This perspective of exogenous and random nature of supply chain volatility was regularly uncovered upon talking with many business professionals during the course of this research[1]. However, the following graph which looks at the same data, this time *with both graphs on the same y-scale*, raises some interesting challenges to this common "weather" assertion in the high-tech industry.

Figure 4: Industry Growth Amplified Dramatically

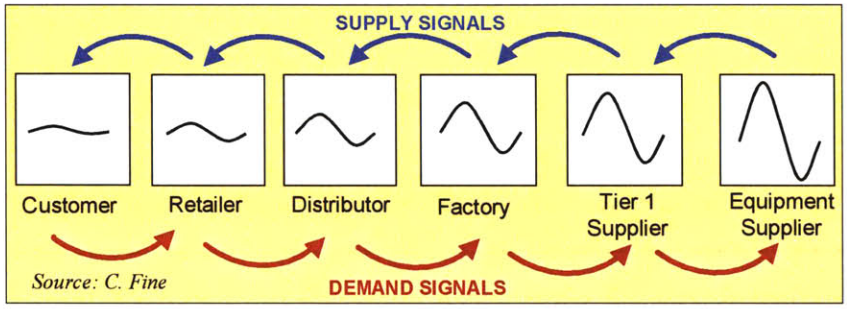


[1] Throughout the research, interviews were held with over forty operations executives at companies representing the semiconductor, personal computer, semiconductor equipment, aerospace and automotive industries.

Volatility – It is Understandable

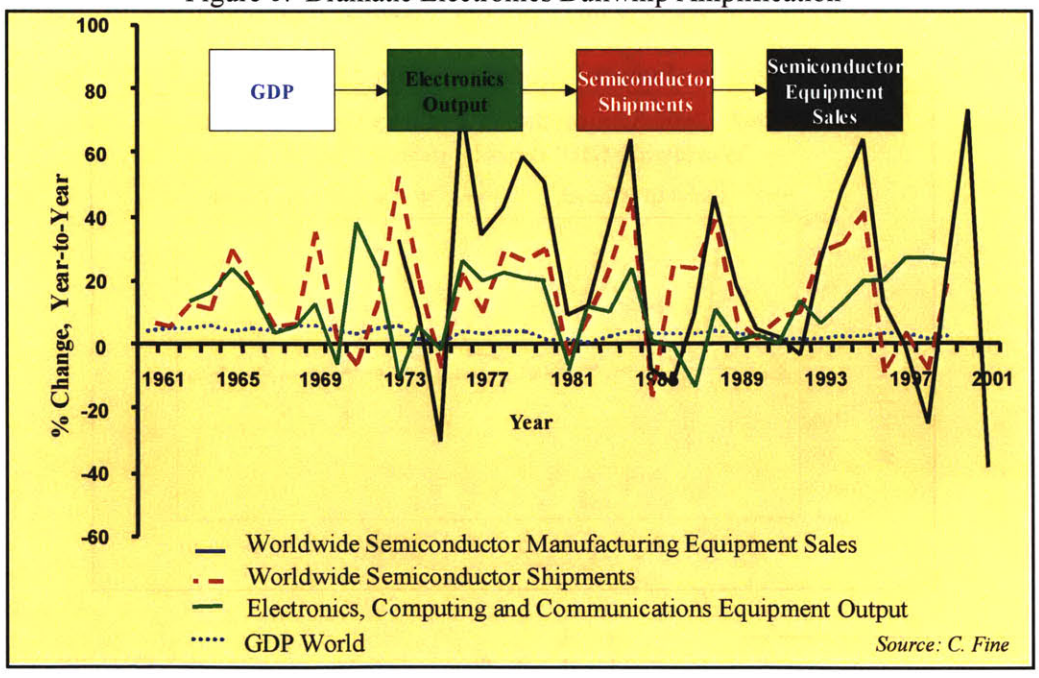
Upon close examination, one notes that the growth signal (from GDP to semiconductor industry) is dramatically amplified, even though the period of oscillation is the same. This amplification is largely due to the dynamic interaction of all members in a particular supply chain. The "Bullwhip Effect" is a well-documented body of knowledge that characterizes this dynamic. The Bullwhip is commonly argued to be a major cause in poor supply chain performance (as measured by missed deliveries, overproduction and large inventory costs, equipment underutilization, poor quality, etc..) [19, 27]. In simplest terms, the Bullwhip Effect refers to the dynamic effects of demand and supply signals being ineffectively transmitted through a supply chain, resulting in demand & supply amplification and corresponding supply chain disruption and inefficiency. Shown in a generic way, research has found that the demand signal and production requirements for typical supply chains increase in amplification as one moves down the supply chain (from customer to equipment supplier) [7].

Figure 5: Amplification Increases as Move Down Supply Chain



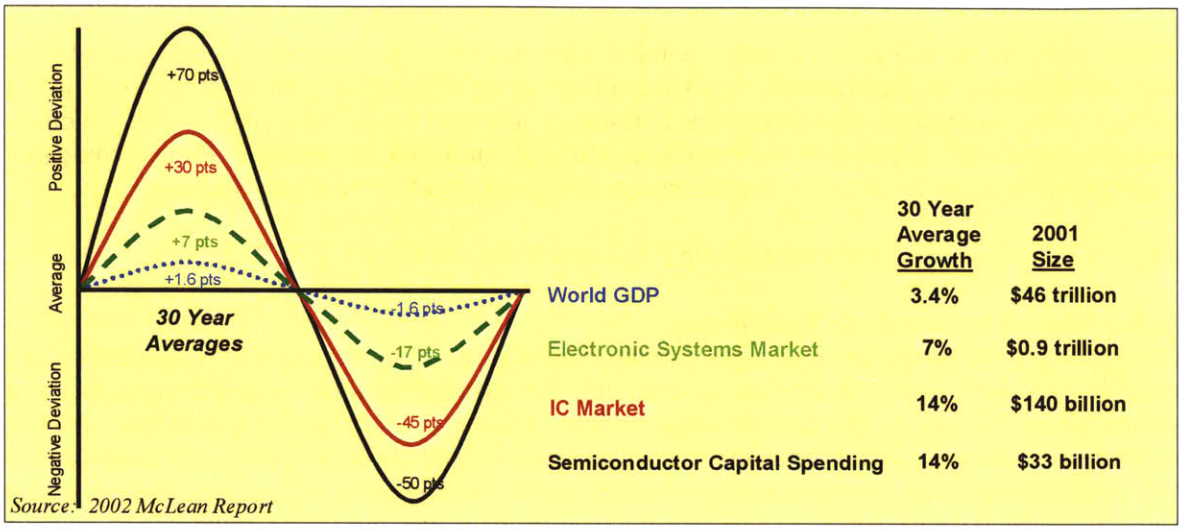
In the semiconductor industry as in most major industries, this behavior has been well documented [22]. As shown below, per Professor Charles Fine of MIT, the amplification of year-to-year growth steadily increases (amplifies) from global GDP, to overall electronics output, to semiconductor shipments, to semiconductor equipment manufacture sales [7, 22].

Figure 6: Dramatic Electronics Bullwhip Amplification



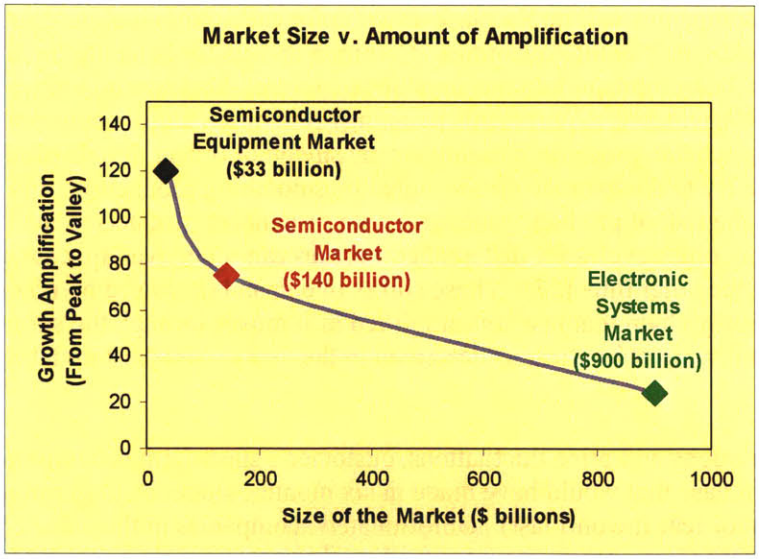
Looking at this amplification over the past 30 years, one notes the consistency of the Bullwhip in the semiconductor value chain in terms of both magnitude of relative amplification and periodicity [22].

Figure 7: 30 Years of Bullwhip In Electronics Industry



The consistency of the behavior is generally explained by two factors: location in the value chain (due to information and product signal complexity) and the relative size of the markets. Research suggests "in general, the larger the market, the smaller the percentage point deviation from the average it will register. Typically, it becomes more difficult to move larger markets as far or as fast as smaller ones" [22, 2-19]. This relationship between size and amplification for the semiconductor value chain is shown below.

Figure 8: Market Size Contributes to Amplification



While the relationship of amplification to both the size of the entity and the location in the value chain are only correlative in nature, research suggests that both factors are contributors to the dynamic pattern characterized by the "Bullwhip Effect" [7, 19].

Volatility – It is NOT Random and It is NOT Exogenous

This volatility creates a difficult environment in which supply chains must operate. Fluctuations in inventory, uncertain investments in capital, lost sales due to product availability, and dozens of other supply chain ills result from the volatility and uncertainty characterized by the Bullwhip.

However, while this volatility and dynamic amplification are present in most supply chains, it is by no means unmanageable or uncorrectable. As we can begin to understand the patterns of this supply chain dynamic, we can understand what causes it and design policies and mechanisms to change it. In other words, a supply chain's volatility is *not* exogenous (out of control) like the weather. Rather, companies can take proactive steps to explicitly dampen the volatility and stabilize their supply chains.

Briefly, four common causes of the Bullwhip Effect have been identified [7, 19, 27]:

Demand forecast updating and lead times:

Each company in the supply chain engages in some form of forecasting process, taking demand signal inputs from their customers, judging them considering their own safety stock and production risks, and passing a "judged" signal further down the supply chain to its suppliers. These suppliers then undergo the same process... and so on down the chain. Just considering the added volumes for safety stock (due to supply chain inefficiencies, production inefficiencies, market uncertainty at each stage), one can easily see how the demand signal can be amplified as it moves from the end-customer through the supply chain. Similarly, one can intuit that when the lead times between links in the chain become longer, the fluctuations (variability) are even more significant. As Simchi-Levi describes, "with longer lead times, a small change in the estimate of demand variability implies a significant change in safety stock, and thus of order quantities"[27]. In combination, the forecast signal processing coupled with lead-time considerations contribute significantly to the bullwhip amplification.

Order Batching:

In simplest terms, companies will rarely place an order for each individual part; rather, they will place orders in daily, weekly, or monthly quantities. Common drivers for batching include: efficiency in the purchasing process, better transportation economics (e.g. truck-load size quantities and associated price discounts), and MRP (material requirements planning) system schedules being run on a monthly basis. This batch-ordering scheme produces a highly erratic stream of orders into its production schedule. While suppliers can try to dampen the erratic signal by smoothing production, this requires a lot of judgment and runs the risk of producing inappropriate amounts of products in the wrong places. Also, in a given supply chain, order cycles for different companies can often overlap, causing a more pronounced surge in demand at the order time [27]. These spikes in demand (followed by no orders) introduce variability in the supply chain that just gets amplified as it moves through the supply chain and contributes to the bullwhip effect (just as described in the demand forecast updating scenario).

Price fluctuations:

With frequent promotions and price fluctuations, customer's short-term behavior is often impacted (e.g. move forward a purchase that would have made in six months, stockpile larger inventory at the lower promotion price out of fear it won't last). Unfortunately, companies in the value chain are often unable to see the customer's reasoning. Without understanding the reasoning, their expectations for long-term behavior can become clouded (e.g. expect the demand to remain high when, in fact, it just pulls forward demand from the next quarter). In other words, price fluctuations inject a lot of noise into understanding the true customer demand for the entire supply chain.

Rationing & Gaming:
When retailers and distributors are expecting a shortage in supply, they may increase their requested order amount in anticipation of only getting a percentage of what they ask for. This "phantom" ordering leads to significant distortions, particularly considering this behavior can get replicated and magnified as information and products flow through a multi-stage supply chain. Another common form of "gaming" that disrupts supply chain stability and efficiency is the ever so common "end of quarter" pushes. When customers have strong incentives to meet their quarterly sales or volume targets, the rash of orders being pulled forward (even if it is known throughout the chain) can add uncertainty and volatility to the supply and production line [19].

As we will explore in Part 2, the uncertainty and volatility introduced by these kinds of causes are contrary to the core behaviors which underlie world-class supply chains, including:

- Stability as the first and essential driver for success
- Valuing the operation of the end-to-end supply chain process instead of just my firm (recognizing my firm benefits from the successful operation of the entire chain)
- Open and honest information and knowledge sharing
- Collective learning (which requires trust and long-term commitment… not monthly or quarterly gaming to optimize one piece/company in the chain)

Generic strategies to counteract the Bullwhip - A Call for Enterprise Collaboration

Understanding these underlying drivers of the supply chain volatility, much research has been done to understand the most effective countermeasures. In almost all cases, the common thread among recommended and successful actions to improve the Bullwhip Dynamic is improved collaboration among the supply chain. While different researchers and practitioners may focus on different tactics, all of them agree on the importance of stronger collaboration to counteract the four drivers. Professor Hau Lee of Stanford University characterizes the collaboration along three dimensions [19]:

Figure 9: The Bull Can be Tamed!

Information Sharing:
Improving the sharing of information about supply and demand throughout the supply chain is the first key lever in reducing the bullwhip effect. Simply, demand information at a downstream site in the supply chain must be transmitted upstream in a timely and non-distorted fashion (reducing delays and errors in the information processing). Supply and capacity information should be similarly communicated. A few effective tactics include:

- Build an understanding of the supply chain system dynamics across the supply chain (educate the supply chain on the bullwhip)
- Establish common metrics across the supply chain that capture system-level performance (e.g. incentives for reduced bullwhip and overall variability over time)
- Eliminate gaming by building trust in the system (delivering on what you say you will, building options in supply line agreements to ensure supply in difficult times)
- Reduce frequency and level of price discounting to stabilize demand signals (e.g. everyday low cost)
- Sharing sales, inventory and capacity data to enable production planning at a supply chain level (vs. an individual firm level)

Channel Alignment:
For information to be shared effectively, the supply chain should be aligned about the importance of stability in the supply chain (e.g. reduced bullwhip) and understand that for any one member of the chain to achieve its ideal performance requires the alignment and cooperation of other members of the chain. A few effective tactics include:

- Develop relationships such that shared ownership for supply chain success exists between upstream and downstream sites in the supply chain
- Enable the coordination of pricing, transportation, inventory planning
- Break order batches (reduce costs of higher order frequency through IT systems; develop transportation and logistics options to reduce costs for small batches)
- Develop supply line agreements that demonstrate long-term commitment to stability and shared information and knowledge
- Hold regular knowledge-sharing and alignment building workshops across the supply chain to build alignment, understanding and cross-supply chain operating strategies

Operational Efficiency:
The final category for bullwhip improvement lies in improving the operational performance of the supply chain and its sub-components. Simply, this suggests reducing costs and lead-time through the vast array of techniques available, focusing both on increasing short-term speed and flexibility and on bringing long-term stability into the supply chain. This may include:

- Product architecture changes to reduce manufacturing time (e.g. modular design and assembly)
- Manufacturing strategy changes to enable build-to-order instead of to forecast
- Supply chain strategy changes to better place inventory (e.g. joint-managed inventory)
- Engage in consumer-direct distribution (minimize delays and filters in the supply chain when appropriate).
- Information technology implementations to reduce processing time and increase fulfillment

Summary: Bullwhip can be managed... and supply chain performance dramatically improved

While this presents just a highlight of the possible tactics, the important takeaway is the essential nature of supply chain collaboration in rooting out the dynamics that making matching supply and demand so challenging, not only in the semiconductor industry... but in most complex supply chains. Perhaps even more importantly, however, we have shown how the volatility of the bullwhip can be managed - - it is not entirely out of our control. Once supply chain leaders realize this, they can begin to take action to realize the great potential improvement that can come from taking on the bullwhip challenge.

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While the Bullwhip effect demonstrates the importance of an enterprise-wide operations strategy for enabling improved supply chain performance, other key dynamics in the high-tech industry also have an important impact in the quest to better match supply with demand. Interestingly, both make a call for the importance of collaboration and enterprise connectedness as key enablers for future success.

1.3 INDUSTRY DYNAMICS

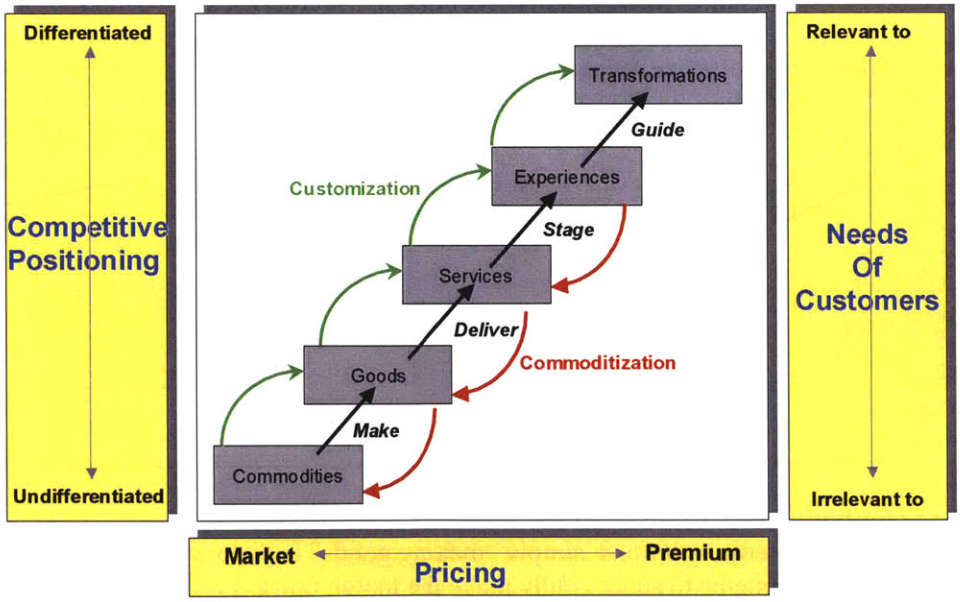
While understanding the Bullwhip Effect provides insight into the short-term, operational dynamics of managing supply and demand, several industry evolution models help shed light on these dynamics from a longer-term perspective. In this section, relative to supply chain and industry dynamics, we explore:

- The 'Theory of Economic Progression'
- Convergence in Computing and Communications
- Globalization
- Technology and Innovation Dynamics

1.3.1 The Theory of Economic Progression

According to the Theory of Economic Progression [26], companies have three options for evolving: climbing up the ladder of economic progression, climbing down the ladder, or standing still. In general, climbing up the ladder entails moving from providing commodities, to making goods, to delivering services, to staging experiences, to guiding transformations. Joseph Pine describes how the highest value positions (Experiences & Transformations) are built on top of services, goods & commodities [26]. An "Experience" is a memorable event that engages customers in an inherently personal way (going to theme park, visiting museum, going to sporting event). A "transformation" is a series of experiences that change the customer in some fundamental way (toning up at fitness center, resolving problems with psychiatrist, improving business through consultant). In moving up each stage, the company offers increasing value to the customer through differentiation and customization which creates a price (and profit) premium. To the contrary, moving down a stage entails offering less unique value to the customer, focusing on undifferentiated offerings through commoditization… which creates prices at a standard market level.

Figure 10: Pine's Theory of Economic Progression



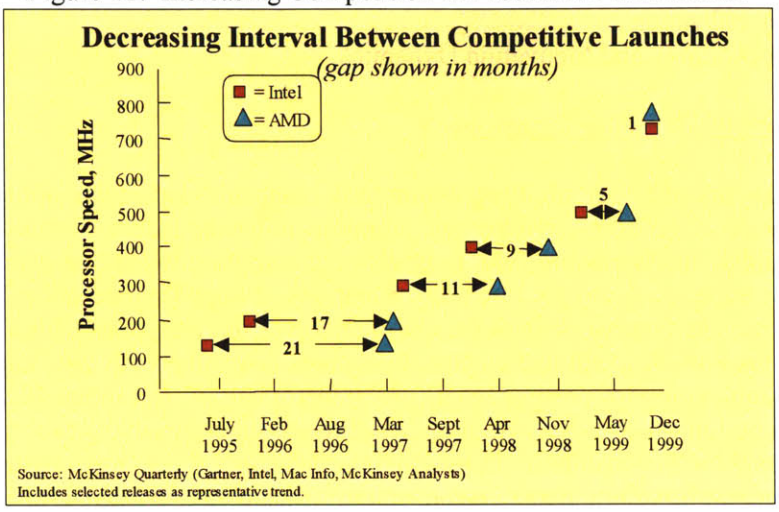
Desire to climb up

In general, Intel is seeking to steadily climb up this ladder. For example, most of Intel's marketing campaigns have focused on how using their products can impact people's lives in increasingly powerful ways. Additionally, the company has always had a steady and strong the push for increasing the need for more computing power by supporting complementary goods (e.g. applications) that deliver more value and impact to consumers (e.g. steadily investing in making the famous "Moore's Law" a reality).

Forces pushing you own the ladder: performance, competition & price sink

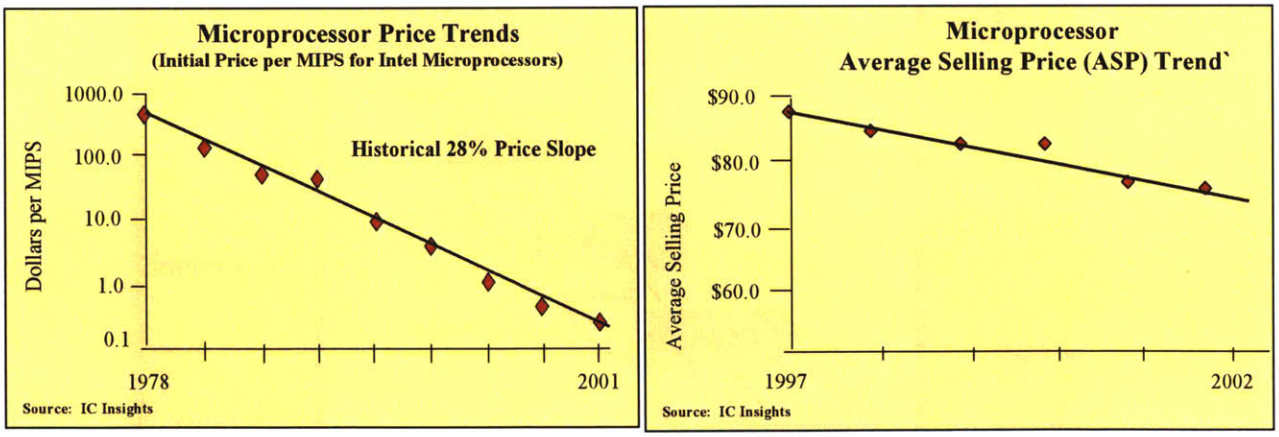
However, many forces are at play against Intel's quest to move up the ladder and stave off a march towards commodity standing. For example, the time it takes a competitor (e.g. AMD) to catch-up to a technology advancement has steadily been decreasing from 21 months in 1995 to 1 month on some products in 2000 [3]. In other words, attempts at product performance differentiation do not last as long as they used to.

Figure 11: Increasing Competition in Processor Performance



In parallel, the market has seen a steady and consistent decline of prices that are pushing microprocessors towards a commodity structure [3, 22].

Figure 12: Prices Steadily Declining in Microprocessor Market



To be able to climb up, need intimacy in value chain

Recognizing Intel's long-term ambitions, simply "making goods" is no longer sufficient to compete. Understanding the requirements to successfully make the march upward is essential to Intel's ability to achieve success. The company must and is finding new ways to engage with its enterprise and offer heightened services, "Experiences" & "Transformations". Delivering these experiences & transformations require an increased intimacy or connection with customers and the enterprise that is much more significant than the requirements of a commodity business. This intimacy is required to deeply understand the unique needs of your customers and value chain partners and to have the trust and connections required to successfully deliver that value [6].

1.3.2 Convergence of Computing and Communications

Intel's newest product launch, the Centrino processor, represents an excellent example of the economic progression trend. Built on a vision of allowing people to take their computing and communications products *"Wherever life takes you"*, the company is clearly making an effort for its products to play an integral part in enriching people's lives wherever possible (e.g. providing experiences... not commodities). Further, Intel recognizes the need for increased supply chain collaboration to be able to deliver this heightened level of enrichment. One of the key messages from Intel's website reads [14]:

> *"The new wireless world will be built on collaboration. That's why Intel is working extensively with the wireless technology industry to develop advanced mobile technology products and offer complete wireless LAN computing solutions. Which means you'll be able to experience true mobility."*
>
> *"To ensure that WLAN access continues to grow, Intel plans to invest $150 million over the next two to three years in companies that are advancing wireless technology. By 2006, estimates show that WLAN access will be available at 42,000 sites worldwide—and that more than 30 million notebooks will be equipped with the technology to connect to these WLANs."*
>
> *Intel is committed to continuously developing advanced mobile-technology products and engaging in extensive industry collaboration to offer wireless-LAN computing solutions that help address your business and home-computing needs. [Samples of our collaboration includes:]"*
>
> - *Adobe*
> - *AT&T Wireless Wi-Fi Service*
> - *Bell Canada*
> - *Borders*
> - *Check Point Software Technologies*
> - *Cisco*
> - *Hilton*
> - *iPass*
> - *Marriott*
> - *McDonald's*
> - *Microsoft*
> - *SAP*
> - *Sony Pictures*
> - *STSN*
> - *T-Mobile HotSpot*
> - *VeriSign*
> - *Wayport*

Looking at this technology from a broader perspective, many in the industry agree on a general trend of some form of structural change: a "convergence" between computing and communications. In a recent interview with Harvard Business School, Andy Grove, Chairman of Intel, described his view of this structural change [8]:

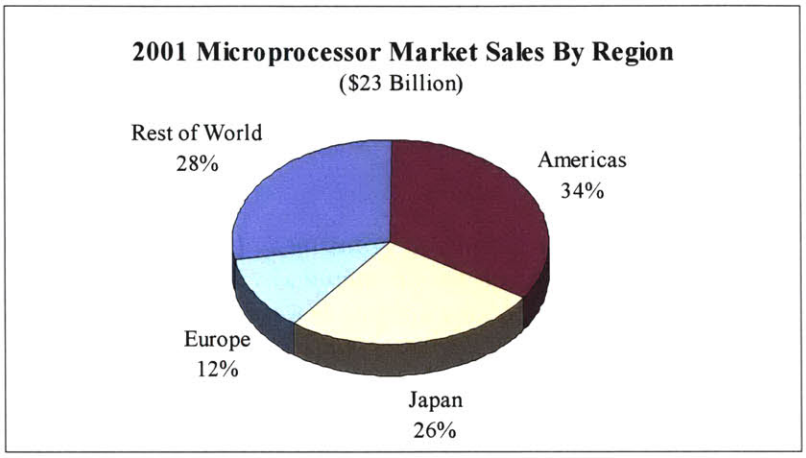
> *"Our last-generation growth had been fueled by a fairly major structural transformation of the computing industry from mainframe, centralized computing to distributed computing, PCs. And that defined the structure for the entire industry [and] defined the growth opportunities.... That framework is changing now... The Internet is redefining the role of computing and communication and their interaction with each other. I still don't understand the new framework. I don't think any of us really do. But some aspects of it are pretty clear. It's proven to be not computing based but communications based. In it computing is going to be subordinated to the communication task"*

This acknowledgment of some form of a structural changes that contains stronger interfaces between once separate components (e.g. computing and communications) offers another example of how Intel (and the high-tech industry) is moving up the ladder of economic progression and, in doing so, is considering the importance of collaborative connections with members of its supply chain.

1.3.3 Globalization – Interfaces increase Operations Complexity

Globalization is another factor that weighs heavily on the dynamics of supply and demand. Due to the simple fact that more business is being done at all corners of the globe, the complexity and importance of a well-functioning sales and distribution network continues to increase [22].

Figure 13: Microprocessor Market Spread around the Globe



With this steady geographic expansion, to maintain the same level of quality in the interface between links in the supply chain requires significant effort. To get in touch with the new demands and interests of the local communities adds complexities which include:

- **Cultural** differences in communication styles (saying "yes" when they mean "no")
- **Technical** differences in product needs
- **Market** differences in growth and profit uncertainty characteristics
- **Incentive** differences in behaviors and priorities

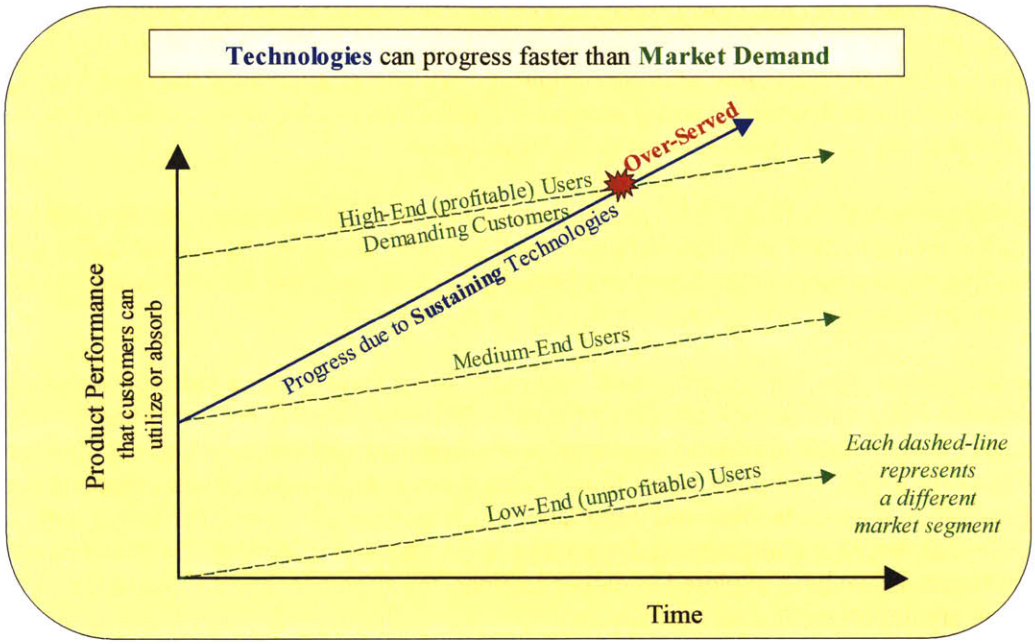
Through the course of this research, these complexities were witnessed daily in the interactions between the core business operations team in the United States and the four geographic business teams located around the world.

The continued trend to wards a global economy demands a stronger dedication to building effective connections among enterprise partners to most effectively and efficiently transmit goods and information through the value chain. In the past, for most companies in most industries, a "firm-centric" strategic focus was fostered by closed national boundaries (economic, political, cultural). However, as borders continue to open and as supply chains continue to enter new areas around the globe, "the ideal way of defining the firm to capitalize on the global network is changing". While few companies have figured out the ideal way to capitalize on this shift, most are working towards that end. In general, Womack contends that the underlying component for success rests in shifting the mindset from "firm-focused" to "enterprise-focused" [36]. Simply, organizations and industries are slowly but steadily recognizing the importance of strategies and capabilities that span across many companies' boundaries, requiring new ways of collaboratively developing strategies and tactics to realize them.

1.3.4 As technology becomes "good enough"… louder call for customization, flexibility, speed

The dynamics of technology and innovation in the industry is another important factor to consider in understanding how to improve a supply chain and a company's overall operational strategy. Clayton Christensen of Harvard Business School has characterized these dynamics through a well-known 'Disruptive Innovation' model show in Figure 14 [4].

Figure 14: Understanding Technology and Market Development Rates



In simplest terms, one of many key insights from Christensen's disruption model is that as a technology evolves, one should consider the rate at which the performance of the technology is increasing (e.g. Moore's Law) relative to the rate at which customer demand for higher levels of performance are increasing. Often times, the rate of technology development exceeds the rate of customer needs (as shown above), eventually resulting in a condition where most customers do not have a need for the high-end products (i.e.. the market is over-served). When this happens, the basis for competition shifts from one where technology and product performance are the most valued attributes, to an environment where supply chain speed, customization and flexibility are the basis for competition (because everyone who supplies parts can deliver technology performance that is 'good enough' for most competitors). This places those companies who focus solely on technology development at risk from being overtaken by a 'disruptive' company that delivers sufficient technology along with a more competitive delivery of that technology. In this new environment, speed, customization and flexibility are important as providing the supplier some way of differentiating their goods. For example, these capabilities may help reduce costs, increase customer service and response times, possibly climbing up the ladder of economic progression by delivering a more customizable solution.

Relative to the semiconductor market, Christensen describes these trends as follows [4]:

> *"Microprocessors have for the past few decades been undergoing the exponential rise in performance prophesied by Moore's Law. Named for Intel Corp.'s cofounder, Gordon E. Moore, it describes how engineers every 18 months or so have managed to double the number of transistors in cutting-edge ICs without correspondingly increasing the cost of the chips. For*

microprocessors, this periodic doubling translates into a roughly 100 percent increase in performance, every year and a half, at no additional cost. The situation has delighted consumers and product designers, and has been the main reason why the microprocessor has been one of the greatest technologies of our time. "

"In coming years, however, this seemingly unshakable industry paradigm will change fundamentally. What will happen is that the performance of middle- and lower-range microprocessors will increasingly be sufficient for growing—and lucrative—categories of applications. Thus microprocessor makers that concentrate single-mindedly on keeping up with Moore's Law will risk losing market share in these fast-growing segments of their markets. ***In fact, we believe that some of these companies will be overtaken by firms that have optimized their design and manufacturing processes around other capabilities, notably the quick creation and delivery of customized chips to their customers."***

It is important to note that there is a lot of disagreement about this assessment. In fact, many in Intel will argue that the public market just does not understand the many potential applications of higher performing microprocessors in the future and hence incorrectly emphasis the shift away from performance (technology) as the primary basis of competition.

Regardless, however, few will disagree with the general trend that more and more of the general uses of microprocessors today are being well-served by microprocessors that are not at the highest edge of performance. Exactly how the rate of market need development will evolve relative to the 'rate of technology development will unfold over time. In the mean time, however, most corporate supply chain groups generally recognize the risk and importance of capabilities like speed, flexibility and customization as potential competitive advantages (or weaknesses) to exploit. In the spirit of achieving these advantages, as we have explored in earlier sections, the alignment and collaboration of the extended supply chain are important enablers for success.

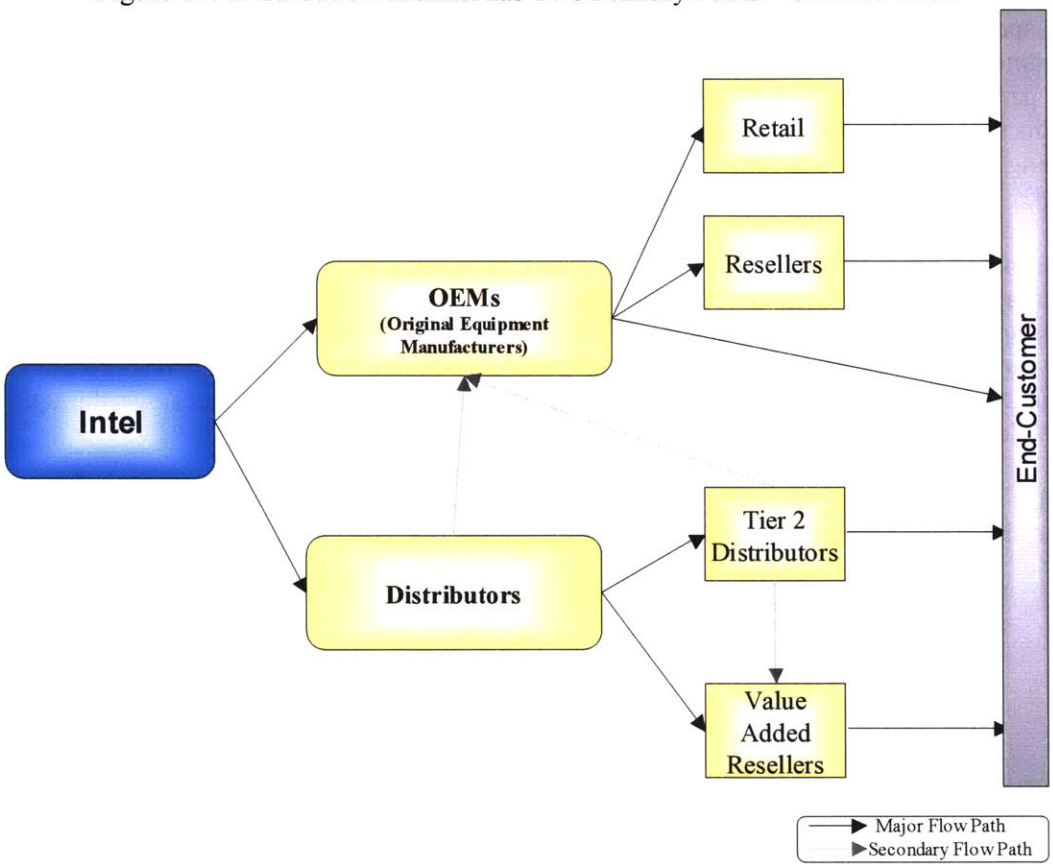
***

After looking at the supply chain and industry dynamics of the semiconductor industry, we now turn to Intel's supply chain operations specifically to build a baseline understanding of how they are working today to navigate these dynamics.

1.4 SUPPLY CHAIN OVERVIEW

Intel has been aggressively seeking to improve "how well it can match supply with demand" (along with most high-tech goods manufacturers) as it operates in this complex and dynamic environment. Over the past few years, dozens of supply chain improvement projects have been attempted – some bringing more success than others (we will explore these further in Part 3). For the purposes of this research, the scope of the supply chain evaluated was bounded between Intel's own factories and the end-customers[2]. The following figure summarizes the key components of Intel's supply chain within these boundaries.

Figure 15: Distribution Channel has Two Primary Paths – OEM & 'Disti'



In general terms, Intel defines its product supply by two major channels: OEMs (Original Equipment Manufacturers) and Distributors. The OEMs represent the larger portion of the company's sales (over 70%), including the major computer manufacturers such as Dell, Gateway, HP-Compaq and IBM. The Distribution ("Disti") channel includes over fifteen major distributors in North America with hundreds of others scattered throughout Asia and Europe. Various channels exist to take the products (e.g. personal computers, semiconductors, motherboards) from the OEMs and the Distributors to the end customer. The primary paths are explained below.

[2] This scope was determined based on the sphere of responsibility of the sponsoring business operations group and the immediate areas of need.

Retail
The 'Retail' path constitutes the 'Brick and Mortar' stores or chains of stores that sell products (primarily finished computers) to consumers and small businesses. This can be further dissected into the office superstores (CompUSA, Best-Buy, Circuit City) and the smaller, independent electronics stores. Personal computer sales totaled approximately $9 billion through the retail channel in 2000 [22].

Commercial Resellers & Value Added Resellers
The 'Reseller' path constitutes those organizations that provide a range of full-service computing and information technology solutions that includes 'reselling' computers and servers from OEMs. These sales are geared towards meeting the needs of large corporate clients, small and medium-size businesses (SMB), and educational institutions. Examples include CDW, Microwarehouse, CompuCom and Avnet. The commercial reseller channel had revenues of approximately $14 billion in 2000. A subset of the reseller path is the "Value Added Reseller" (VAR). These are resellers who, in some form, add value to the product they supply before passing it on to the end-customer. This value ranges from installing the computing systems, providing ongoing support services, designing the information system requirements, etc. [22].

Distributors
Distributors are often referred to as the 'middlemen' of the supply chain, responsible for warehousing products and selling them on to retailers, corporate resellers, and other channel players. The sales volume for personal computers and servers through the distribution channel totaled approximately $12 billion in 2000 [22]. Also of note, the largest portion of the distribution product flows through VARs (Value Added Resellers).

Given this supply chain architecture overview, we will now paint a picture of the organization and processes Intel uses to manage supply and demand for the semiconductor business.

1.5 SUPPLY-DEMAND OPERATIONS

To manage this web of companies and navigate the complex business dynamics, Intel has a supply chain management team that spans the globe. Although complex, like any process or organization, it can be broken down into its basic elements. Starting at the highest level, the organization has two components:

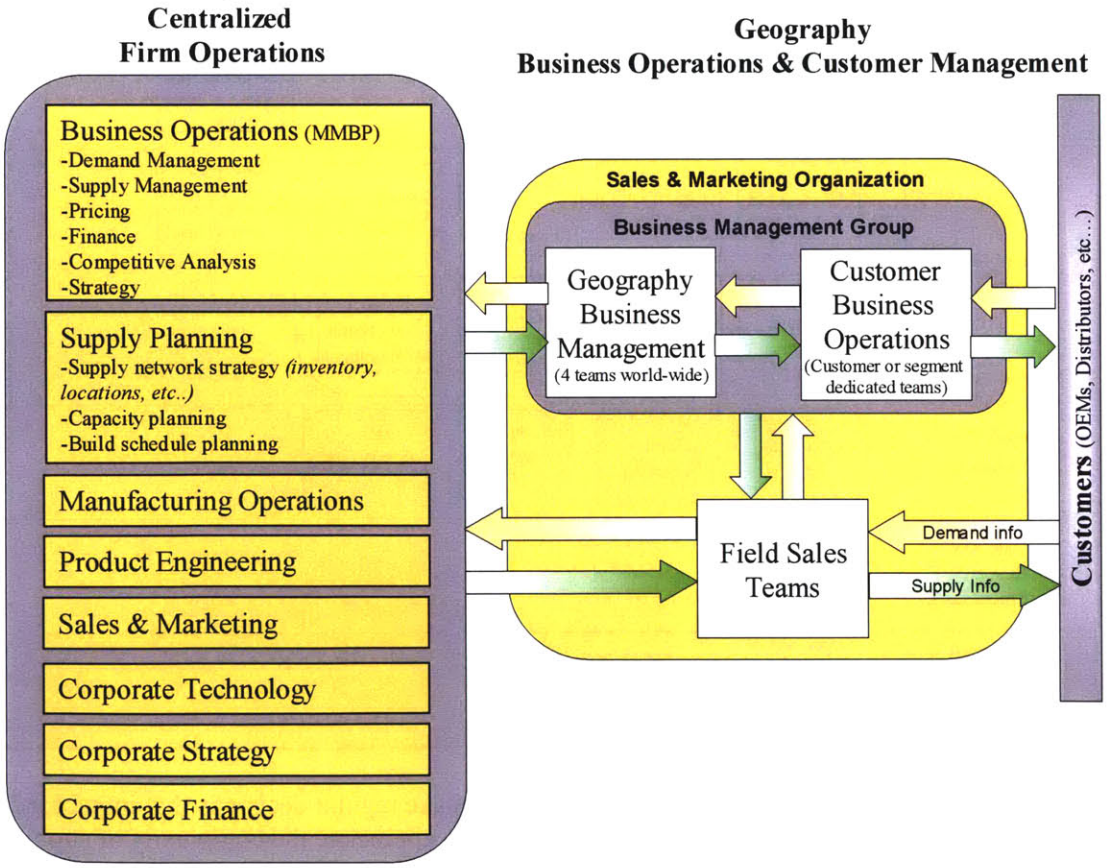
- The **centralized** operations of the firm, where Microprocessor Marketing and Business Planning (MMBP) serves as a coordinating body for all supply-demand activity
- The **distributed** operations of the firm, where four geography business teams (Americas, Europe, Asia and Japan) serve as the interface between central operations and the customers

Considering the process of supply-demand management, the major process types that are weaved through both the centralized and distributed components of Intel's organization include:

1. Pricing
2. Demand Forecasting
3. Supply Allocation
4. Finance
5. Competitive Analysis
6. Sales and Marketing
7. Customer Business Operations
8. Production & Supply Planning
9. Manufacturing
10. Product Development

The core business operations group (MMBP) has the first five of those groups under its organizational umbrella. Operationally, the remaining functions are connected to the first five through various cross-functional teams and dotted-line organization connections. Figure 16 shows a simplified view of the extended organization responsible for supply-demand management.

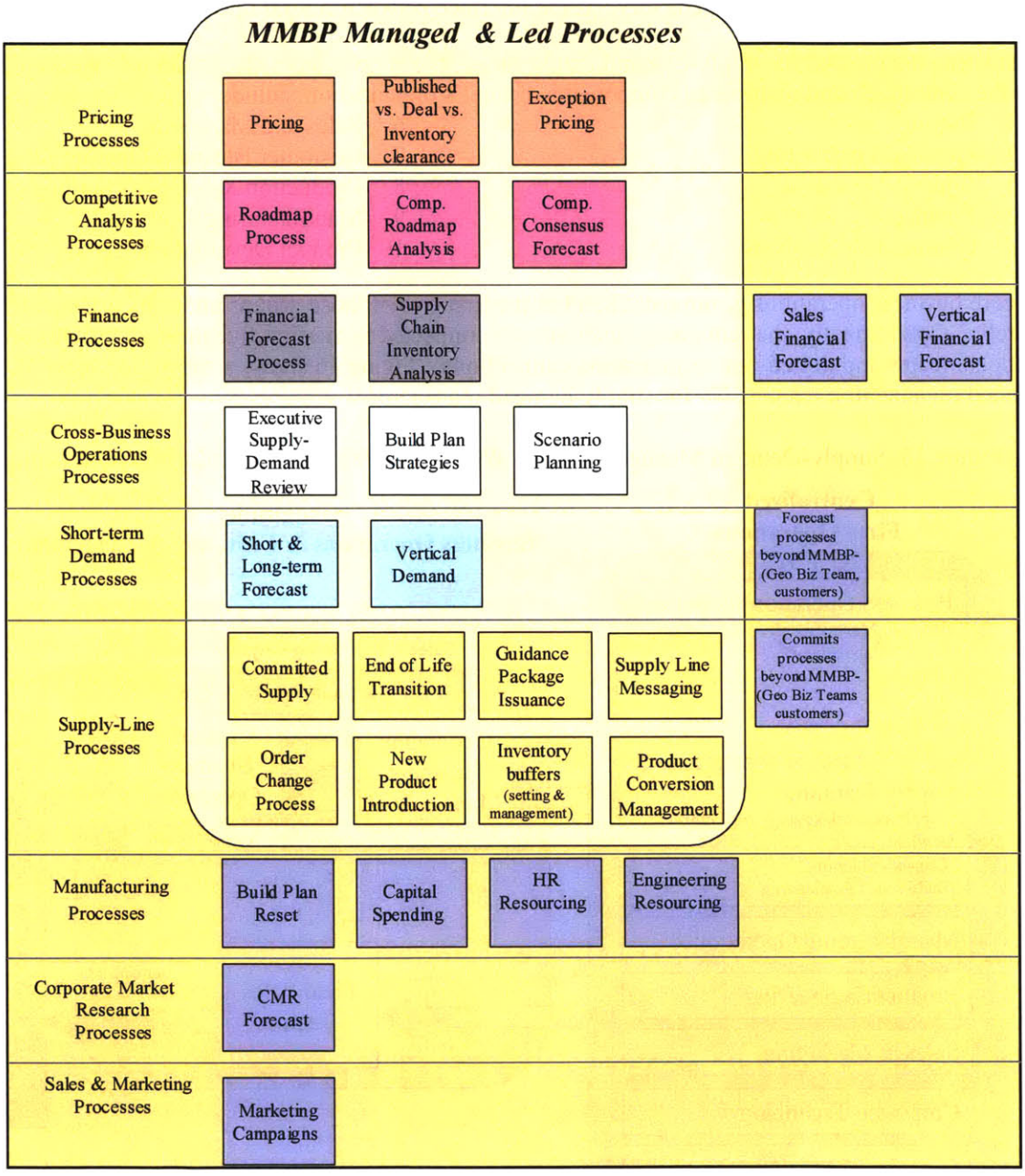
Figure 16: Supply-Demand Managed through Web of Centralized & Distributed Organizations



Many Possible Levers in Balancing Supply & Demand

In the quest to improve matching supply with demand, each of these organizations has potential 'levers' that can be pulled – tactics that can be executed to change the balance in some way. Looking at each of these organizations from a process-perspective, we see in Figure 17 that over thirty-two sub-processes (i.e. a process led by a particular function or group) constitute the overall supply chain management process.

Figure 17: Key Sub-Processes that Govern Success of Supply-Demand Management



Through each of these sub-processes, operations personnel make regular decisions that impact the supply-demand balance. From this viewpoint, one quickly begins to appreciate the complexity of supply chain and the challenge facing leaders attempting to improve its performance.

In recent years, dozens of strategies and tactics have emerged to help better balance supply with demand. A thorough benchmarking analysis and literature search yielded a list of the most common strategies.

Figure 18: Common 'Tools' to Balance Supply and Demand [19, 27]

- Dynamic (real-time) pricing strategies
- Inventory staging strategies (e.g. vendor managed inventory – VMI)
- Collaborative Planning, Forecasting and Replenishment
- Structured contracts (e.g. options methodologies)
- Late product configuration (postponement)
- Supply chain visibility improvements (demand, supply capacity, inventory)
- Information technology application to streamline processes (forecasting, customer order-taking, customer-order changes, build planning, pricing, etc…)
- Supply chain modeling and optimization (e.g. inventory levels and placement)
- Supply line agreements (e.g. structured contracts)
- Third Party logistics partnerships
- Data quality initiatives for IT systems
- Supply chain alliance programs
- Every-day low pricing (EDLP)
- Sales incentives alignment
- Academic research partnerships to understand key supply chain challenges

Interestingly, upon researching and working with the operations teams at Intel, nearly all of these tactics are being implemented or explored somewhere within the supply chain operations organization. While this research could have taken a path of understanding and implementing a particular tool(s), we opted to take a different approach.

Key Question is Not WHAT Lever to Pull… But HOW do we go about pulling any lever

Upon entering the supply chain operations group and developing the list of tactics shown in Figure 18, I was immediately reminded of earlier experiences in working at factories attempting to implement the Toyota Production System (TPS) in the mid 1990s. Also known as 'lean manufacturing', TPS swept through the global auto industry in the 1990s as Toyota's manufacturing efficiency and productivity enabled them to roll over the competition (in terms of quality, market share, profitability, etc.). This left companies like Ford, GM and Chrysler frantically trying to develop their own version of TPS in an effort to catch up and improve their complex manufacturing processes. A truck factory where I worked, for example, was embarking on a lean transformation. The management of the company and factory was aggressively assigning operations personnel to implement a dozen of the catchy and popular tools modeled after Toyota's system – andon boards, standard work instructions, kanban cards, etc [2, 35].

Figure 19: Common 'Tools' to achieve Lean Manufacturing

- JIT Inventory
- Kanban Cards
- Quick Setups
- One-Piece Flow
- 7 Waste Reductions
- Five S's
- Lean 'Kaizen' Workshops
- Sharing Forums
- Visual Management
- Standard Work Instructions
- Takt Time
- SPC
- Root Cause Problem Solving
- Error Proofing
- Auto machine stop
- Preventative Maintenance

However, much like hundreds of other plants and companies, the truck plant's significant investment in time and money failed to generate any meaningful gains in operations improvement. Today, we understand the error of their ways was in their lack of understanding of the underlying behaviors and principles that were necessary for the tactics to be successful. Looking at the laundry list of supply chain tools in Figure 18, one can't help but ask if the world of supply chain operations is experiencing a similar mindset as it attempts to improve its complex operations processes. In other words, this research suggests that supply chain organizations are falling into the same kind of 'Tool Trap' that has plagued many manufacturing organizations.

Learning from the broad set of knowledge around complex operations management (not just supply chain operations), this research focused on understanding the core behaviors and principles which should serve as the foundation for operations improvement efforts, using Intel's supply chain operations as the primary example. Specifically, the remaining sections attempt to articulate the essential capabilities the supply chain organization should be developing such that all of the possible 'tools' have the probability of being successful in improving the balance of supply and demand.

1.6 DYNAMICS CONVERGE ON ENTERPRISE-THINKING

To summarize Part 1, an assessment of both the business and industry dynamics lead us to better understand the importance of supply chain collaboration. The bullwhip dynamics demonstrate this importance from an immediate business operations perspective (e.g. improving demand and supply management today). The broader industry dynamics suggest collaboration as essential for longer-term strategic reasons (e.g. meeting higher-value customer needs, keeping up with globalization trends, need to compete on speed and customization instead of solely technology).

These key messages were reinforced by a leading Intel supply chain strategist, who characterized the dynamics of the microprocessor market environment as follows [13]:

- "solutions are preferred over building blocks"
- "competition is global and fierce"
- "technology alone is no longer a sustainable advantage"
- "deliberate management of technology innovation coupled with market intelligence will bring competitive advantage"

In following, she goes on to emphasize the importance of "agility", "speed" and "collaborative integration of the entire enterprise" as key enablers of a successful supply and demand management capability. With this convergence around the importance of fast, collaborative and flexible operational capabilities, supply chain organizations are presented with a multitude of possible 'levers' to balance supply with demand in this dynamic environment.

Ranging from dynamic pricing to vendor-managed inventory, the list of possible tools is endless. Rather than focusing on any specific lever, this research explores *how we should go about pulling whichever lever we choose* in an effective way that brings about lasting improvement. With this understanding of the underlying principles and behaviors that bring about success, operations leaders can more effectively choose, design and implement any one of the possible tactics. Without establishing this behavioral foundation, however, it may not matter which tool is chosen as it runs the risk of not getting off the ground or meeting its full potential.

***

We now move on to Part 2 where we explore the key capabilities, behaviors and structures that can enable success in navigating these dynamics and implementing improvement projects: process-thinking, learning and balanced sensitivity response.

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PART 2: ENTERPRISE THINKING – PROCESS-FOCUS, LEARNING & BALANCED RESPONSE

"Process-Thinking - the Clark Kent of business ideas: seemingly mild and unassuming but actually amazingly powerful"
Michael Hammer - Business Consultant, Author & Guest Professor MIT [10]

"The true test of intelligence is not how much we know how to do, but how we behave when we don't know what to do"
John Holt - Psychologist, Consultant & Author [12]

"A tortoise and a hare once got into an argument about who could run faster...
The tortoise plodded along, going slowly, but ... on and on he went...
Eventually, just as the hare was waking up,
the tortoise crossed the finish line.
The tortoise was slow but he had won the race."

"The moral: Sometimes it is better to be steady than fast"
Aesop - Legendary Greek Fabulist [37]

PART 2: ENTERPRISE THINKING: PROCESS-FOCUS, LEARNING & BALANCED RESPONSE

This section builds on our understanding of the dynamics of the environment by developing a recommended behavior and structure for the supply chain operations.

2. 1 FRAMING THE ENTERPRISE CHALLENGE – STRUCTURE & BEHAVIOR

As one seeks to develop strategies to improve complex operations, having an understanding of the organization from both a 'structural' and 'behavioral' perspective is an essential step [6].

Behavior:
From a behavioral perspective, the enterprise should explicitly and regularly identify and develop a set of common behaviors for all entities within that enterprise. This research explored a common pattern of behaviors underlying world-class processes – whether they be manufacturing processes or business processes. This common foundation consists of a deep understanding between short-term and long-term responsiveness, a strong process-focus, and an evolved learning capability.

Structure:
From a structural perspective, organizations should explicitly and regularly define the boundaries of its operations, clearly articulating with whom we should collaborate, why and how. Although most of this research focused on the supply chain behavioral factors, a simple structural framework was created for thinking about how to develop an enterprise structure to achieve its desired behaviors.

The structural and behavioral guidelines are explored in the following two sections.

2.2 STRUCTURE – THE ENTERPRISE PYRAMID

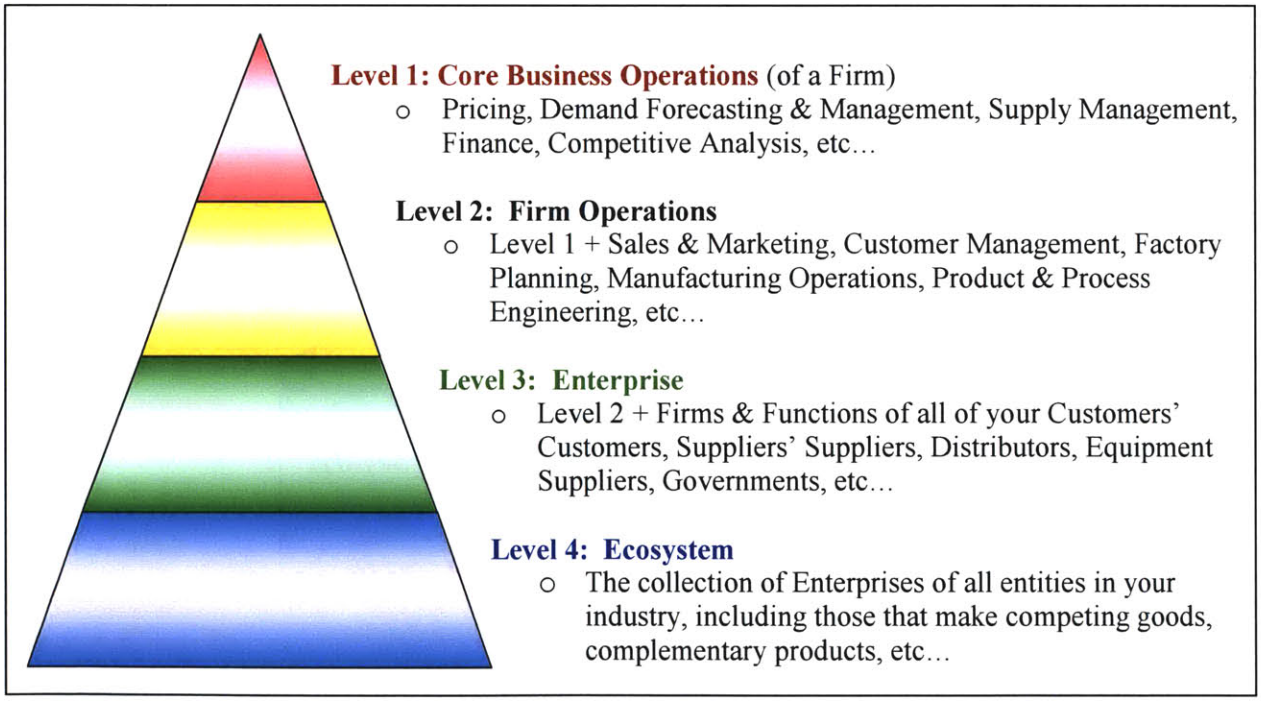
2.2.1 Enterprise Definition

For the purpose of this work, "enterprise" is used to describe the collection of firms (and the functions within those firms) that work together to deliver value to an end-customer. More specifically, Nightingale, Murman etc. in their breakthrough book, 'Lean Enterprise Value', characterize the enterprise as follows:

> *"The core enterprise consists of entities tightly integrated through direct or partnering relationships. Less tightly coupled customer, suppliers, and government agencies encompass the extended enterprise – all the entities along an organization's value chain, from its customer's customers to its supplier's suppliers, that are involved in the design, development, manufacture, certification, distribution, and support of a product or family of products. Products include all of the goods and services that satisfy the customer's, and ultimately, the end-user's needs [25-163]."*

Given this macro definition of an enterprise, when attempting to understand supply chain dynamics, it is important to understand how the various levels within the enterprise may or may not impact those dynamics. The following diagram refines the above definition and provides a simple model for describing the entities and structures of business and industry operations.

Figure 20: The Enterprise Pyramid



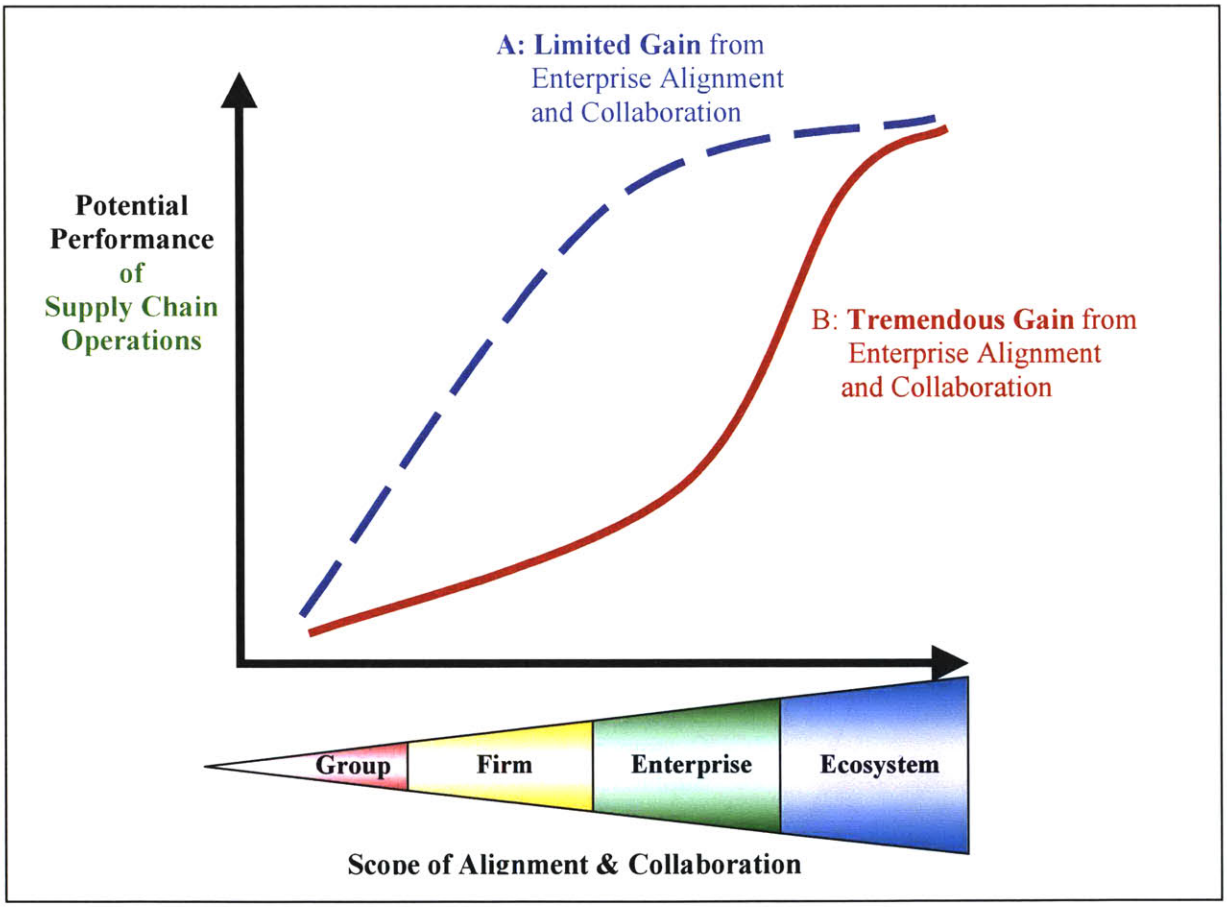
All companies have a structure (whether explicit or implicit) for how it views itself and its related entities at each of these four levels. A major challenge for all companies and value chains is how to develop strategies to capitalize on each level of the structure and determine how those entities interact and work with each other.

2.2.2 Enterprise Alignment & Collaboration

Much research and practice have gone into answering these structural design questions across industries. From outsourcing strategies to collaborative supplier partnerships, competitive advantage can be gained (or lost) based on these structural decisions [6,7]. A key determinant in developing an enterprise structure is thinking about the importance of enterprise alignment and collaboration for your particular industry and supply chain.

The following model was developed to help individuals think through the dynamics and drivers in their industry by considering two sample industries with very different enterprise dynamics. The x-axis represents increasing alignment and collaborative capability as one moves to the right. The y-axis represents the potential performance of the enterprise supply chain operations.

Figure 21: Supply Chain Performance vs. Enterprise Alignment & Collaboration



Plotted on the graph is the performance potential of two different types of enterprises. 'Enterprise A' receives very little performance improvement potential in its supply chain operations from stronger alignment and collaboration at the enterprise level. Rather, most of the performance potential comes from alignment within the individual firm and group operations. In contrast, 'Enterprise B' gets significant performance improvement potential from stronger enterprise alignment and collaboration.

The following table summarizes the general conditions under which strategy A or strategy B is most likely to be appropriate for a particular company or groups of companies.

Figure 22: Characteristics of A-Type and B-Type Operations [6]

	A-Type	B-Type
Gain from enterprise alignment and collaboration	Limited	Substantial
Volume of exchange between entitles	Low	High
Degree of supplier-buyer interdependence	Low	High
Ability to effect each others costs & operations	Low	High
Primary emphasis on short-term cost reduction	High	Low
Emphasis on long-term value creation	Low	High
Interest in improving complex industry and market dynamics (e.g. Bullwhip) for long-term benefit of the firm and supply chain	Low	High

Upon looking through the criterion, it is helpful to begin by thinking about these factors relative to the key relationships in the supply chain. As the benefit from aligning and collaborating may be different for different suppliers and customers in the value chain, thinking about each relationship independently will help build a solid foundation on which a more aggregated supply chain strategy for the entire extended enterprise will emerge.

Major supply chain challenges require enterprise-wide alignment

As explored in Part 1, the dynamics of the semiconductor industry suggest that Intel, for example, falls in the category of 'Enterprise B'. The Bullwhip Effect in the high-tech supply-demand dynamics, the pace of technology development and the importance of alignment with complimentary goods, and the increasingly complex and global structure of its supply chain combine to suggest enterprise alignment is very important for their success. In general, major dynamic challenges in supply chain operations (like the 'Bullwhip') require enterprise-wide solutions and explicit enterprise-wide thinking (not just firm-level solutions or strategies) to make meaningful improvements. Interviews and discussions with many leaders in Intel's business operations support this assessment that Intel is working to evolve itself into an "Enterprise B' type. While the intent may be clear for Intel and many other companies, however, few organizations have developed as strong of a strategic thinking or tactical execution capability at the enterprise wide level.

Enterprise interfaces are more difficult than those at Firm level

As you move up the pyramid from the enterprise to the firm level, you have more and more control over the systems and processes... and hence a more explicit and manageable strategy and set of tactics that can be designed and executed. Accordingly, our skill and knowledge of developing and executing strategies at the firm level far surpass our abilities at an enterprise level. Most firms rigorously engage in strategic operations planning for their own supply chain practices and for their own manufacturing operations. These are capabilities that fall largely under their control. In contrast, 'enterprise-wide' strategies inherently present less control to any individual firm and bring more complex dynamics to the collection of firms to manage. While firm-level strategies cut across functional and geographical boundaries, enterprise strategies demand cutting across (or connecting across) firm boundaries in addition to the functional and geographic complexities. While dozens of interviews indicate that most supply chain strategists and operations personnel recognize the power of enterprise alignment and collaboration, the common response was 'we just don't know how to do that as well as we do at the firm-level.' The magnitude and scope of an enterprise-wide strategy can be intimidating and overwhelming, often leading many to not seriously or explicitly develop strategies and supply chain tactics at that level. However, this research identified several observations that can help organizations overcome these concerns.

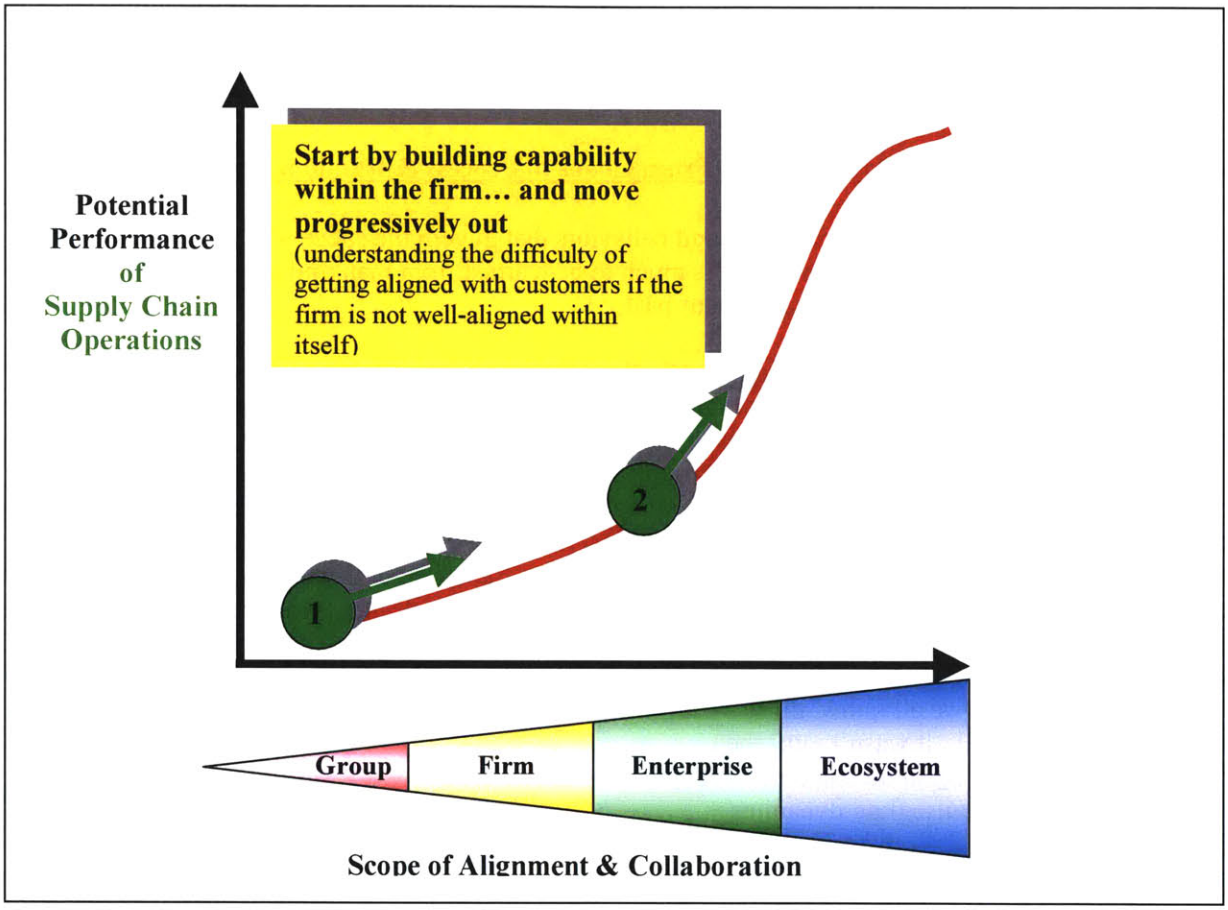
Common behavioral principles apply... no matter the level of structure

First, regardless of whether the connection in question is between two groups within a firm... or between two firms in an enterprise, there are basic building blocks in behaviors that enable successful connections and collaboration. In other words, when we learn the behaviors necessary for successful alignment and collaboration in one setting, we can readily adapt them to another. The following sections explore these central behaviors and capabilities in detail.

Start building behaviors within the firm… and cascade through the enterprise

Second, no matter the complexity of your enterprise, the first step is to build a strong foundation of these essential behaviors in the core of your own firm's supply chain operations. In other words, start with what you know and what is under your immediate control. Once that behavioral core is established, moving on to applying those principles and building alignment and collaboration with partners at an enterprise level is much more likely to succeed.

Figure 23: Build Behavior Foundation from the Firm Out



These core behaviors center around three themes: process-focus, learning, and balanced time-response. Trying to establish a strong, collaborative web of interfaces and relationships at an extended enterprise level without understanding and demonstrating these essential behaviors in the core of your own firm is a formula for frustration, failure, and lost opportunity.

With this perspective in mind, the research with Intel's supply chain operations began and focused primarily in the behavioral domain of the core business operations group. The following sections explore some of these key foundational behaviors and offers examples of their application.

2.3 BEHAVIOR – PROCESS-THINKING, LEARNING & SENSITIVITY BALANCE

This research has identified that from a behavioral perspective, enterprises most successful in navigating complex dynamics – including the dynamics of supply and demand – have several common organizational capabilities and behaviors. Those capabilities include:

- An understanding and alignment of the end-to-end business process [2, 7, 10, 11, 25, 27]
- A dynamic learning capacity [2, 12, 20, 24, 28, 31, 32]
- Leadership enabling a successful long and short-term response capability [2, 23, 33]

The rest of this chapter explores each of these capabilities in detail. The subsequent chapter then explores various tools and mechanisms to help develop these capabilities in a supply chain, providing examples from their implementation in Intel's business operations group.

2.3.1 Paradigm Changes in Behavior – From Chaos to Process & Random to Understood

As we strive to understand key capabilities and behaviors that govern the success of a complex dynamic like supply and demand management, there is much to be learned from mankind's approach to understanding other complex challenges in our past.

Learning to Fly: Don't Just Flap Harder– Challenge Assumptions & What Governs Success

Centuries ago, man struggled to understand the complexities of flight (much like many supply chain operators struggle to understand the complexities of supply-demand dynamics today). We watched the birds and marveled at their abilities to soar through the skies. For centuries, man tried to replicate their capabilities by strapping wings to our arms, jumping from cathedral towers and flapping our arms with all of our might. Sadly, failure after failure occurred (e.g. like the many sad stories of failed supply chain solutions such as information systems, just-in-time delivery strategies, joint-managed inventory attempts, etc. Some concluded we just needed to flap harder or alter the wing design… and, as we now know, their efforts didn't succeed. In the late 1200s, the notion emerged that man couldn't fly by flapping wings because of the difference in bone density, so some suggested the need for machines to flap wings for man instead of muscle. As we all know, those machines failed as well. It wasn't until the aviators developed, understood and embraced the laws of nature (gravity, fluid dynamics, Bernoulli's principles, drag, lift, etc…) that success emerged. Once man understood these governing laws of behavior (the underlying processes of nature that enable flight), we became able to fly better than most had ever imagined [4][3].

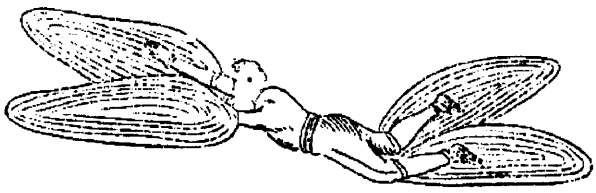


Figure 24: Attempt At Flapping Harder
(Marquis de Bacqueville in 1742)

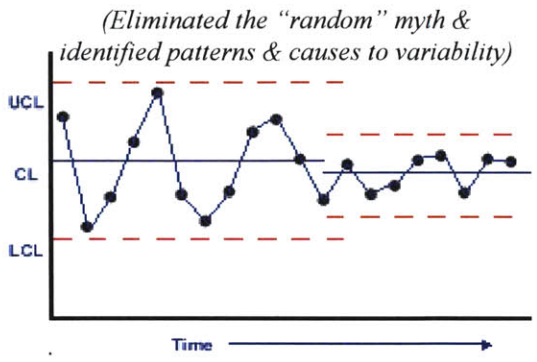
The lesson from flight: in the complex physical dynamics of aviation, we experienced centuries of failures because we tried to improve without a deep understanding and application of the underlying laws and processes that govern success.

[3] Professor Shoji Shiba, a world-renowned management advisor, has shared with the world many wonderful pieces of wisdom from his decades of rich operations experiences. One particular lessons is the importance and power of images in telling a story. Shiba explains that while a bullet-list can succinctly capture a message, a well-thought out image can tell the same story in a way that will be better remembered. Accordingly, throughout this work, images are used in an effort to attempt to relay the messages in more compelling ways than simple text might achieve.

Understanding Variability in Quality: Don't assume it is all "Random"

One might argue that governing principles might apply in the physical world… but they can not apply in the world of business. They would be wrong… as demonstrated by the evolution of management practices in quality control. For centuries, and as recently as the 1960s, manufacturing personnel attributed deviation in quality and production to "randomness". Even in the 1970s when SPC was emerging, many taught that the reason for scatter on the chart was because of randomness in the processes. In the 1980s, a new paradigm emerged which stated that every deviation has a cause - - we just may not have a deep understanding of what that cause is - - yet! The new paradigm challenged the organization, contending that when we didn't understand the factor that caused variation, it *appeared* random. In reality and upon taking a deeper look, each deviation actually does have a cause. We developed tools to identify and understand the factors that contributed to variability. Those tools allowed us to improve or change those contributing factors and improve the results.[4] It is important to note that the prerequisite for those tools to be of value was having a solid understanding of the manufacturing process. Combining a rich process understanding and the ability to apply quality improvement tools gives us the ability to make products (e.g. achieve results) using a process that achieves exactly what we intend.

Figure 25: SPC & Quality Movement



The lesson from quality: we should not accept 'random' causes of unexpected or unwanted results just because a process or system is complex. We must work rigorously to understand both the process and the causes of deviation and take action to improve.

Supply Chain Operations can learn Lessons from Aviation and Quality

These same lessons that transformed man's ability to fly and our ability to manufacture quality products apply directly to the dynamics of supply and demand today. As we look to improve our supply chains and other complex systems, these lessons can be translated into general behaviors essential for significant improvement to occur:

Behavior 1: Process Focus

- Develop a rich and explicit understanding of the **processes** that govern your supply chain
- **Don't just flap harder** (do what we have always done) and ignore the underlying 'laws' and processes that govern success (e.g. Bullwhip drivers)
- **Align** individual behaviors and practices with the 'laws' and 'processes' required for success

Behavior 2: Learn Rigorously and Drive out Variation

- Understand all **variation has a cause** (or series of causes) that can be understood
- Take a rigorous approach to understanding deviations (variation) in your performance through **learning**
- **Develop and apply tools** to aid in this learning and variation control effort

The following sections explore these behaviors in detail.

[4] The stories of flight and SPC were respectfully adapted from a lecture Clayton Christensen gave at MIT in the Spring of 2002. At that time, the stories were used to articulate an approach to understanding the complexity of innovation, just as we are seeking in this research to understand the complexities of supply chains and operations.

2.3.2 Behavior 1: Understanding and Aligning the End-to-End Process

While we are developing a deeper understanding of the underlying processes and behaviors that govern success in supply chain operations (e.g. Bullwhip Effect), many companies are only haphazardly applying those insights into the actual business operations. A key reason for this haphazard application is our limited understanding and control over the end-to-end supply chain process.

Supply-Demand dynamics inherently involve many firms, many functions within each of those firms, and many individuals within each of those functions. One can easily get overwhelmed by the complexity of the underlying supply chain processes and their resultant dynamics (like those found in the bullwhip effect). As in any complex system, however, whether in a manufacturing plant, an on-line service operation, or in a demand forecasting and supply fulfillment operation, with the appropriate energy and commitment, the system can be deeply understood from an end-to-end process perspective. With a goal of improving operations performance, Michael Hammer (a leading strategic management and business process consultant) describes the power of processes as "the Clark Kent of business ideas: seemingly mild and unassuming but actually amazingly powerful" [10 -52].

Figure 26: Process-Thinking
The Superhero of Business Ideas

As we did with flight, many researchers and companies are working to understand the underlying principles governing successful supply chain operations. In Part 1, we looked at those principles as understood through the Bullwhip Effect in supply chains. Understanding the major causes of the Bullwhip is an important first step; however, to be able to apply those insights to your supply chain, one must understand the supply chain processes themselves. Before delving deeply into the supply chain processes themselves (which we will do in Part 3), let us not overlook understanding the general characteristics of excellent process design and operation.

What is a Process? Organized group of related activities that together create value

Much research has been devoted to understanding processes in a business context. A simple and generally accepted definition reads: "*Process - an organized group of related activities that together create a result of value to customers*" [10].

Each component of this definition carries important meaning as one assesses and designs a process.

- **"Group" = Cross-Boundary Thinking and Accountability**
  This emphasizes that as most processes have more than one entity or step connected, *"value is created by the entire process in which all these tasks merge in a systematic way for a clear purpose."* In other words, success is not found in successful performance of just one activity [10, 11].

- **"Organized & Related" = Actively Designed**
  This emphasizes that the collection of "*activities in a process are not random or ad hoc – they are related and organized"* [10]. In other words, the activities are designed and placed in a structure. It depends on the particular process as to what degree (how actively) they are designed in a thoughtful way (versus passively being expected to self-emerge).

- **"Together" – Alignment of Purpose**
  This emphasizes that *"all activities in a process must work together toward a common goal. People performing different steps of a process must all be aligned around a single purpose, instead of focusing on their individual tasks in isolation"* [10].

- **"Value" – Process and Results Focus**
  This emphasizes that *"processes are not ends in themselves.... They have a purpose that transcends and shapes all their constituent activities"*[10]. In other words, the activities and individuals must not just be aligned and together around the process itself... but also around the results they are trying to achieve.

Why are Processes Difficult? Traditional Functional & Silo Perspectives Drive Failure

Very few processes actually achieve the ideal state as just prescribed. Traditional organizations are structured around departments, each focused on one task and that task alone (e.g. sales and marketing, pricing, demand management, supply management). While the functions interface informally, rarely is the process understood and owned across functions. Due to functional priorities, process complexity, lack of leadership encouraging process-focused behavior, and many other barriers, most "organizations are not friendly to processes". Accordingly, their business processes exhibit common pitfalls that can include [10,11]:

- **Piece Focus**
  Focusing on individual pieces (e.g. demand forecasting, pricing, supply allocation)... not having everyone explicitly work together toward achieving the goal that serves the collective interest of all.

- **Lack of Task Definition**
  Activities and connections lack clarity and consistency in how they are to be performed, by whom, when, how and where.

- **Meandering Work**
  Work drifts from person to person and function to function without an organized design that integrates all the pieces into a whole process.

Why Process Thinking? Processes drive Repeatability which drives Quality

Process design and control has been proven to be a "prerequisite for repeatability." Without repeatability, these kinds of traps drive a proliferation of errors into the process. Because the design and structure of the process carries so much influence in the success of the enterprise, no matter how "hard a single individual might work, they are not able to overcome a flawed process design, much less the burden of no design at all [10]."

How lead complex processes? A Process Owner that Crosses All Boundaries

Given this complexity, a holistic and inclusive view is required for designing the process. Even more importantly, leadership of the process must span from end-to-end (either by a single individual or a tightly connected small team) that effectively floats above the functional and local interests and allows the holistic end-to-end process intent to be realized. Without a clear process leader that crosses boundaries and functions, left to a collection of individual managers (e.g. one focusing on pricing, others on forecasting, others on sales and marketing, others on distribution, others on production planning), the end-to-end process perspective is never owned and the process will never reach its full potential.

While establishing this process owner is challenging, one can envision a structure that allows it to emerge. Success would require commitment and resources from senior management, along with alignment among all people in the process about the value of process-thinking and learning. Once established, this leader can help the process participants see the "end-to-end process" and help break through the organizational and mental model barriers required to have the process achieve its potential.

Summary: Process-Thinking as Foundation for Operational Improvement

In summary, this section summarized the importance of understanding the supply chain from an end-to-end process perspective if one is looking to improve its capability. This end-to-end perspective includes:

- explicitly defining and connecting processes across organizational boundaries
- actively designing activities and tasks (not leaving them to random chance)
- aligning the connected web of activities, people and processes to a common purpose
- balancing focus on both on the end-value (purpose) and the processes required to achieve them

Having established a high-level definition of 'process-thinking', the following sections develop a deeper understanding of how to design and operate a world-class process.

2.3.3 'Ideal' Process Performance? Defect-Free, On-Demand, Batch-of-One, Without Waste

In designing a supply chain process, or any other complex process for that matter, a necessary component of the design is establishing a common understanding of the "ideal" performance. In other words, for a process to work effectively, each participant should have an understanding of not just what the process is in terms of activities and procedures... but how the process is intended to function in its ideal state.

In the world of manufacturing and supply chain, a consensus has been emerging over the past decade on how to characterize this "ideal" state. In general, "ideal" production and delivery is that which [2, 32]:

- is defect-free (has the features & performance the customer expects)
- is supplied on demand in the version requested
- can be delivered one request at a time (batches of one)
- can be made and delivered without waste (labor, materials, energy, inventory, etc...)
- can be done in an environment that is physically, emotionally, and professionally safe for all employees

Beyond these specific attributes, the notion of the "ideal" is an important motivator for each individual to learn in order to improve their piece of the process, in an ongoing quest for perfection. This "anchor" helps to prevent a "good enough" mentality from emerging in the organization, charging the organization to continuously improve. While this precise definition may not apply in exactly the same way across every process, it has been found to have meaningful applicability across most industries and functions. Nonetheless, there may be some differences from company to company. Regardless, all organizations should examine the criteria and develop their own "Ideal Anchor"... evolving and phrasing the components as it best suits their process. The key, however, is to maintain the spirit of this definition and to anchor all members of the process team to excellence and perfection[5].

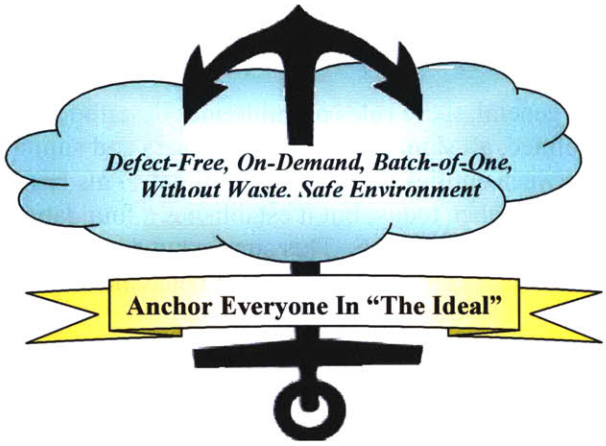


Figure 27: The Ideal Supply Chain Anchor

Having aligned all participants in the process as to the goal of the process, we come to the next step in our quest of characterizing and establishing process excellence: how to achieve this ideal.

How do you achieve the "ideal"?

Relative to an organization's manufacturing and operations capability, Toyota Motor Corporation is generally considered one of the premier process organizations in any industry. Their consistent growth and success driven by operational excellence (e.g. process capability) has been studied and published in detail. Extrapolating the insights of an automobile manufacturer to a semiconductor supply chain may appear difficult; however, the work of Steve Spear and Kent Bowen from Harvard Business School has found a way to bridge this gap. After in-depth study of the Toyota Production System, they synthesized the operations practices into four basic rules which capture the essence of how they achieve process and

[5] Throughout the thesis, various images are used to attempt to summarize the key themes and insights. While some of them present a 'playful' representation, they are intended to provide memorable and powerful mental images to help the reader capture and remember the ideas.

operations excellence in all facets of their business. These "Four Rules" have relevance and applicability across all process types and forms: from building a car... to making a hamburger at a fast food restaurant... to operating a hospital... to making and delivering semiconductors.

Briefly, the "Four Rules" as characterized by Bowen & Spear are as follows [2, 32]:

1. **How People Work**
   All work shall be highly specified as to content, sequence, timing and outcome.
2. **How People Connect**
   Every customer-supplier connection must be direct, and there must be an unambiguous yes or no way to send requests and receive responses.
3. **How the Network (Production Line or Supply Chain) is Constructed**
   The pathway for every product and service must be simple and direct.
4. **How to Improve**
   Any improvement must be made in accordance with the scientific method under the guidance of a teacher, at the lowest possible level in the organization.

While these four rules seem obvious, their proper and thoughtful application has proven to have dramatic improvement in processes ranging from the most simple to the most complex [2].

In general, these rules or guidelines describe the architecture of a process such that all activities are well-defined, all signals between customers and suppliers are unambiguous and direct, and all connections between entities are simple and direct. This basic process definition allows not only for strong process performance today, but it establishes a foundation on which the process improves every day in a quest for "ideal" performance. This simple but powerful improvement capacity (otherwise characterized as learning) is the focus of the next behavior.

Summary – Skillful Process-Thinking is an Essential Supply Chain Behavior

In summary, the necessary first steps to drive supply chain improvement is to design and manage their demand and supply processes as "processes" with the characteristic behaviors just described. This process-focus mentality includes viewing processes not as a random collection of activities or as activities lacking clear definition where work meanders through the "system." Rather, this focus drives discipline into the design of the process such that work is clearly specified, signals are direct and unambiguous and the network of process connections (design) is simple and direct.

While this process-focus helps the supply chain define and understand the process (the way work is done) today, this process cannot be viewed in a static state. Having a great process is not enough. Knowing how to manage that process is the second necessary step. This leads us to the second fundamental behavioral capability required for supply chain operational excellence: learning. Truly great processes have an organic capability to learn at every interface and in every transaction [30].

2.3.4 Behavior 2: EFE Learning – Building Capabilities One Lesson at a Time

The idea of improvement, whether it be in a manufacturing line or a supply chain, is strongly grounded in an organizations ability to learn. The ability for individuals and organizations to learn has been shown to be a key enabler for high-performing processes [2, 12, 20, 24, 28, 31, 32]. Interestingly, while many types and forms of learning exist, decades of research have developed a common and simple principal in learning excellence which holds true across any discipline or function. This principal is about how individuals fundamentally interact with the world.

EFE Learning: Given Uncertainty, Learn through Experiential, Frequent Experimentation

Simply, there are many things that we do not know. 'Great' learners (and great learning organizations) respond to this uncertainty in a different way than 'poor' learners. John Holt, an expert in learning capabilities for individuals and organizations, explains [12]:

"The true test of intelligence is not how much we know how to do, but how we behave when we don't know what to do"

Figure 28: Given uncertainty, we are all presented with a choice - - *to Learn... or Not to Learn*

Simply, great learning individuals and organizations have at their core an instinctive response when faced with uncertainty. This instinct guides them to learn by real-world experimentation, recognizing every transaction and interaction as an experiment. In organizations with strong learning capabilities, there is a constant drive to increase the frequency of the experiments (experiences) while decreasing their costs in an effort to continuously improve operations.

Through Professor Stephen Spear's research and work in operations, he has found many independent research efforts suggesting this principle holds true across disciplines [30]. From a child learning to walk [12], to a market research team researching a new product [20], to an engineering team designing a new product [35], to hiring a new employee, to running a factory [2], to professionals running business operations processes [1] - - this principal of experimental and experiential learning as an essential component of operations success has been consistently demonstrated.

The synthesis of these principled learning methodologies through this research with Intel has been named "EFE Learning":

- **E** – Experiential (Not lab-based, but 'real-world')
- **F** – Frequent
- **E** – Experimental (Not random, but thoughtfully designed)

Figure 29: EFE Learning

Simply, EFE Learning tells us that if we don't get what we expect from our processes, take the occasion as an opportunity to learn, don't just assume the cause is random and passively respond to the disruption. Many will argue that their organizations think through this informally. While that may be true, engaging in an 'informal, ad hoc' approach to learning yields little relative benefit to a thoughtful, experiential and experimental approach [2, 32]. This approach to understanding uncertainty and complexity is not new. In fact, the basic ideas are rooted centuries ago in the 'Scientific Method". Applying the Scientific Method to business processes demonstrates how one might understand and operationalize this EFE learning principle.

Scientific Method – A way of thinking about Learning in Business Operations

In the world of science and engineering, the "Scientific Method" is the foundation for analytical thinking. In simplest terms, it is a methodical approach to understanding complexity. This same approach, which is so rigorously and successfully applied in other disciplines, is only sparingly applied in the day-to-day world of business operations. As the following example will show, however, the basic thinking is easily applied [2].

The method begins with a very basic hypothesis:

> The process is designed to achieve a specific, known result. If we execute the process correctly, we will achieve that desired result.

If we do not achieve the desired results, we have only a few possible causes for failure:

1) The business processes **were not executed** the way they were designed... and hence did not achieve the targeted results.
   - Possible factors may include:
     - Lack of clear, standardized process (e.g. it is done different every time)
     - Lack of training on how to do the process

2) The business processes were **not adequately designed**... and hence their execution yielded results different than those expected
   - Possible factors may include:
     - Lack of robust process design (overly performance sensitive to variation)
     - Unknown change in environment or conditions in the process

3) The processes were executed correctly, but external factors make it such that regardless of how the process was executed, one would not achieve the results desired. In other words, **the processes are NOT a direct or strong determinant of the results**. Rather, other processes, other interactions between processes, or other environmental factors are stronger determinants of success.
   - Re-focus effort on these other processes and factors & apply 'scientific method'

Thus, given an unexpected outcome from a process, the cause can be generally categorized into one of three types. Depending on that type, root cause analysis can be done to identify the source of the problem and make the necessary adjustment.

The Firefighting Cycle – A Barrier to Learning

In principle EFE Learning and the Scientific Method sound logical and great to apply. Sadly, the energy required for EFE learning and the line of questioning and inquiry of the Scientific Method does not generally take a major role in business operations meetings. For example, ask yourself how much time is spent in your regular supply chain meetings exploring how much we learned from supply chain disruptions last week (e.g. inventory higher than expected, orders changed more than expected, out of stock on items)? Perhaps you also ask how this learning translated into improving the process over last month? Odds are, if your supply chain operations are like most, very little time or energy is focused on these learning questions. Rather, more likely than not, much of the focus is on how to react to the problem and demands of the day... as opposed to rigorously understanding the root cause and improving the process day-by-day with the supply chain partners to bring stability and improvement to the underlying processes.

Nonetheless, it is important to acknowledge that this line of EFE Learning and Scientific Method reasoning could easily be applied to any organization responsible for getting orders, making parts, and delivering those parts to customers. Let's assume, for example, this organization is seeking an on-time delivery rate of 100%. Over the past few weeks however, the actual delivery has been between 85% and 90%. The supply chain team did a fantastic job responding to the late deliveries, expediting orders through the factory and supply chain to get them to the customers as soon as possible. For the next month, 100% was achieved again... until two months later when it fell to 75%. Just as before, the supply chain team did a great job expediting orders through the factory and supply chain to make sure the customers received their orders as soon as possible, attempting to minimize customer frustration. Now, imagine a supply chain that has thousands of skus, hourly deliveries, dozens of factories around the world, and hundreds of customers to manage. One can see how easy it would be to fall into the reactivity trap, focusing on 'fighting fires' to respond to today's disruption. Often, the reactivity is justified away as the process team members assume (their "mental model") the cause of deviation is exogenous (something that happened and can't be changed) and doesn't recognize the opportunity to improve the underlying process every time something unexpected happens. As we noted earlier, this is the same mental model found in those struggling to learn how to fly or accepting "random" variation in quality control. Sadly, this mental model trap can lead organizations to operate in such a way that 95% of their energy is fire-fighting (reacting), with only a little time or energy spent on proactively improving the process (through EFE learning). Accordingly, the volatility in performance continues and frustration builds. Little time is spent on explicitly learning from today's disruptions [6]. It is not difficult to imagine how the Bullwhip amplification pattern can stay so strong and consistent over 30 years (Figure 7).

Without a commitment to understanding the underlying process deficiencies, substantial improvement will not come. This trap is well-understood and acknowledged across business operations groups. Because of the complexity of global supply chain processes, improvement does not come easily and many assume the process is too complex to control (e.g. flight and SPC stories). The challenge for leaders and managers, however, is to break out of this cycle. To make this break and to dramatically improve supply chain performance, it requires a strong leadership mindset that embraces EFE Learning.

Role of Managers & Leaders - Teach how to learn and provide support to experimentation

Leaders and managers play an essential role in driving operational improvement into complex processes, like supply and demand management. While they need not be experts, they must have a strong enough understanding and skill in process-thinking and learning principles to be able to champion their application throughout the organization. This leadership is essential when embarking on a path of improvement.

With the knowledge of learning processes, managers will realize that the deepest improvements come through their team members and process participants gaining real-world experience and insight through experimentation. This insight encourages them to provide the support, resources and understanding required for an organization to develop meaningful learning and process-thinking capabilities.

In this spirit, managers are not expected to tell workers how the work should be done. Rather, they provide the coaching necessary to develop experiments to learn from the process events, to guide and manage the frequency of those experiences, and to provide the boundaries that allow the experiments to happen without fear and distrust [2, 32].

[6] Peter Senge characterized this common pitfall in his well-known system dynamics "Fixes that Backfire" Archetype

The role of the manager clearly requires a strong level of trust and commitment at all levels of the organization to allow experimentation to be undertaken without fear, where learning is seen as a priority in each individual involved in the processes.

Learning and Process-Thinking are two Key Complementary Behaviors

Summarizing where we have come thus far:

- we have identified the key dynamics that are driving the challenging and complex environment of supply and demand management processes
- we have identified the importance of understanding the 'enterprise' and how supply chain dynamics are heavily impacted by the design and day-to-day interactions of entities within that enterprise
- we have developed a progression of how to improve the supply chain: building behaviors from within the core firm and outward to the enterprise
- we have developed two key behaviors that govern success for improving the supply chain operations: process-thinking & learning
- we have developed general guidelines for designing processes and learning approaches to achieve operational excellence

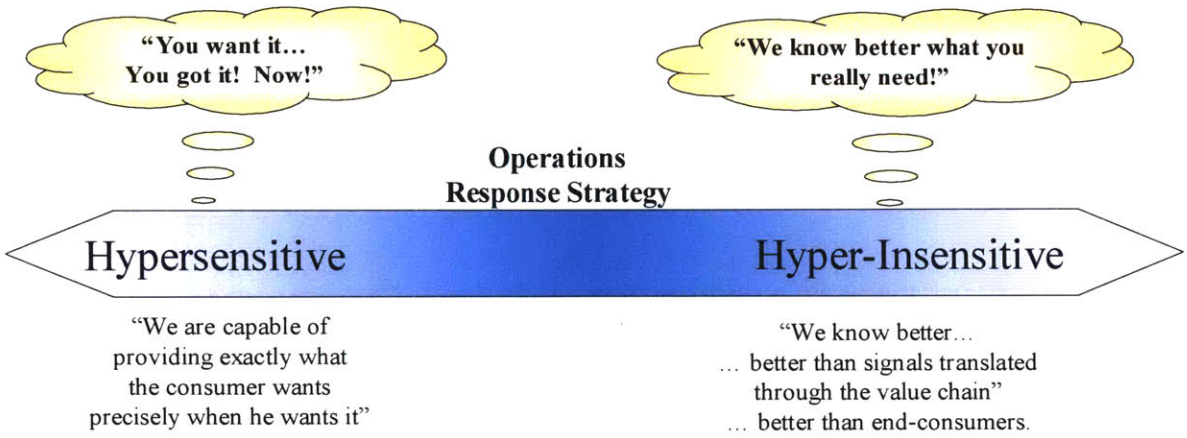
This brings us to a third and essential behavior for operational excellence in supply chains. Given an organization with process-thinking and learning capabilities, the third behavior describes how the supply chain translates inputs from the dynamic outside world into its operations.

2.3.5 Behavior 3: Balance of Long-term & Short-term Thinking – The Tortare Strategy

Now, in the "ideal" world as we explored in the earlier section, the factory makes and delivers the exact product immediately when the customer wants it. In the real world, however, there are many factors that complicate the supply chain. As we explored in Part 1, these complexities in product and information movement can catalyze difficult-to-manage dynamics like the Bullwhip.

When considering how a firm responds to order inputs, one could paint a spectrum of possibilities. On one-end, the firm would immediately make and supply (instantaneously) exactly what the customer says they want. Effectively, this would be the "Super Just-in-Time" supply chain capability. On the other end of the spectrum, the firm would completely ignore today's demand signal from the customers and would produce according to their own very stable and steady schedule. This spectrum is shown in the figure below:

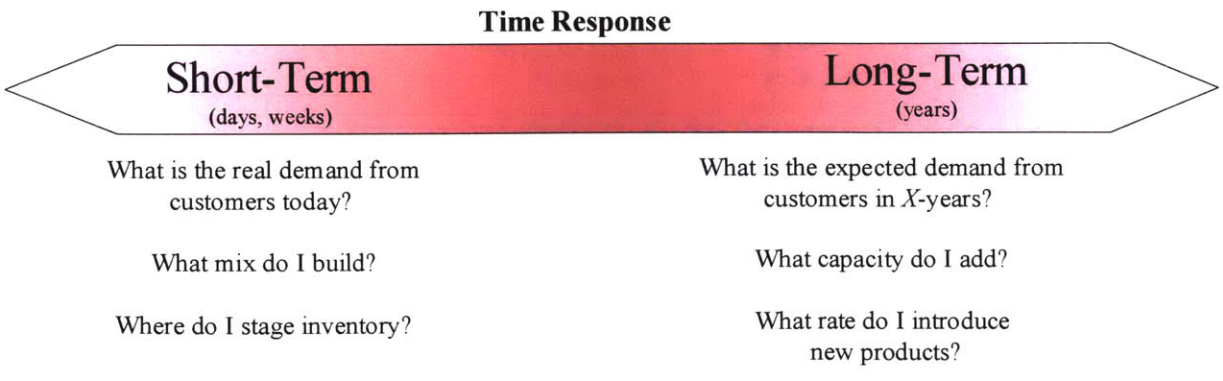
Figure 30: Operations Response Spectrum to Today's Customer Signal



After thinking for a moment, a logical question is "where on the spectrum" is it appropriate to operate your supply chain. In fact, a more precise question is not "where" on the spectrum, but "when" on the spectrum. In other words, when (under what conditions) do you want to exhibit each of these behaviors?

Considering the "when" question, we can paint another operations spectrum on which to consider our behavior. At one end, we have the short-term operational capabilities (asking questions in terms of hours, days and weeks). At the other end, we have the long-term operational capabilities (asking questions that deal with months and years).

Figure 31: Time Response Spectrum



Combining the spectrums of response sensitivity and time-horizon, an interesting picture emerges. The hypersensitive (Super JIT) behavior is ideal when trying to meet the short-term, immediate needs of customers. Thus, 'the faster the better' when considering the following kinds of operational questions:

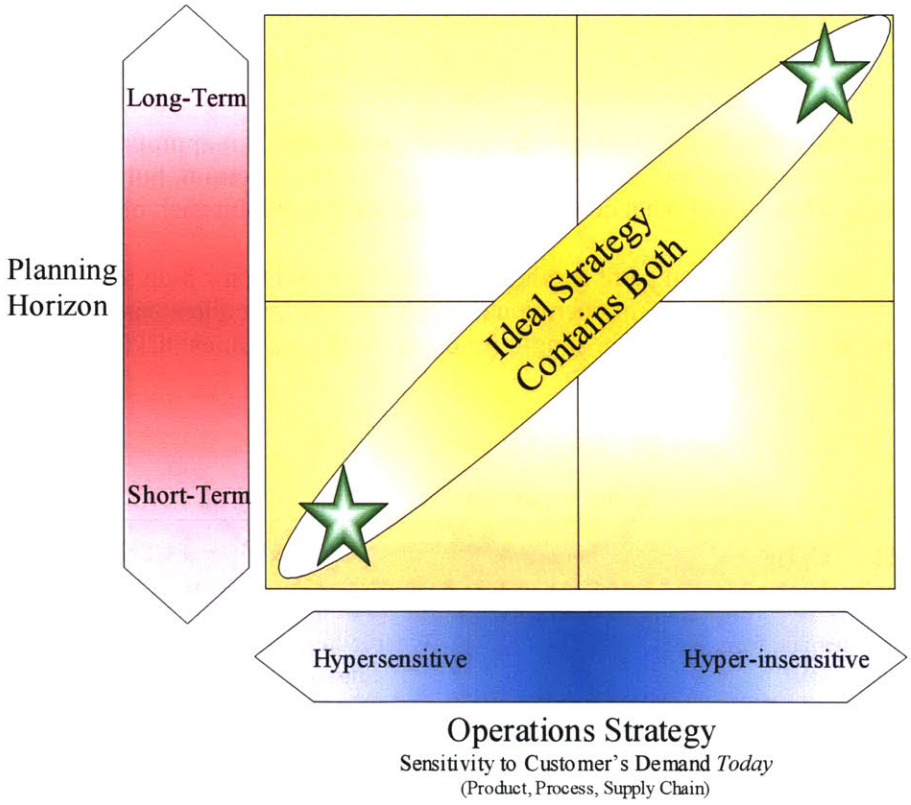
- How long does it take us to make a part that the customer wants today?
- What mix do I build into this week's production schedule?
- Where do I stage inventory this month?

The faster we are able to process information through the supply chain about the customer's short-term needs, the "better" (e.g. higher performing) our supply chain will be behaving. 'Hypersensitivity', implying increasing speed, flexibility and customization, is an ideal supply chain behavior and capability when considering this short-term time horizon.

However, the ideal response sensitivity changes when considering the realities of long-term needs for successful supply chain operations. The signal from customers *today* is precisely representative of what they actually need *today*. However, the signal from customers *today* about what they will need in 1 year… or 3 years is much less precise or certain. Thus, when considering the corporate response to the longer-term needs of the company and the supply chain, listening to the voice of the customer *today* is potentially dangerous behavior. In this long-term horizon, a more thoughtful, steady strategy that brings stability to the growth and operations processes is generally preferred [23, 33].

Thus, the ideal operations response capability is one which combines both speed and flexibility (sensitivity) in the short-term with thoughtful, steady & stable (insensitive) growth strategies in the long-term.

Figure 32: Sensitivity Behavior for Supply Chain Operations



Understanding the Tortoise – Stability

Combining this ideal combination, one can visualize the behavior in term of the strengths and weakness of a tortoise and a hare (remembering Aesop's famous fable). The 'hare' has the capabilities of speed, agility and responsiveness as we would ideally want for our short-term operations (without the tendency to fall asleep, of course). The 'tortoise' brings the ideal capabilities for long-term operations of stability, thoughtfulness and strength in response to shocks in the environment. The capabilities of the 'hare' are well-understood and sought after in most companies' supply chain efforts (reducing lead times, increasing customer responsiveness, etc...). However, the behavior of the 'tortoise' is not as well embraced or understood.

Without long-term success in the supply chain (which depends on, among other things, this restrained sensitivity), it does not matter how fast or responsive your short-term performance is – the company may not be alive to utilize the short-term speed and flexibility (e.g. because it collapsed during the 'bust' or overextended itself during a 'boom'). In the spirit of the 'tortoise', the bullwhip dynamic offers many illustrations of how a more insensitive supply chain can bring stability to the operations that are essential for successful growth. In effect, the 'tortoise' represents the damping capability in the supply chain to reduce variability in inputs and outputs to create a more stable environment for the enterprise (e.g. reduce bullwhip amplification). The following examples help demonstrate the value of and importance of "tortoise-like" (thoughtful, steady, stable) behavior for the supply chain [25, 33]:

- **When a major manufacturer stabilizes the drum beat for the supply chain**
  For example, when a distributor simply refuses to follow the "noise" of the system and continues only to ask for and distribute a stable, steady quantity each time. Many will note that this is a common scenario played to 'beat the bullwhip' in the supply chain simulation exercise known as the 'Beer Game'.

- **When a supplier knows the pipeline is well over any possible demand**
  For example, telecommunications suppliers did *not* exhibit this behavior in the 90s and have been suffering since the tech collapse. The suppliers continued investing in capacity and selling products because their customers were begging for it, even though they knew a huge overcapacity bubble was being built.

- **When customers do not know knew technology five years ahead... but the manufacturers do**
  For example, when a company invests in a new semiconductor fab because they have a better window than today's end-customers as to the technologies that will use those products in three to five years.

- **Stable growth valued over lost sales**
  For example, some companies choose not to follow every growth opportunity (e.g. don't follow the huge upswings), recognizing the net impact after bubble is worse than gain by chasing after unsustainable growth.

In all of these cases, the long-term direction of the company is deliberate and thoughtful, not rooted in the volatile short-term customer signals. Companies like Toyota and Southwest are well-known for their success with this strategy. Companies like GM and People Express are well-known for the 'chasing' behavior (e.g. relatively strong incentives and promotions, frequent layoffs, etc...). This notion of controlled growth and long-term stability is well-documented and researched across fields of study and across industries[7].

[7] Various disciplines have captured how this behavior impacts business operations. Several excellent sources to explore this strategy include: System Dynamics - Overshoot & Collapse Behavior [33]; Finance & Sustainable Growth Strategies [9]; Supply Chain / Manufacturing & Lean Operations [23, 36]

Lean Operations Thinking – The Need to be the Tortoise & the Hare

Specifically, in fact, this "hare and tortoise" mentality is actually at the essence of many world-class "lean" operations. From Toyota in the auto industry to the Dell in the PC industry, the power of these principles in creating competitive advantages is well-known. The intent of this section is to briefly highlight the key dimensions of lean operations and identify how this "hare and tortoise" framework captures the spirit of this powerful operations approach. It will explore briefly how our model may help to identify the untapped potential for supply chains from lean practices.

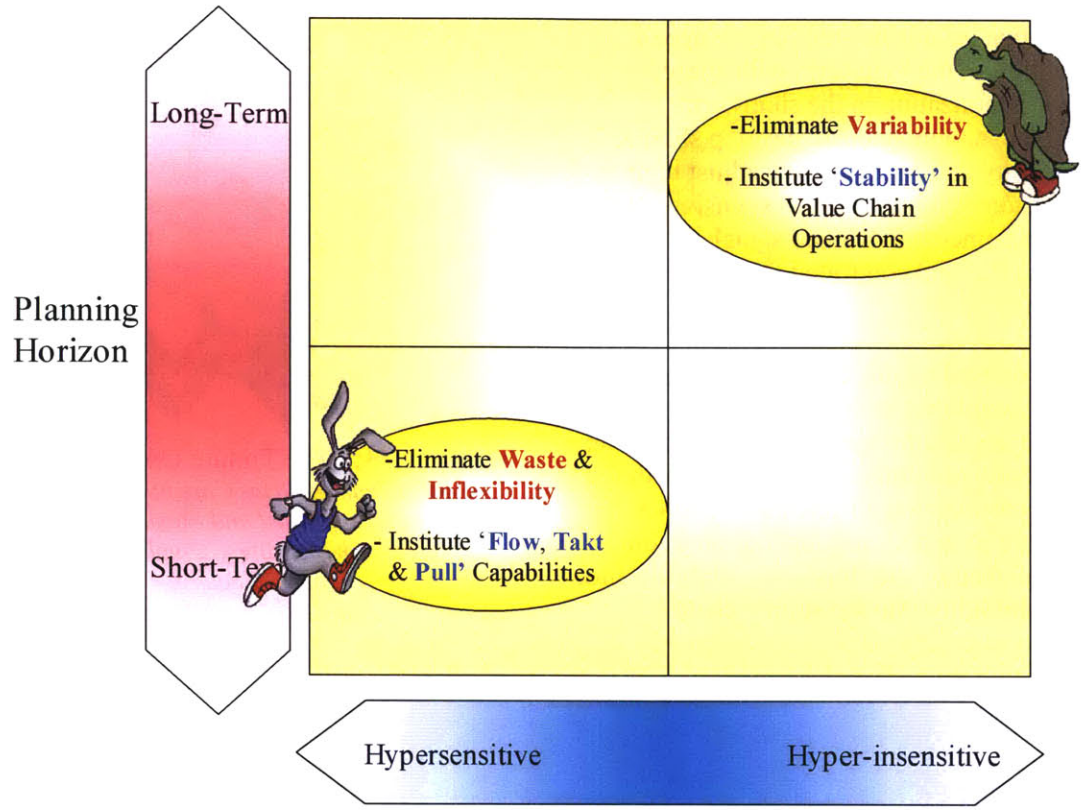
While many companies acknowledge 'elimination of waste' as the primary goal of lean operations, in fact, waste is only one of the "Three Evils" to be eliminated. From Taichi Ohno, the "Three Evils" are: Variability, Inflexibility and Waste [23]. To eliminate these evils and enhance the capabilities of the operation, lean practitioners embrace four key tactics [23, 36].

- **Stability:** reduce input variability to allow smooth flow to happen
- **Flow:** designing the process such products move smoothly, without disruption (e.g. single-piece flow)
- **Takt:** matching the rate of production with the rate of customer demand
- **Pull:** controlling production and supply chain movement by simple signals triggered by the consumer

The evils of Inflexibility and Waste relate to common supply chain goals of increasing speed (velocity) and customization capabilities. The third evil, variability, is perhaps the most overlooked of the three. Research has shown that for the tactics of flow, takt and pull to be truly effective, the supply chain must have some form of stability (lack of variation) in the input to the supply chain [23]. This stability relates in principle to the "tortoise" behavior in our model.

Mapping the 'Three Evils' and the four key tactics to our model, we again see the importance of a supply chain operations strategy that is capable of both short-term speed, flexibility and customization (the hare) as well as the thoughtful, rational, deliberate growth and production planning strategy (the tortoise).

Figure 33: Lean Thinking Applied to Sensitivity Matrix



Beyond characterizing the core components of lean, other insights captured in the model include:

- **Dual Strategy requires alignment and understanding beyond firm**
  To be able to behave as a 'hare' in certain situations and the 'tortoise' in others, the entire supply chain should be aligned around these behaviors and values; otherwise, disruption and inefficiency will result from the lack of mutual understanding. Additionally, implementing stabilizing policies in the supply chain (e.g. don't excessively chase growth , don't overreact in the short-term and fire tens of thousands in the downturn) will require the support of the most senior management within the firm, as well as within that of key supply chain partners.

- **Most supply chain projects only improve the 'hare' capabilities**
  When looking at the major supply chain tools and strategies of the past decades, most (if not all) can be classified as intending to increase speed of information or product flow, short-term flexibility, and customization; very few emphasize value chain stability. This is explored in more detail in Part 3.

- **Stability of Tortoise is key on multiple dimensions, including information and personnel**
  While stability in production and supply chain signals are essential dimensions of the 'tortoise' behavior, we must also acknowledge the importance of personnel stability in operational performance. In long-term relationships that are rich in personal contact, knowledge and connections, even minor disruptions in some such relationships should be managed with care and thoughtful planning.

Balance of Hyper-Sensitivity & Insensitivity a Key Operations Behavior

In summary, this section established a supply chain behavior model that establishes the importance of combining stability in the long-term with speed, flexibility and customization in the short-term. Companies need to simultaneously develop short & long-term capability and appropriately adjust their sensitivity to customer inputs: fast, responsive, and customizable for immediate demand signals… deliberate, thoughtful and controlled for the long-term horizon decisions.

The approach proposed by this dual-pronged operations strategy was then explored in the context of lean operations principles. Although most people attribute the benefits of lean operations to those found with the 'hare' (speed, customization, efficiencies), in fact, the success of the hare's capabilities depends on a solid foundation established by the 'tortoise' – stability and elimination of variability into the supply chain.

Figure 34: 'The Tortare Operations' *Supply Chain that Has Capability in both Short-term Speed and Flexibility & Long-term Stability… coupled with Process Focus & Learning Capabilities*

2.4 SUMMARY: BEHAVIORS UNDERLIE ENTEPRISE OPERATIONAL SUCCESS

Summarizing where we have come thus far, Part 1 explored the key dynamics that drive the complex environment of supply and demand management processes. It also presented a summary of Intel's supply chain and operations, developing an understanding of the importance of behaviors and capabilities in the foundation of complex operations. Part 2 first mapped how to understand how the 'enterprise' dynamics are impacted by the interactions of entities within that enterprise. Second, we developed a progression of how to improve the supply chain by working from the inside out. Third, we have developed an understanding of three key behaviors that govern success for improving the supply chain operations: process-thinking, learning and balanced sensitivity throughout the operations.

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Part 3 develops various tools and tactics an organization can undertake in an effort to navigate the dynamic complexity of its environment (Part 1) while building the behaviors and capabilities required for operational success (Part 2). Three case examples are presented from the work done with Intel's business operations group.

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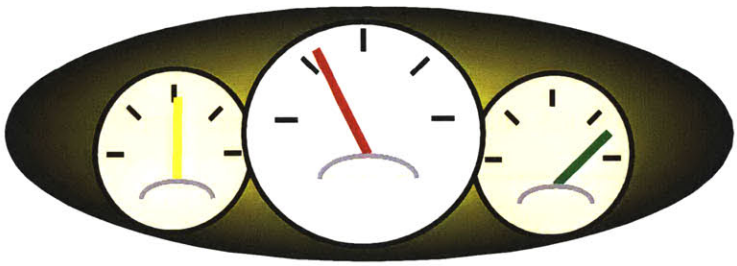
PART 3: ENTERPRISE DESIGN: MECHANISMS & MANAGEMENT PRACTICES



"Trying to guide a team without a good simple, guidance system is like trying to drive a car without a dashboard"

- Chris Meyer, Management Consultant & Author [24]

PART 3: ENTERPRISE DESIGN: MECHANISMS & MANAGEMENT PRACTICES

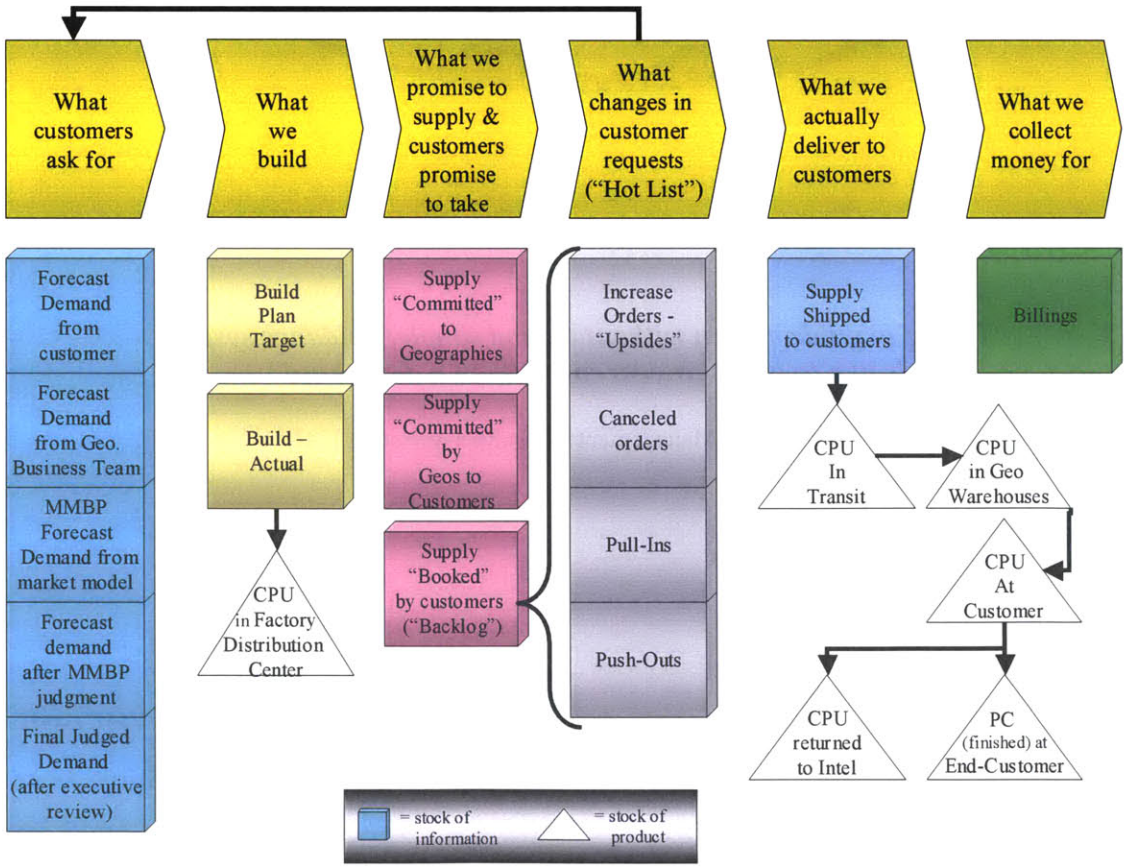
This section presents various mechanisms and tactics an enterprise might use to achieve the desired behavior in its operations. Specifically, we explore how to develop these behaviors in Intel's supply chain operations in an effort to better match supply with demand. Using three examples from the research and work done with Intel's business operations group, it presents the implementation of several tools and tactics which are rooted in the behavioral approach to operations described in Part 2.

3.1 MAPPING THE INTEL SUPPLY-DEMAND PROCESSES

As we have explored in Part 1, Intel is seeking to improve "how well it can match supply with demand" as it operates in a complex and dynamic environment. This can be stated more generically as seeking to improve the operations of its supply-demand 'processes' as we defined in Part 2. No matter the complexity, the basic capability of process-thinking, learning and sensitivity balance can help bring order to the apparent chaos, drive out uncertainty and drive forward meaningful improvement.

Building on the overview of Intel's supply chain from Part 1, the following figure summarizes the basic flow of products and information in Intel's process of taking orders, producing products, and delivering products to customers.

Figure 35: Information Staging in Demand-Supply Process



Through the course of the research, each of these sub-processes in the map was explored with the relevant operation members in order to build an understanding of the end-to-end process. As an example of more detailed-level mapping, the following diagram shows the first phase of the demand forecasting process.

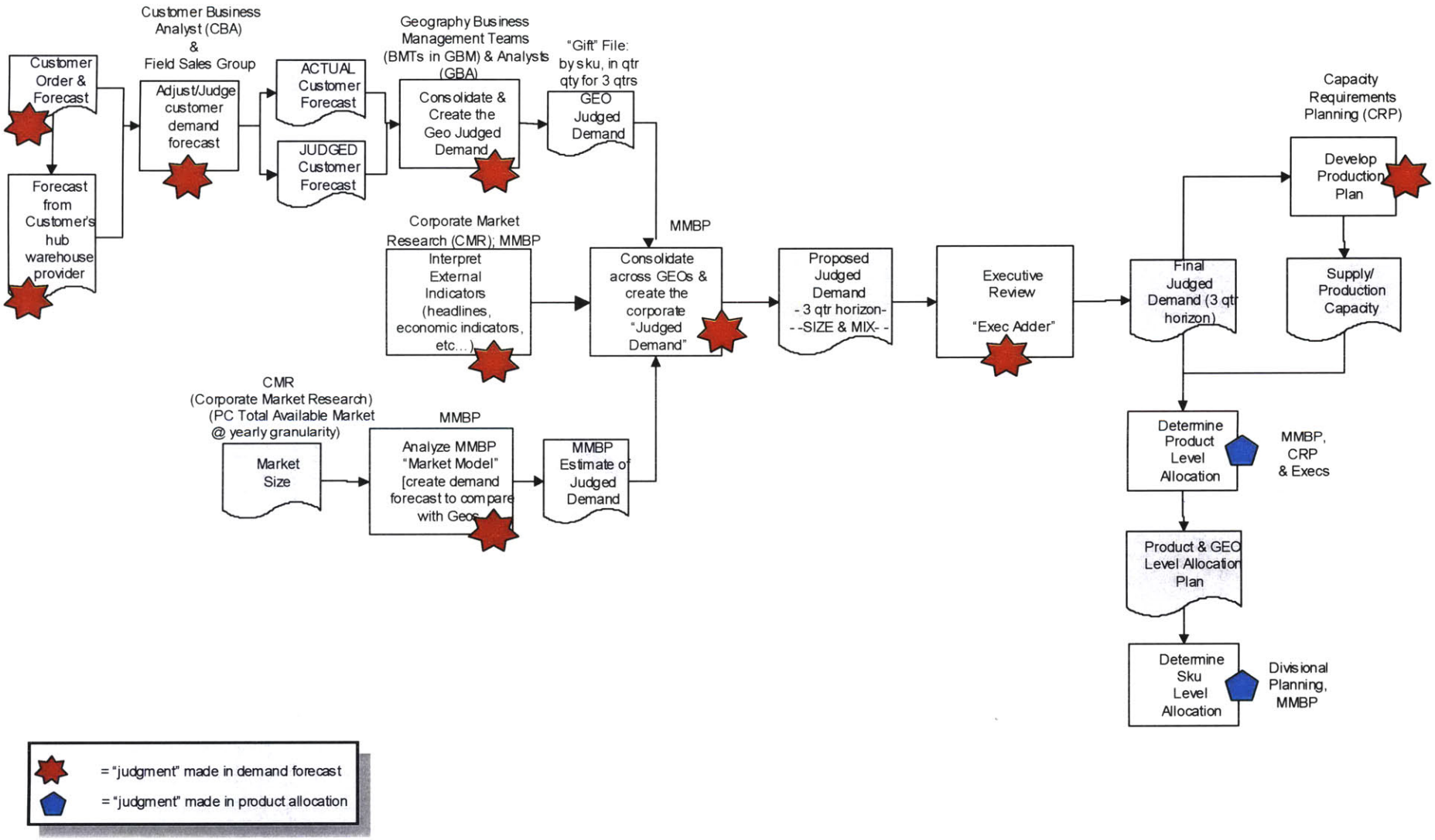


Figure 36: Summary of Demand Forecasting Process and Information Flow into Supply Allocation Planning

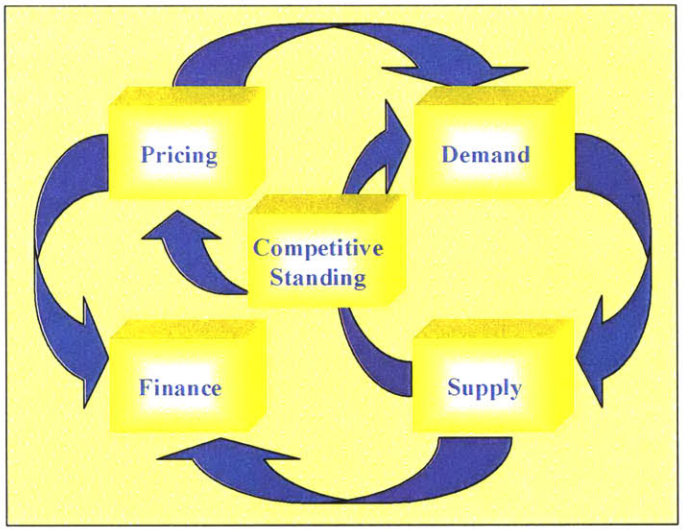
While we will not go into great detail here, several key observations of this process are worth noting as a representation of the characteristics and environment of the other key supply-demand processes:

- Many cross-functional exchanges occur
- Many cross-geographical exchanges occur
- Many cross-organizational chart exchanges occur
- Many individuals are involved
- Dozens of complex interfaces exist between customers and suppliers of information
- Many 'judgments' are made before information is passed down the line

Process Interdependency adds Complexity

While the sheer number of processes involved is important in painting the picture of complexity, it is also important to understanding that the success of the overall supply-demand process depends on each of these different groups working in alignment. For example, changing the pricing impacts the sales, which impacts inventory, which impacts our forecasting, which can lead to shortages, which can impact our competitive standing, etc. Mapping this interdependency and developing learning mechanisms to understand it are essential when making decisions in such an interdependent and dynamic environment.

Figure 37: Process Inter-Dependency in MMBP



With the past section only shows a subset of the overall supply demand process for Intel, it is well representative of the other segments of the supply-demand process (both within the firm and within each of the supply-chain partners). The number of interactions and the complexity in information and product flows can seem overwhelming. With hundreds of individuals transferring and receiving information, making judgments on that information, and then passing it down the line, the opportunity for mistakes, gaming, delays and mis-signaling is tremendous. We will recall from Part 1 that these process risks are exactly the key causes of the bullwhip effect and other supply chain inefficiencies.

Incentives drive behaviors in the processes

Additionally, considering the many functional and organizational groups involved, it is important to acknowledge and understand the incentives for each of the different functions. The following figure shows a representative sample of how different functions at Intel can be driven to place bias on different results. This awareness is essential as any attempts to improve the process or change behavior.

Figure 38: Incentives & Priorities Vary Across Function

Key Results Incentives	Business Operations	Geo Business Teams	Planning	Manufacturing
Market Segment Share	High	High	Med	Med
Average Selling Price	High	High	Med	Med
Revenue	High	High	Med	Med
Margin	High	Med	Med	Med
Cost	High	Med	Med	High
Inventory	High	Med	High	High
Delivery Performance (to Backlog)	High	High	High	High

Extrapolate Intra-Firm Process-Alignment to Supply Chain - - Significant Complexity Emerges

To make the challenge of balancing supply and demand even more difficult, when considering the bullwhip dynamics from Part 1, we note that, in fact, the success of the supply-demand process does not just depend on the successful alignment of these Intel processes… but it depends on the alignment of an equally complex web of processes for all other companies within its supply chain (customers, distributors, retailers, suppliers, etc…).

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In total, we can paint the picture of complexity in supply chain operations quite quickly. Nonetheless, using the key behaviors and capabilities explored earlier (process-thinking, EFE learning & balanced response), we can quickly begin to get our arms around the challenge. The first tactic we will explore is a 'Supply Demand Dashboard'. First, it is a vehicle for identifying the key processes that govern successful operations. Second, it creates a mechanism for bringing EFE learning into the organization to improve those processes and our understanding of them. Third, it can be a gauge for ensuring the balance between long-term and short-term sensitivity in the operations.

3.2 DASHBOARD – BUILDING PROCESS-FOCUS, ALIGNMENT & LEARNING

As we discussed in Part 2, it is important for organizations to have a way to boil down the immense complexity of their supply chain operations into something that can be managed. Recognizing the need to get alignment around both the **results** of the business process as well as the **processes** that were used to achieve those results, a "Supply Chain Dashboard" (SDD) has been proven to be a powerful and effective tool [5, 24, 15, 16, 17]. This section follows the implementation of an SDD within Intel's business operations group.

Meeting the Concern: Not Optimally Matching Supply and Demand

At Intel, there was a general consensus that the supply chain operations processes were not optimally matching supply with demand. A reported $225MM underutilization charge in the third quarter of 2002 , large inventory fluctuations, and frequent forecast errors are just several examples of how improved supply-demand management could benefit the company.

Common Operations Measurement Pitfall: Lose sight of the Processes

When managing a complex process like matching supply with demand, the most common metrics used focus on ***results*** (e.g. quarterly revenue/profit; inventory levels). Rarely do metrics clearly capture or connect with the ***processes*** that are intended to achieve those results. As metrics can be an important guide to an organization trying to improve, high-performing operations understand the need to utilize both process-focused and results measures in a proactive sense.

To assess whether your measurement system is well-balanced between results and process thinking, some helpful questions to be ask include:

- Do we know how our performance in a particular process (e.g. forecasting, pricing) impacted the result (revenue)? Do we use that information to improve our processes?
- How well (poorly) do we perform our processes? Did we do better than last week? Why or Why not?
- Are we looking at improving the correct processes to achieve the desired results?

These kinds of questions help the organization to start building connections between their day-to-day processes and the larger business results they are trying to achieve. In doing so, the teams responsible for the processes are motivated to deeply *understand the end-to-end process* that brings about success (our first essential behavior). Once the organization begins thinking about these kinds of process questions, the groundwork is also established to engage in the intensive and powerful learning and improvement cycles imbedded in EFE Learning and the Scientific Method (our second key behavior). The Supply Chain Dashboard is a tool for bringing this thinking in a systematic way to an organization.

Dashboard – A Vehicle for Capability Building, Not Just Reporting

Simply, the Supply-Demand Dashboard (SDD) is a consolidated measurement process and tool that provides two things:

1) a reporting tool (display) for key results metrics and process metrics (10 – 15 at most) to regularly inform the operations team and management how they are doing in the supply-demand process
2) a forum and process to build the organizations capability in EFE Learning and Process-Thinking

The basic idea is very similar to the popular Balanced Scorecard concept [5, 15, 16]. Both are intended to bring alignment to people working in complex operations across functions in terms of priorities and expectations. The primary difference is the SDD emphasizes the processes underlying the results and using the dashboard not as a reporting tool, but as a vehicle for learning and process-thinking.

Results & Process Metrics – Both Necessary & Important

As a team embarks on creating a Supply Chain Dashboard, the distinction between results and process metrics is important not to overlook. Results Metrics tell an organization where it stands in its efforts to achieve goals, but *not* how it got there or, more importantly, what it should do differently to improve [5]. Some typical supply chain results metrics at Intel included market share, average selling price, revenues and gross margins.

Process Metrics, on the other hand, monitor the tasks & activities throughout an organization that produce the desired results. For example, they can include the quality of synchronization between groups or the quality of learning or improvement in a process, bullwhip amplification, etc….

To help clarify the difference, consider a dieter wants to lose weight. Often , a dieter who focuses solely on their body weight *[results metric]* will struggle to find lasting success on their journey. However, a dieter will experience a much higher success level when they balance their eye on results with an eye on exercise frequency, calorie & nutrient intake, and lifestyle quality *[process metrics]* [5]. In other words, without the good design and execution of the processes, no good results will follow. Thus, our challenge is to make sure our processes are as good as they can be – whether we are getting our bodies in shape… or our supply chains.

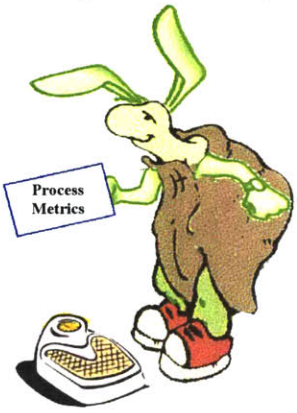


Figure 39: 'Tortare' Uses Results & Process Metrics for 'Fit Operations'

Modes of Failure – How does Supply-Demand Process get Disrupted?

In manufacturing, one could contend that measuring process performance is relatively straight-forward. If you do not meet expected quality and production volume, for example, one can conclude the production process incurred some form of a disruption. In supply chain operations, these same kinds of disruptions happen every day. They can manifest themselves, for example, in the following ways [27]:

- Forecast error – when actual demand is over/under your expected
- Delivery performance – when you fall below target on-time delivery
- Price Trend – when average pricing falls (rises) more than expected
- Cancellations / Upsides – when a customer cancels /increases volume of an order
- Obsolete – when parts are discarded because there is no demand
- Swaps – when a customer wants a different part today than he wanted yesterday
- Pull-ins / Push-outs – when a customer wants parts delivered sooner / later

Acknowledging the many perturbations in the supply chain, the following chart characterizes some of the more common measures of supply chain performance. It identifies whether they are most prevalent when demand is greater than supply, when demand is less than supply, when the overall process is disrupted, and how that disruption translates into end business results.

Figure 40: Common Measures of Supply-Demand Process Disruption

If one were to monitor any of the items on this list, you could identify if something in the process happened that was not expected. Of course, every disruption signal can have many possible causes (i.e. uncertainty). As we explored in part 2, our reaction to this uncertainty is a key differentiator of 'intelligent' operations. This 'disruption' or 'surprise' presents an opportunity for learning and process improvement. Does the organization engage in rigorous learning through thoughtful experimentation, or does it passively react to the disruption?

Take the customer demand quantity from an OEM, for example. In some cases, the simple cause of a change in their order volume may be because their end-customer demand changed and it is getting handed down the supply chain to you. In others, it may be because they are gaming their orders to make sure they get the parts they want. In others, they may be reacting to a price change you made or they are expecting you to make. In fact, the cause may be one of more than a dozen possible things. The challenge and opportunity for supply chain operators is develop the capability in the supply chain to quickly and effectively learn from the disruption, understand the real cause, and optimize the supply chain response accordingly. Each time one of these events occurs, organizations have an opportunity to learn (e.g. the scientific method or other thoughtful problem solving methods), improve the process and make it less susceptible to variation or a repeat of a similar problem in the future.

Clearly, in a process as complex as Intel's (with thousands of orders input and changed a day), every disruption across every possible measure can not realistically be assessed in a rigorous fashion. Instead, the organization must have a way of prioritizing those items which are most essential to learn from and those that have the biggest impact on the key results. Accordingly, this research developed a "Supply-Demand Dashboard Process" with the business operations group to serve this end.

Process for Developing a SDD – Start with the core group and work out

The process for developing the SDD with Intel emphasized the following goals:

- get alignment and participation across functions at all levels
- build understanding of process & results thinking
- develop mind-set to embrace EFE learning (i.e. it is not just a reporting tool)
- keep it simple with minimal administrative burden to build momentum quickly
- ensure senior management adoption and support

With this mindset, the steps in developing the SDD for Intel's business operations group are explained below [16, 17].

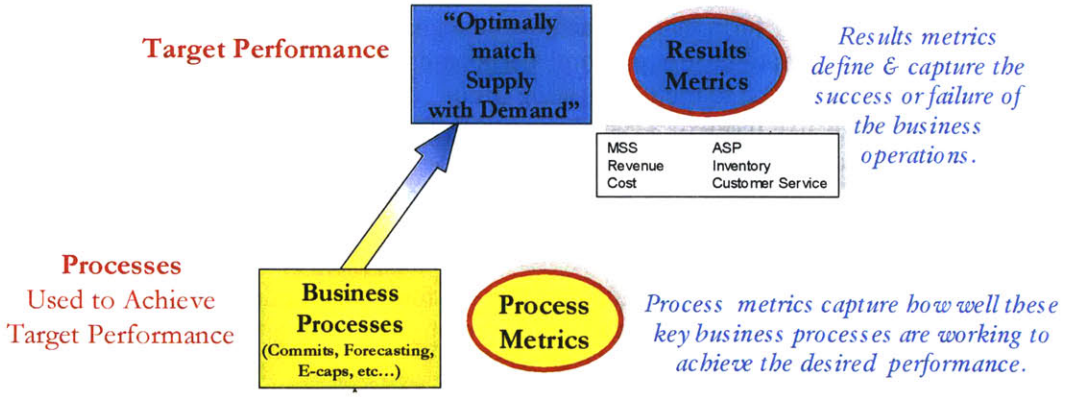
Step 1: Define boundaries… start with the core

As we explored earlier, given the importance of behaviors in driving operational improvement, these behaviors and principles must be well-established in the core of the firm before they are rolled out to the supply chain partners. Accordingly, the process for developing the SDD started with a focus on Intel's core business operations team (MMBP – Microprocessor Marketing and Business Planning). As MMBP contains five of the ten core supply-demand process components (Pricing, Demand Forecasting, Supply Allocation, Finance, Competitive Analysis), a solid nucleus was established for bringing the SDD to Intel's supply chain. A cross-functional team representing these five groups was formed to develop a draft SDD.

Step 2: Develop metrics list… learn behaviors… prioritize through iteration

In the early stage, the team walked through a brainstorming process to generate a list of the many possible results and process metrics, thinking through those that really defined and governed success. Over the course of several weeks, the SDD team held meetings to iterate through and filter this list more than four times. This iterative process also served to instill the values of process-thinking and learning in the core team.

Figure 41: Iterating Between Process & Results Metrics To Develop SDD



By the end of the fourth iteration, the metrics had been narrowed down to a total of 15 key metrics, each of which was confirmed viable (in terms of ability to collect and process data to report).

Step 3: Determine levels and roll-up process
While a single dashboard was defined for the overall supply-demand processes managed by the division (MMBP), the individual groups (e.g .Demand Management, Supply Management) found value in having a more focused dashboard to help them manage the sub-processes of their group in a more local fashion. Accordingly, the key metrics from the group-level dashboards were simply rolled up into the division-level dashboard (helping to reduce the administrative burden).

Step 4: Design the format for learning from the dashboard
Once the metrics were established, the real value of the SDD Process begins: the iterative cycles of learning and process improvement. Through occasional update and review, the cross-functional team will update the process and results metrics. This is not simply a reporting exercise; rather it is a catalyst for each operations member and the collective team to learn from what the measures are indicating. It is a trigger to apply the Scientific Method to results that are surprises, difficult to explain, and/or critical disruptions in the success of the overall supply-demand process.

The SDD core team at Intel determined the desired frequency of reviewing the dashboard at the division level should be every other month, while a more frequent use would be planned for the group-level (e.g. every other week). These sessions promote active problem-solving and learning as the team seeks to better understand the interconnectedness of the complex processes and to steadily improve them (not simply reporting how we reactively engaged in 'firefighting' in response to a problem).

Step 5: Review with broader group for buy-in & Get Started
With a draft set of metrics in-hand and a vision of how the tool could be used to develop the organizational capabilities, it was reviewed and approved at the Vice-President level to be piloted and sponsored by the MMBP division. Shortly after launching the pilot in MMBP, the idea was introduced and warmly received by other groups who are intimately involved in the supply-chain process (e.g. Customer Business Groups) in an effort to build awareness for an eventual roll-out once the process is practiced and proven at the core business level.

Step 6: Refine the presentation format
The format of the dashboard is a common question - - Is it a spreadsheet? Is it a collection of graphs? The best answer is that it may take any form that best achieves the goals of capturing the information of importance for the particular operations group. Some dashboards may be nothing more than a document with a list of metrics and arrows next to them indicating strong, weak or negative performance to target. Others may prefer to use dials like those of a car's speedometer to capture status to target. Others may use a spreadsheet that has a column of actual values next to target values and then highlight the cells in red, yellow or green depending on the status. Others may wish to show plots of trend data. Others may be a unique combination of these and other formats.

In general, however, the dashboard format should consider the following guidelines [5]:

- it should be simple and visual like the dashboard of your car (e.g. colors, graphs, indicator arrows)
- it should be contained to a single page for simplicity
- it should be able to updated with limited administrative burden
- it should be easy to change (as the metrics may fluctuate over time as the team learns about what works and what does not)
- it should be accessible by a many people (all of those involved in the relevant processes)

Avoid Pitfalls: Just Keeping Score & Not Building Capabilities

While the pilot Supply-Demand Dashboard was launched with good success, the organization must be cautious to avoid common pitfalls:

- **Don't lose sight of the value of the tool as a forum for learning, and just see it as a goal alignment tool!**
    - It is easy to just think of the dashboard as a summary performance scorecard, and forget about the behavior-building intent of the tool. While scorecards are helpful in their own right, the most meaningful impact from the SDD will come from developing behaviors and methodically learning from disruptions in performance.

- **Don't get lost in the numbers!**
    - Because of the complexity of the supply chain, it is easy to get frustrated and overwhelmed by the numbers and process complexity. Keep the metrics limited in number (15 at most). If they are really important, then it is worth spending the administrative energy to collect the data. If they are not, don't waste time and risk losing momentum around the idea.

- **Leadership and courage are essential!**
    - The SDD process demands additional time and energy from the staff to focus on learning and understanding processes in a deeper way than had been done before. It also involves most people learning new skills: learning how to learn... and learning ways to understand process complexity. This naturally will demand more time from them. For the organization to really evolve, the leadership must embrace and champion the importance of long-term behavioral growth and accept the potential short-term impact on the staff's time. If the leader does not understand the power of learning and process-thinking in a methodical way himself, he will not support the effort and it will not succeed in the long-run. The organization will be forced to settle with a traditional report-card instead of a powerful vehicle for dramatic process improvement and organizational capability building.

Value of Supply-Dashboard Approach at Intel

Upon starting the pilot introduction of the Supply-Demand Dashboard at Intel, those who participated identified the following benefits and successes:

Figure 42: Dashboard to Help Steer Organization to Success

- **Aligns** the organization around common goals (for results and processes)
- **Connects** the Processes & the Results
  - Explicitly capture "how" we plan to achieve the results targets
  - Don't lose track of the process just because the external environment is complex and volatile (e.g. blame the weather for everything)
- Connects **'My Work'** to the Target Results
  - Measure things on which we have a direct impact… things which we can control
- Provides **mechanism for dialogue that facilitates learning** and institutionalizing knowledge
  - continuously improving the performance of supply-demand matching
  - Tool to build common understanding of key challenges and interactions among the processes/groups; creates a forum for knowledge and insight exchange (not just data transfer)
- Creates **cross-functional alignment**
  - Not just assessing "my" process… but looking at how key connected processes and groups are interacting… which collectively determine success for the system

Sample Dashboard Metrics – Results and Processes at Intel

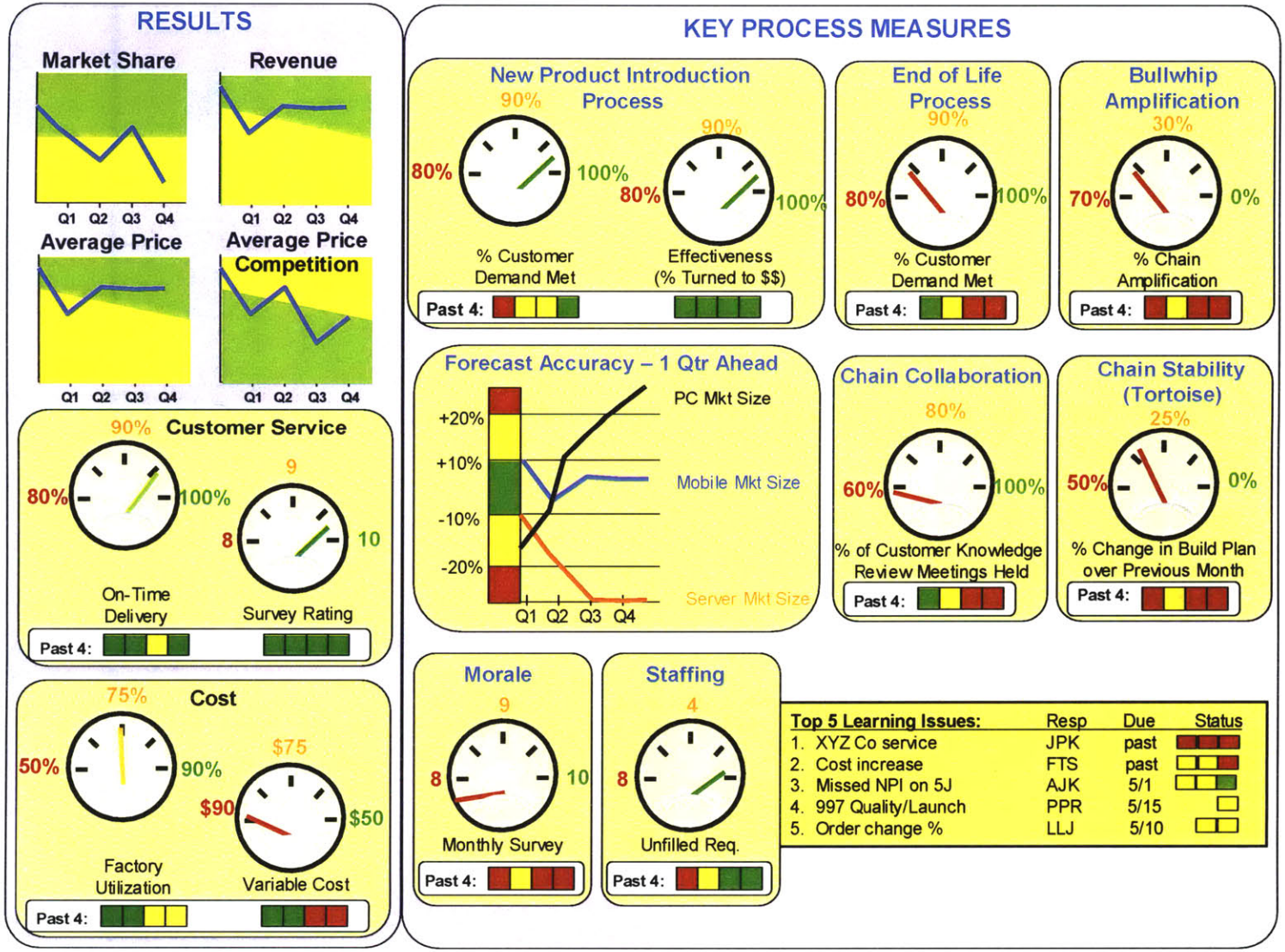
The importance of the implementation of the SDD at Intel did not lie in the specific metrics derived. Rather, the value came in building the awareness of the importance of behaviors and how those behaviors drive success. By using a tool like the SDD, the metrics themselves will evolve over time (as has been seen in the first few months at Intel), but the desired behaviors will be reinforced on a regular basis as the team iterates through the learning process and the improvements are steadily found.

Additionally, as the SDD takes shape, the team has the ability and option to use increasingly sophisticated statistical analysis techniques to identify disruptions and anomalies in the process that warrant further attention. The first step, however, is to build the behavior pattern founded in process-thinking and learning… after which many analytical tactics might be pursued to aid the learning process.

A sample of a supply-demand dashboard is shown in Figure 43 [8]. While the data is fictitious, the sample is intended to present a spectrum of possibilities for ways your organization might present and capture the metrics. In Intel's case, a simple spreadsheet was used to start the process instead of the visual dial-indicator approach shown here. Depending on the corporate culture, data availability, types of metrics selected, each dashboard will have it's own distinct appearance. The important thing to remember, however, is staying true to the intent of the dashboard in terms of both its content and the process for using it to learn.

[8] The actual metrics used by Intel have been disguised for confidentiality purposes. This dashboard is only intended to serve as an example with which each person might develop their own creative way to capture and communicate the status of their processes and to stimulate the organization to embrace the tool and process for ongoing learning.

Figure 43: Sample Dashboard Components



Summary: Dashboard serves as vehicle for process-thinking and learning to drive improvement

In summary, the Supply-Demand Dashboard concept provides a framework for understanding where a complex process is strong and where it is weak. It not only gives static information on reported performance, but it more importantly creates a cross-functional forum where the team can engage in experiential, frequent and experimental learning. This learning cycle develops a better understand of how processes connect with results and enables the organization to drive improvement with that understanding. Additionally, it provides an opportunity for key behaviors like process-thinking, enterprise collaboration, and balanced sensitivity to inputs to be prioritized, emphasized and communicated throughout the organization.

3.3 CUSTOMER CONTRACT DEVELOPMENT – KNOWLEDGE SHARING & LEARNING

The previous section explored how the Supply-Demand Dashboard develops intra-firm capabilities in learning and process-thinking, essential steps in building the capability in the rest of the value chain. Based on work done with Intel during this research, this section explores how structuring contracts with suppliers offers unique opportunities for building and cascading the same capabilities in the supply chain. It explores the importance of thinking strategically about the content of the contracts and the motivations underlying their development.

Contract development and new program introductions present firms with great opportunities to strengthen the customer-supplier relationships and to evolve their quality and behaviors to better meet the operational demands. In the Fall of 2002, Intel was in the midst of developing a new technology and supply chain partnership with a collection of customers of emerging power and influence in the computing industry, "ISN Corporation"[9]. While traditionally Intel's Sales & Marketing organization led supply line agreement development, this particular partnership had unique strategic components that pulled in a cross-section of people from the business operations team (MMBP). A cross-functional team was chartered (in which I participated) to develop a strategy for the contract, specifically focusing on what Intel would "give" to the customer in terms of supply chain support and what it would "get" in return.

Initially, the team was heavily focused on information and data exchange as the primary "give" or "get" vehicle for the contract. However, upon thinking more broadly about the connection between Intel as a supplier and ISN as a customer, the richness of the contract opportunity to more dramatically improve supply chain operations was seen. Reflecting the key dynamics explored in Part 1 and the key behaviors explored in Part 2, several key themes emerged. These themes help present a framework which can be generally applied when embarking on any customer-supplier contract development effort.

Core Themes of Contract Development [6, 19, 25]**:**

- Establish a framework and method for **sharing knowledge and information**
  - Specific to this supply chain, build awareness and get alignment on the nature and impact of key supply chain dynamics
    - Bullwhip effect
    - Technology development cycles
    - Globalization
  - Use information and knowledge, exchanged in both directions, to help minimize supply chain volatility and improve efficiency

- Develop supply chain alignment and **process-focus**
  - Align processes across the organizational boundaries; map and understand the **end-to-end processes** relative to this specific customer-supplier connection
  - Agree on the **"ideal"** way the supply chain should perform (set expectations)

- Develop a vehicles for **learning** and **process improvement**
  - Establish **forums** for regular interface (e.g. weekly conference calls, quarterly learning forums, etc…)
  - **Train** the supply chain operations personnel in learning and process-thinking techniques (e.g. Scientific Method, Bullwhip – Beer Game)

[9] "ISN Corporation" and the exact nature of ISN's business have been disguised for confidentiality purposes.

- Establish clear **norms** for how to work together (e.g. EFE learning, process-focused operations)
- Establish clear **mechanisms** for capturing how well the process is working (e.g. Supply-Demand Dashboard applied to customer-supplier performance)

With this framework in mind, the contract eventually crystallized with the following elements being exchanged between Intel and their customer, ISN.

"Gets" – From Customer to Supplier:

The customer, situated downstream in the computer value chain, has valuable insight and perspective as to what the market is doing which Intel does not have as a component supplier. Accordingly, as we explored in Part 1, Intel has much to gain from a collaborative and trusting relationship where knowledge and information can be shared openly and regularly. In this spirit, some of the key items ISN will provide to Intel via this contract include:

- Pipeline Inventory
  - Raw Materials, Work-in-process, Finished Goods at the customer's factory, Finished Goods at the distribution locations
- Sales Breakdown
  - By Path: Direct to customer, OEM , Distribution Channel
  - Geography: List major locations for each distribution path
  - Customer Segment: Consumer vs. Corporate
- Build Plan (Forecast and Actual)
- Subjective Assessments (Surveys / Quarterly Business Meetings)

"Gives" – From Supplier to Customer:

Because Intel supplies over 80% of the microprocessors to the computing world, it has a unique visibility into the supply chain and its behavior. This visibility can be very useful in smaller firms up the chain managing their production and inventory strategies. While legal and proprietary information restrictions need to be carefully managed, Intel has a tremendous amount of potential insight and assistance to provide to companies like ISN, who in turn, can help Intel bring a better sense of stability and efficiency to the overall supply chain. Specifically, some of the key items Intel might provide to ISN via this contract include:

- High - Level Market Analysis
  - Guidance Package (volume mix, product end-of-life scheduling, capacity & supply limitations)
  - Growth expectations (overall market, vertical segment, customer segment)
  - Roadmap training on new products and technologies
- Market Analysis & Performance Assessment
  - Analyze where customer stands with respect to their peer group whom Intel supplies
  - Provide both objective and subjective feedback on customer performance
- Feedback on Chain Dynamics
- Regular Senior Level Access
  - Quarterly meetings: dialogue around above information & market activity
  - Annual conferences: cross-company, cross-value chain dialogue

Summary: Contracts offer opportunity for building enterprise alignment and learning mechanisms

As we explored in Part 1, knowledge exchange via trusting, collaborative relationships is a key factor in supply chain operational stability and performance. Approaching a new contract with these broader themes rooted in knowledge exchange and in the desired operational behavior of the supply chain will yield a much more meaningful connection with the customer. However, for these themes to be embraced by a customer, the first hurdle is getting them to be understood and practiced within the firm itself. Accordingly, the SD Dashboard was implemented at roughly the same time as the ISN contract work to begin to instill the behavioral values within Intel, such that it can develop these kinds of customer-supplier contracts and other supply chain tools in a way that brings lasting value to the enterprise. While the finished ISN contract presents an opportunity for strong supply chain operational improvement, the success will hinge on the learning, commitment and practice of the core behaviors underlying the contract details by those within the Intel business operations group.

3.4 SUPPLY CHAIN PROJECT PORTFOLIO - AVOIDING THE 'TOOL TRAP'

The complexity in managing supply chain operations and architecting strategies to manage those dynamics can seem overwhelming at times. Summarizing where we have come thus far, this research contends that in order to drive truly lasting change and improvement, this complexity can and should be boiled down into simple behaviors that govern successful operations. This behavior is what drives all of the processes, structures and tools that are enacted. Accordingly, the greatest leverage comes from understanding and evolving the behaviors to best suit your supply chain.

Unfortunately, developing strategies based on underlying behavioral principles is not a traditional or easy approach to take. Most supply chain organizations have a collection of tools and tactics they are implementing and developing, each with a unique set of motives and intentions. For example, at a single point in time, Intel was juggling the design and implementation of over twenty different supply chain projects, each demanding a significant investment in time and money. Some of the most common of these initiatives underway at Intel and many leading corporations include:

- "End-to-End" Information Technology System (within the firm)
- Joint-Managed Inventory
- Inventory and Supply Chain Modeling
- Customer Order Change IT System
- Data Quality initiative to improve inputs and outputs of IT systems
- Process Re-engineering (e.g. Demand Forecasting)
- Supply Line Agreement Restructuring
- Product Late Configuration Strategy
- Distribution Channel Design
- Demand Planning Software implementation

Each program on its own has solid reasoning and value for improving the supply chain's performance. However, as we have explained in earlier sections, for dramatic improvement to bee seen in overall supply chain operations, each of these programs should share a common foundation. This foundation should:

- Crystallize the "ideal" performance and behavior of the supply chain
- Give everyone an understanding of how each project supports this quest to the "ideal"
- Help people understand how their individual role maps to this plan.

Over the course of this research, Intel came upon the recognition of the importance of establishing a unifying foundation for these projects and for those people working to design and implement them. A filtered version (for confidentiality reasons) of this renewed strategic foundation is captured in Figure 4.

Figure 44: Highlights of Supply Chain Strategic Foundation

A Simplified Supply Chain Vision
Develop a competitive advantage in demand & supply management to maximize margin & market share

Key Goals: Be Faster, More Responsive & More Accurate
- Reduce cycle time
- Reduce response time

Key Tactics:
- Develop partnerships & collaboration across the firm & the business landscape (e.g. enterprise)
- Focus on process & localized decision-making

Having simplified the complexity of twenty projects and capturing the essence of some of the key behaviors (process-focus, enterprise thinking) in the vision and framework is an excellent starting point for this supply chain operations group. However, taking a more critical eye, one may identify some opportunities for improving this foundation given our exploration thus far in understanding the key behaviors and principles that govern successful operations. Some recommendation include:

- **Include stability as a key goal (elimination of variability)**
  Most companies are focusing on speed (which is necessary and important) as they look to improve their supply chains. Few (in fact only those that are most successful) understand the importance of long-term stability as a key enabler for faster, more responsive and more accurate short-term results. Without having stability as a core component of the strategic foundation, the organization will likely only focus on the short-term responsiveness, leaving little energy spent on the longer-term value chain stability.

  While dozens of supply-chain tools and strategies can help bring about improved speed and flexibility, there is not nearly as clear of a path for how to bring stability to the enterprise and improve the larger business dynamics as we explored in Parts 1 and 2. Nonetheless, supply chain organizations must have (at senior levels) the leadership, courage and long-term thinking to begin asking the question such that solutions can be developed. Because of the complicated and interconnected dynamics in a supply chain, stability is difficult to achieve as just a single firm. For a firm like Intel, with tremendous market share and power in their industry, a great opportunity is available to lead other companies in the supply chain (and other industries) in this endeavor of bringing stability and, through that stability, far improved speed and flexibility in the short-term supply chain operations.

  The Supply-Demand Dashboard, for example, presents an opportunity to capture both the short and long-term sensitivity performance. The short-term responsiveness is easily measured by, for example, 'percent of order change requests met within 24 hours'. While this is great to capture effective short-term responsiveness, it needs to be coupled with a measure of long-term stability (remembering the need for two halves of the "hare and tortoise" behavioral capability). For example, what percent of the overall order volume changes over time, what percent of our build volume changes over time, how much bullwhip amplification did we see, etc. Although equally important, capturing this half of the story is more complex and difficult to achieve. It requires a deep process understanding across the supplier-customer interface and the patience and wisdom to take a long-term view with your supply chain partners.

- **Describe the "Ideal" Performance**
  This "ideal" performance could, for example, read *"Defect-Free, On-Demand, Batch-of-One, Flexible, Without Waste, Stable in a Safe Environment"* or some other synthesis of what this group feels is "ideal" operations behavior for the supply chain. While saying we want to be "accurate, fast, flexible" is an important message, it doesn't place a specific vision for "how accurate", "how fast", or "how flexible". When saying "fast", many may interpret reducing our lead times from 13 weeks to 10 weeks. When saying "immediate" or "on-demand", however, it portrays the vision of being able to instantly supply a customer with what they want. Although this stretch goal is very stretched (perhaps impossible), it anchors people in the mindset of limitless possible performance potential... as opposed to moderate improvement. Anchoring all of the people and all of the supply-chain projects in this "ideal" state helps to establish a common vocabulary and unifying vision across the supply chain.

- **Clarify that "Tactics" are actually "Behaviors"**
  Process-thinking, local responsibility, and collaboration across the enterprise are certainly excellent components of this strategic foundation. As we have explored throughout this paper, acknowledging that they in-fact are "behaviors" of individuals (and collective organizations) more clearly and strongly drives home the fact that success relies on every individual, every process and every new project demonstrating these behaviors each day.

- **Include "Learning" as a key capability**
  Explicitly capture the need, not just for "localized decision-making", but also for localized learning. The strategic foundation should capture the meaning of EFE Learning and refer to how the Scientific Method (or some form of thoughtful problem solving approach) can and should be applied to all of the supply-demand processes at each level of the operations, from each individual analyst to the senior managers... from Intel to each of the supply chain partners.

Summary: While tools are great... don't get lost in the 'Tool Trap'

In summary, it is easy for supply chain organizations to get lost in the web of possible supply chain tools presented to them – the 'Tool Trap'. Many supply chain organizations today are looking to "tools" as the answer to their problems without a deep understanding of the underlying principles and strategies. Great operations do not get lost in the complexity; rather, they design and execute projects with a clear strategic foundation rooted in operational behaviors to clearly guide their firm... and their enterprise. This requires leaders who have the courage and long-term interest to dedicate the time and energy to building the skills in herself and the organization Avoiding the 'Tool Trap' and building these underlying capabilities in your firm will help catalyze new levels of excellence in your supply chain.

3.5 A PROCESS TO UNDERSTANDCOMPLEXITY & DRIVE IMPROVEMENT

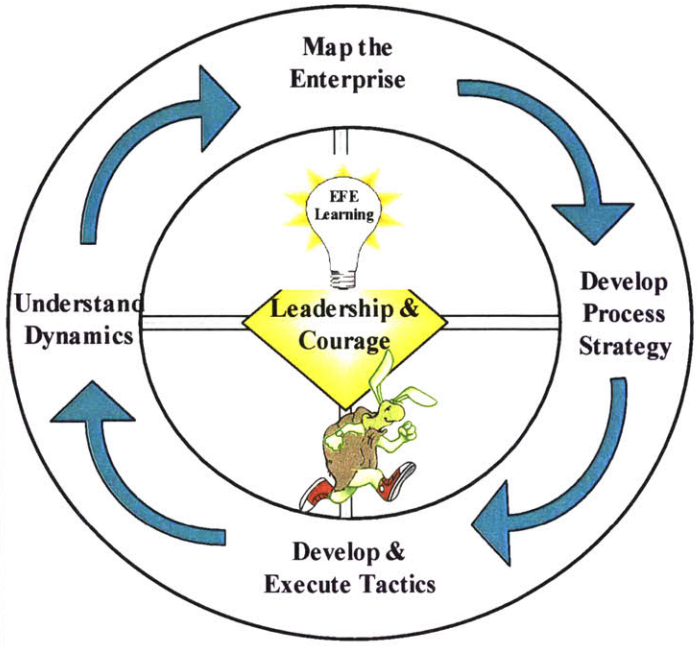
Summarizing our journey thus far, we started out seeking to understand how to achieve operational excellence in complex business operations. With dozens of tools and strategies being frantically cast around the business world, the complexity in managing supply chain operations and architecting strategies to manage the chain dynamics can seem overwhelming. This research contends that in order to drive truly lasting change and improvement, this complexity can be simplified by identifying and understanding the basic behaviors that govern successful operations. Because these behaviors drives all of the processes, structures and tools that are enacted, tremendous leverage can be gained by understanding and evolving these behaviors to best suit your enterprise.

We have walked through several key areas that have shown us:

- the importance of understanding the dynamics in which your business (supply chain) is working in... and building that understanding at every level of the organization
- the importance of thinking how your strategy connects with the extended enterprise and then mapping your strategy accordingly
- the core behaviors essential to operational success... and the importance of developing a business strategy rooted in those core behaviors... and then developing those behaviors from the core of your firm and broaden outward to the enterprise
- to take advantage of all opportunities to build those behaviors... recognizing we have many possible tools and mechanisms with which to do so

The following figures synthesizes our journey of the previous sections into models that more generally capture a process for operations improvement rooted in complex enterprise dynamics, a deep process-focus, a strong learning capability and a balance between long and short-term sensitivity.

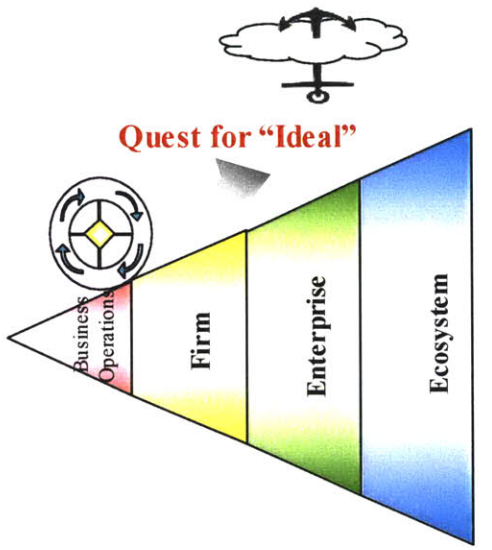
Figure 45: How Process-Thinking and Learning Drive Complex Operations Improvement



1) Understand the market dynamics
2) Determine what your 'Enterprise' is & how it ties into the dynamics
3) Develop process-focused operations at the appropriate enterprise level
4) Develop and execute tactics to build essential capabilities (process-thinking, learning, sensitivity balance); run & steadily improve the operations processes

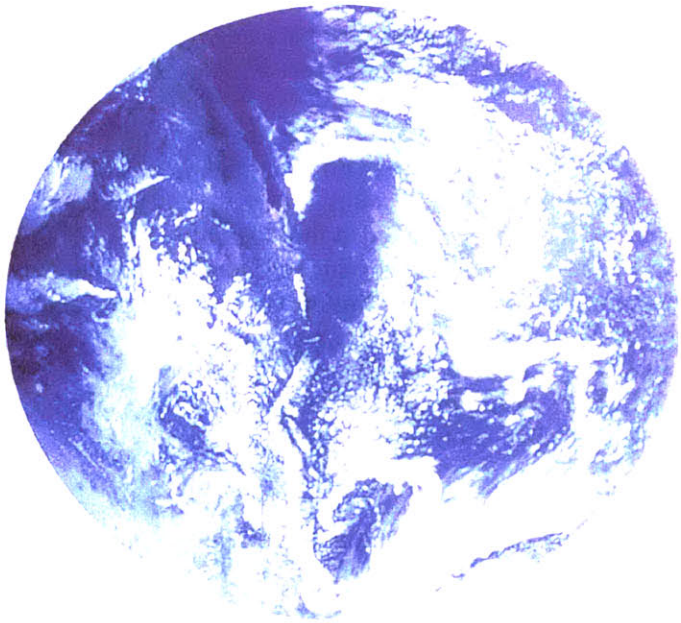
- Success hinges on leadership and courage to attempt to understand complexity and invest in long-term success through process-thinking and learning

Figure 46: Building Enterprise Capability –The Quest for the Ideal Through Core Behavior



- Start by building core behaviors (process-thinking & learning) and leadership at the 'Business Operations' level, effectively acting as a "pilot" lab in the firm
- Steadily expand such that the process and tactics encompass the complexity of increasingly larger components of the extended enterprise (as appropriate based on your industry dynamics and business strategy)
- In quest for the "Ideal", iterate through the 4-step process… learning at every transaction.

EPILOGUE: BEYOND SUPPLY CHAINS



"Some look at the world and ask, 'Why?'
I dream of a world that isn't yet and ask, 'Why not?'"

- Robert F. Kennedy

EPILOGUE: BEYOND SUPPLY CHAINS

Thus far, this thesis has explored the importance of thinking beyond the boundaries of a single-firm, understanding the dynamic complexity of operations from an end-to-end process perspective, and making collaborative decisions that benefit the larger enterprise. Towards these ends, we have identified the building blocks of world-class operations, the importance of building a safe environment where learning can flourish, and the importance of anchoring our ambitions to an 'ideal' state. Interestingly, these insights are not limited to improving supply chain operations; rather, these same principles can be successfully applied to a broad spectrum of operations challenges.

Operations: From Building PCs... to Teaching a Child... to Delivering Surgery...

Thinking broadly, the spectrum of operations includes any challenge facing the world that is impacted by the design, development and delivery of products or services through a web of interconnected people and organizations. Whether the organization is delivering semiconductors to a PC maker, providing surgery at a hospital, educating a student, or delivering food and medicine to the suffering of the world, all of these organizations are dealing with similar operational challenges - - how to best design and deliver these products and services to the betterment of their enterprise.

Upon examination of this diverse spectrum, one will see that the world is experiencing troubles that could benefit greatly from better operations practices. For example, in health care, hospital-acquired (nosocomial) infections represent the fourth leading cause of death in the US. Interestingly, experts contend that most of these deaths could be avoided through improved operations processes and discipline in our hospitals [28]. In education, we are struggling to find sufficient and equitable ways to bring technology and computers into every classroom, to provide equal opportunities to all students around the world. In manufacturing and service operations, companies are laying off tens of thousands of people due, in some cases, to lack of appropriate operational growth strategies. In governments, we struggle to find ways to manage the inflows, outflows and distribution of funds to enable effective and sustainable delivery of major social services like health care and social security.

Most people agree we face these and many other significant challenges as a global community. However, few fully understand and acknowledge the potential impact that sound operations and enterprise thinking can bring to meeting those challenges. From an operations perspective, each of these classes of problems shares a common thread: the need to improve the way we design and execute strategies and tactics for complex processes that connect people and organizations around the world.

Common Threads - Connectedness across Complex Boundaries, Call for Leadership

This epilogue is intended to be a gentle reminder that our efforts to 'improve a supply chain's performance and better match supply with demand' are not disconnected from our efforts to solve these complex, dynamic challenges facing the world. It is important to remember this common thread. If we can enable the necessary courage and leadership to effectively build operational excellence in the business world, perhaps it can serve as a catalyst for similar thinking and actions in other enterprises and other meaningful challenges outside of traditional 'operations' disciplines. In this spirit, Peter Senge, a leading thinker in management science and change, articulates:

> "How do we get a critical mass of people doing things differently? Through the sharing of generative ideas, ideas that can change how people think and act. An idea has started to creep into the public consciousness that we are much more interdependent than we ever used to be. What we as a planet need in order to transform how our large systems work is a network of people spreading ideas of interdependency and sustainability.... If organizations don't change, how can the world change? A single person acting alone cannot shape how the world evolves—no king,

president, or CEO has ever had that power. The world changes when many people in many places begin to act differently in concert with each other."

Thus, as we generate insights in the world of manufacturing or supply chains about how to establish and sustain successful connections and improve the operations of complex organizations, let us endeavor to share those insights to the betterment of the broader society. While nations and communities struggle with rising health care costs, poor education, ineffective social services, and many other ailments, let us not forget the potential power and impact of the lessons from the 'business' world. Everyone, in every organization around the world, has a stake in these challenges. Accordingly, every organization has the capacity— and the responsibility—to pursue excellence in their operations and in what products or services they deliver to the world. From the simple notion of establishing an 'ideal' state of performance to inspire and guide our endeavors, to building mechanisms to align and connect complex organizations across boundaries, to building a deep learning capability in all people, the lessons from 'business' operations can be leveraged far beyond a factory floor or a supply chain. By better understanding and managing the complex systems of the 'business' world, we are building lessons and knowledge that not only increase our own organization's effectiveness... but also can contribute to the well-being of our people, our communities and our nations through sharing and development of these capabilities across society.

Learning and Growing Beyond Ourselves and our Organizations

The scope of our jobs is not just to reduce inventory or increase throughput. Rather, our job is to learn, teach and implement the most effective operations practices to the betterment of society. In doing so, we contribute to building the larger capability of a company, an industry and a society to solve complex problems. These are the challenges facing leaders in 'operations'. 'Making the world a better place' through our work is the scope of the responsibilities and opportunities upon each of us. Whether working in a manufacturing plant or a global supply chain, we have the opportunity to set examples for how operations can successfully embrace stakeholders from around the world... working through differences in culture, geography, and personality to find common ground... developing strategies that elevate an enterprise to solve the most complex type of problems. In this spirit, we can and should encourage our operations leaders to have the courage to bridge this knowledge across practices and disciplines, to expect excellence in what we can achieve together, and to believe in our ability to solve the complex operational challenges facing our communities and our world.

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