

A hand is shown in the lower right corner, using a yellow chalk to draw a star on a blackboard. The blackboard is covered with several white arrows pointing upwards and to the right. The text is overlaid on the left side of the image.

# ADDRESSING CANADA'S PRODUCTIVITY CHALLENGE

SUSTAINABLE COMPETITIVENESS THROUGH INTEGRATIVE SUPPLY CHAIN SYSTEM  
THINKING

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Image: iStock

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## FEEDBACK FROM INDUSTRY

"Hits the mark for all companies worldwide, not just within Canada, corporate leaders should take note. This message of improvement made via integrative thinking needs to get out there & accepted - well done!" *Craig Maw, President, Logikor Inc.*

"This paper identifies the importance of a holistic systems approach to operational improvement and customer value creation. It highlights some of the challenges faced by Canadian firms and provides clear direction on how to address it. Supply chain specialists well versed in system thinking can help firms begin the journey to sustainable competitiveness. This will prove to be indispensable for productivity and competitiveness in Canada. Well done, a must read!" *Tanya Bischoff, Director of Supply Chain, Thalmic Labs*

"Addressing Canada's Productivity Challenge is a must read for those supply chain and operations professionals intent on achieving excellence in their respective supply chains. Only by incorporating 'Integrative supply chain system thinking' (seeing the big picture) will Canada emerge as a nation of World Class Manufacturers. Added value for the reader's body of knowledge are the skills and competencies described in this paper to address Canada's productivity challenge." *Deborah Cripps, Production Manager, Pride Bodies Wabtec Corporation*

"The transformation from traditional to innovative manufacturing requires different thinking and a synchronicity across all functions in an organization. The skills and competencies involved with integrative supply chain systems thinking provide the method which enable this transformation and are vital to addressing Canada's productivity challenge." *Matt Weller, Founder, Berlin KraftWorks Inc.*

"Effectively managing and interpreting the volume and rate of data and information generated in business today is challenging and can be overwhelming. The competencies outlined in this paper are necessary in addressing this challenge. Personnel with developed integrative supply change thinking competencies are the 'organizational glue' and leaders in driving to higher levels of competitiveness in today's (and tomorrow's) global economy." *Robert O'Carroll, Manufacturing Manager, Avidbots Corp.*

## CONTENTS

This paper was written to introduce integrative supply chain system thinking and its importance in improving organizational effectiveness in the quest for sustainable competitiveness. This paper is presented in two parts.

### PART ONE

Part One outlines the productivity challenge facing Canada, and the emphasis placed on investment in technology to address it. Part One includes key definitions and descriptions in building the case for integrative supply chain system thinking.

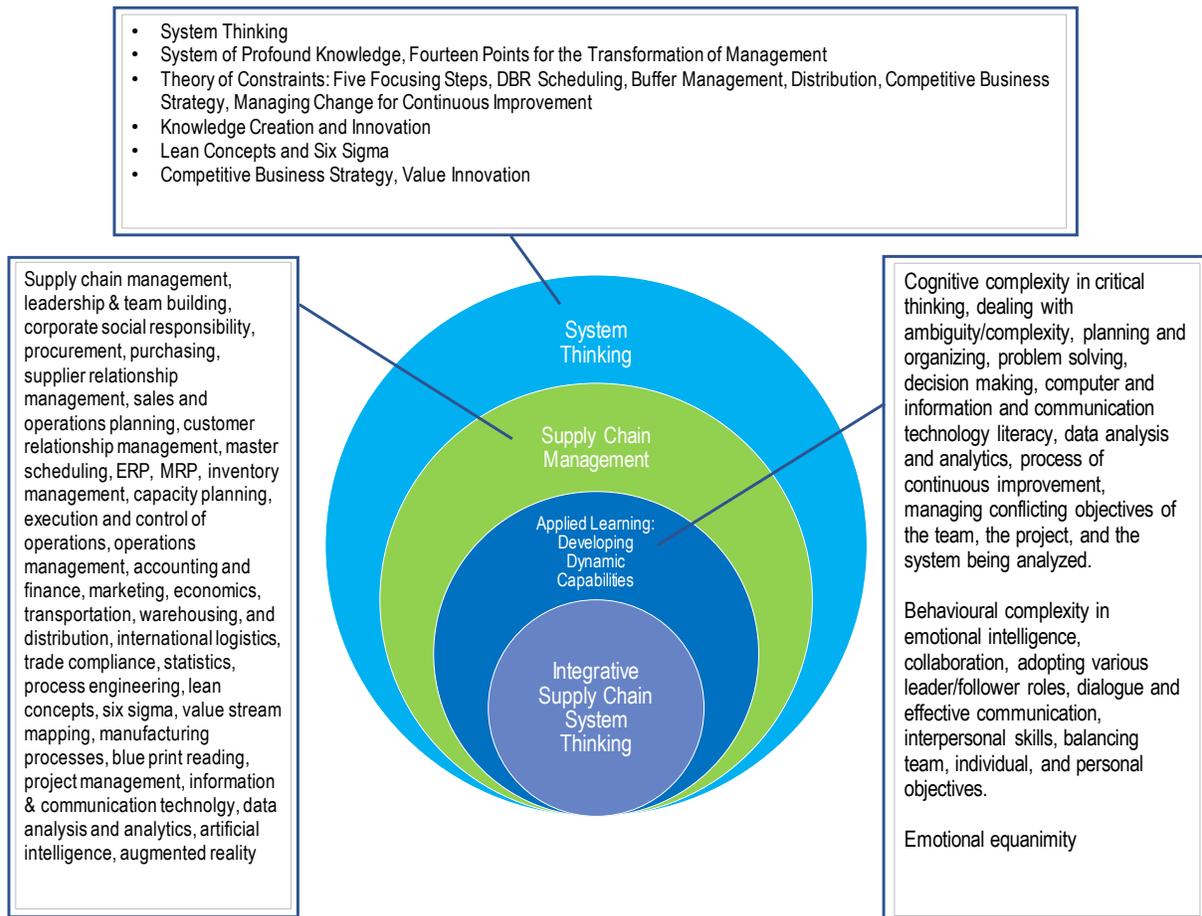
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### PART TWO

Part Two of this paper provides details on the development of integrative supply chain system thinking competencies. It covers the teachings of a number of key thought leaders and how their work contributes to the development of those competencies necessary for improving organizational effectiveness toward achieving sustained competitiveness.

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## Developing Integrative Supply Chain System Thinking Competencies

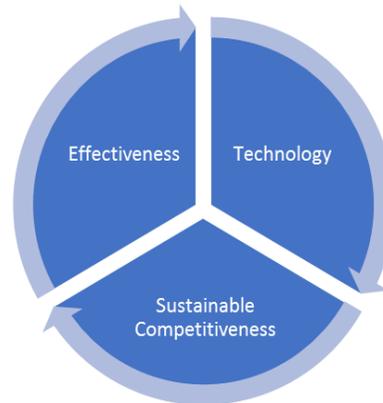


The diagram above illustrates the development of integrated supply chain system thinking competencies. In the context of system thinking, leading supply chain management approaches and effective leadership are employed in creating an organizational culture that focuses on continuously improving organizational effectiveness at delivering ever increasing customer value. Key competencies are developed as innovative new solutions are implemented to that end. Improved productivity, operational, and financial performance is the expected outcome as the organization increasingly becomes the supplier of choice. By first focusing on improving effectiveness in the delivery of customer value and productivity, a firm generates the financial and human capital which can be selectively invested in appropriate technologies to leverage their improvements and leap ahead of the competition. Continuously employing such an approach will lead an organization to sustainable competitiveness in the dynamically complex global economy.

## Executive Summary

Canada's economy lags behind many other nations in terms of productivity. It is projected that Canada's productivity growth rate will be slower than many of its peers over the next thirty years. Addressing Canada's productivity is a dynamically complex challenge, impacted by international, national and organizational factors. While governments hammer out trade agreements, tax and business policy regimes, there is much that individual organizations can and must do to address productivity improvement.

The predominant argument put forward to address productivity improvement is that of investment in technology. While investment in technology is necessary, it is not sufficient in addressing Canada's productivity challenge. Many SME's do not have the resources or skills to invest in technology, while other firms invest in technology without truly understanding its impact, often resulting in unintended negative consequences. Organizations must first place their efforts and resources on improving system effectiveness in delivering ever increasing customer value. Only then should investment in technology occur. Effectiveness first, then selective investment in technology where appropriate, in a never-ending process of innovation, knowledge creation, continuous improvement and value creation. Doing so generates much needed financial and human capital and improves operational and financial performance, allowing the organization to leap ahead of the competition and establish sustainable competitiveness in the process. To achieve this, a transformation in thinking and behaviour is required.



This paper will identify two key areas requiring the immediate attention of executives and senior management across all organizations. The first is the development of mission critical integrative supply chain system thinking competencies in their organizations. Integrative supply chain system thinking marries training in effective supply chain management with system thinking, then applies these in addressing the productivity challenge. In the process key competencies are developed, necessary for improving an organization's effectiveness in delivering ever increasing customer value and improved productivity in today's (and tomorrow's) dynamically complex global economy. Of note, in 2016 the World Economic Forum (WEF) identified the top ten skills required by organizations needed to thrive in the fourth industrial revolution.<sup>1</sup> Those top ten skills include;

- 1) Complex problem solving
- 2) Critical thinking
- 3) Creativity
- 4) People management
- 5) Coordinating with others
- 6) Emotional intelligence

<sup>1</sup> The Future of Jobs, Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution Report, World Economic Forum, January 2016, as summarized in, Alex Gray, *The 10 skills you need to thrive in the Fourth Industrial Revolution*, January 19, 2016, <https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution> World Economic Forum, Retrieved February 26, 2018.

- 7) Judgement and decision making
- 8) Service orientation
- 9) Negotiation
- 10) Cognitive flexibility

Integrative supply chain system thinking competencies, when developed as outlined in this paper, and in concert with effective leadership, embodies all of these skills.

The second key area requiring immediate attention is that of organizational culture. An organization's culture must be one that encourages collaboration, risk taking, is focused on customer value creation, adopts continuous improvement as foundational to its strategic approach, and regards all employees and key supply chain partners as critical to the creation of innovative new knowledge. Developing such a culture requires organizational leadership that values and adopts such principles and approaches in the day to day managing of the firm. Unfortunately, such leadership is at odds with traditional cost-focused management culture found in many organizations today yet is absolutely essential to achieving sustainable competitiveness in today's (and tomorrow's) dynamically complex global economy.

World leading productivity, and with that true sustainable competitiveness in the global economy, comes through the effective application and leveraging of all of an organization's resources, not just technology. This is true for organizations in all sectors of the economy. It takes skilled supply chain specialists trained in system thinking to effectively leverage *all* resources including technology; integrating, coordinating, and optimizing them to achieve world leading productivity and system performance. It also takes a leadership culture that fosters an environment in which knowledge creation, innovation, and continuous improvement toward true sustainable competitiveness can flourish.

This paper reviews the work of a number of key thought leaders in defining integrative supply chain system thinking. Additionally, a case involving a manufacturing firm is outlined throughout the paper in an effort to better understand the importance of integrative supply chain system thinking to improving organizational effectiveness.

Improving productivity in Canada is an urgent matter that must be addressed by governments, business, and education systems alike. Unless taken seriously and accompanied by specific action, Canada's productivity, and with it our competitiveness and standard of living will continue to fall behind. This paper is a call to action to all organizational leaders to address the productivity challenge. It is also a review of what needs to be in place for improved productivity and sustainable competitiveness to be achieved. If you are an organizational leader charged with the responsibility to improve your organization's/supply chain's performance then I encourage you to continue reading.

## Introduction: Integrative Supply Chain System Thinking

It is widely reported that Canada lags behind other nations in terms of productivity. Simply stated, productivity is the ability to deliver customer value using fewer resources, or to deliver increased customer value with the same (or fewer) resources to do so. Productivity is of particular importance when it comes to our largest trading partner, the United States. From 2017 to 2020, it is projected that Canada's productivity will lag<sup>2</sup> behind the US by over 20% each year. Currently, our \$CDN exchange rate against the \$US offsets the productivity lag. We know however that economies move in cycles, and our dollar will at some point rise against the \$US, eliminating the offset against lower productivity. The Organization for Economic Cooperation and Development (OECD) forecasts that over the next 30 years, the Canadian economy will grow at a slower GDP per capita rate than many other key trading nations.<sup>3</sup> When a nation's productivity lags behind other nations, its goods and services are relatively more expensive. That impacts competitiveness, results in sluggish GDP growth, and is a drag on our standard of living here in Canada. In turn, this reduces the amount of money available to business and government for future investment in our economy.

Productivity, and more importantly how to improve it, is quite a complex matter with no simple solution. Many factors impact Canada's productivity<sup>4</sup>. There are international economic and political factors, such as trade agreements, shifting world commodity prices, and geo-political events. Canada is facing economic uncertainty with the United States threatening to impose tariffs, NAFTA renegotiation, and instability in the European Union. At a national level, business and government policy influence productivity. Such policies affect things like foreign investment, taxation, openness to competition and trade, industry structure, and the clustering of firms into ecosystems, among others. In Canada there are provincial or regional differences that impact productivity, such as interprovincial trade barriers. A current example of this is the different regional attitudes/authorities impacting the construction of the approved Kinder Morgan pipeline. Then there are firm level factors, such as investments in R&D, and in physical capital on things like machinery, equipment and technology. There are also investments in human capital and the identification and development of key competencies, as well as policies related to knowledge creation and innovation, training and education, and talent management (including succession planning). Given the complexity of the productivity challenge there is no one simple solution.

Organizations must strive to insulate themselves as much as possible from the vagaries of political turmoil, international and interprovincial trade agreements, floating exchange rates, and the global economy. This can be realized to a large degree by possessing a single-minded focus on delivering increasing customer value while improving productivity toward achieving sustainable competitiveness. The predominant argument put forward to address productivity improvement is that of investment in technology. Investment in technology can take many forms. It can be the implementation of Enterprise Resource Planning (ERP) systems, cloud computing, robotics, digitization and the use of augmented reality (AR), artificial intelligence (AI), machine learning, big data analytics, and the internet of things. Investment in technology while necessary is not sufficient<sup>5</sup> in addressing Canada's productivity challenge. Many SME's do not have the resources or skills to invest in technology, while other firms invest in technology without truly understanding its impact, often resulting in unintended negative consequences. Consequently, a transformation in thinking and behaviour is required. World leading productivity, and with that true sustainable competitiveness in the global economy, comes through the effective application and leveraging of all of

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<sup>2</sup> GDP per capita PPP Forecast 2017-2020, <https://tradingeconomics.com/forecast/gdp-per-capita-ppp> , Trading Economics, Retrieved Nov. 14, 2017

<sup>3</sup> Government of Canada, Canada Transportation Act Review Discussion Paper, <http://www.tc.gc.ca/eng/ctareview2014/discussion-paper.html> , as found in *The Digital Supply Chain, Creating Skills for the Future*, Canadian Supply Chain Sector Council, January 2018.

<sup>4</sup> What Drives Productivity Growth? <http://www.conferenceboard.ca/hcp/provincial/economy/labour-productivity.aspx> Conference Board of Canada, Retrieved Nov. 14, 2017.

<sup>5</sup> Thank you Dr. Goldratt for your work in this area. Goldratt, Eliyahu, Schragenheim, Eli, Schragenheim, Eli, Ptak, Carol, *Necessary But Not Sufficient*, (Great Barrington, MA, North River Press, 2000).

an organization's resources, not just technology. It takes skilled supply chain specialists trained in system thinking to effectively leverage *all* resources including technology; integrating, coordinating, and optimizing them to achieve world leading productivity and system performance. This is the true path to improving Canada's productivity and competitive position in the global economy. Supply chain specialists trained in system thinking have the ability to lead productivity improvement within firms and extend that improvement up and down the firms' supply chain(s), influencing the productivity of both suppliers and customers in the process. Supply chain specialists are the integrators and enablers that not only keep the economy moving (literally), but they are arguably the strongest influencer in driving productivity improvements in their industry's supply chains, ultimately impacting our entire economy!

It's important to point out that integrative supply chain system thinking is transferrable and can be applied in any organization or economic sector wishing to improve customer value delivery and productivity. Over the past forty years the author has visited many organizations across various sectors; manufacturing, health care (hospitals, clinics, LHIN's<sup>6</sup>), logistics, transportation, warehousing and distribution, and education. During each visit, integrative supply chain system thinking is employed in an effort to gauge the effectiveness of the organization in delivering customer value. An example of one such visit will help with understanding. Company A is an engineering led manufacturing firm, producing and selling highly engineered, high precision machined and assembled products to the highest of specifications and tolerances, exporting most of what they produce around the globe. They produce to order and have invested heavily in information and communication technology (ICT), including an enterprise resource planning (ERP) system. The firm employs a batch/push approach to scheduling production, with an emphasis on minimizing the number of equipment change overs and maximizing utilization through large batch sizes. The firm is set up to run three shifts per day, five days per week. Currently, on time customer delivery performance is poor, with over two million dollars in past due customer shipments on the one product line visited. Customer shipments typically follow a hockey stick pattern each month, with approximately forty percent of shipments occurring in the last four to five days of the month following a significant expediting effort. The firm is also experiencing cash flow problems. In an effort to resolve the situation, Company A is running scheduled weekend overtime, incurring significant premium costs. Company A runs the risk of losing key customers as they grow increasingly impatient while they wait for their order(s) to be delivered. The firm currently holds approximately two plus years of inventory for this one product line, (remember, it's a make to order shop), and the sales team is quoting twelve-week delivery on new orders. Recruiting and hiring production employees is also a problem for the firm with local labour shortages. One area where labour shortage is not an issue for the firm is STEM<sup>7</sup> resources, with sufficient STEM employees in house to meet the needs of the products and markets they serve. Company A is in real difficulty, but management is unclear on how to resolve their issues or even where to start. One thing is for certain, investing in new technology at this firm will not solve their problems nor improve their productivity nor their operational or financial performance. The real problem for Company A is the fact that it lacks key specialized skills required to effectively manage in the dynamically complex environment in which it operates.

“Company A is in real difficulty, but management is unclear on how to resolve their issues or even where to start.”

Skilled supply chain specialists trained in system thinking are able to guide firms not only on where to start to address a problem, but also on what must be done specifically to improve productivity. As stated earlier, such skilled supply chain specialists are trained to leverage *all* resources the firm has invested in including technology; integrating, coordinating, and optimizing them to achieve world leading productivity and system performance. Supply chain specialists trained in system thinking understand how to leverage capital and human investments to improve

<sup>6</sup> LHIN: Local Health Integration Network

<sup>7</sup> STEM: Science, Technology, Engineering, Mathematics

productivity, operational and financial performance toward achieving a sustainable competitive advantage. They can guide decisions on where to best invest capital. They also understand that while investment in machines and new technology is important, it must only occur *after* system performance is optimized and is effective at maximizing customer value. When this occurs, productivity is at its highest for the firm, as is operational and financial performance, given its current investment in resources. Note the sequence of events. First, take specific actions to improve system effectiveness at delivering customer value, thereby achieving a high state of productivity and performance. Then and only then selectively invest in appropriate technology, equipment, and people to grow the firm. Were Company A to invest in new technology in its current state, it would not improve productivity nor performance. In fact, such an investment would harm the firm by tying up capital at a time it cannot afford to, making its situation worse, not better.

“And that doesn’t mean laying off nurses or teachers or machine operators. For enlightened organizations it means freeing up existing employees to take on new business. That’s how productivity is improved!”

It's important to note that supply chains exist everywhere in all sectors of our economy. Hospitals and educational institutions benefit from supply chain specialists trained in system thinking. From procurement to inventory management to value stream mapping, supply chain specialists help to deliver increased customer (i.e. patients, students, taxpayers) value while lowering the cost to do so. And that doesn't mean laying off nurses or teachers or machine operators. It means becoming agile and responsive, doing things smarter, faster, better, and leaner, allowing for improved delivery of products and/or services with the same (or fewer) resources. For enlightened organizations it means freeing up existing employees to take on new business. That's how productivity is improved!

Effective supply chain management is critically important across all sectors of the Canadian economy. The supply chain sector employs over 878,000<sup>8</sup> Canadians, and is responsible for planning, coordinating and moving more than \$1 trillion<sup>9</sup> worth of goods each year. It is broadly reported that Canada's supply chain sector is experiencing a critical shortage of skilled supply chain specialists. The Canadian Supply Chain Sector Council<sup>10</sup> has identified a need to fill approximately 10,000 supply chain positions per year between 2017-2021 due to new job creation, retirements, and turnover. This shortage of skilled supply chain specialists will continue to negatively impact our Canadian economy.

### What is a Supply Chain?

A supply chain is a system of organizations, activities, people, information and resources involved in producing and distributing products and/or services from suppliers to customers. The Canadian Supply Chain Sector Council defines supply chain as follows;

“Definitions of a "supply chain" virtually universally encompass the following three functions: i. supply of materials to a manufacturer; ii. the manufacturing process; and, iii. the distribution of finished goods through a network of

<sup>8</sup>Supply Chain Sector Facts and Figures, <http://www.supplychaincanada.org/assets/u/SectorFactsandFiguresEnglish.pdf> , Canadian Supply Chain Sector Council, Retrieved Nov. 14, 2017

<sup>9</sup> Canadian GDP Goods Expenditures current dollars, Stats Canada CANSIM Table 380-0064, <http://www5.statcan.gc.ca/cansim/a37> , as stated in *The Digital Supply Chain, Creating Skills for the Future*, Canadian Supply Chain Sector Council, January 2018.

<sup>10</sup> Supply Chain Sector Facts and Figures, <http://www.supplychaincanada.org/assets/u/SectorFactsandFiguresEnglish.pdf> , Canadian Supply Chain Sector Council, Retrieved Nov. 14, 2017

distributors and retailers to a final customer. Companies involved in various stages of this process are linked to each other through a supply chain.”<sup>11</sup>

### What is Supply Chain Management?

“Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.

Supply chain management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology.”<sup>12</sup>

### What is System Thinking?

System thinking, or systems thinking as it is also known as, is simultaneously a framework, a discipline, and a set of tools used to address dynamically complex situations. Dynamically complex situations are “situations where cause and effect are subtle, and where the effects over time of interventions are not obvious”<sup>13</sup>. Improving productivity is a dynamically complex problem. It involves increasing customer value while maintaining and even lowering the cost of inputs. “Ultimately, it [system thinking] simplifies life by helping us to see the deeper patterns lying behind the events and the details.”<sup>14</sup>

“Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static “snapshots”.”<sup>15</sup>

“Systems thinking is a discipline for seeing the “structures” that underlie complex situations, and for discerning high from low leverage change...And systems thinking is a sensibility – for the subtle interconnectedness that gives living systems their unique character.”<sup>16</sup>

“Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static “snapshots”.” P. Senge

That last statement above is particularly illuminating. System thinking is a way of seeing underlying structures, assumptions, and relationships that form systems, whether they be hospitals, universities, or manufacturing firms. Seeing and understanding these structures, assumptions, and relationships allow for the identification of meaningful, high leverage change opportunities, distinguishing them from low leverage change opportunities. Low leverage change is often seen in the form of actions to address individual events, often accompanied by higher associated costs, with little or no improvement to the system as a result. Seeing and understanding system structures,

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<sup>11</sup> Definition of a supply chain, <http://www.supplychaincanada.org/en/supply-chain> , Canadian Supply Chain Sector Council, Retrieved October 10, 2017

<sup>12</sup> Definition of supply chain management, Council of Supply Chain Management Professionals as found on the Canadian Supply Chain Sector Council website, <http://www.supplychaincanada.org/en/supply-chain> Retrieved October 10, 2017.

<sup>13</sup> Senge, Peter M., *The Fifth Discipline*, (New York, Crown Publishing Group, 2006),71

<sup>14</sup> Senge, Peter M., *The Fifth Discipline*, (New York, Crown Publishing Group, 2006), 73

<sup>15</sup> Senge, Peter M., *The Fifth Discipline*, (New York, Crown Publishing Group, 2006), 68

<sup>16</sup> Senge, Peter M., *The Fifth Discipline*, (New York, Crown Publishing Group, 2006), 69

assumptions, patterns and relationships helps to simplify dynamically complex challenges. Otherwise stated, it helps one in being able to see the 'forest and the trees' so to speak.

### What is Integrative Supply Chain System Thinking?

First, *integrative* versus *integrated*. There is a difference, especially when it involves new knowledge creation, innovation, and continuous improvement. For individuals in their chosen career, the term *integrative* would describe someone who has achieved a high level of education and experience across a broad range of subjects in their field. In health care for example, *integrative* health care could indicate a practitioner with expertise in both conventional and complementary medicine. Based on their highly developed capacity to do so, such a practitioner may combine the use of homeopathy, or naturopathy, or acupuncture therapy in concert with conventional medical therapies in the treatment of their patients. Considering the breadth of knowledge and experience of such individuals, "there is no need for interdisciplinary collaboration or cross-referrals"<sup>17</sup>.

The term *integrated* denotes the linking together or coordination of various elements. Again, in health care or even in supply chain management, it would mean drawing on the varied knowledge and experience of others for the benefit of the patient or system. In health care, it could indicate a medical doctor with a family practice collaborating with a chiropractor and/or osteopath in the treatment of a patient. In such a case, "integrated medicine then offers a greater diversity of options and can potentially bring integrated/integrative healthcare to a deeper and broader level."<sup>18</sup>

"Such collaboration draws on the diverse tacit knowledge of all individuals in the firm and broader supply chain partners, resulting in higher levels of commitment, value creation and productivity improvement than would otherwise be achieved by any one person (manager) acting in isolation."

*Integrative* supply chain system thinking specialists are trained in supply chain management and in system thinking. Through acquired knowledge and experience they develop the capacity to guide and direct customer value creation and productivity improvement activities to the benefit of the system. It is important however to recognize that none of us has all of the answers to all the unknowable challenges that lie ahead. We are all limited by the sum of our training and experiences of the past. In consideration of effective leadership and its positive impact on employee commitment<sup>19</sup>, knowledge creation, innovation, and continuous improvement, it is incumbent upon the supply chain specialist to collaborate with others to the benefit of the system. Such collaboration draws on the diverse tacit<sup>20</sup> knowledge of all individuals in the firm and broader supply chain partners, resulting in higher levels of commitment, value creation and productivity improvement than would otherwise be achieved by any one person (manager) acting in isolation. Integrative supply chain system thinking specialists are capable of

collaborating with all areas of the organization in the process of delivering improved customer value and productivity. In reality, both *integrative* and *integrated* supply chain system thinking is being employed by the trained specialist to

<sup>17</sup> Integrative Healthcare versus Integrated Healthcare, What is the Difference and Why is this Important? Lise Alschuler, ND, FABNO, <https://www.integrativepractitioner.com/whats-new/all-news/integrative-versus-integrated-what-is-the-difference-and-why-is-this-important/> Retrieved Dec. 13, 2017

<sup>18</sup> Integrative Healthcare versus Integrated Healthcare, What is the Difference and Why is this Important? Lise Alschuler, ND, FABNO, <https://www.integrativepractitioner.com/whats-new/all-news/integrative-versus-integrated-what-is-the-difference-and-why-is-this-important/> Retrieved Dec. 13, 2017

<sup>19</sup> Much is written on the impact of effective leadership in creating an environment which encourages employee problem solving, idea generation, risk taking, and innovation. Where such an environment exists, employees commit to the goals and aspirations of the organization, often going above and beyond the parameters of their jobs to ensure success. Where such an environment does not exist and employees are often discouraged from sharing their ideas for improvement, the most an organization should expect is employee compliance to the dictates of management. Employee knowledge creation and innovation is typically absent.

<sup>20</sup> Tacit knowledge is discussed in the Knowledge Creation and Innovation section of this paper.

the benefit of the system as a whole. In this instance, the phrase 'integrative supply chain system thinking specialist' is intended to describe an individual who is highly trained in supply chain management, as well as system thinking. Such individuals employ both integrative and integrating thinking and behaviour, guiding continuous improvement activities in pursuit of increased customer value and productivity improvement to the benefit of the system as a whole.

The effective integration and coordination of activities across all business functions and processes, within and across various enterprises into a cohesive high-performing system is a dynamically complex challenge! Attempting to anticipate and control the multitude of simultaneous events that are happening (and will continue to happen) is virtually impossible to do with any measure of effectiveness. This is especially true when attempted using traditional (hierarchical) approaches to manage system performance. Integrative supply chain system thinking involves the application of the skills developed in the study of supply chain management toward addressing the productivity challenge faced by organizations. It does so within a system thinking framework, through the application of system thinking discipline, tools and techniques.

Supply chain specialists trained in system thinking view dynamically complex supply chains differently than unskilled or even supply chain specialists trained in conventional theory alone. Supply chain specialists trained in system thinking view organizations and their supply chains as a series of interconnected systems and/or sub-systems. Each of these systems operate dynamically, impacting other systems and sub-systems in the process. Let's refer back to Company A, and the average of two years of inventory it is carrying.

"Inventory management is the management of inventory and stock. As an element of supply chain management, inventory management includes aspects such as controlling and overseeing ordering inventory, storage of inventory, and controlling the amount of product for sale. Simply put, inventory management is all about having the right inventory at the right quantity, in the right place, at the right time, and at the right cost."<sup>21</sup>

Viewed as a subsystem, there are a number of key elements in inventory management; discrete product numbers (of which there may be hundreds or even thousands), available quantities of each discrete product, the timing and/or location (of which there may be many) of the available quantities of each discrete product, the cost of each discrete product and all associated costs of holding that inventory, borrowing costs, inventory aging, obsolescence, lot traceability, serial numbers, and traditional elements of desired order fill rates, protection against variable supply and demand, decoupling of resources, etc., all of which is in constant motion. Inventory management impacts other sub-systems, such as quoting new orders, product lead times, cash-to-cash cycles, delivery performance, operating expenses, and overall profits. When inventory management is ineffective, it negatively impacts other subsystems. In Company A's case, any new orders launched to production will take untold weeks to move through all stages of production, given the excessive amount of inventory it is holding. The sales and marketing subsystem is impacted by ineffective inventory management as quoted twelve-week delivery dates are missed. In an effort to resolve missed deliveries, excessive fire-fighting, expediting and overtime work occurs, driving up costs, drying up cash flow, and driving down profits. Firms such as Company A take this approach because they typically view late deliveries as separate events, not as symptoms of some greater underlying problem. When expediting occurs, customer order priorities are shifted, resulting in increasing numbers of late customer orders and more expediting. As the number of late orders grows, inventory and lead times grow, further exacerbating the problem in a downward spiral. Cash-to-cash cycles grow, cash flow dwindles, and profitability goes down.

Consider how this situation (average of two years of inventory on hand) is typically handled in firms with supply chain personnel possessing different skill levels; Unskilled (untrained in any supply chain theory), Skilled (trained in conventional supply chain theory), and Integrative System Thinking supply chain specialists. Please note that these

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<sup>21</sup> Inventory management definition, <https://www.tradegecko.com/learning-centre/what-is-inventory-management> Retrieved November 6, 2017.

skill levels and their descriptions are those of the author. The skill levels, and the information contained in the table below are anecdotal, based on over forty years of experience, expertise and observation of the firms visited.<sup>22</sup> It has been the author's experience that the organizations visited typically employ Unskilled or Skilled personnel in supply chain related roles. It was/is very rare that an organization being visited employs integrative system thinking supply chain specialists in supply chain (or other<sup>23</sup>) roles. Where the latter is the case, the firm typically was found to have established an effective culture of innovation and continuous improvement.

Supply Chain employee skill level.	Typical response to two years of inventory based on supply chain skill level.
<b>Unskilled employee</b>	<p>Inventory is an asset.            With more inventory we can sell off the shelf (so to speak) and increase sales.            Often, non-standardized containers and container quantities are in use.            Purchase more containers for inventory, put up inventory storage racks.            Rent storage trailers and hire shunt operator or rent or build warehouse space to hold inventory.            No structured approach to demand management, scheduling and execution of operations.            Scheduling objective is to keep people working and equipment running "if we want to make money".            No accurate inventory information, constantly searching for inventory to run and/or ship.            Production execution is chaotic at best.            Work overtime and expedite to deal with past due customer orders.            Shop floor primary measures of efficiency, utilization and overhead absorption.            Physical inventory at year end (with accompanying errors created). Find the inventory \$.</p>
<b>Skilled employee</b>	<p>Inventory is an asset and has probably learned that inventory is a waste (conflict).            Typically, heavy use of spread sheets for scheduling.            "Batch/Push" approach to scheduling and execution of operations based on a Master Production Schedule.            Employ an ERP system, or are planning to invest in one, 'maybe' have a business plan in place to do so.            Use ERP to control shop floor production execution.            Check BOM's for accuracy, check that lot sizing and lead times are correct in the planning system.            The use of inventory (safety stock, lot sizing other than lot for lot, etc.) is tactical, and coded in the planning system.            Planned queues are scheduled between operations and coded in the planning system.            Scheduling objective is to manage the flow of inventory to meet MPS delivery commitments.            Often, non-standardized containers and container quantities are in use.            Regularly counting and updating inventory in the system (not true cycle counting).            Production execution is often chaotic as system generated priorities change often.            Work overtime and expedite to deal with past due customer orders.            Shop floor primary measures of efficiency, utilization and overhead absorption.            Purchase more containers, and possibly racking.            Possibly rent storage trailers and hire shunt operator or rent or build warehouse space.            Physical inventory at the end of the year (with accompanying errors created). Find the inventory \$.</p>
<b>Integrative Supply Chain System Thinking employee</b>	<p>Inventory beyond that required for customer orders is a waste.            Find reason(s) (root cause) as to why inventory is high and eliminate it/them.</p>

<sup>22</sup> The relationship between the level of supply chain expertise in firms and firm effectiveness in delivering increasing customer value, productivity, and operational and financial performance is an area for future research.

<sup>23</sup> System thinking supply chain specialists have the requisite skills, after a number of years of direct experience, to effectively move into operation management roles.

	<p>“Pull” approach to scheduling and execution of operations based on actual customer orders only (demand driven scheduling<sup>24</sup>).</p> <p>Scheduling objective is profit velocity, and inventory is strategically employed to the benefit of the system.</p> <p>Possibly spread sheets and/or ERP system are employed to schedule the operation, not to execute the schedule.</p> <p>Schedule execution employs visual pull replenishment (Kanban) and possibly drum buffer rope scheduling<sup>25</sup> approach.</p> <p>Containers are standardized and hold standard quantities. The number of required containers to meet customer orders are specifically calculated, resulting in a significant reduction of containers in the plant, and with that a significant reduction in inventory, material handling, faster identification and elimination of waste and potential quality issues, and lower overall costs.</p> <p>True cycle counting is in place and inventory accuracy is high.</p> <p>There is a structured approach to continuously improve and reduce overall inventory investment, improving customer value and productivity.</p> <p>The system is measured on profit velocity using primary measures associated with Throughput, Inventory, and Operating Expense<sup>26</sup>.</p>
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## Organizational Culture

Organizational culture plays a significant role in determining the level of supply chain skills found in firms, and therefore the level of customer value creation and productivity improvement that firms enjoy. Traditional managers, many of whom lack understanding of the importance of integrative supply chain system thinking to firm performance, often employ Unskilled staff in the planning of their supply chain activities. Such managers are typically measured on the efficiency and utilization of equipment and people under their direction. The rationale is that equipment and labour are expensive, and therefore people and equipment must be constantly producing if “we want to make money”. Traditional managers often employ positional power as their primary approach to directing employees, relying on explicit<sup>27</sup> knowledge to deal with challenges on an event by event basis. In such instances employees are required to do very little thinking and may even be discouraged to do so. Often frustrated by the lack of management interest in their suggestions for improvement, employees become compliant to the directives of management. In turn, the best employees often leave for other organizations. Any commitment from the remaining employees to initiate future improvement ideas is gone. Organizational culture such as described here presents a real challenge for even the most highly skilled supply chain specialist trained in system thinking. The trained specialist will be in conflict with a management culture that insists on keeping employees and equipment running, a culture that results in excess inventory, fully consumed capacity, poor customer delivery performance, poor operational performance and all the high costs that come with it. While such a culture represents a difficult challenge, it is not an impossible challenge. That's why it's important that all supply chain specialists are trained in system thinking.

<sup>24</sup> While other systems exist, world leader SAP recently announced the August 2017 release of Demand-Driven Material Requirements Planning (DDMRP) capability as part of their overall strategy to support DDMRP across S/4 HANA and SAP Integrated Business Planning solution, <https://news.sap.com/sap-releases-support-for-demand-driven-mrp-in-sap-s-4hana/> Retrieved November 28, 2017.

<sup>25</sup> Drum Buffer Rope scheduling system can be found in a number of Dr. Goldratt's books including, The Goal, The Race, and The Haystack Syndrome.

<sup>26</sup> These measures were identified by Dr. E. Goldratt as the critical measures for a firm. They, and their definitions are found in many of Dr. Goldratt's writings. They can be found in his best-selling book, 'The Goal'.

<sup>27</sup> Explicit knowledge is discussed in the Knowledge Creation and Innovation section of this paper.

## A Comment on Culture, Unions, and Labour Costs in Ontario

How often have I heard from traditional managers that 'labour is too expensive in Ontario, so we have to move our business to Mexico or Asia or India'? Such managers now have even more 'evidence' to support their claim given the new legislation in Ontario increasing the minimum wage rates across the province effective January 1, 2018<sup>28</sup>. Integrative supply chain system thinking specialists take a different view of labour. First, for those organizations that have unionized labour, the union representing their employees is a sub-system of the larger organizational system. With that, it's important to point out that labour is only one resource, and studies in manufacturing sector have shown that labour in some instances is the smallest portion/percentage of the total cost of a product, depending on the business. "In some companies, direct labour has become as little as 5 percent of the total cost."<sup>29</sup> The bulk of a product's cost are typically in material and overhead. That said, a high level of productivity can in fact make labour costs essentially a non-issue for a firm. There are firms in Ontario that pay some of the highest wages in the country, yet they are highly productive and as a result have lower overall costs than plants in other jurisdictions producing the similar products. Toyota Motor Manufacturing Canada in Cambridge, Ontario is a perfect example of this fact. Consider also Frank Stronach, founder of Magna International. Mr. Stronach could be considered anything but a traditional leader. In 2007, Mr. Stronach invited the Canadian Auto Workers (CAW) union to hold votes in Magna's Canadian plants to join the CAW.<sup>30</sup> In an historic agreement, Magna and the CAW pledged to work together in a Framework of Fairness agreement. Employees in Magna's plants are among the highest paid workers in Canada, yet Magna plants are highly productive and enjoy operational and financial success. There are other examples, including the author's own experience with labour unions in much smaller firms, showing how effective collaboration with employees and their union can result in tremendous improvement in customer value delivery and productivity gains for the firm. In the author's experience, unions and labour costs are not the issue. Traditional management culture and a lack of effective leadership and integrative supply chain system thinking skills are!

"...unions and labour costs are not the issue."

Back to the supply chain excess inventory scenario above. It's important to note that the responses of the Unskilled and Skilled supply chain employee are event focused, that of having an average of two years of inventory on hand. It is often the case that such firms have no real appreciation for the actual amount of inventory they are carrying (i.e. days, weeks, months, or years of supply) or how it relates to customer demand, beyond the dollar amount indicated on the Balance Sheet.

The Skilled employee response to the two years of inventory is largely based on conventional supply chain training. Their typical event focused response is to look at the planning system, making sure the data base is accurate. The underlying assumption is that if the data base, the inventory information, the schedule, and all of its planning parameters are accurate, the planning system is operating exactly as intended, and we are supposed to have that amount of inventory on hand. In this batch/push environment, it's of primary importance to minimize costly changeovers, and maximize labour and machine utilization. That in turn drives down unit costs and makes the product more profitable, right? Unfortunately, there is plenty of conventional 'wisdom' around to support such a claim.

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<sup>28</sup>Lost jobs, cut hours, no paid breaks. Do minimum wage hikes hurt workers? Global News, January 4, 2018, <https://globalnews.ca/news/3943682/minimum-wage-hike-ontario-alberta/> Retrieved January 5, 2018

<sup>29</sup>Weygandt, J., Kieso, D., Kimmel, P., Aly, I. *Managerial Accounting, Tools for Business Decision-Making*. Mississauga, ON, John Wiley & Sons Canada, Ltd. (2006), 12.

<sup>30</sup> *Magna to let CAW organize in its plants*, CBC News, October 15, 2007, <http://www.cbc.ca/news/business/magna-to-let-caw-organize-in-its-plants-1.646438> Retrieved Jan 3, 2018.

The supply chain system thinking response is different. It's not reactive to any one event. The supply chain system thinking response looks at other factors to see if there are connections between the two years of inventory and other system performance issues; identifying patterns, trends, and relationships. The supply chain system thinking specialist will look at the excessive inventory and question why delivery performance is so poor. With so much inventory available, shouldn't customer delivery performance be one hundred percent? They will ask why there are two years of inventory on hand when production is supposed to occur to customer orders. They will ask what drives the firm to produce over two years of inventory in a make to order environment, and why production occurs on product that cannot be immediately sold. Upon investigation, such questions will lead to a connection between traditional performance measures of efficiency, utilization, productivity and the batch/push production of unwanted (no immediate orders) inventory. As the old adage states, *you get what you measure*, and if the organization is employing traditional measures of efficiency, utilization, and productivity as their prime measures, the organization will get higher levels of each, and with that the resultant problems that accompany them. They will ask why efficiency, utilization, and productivity are used as the prime measures for production. An investigation of this question reveals a connection between production measurements and product unit costs via the costing system (standard or activity based). It exposes an underlying conventional 'wisdom' that is false. Standard cost accounting identifies that the more efficient a firm becomes at utilizing its resources (keep the people and equipment running), the more overhead is absorbed across a higher volume of units produced, resulting in lower unit product costs. This thinking drives up batch sizes and reduces the number of equipment change overs, as seen with Company A. With lower unit product costs, a firm makes more money on the sale of each of those products. If all of this is in fact true, then Company A should be making 'piles' of money, and yet it is not. It is struggling to ship products to customers on time, is drowning in an ocean of inventory, and is challenged with diminished cash flow. Conventional wisdom, and the traditional approach to managing manufacturing firms is harming the manufacturing sector<sup>31</sup>, directly contributing to the productivity problem in Canada. And the infusion of technology investments will not help this situation. A transformation in thinking and behaviour is required.

“...thousands and millions of dollars of investment in technology (including ERP systems) is wasted each and every day/week/month/year in organizations that have not first become effective in getting the most out of the resources they currently have.”

Supply chain system thinking specialists focus on revealing the connections and relationships between the various events and subsystems across the firm that impede higher levels of performance. In the Company A example, there are many connections between inventory and other subsystems; ERP systems and how they're setup for scheduling production (batch/push), sales and quoting subsystem, accounting and the costing subsystem, performance metrics, and underlying assumptions and long-held 'truths' about measuring production and how a firm makes money. Unless a supply chain specialist is trained in system thinking, true customer value creation and productivity improvement cannot occur, at least not to the potential it otherwise could be. In such situations, thousands and millions of dollars of investment in technology (including ERP systems<sup>32</sup>) is wasted each and every day/week/month/year in organizations that have not first become effective in getting the most out of the resources they currently have. In such situations, investment in technology without first becoming effective may in fact drive some firms into bankruptcy.

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<sup>31</sup> Thank you to Dr. Deming, Dr. Goldratt and others for their work in bringing to light the damaging effect of managing manufacturing firms based on traditional production metrics established over 100 years ago.

<sup>32</sup> There are numerous studies identifying the low success rates, high cost and schedule overruns of ERP system implementations.

Key to the above scenario is the fact that skilled supply chain specialists are trained to understand that that one cannot look at individual 'events' and try to manage and 'fix' each one in isolation. "Improving the performance of the parts of a system taken separately will not necessarily improve the performance of the whole; in fact, it may harm the whole."<sup>33</sup> Supply chain specialists trained in system thinking understand the interconnectedness of systems and subsystems. As such, they are trained to look at interrelationships, patterns of change, underlying assumptions and the interplay of seemingly isolated events and subsystems that impact system performance. It is through understanding the interrelationships, patterns of change, underlying assumptions, and interplay of all resources and stakeholders that high leverage opportunities for real, sustainable improvement in productivity and customer value creation are discovered, new knowledge is created, and innovation occurs. This is the secret to achieving world leading performance and a sustainable competitive advantage.

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<sup>33</sup> *A Lifetime of Systems Thinking*, Dr. Russell Ackoff, The Systems Thinker, <https://thesystemsthinker.com/a-lifetime-of-systems-thinking/> , Retrieved March 18, 2018

### Developing Integrative Supply Chain System Thinking Competencies

Developing integrative supply chain system thinking competencies starts with a post-secondary education in supply chain management. That said, integrative supply chain system thinking competencies can be developed in the workplace in partnership with a post-secondary institution currently delivering such programming. Supply chain management education must include elements of business administration, including a study of economics, statistics, accounting, finance, sales and marketing, communication, organizational behavior, and interpersonal relationships. It must cover all aspects of a supply chain, from a supplier's supplier to the customer's customer. Training must include forecasting and demand management, customer relationship management, procurement and purchasing (including total landed cost), key elements of sourcing, negotiation, vendor selection and management, blueprint reading, risk management, business law, and the (electronic) tendering process including the use of RFP's and RFQ's. It must cover transportation, warehousing, distribution, logistics, international trade compliance, and customs brokerage. It must include training in information technology, computer enabled planning and scheduling, resource planning (material, labour, equipment, etc.) supply management, inventory management, capacity planning, the use of spread sheets and commercial ERP systems, and data analysis and analytics in a world which increasingly includes the use of augmented reality, artificial intelligence, machine learning, and the internet of things. Training in operations management is required, including system thinking, an understanding of competitive business strategy, leadership and team building, manufacturing processes, project management, process engineering, quality management systems, the execution and control of operations, and measuring operational performance. Further, supply chain management training must include corporate social responsibility, continuous improvement concepts, principles, and techniques, including training in lean concepts, six sigma, value stream mapping, and the Theory of Constraints.

Developing integrative supply chain system thinking in the workplace will require a firm to seek out post-secondary institution(s) that offer such programming. An assessment will be required to understand existing organizational culture and readiness to learn and employ system thinking toward improving organizational performance. The assessment will also indicate what areas of training and development are required, from which a plan can be developed to provide such training.

This now brings us to the place where supply chain management integrates with system thinking.

“I believe that, the prevailing system of management is, at its core, dedicated to mediocrity. It forces people to work harder and harder to compensate for failing to tap the spirit and collective intelligence that characterizes working together at their best.” P. Senge

### System Thinking - Dr. Peter Senge

Developing system thinking competencies starts with an understanding of what system thinking is. While there are a number of thought leaders in this area, one might start with a review of Dr. Peter Senge's best-selling book, *The Fifth Discipline*<sup>34</sup>. Dr. Senge is a highly regarded researcher, writer and speaker on the topic of system thinking. Dr. Senge's definition of system thinking was outlined earlier in this paper. When asked by his editor as to whom might write a comment for the book jacket, Senge shares his response.

<sup>34</sup> Senge, Peter M., *The Fifth Discipline*, (New York, Crown Publishing Group, Revised Ed., 2006)

"After thinking for a while I realized that there was no one I would rather have write something more than Dr. W. Edwards Deming, revered around the world as a pioneer in the quality management revolution. I knew of no one who had a greater impact on management practice."<sup>35</sup>

Senge goes on to pay homage to Dr. Deming.

"Deming had almost completely stopped using the terminology of "Total Quality Management," "TQM", or "TQ" because he believed it had become a superficial label for tools and techniques. The real work, which he simply called "the transformation of the prevailing system of management", lay beyond the aims of managers seeking only short-term performance improvements. This transformation, he believed, required "profound knowledge" largely untapped in contemporary institutions."<sup>36</sup>

Senge rightly claims that Deming's work laid the foundation for his work and the work of others. Informed by Dr. Deming's writings, Dr. Senge's own work led him to the following understanding of traditional management systems.

"I believe that, the prevailing system of management is, at its core, dedicated to mediocrity. It forces people to work harder and harder to compensate for failing to tap the spirit and collective intelligence that characterizes working together at their best. Deming saw this clearly, and I believe that now, so do a growing number of leaders committed to growing organizations capable of thriving and contributing to the extraordinary challenges and possibilities of the world we are living into."<sup>37</sup>

A damning statement on traditional management practices, and a call to transform management thinking and behavioural approaches toward improving system performance.

### System of Profound Knowledge - Dr. W. Edwards Deming

The application of system thinking must begin with the teachings of W. Edwards Deming. Dr. Deming, widely known as the Father of Quality, was largely responsible for teaching Japan's industrial leaders following WWII in the use of statistics to drive quality improvement and increase productivity. Japanese leaders embraced Dr. Deming's teachings, and the impact of that is still being felt in the global economy today. Two major areas of Dr. Deming's teachings include The Fourteen Points for the Transformation of Management, and the System of Profound Knowledge (SoPK)<sup>38</sup>. The Fourteen Points are an application of the System of Profound Knowledge. Dr. Deming held innumerable seminars teaching business and industry leaders the world over.

Dr. Deming's System of Profound Knowledge provides a framework for system thinking to integrate with and guide the application of supply chain and operations management theory and techniques. It includes four key elements.

- i) Appreciation for a system.

This element begins with the understanding that all systems start with an aim, that of delivering increased customer value. With that in mind, this element emphasizes that systems such as hospitals (or universities, banks, manufacturing firms, etc.) are made up of interdependent components that work together in cooperation to accomplish the aim of the system. This system view is significantly different from the traditional reductionist view of an organization, such as found in the scientific management<sup>39</sup> approach. Simply stated, scientific management

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<sup>35</sup> Senge, Peter M., Introduction To The Revised Edition, *The Fifth Discipline*, (New York, Crown Publishing Group, Revised Ed., 2006)

<sup>36</sup> Senge, Peter M., *The Fifth Discipline*, (New York, Crown Publishing Group, Introduction To The Revised Edition, 2006)

<sup>37</sup> Senge, Peter M., *The Fifth Discipline*, (New York, Crown Publishing Group, Introduction To The Revised Edition, 2006)

<sup>38</sup> Dr. Deming's teachings of the Fourteen Points and System of Profound Knowledge can be found in his two seminal books, *The New Economics*, and *Out of The Crisis*.

<sup>39</sup> An understanding of scientific management can be found in the study of Frederick W. Taylor's work. Taylor, broadly considered to be the founder of the scientific management movement, published "The Principles of Scientific Management", 1909.

breaks down a system into individual components, then strives to optimize those individual components. The underlying assumption is that if each individual component is optimized to its potential, the performance of the entire system is optimized and unit costs go down. While that was the accepted wisdom in a time of mass production and seemingly limitless demand, such thinking is at best outdated in today's hypercompetitive global economy. By contrast, system thinking views the entire system and looks for ways to improve system performance in the delivery of customer value. The focus is on improving customer value delivery, not cost reduction. You cannot cut your way to sustainable competitiveness. System thinking recognizes that it is the system, not individual resources, which delivers customer value and improved productivity, operational and financial performance. It is recognized in the SoPK that higher system performance will require lower than optimal performance in most of the resources within the system, a notion that is foreign to scientific management and traditional management understanding.

The focus is on improving customer value delivery, not cost reduction. You cannot cut your way to sustainable competitiveness.

ii) Knowledge about variation.

This element of the SoPK identifies that variation exists in all systems, including educational institutions, manufacturing firms, hospitals, etc. Variation occurs naturally, impacting all elements in a system. Variation can also occur due to a specific event or an assignable cause. Key to this element is the understanding that variation results in lower productivity and higher costs (waste), all of which negatively impacts the delivery of customer value and organizational performance. Another key understanding is the importance of collecting and analyzing data and information toward identifying the specific type of variation that is occurring. Once identified, analysis followed by appropriate action based on the type of variation is taken in an effort to reduce and/or eliminate the variation. The reduction and elimination of variation results in systems capable of delivering high quality products and/or services to customers, on time, at the highest level of productivity and the resultant lowest possible cost to the firm (given current resources), over and over and over again and again!

iii) Theory of Knowledge.

This element of the SoPK identifies that continuous improvement is critical for organizations to provide increasing customer value and higher productivity. Continuous improvement occurs when new knowledge is created and innovative ideas and solutions are developed. Knowledge creation and innovation begins with a theory or idea to address a current issue or need which is impeding productivity and the delivery of customer value (the aim of the system). With that theory or idea in mind, a prediction occurs in an effort to improve the system's ability to deliver increased customer value and higher levels of productivity. A plan is then developed to extend or apply that prediction. The plan is executed, observed and measured to see if it achieves the prediction (desired outcome). The planned application of a prediction, and subsequent observation and measurement, results in the identification and implementation of new knowledge and innovation in the form of improvement ideas. It also means increased customer value and higher productivity. This process is known as the Plan/Do/Check/Act (PDCA) process of continuous improvement<sup>40</sup>. Dr. Deming stressed the importance of *all* employees being involved in the process of knowledge creation and innovation. He stressed the importance of having the employees that do the actual work directly involved in the knowledge creation process, not just the managers, supervisors, and the engineering department. When this is the case, true knowledge creation and innovation can occur.

iv) Psychology (Human Behaviour)

This element of the SoPK identifies that *all* employees are integral to the success of the system in delivering ever higher levels of customer value and productivity. How people interact with the interdependent elements of the system

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<sup>40</sup> PDCA is often referred to as the Deming Circle, or Deming Wheel, as well as the Shewhart Cycle.

and with each other is an issue of strategic importance to management. Matters of leadership (versus management) such as valuing and demonstrating mutual respect, collaboration, honesty, integrity, trust, employee education, training and development, relationship development, effective leader communication, the use of appropriate motivators, autonomy, and valuing people and their contributions as integral to the success of the firm are of paramount importance to firm management. Dr. Deming was critical of top-down hierarchical managers that rely on lagging financial measures, positional power, and carrot and stick approach to managing people and operations. Rather, Dr. Deming espoused effective leadership, the use of personal power, and the importance of people across all levels of the organization, including vendors and customers, collaborating in the creation of new knowledge and innovating new ideas toward increasing customer value and productivity.

Many, including the author, hold the opinion that Dr. Deming was a preeminent thought leader in the area of quality, continuous improvement, and improving organizational performance. His teachings are foundational and transformational with respect to the way management should occur in organizations around the world. Organizations (hospitals, education systems, manufacturers, governments, etc.) that embrace Dr. Deming's SoPK enjoy sustained success. His teachings provide both a framework and structured approach for the application of system thinking in organizations across all sectors of the economy.

### Quality Loss Function - Dr. G. Taguchi

Green house gas (GHG) emissions and global warming (i.e. climate change) are issues that no one can ignore. Corporate social responsibility and environmental sustainability are issues of increasing importance around the world. In Canada, the Federal government forced the matter with its December 2016 announcement of carbon pollution pricing<sup>41</sup>. Enter Dr. Genichi Taguchi<sup>42</sup>. Dr. Taguchi's Quality Loss Function (QLF) stands out as important teaching for supply chain specialists. His QLF illuminates the connections between variation reduction through continuous improvement, increased customer value delivery and improved productivity, improved operational and financial performance, and the reduction of GHG and a firm's carbon footprint. This teaching aligns with Dr. Deming's teaching on variation. In this we see the interconnectedness and interdependencies between and among systems and sub-systems. Organizations do not stand alone. It must be understood that there really are no such things as individual events or decisions. All decisions and actions ripple through the systems and sub-systems they interact with, ultimately impacting the environment in which we live for better or worse.

Dr. Taguchi's QLF incorporates three key elements. It starts with the customer and what their desired level of quality is in the product or service being offered. Of note, anything a firm does should start with the aim of delivering increased customer value. The customer's desired level of quality becomes the target or optimum quality that the organization will continually strive to achieve. The second element is variation. All systems exhibit variation which drives actual output quality away from the optimum (customer desired) quality. Third, as variation moves actual output quality farther and farther from optimal quality, losses to the organization occur at an increasing rate. The losses incurred due to non-conformance to optimal quality extend to the wider community and results in losses to society. Dr. Taguchi's loss function is expressed by;

$$L(x) = k(x - T)^2 \quad 43$$

We see the QLF illustrated in the diagram below. Loss (L) is defined on the vertical axis, while Variation is defined on the horizontal axis. On the Variation axis, we find the Target or Optimal Quality (T) as defined and expected by our

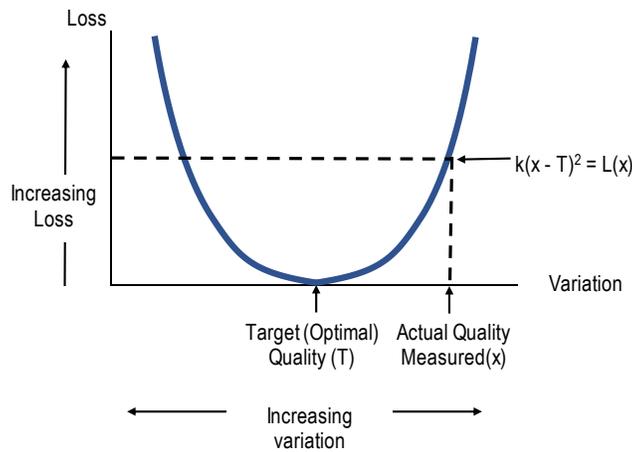
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<sup>41</sup> Pricing carbon pollution in Canada: how it will work. [https://www.canada.ca/en/environment-climate-change/news/2017/05/pricing\\_carbon\\_pollutionincanadahowitwillwork.html](https://www.canada.ca/en/environment-climate-change/news/2017/05/pricing_carbon_pollutionincanadahowitwillwork.html) , Government of Canada, Retrieved

<sup>42</sup>Dr. Taguchi has authored and co-authored many books on quality and quality systems. Two highly regarded among these is, "Taguchi's Quality Engineering Handbook", and "Quality Engineering in Production Systems". Supply chain specialists need not read all of Dr. Taguchi's works, but must become familiar with the Quality Loss Function and its contribution to system thinking.

<sup>43</sup> Evans, J.R., Lindsay, W.M., *The Management And Control Of Quality 6e*. (Mason, Ohio, Thomson South-Western, 2005), 594.

customer. Quality is a key aspect of perceived customer value for the product or service being offered. On the Variation axis we also find Actual Quality Measured (x). Actual Quality is a measure of quality of the output from the system for the product or service produced. Variation that occurs during the process of delivering the product or service results in the Actual Quality of the delivered product deviating from the Target Quality expected by the customer. Actual Quality can vary in either direction, i.e. can be higher or lower than the Target or Optimal Quality desired by the customer. We see this on the Variation axis where Actual Quality variation from Target Quality can move in either direction as indicated by the arrows. The greater the Actual Quality (x) varies from Target Quality (T), the greater the Loss to the organization. From a customer perspective, the greater the Actual (delivered) Quality varies from Target Quality, the greater the loss in perceived value by the customer. If this situation continues unresolved, the loss in perceived customer value results in lost demand and often in lost customers for the firm.



**Taguchi's Quality Loss Function**

The unfortunate part of the above situation is that many if not most organizations treat quality issues as individual events only after the customer complains about poor quality or delivery. Far too many organizations have no understanding of system variation and its impact on quality and the customers' perceived value of their product or service, nor do they understand the loss to the organization resulting from system variation beyond that of losing sales or even customers. Dr. Taguchi helps make the connections between quality, variation, and loss in his Quality Loss Function. Integrative supply chain system thinkers are trained to collect and analyze system variation data, and in taking actions to reduce variation. In doing so they simultaneously increase customer (perceived) value and the organization's productivity. That results in increased sales as the organization becomes the preferred supplier of the product and/or service they are offering.

Dr. Taguchi argues that the loss to the organization due to variation extends beyond the firm to society, ultimately having a negative impact on the living environment. A simple example will illustrate.

System variation can present itself in many ways. In a manufacturing firm it can be in the form of excess inventory produced to compensate for widely varying change-over times. It can also be in the form of defective product that must be reworked or scrapped. In a financial organization it can be in the form of long and/or varying times in the loan or mortgage approval process. In a logistics firm it can take the form of transportation delays, or loss or variation in temperature in refrigerated cargo. In a hospital emergency room, it takes the form of variation in the amount of time to prepare an emergency ward bed for the next patient. All of these represent examples of system variation that can occur, resulting in a loss to the firm and negatively impacting customer value delivery.

Consider a defective product (or service). A defective product results from variation in a system. When a product is defective, it may very well have to be scrapped. As a result, the material, time, energy, money and other resources used to produce that product has been wasted. The scrapped item may also end up in a landfill site if not recycled. Even if it is recycled, the process of recycling takes time, energy, money, manpower, etc. If the product must be remade, more material, time, energy, money, and other resources must again be used. To replace the scrapped product, more material must be produced and shipped from a supplier. That replacement material must be delivered to the firm. Delivery of that material takes up space on a truck, train, ship or plane. Delivery to the customer typically occurs on a truck, where the truck is driving on the transportation infrastructure, requiring increased road construction and maintenance as a result of the extra travel. That also means more trucks are required, more truck tires, more steel being produced, more mining of resources, more electricity required, more diesel fuel burned, more environmental pollution, higher healthcare costs, etc. Now, extend this scenario across all organizations in Canada and around the world, and one soon get's a sense of the magnitude of issue!

Dr. Taguchi's QLF helps in understanding that system variation occurs in all systems. System variation negatively impacts process and product quality, negatively impacting the customers' perceived value of the product offering, resulting in a loss to the firm. That loss ripples out through systems and subsystems, ultimately impacting our living environment. In that regard, Dr. Taguchi's Quality Loss Function is a key component of the system thinking framework and therefore necessary for integrative supply chain system thinking competency development. Such competencies, when deployed across all sectors of an economy will improve customer value, increase productivity, lower the production of green house gasses and improve the living environment in the process.

### Lean, Toyota Production System - Dr. S. Shingo

The Toyota Production System (TPS) is probably the most well-known application of lean system thinking. In essence, lean is about delivering ever increasing customer value through the application of continuous improvement and driving out wasteful practices. Much has been written about the success of the Toyota Production System. Dr. Shigeo Shingo in his book, *A Study of the Toyota Production System: From an Industrial Engineering Viewpoint*<sup>44</sup>, clearly outlines the approach for continuous process improvement and the implementation of the Toyota Production System. Dr. Shingo covers key elements including the identification of the seven kinds of waste, defect reduction, cellular manufacturing, mixed model level scheduling, set up reduction, the use of Kanban to establish 'pull' production execution, standard operating procedures, and integrated synchronized flow of materials to deliver high quality products and/or services, on time, every time! However, a word of caution. It's important to note that organizations that simply try to implement lean techniques to improve performance will achieve limited success. Only in the context of system thinking, customer value creation and continuous improvement, all adopted by the organization's leadership as integral to the strategic plans and culture of the firm, will lean and TPS implementation lead to true success.

While TPS and lean system thinking were established in manufacturing, the concepts, principles and techniques have direct application across all sectors. The healthcare sector has begun to apply lean system thinking in the delivery of health services. In the example of the hospital emergency room bed turn-around time, set up reduction techniques developed in manufacturing can be applied to dramatically reduce the time it takes to make the bed available for the next patient. Reduced bed turn-around time means better patient care (improved customer value), improved productivity of the bed and staff needed to prepare it, lower overall costs to the hospital, and lower losses to society through better healthcare services.

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<sup>44</sup> Shingo, Shigeo, Dillon, Andrew, *A Study of the Toyota Production System: From an Industrial Engineering Viewpoint*, (Boca Raton, Florida, CRC Press, Revised Ed., 1989) Note: A. Dillon provided translation for the book.

As with Dr. Senge's, Dr. Deming's and Dr. Taguchi's teachings, the TPS and Dr. Shingo's teachings provide both a framework and application of system thinking necessary for the development of integrative supply chain system thinking competencies. Once these competencies are deeply and broadly deployed across all sectors, customer value delivery will improve, productivity will improve, and operational and financial performance will improve, resulting in sustainable competitiveness. As identified by Dr. Taguchi, these improvements reduce losses to organizations and society at large, resulting in lower green house gasses and improvement/reduced harm to the living environment.

## Six Sigma

Associated with lean is Six Sigma. Six Sigma is an approach developed by Motorola in the 1980's. Six Sigma incorporates a structured approach to strive for near perfection with respect to process, and therefore product (again, a product can be a service) quality. The focus is on collecting and analyzing data on process performance/output. Once collected, the data is statistically analyzed, identifying the amount of variation in process output and the mean value of that output. In other words, actual output variation data is collected and analyzed, then compared to the desired or target quality as identified by customer specifications (recall the discussion on Dr. Taguchi's QLF above). Once identified, actions are then taken to narrow (reduce) the amount of process output variation, and to move the mean or average of the process output closer to the desired or target output as defined by the customer. Variation reduction and a process that delivers output in line with customer specification means less waste, increased productivity, and increased delivered customer value. It also reduces the loss to society and the environment. The objective is to strive for six standard deviations of variation between the mean of the process output readings and the process/product specification limits. Once that is accomplished, the probability of the process producing a defect is exceedingly low. Correspondingly, the losses to the organization and society are exceedingly low. "To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities."<sup>45</sup>

It's important to note that Six Sigma methodology is grounded in Dr. Taguchi's Quality Loss Function. Both Six Sigma and QLF are grounded in Dr. Deming's teaching on statistical variation and measurement. For anyone directly involved in the continuous improvement of delivered customer value and productivity, understanding and applying Six Sigma is a critical component of integrative supply chain system thinking competency development.

## Effective Leadership

A key aspect of continuous improvement is the need to continuously innovate new knowledge necessary to improve customer value and productivity. None of us has any idea as to the nature of tomorrow's challenges. The one thing we should understand is that tomorrow challenges will occur in an already dynamically complex environment. Culture has a direct impact on an organization's ability to generate innovative new knowledge toward improving customer value and productivity. Organizational culture is a reflection of a firm's leadership values and approach. To that end, learning how to be an effective leader, as opposed to a manager, is foundational for developing integrative system thinking competencies. There are many excellent thought leaders in the area of leadership in addition to those already mentioned in this paper. Others include James Kouzes and Barry Posner, Ken Blanchard, Stephen R. Covey, Jim Collins, and many more. Richard Daft in his book entitled, *The Leadership Experience*<sup>46</sup> clearly outlines effective leadership theory supported by current day leader experiences and events. Dr. Daft defines leadership as, "An influence relationship among leaders and followers who intend real changes and outcomes that reflect their shared purposes."<sup>47</sup> There are two key words that stand out in the definition, "*influence relationship*". In order to create a culture of innovation and continuous improvement, it is incumbent upon leaders to establish positive relationships with all employees, customers, suppliers, unions, etc. It is through positive relationships that leaders

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<sup>45</sup> What is Six Sigma? <https://www.isixsigma.com/new-to-six-sigma/getting-started/what-six-sigma/> iSixSigma, Retrieved Nov. 14, 2017.

<sup>46</sup> Richard Daft, *The Leadership Experience 7<sup>th</sup> Ed.*, (Boston, MA, Cengage Learning, 2016)

<sup>47</sup> Richard Daft, *The Leadership Experience 7<sup>th</sup> Ed.*, (Boston, MA, Cengage Learning, 2016), p. 5

can influence others in the system to work collaboratively toward the improvement of the system in delivering increasing customer value. Effective leadership and establishing positive relationships requires understanding and adopting emotional intelligence, system thinking, the effective use of leader power, demonstrating leadership values of honesty, integrity, transparency and trust, effective leader communications, team building, change management, the effective use of dialogue, Socratic questioning and effective listening, relationship building, effective motivational approaches (organizational and individual), and servant leadership<sup>48</sup>. Additionally, understanding the process of knowledge creation and innovation, and effective talent and knowledge management are all critical for integrative supply chain system thinkers. Understanding and employing appropriate leadership theories, principles and techniques is critical for the creation of an organizational culture that fosters customer value creation and productivity improvement through innovation, knowledge creation and continuous improvement. The following sums up key characteristics of organizational culture that need to be in place for firms to successfully improve customer value delivery and productivity simultaneously.

"The critical task for supply chain managers is to create a work environment that supports the knowledge-creation process, enabling unique, game-changing knowledge that can be institutionalized for the benefit of the organization.

Managers need to value and emphasize attributes such as entrepreneurship, creativity, innovation, adaptability, risk taking, growth, goal achievement, and competitiveness. This helps employees feel secure about finding ways to create new knowledge.

Companies should be externally oriented, exhibiting responsiveness and flexibility in satisfying market demands. This will help identify new opportunities that require the discovery and implementation of new knowledge to capitalize on those opportunities. The new knowledge needs to be implemented in a way that makes it difficult for competitors to copy. This implies that the business continuously creates new, unique knowledge to help satisfy the market.

Businesses need to engage the collective tacit knowledge of their employees to find ways to implement game-changing ideas.

Firms must develop and enhance knowledge-creating potential of their employees through training and skills development.

Managers must have the courage to test possible better ways.

Leaders should be focused on the long term, not driven solely by the next quarter's results. In that way, a business is focused on building sustainable competitive capabilities."<sup>49</sup>

## Knowledge Creation and Innovation - Dr. I. Nonaka and Dr. H. Takeuchi

In their book entitled *The Knowledge-Creating Company*<sup>50</sup>, Dr.'s Nonaka and Takeuchi provide key insights as to how new innovative knowledge is created.<sup>51</sup> First, they identify that knowledge creation is a human activity that occurs at an individual level, in context, and that organizations in and of themselves cannot create new knowledge. They draw on the work of Dr. M. Polanyi<sup>52</sup>, who identified two types of knowledge, tacit and explicit. Explicit knowledge is knowledge previously created, captured and codified in the form of a book, a musical score, computer code,

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<sup>48</sup> "Servant leadership is leadership upside down. Servant leaders transcend self-interest to serve the needs of others, help others grow and develop, and provide opportunities for others to gain materially and emotionally." Richard Daft, *The Leadership Experience 7th Ed.*, (Boston, MA, Cengage Learning, 2016)

<sup>49</sup> Impossible To Replicate: Develop Airtight Knowledge To Keep Competitors At Bay, APICS Magazine, (May/June 2016) 32-37, B. Watson, S. Hummel, K. Harling.

<sup>50</sup> I. Nonaka, H. Takeuchi, *The Knowledge Creating Company* (New York, Oxford University Press, 1995)

<sup>51</sup> It is highly possible that the most successful Japanese firms studied in their research were among those which had embraced Dr. Deming's SoPK in the managing of their firms.

<sup>52</sup> M. Polanyi, (1983) *The Tacit Dimension* (Gloucester, MA, Peter Smith Publisher Inc., 1983) as found in I. Nonaka, H. Takeuchi, *The Knowledge Creating Company* (New York, Oxford University Press, 1995)

embodied standard operating procedures, equipment, etc. It was knowledge developed in a different context, to address a problem or achieve a desired goal in the past. Explicit knowledge is easily shared and disseminated, and as such is not a good source upon which to try and create a sustainable competitive advantage.

Tacit knowledge creation is the key. It happens at an individual level, in the context of addressing a problem or creating a solution or new innovative idea. It requires the interaction of people sharing that same context, but from diverse perspectives. As new knowledge is a human construct, organizations cannot create new knowledge in and of themselves. The best an organization can do is create the environment that fosters the continuous creation of new innovative tacit knowledge. Once created, new tacit knowledge is then combined with existing explicit knowledge in the organization, resulting in new innovative knowledge to be shared across the organization for the improvement of customer value delivery and system productivity. Given the fact that the new innovative knowledge is unique to the organization, once implemented it may provide a competitive advantage for the firm. The process of new knowledge

“...the firm’s ability to effectively meet the challenges of today’s (and tomorrow’s) dynamically complex global economy is limited to the explicit knowledge contained in their system.”

“Tacit knowledge creation is the key!”

creation must occur on a continuous basis for an organization to realize sustainable competitiveness. Far too many organizations rely on explicit knowledge in “the way we’ve always done things”. Traditional managers of all stripes rely on their expertise to direct employees. As such, the firm’s ability to effectively meet the challenges of today’s (and tomorrow’s)

dynamically complex global economy is limited to the explicit knowledge contained in their system. The longer that is the case, the further the firm falls behind the competition in delivering increased customer value and improving firm productivity. Considering that this issue exists across many organizations and sectors, one can make the argument that this lack of innovative knowledge creation is directly contributing to Canada’s productivity challenge.

Through their research, Dr.’s Nonaka and Takeuchi identified five enabling conditions that must be in place for organizational knowledge creation and innovation to occur. The five enabling conditions include: i) Intention, ii) Autonomy, iii) Fluctuation and Creative Chaos, iv) Redundancy, v) Requisite Variety<sup>53</sup>. These enabling conditions in their totality are essential to the creation of a culture of innovation and continuous improvement in an organization. By their work, Dr.’s Nonaka and Takeuchi have contributed to the system thinking framework by illuminating how new knowledge creation and innovation for continuous improvement occurs at an individual level, and how it can be captured and employed to the benefit of the system. New knowledge creation and innovation is critical to improving customer value delivery and productivity. Integrating this system thinking understanding with supply chain management is critically important for organizations. In their role as integrators, coordinators, and enablers, integrative supply chain system thinking specialists must strive to improve customer value delivery and productivity in dynamically complex supply chains, and they must do that with and through people. Establishing a culture of innovation is key, and effective leadership is essential in developing the right culture. As new problems and challenges surface each and every day, understanding how new innovative knowledge is created to address those challenges is critical for integrative supply chain system thinking specialists!

### Value Innovation - Dr. R. Mauborgne and Dr. W. C. Kim

Integrative supply chain system thinking specialists understand the importance of embedding continuous improvement into an organizations’ competitive business strategy. Three thought leaders in this area are Dr.’s Mauborgne and Kim, and Dr. Goldratt. In their book, *Blue Ocean Strategy*<sup>54</sup>, Dr.’s Kim and Mauborgne’s research

<sup>53</sup> I. Nonaka, H. Takeuchi, *The Knowledge Creating Company* (New York, Oxford University Press, 1995)

<sup>54</sup> Kim, W. C., Mauborgne, R. *Blue Ocean Strategy*, Boston, MA, Harvard Business Review Press, (2005)

identified a shift from conventional business strategy theory. Conventional business strategy identifies three primary approaches that a firm chooses from in setting their strategic business approach. Conventional business strategy further identifies that industries are bounded, and competition occurs within the boundaries as defined by the competitive forces<sup>55</sup> of the industry. Market potential and profit potential are also established by those same competitive forces and industry boundaries. Conventional wisdom identifies that the choice of strategic business approach adopted by a firm typically involves a tradeoff between lower firm costs (lowest cost strategy) or increased customer value (differentiation strategy, typically at higher cost). Dr.'s Kim and Mauborgne identified in their research that the most successful firms do not buy into the bounded industry paradigm. Rather, those firms create their own uncontested market space, and therefore profit potential, breaking away from the conventional wisdom of bounded industries. Their research introduced in the idea of value innovation.

“Value innovation is the cornerstone of blue ocean strategy. We call it value innovation because instead of focusing on beating the competition, you focus on making the competition irrelevant by creating a leap in value for buyers and your company, thereby opening up new uncontested market space.”<sup>56</sup>

Value innovation involves the simultaneous pursuit of increased customer value (differentiation strategy) *while* lowering costs (lowest cost strategy) through increased productivity. Value innovation eliminates the need for a tradeoff in deciding which strategic approach to pursue. Value innovation is the result of the application of the Four Actions Framework<sup>57</sup>. This framework requires an organization to answer the following four questions;

Eliminate: Which of the factors that the industry takes for granted should be *eliminated*?

Reduce: Which factors should be *reduced* well *below* the industry's standard?

Raise: Which factors should be *raised* well *above* the industry's standard?

Create: Which factors should be *created* that the industry has never offered?

In answering these four questions and acting on the answers, an organization can simultaneously increase customer value while increasing productivity (effectively lowering costs), creating a blue ocean of uncontested market space. Blue Ocean Strategy contributes to system thinking by providing both a framework and a structured approach to improving customer value and productivity simultaneously. Of note, there are many parallels between the work of Dr.'s Kim and Mauborgne and that of Dr. E. Goldratt. Dr.'s Kim and Mauborgne's research and teaching adds to the development of integrative supply chain system thinking competencies needed to increase the competitiveness of Canadian firms in the global economy.

### Theory of Constraints - Dr. E. Goldratt

Dr. Eli Goldratt was a modern day thought leader in the application of system thinking. His work on the Theory of Constraints (TOC) is captured in his many books, the most well known of these is *The Goal*<sup>58</sup>. TOC provides both a framework and a structured approach for improving a system's performance. Originally developed for manufacturing firms, Dr. Goldratt clearly identifies that the goal (or aim) of the system is to “make money now as well as in the future”<sup>59</sup>. In not-for-profit firms, the goal is to achieve ‘goal units’ as opposed to money. Achieving the goal of the firm is subject to two necessary conditions. The first necessary condition requires that a firm, “Provide a secure and satisfying environment for employees now as well as in the future.”<sup>60</sup> This is clearly consistent with Dr. Deming's teachings and the importance he placed on having all employees of the firm committed to working together to

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<sup>55</sup> The reader is invited to review Dr. Michael Porter's work on the Five Competitive Forces.

<sup>56</sup> Kim, W. C., Mauborgne, R. *Blue Ocean Strategy*, Boston, MA, Harvard Business Review Press, (2005)

<sup>57</sup> Kim, W. C., Mauborgne, R. *Blue Ocean Strategy*, Boston, MA, Harvard Business Review Press, (2005)

<sup>58</sup> *The Goal* by Dr. E. Goldratt, has sold over 6 million copies worldwide, and has been translated into nine languages (including English). Goldratt, E., *The Goal*, Great Barrington, MA, (1984)

<sup>59</sup> Goldratt, E.M. *It's Not Luck*, Great Barrington, MA, North River Press (1994)

<sup>60</sup> Goldratt, E.M. *It's Not Luck*, Great Barrington, MA, North River Press (1994)

achieve the aim of the system. There is considerable literature available on how to effectively lead (as opposed to manage) employees to achieve the aim of the system. The second necessary condition is based in the knowledge that "...the market punishes companies that don't satisfy the *market perception of value*"<sup>61</sup> (author's italics for emphasis). As such, the second necessary condition requires that a firm, "Provide satisfaction to the market now as well as in the future."<sup>62</sup> To provide satisfaction to the market, we must clearly understand what the market/customer values and then deliver it effectively and consistently better than the competition. When this happens, the firm becomes the supplier/product of choice, improving the competitive position of the firm. All that said, if either necessary condition is violated by the policies and practices of (traditional) management, the goal of the organization cannot be fully achieved. The emphasis is clear, continuously improved system performance comes *only* through satisfied employees committed to and focused on innovating new knowledge toward delivering ever increasing customer value.

TOC embodies system thinking. It identifies that the key to delivering increasing customer value and productivity is through the identification and leveraging of the weakest link in the system. All other resources in the system are then aligned and synchronized to the performance of the weakest link, thereby delivering increased customer value while improving productivity. This is consistent with what Dr.'s Kim and Mauborgne found in their research, i.e. value

"...continuously improved system performance comes *only* through satisfied employees committed to and focused on innovating new knowledge toward delivering ever increasing customer value."

innovation. Through the leveraging of the weakest link and aligning and synchronizing all other activities to the capabilities of the weakest link, productivity and customer value improvement occurs at an ever-increasing rate, at a rate superior to that of the competition, while productivity improves and costs go down. Adherents of

scientific (traditional) management and standard cost accounting have difficulty with this approach, as it requires that most of the resources employed in the value creation process run at less than peak efficiency. In a standard cost environment, employees and/or equipment running at less than peak efficiency is ineffective and seen as an opportunity to cut costs. During the continuous improvement process, employees innovate ways to improve system performance through the application of lean techniques including set up reduction, small lot production, and variation analysis as guided by the principles in TOC. Dr. Goldratt prescribed Five Focusing Steps<sup>63</sup> to guide the approach to improving system performance. The Five Focusing Steps include; i) Identify the system's constraints, ii) Decide how to exploit the system's constraints, iii) Subordinate everything else to the above decision, iv) Elevate the system's constraints, and v) If in the previous steps a constraint has been broken, go back to Step i), and do not allow inertia to cause a system constraint. Employing Dr. Goldratt's Focusing Steps on a continuous basis drives the creation of new innovative knowledge, elevating the effectiveness of the system in maximizing customer value delivery and productivity *with existing resources*. It is only at that point that it makes sense to invest in new technology, if that is what is required to further improve customer value delivery and organizational performance. Any such investment is guided by TOC principles, i.e. does the proposed investment in technology increase system Throughput?

It's important to note that the principles of TOC can apply to any organization, including service organizations. The principle of identifying the weakest link, then aligning and synchronizing all activities to the performance of the weakest link applies in service organizations, be they hospitals, banks, or colleges. Once identification, alignment, and synchronization occur, the delivery of customer value improves, productivity improves, and overall system

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<sup>61</sup> Goldratt, E.M. *It's Not Luck*, Great Barrington, MA, North River Press (1994)

<sup>62</sup> Goldratt, E.M. *It's Not Luck*, Great Barrington, MA, North River Press (1994)

<sup>63</sup> E. Goldratt, *What is this thing called Theory of Constraints and how should it be implemented?* (Great Barrington, MA, North River Press, 1990)

performance improves. Only at this point should technology be introduced to a system that is now performing effectively given its current resources.

## Value Stream Mapping

Dr. Senge's system thinking, Dr. Deming's System of Profound Knowledge and Plan, Do, Check, Act, Dr. Taguchi's Quality Loss Function, Dr. Shingo's Toyota Production Systems, Dr. Goldratt's Theory of Constraints, Dr.'s Nonaka and Takeuchi's knowledge creation and innovation process, and Dr.'s Mauborgne and Kim's value innovation together provide a framework and structured approaches for the application of system thinking. The collective work of these thought leaders provides a system thinking framework, prescribing implementable, structured approaches that any organization can employ in the creation of new innovative knowledge and increasing customer value delivery while improving productivity. Value stream mapping<sup>64</sup> (VSM) is another key tool employed by the specialist in mapping out the current state of the organization's ability to deliver customer value. VSM clearly distinguishes between wasteful practices and value adding practices. It clearly captures both material and information flows (i.e. planning and scheduling systems) and is an excellent tool for identifying the weakest link in a system. It is also an excellent tool for clearly presenting the facts regarding the organization's current state, visible to all and easy to understand. That makes it an excellent tool for transferring knowledge and breaking down frozen preferences, 'the way we've always done it'. Once a current state map (CSM) is complete and the weakest link is identified, a future state map (FSM) is created, drawing on the tacit knowledge of employees that currently do the work being mapped, including members of other departments (such as accounting, engineering, purchasing, shipping, etc.). Their newly created tacit knowledge is combined with existing system explicit knowledge to innovate an improved approach to customer value delivery and productivity. The new future state will draw on TOC to align and synchronize all other activities in the firm to the capabilities of the weakest link. Lean techniques and Six Sigma will be employed to achieve the improvements identified in the FSM. Planning systems (such as ERP) will have to be modified to support the future state, as will policies, procedures, and performance metrics. Integrative supply chain system thinking specialists understand the implications of any proposed change before they are made, as captured in the FSM implementation plan. Management and accounting will employ new rate-based metrics (remember, *you get what you measure*) to measure the system's ability to deliver ever increasing customer value while improving productivity. As system effectiveness improves, future improvements may include investments in new technology, guided by TOC and system thinking, where technology will be employed to improve and increase system performance in the delivery of customer value. All of this can be achieved in a culture that is customer focused, embraces continuous improvement as its strategic business imperative, and recognizes and encourages all employees to fully participate in creating new innovative knowledge each and every day. Trained as effective leaders, integrative supply chain system thinking specialists work with all levels in an organization to drive continuous improvement. They employ personal power and servant leadership to build trusting relationships with those that must cause the change. They ask questions and listen to responses, guiding people to innovate solutions to the challenges they face. And that is the true road to world leading productivity and customer value creation!

## Developing Competencies

Competence is defined as;

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<sup>64</sup> For understanding of value stream mapping, the reader is encouraged to read, Rother, Mike, Shook, John, *Learning to See*, (Cambridge, MA, Lean Enterprise Institute, 1999)

“A cluster of related abilities, commitments, knowledge, and skills that enable a person (or an organization) to act effectively in a job or situation. Competence indicates sufficiency of knowledge and skills that enable someone to act in a wide variety of situations”<sup>65</sup>.

Skills become competencies when applied in context. As stated earlier, integrative supply chain system thinking can be developed in post-secondary programs. Aspects of integrative supply chain system thinking competencies can also be developed in the workplace in partnership with a post-secondary institution currently delivering such programming. In such programs, the skills, frameworks, and structured approaches learned begin to develop into competencies through the use of applied business and/or industry projects. Key competencies being developed include those of cognitive and behavioural complexity, and emotional equanimity.

Cognitive complexity is, “An ability to recognize and accept the interrelated relationship of underlying tensions. It enables actors to host paradoxical cognitions—the cognitive frames that accept contradictions”<sup>66</sup>. Those who hold to frozen preferences lack cognitive complexity. The ability to accept the contradictions of dynamically complex systems is supported by the system thinking frameworks and approaches developed by the thought leaders described earlier in this paper. Cognitive complexity is embodied in critical thinking and the ability to deal with ambiguity. It is embodied in analysis, analytics and making sense out of data, in the seeing of patterns and relationships between systems and subsystems, and in asking questions and addressing underlying assumptions about the way things are done in the process of problem solving and decision making. While the skills and techniques that support cognitive complexity development can be learned, they become competencies when applied to real business and industry problems.

Behavioural complexity is, “The facility to adopt competing behaviors, enabling acceptance of paradoxical tensions”<sup>67</sup>. Leadership training is essential in the development of behavioural complexity. It is embodied in emotional intelligence, and in the ability of a leader to modify roles based on changing contexts and individual needs. It’s about understanding motivational theory and human behaviour, understanding what it takes to develop trusting relationships, and the ability to effectively adopt a continuum of leadership styles when required to motivate others toward the attainment of the aim of the system. The ability to develop behavioural complexity in dynamically complex systems is supported by the system thinking frameworks and structured approaches developed by the thought leaders described earlier. As with cognitive complexity, while the skills and techniques that support behavioural complexity development can be learned, they become competencies when applied to real business and industry problems.

Emotional equanimity is, “An emotional calm and evenness”<sup>68</sup>. When a skill is learned, and through successful application develops into a competency, one develops the ability to act effectively in a wide variety of situations. Once developed, such competency allows an individual to approach dynamically complex situations with a sense of calm and evenness. Achieving emotional equanimity in dynamically complex systems is supported by the system

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<sup>65</sup> Business Dictionary, Definition of Competence, <http://www.businessdictionary.com/definition/competence.html> Retrieved October 16.17.

<sup>66</sup> Smith, W. K., & Tushman, M. L. 2005. Managing strategic contradictions: A top management model for managing innovation streams. *Organization Science*, 16: 522–536, in Smith, Wendy K., Lewis, Marianne W., *TOWARD A THEORY OF PARADOX: A DYNAMIC EQUILIBRIUM MODEL OF ORGANIZING*, Academy of Management Review, 2011, Vol. 36, No. 2, 381–403.

<sup>67</sup> Denison, D., Hooijberg, R., & Quinn, R. 1995. Paradox and performance: Toward a theory of behavioral complexity in managerial leadership. *Organization Science*, 6: 524–540, in Smith, Wendy K., Lewis, Marianne W., *TOWARD A THEORY OF PARADOX: A DYNAMIC EQUILIBRIUM MODEL OF ORGANIZING*, Academy of Management Review, 2011, Vol. 36, No. 2, 381–403.

<sup>68</sup> Huy, Q. N. 1999. Emotional capability, emotional intelligence, and radical change. *Academy of Management Review*, 24: 325–345, in Smith, Wendy K., Lewis, Marianne W., Smith, Wendy K., Lewis, Marianne W., *TOWARD A THEORY OF PARADOX: A DYNAMIC EQUILIBRIUM MODEL OF ORGANIZING*, Academy of Management Review, 2011, Vol. 36, No. 2, 381–403.

thinking frameworks and structured approaches developed by the thought leaders described earlier. As with cognitive and behavioural complexity, while the skills and techniques that support the development of emotional equanimity can be learned, they become competencies when applied to real business and industry problems.

### Proof of Concept

The skills and competencies as described in this paper are embodied in the curriculum of the Business Administration Supply Chain and Operations Management (SCOM) program at Conestoga College. The SCOM program design is based on Dr. Deming's System of Profound Knowledge. Incorporated into the curriculum design are the four elements of SoPK, as well as the teachings of all the other thought leaders described above. Working closely with the Magna Centre for Supply Chain Management, student teams complete real business and industry VSM capstone projects in their final academic semester. For the most part, these projects are success stories, resulting in tremendous improvement opportunities for organizations. Many of the projects identify tens to hundreds of thousands of dollars, and in some cases millions of dollars in improvement opportunities while increasing delivered customer value! That said, far too often student teams run into the frozen preferences of traditional management. Some traditional managers have gone so far as to say "The data contained in the Current State Map is wrong and it needs to be changed to show....." Despite the fact that the data contained in the CSM is theirs, what these (embarrassed) managers are really saying is that they are not willing to change. It is situations such as these, multiplied many times over, that is negatively impacting Canada's productivity. And no level of investment in technology will solve this issue!

If one is willing to look, you can find examples of organizations which have embraced integrative supply chain system thinking. They are out there, but they don't publicly announce that fact in an effort to maintain their competitive advantage. That's why it's important for all organizations to incorporate the development of system thinking competencies as a strategic imperative, be they public or private sector organizations, in health care, education, retail, manufacturing, government, for profit and not-for-profit, etc., and across all disciplines including sales and marketing, finance and accounting, and supply chain and operations, engineering, etc.

Recall Company A. A VSM project was completed at Company A. The proposed FSM improvement projections were astounding. Three capacity constraining resources were identified requiring action. Unless actioned, the firm would not have the capacity to achieve the budgeted sales for the next fiscal year. Three primary improvement recommendations were made by the VSM team;

- 1) Increase the primary and secondary constraint availability by initiating a SMED<sup>69</sup> project to dramatically reduce set up times, first at the constraints, then adopt the practice across other work centres as necessary as volumes grow. Also investigate, document, and address the causes of unplanned downtime and scrap rates at the constraints in order to increase the work centres' capacity.
- 2) Investigate the third constraining resources' capacity issue by digging deeply into the identified cycle time in an effort to understand why it's so long and take actions to reduce it. Implement 5S in the area to improve organization and flow in that work area.
- 3) Move away from the current batch/push scheduling approach and implement level mixed model pull scheduling<sup>70</sup>. This change will dramatically reduce the current production batch size and therefore inventory levels, and directly link each operation and all employees to the takt time of customer demand.

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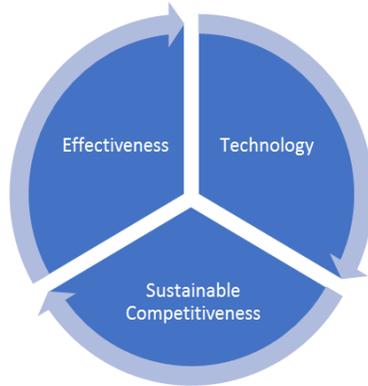
<sup>69</sup> Single Minute Exchange of Dies, a proven methodology developed to dramatically reduce changeover/set up times to less than 10 minutes. Refer to, *A Study of the Toyota Production System* by Dr. Shingo

<sup>70</sup> Given the produce to order, low volume environment, this would be relatively simple to implement after actions 1) and 2) are completed.

These three actions once implemented would reduce inventory by a targeted eighty-five percent, eliminate planned overtime, ship two million dollars in past due shipments, eliminate the month end shipping 'hockey stick', dramatically improve cash flow, free up direct and indirect labour for new business (remember the labour shortage), and free up significant capacity. The resultant freed up capacity and labour will allow the firm to increase sales by approximately six million dollars per year with no investment in capital equipment! However, this can only be achieved if the firm's management *'have the courage to test possible better ways'*.

## Summary

Success in delivering increasing customer value while improving productivity can only occur if organizational culture enables it to happen. Integrative supply chain system thinking specialists have the potential to positively impact culture when trained in the framework and techniques described in this paper. The path to achieving sustainable competitiveness begins with the learning and application of system thinking, with the goal of improving the



operational effectiveness of the system, thereby improving customer value delivery. Once that happens, additional capital and human resources are freed up, allowing for the selective investment in appropriate technologies to leverage that effectiveness and leap ahead of the competition. This approach occurs in a continuous cycle to achieve ever higher levels of performance and sustainable competitiveness. Every sector in society should employ system thinking if we are to truly address our productivity challenge here in Canada. Investment in technology alone in the absence of

system thinking will not get us there!

Post-secondary degree and diploma programs in all disciplines including accounting, finance, sales, marketing, engineering, operations management and others should incorporate system thinking in their curriculum. That curriculum should include a study of the work of the thought leaders described earlier<sup>71</sup>, and the application of that learning in the development of graduate competencies. It should also be introduced in high school curriculum. Such an approach should be amenable to colleges and polytechnic institutions, and possibly to some universities. Some have suggested that Canada adopt a national education strategy that better aligns curriculum delivered by our education systems with the true needs of business, industry, and Canadian society. A case could be made that the lack of alignment between our secondary and post-secondary education and the needs of Canadian society is directly contributing to Canada's productivity challenge. Given the experience in some European countries, such alignment once achieved would have a tremendous positive impact on Canadian productivity and the standard of living for all Canadians well into the future.

**“Investment in technology alone in the absence of system thinking will not get us there!”**

<sup>71</sup> In the context of continuous improvement, program curricula should be updated based on the latest research findings of not only current, but future thought leaders as well.

## **Brian Watson, BA, MBA, CPIM**

*Brian Watson is the Director of the Magna Centre for Supply Chain Excellence at Conestoga College since its inception in 2017. Brian joined Conestoga College in 1999 as a Professor in the Supply Chain & Operations Management Program. In this capacity, Brian twice served as Program Coordinator, and was the lead professor in the development of the International Business Management degree program's supply chain specialization. Following graduation from the University of Waterloo in 1978, until joining Conestoga College in 1999, Brian was employed in Canada's supply chain sector, holding senior management positions in both supply chain and operations management. In 2008 Brian completed an MBA in Management with the Edinburgh Business School at Heriot Watt University. Brian's research focuses on system thinking, continuous improvement, leadership and team building, and organizational culture and innovation.*

*Brian is a Past President of the Ontario Grand Valley (OGV) Chapter of APICS, and has been an active member of APICS since 1983. Brian has presented at numerous APICS professional development meetings on a variety of supply chain and operations management topics, and has published in the APICS Magazine. Brian holds the APICS professional designation CPIM since 1983, and completed system thinking and Theory of Constraints training with the Goldratt Institute in 1991.*

*In 2000, Brian was nominated for the Aubrey Hagar Distinguished Teaching award at Conestoga College. In 2002, and again in 2008 Brian was selected as the APICS OGV Chapter Member of the Year.*

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