The Spectrum of Supply Chain Agility

CSCR® WHITE PAPER

August 2021

Contributing Authors

Steve Tracey  Kusumal Ruamsook  Galen Smith

The Center for Supply Chain Research®
Smeal College of Business, The Pennsylvania State University, in collaboration with IBM
CONTENTS

Introduction .............................................................................................................................................................................2
What's in a Name? ................................................................................................................................................................ 4
  The Conceptual Ambivalence of Supply Chain Agility ................................................................. 4
  The Emerging Conceptual Consensuses ..................................................................................... 5
Supply Chain Agility in a Nutshell .................................................................................................................................... 7
  The Dual Cores and Manifestations .............................................................................................. 8
    Supply Chain Flexibility ................................................................................................................ 8
    Supply Chain Responsiveness ...................................................................................................... 9
Enabling Infrastructure ........................................................................................................................................... 11
  Technological Enablers .................................................................................................................. 11
  Organizational and Human Enablers .......................................................................................... 12
The Spectrum of Supply Chain Agility ........................................................................................................................... 16
References............................................................................................................................................................................. 19

List of Tables and Figures

Figure 1: Supply Chain Agility Framework ................................................................................................. 7
Figure 2: Supply Chain Responsiveness Technology Enablers .................................................................. 12
Figure 3: The Spectrum of Customer-Focused Supply Chain Agility ..................................................... 16

Table 1: Examples of Supply Chain Flexibility Manifestations ................................................................. 8
Table 2: Examples of Supply Chain Responsiveness Manifestations .................................................... 10
Table 3: Key Characteristics of Agile Supply Chain Organizations ...................................................... 13
Table 4: Key Characteristics of Agile Supply Chain Talents ................................................................. 15
INTRODUCTION

In today’s increasingly competitive and turbulent business environment, agility has been widely recognized as one of the fundamental characteristics of forward-looking supply chains. Research studies and business leaders underscore potential positive impacts afforded by supply chain agility (SCA) on various performance areas, including financial performance (e.g., profit, sales growth, cost reduction, return on assets), market performance (e.g., market share, customer satisfaction, market differentiation), and operational performance (e.g., new product development, customer service, and inter-organizational relationships).\(^1\)

While the appreciable attention towards SCA has been much discussed, attention to adoption is recently accelerating due to the COVID-19 pandemic crisis. The effects of the virus and government efforts to contain its spreads through travel restrictions, social distancing, shelter-in-place orders, and non-essential closures have led to unprecedented changes in both demand and supply. These shifts are disparate and unpredictable across markets (e.g., critical vs. non-critical goods and services), across geographic locations, and over time from the initial maximum restrictions to the varying stages of reopening and economic reactions. As companies try to deal with these phenomena, those with the agility to rapidly pivot their supply chains have shown to be better able to weather the storm, and would likely emerge in a better position to thrive in the new normal that has yet to materialize.

Indeed, the cultivation of agility in supply chains has become the central aspect of strategic moves required not only to foster resilience in the vulnerable and disruptive supply chains, but also to promote competitive advantages in the hyper-dynamic and competitive markets. However, there remains a great deal of confusion around the concept of agility what it construes and, what its applications might look like. In discussing SCA with various companies, we often ask them to self-evaluate their current level of agility. A typical response is “we’re very agile, when a situation comes up for an un-anticipated customer demand, or a supply disruption we do whatever it takes to satisfy the customer.” When queried further as to ‘how’ this was accomplished, there are stories of hero cultures where people are rewarded for herculean efforts to satisfy customers and how significant the additional efforts and resources are expended to meet those needs. While it is broadly true that most firms will go above and

\(^1\) Abdoli Bidhandi and Valmohammadi 2017; Eckstein et al. 2015; Gligor et al. 2020; Gligor and Holcomb 2012b; Shashi, Cerchione, and Ertz 2020; Um 2017
beyond to respond to unanticipated demands or supply disruptions, what is thought of as agility is in reality heady reactive problem solving.

Let’s not confuse successful fire-fighting capability with agility. Any endeavor to bring SCA into fruition would be seemingly impossible without this fundamental clarity. Drawing on the authors’ research and experiences working with supply chain professionals in this area, this paper presents a conceptual foundation of SCA and describes the spectrum of SCA applications. The purpose of this paper is to bring clarity to SCA conceptual lenses and call attention to the contextual factors in SCA applications for supply chain managers embarking on their journey towards SCA.
WHAT’S IN A NAME?

Several conceptual studies of SCA have emerged since its introduction as a business concept about three decades ago. Extant research literature largely conceptualizes SCA as a strategic capability that pertains to both operational and relational aspects, and predominantly focuses on examining the dimensions and antecedents of SCA. In its broadest purport, literature consistently regarded SCA as the ability of a supply chain to effectively and timely respond to changes. However, a more granular question of what exactly constitutes SCA, thus the aptitudes required to successfully develop this dynamic capability, is still largely shrouded by ambiguities and discordance.

The Conceptual Ambivalence of Supply Chain Agility

The current lack of conceptual clarity is due primarily to the disparate, multidisciplinary nature of SCA literature, and several connotations used in relation to SCA. Research has considered SCA as a higher order capability derived from various inter-related, underlying capabilities, most frequently associated terms of which include flexibility, adaptability, and responsiveness. Each extensively studied in and of itself or in conjunction with the others, it is observed that these popular connotations are often used interchangeably, referred to without clear distinction, or portrayed with inconsistent depictions.

Equally, agile thinking, a relevant philosophical mindset has emerged amidst agile concept conversations. Originated in software development, agile thinking is a project management approach based on central tenets of customer centricity, iterative processes of empirical-based updates and experimentation, cross-functionality, and team empowerment. These tenet have been applied in numerous industries, functions, and contexts and manifested in multiple methodologies such as Scrum,
Kanban, Scrum, Scrum@Scale, Dynamic Systems Development Method (DSDM). In this respect, literatures on agility-related organizational factors posit that effective SCA requires more than dynamic operational and relational capabilities. For the dynamic capabilities to be effectively devised and leveraged, it requires organizational capabilities that combine leadership competency, organizational culture, collective commitments, managerial supporting processes, and development of human competencies and expertise. Despite these research conclusions, agility from the philosophical perspective is noticeably absent in the supply chain domain.

The Emerging Conceptual Consensuses

Propitiously, a number of constellations of insights began to emerge and provide a basis for the conceptual frameworks presented in this paper. First, SCA literature shows an emerging consensus that emphasizes *flexibility* and *responsiveness* as the key elements of agility—each of which comprises a complex set of aptitudes that are enabled by a synthesis of multiple technologies. These elements will be further discussed later on in the paper.

Second, while both supply chain “agility” and “adaptability” as dynamic capabilities pertain the ability to respond to changes, they are distinguished on the basis of nature of change stimuli and the extent of responses. Specifically, while agility focuses on coping with *short-term, temporary* changes (e.g., supply fluctuations and demand variations like variety and volume), adaptability addresses *long-term, fundamental* changes (e.g., socio-political change, demographic change, radical technological advances). Also, whereas agility responds to changes through adjustments within the *existing* configurations of the supply chain system, adaptability do so to such an extent that involves *reconfiguration* of supply chain network and operations. In respect of these distinctions, agility is acknowledged as a key element of

---

10 APQC 2019a; Meyer 2019b
11 Al Humdan, Shi, and Behnia 2020; Daniel et al. 2020; Fayezi, Zutshi, and O’Loughlin 2017; Gligor et al. 2019a; Sharma et al. 2017; Shashi, Cerchione, and Ertz 2020; Van Wassenhove and Delagarde 2017
13 Abdoli Bidhandi and Valmohammadi 2017; Al Humdan, Shi, and Behnia 2020; Chen 2019; Doz and Gaudalupe 2021; Gunasekaran et al. 2019; Pahwa and Kumar 2018; Sharma et al. 2017; Shashi, Cerchione, and Ertz 2020
14 Interested readers are referred to work by Abdoli Bidhandi and Valmohammadi (2017), Al Humdan, Shi, and Behnia (2020), Braunscheidel and Suresh (2018), and Sharma et al. (2017) for a summary of various definitions of supply chain agility posited in extant literature.
15 Bernardes and Hanna 2009; Cohen and Kouvelis 2020; Eckstein et al. 2015; Lee 2004; Manenti 2019
adaptability and, by extension, a related concept of resilience that required the supply chain’s ability to adapt in response to disruptions.\textsuperscript{16}

Third, in line with the agile thinking’s central tenet of customer centricity, customer- or demand-driven agility has emerged as one of the key themes in SCA research.\textsuperscript{17} Further, literature begins to systematize SCA concepts from both dynamic capability and organizational model perspectives. A notable example is a conceptualization by Braunscheidel and Suresh (2018) who described two sets of antecedents to SCA, which include indirect, cultural antecedents (e.g., organizational culture and learning orientation) and direct antecedents, involving supply chain initiatives.

\textsuperscript{16} Colicchia and Strozzi 2012; Durach, Wieland, and Machuca 2015; Pettit, Fiksel, and Croxton 2010
\textsuperscript{17} Abdoli Bidhandi and Valmohammadi 2017; Eagle and Earley 2015; Gligor et al. 2019a
SCA is the ability of a firm and its supply chain members to effectively and timely respond to short-term, temporary changes in supply chain and market environment by adjusting resource, tactics, and operations within the existing supply chain structure. As depicted in Figure 1, SCA is founded on dual cores that must be in congruous coexistence, namely flexibility and responsiveness, which in turn, are enabled by technological and organizational infrastructure. Essentially, flexibility is a foundational boundary within which a supply chain’s ability to adjust will be constrained, and responsiveness primarily concerns a nimble maneuver of adjustments within the flexibility boundary to address different stimuli. Thus, responsiveness is not possible without certain levels of flexibility, and flexibility without responsiveness is devoid of deployment apparatus by which a supply chain can devise and execute a specific course of actions in a timely and cost-effective manner.18

Figure 1: Supply Chain Agility Framework

---

18 Angkiriwang, Pujawan, and Santosa 2014; Cohen and Kouvelis 2020; Fayezi, Zutshi, and O’Loughlin 2017; Gligor et al. 2020; Zitzmann 2014
The Dual Cores and Manifestations

Supply Chain Flexibility

An ex-ante capability, supply chain flexibility is developed through a configuration of different networks, processes, and resources required to manage goods/service, financial, and information flows in the supply chain. Configured with anticipated changes in mind, the supply chain pre-establishes a range of alternative options for potential future adjustments without significant penalty in time, effort, cost, or performance.  

Flexibility is a multidimensional capability that encompasses a breadth of supply chain processes (e.g., sourcing, manufacturing, logistics, etc.), as well as the depths of flexibility attributes and hierarchical layers. Flexibility attributes could vary in terms of volume, variety, functionality, and skill; while the hierarchical layers could encompass strategic/operational/tactical management layers, and intra-firm and inter-firm network layers. Thus, the “range” of alternatives, which prescribes the flexibility boundary, can be afforded through a combination of range quantity (number of options available) and range heterogeneity (diversity of options available in terms of functions, attributes, layers, etc.).

Examples of flexibility manifestations across key supply chain processes are provided in Table 1.

Table 1: Examples of Supply Chain Flexibility Manifestations

<table>
<thead>
<tr>
<th>Key Supply Chain Processes</th>
<th>Examples of Flexibility Approaches</th>
</tr>
</thead>
</table>
| Sourcing                   | Multi-sourcing for critical purchase item  
                              | Suppliers with multiple production sites  
                              | Suppliers with capability to handle product variants  
                              | Flexible supplier contracts (e.g., low minimum order quantities, high delivery frequency, expedited lead time) |
| Manufacturing              | Future expansion and re-configurability capabilities built-in during facility design |

References:

19 Bernardes and Hanna 2009; Engelhardt-Nowitzki 2012; Gligor 2014; Gligor et al. 2019a; Huo, Gu, and Wang 2018; Liao 2020; Sharma et al. 2017
20 Braunscheidel and Suresh 2018; Fayezi and Mirkovski 2017; Fayezi, Zutshi, and O’Loughlin 2017; Hippold 2020; Huo, Gu, and Wang 2018; Jafari 2015; Liao 2020; Manders, Caniels, and Ghijsen 2017; Novais, Maqueira, and Bruque 2019; Pearson 2013; Reeves and Levin 2017; Sushil 2015
21 Source: Abdoli Bidhandi and Valmohammadi 2017; Angkiriwang, Pujawan, and Santosa 2014; Braunscheidel and Suresh 2018; Brind 2020; Hippold 2020; Envista 2020; Fayezi and Mirkovski 2017; Gligor and Holcomb 2012a; Gunasekaran et al. 2019; Hippold 2020; Lesmeister, Kwasniok, and Peters 2020; Liao 2020; Lim 2020; Manders, Caniels, and Ghijsen 2017; Novais, Maqueira, and Bruque 2019; Pellegrino, Costantino, and Tauro 2020; Trent 2015; Um 2017; Yücesan 2017
<table>
<thead>
<tr>
<th>Key Supply Chain Processes</th>
<th>Examples of Flexibility Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quick changeover times, e.g., Single-Minute Exchange of Dies (SMED)</td>
</tr>
<tr>
<td></td>
<td>Capacity utilization reserves</td>
</tr>
<tr>
<td></td>
<td>Versatile machine functionality (e.g., variety of outputs, customizability)</td>
</tr>
<tr>
<td></td>
<td>Versatile production line (e.g., lot size, routings, sequencing)</td>
</tr>
<tr>
<td></td>
<td>Access to temporary labor</td>
</tr>
<tr>
<td></td>
<td>Flexible worker shift models</td>
</tr>
<tr>
<td></td>
<td>Multi-skill workers</td>
</tr>
<tr>
<td>Distribution and Logistics</td>
<td>Future expansion and re-configurability capabilities built-in during facility design</td>
</tr>
<tr>
<td></td>
<td>Multiple facility locations</td>
</tr>
<tr>
<td></td>
<td>Versatile facility functionality (e.g., volume, customers served, material handling capabilities)</td>
</tr>
<tr>
<td></td>
<td>Diversified delivery channels (e.g., wholesale, retail, drop ship, direct-to-customer)</td>
</tr>
<tr>
<td></td>
<td>Diversified vehicle fleet</td>
</tr>
<tr>
<td></td>
<td>Pre-approved multiple route and modal choices</td>
</tr>
<tr>
<td></td>
<td>Pre-approved alternative carriers</td>
</tr>
<tr>
<td></td>
<td>Flexible logistics service contract (e.g., destination, time, volume, frequency, assortment)</td>
</tr>
<tr>
<td>Product Design</td>
<td>Design with part commonality</td>
</tr>
<tr>
<td></td>
<td>Modular product design allowing reconfigurability and modification</td>
</tr>
<tr>
<td></td>
<td>Design with pre-approved material substitutes</td>
</tr>
</tbody>
</table>

Supply Chain Responsiveness

Supply chain responsiveness entails the use of the preparatory options to cope with different stimuli (e.g., demand changes, supply shortages, natural disaster events) by leveraging sense-and-response capabilities.\(^{22}\) Sensing capabilities pertain a supply chain’s ability to: (1) scan and detect short-term, temporary changes in the environment, (2) understand how these changes affect the dynamics of the supply chain, and, in turn, (3) quickly and clearly translate the insights to make decisions for an action plan.\(^{23}\) It is associated with various aptitudes such as alertness, awareness, sensitivity, visibility,

\(^{22}\) Bernardes and Hanna 2009; Charles, Lauras, and Van Wassenhove 2010; Gligor 2014; Thatte, Rao, and Ragu-Nathan 2013
\(^{23}\) Cutsey 2020; Eckstein et al. 2015; Fayezi, Zutshi, and O’Loughlin 2017; Gligor, Holcomb, and Stank 2013; Gonce et al. 2015; Jafari 2015; Leung 2021; McBeath 2020; Sharma et al. 2017
transparency, and decisiveness. Responding capabilities entail a firm’s ability to implement the action plans quickly. It is associated with various qualities, such as speed/swiftness/velocity, integration, alignment, coordination, and synergistic collaboration.

Overall, the sense-and-response capabilities required to achieve SCA can be categorized into four salient elements, hereafter referred to as VICE – Visibility, Intelligence, Collaboration, and Execution. Examples of VICE capability manifestations are provided in Table 2.

**Table 2: Examples of Supply Chain Responsiveness Manifestations**

<table>
<thead>
<tr>
<th>VICE Capability Elements</th>
<th>Examples of Sense-and-Response Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility</td>
<td>Ability to seamlessly and promptly exchange information internally and externally</td>
</tr>
<tr>
<td></td>
<td>Availability of key information (e.g., identity, location, and status of entities transiting the supply chain) at the point of decision making</td>
</tr>
<tr>
<td></td>
<td>Integrated information from many sources with ease of accessibility at the point of decision making</td>
</tr>
<tr>
<td>Intelligence</td>
<td>Ability to detect changes (e.g., customers’ demand and requirements, supply markets, business environment)</td>
</tr>
<tr>
<td></td>
<td>Ability to understand the implications of changes (e.g., opportunities, disturbances requiring quick response)</td>
</tr>
<tr>
<td></td>
<td>Scenario analysis capability that accommodates rapid, incremental planning</td>
</tr>
<tr>
<td></td>
<td>Concurrent supply-demand planning capability that accommodates multiple planning horizons</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Established cross-functional planning process to respond to changes</td>
</tr>
<tr>
<td></td>
<td>Collaborative relationships and cooperative attitude with internal and external partners</td>
</tr>
</tbody>
</table>

24 Gligor et al. 2019b; Gligor, Holcomb, and Stank 2013; Leung 2021; Shaikh 2020; Van Wassenhove and Delagarde 2017
<table>
<thead>
<tr>
<th>VICE Capability Elements</th>
<th>Examples of Sense-and-Response Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Joint strategic determination, problem-solving, and implementation planning with key customers and supply chain partners</td>
</tr>
<tr>
<td>Execution</td>
<td>- Multi-tasking teams</td>
</tr>
<tr>
<td></td>
<td>- Integrated planning and execution, with incremental, continuous planning process embedded within execution processes</td>
</tr>
<tr>
<td></td>
<td>- Coordinated processes with intra- and inter-organizational partners</td>
</tr>
<tr>
<td></td>
<td>- Active feedback exchanges for continuous improvements</td>
</tr>
</tbody>
</table>

**Enabling Infrastructure**

**Technological Enablers**

Technologies of course emerge as an essential component that empowers the dual cores of SCA. In terms of flexibility, advances in industrial systems technologies, with machine and routing flexibility, now allow a higher degree of freedom for manufacturing plants and distribution centers to process a range of different products, batch/order sizes, and volumes without significant penalties in retooling and reprogramming time. These systems are particularly enhanced with Industry 4.0 technologies like Artificial Intelligence (AI), Internet of Things (IoTs), robotics, augmented reality (AR), and additive manufacturing that automate the processes with more intelligence and versatility.\(^{27}\)

Equally, digital and information technologies sit at the forefront of enablers for a supply chain’s ability to tap into its pre-established flexibilities. Responsiveness is enabled through a portfolio of applications that have capabilities to increase visibility (e.g., demand sensing software, block-chain, social media scraping/monitoring), improve data capture and information sharing (e.g., point-of-sale data capture and transmission, track-and-trace technologies), provide decision support (e.g., scenario planning, advanced analytics), and accelerate execution (e.g., digital control tower, workflow automation). Examples of digital and IT technology applications across VICE elements are illustrated in Figure 2.\(^{28}\)

---

\(^{27}\) Ferrari Consulting and Research Group 2020; Newberry et al. 2021; Sullivan 2020; Taliaferro 2016

\(^{28}\) Source: Banker 2019, 2020b; Braun 2021; Cecere 2015; Crane, Rainwater, and Rebello 2019; Cutsey 2020; Dohnalek 2020; Envista 2020; Essaides 2018; Doz and Gaudalupe 2021; Fayezi, Zutshi, and O’Loughlin 2017; Gunasekaran et al. 2019; Joglekar 2020; Lee and Malladi 2020; Lemoine 2016; Lesmeister, Kwasniok, and Peters 2020; Leung 2021; McBeath 2020; Munholland 2019; PwC 2020; Schatteman, Woodhouse, and Terino 2020; Shaikh 2020; Sharma et al. 2017; Shashi, Cerchione, and Ertz 2020; Tarafdar and Qrunfleh 2017
Organizational and Human Enablers

Traditional organization models that have evolved primarily based on the assumptions of stability and predictability are ill-suited for today’s volatile environment. Rather, a new and fundamentally different kind of organizational models in such areas as governance, processes, culture and behavior, and leadership and talent are required to unlock the potentials of SCA. Equally, the supply chain practitioners themselves will also have to evolve to lead the way in agility. Individually, they need to be comfortable with change and with being as flexible and responsive as the supply chain needs to be.

Organizational Enablers: Agile Organization Models

Built on the agile thinking philosophy, agile organization models are characterized by senior management commitment to agility and an agile culture, decentralized decision making, and distributive organizational structures, and dynamic resource allocation. Such an organizational infrastructure, thus, resembles a network of smaller empowered units, with fewer hierarchical layers,
greater transparency, and less authoritative governance than the traditional counterparts.\footnote{Abdoli Bidhandi and Valmohammadi 2017; Agile Business Consortium 2017; De Smet et al. 2018; Deloitte 2018; Hippold 2021; Karpie 2018; Pivot International 2020} Key characteristics of agile organization models are summarized in Table 3, which collectively underpin a supply chain’s ability to embrace uncertainty and changes, as well as rapidly sense and respond to the changes.


<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organizational Structure and Governance</strong></td>
<td>■ Agile SC organizations deploy minimal bureaucracy, moving away from siloed, vertical to horizontal organization structure that delegate authority to those lower in the organizational hierarchy.</td>
</tr>
<tr>
<td><strong>Horizontal organizational structure, with minimal bureaucracy</strong></td>
<td>■ Broad spans and few hierarchical layers reduce bureaucratic complexity, break down organizational silos, and encourage cooperation for accelerative decision making and action.</td>
</tr>
<tr>
<td><strong>Team-based Model</strong></td>
<td>■ <strong>Teaming.</strong> Team is a core element of agile organization models. Designed for collaboration and aligned around corporate goals, a network of small, decentralized, multi-disciplinary teams with skills and the authority to make decisions is used. This agile approach to teaming facilitates rapid and innovative responses to emerging needs and opportunities through the balance of individuals’ empowerment and collective coordination within and among teams.</td>
</tr>
<tr>
<td><strong>Small, autonomous, cross-functional teams with customer-oriented accountability</strong></td>
<td>■ <strong>Customer-oriented accountability.</strong> Empowered teams are built around the missions to clearly understand and meet the needs of internal and external customers. Team members share accountability for the outcomes, thus have a shared sense of team ownership and purpose toward the objectives with which they are tasked.</td>
</tr>
<tr>
<td><strong>Leaderships</strong></td>
<td>■ <strong>Committed role models.</strong> Leaderships set the tone for agile culture by being role models who commit to transform themselves and develop agile mindsets and behaviors.</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Roles.</strong></td>
<td>Leaderships’ focuses shift from directive, command-and-control roles to strategists who provide guidance and allocate resource to support individual contributors in developing agile mindsets and capabilities.</td>
</tr>
<tr>
<td><strong>Workplace Culture</strong></td>
<td>Conditions for effective teamwork are created through fostering psychological safety and learning-oriented openness environment.</td>
</tr>
<tr>
<td><em>Psychological safety, with learning-oriented openness</em></td>
<td><strong>Psychological safety.</strong> Individual contributors feel comfortable to offer ideas and express concerns without risk of negative ramifications, and to experiment with process changes or new ideas without fears of failures. Thus, an environment where creativity and innovation can flourish is created.</td>
</tr>
<tr>
<td></td>
<td><strong>Learning-oriented openness.</strong> Processes are engineered to facilitate interaction and communication between teams, and evaluation tools are designed to reward cooperation and information sharing such that trust, knowledge distribution, and learning are fostered and embedded into everyday ways of working.</td>
</tr>
</tbody>
</table>

**Human Enablers: Data-Savvy Orchestrators with Growth Mindset**

As technologies emerge, supply chain practitioners will need upskilling to learn and engage in new technologies through new roles like *Data Scientist*. Processes will shift from being run by people supported by technologies to being run by technology supported by people. With advanced workflow automation, processes will not run left to right, but will be fluid, reacting to the situation and supported by key data to enable rapid decision making. A “Day in the Life” of supply chain practitioners dramatically changes as they move from spreadsheets to digital control towers supported by AI and analytics. Users will be integrated into the design and implementations of these changes in order to trust the outputs. These new technologies will surround supply chain practitioners, propelling them to transition from *operators* to *orchestrators*. Their role moves from a single function task-oriented activity dependent on finding answers through manual data mining to an orchestrator with immediate access to end-to-end supply chain data presented in robust visuals that highlight data related to the situation at hand. These data will help to augment rapid decision making and, in certain cases, generate automated execution of the results of those decisions. These orchestrators will be collaborative and innovative in delivering solutions both tactical and strategic.\(^{33}\)

---
\(^{33}\) Graefe 2021
A growth mindset is key for each person to be agile in their attitude and in their approach to new technologies. This belief in themselves to develop their abilities leads to an openness for continual learning and an attitude that views setbacks as opportunities for growth.\textsuperscript{34} While process automation strives to reduce variability, in reality, the ability to handle variability in events affecting the supply chain can also improve agility, including how people choose to handle these dynamics. The other positive impacts are the learning feedback loop that is created by success and failure from certain scenarios. People are a supply chain’s greatest resource, so the ways in which people handle the daily surprises and challenges, and how they adapt to new ways of working will greatly affect their resiliency and agility. Key characteristics of agile supply chain talents are summarized in Table 4.

Table 4: Key Characteristics of Agile Supply Chain Talents\textsuperscript{35}

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human-Technology Interface</strong></td>
<td>• Designer, trainer, and user of emerging exponential technology&lt;br&gt;• Fact- and data-based outputs augment decision making&lt;br&gt;• Automation delegates tasks to digital workers.</td>
</tr>
<tr>
<td><strong>Job Role</strong></td>
<td>• Specific functional roles evolve into end-to-end cross-functional roles.&lt;br&gt;• Shift from operators to orchestrators with data available for collaboration and rapid decision making.&lt;br&gt;• Manage workflows augmented with data and insights to adjust and optimize.</td>
</tr>
<tr>
<td><strong>Growth Mindset</strong></td>
<td>• Embrace change and continual learning from both positive and less positive outcomes.&lt;br&gt;• Eagerly approach new situations as opportunities.&lt;br&gt;• Belief in oneself to be innovative.</td>
</tr>
</tbody>
</table>

The significance of organizational and human enablers is further accentuated by the fact that developing agile organization and talent goes hand in hand with nurturing innovations. By cultivating an environment that encourages workers to be creative, innovation can permeate into all aspects of their jobs, empowering them to infuse the innovative insights gained in their decisions with greater agility. As such, a self-sustaining loop of enhancing supply chain agility is formed wherein organizational and human enablers create an environment to propagate innovation that increases the ability to be more agile which, in turn, lends to more innovation.

\textsuperscript{34} Armstrong 2019  
\textsuperscript{35} Gartner 2020
As uncertainties and changes have become norms in today’s business environment, SCA is no longer limited to those situations pertaining to innovative products or services renowned for such characteristics, but must be ingrained in all types of supply chain activity. In so doing, successful SCAs are fundamentally contextual, taking into consideration circumstantial factors—such as location, industry, corporate strategy, and customer value—that influence the degrees, types, and characteristics of changes as well as their associated impacts on supply chain performance.

Figure 3: The Spectrum of Customer-Focused Supply Chain Agility
As illustrated in Figure 3, SCA is effectuated, with a focus on serving customers, through different combinations and intensities of dual cores’ levers and enablers discussed previously to create a varying degree of reactive and proactive proficiency to cope with different stimuli faced by the supply chains.36 On the one end of the spectrum, reactive agility focuses on the capability to adjust a firm’s supply chain in respond to changes after they have happened. On the other, proactive agility focuses on the capability to anticipate changes and use that knowledge to impose changes in the environment or make adjustments before they perceptibly emerge in the environment. The former, thus, acts as a defensive mechanism aimed to manage the consequences of the stimuli; while the latter acts as preventative or exploitative mechanisms aimed to mitigate the threats or capitalize on opportunities brought by the anticipated stimuli.37

In general, the breadth and depth of flexibility capabilities prepared, the levels of advancement in Visibility, Intelligence, Collaboration and Execution (VICE) technologies employed, and the scale of agile-thinking ways of operations exercised elevate when contextual factors call for more proactive mechanisms, compared to those for the reactive counterparts. It is through these spectrums of initiatives—as propelled by innovative and agile thinkers—that a company prevails with effective uses of resources in any changing conditions, whether those that demand highly proactive agility, those where reactive agility suffice, or those that require something in between.

In conclusion, the fast pace of changes and uncertainties that are pervasive and entrenched in today’s business environment have called forth the imperative of supply chain agility. Our discussions with various companies on SCA revealed that what is thought of as agility is, in most cases, a heady firefighting practices. Having a unified understanding of what agility construes is, thus, the first critical step to moving forward on the journey towards SCA. This paper presents insights on the dual core capabilities of SCA in which flexibility provides a foundational boundary of alternatives for potential future adjustments, and responsiveness leverages sense-and-response VICE capabilities to maneuver across the prepared ranges of options.

Equally, a synthesis of multiple technologies, agile-thinking approach to organization models, and agile-inspired supply chain talents furnish important sources of enablement to the operational and relational

---

36 Al Humdan, Shi, and Behnia 2020; Fayezi and Mirkovski 2017
37 Al Humdan, Shi, and Behnia 2020; Bernardes and Hanna 2009; Sharma et al. 2017; Thatte, Rao, and Ragu-Nathan 2013
capabilities of the dual cores. The importance of organizational and human enablers as catalysts for the perpetual concurring of agility and innovation is also emphasized. Together, the dual cores, their enablers, and innovations garnered form a foundation for contextual applications that effectively balance a varying degree of reactive and proactive proficiency appropriate to diverse types of changes and their different impacts on the dynamics of supply chains.

To this end, the key components of agility described in this paper accentuate that truly agile firms are both prepared and capable of responding to most variations without the need to over-task the existing supply chain extensively. While practical manifestations of SCA will differ across supply chains, it is the ineluctable realities that SCA is becoming mandatory for enterprises seeking to simultaneously foster resilience against disruptions, promote competitive advantages against competitors, and provide superior values to customers. The time to refocus “agility” lenses and transform into a truly agile supply chain is now.


