IBM Center for The Business of Government

The Key to Modern Governmental Supply Chain Practice:

Analytical Technology Innovation

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FOREWORD

On behalf of the IBM Center for The Business of Government, we are pleased to publish, *The Key to Modern Governmental Supply Chain Practice: Analytical Technology Innovation* by Dr. David Preston, Dr. Daniel Chen, and Dr. Morgan Swink of Texas Christian University.

DANIEL J. CHENOK

TROY EDGAR

Over the past few years the COVID-19 pandemic has done much to expose and highlight critical gaps and flaws in the global supply chain. While demand for products and services continues to surge, key players in the supply chain delivery value chain struggle to meet that demand in a timely fashion. Scarce supply has resulted in increasing prices for finished goods and raw materials and an inflationary global economy.

With this scenario as context, recognize that the United States government, including federal, state, and local entities are estimated to have purchases that contributed about $3.18 trillion, or about 17 percent of the total GDP in 2018. In addition, the cost of operating supply chains is estimated to contribute up to two thirds of the final cost of goods sold. Any improvement in supply chain operations achieved through effective supply chain management will have a significant positive impact on timely delivery and appropriate pricing of goods and services. Many of these improvements can be realized through analytical or technology improvements, yet both commercial and government entities have not tapped into the full potential of technologies and analytical approaches available to them.

To address this critical issue, the IBM Center for the Business of Government commissioned a report researched and produced by Dr. David Preston and his colleagues, Dr. Daniel Chen and Dr. Morgan Swink of Texas Christian University. The report is entitled *"The Key to Modern Governmental Supply Chain Practice: Analytical Technology Innovation"* and it provides insight into the impact of analytics, block chain and artificial intelligence (AI) on supply chain management practices. The report also provides the reader with three frameworks that are helpful for designing and implementing an effective supply chain practice, enabled by technology and analytics. The first framework examines the key drivers of analytics usage for SC practice, the second examines the influence of analytics usage on SC performance outcomes and the final framework goes deeper into the ways to optimize analytics and incorporating continuous learning for the organization.

This report joins a recent IBM Center report focusing on supply chain management: *Planning for the Inevitable: The Role of the Federal Supply Chain in Preparing for National Emergencies* by Robert Handfield, Bank of America University Distinguished Professor of Supply Chain Management at North Carolina State University.

We hope that this report will provide you with a view into the opportunity provided by practical application of analytics and emerging technologies to supply chain practice.

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EXECUTIVE SUMMARY

Supply chain management (SCM) is a fundamental practice of government organizations that facilitates the exchange of products for its stakeholders.

However, public entities often lag in technological innovation and as such their supply chain (SC) practices are affected accordingly. Government organizations should look to industry practice to model how technology innovation can improve SCM. In this study, technology innovation is examined via the potential use of analytics, Blockchain, and artificial intelligence (AI) as they apply to SCM practice. We first examine analytics usage for SC impacts since analytics currently has wider rates of adoption in industry. Through an empirical analysis of industry survey data, the research design develops three frameworks for analytics usage.

- **Framework I:** The first framework examines the key drivers of analytics usage for SC practice which consists of the following contexts: 1) Technical; 2) Organizational; 3) Environmental. Specifically, this framework examines how the mechanisms within each context either directly or indirectly influence analytics usage.
- **Framework II:** The second framework examines the influence of analytics usage on SC performance outcomes: 1) Asset Productivity; 2) Organizational Growth. Furthermore, this framework examines the moderating effect of a dynamic environment that influences the degree to which analytics usage is able to impact each component of SC performance.
- **Framework III:** The final framework examines analytics usage through more granular dimensions: 1) Analytics use for Optimization; 2) Analytics use for Learning. In addition, this framework examines the mechanisms through which each of these dimensions of analytics usage influences organizational decision-making capability.

In addition, this study examines organizational potential for blockchain and AI. Blockchain and AI are assessed with consideration to the analytics frameworks as applicable and also based on their idiosyncratic technology characteristics. We examine adoption of these three technologies via the approach of a technology portfolio. Implications and recommendations for practice are provided to government executives for actionable results. Such recommendations include a series of managerial and organizational factors relevant for adoption of these technologies, specifically:

Recommendations

1: Leverage the Lessons Learned from Analytics Analysis

2: Follow the Leader

3: Develop a Technology Portfolio

4: Empower Technology Champions

5: Facilitate a Climate for Innovation

6: Ensure Strategic Alignment

7: View Functional Managers as Key Stakeholders

8: Manage Technology Talent

INTRODUCTION

Government purchases include expenditures on goods and services by federal, state, and local governments. Each year the United States spends trillions of dollars to purchase goods and services for public use.

For example, it was estimated that the U.S. government purchases contributed about $3.18 trillion, or about 17 percent of the total GDP in 2018.[1] The cost of operating supply chains is a cumbersome endeavor and accounts for up to two-thirds of the final costs reflected in traded goods (Niforas 2017). As such, effective SCM is essential for procurement operations.

Investment in information technology (IT) is often considered an essential means to improve SC effectiveness and efficiency. However, government executives remain in a quandary on how to best invest in technology to truly make such performance improvements in SC practices. An even greater level of uncertainty has arisen with regard to SCM due to recent issues associated with COVID-19 and tenuous international relationships that can alter the nature through which government organizations provide its services. Therefore, effective use of technology to improve SC practices has become essential for governmental organizations. This study examines the role that organizational use of technology innovation plays in improving SCM activities for public organizations.

Technology innovation is imperative to SCM success since organizations along the value chain require information flows and knowledge creation. Technology innovation has key organizational implications to the domain of SCM. SCM activities are boundary-spanning by their nature since they often most involve other organizational partners across the value chain. Furthermore, SCM

1. Source: https://www.investopedia.com/terms/g/governmentpurchases.asp.

activities are cross functional as they involve multiple functional units within a particular organization. Although technology innovation has been touted as a means to instantly improve SCM practice, the true understanding of how technology innovation can impact SC practice has been limited. Nevertheless, senior level executives are beginning to more fully recognize that technology innovation may have enduring and ubiquitous implications within and across government sectors and as such there will be the need to manage technology innovation via a programmatic approach. An emerging realization is that a singular approach may not be sufficient since technology innovation includes a broad range of tools and techniques that require distinct management approaches. Existing literature has also noted that there are numerous barriers that prevent successful innovative technology initiatives in government.

The body of knowledge that addresses technology adoption at the level of individual end-users has been established to some degree within both the practitioner and academic literature. However, there are few studies to date that examine technology adoption at the organizational level. This dearth of literature remains despite the importance of understanding this phenomenon, particularly within the domain of governmental entities. Further, the limited number of organizational IT adoption studies that do exist generally focus on adoption intentions, rather than post-adoption outcomes such as technology usage and the derivation of value creation. As such, to comprehend the drivers of technology usage, government executives would benefit from developing an understanding of the potential organizational performance impacts of technology competency.

The growing popular press recounts stories of particular applications of analytical technology in specific functional areas; however, a more holistic view of analytics and technology and their associated capabilities has not been advanced. Government is currently seeking to operate in a more similar fashion to private industry per the new public management (NPM) initiatives (Dawson et al., 2016). Recognizing that there are some variations between public/governmental services and private industry (e.g., stakeholders, business objectives, governance structures, operational processes, performance measures, etc.), in this research report, frameworks are developed for government leaders and managers to implement and manage technology innovation to yield greater SC practices in public entities.

Impact of Analytics on Supply Chain Practice

“Big data” is a comprehensive term for data sets of substantial volume and often associated complexity. Recently there has been a massive accumulation of data (both structured and unstructured) collected and stored via various mechanisms: transaction processing, online activity and social media, and via various sensors/devices (e.g., Internet of Things, or IoT). Analytics employs the process of using advanced technologies to examine data in order to uncover key insights (e.g., undiscovered patterns, correlations, etc.) to facilitate organizational decision-making (Chen et al., 2021).

Although many organizations claim to be at the “leading edge” of analytics utilization and effectiveness, this is far from an accurate assessment. Most organizations are still in the learning phase how to potentially capitalize on data investments and initiatives. Big data is a broad and comprehensive term for information assets that are of appreciable levels of magnitude and complexity. Specifically, big data has been defined in terms of: 1) volume (e.g., high-scale); 2) velocity (e.g., fast moving); and variety (e.g., structured and unstructured). The rise in analytics can be attributed in both structured and unstructured data. Structured data generally consist of traditional numeric data. Recently unstructured data has contributed the volume and complexity of data, which includes: images, video clips, and textual content derived from online posts and social media. The recent phenomenon of big data is attributed to the ability of organizations to collect vast quantities of both structured and unstructured data and then curate such data via analytical methods.

Many organizations contend that they are properly positioned to capitalize on analytics initiatives. However, such organizations often overestimate their analytics capability. This is particularly the case for public entities, which tend to lag further behind than private enterprises in analytics initiatives. For example, research evidence suggests that most governmental organizations are not currently in an advanced enough state to address urgent organizational needs to leverage analytics. Organizations that wish to be capable analytical organizations need be proficient in a wide range of duties including: developing requisite analytical talent, considering risks involved in employing analytics, and making a compelling case for necessary substantial investments. As such, the underlying mechanisms that lead to organizations’ analytics usage, as well as the performance outcomes of such usage, deserve to be closely investigated across government organizations.

In particular, many organizations are unable to fully exploit big data, because they do not know its true value. For example, despite the growing anecdotal evidence touting benefits of analytics, many organizations are not certain how analytics is actually going to aid with improving their decision-making capabilities. In addition, although different structures and applications of analytics exist, both the scholarly and industry press treat analytics monolithically. In other words, it is less clear whether different types of analytics usages exist. If this is the case, it is questioned if different categories of analytics usage contribute to organizational decision-making differently.

Through initial interviews and a research survey, this study examines how analytics usage influences SC practice. Specifically, the study develops three key frameworks to address the following questions related to governmental applications of analytics tools to SC practices.

- Framework I examines the key drivers of organizational analytics usage.
- Framework II examines how analytics usage impacts specific SCM performance levels.
- Framework III examines if underlying dimensions of analytics usage influence SC related decision-making capability.

The researchers conducted interviews with industry experts to first gain a better understanding of the phenomenon and to formulate the research questions. With the assistance of a major technology consulting firm, the researchers collected survey data from SC executives of 157 North America-based organizations to understand their current analytics practices in SCM. The majority of these organizations are within for-profit industries. The research controls for industry and various organizational factors and found no statistical differences. As such, from both a conceptual standpoint and based on the empirical analysis, the findings generalize to organizations in all industries including the public sector. The research methodology is outlined in Appendix A. The survey design, items, and sources can be referenced in Appendix B. In addition, the summary statistics for the empirical findings from each framework are presented in Appendix C. The following sections outline the findings of each of the three frameworks.

Analytics Framework I: Drivers of Analytics Usage

To examine how organizations can potentially adopt and apply analytics for SC practice, this study employs the technological, organizational, and environmental (TOE) framework for this research. This framework posits that various drivers for the organizational process of adoption and implementation of analytics are contingent upon the following contexts:

1. Technical
2. Organizational
3. Environmental

Table 1: Definitions of Analytics Usage Antecedents

Context	Expected	Definition
Technological	**Benefits**	The extent to which analytics is anticipated to bring operational and strategic advantage to the organization.
	Technology Compatibility	The extent to which analytics is perceived as being consistent with existing organizational culture and practices.
Organizational	**Organizational Readiness**	The extent to which organizational resources are available for using analytics.
Environmental	**Competitive Pressure**	The influences from the competitive environment for the organization to use analytics to maintain or increase competitiveness.

The results of our empirical analysis show that each of these contexts can influence analytics usage for SC practice. However, there are different avenues: a) technological aspects directly influence analytics usage; and b) organizational and environmental aspects indirectly influence analytics usage as they must first gain top management support to be able to influence analytics usage.

Table 2: Summary—Drivers of Analytics Usage

Context	Expected	Impact Path to Analytics Usage
Technological	Benefits	Direct
	Technology Compatibility	Direct
Organizational	Organizational Readiness	Indirect via TMT Support
Environmental	Competitive Pressure	Indirect via TMT Support

The technological context is comprised of both the organization's expected benefits and its technological capability. Such technological concerns are relevant to both public and private organizations. To adopt a technology to an appreciable and useful degree, an organization must expect to benefit from such technology. For an organization to adopt analytics for SCM, it should expect a series of operational and strategic benefits will arise: cost savings, inventory reduction, reduced cycle times, better product/service delivery rates, improved customer service, improved knowledge sharing, and increased confidence levels in decision-making, etc. Some benefits may be more immediate (e.g., cost saving) and readily discerned while more strategic benefits (e.g., improved confidence) may be less tangible and require some lag time before taking effect. In addition to expected benefits, organizations need to have the technology capability to be able to effectively adopt and utilize analytics. In this current study, consistent with the established research, technology capability is examined in terms with which analytics usage is compatible with existing culture and organizational practices (including the existing SCM practices) of the organization (Chen et al 2106). Therefore, key decision-makers will need to assess if analytics use as a technology is truly compatible with the values and SCM work practices of the organization.

The organizational context is considered in terms of "organizational readiness," which is the degree to which an entity has the required organizational resources to effectively implement analytics. Such resources include financial capital available for allocation and technical infrastructure as needed. However, the human resources a key component to allow for requisite technical knowledge and expertise. For an entity to have the proper level of readiness it must acquire or develop personnel savvy to perform such technical analysis and also the managerial staff to properly manage the analytical process to meet organizational goals. The external context is represented as the competitive pressure an organization experiences, which necessitates analytics usage. As with organizational readiness, the influence of competitive pressure on analytics usage is mediated by top management support for analytics. Top management is key in assessing the external landscape and how the industry is engaging with from technology standpoint.

Findings indicate that the organizational and environmental factors alone are not sufficient to influence analytics adoption and usage directly and adequately, rather managerial leadership is needed as a mediating effect. When business unit and SC executives see value of analytics and its potential congruence within the organizational structure, they are more likely to ensure that analytics initiatives are implemented. These senior executives are essential to sponsor analytics and facilitate any changes that are introduced that would alter established organizational process, norms, and culture. Such support from top management enables analytics to be successful adopting the new technology while mitigating pushback from other stakeholders. Hence, top management is likely to sponsor analytics ubiquitously for organizational functions if it views that the entity has proper resources in place and there are salient competitive pressures.

Public institutions are likely to assess organizational readiness in a similar fashion as private firms; however, the influence of environmental factors may differ vis-à-vis private firms. Public entities generally have some differences with regard to the external pressures they face vis-à-vis private firms. As the TOE model is applied to public entities, the environmental influence on analytics usage may be dampened to some degree. However, government organizations do have competition from the private sector as well as other public institutions. Even for services where government is the monopoly provider, there are both citizen and political pressures to deliver consistent customer service imperatives. Also, external pressure for managerial reform or privatization of the public entities will require proactive leadership to effectively address such political pressure (Hahm et al., 2013). As such, top executives within government organizations are particularly important in filtering the relevance of actions taken in response to the external environment. To put these findings into practice, government organizations should assess their current level of proficiency in each of the contexts. As noted, many public entities are still considered "analytical laggards." In such an organization, there may not be substantial support by top management leaders. In such cases, technological capabilities may be the primary driving force to derive analytics usage until top-down leadership enables the additional contexts.

Analytics Framework II: Impact of Analytics Usage on Supply Chain Performance

The research design also develops a framework to examine how analytics usage can impact SC performance levels. Despite the optimism expressed about the benefits of analytics usage in the SC context, there has not been substantial empirical support for this direct link. For effective use of analytics in SCM, it is essential that such tools are fully assimilated within SCM processes. SCM processes are clearly noted to be of great complexity since they can involve varied roles and tasks (e.g., purchasing, inventory management network optimization, etc.). Furthermore, the management involved in SCM processes can span various hierarchical levels within a particular organization as well as several organizational partners across the value chain. As such, analytics can be viewed as a dynamic capability for an entity that can potentially add value by enabling SCM processes (Chen et al., 2016)

Large amounts of operational and strategic information are disseminated to the SC partners across the various stages of an organization's supply chain. As such, an organization within the supply chain needs to ensure that it generates an understanding of both the transactional and relational data through the use of its dynamic analytics capabilities in order to impact the efficiency and effectiveness of its supply chain (Chen et al., 2016). The results found that analytics usage directly influences the following two fundamental components of SC performance:

1. Asset productivity
2. Organizational growth

With the exception of profit maximization, the performance goals between private and public entities are generally in parallel (Dawson et al., 2016). Asset productivity is a primary measure used to assess SC performance with established measurements including turnover rate and return on assets. Both private and public entities engaged in SC activities are clearly concerned with asset productivity. Organizations can potentially use analytics to collect and integrate information from various sources along the supply chain and consequently disseminate such aggregated knowledge to key decision-makers. The knowledge derived from analytics usage can mitigate certain levels of uncertainty with regard to managing inventories and demand capacity. Withsmoother management of the supply chain, an organization can operate with leaner asset inventories while also ensuring that financial and inventory assets are not fully depleted. Analytics usage can enable more accurate predictions that allow asset managers greater forecasting accuracy help them properly manage resources for optimal asset allocation.

In addition, the study examines the influence of analytics use in SC activities to generate growth opportunities for the organization. Although private entities are generally more concerned with growth, this outcome also pertains to public organizations that wish to expand operations and service opportunities. Through the use of analytics, organizations can identify innovative opportunities to capitalize on temporary advantages driven through SC activities (Chen et al., 2016). For instance, the analysis of inventory and resources capacity across the supply chain can result in better availability of products, reduced shipping time, customized services, and customer analysis. As such, analytics use can enable organizational executives to anticipate and hence exploit emerging opportunities for driving growth.

Organizational supply chains experience high levels of turbulence in the dynamic environment of the global economy. The findings also indicate that a dynamic environment experienced by an entity will further dictate the degree that analytics use can influence SC outcomes. Turbulent environments require entities to attempt to leverage organizational knowledge to deal with greater levels of uncertainly to which they are exposed. Volatile markets lead to the need for more idiosyncratic decision-making requirements. Organizational executives will have less ability to rely of standard decision-making approaches and will need to rely on timely and comprehensive data for both tactical and strategic decision-making. Furthermore, for such uncertain conditions, the dynamic capabilities of an organization rely predominantly on developing and capitalizing on new knowledge that is current and specific to the new conditions

(Chen et al., 2016). Analytics usage may be even more critical in turbulent environment since analytics is designed to aid organizational executives with the exploration of new insights. This is particularly the case for SCM practices where executives and managers need data to provide additional confidence in their decisions. SCM in many organizations is widely dispersed across a multitude of sources. Analytics use is needed for a modern entity to properly integrate and disseminate information for decision-making.

The findings provide empirical support that the degree to which the environment is uncertain will moderate the degree to which analytics usage can influence these SC outcomes. The results indicate that analytics usage has a greater degree of influence on organizational growth when the external environment is dynamic vs. stable. However, the results indicate that analytics usage has a diminished degree of influence on asset productivity when the external environment is dynamic.

Table 3: Summary—Influence of Analytics Usage on Supply Chain Performance

Influence of Analytics usage on Supply Performance	Effects of Dynamic Environment
Analytics Usage → Asset Productivity	Diminishes Relationship
Analytics Usage → Organizational Growth	Enhances Relationship

Findings note the diminished effect of analytics usage on asset productivity, vis-à-vis growth, within an uncertain environment. Asset productivity may require structural changes which tend to be static physical assets (e.g., equipment, infrastructure, etc.), which are not readily altered and require substantial organizational capital. Further, the volatility of the external environment creates uncertainty, which may make the ability to understand how to make adjustments to company assets more difficult to comprehend. Hence, the analytics usage may not be as influential under dynamic conditions. As noted earlier in this report, public organizations are buffered to some degree from the volatility of the external environment yet not fully.

Although the fundamental arguments (i.e., related to moderating effect on asset productivity and growth) hold for both public entities and private firms, the external environment may not have the same moderating effect on public entities vs. private firms. It would be expected that this effect would be contingent upon the particular sector that the public entity is in and the congruence of that sector to private industry. To put these results into practice, government leaders should first ensure they fully comprehend the multiple performance outcomes that can be facilitated via analytics usage. Furthermore, these leaders need to assess the degree that their environment is dynamic and understand how this environment may have differential effects on the degree to which analytics impact supply chain operations. For instance, changes in the health care industry (due to new outbreaks [e.g., COVID-19], innovation, or new regulations) may have implications for how such government entities are able to effectively use analytics for supply chain purposes. A government entity may have greater need for growth over asset productivity for which analytics is well suited in a dynamic environment.

Analytics Framework III: Influence of Analytics Dimensions on Decision-Making Capability

The analysis of the data revealed that here are two fundamental dimensions of analytics usage for SC activities:

1. **Analytics use for SC optimization:** Analytics use is designed to solve structured problems with established SC objectives (e.g., inventory control, production scheduling, network design, etc.).
2. **Analytics use for SC learning:** Analytics usage is designed to solve unstructured problems aiming to identify new opportunities (e.g., exploring possible changes to transactions and relationships with suppliers, customers, as well as pointing out opportunities for new products and processes).

These two distinct patterns of analytics usage involve different analytics approaches and applications:

1. **SC optimization** activities generally use advanced mathematical programming algorithms to evaluate alternative solutions to highly structured problems, using highly structured data.

2. **SC learning** activities make use of analytics which apply a broader array of tools and address solutions for a wider range of questions posed. They may analyze both programmable and nonprogrammable questions using structured or unstructured data.

These findings provide essential managerial implications for government organizations. Many organizations wish to capitalize on analytics. However, many entities take a haphazard approach with no a-priori design strategy. The public entity should first understand the objectives of analytics initiatives before committing organizational resources. Such knowledge will help public entities establish an analytical strategy to best derive organizational impacts from its analytics initiatives.

As it is now established that there are two distinct facets of analytics usage for SC initiatives, it is requisite to understand how each of these two dimensions of SC analytics usage influences the capability of the organization to make decisions. These two dimensions are applicable to both private and public entities. SC decision-making capability is fundamental to the organization's SC strategy. Prior research has posited that managerial decision-making is particularly critical in high velocity conditions to deliver organizational performance (Chen et al., 2021). The results find that analytics usage can enhance both speed and quality of the collection, analysis, and dissemination of information for organizational decision-making. In times of duress, a wider variety of information is needed to allow for a greater scope of viewpoints so a more comprehensive set of viewpoints can be assessed. Furthermore, dynamic times put stress on the decision-making process. Supply chains are also characterized by high levels of complexity, which are composed of a series of networks of interdependent processes and organizations (Chen et al., 2021).

Supply chain executives have traditionally made "gut decisions" rather than using analytical intelligence. There may also be incongruent goals among the different decision-makers across the various partners of the supply network. Certain powerful executives and managers along critical nodes in the SC network may dominate the decision-making process. There is great demand for SC organizations to implement analytics to capture more detailed data for decision-making at multiple points within the supply chain (e.g., sourcing analysis, network design, inventory optimization, demand management, etc.). The thorough implementation and utilization of analytics allows for the development of a knowledge base that can be collectively shared among the various leaders during different stages of the supply chain. Such pooling of knowledge can lead to faster and higher quality decision-making from both an individual and collective level.

Specifically, the results of the analysis reveal that the two dimensions of analytics usage in SC have different yet complementary channels via which the two analytics usage patterns impact a supply chain organization's overall decision-making capability:

1. Analytics use for SC optimization directly improves a supply organization's decision-making capability

2. The influence of Analytics use for SC learning does not impact organizational decision-making directly, but indirectly via the level of organizational integration

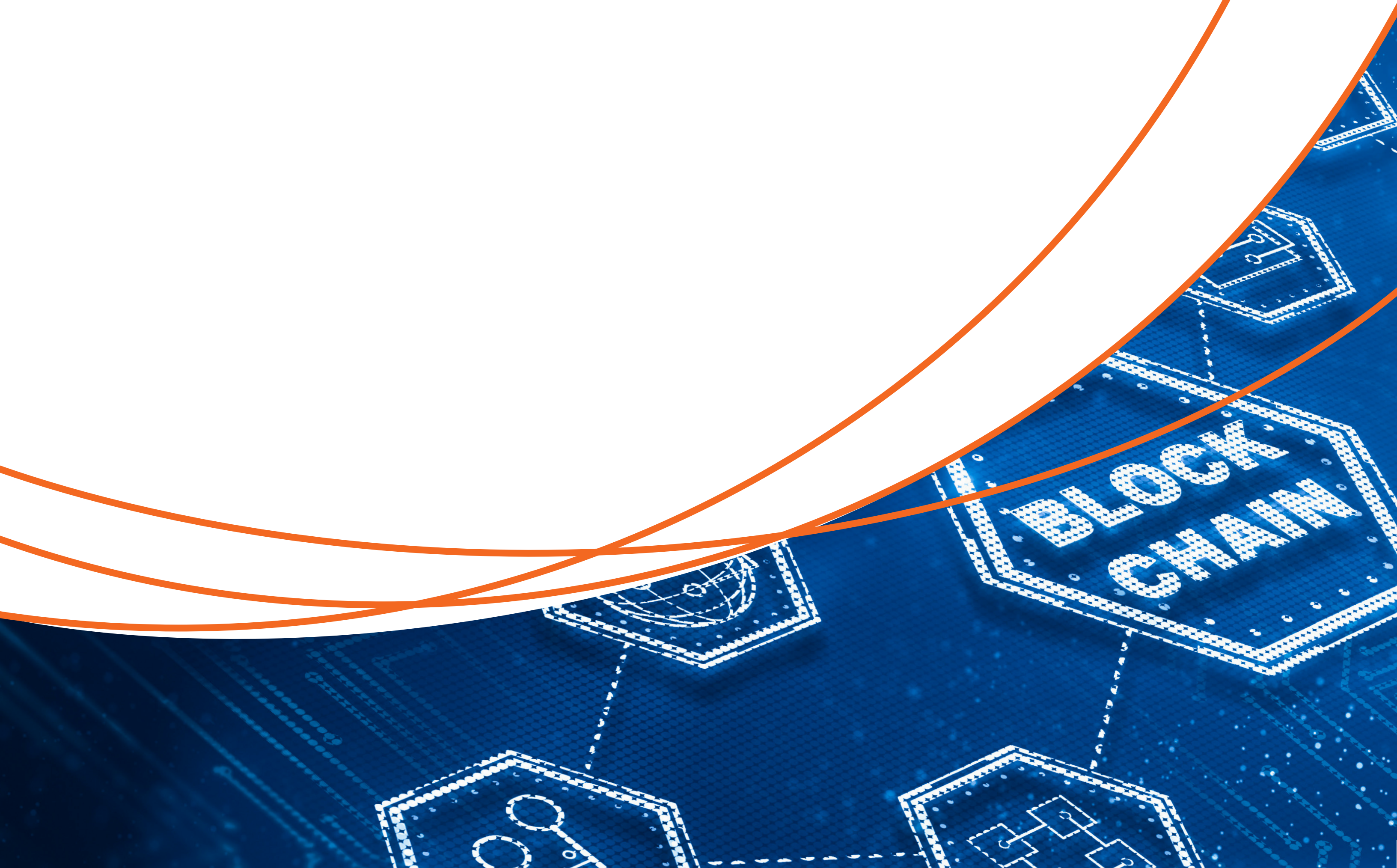
Table 4: Summary—Influence of Analytics Usage Dimension Decision-Making Capability

Analytics Usage Dimension	Impact Path to Decision-Making Capability
Analytics for SC Optimization	Direct
Analytics for SC Learning	Indirect via Organizational Integration

The findings provide evidence that analytics use for SC optimization has a direct influence on organizational decision-making capability without the need for human/managerial intervention. However, analytics use for SC learning does not have a direct, but an indirect effect to decision-making capability, which requires internal integration. These findings provide government SC executives with insight into the mechanisms through which analytics can influence decision-making capability. Analytics usage can directly impact decision-making benefits for more routine supply chain activities geared toward SC optimization. However, SC learning aspects of analytics usage tend to be less routine and are more strategically oriented. Therefore, organizational factors are essential to the successful exploitation of analytics.

Government SC executives should ensure integrative mechanisms (e.g., cross functional communication, team integration, etc.) are put in place to integrate analytics inputs from various functional areas, to allow for more comprehensive and higher quality decisions. Most public entities will be focused on optimization to some degree. However, such organizations need to have the right mindset and integration across channels to benefit from analytical learning opportunities. For example, the Tennessee Government Management Institute has established a culture that focuses on a long-term view that seeks to attract new talent based on collaboration and learning opportunities (Burkett and Holliday 2018). Such a culture is also conducive for establishing analytics for enhancing organizational learning.

Impact of Blockchain on Supply Chain Practice



Blockchain is an emerging open-source recordkeeping technology that enables intra or inter organizational transactions via a series of peer-to-peer transaction represented by blocks that are “chained” together. Specifically, blockchain technology utilizes time stamps and cryptographic hashes to ensure information within a block is tamperproof (Liang et al., 2021). There are three primary categories of blockchain: 1) public; 2) private; 3) permissioned. Public blockchains (e.g., most cryptocurrencies) have greater security concerns and governance structures that must be implemented (e.g., proof of work, proof of stake, etc.). Therefore, public blockchains are generally not a viable alternative for most public government organizations

Technological advances are transforming traditional linear supply chains into dynamically connected digital supply networks; however, most organizations are not properly prepared for such disruptions (Kehoe 2017). The Global Alliance for Trade Facilitation has noted that documentation costs account for seven percent of the value of global trade (Niforas 2017). Organizations seek to obtain complete SC visibility; however, providing traceability and transparency while simultaneously providing timely service and managing costs remains difficult. Blockchain is considered a potential technological innovation that can make the supply chain more efficient and resilient, despite volatile environments (Niforas 2017). As such, blockchain is an emerging technology that can efficiently connect stakeholders of government supply chains and also monitor and document the transitions of goods across the supply chain. Government organizations can seek to benefit from the potential promise of blockchain for an array of necessary activities: financial/real estate transactions, health care data, and SC activities related to an assortment of products and services.

Specifically, blockchain is a key technology for e-government that can help mitigate fraud and corruption associated with both process and document-related SC activities (Sarker et al., 2021). Blockchain provides the public entity or regulatory agency with the ability to track and validate a product from it source, through intermediary points, all the way to the final destination. As an industry use case, private industry is working with Walmart to tracking its multitude of products from their source in China to their final retail store destinations overseas. As such, government organizations can use this proof of concept to develop such blockchain capabilities for traceability of its own products.

The potential use of blockchain via case examples in the food and health care sectors is particularly salient. The U.S. Government is deeply involved in the oversight and regulation of its food industry. The Food Safety Modernization Act was passed into effect in 2011 as a major reform in food safety laws (Shacklett 2017). In addition, the U.S. Department of Agriculture (USDA) has recently worked to ensure the nation’s food supply chain threatened by the COVID-19 pandemic is secure via various steps (Coyne 2020). Blockchain can help enable the food supply chain system by allowing for end-to-end visibility to address a variety of risks (e.g., distribution issues, sanitary risks, “food fraud,” etc.) (Johnson, 2014). The importance of blockchain has equally important implications for the health care/ pharmaceutical industry. The Food and Drug Administration (FDA) is exploring opportunities to partner with private industry to utilize blockchain for health care records and the exchange of patient data. After experimenting first with such endeavors, the FDA should seek wider applications. Due to the coronavirus pandemic his past year, the FDA is dealing with a profound backlog in inspections of drug manufacturing facilities both in the U.S. and abroad, which has created the risk of shortages in a number of vital medicines (Wechsler 2021). As such, the international pharmaceutical supply chain has shown itself to be highly vulnerable. Blockchain can help document, monitor, and manage the pharmaceutical supply chain to ensure such shortages are mitigated.

U.S. government agencies are also concerned about monitoring the veracity of products, especially luxury items. Specifically, the Federal Trade Commission (FTC) has released warnings that jewelry and precious metals are often either spuriously or falsely advertised. Blockchain allows the retail buyers or end consumer to trace materials such as diamonds or custom jewelry (i.e., including all raw materials) from the original source(s) extending through each node within the supply chain until final destination. As such, blockchain can provide verification of authenticity of products and increase trust among network members. In addition, there are currently grave concerns that certain products are produced via unethical or inhumane methods.

The U.S. Department of State is responsible for upholding the Clean Diamond Act of 2003 in which participating nations work to ensure that “blood diamonds” mined via inhumane or questionable practices are not afforded an end marketplace (Miller 2007). The International Labor Office (2017) estimates that over 70 million people are involved in forced labor associated with the generation of diamonds (Sumkin et al., 2021). Blockchain technology is ideal for verifying the source of origin of the product and ensuring that the product was not tampered with when distributed across the supply chain. Specifically, the TrustChain Initiative, which utilizes blockchain technology, was developed by a group of gold and diamond companies to track finished jewelry from the original mine all the to the retail store (Kharif 2018).

Impact of Artificial Intelligence on Supply Chain Practice

Applying AI technology—machines and algorithms—to make predictions, recommendations, and decisions has enormous potential to improve social welfare and organizational productivity. With promises to open completely new horizons in process improvement and performance of government services, AI-led transformation can certainly improve government services, fundamentally changing how government delivers value to its citizens. Many government organizations have initiated planning as to how to incorporate AI into current technology infrastructure and overall organizational mission. For example, AI has been reportedly generating powerful new abilities in areas like national security, food safety, regulation, and health care.

However, very few government organizations have initiated plans on taking advantage of AI capabilities to improve their SC processes. Supply chains are difficult to manage because they generally involve multiple organizational members and are continually dynamic. AI-based applications have the potential to reduce backlogs, cut costs, stretch resources, release workers from routine tasks to perform higher value work, improve the accuracy of projections, and bring intelligence to scores of processes, systems, and uses. For example, changes in weather patterns, trade policies, and the inventory status of suppliers of cryptic ingredients or secondary parts can make it hard to know how much of anything to order at one time in any location. Machine learning and AI applications are helpful with estimating resource management related inputs and parameters to help to prepare for anomalies. As such, many traditional businesses, including those in the manufacturing and service sectors, have already made important progress in digitizing and redesigning their SC models by developing sophisticated data platforms and AI capabilities.

In general, public entities are behind the private sector in the implementation of AI technological initiatives. Causes of the lag in AI-based SC initiatives include many reasons ranging from resource constraints to lack of knowledge or insufficient talent. A primary cause appears to be a lack of an AI strategy for SC functions. According to the results of a 2019 survey of greater than 600 U.S. federal AI decision-makers, the most commonly cited obstructions to AI included: 1) resource/talent shortages; and 2) lack of clear policies or direction from leaders (Geyn 2019). In fact, 60 percent of the respondents indicated they believed their leadership was not aligned with the needs of their AI team. A lack of an AI strategy is not uncommon across organizations of all types, both private and public. According to a recent IDC survey, half of responding businesses believed AI was a priority, but just 25 percent had a broad or legitimate AI strategy in place.

AI can help with predicting and making sense of SC dynamics by identifying and differentiating varying supply sources, or using sensor data in a variety of ways that improve efficiencies. However, AI-based SCM may not be effective merely by layering AI over existing organizations or processes without appropriate investment in the transformation and reimagination of the delivery model. As compared to counterparts in private sectors, SC functions of a public entity may receive even fewer resources to support their AI initiatives. From this perspective, developing an appropriate AI strategy is particularly important for governmental SC functions. Maximizing the value of AI for government SC organizations will require an integrated series of decisions and actions. These decisions will involve complex choices (Desouza 2018):

- Which SC components to prioritize?
- How to explicate AI's value to the existing SC professionals?
- Which AI technologies to use?
- How can we manage AI projects?
- Should we use internal talent, external partners, or both?

Recommendations for Government Technology Innovation

Recommendations for Government Technology Innovation

Recommendation 1: Leverage the Lessons Learned from Analytics Analysis

Government organizations should leverage the empirical findings outlined about analytics frameworks. As noted, the empirical analysis conducted provided key insights into the research regarding antecedents of analytics for SCM, consequents of analytics on SC performance, as well the influence of key analytics dimensions on decision-making capability. Public organizations should seek to examine how these analytics findings can be applied to blockchain and AI for SC practice. The decision to adopt blockchain or AI may have similar technical, organizational, and environmental factors that parallel that of analytics but differ based on the idiosyncratic nature of these different technologies. Specifically, Framework I (TOE framework) introduced earlier in this report offers a highly relevant foundation for governmental SC organizations to strategize their blockchain and AI initiatives. Based upon this framework, there exist three parallel but interrelated key forces (i.e. technological, organizational, and environmental) that can shape a superior blockchain and AI strategy for government SC organizations. Public entities should consider a series of strategic questions, covering the three identified aspects when crafting their blockchain and AI adoption strategies. These questions are provided in Table 5 below.

Table 5: Strategic Questions for Implementing Blockchain and AI-based SC Models

Technological Benefits	Organizational Readiness	Environmental Pressure
What are the expected values of blockchain and AI to our supply chain organizations?	What blockchain uses and AI applications should we target and do we have the right IT infrastructure to support them?	What blockchain and AI features are suppliers / customers using?
How will these values be defined and measured?	What are the resource requirements to support our blockchain and AI initiatives and where do we locate these resources?	What blockchain and AI related initiatives are other functions of the government organizations pursuing?

Recommendation 2: Follow the Leader

When considering the adoption of technology, an organization can seek several pathways with regard to innovation: first mover, fast follower, slow follower, or laggard. As emphasized, there is little value that a government organization can derive as a laggard. If a smaller government institution truly cannot obtain the resources or develop the capability to implement and capitalize on technology then such an entity may have to settle as a laggard. However, such positioning will limit its effectiveness to reach organizational goals. On the other hand, being a first mover may not be worth the risk as government organizations generally do not benefit from seeking extreme risk-taking opportunities. As such, this study recommends that government organizations seek to fall somewhere between a fast follower and slow follower based on organizational goals. It is noted that there are indeed use cases of government agencies engaging in IT innovation to some degree (Dawson and Denford 2015); however, this is not yet likely to be the case with cutting edge technologies. As addressed within the following portfolio recommendation, public entities should seek to first gain capabilities in analytics and rapidly follow industry use cases from industry and other public entities as applicable. Government organizations would likely benefit from a more conservative approach to blockchain and AI initiatives and can follow suit after these technologies have greater proof of concept and the fit with organizational objectives are clear.

Recommendation 3: Develop a Technology Portfolio

Government organizations and regulatory agencies need to consider developing a technology portfolio. This portfolio should have a sequence of adoption. The technologies of analytics, blockchain, and AI are independent yet highly complementary. Government organizations should prioritize developing its capabilities in analytics. All government organization will need some level of competence in analytics to optimize operations and learning. It should be noted that analytics capabilities should not be viewed as dichotomous—but on a continuum. Based on the outlined findings from the empirical analysis in this study, it is observed that analytical savviness can be developed via series of managerial efforts and organizational commitments. Although there are clearly potential benefits that can be derived from blockchain, some government organizations may not be fully ready to adopt blockchain until it has become viable in a way that will readily fit its organizational objectives. Blockchain adoption can be considered an independent organizational decision. But it should be noted that blockchain will facilitate the organization's ability to enhance its capabilities in both analytics and AI. As outlined, AI has promise for great potential for public entities; however, AI is still very much in its infancy. Government organizations should first develop analytical maturity prior to seeking to fully engage in AI.

Recommendation 4: Empower Technology Champions

To fully engage and capitalize on technology innovation, organizational leadership is paramount. It is rare that technology will be fully infused in an organization without the sponsorship of its leaders. Visionary technology leaders play a primary role in the assimilation and effectiveness of technology initiatives (Chen et al., 2015). The Federal Information Technology Acquisition Reform provisions (FITARA), which were enacted by Congress in 2014, establish guidelines for government entities to address their technology investments so that such investments promote the strategic goals of the government (Harris 2019). Furthermore, FITARA provides direction for the role of the chief information officer (CIO) of public entities to establish and execute the strategic vision of that entity. The organization may choose to use another title for this top technology executive; however, what is imperative is that this individual is considered a member of the top management team and reports directly to the organizational top executive. Organizations that merely appoint a top technology executive but fail to provide this individual with both formal and informal means to provide influence will likely fail in fully capitalizing on innovative technology initiatives. Information derived from analytics has become the key organizational "currency" and as such many "data owners" across the supply chain may intentionally or inadvertently hoard such information rather than share it across channels. This data should be treated as an enterprise asset. The full collection of the organization's senior technology executives (i.e., CIO, chief data officer [CDO]), chief technology officer [CTO], etc.) must understand the organizational goals and SC operations to be able to synthesize this information for SC effectiveness.

Recommendation 5: Facilitate a Climate for Innovation

The organizational climate is fundamental to the adoption and utilization of technology. Government organizations are often considered bureaucratic and hierarchical when compared to private industry. Such hierarchical structures can provide benefits in providing organizational efficiencies and standardized processes. However, such structures do not necessarily foster a climate for innovation. An innovative technology strategy entails an organizational perspective to continuously seek to innovate through taking calculated risks to explore, adopt, and leverage novel technologies. Having a "data-driven" culture is imperative for an organization to derive expansive value from information-related technologies; however, such a culture is often difficult to implement (Davenport and Bean 2018). A climate that is considered "organic" is characterized accordingly: eschews conformity, drives creativity, incentivizes for wise risk taking, encourages ideas, and facilitates collaboration across hierarchical levels and functional groups (Chen et al., 2015). Such a climate that enables knowledge dissemination and organizational learning is particularly relevant for SCM. It would not be expected that public entities should eliminate hierarchical structures since that would hardly be feasible nor recommended. However, where viable, fostering a climate for innovation within the structures is essential for a government organization to fully capitalize on the potential of analytics, blockchain, and AI.

Recommendation 6: Ensure Strategic Alignment

For optimal performance value, a public organization needs to ensure that the supporting technology strategy is aligned with organization's SC strategy. It is not enough for an organization to realize technology as potential strategic resource. The organization must strive for strategic alignment of the technology strategy with the supply chain to derive a competitive advantage. Technology investments can become a "bottomless pit" for an organization that does not discern wisely. It is essential that organizations strategically invest in the technology resources that will aid the SC function. There are two elements of technology strategic alignment that must be considered: 1) social dimension, which constitutes a shared level of understanding of the role of technology within the organization; and 2) intellectual dimension of alignment, which addresses the congruence of the entity's technical strategy with the organization's mission (Karahanna and Preston 2013). Technology resources geared for the SC function that do not promote the organization's SC strategy may be considered mere expenditures rather than worthy investments. Each public entity should not merely follow the herd when it some to technology investments, it is imperative that alignment of each technology is assessed with organizational goals.

Recommendation 7: View Functional Managers as Key Stakeholders

Public organizations have been noted to have a multitude of stakeholders often with ambiguous and competing interests (Dawson et al. 2016). To fully implement, adopt, and capitalize on analytics, blockchain, and AI for SCM, functional managers must be viewed as key stakeholders in the process. Functional managers serve as a bridge between top management and the end users of technology. It has been observed that within public entities, the vast majority of innovation arises at staff levels and tends to diffuse upward yet strategy is implemented from the higher ranks top-down (Dawson and Denford 2015). As such, functional managers who understand the purpose of technology to achieve SC objectives are needed to ensure a pervasive utilization of analytics, blockchain, and AI. Further, functional managers who are engaged with top management are well positioned to understand the overall technology strategy of the entity and transfer this vision to the end users of the technology (Milovich et al., 2015). As SCM is cross-functional by nature, it is also critical to include other functional managers as stakeholders within the SCM technology-related adoption and implementation decisions. Functional managers that are relevant to SCM activities may include an array of individuals from different functional areas. When associated with SCM, such functional managers serve as a lateral means to expand or hinder technology adoption in areas of analytics, blockchain, and AI beyond functional silos in a ubiquitous manner across the organization.

Recommendation 8: Manage Technology Talent

The competition for technical and analytical talent remains fierce. Government organizations and agencies have had notorious difficulty in the attraction technical talent for strategic purposes and have even had a lack of success with external consultants (Dawson and Denford 2015). The cutthroat demands for top talent for data scientists and technologists has been in effect for over a decade. Although government organizations should seek to hire top talent from the marketplace when feasible, greater emphasis should be on developing analytical and technology talent internally. To develop talent resources for SC analytics, blockchain, and AI, it requires both technology experts and SC experts. It is mandatory that there is collaboration between these two groups and that there is some overlap in knowledge. To optimally perform and deliver value, there must be analytical/technical training for the SC professionals and SC/operational training to develop the knowledge of the technologists. To facilitate this knowledge development and transfer among key analysts, a steering committee should be created and dedicated to managing oversight.

CONCLUSIONS

In conclusion, this report aims to provide insight on how technology innovation can facilitate SCM practice within government organizations. Technology innovation is examined through the lens of emerging technologies via analytics, blockchain and AI. An empirical analysis was conducted to examine the influence of analytics on SCM practice via three frameworks:

Framework I (drivers of analytics usage)

Framework II (influence of analytics usage on SC performance)

Framework III (dimensions of analytics usage and respective influence on decision-making capability).

Furthermore, this report outlines the potential for blockchain and AI as part of the technology portfolio that can benefit government organizations. Recommendations are outlined for practice for executives within both public and private organizations.

APPENDICES

Appendix A: Research Methodology

This research design tested hypotheses via a field study to collect data from supply chain executives via a questionnaire. The researchers designed the survey instrument in collaboration with: a) a major technology consulting firm with a large supply chain practice; and b) an established supply chain management trade journal. The survey instrument targeted supply chain executives as respondents, who could appropriately represent the SCM organization as the unit of analysis. Invitations to the online survey were sent via email to the clients of the consulting firm, members of the supply chain management council of professionals, and a list of the researchers' professional contacts. In order to enhance the quality of the key informants, responses were screened and informants whose titles were not directly related to a supply chain function were eliminated.

A series of three rounds of invitations were sent to the prospective respondents over a six-week period. A total of 157 responses were collected (after outliers were removed) in response to this survey administration yielding respondents in a wide variety of organizations representing multiple manufacturing industries and geographic regions. The respondents held a range of senior and upper-level supply chain executive/managerial positions, suggesting that such individuals have relevant knowledge regarding the study questions, thus provided appropriate respondent validity. The sample spans a wide range of organizations (e.g., size and industries) and thus allows for certain assumptions with regard to generalizability. The majority of the sample consisted of for-profit organizations; however, t-tests based on average of key indicators indicated no statistically significant differences between for-profit and not for profit organizations.

The research team conducted interviews with consultants and academics to ensure validity in the design of the measures, and also to provide relevance and readability for the respondents. The questionnaire contains both existing and new measures, including: Expected Benefits, Technology Compatibility, Top Management Support, Organizational Readiness, Competitive Pressure, Analytics Usage (Comprehensive), Asset Productivity, Organizational Growth, Environmental Dynamism, Analytics Use for SC Optimization, Analytics Use for SC Learning, Internal Integration, Analytics-Enabled Decision-Making Capability. The research model employed a regression analysis of the survey data, in order to examine the nomological validity of the research models and assess statistical significance. In addition, the model accounted for control variables including: industry, annual sales, number of employees, number of IT professionals, the respondent's managerial level, and strategic focus of the organization (i.e., operations focus, customer focus, new products/services focus) in the organization. Based on these statistical results, the findings are outlined in the body of the paper.

Appendix B: Survey Items

Appendix B-1: Framework I—Survey Items

Survey items were derived from Chen et al. (2016) and Chen et al. (2021)

Expected Benefits

Using analytics enables/will enable our organization to:

1 =strongly disagree 3 =neutral 5 =strongly agree

a) Improve the quality of work

b) Make work more efficient

c) Lower costs

d) Improve customer service/patient care

e) Grow sales to new customers or new markets

f) Identify new product/service opportunities

Technology Compatibility

Please indicate your level of agreement with the following statements:

1 =strongly disagree 3 =neutral 5 =strongly agree

a) Using analytics is consistent with our business practices

b) Using analytics fits our organizational culture

c) Overall, it is/will be easy to incorporate analytics into our SCM practices

Top Management Support

Does the top management team (TMT, e.g., CIO, COO, CSCO) support the use of analytics?

1 = not at all 3 =somewhat 5 =it is among the highest priorities

a) To what extent does the TMT promote the use of analytics in your organization?

b) To what extent does the TMT create support for analytics initiatives within your organization?

c) To what extent has the TMT promoted analytics as a strategic priority within your organization?

Organizational Readiness

To what extent are the following factors preventing your business unit from fully exploiting analytics?

1 =not at all 3 =somewhat 5 =to a great extent)—(reverse coded)

a) Lacking capital/financial resources

b) Lacking needed IT infrastructure

c) Lacking analytics capability

d) Lacking skilled resources

Competitive Pressure

How many others in your industry have been implementing analytics?

[0] = don't know [1] =none have adopted [3] =some have adopted [5] =almost all have adopted

a) To what extent have your competitors implemented analytics?

b) To what extent have your suppliers implemented analytics?

c) To what extent have your customers implemented analytics? (leave blank if you sell to individual consumers)

Analytics Usage (Comprehensive)

To what extent has your organization implemented analytics in each area?

[1] =little or no usage [3] =moderate usage [5] =heavy usage

a) Sourcing analysis

b) Purchasing spend analytics

c) CRM/customer/patient analysis

d) Network design/optimization

e) Warehouse operations improvements

f) Process/equipment monitoring

g) Production run optimization

h) Logistics improvements

i) Forecasting/demand management – S&OP

j) Inventory optimization

Appendix B-2: Framework II—Survey Items

Analytics Usage (Comprehensive)

To what extent has your organization implemented Analytics in each area?

[1] =little or no usage [3] =moderate usage [5] =heavy usage

a) Sourcing analysis

b) Purchasing spend analytics

c) CRM/customer/patient analysis

d) Network design/optimization

e) Warehouse operations improvements

f) Process/equipment monitoring

g) Production run optimization

h) Logistics improvements

i) Forecasting/demand management—S&OP

j) Inventory optimization

Asset Productivity

Please indicate your business unit's level of performance relative to your industry average for the most recent reporting year.

1 = in the bottom 20% 3 =in the middle 20% 5 =in the top 20% of industry performers

a) Cash-to-cash cycle time (receivables + inventory – payables)

b) Inventory turnover (sales/inventory)

c) Asset turnover (sales/total assets)

d) Return on asset (ROA)

Organizational Growth

Please indicate your business unit's level of performance relative to your industry average for the most recent reporting year.

1 = in the bottom 20% 3 =in the middle 20% 5 =in the top 20% of industry performers

a) Average year on year sales growth for the last three years

b) Market expansion (percentage of growth coming from new markets entered in the last three years)

c) Market share growth

Environmental Dynamism

What is the rate of change (volatility) in your business unit's competitive environment relative to change in other industries?

1 =very stable 3 =about average for all industries 5 =very volatile

a) The rate at which your customers' product/service needs change.

b) The rate at which your suppliers' skills/capabilities change.

c) The rate at which your competitors' products/services change.

d) The rate at which your firm's products/services change.

Appendix B-3: Framework III—Survey Items

Analytics Use for SC Optimization

To what extent has your organization implemented analytics in each area?

1 =little or no usage 3 =moderate usage 5 =heavy usage

a) Network design/optimization

b) Production run optimization

c) Inventory optimization

Analytics Use for SC Learning

To what extent has your organization implemented analytics in each area?

1 =little or no usage 3 =moderate usage 5 =heavy usage

a) Sourcing analysis

b) Purchasing spend analytics

c) CRM/customer/patient analysis

Internal Integration

Please indicate your level of agreement with the following statements:

1 =strongly disagree 3 =neutral 5 =strongly agree

a) Functional teams have a common prioritization of customers in case of supply shortages and how allocations will be made.

b) Operational and tactical information is regularly exchanged between functional teams.

c) Planning decisions are based on plans agreed upon by all functional teams.

d) All functional teams use common plans and procedures.

Analytics-Enabled Decision-Making Capability

Please indicate your level of agreement with the following statements:

1 =strongly disagree 3 =neutral 5 =strongly agree

a) We easily combine and integrate information from many data sources for use in our decision-making.

b) We often deploy dashboard applications/information to our managers' communication devices (e.g., smart phones, computers).

c) Our systems automatically make operational changes, based on performance criteria/ business rules, in response to signals from sensors.

d) Our systems give us the ability to decompose information to help root cause analysis and continuous improvement.

Appendix C: Summary Statistics

Appendix C-1: Framework I—Summary Statistics					
Variable (# items)	N	Mean	Std Dev	Min	Max
Expected Benefits (6)	157	3.77	0.68	1.00	5.00
Technology Compatibility (3)	157	3.16	0.82	1.00	5.00
TMT Support (3)	157	2.99	1.05	1.00	5.00
Organizational Readiness (4)	157	2.85	0.88	1.00	5.00
Competitive Pressure (3)	143	2.59	0.84	1.00	5.00
Analytics Usage (10)	157	2.50	1.04	1.00	5.00

Appendix C-2: Framework II—Summary Statistics					
Variable (# items)	N	Mean	Std Dev	Min	Max
Analytics Usage (10)	157	2.50	1.04	1.00	5.00
Asset Productivity (4)	138	3.81	0.97	1.00	5.00
Organizational Growth (3)	141	3.77	1.08	1.00	5.00
Environmental Dynamism (4)	157	2.95	0.82	1.00	4.50

Appendix C-3: Framework III—Summary Statistics					
Variable (# items)	N	Mean	Std. Dev.	Min.	Max.
Analytics-optimization (3)	157	2.54	1.14	1.00	5.00
Analytics-learning (3)	157	2.46	1.12	1.00	5.00
Internal-integration (4)	157	3.46	0.80	1.50	5.00
Decision-making capability (4)	157	2.80	0.94	1.00	5.00

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