Digitalization of operations and supply chains: Insights from survey and case studies

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Abstract

Purpose – This article aims to understand where industry is in terms of digitalizing their operations, what features of this transformation are essential for practitioners, and what barriers they are facing during their journey. In addition, the authors aim to provide recommendations for organization to start their digital transformation.

Design/methodology/approach – Through literature review, the authors summarize the emerging tools and technologies in operations and supply chains to inform the practitioners. Then, the authors use surveys conducted on 183 operations and supply chain professionals, and use statistical tools to examine the association between variables of the data set. The authors present real-life case studies to explain important steps of a digital transformation project.

Findings – The survey results indicate that real-time monitoring and data analytics are viewed as the most important and needed tools for organizations. High cost, lack of stakeholder buy-in and lack of successful business use cases are major barriers for companies when starting a digital transformation.

Practical implications – The authors provide recommendations for practitioners based on the survey responses, and outline that starting small, focusing on stakeholder buy-in and implementation of software are the three key steps for a successful transformation journey.

Originality/value – Main contributions of this article are to understand practitioner perspectives in digitalization and provide guidelines for organizations to follow when transforming their operations. This research closes the gap between academic research and practice by collaborating with operations and supply chain professionals.

Keywords Digitalization, Operations management, Supply chain management, Visibility, Real-time monitoring, Data analytics

Paper type Research paper

1. Introduction

Supply chain management (SCM) has been a familiar term for practitioners and academics who have been working in the field. It has become more widely known after the beginning of a global pandemic in 2020, COVID-19. With essential home goods slowly disappearing from the shelves of grocery stores, news channels started reaching out to supply chain experts to inform the citizens about why these disruptions occurred and whether there are strategies that can minimize the impact of them.

The main objective for supply chains is to provide their customers with the best value (Lambert & Cooper, 2000; Stock, Boyer, & Harmon, 2010). However, supply chains are

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becoming more and more complex as companies have multiple suppliers and multiple customers at different locations, which cause challenges for the decision makers (Mentzer *et al.*, 2001). This high level of complexity makes supply chains vulnerable to disruptions (Wu, Blackhurst, & O'grady, 2007), which impact delivery times and eventually leading to a negative customer experience.

In addition to disruptions, without knowing where the raw material is along the supply chain, what the inventory level is within the company and within the suppliers, and what the customer demand is, it is inevitable that the organizations will deviate from the goals they set for their supply chains. More importantly, the growth of e-commerce, having been accelerated by the COVID-19 pandemic, forced more customers to shop online (Kannan & Hongshuang "Alice" Li, 2017; Al Mashalah, Hassini, Gunasekaran, Angappa, & Bhatt, 2022). Customers expect their orders to be delivered right at their doors within a day, and sometimes, on the same day. Therefore, it is safe to conclude that supply chains cannot be managed in the same way as they used to be in the past (Lyall, Mercier, & Stefan, 2018). Faster, more flexible, more granular, more accurate and more efficient supply chains are necessary to meet the customer demand, and digitalization (or digital transformation) is a solution to achieve these (Alicke, Rachor, & Seyfert, 2016). Those that transform their operations will grow and have the ability to survive in the competition. A prime example of this is a large global fashion retailer, which increased its market share by over 28% through major investments in supply chain digitalization. They also doubled their operating profit, and were able to accomplish all of these in only three years (Simchi-Levi & Timmermans, 2021).

Digital transformation is a big undertake, requiring advanced technology, collaboration and infrastructure. According to Olsen and Tomlin (2019) and Min, Zacharia, and Smith (2019), the tools and technologies that are used in digitalization include blockchain, three-dimensional (3D) manufacturing, data science and analytics, Internet of Things (IoT) and automation. Some other technologies such as augmented reality (AR) (Rejeb, Keogh, Wamba, Fosso, & Treiblmaier, 2020) and generative artificial intelligence (GenAI) (Hendriksen, 2023) are also available, although their applications in operations and supply chains are currently limited. Rejeb *et al.* (2020) explain that the reason for the limited number of industry applications of AR can be the lack of awareness and knowledge about this technology. This is a valid argument for GenAI tools as well since their launch has been relatively new (e.g. ChatGPT was launched in December of 2022). Hence, in this study, we follow the footsteps of Olsen and Tomlin (2019) and add real-time monitoring and visibility as emphasized in Lyall *et al.* (2018) in our survey and analyses.

Digital transformation of operations and supply chain management has received attention in the recent literature. Although there are studies in the literature that focus on digital transformation, the number of articles that shed light on the current status of the industry is scarce as we present in the next section. In this research, we aim to close the gap between academia and practice, and conduct a survey on 183 practitioners to draw insights. We use Cramer's V values and hypothesis testing to understand the association between the survey responses. The research questions we aim to answer are:

RQ1. Which of the emerging tools and technologies are viewed as the most important by practitioners?

RQ2. What associations exist between the practitioners' characteristics and responses?

RQ3. What are the critical barriers for organizations when starting transforming their operations?

The remainder of this paper is organized as follows: Section 2 reviews the literature and provides real-life examples demonstrating the use of advanced tools and technologies in operations and supply chain management (SCM); Section 3 presents the methodology;

Section 4 discusses the empirical survey results; Section 5 provides recommendations to practitioners and Section 6 concludes this article.

As a product of collaboration between authors from both academia and industry, our research has implications for both academic community and operations/supply chain practitioners.

2. Literature review

2.1 Digitalization of operations and supply chains

Digital transformation of operations and supply chain management has received the attention of researchers in the recent years. Lyall *et al.* (2018) argue that companies need to digitalize their operations to stay competitive and emphasize that real-time monitoring, visibility and automation are essential in this transformation. Olsen and Tomlin (2019) provide an overview of the Industry 4.0 technologies and discuss future research opportunities for operations management (OM) researchers. Studies such as Cole, Stevenson, and Aitken (2019), Asokan, Anisul, Smith, and Stevenson (2022), Son, Kim, Hur, and Subramanian (2021), Maghazei, Lewis, and Netland (2022) review aspects of digital transformation in the literature, however, our contribution is that we close the gap between academia and practice by conducting a survey on industry practitioners, presenting insights and providing a framework for a successful digitization journey.

2.2 Emerging technologies and capabilities

As outlined in Olsen and Tomlin (2019) and Lyall *et al.* (2018), digitalization of OM and SCM requires advanced technology and capabilities. In this section, we review the benefits they offer to organizations along with successful real-life use cases. While doing so, our goal is to inform the readers from both academia and industry about the benefits they offer for organizations.

Blockchain is a decentralized digital system that allows companies to record and track transactions that take place between multiple parties (Gaur & Gaiha, 2020). Its major advantages are improved traceability, more efficient delivery of products, enhanced coordination between the companies, increased product safety and security, enhanced quality control and management practices, and reduced illegal counterfeiting (Cole *et al.*, 2019; Gaur & Gaiha, 2020). Companies such as Napolina (an olive oil producer), Anchor (milk producer), Raw Seafoods (seafood producer), Walmart (U.S. based grocery store) and Carrefour (European grocery store) have implemented blockchain technology by partnering with providers such as International Business Machines Corporation (IBM) and Provence (Ji, Zhou, Lai, Tan, & Kumar, 2022). This way, consumers can see the history of the goods they are purchasing as they move from farm to shelves (Ji *et al.*, 2022), which is essential to ease and eliminate food safety concerns.

3D manufacturing is a technology that transforms an abstract digital design file into a physical object using a 3D printer (Chan *et al.*, 2018). It reduces transportation requirements and carbon emissions, increases product customization, energy savings and efficiency in production processes (Manyika *et al.*, 2013; Halassi, Semeijn, & Kiratli, 2019). Airline companies Air New Zealand, Emirates and Etihad started using 3D printing for cabin parts either through partnerships with additive manufacturing companies or in-house capabilities; allowing them to reduced lead times and inventory costs (Friedrich, Lange, & Elbert, 2022).

General Electric (GE) engineered a new nozzle tip design for their LEAP aircraft engine, which is essential to improve fuel efficiency. This new design was complex-shaped and could not be made easily (actually, it was thought to be almost impossible to make!). However, GE is now able to manufacture these products using additive manufacturing at a manufacturing plant in the United States (Kellner, 2017; Olsen & Tomlin, 2019).

Data Analytics is an essential figure in operations and supply chain management. When the operations are digitalized in an organization, they gain access to a significant amount of data. Through the use of analytics, organizations can improve their forecasting, inventory management, marketing and transportation planning (Choi, Wallace, & Wang, 2018). Blue Diamond Growers, an agricultural cooperative and marketing organization, partnered with System Analysis Program Development (SAP) to forecast demand more accurately and manage supply and demand more effectively (SAP, n.d.a). Motor Oil Group was able to identify root-causes of abnormal events with up to 77% accuracy in 20 hours using historical data, which would take 120 hours without the aid of an analytics tool. Furthermore, they achieved up to 70% accuracy for predicting future sensor measurements using root-case analysis and time-series analysis, respectively (SAP, n.d.b).

IoT is a technology that allows communication between digitally connected devices. According to Nižetić *et al.* (2020), the use of IoT technologies in industrial applications leads to more efficient production processes, efficient communication between operators and machines, and efficient quality control with reduced losses. IoT technology can improve tracking and visibility in supply chains, for example, GAP, Inc. (a clothing store) used radio-frequency identification (RFID) technology to establish an item level tracking for their denim apparel in their Atlanta store. With this, they reached to an almost complete on-shelf availability and increased sales by about 12% (Wilding & Delgardo, 2004).

Automation involves robots and/or automated guided vehicles (AGVs) that can take part in manufacturing and/or transportation. As summarized in Bechtsis, Tsolakis, Vlachos, and Iakovou (2017), its benefits include increased productivity, labor cost savings, reduced energy consumption and enhanced safety. British Petroleum (BP) invested in an automation technology (namely, Fairmarkit) and was able to actively source $100M via automated processes with no human intervention. Furthermore, they reduced their cycle time by half (Fairmarkit, n.d.).

Real-time monitoring opens doors to better managing volatility, increased asset utilization and providing customer convenience at an optimized cost (Lyall *et al.*, 2018). It may include tracking orders, production or delivery status; inventory level at the supplier(s), and demand amounts of the customer(s). Allbirds Inc., a shoemaker, for example, labels every product with their carbon footprint to inform consumers on the environmental impact of the supply chain. Furthermore, they can track the inventory level in real time and seek new opportunities to minimize waste (SAP, 2021). Real-time monitoring can help mitigate disruption risks, as well. For instance, the Suez Canal was blocked in March 2021 as the Evergreen Ship became stuck. This Canal is home to about 12% of the global shipping, and the disruption caused by this blockage led to more than $10M loss per day for the Canal and more than $7B loss per day in trade (Fan, Yang, Wang, & Marsland, 2022; Michaelson & Safi, 2021). For disruptions of this magnitude, companies with real-time tracking capabilities are much ahead in risk mitigation as not only could they reroute their shipment well ahead of time, but also prepare the associated parties of the impact and delays, reducing the risk and providing ample time to make way for alternatives.

In addition to improving operations through advanced technologies, visibility between supply chain partners is essential for offering the best value to the customers. Lamming, Caldwell, Harrison, and Phillips (2001) define visibility as "the two-way exchange of information and knowledge between customer and supplier". Kalaiarasan, Ravi, Jan, Kumar, and Wiktorsson (2022) summarize the benefits of visibility as improved agility and flexibility, enhanced decision-making, increased planning capabilities, better risk management, higher profit levels, reduced inventory cost and sustainability. Scottish Courage, a brewing company in the United Kingdom (UK) implemented RFID technology and was able to reduce the number of kegs losses by half; and container cycle time by four days, which led to reduced inventory levels (Wilding & Delgardo, 2004).

In our survey, we ask questions to participants to learn how important they view these technology and capabilities, and use analytical and empirical tools to draw insights into their responses. Ultimately, our goal is to shed light on where industry is in terms of digitalization.

2.3 Methods for examining the association between survey responses

Based on the survey responses, to understand the associations between the variables, we calculate Cramer's V values and perform hypothesis testing. Cramer's V values represent the relationship between categorical variables. Similar to the correlation coefficient, it takes values between 0 and 1, and the closer it is to 1, the stronger the relationship is.

In terms of hypothesis testing, we use Whitney-Mann u-test, which is suitable for ordinal or count scale (Weathington, Cunningham, & Pittenger, 2012). Naghshpour (2016) provides characteristics of this test as follows: It does not require the distribution functions of the populations to be normal unlike the *t*-test. Another advantage of this test compared to the *t*-test is that it can be used when the sample size is small. The null hypothesis of the test states that the two populations have the same distribution. Since our data set includes variables that are ordinal or categorical, Whitney-Mann u-test is appropriate. Furthermore, we use the z-test for proportions as additional analysis to confirm the results.

3. Methodology

In this section, we present our survey design, administration process and a number of hypotheses to analyze. Then, we provide a descriptive summary of the sample data, which provides details about the participant background and characteristics.

3.1 Survey development and administration

To share the views of operations and supply chain practitioners about the emerging technology and capabilities we summarize in Section 2, and identify the biggest barriers that the organizations are facing in a digital transformation process, we conducted an online survey of 183 professionals between the last quarter of 2022 and third quarter of 2023. The sample size is consistent with the other similar survey studies such as Wang and Wei (2007), Son *et al.* (2021), Mubarik *et al.* (2021). To collect responses, we reached out to the participants individually. The participants are employed at various scales of organizations that are located in North America, Europe and Asia, and we did so to ensure a diverse set of responses. As mentioned before, we picked the technology and capabilities in our survey questions based on the emphasis on them in the literature as listed in studies such as Olsen and Tomlin (2019) and Lyall *et al.* (2018).

3.2 Measurement

To hear the professional's voice and provide insights into the current status of operations and supply chains, we directed questions to the participants about which emerging technology and capabilities that we present in Section 2 are most important from their perspective. Although some of these are interconnected (e.g. IoT can allow traceability, visibility, real-time monitoring capabilities) and the list includes both technologies (e.g. blockchain) and capabilities (e.g. visibility), we included them together to examine the practitioners' reactions. This is because, for example, leadership may want to invest in real-time monitoring capabilities and may not be familiar with the details that enable it. A consultant, information technology (IT) or OM team member may be familiar with what type of IoT tools are a best fit for their organization to create real-time monitoring capabilities. From an organizational standpoint, we asked whether their organizations started digitalization and if so, how much progress they have made.

Most of the survey questions are in the form of multiple-choice or follow a Likert scale. For multiple-choice questions, we also gave an option to enter a new answer if none of the choices are a good fit for the participant. In addition, we directed open-ended questions to use in our text analysis. For example, we asked what barriers the companies face when it comes to digitalization projects, and what type of data and information would be the most crucial to have access to in real-time. Finally, we asked questions to identify the experience level, current role and functional area of the participants as well as the company profile (e.g. digital maturity, annual revenue) at which they are employed.

3.3 Sample

Our sample mostly consists of executives, managers, consultants, analysts, engineers, and research scientists. About 8% of the participants have more than 20 years of experience; 17% of them have 11 to 20 years; 30% of them have 5 to 10 years; and 45% have less than five years of experience. In addition, about 62% of the participants are employed at organizations that have some level of digitalization within their operations, and the others are either exploring possibilities or in the process of implementing (about 34% of the participants are employed at organizations that started transforming their operations and are in the continuous improvement phase, about 28% work at organizations that are in the implementation and deployment stages, and about 23% of the respondents indicate that their organizations are in exploring and evaluation stages). About 70% of the professionals we surveyed responded that they are very familiar with the benefits of digitalization. While about 12% indicated that their familiarity is limited, the remaining 18% said that they are somewhat familiar. We find this encouraging in terms of the audience we picked for our study who can give us insightful responses towards the current status of the industry, and importance of digitalization.

3.4 Hypotheses

To understand how participants with different characteristics view the importance of the technology and capabilities we present in Section 2 and answer Research Question 2, we develop hypothesis tests. Specifically, we test if responses vary based on the experience level of the participant, whether the participant holds a leadership role and the financial position (e.g. annual revenue) of the organization they are employed at. We picked the experience level because we wanted to examine if there is a difference in responses between less experienced and more experienced professionals. More experienced participants might have been employed at a larger number of organizations in the past and have faced different challenges of various scales. Less experienced ones may not have had as much time in practice, but may have more familiarity with technology and digitalization. To explore this question, we develop the following hypothesis:

H1. Ratings for a given option (visibility, analytics, blockchain, monitoring, automation, 3D, IoT) differ based on the experience level of the professionals.

The role or position of the participants can impact the response they provide for the survey questions, as well. Specifically, at the leadership level, priorities can be different compared to other roles. For example, an operations manager may have different priorities or problems to solve than a consultant. An executive may be interested in larger scale outcomes, whereas an engineer may be working to improve the production processes. To test if there is a difference in ratings between leadership and other roles, our hypothesis is:

H2. Ratings for a given option (visibility, analytics, blockchain, monitoring, automation, 3D, IoT) differ based on whether the professional is in a leadership role.

Finally, participants who are employed at organizations with more (financial) resources may have more experience using technological advances in OM and SCM, which may impact their responses. For example, because blockchain applications in supply chains is still fairly new, it is possible that only organizations with more financial resources might have made investments in it. If a participant's organization has invested in a blockchain technology, they may have experienced its benefits and can comment on it accordingly. On the other hand, if their organization has not used blockchain, they may not rate it highly due to the lack of successful use cases. To test whether this is the case, our hypothesis is:

H3. Ratings for a given option (visibility, analytics, blockchain, monitoring, automation, 3D, IoT) differ based on the annual revenue of the organization in which the professional is employed.

We analyze and discuss these results of these hypotheses in Section 4.4.

4. Empirical results and insights

In this section, we answer the research questions and test the hypotheses from Section 3, understand which technology and capabilities are viewed as most important, and examine the association between the ratings using Cramer's V values and hypothesis testing.

4.1 Identifying the most important technology and capabilities based on survey responses

When answering Research Question 1, we provide descriptive analysis on the ratings that participants provided on the survey questions. As mentioned previously, we followed a five point Likert scale, and for the purposes of descriptive analysis, we converted responses into a more condensed form as follows: We categorized responses "4" and "5" (out of 5) as "strongly agree", "2" and "3" as "somewhat agree", and "1" as "strongly disagree". Similarly, for questions that ask the participant to rate the importance of a given option, a "4" or "5" would then correspond to "very important". Table 1 summarizes the percentage of responses that rate the given option as very important. Based on this table, data analytics and real-time monitoring are regarded as the most important aspects of digitalization: Approximately 89% of the respondents rate data analytics and 84% rate real-time monitoring very important for their organizations. Following these, supply chain visibility and automation were rated as very important by 78% and 76% of the professionals we surveyed, respectively. On the other hand, we find it surprising that blockchain technology and 3D manufacturing are not rated as one of the most important technologies in our survey (34% and 25% of the participants rating them very important) although they offer many benefits for organizations. For both 3D manufacturing and blockchain, the reason for low preference can be the lack of information about these technologies. While we acknowledge that these terms are becoming more and

Item	Percentage of "very important"
Data analytics	89%
Real-time monitoring	84%
Supply chain visibility	78%
Automation	76%
IoT	60%
Blockchain	34%
3D manufacturing	25%

Source(s): Table by author

Table 1. Summary of responses about the importance of emerging tools and technologies

more popular, it is possible that their business use cases are not clear to professionals. We believe that as there is more awareness about these topics as well as their contributions for organizations (as we aim in Section 2.2), supply chain leaders will start investing in them and take advantage of the benefits they offer.

To further investigate the the top two results from Table 1, we look into the characteristics of the participants who rated them as very important. Within the group of participants who picked data analytics as very important, about 29.45% are managers, 22.09% are consultants, 17.79% are analysts and 17.18% are in an executive position. For these participants, the next highest rated options are real-time monitoring (average of 4.39 out of 5) and supply chain visibility (average of 4.32 out of 5). On the other hand, about 33.33% of those who picked real-time monitoring as very important are managers, 22.92% are consultants, 20.83% are analysts, and 15.97% are in an executive position. These practitioners also value data analytics very highly with a mean of 4.48 out of 5, and the average rating for supply chain visibility is 4.33. The next highest rating is for automation, which is about 4.29 within this group of participants. These results indicate that having access to real-time data and being able analyze it are the top priorities for those who are actively involved in the decision-making process.

4.2 Identifying the association between participant characteristics and responses

To answer Research Question 2, one of the methods we implement is a correlation analysis using Cramer's V values. As mentioned in Section 2, Cramer's V provides a range of values between 0 and 1 similar to the correlation coefficient, but it is for categorical variables. Figure 1 summarizes the results in which lighter colors represent stronger relationships. For example, the strongest association exists between responses for blockchain and 3D manufacturing. Relationships between visibility and data analytics, real-time monitoring and data analytics, visibility and real-time monitoring, and automation and analytics come next.

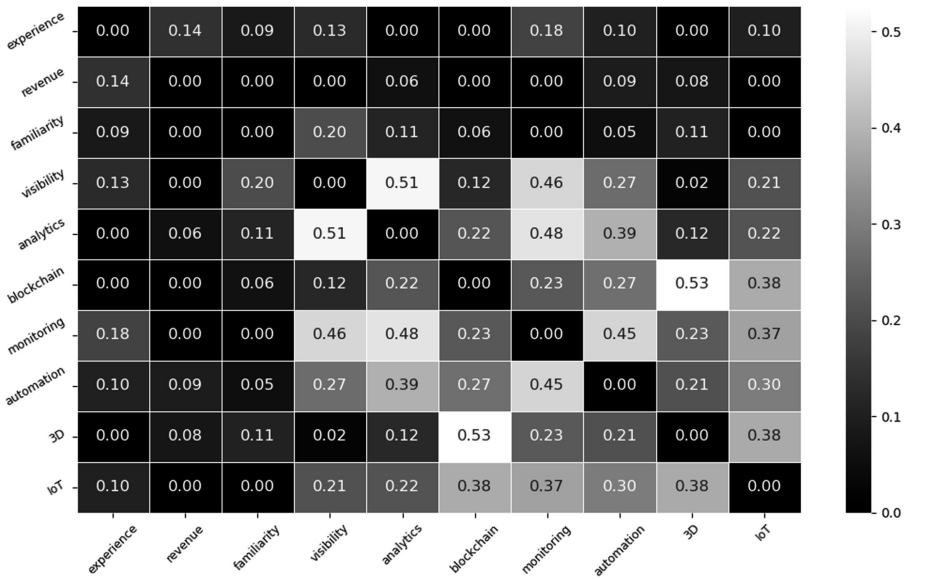

Figure 1.
Cramer's V matrix representing the correlation between the variables of the data set

Source(s): Figure by author

4.3 Hypothesis tests

In this section, we examine the relationship between the variables of our data set by using hypothesis testing at a significance level (i.e., α) of 0.05. More specifically, we analyze if there is a change in responses based on (1) the experience level of the participant (Hypothesis 1), (2) whether the participant holds a leadership role or not (Hypothesis 2) and the financial position (e.g., annual revenue) of the organization they are employed at (Hypothesis 3).

For Hypothesis 1, the Whitney-Mann u-test results are in Table 2. Based on this table, we find that visibility ratings can vary depending on the experience level of the professionals, and more specifically, the proportion of those who view visibility very important is higher within the group of participants with more than 10 years of experience. For Hypothesis 2, we can observe that there is no evidence to conclude that responses vary between leadership and other roles at an α level of 0.05. Finally, analyzing Hypothesis 3, the same conclusion can be drawn.

For the analyses that Tables 2 through 4 present, we also perform a z-test for proportions. Before doing so, we calculate the required sample sizes for effect size values of 0.2 and 0.5 with power = 0.8, where effect size represents the magnitude of the effect relative to the total variation in a data set, and statistical power is the probability of rejecting the null hypothesis when it is indeed false. Although our sample size is not sufficiently large for an effect size of 0.2, it is for an effect size of 0.5, which is considered a medium effect size. The test results are consistent with the ones that Whitney-Mann u-tests produce.

4.4 Barriers to digitalization and most needed information

To answer Research Question 3, we perform text analysis on the participants' responses to understand the possible reasons for not digitalizing operations, or not achieving a desired level of digital maturity. Toward this end, in our survey, we asked the participants what barriers their organizations are facing in terms of starting their digital transformation or

Variable	*p*-value
Visibility	0.031
Data analytics	0.541
Blockchain	0.298
Real-time monitoring	0.051
Automation	0.504
3D	0.482
IoT	0.170

Source(s): Table by author

Table 2. Whitney-Mann u-test results for response differences based on experience levels of the participants

Variable	*p*-value
Visibility	0.152
Data analytics	0.818
Blockchain	0.163
Real-time monitoring	0.276
Automation	0.473
3D	0.769
IoT	0.251

Source(s): Table by author

Table 3. Whitney-Mann u-test results for response differences between leadership and nonleadership roles

increasing its scale if they have already started the process. Table 5 summarizes the top five reasons the respondents shared.

Based on the responses, cost and failing to obtain stakeholder buy-in due to lack of business case objective are the top two reasons. While we find the concern about cost expected, we believe that there is evidence in practice that proves otherwise as we discuss in Section 5. Lack of evidence to provide its benefits for the organization, and not knowing where to start are also significant reasons for not pursuing digitalization. In the next section, we share our recommendations based on industry experience to guide organizations in overcoming these difficulties and presenting business use cases demonstrating the benefits of digitalization.

In terms of what type of information is the most important that the participants wish to have access to, our text analyses lead to results aligned with the summaries we provide in Table 1. We look for groups (specifically, composed of two words), and the ones with the highest frequencies are "real-time" and "inventory levels". When analyzing text with three words, "real-time visibility" and "real-time data" have the highest frequency "inventory levels", and "demand amounts" are the information that are listed by most participants. As Table 1 identifies real-time monitoring as one of the most important capabilities for the participants, we believe that these results are not surprising.

5. Recommendations to practitioners

In this section, we provide guidelines to practitioners to (1) start digitalization in their organizations and (2) make progress in the transformation process if they already started.

Digitalization requires various steps and projects for organizations to successfully complete. First, all departments and stakeholders should be on board. If there are departments or team members that question the need for transformation, this can cause

Table 4.
Whitney-Mann u-test results for response differences between companies of different annual revenues

Variable	*p*-value
Visibility	0.882
Data analytics	0.200
Blockchain	0.576
Real-time monitoring	0.441
Automation	0.115
3D	0.137
IoT	0.625

Source(s): Table by author

Table 5.
Top five reasons for not starting digitalization

Factor	Percentage of the participants who listed the factor as a barrier
High cost	44.81%
Unable to get stakeholder buy-in due to lack of business case objective	30.60%
Lack of evidence to provide its benefits for the organization	25.14%
Not knowing where to start	15.85%
Lack of infrastructure	10.38%

Source(s): Table by author

delays and possibly lead to a failed project at the end. This argument is also supported by the study of Lai, Sun, and Ren (2018). Second, the organizations should start small. Undertaking big projects without much digital maturity does not promise success. Furthermore, as our survey indicates (see Table 5), cost is a big barrier that stops organizations from transforming their operations. The first and second steps combined can help address these concerns and convince the stakeholders about the benefits that could be gained through this investment. Third, necessary tools and software should be implemented. This may include purchasing products from leading providers, or building in-house systems. Again, as cost is a factor that can raise concerns, we provide examples about how there can be solutions that can be obtained by smaller budgets. In the next subsections, we detail these three steps.

5.1 Stakeholders must be fully on board

As Table 5 of our survey results demonstrates, one of the reasons for failing to start digitalization for organizations is the lack of stakeholder buy-in. Organizations must invest time in ensuring that all stakeholders are fully on board and understand the purpose of the transformation. This is the most crucial step, as the digital transformation journey is not a one department task; it requires a holistic and collaborative approach. Outlining the benefits such as additional profit and/or savings that each department can make, along with case studies and success stories of those that transformed their operations can be some approaches to convince the stakeholders. Clearly defining the business challenges that the organization is facing, identifying key performance indicators (KPIs) and measuring the progress through data and software output are also important steps. For example, having answers to questions such as "How does the inventory management software implementation help the organization reduce slow-moving stock keeping unit (SKU) safety-stock levels?", or "Will this transformation allow the organization to use available capacity to stock higher levels of fast-moving SKUs and better serve customers?" can be a way to achieve this.

5.2 Starting small is key in digitalization

As an organization considers transforming their operations, starting small is the way to success. For example, it could be as small as automating a dashboard that shows the up-to-date inventory level, or generating a report to view defective productions. While the IT team still takes the lead in the implementation and integration phases, leadership team has an important role in defining the workflow, reinforcing the links back to the business case(s), performing validation and providing feedback. Starting off with a pilot project allows organizations to get a gauge on the level of interest associated with a digitalization project as well as stakeholders' understanding of the end goal, importance and level of continuous cooperation that is necessary for the success of the project. This also gives organizations critical insights in preparing for larger scale projects. In addition, convincing the stakeholders about how a larger scale digitalization project benefits the company can be less challenging with a successful pilot project.

5.3 Software and technology help start Digit(al)ization

There are challenges that companies face when it comes to digitalization as we present with our survey in Section 4. Perhaps, the most concerning of these is the lack of a digital platform; there are still companies that don't store data digitally. For some organizations (i.e. mostly the ones with low maturity levels Ad Hoc and Defined based on Table 6), this may be addressed with a simple software such as Microsoft Excel to store data. This way, the organization has the ability to analyze past data to draw critical insights. As we share in Table 5, high cost

perception about digitalization efforts is the number one barrier for companies. However, there are low code or no code platforms that can transform physical operations into a digital environment without being too costly. These platforms can provide real-time access to internal operations and be used to produce insights to improve the processes. The "Low-code and No-code" team at Deloitte states that these platforms can provide companies with innovation and speed in marketing, rapid prototyping, "fast-fail" capabilities, improved efficiency of processes and workflow automation (Deloitte, 2021). In addition to low-code and no-code platforms, using supply chain business-to-business (B2B) software and platforms can bring in the desired visibility between the partners. These are especially well-suited for large organizations or companies with high maturity levels (Integrated or Extended). Leading software companies such as IBM and SAP provide these services that enable real-time monitoring, end-to-end visibility, AI driven decision-making and effective management of disruptions.

Although there are key steps that any given organization needs to follow as we outline in Sections 5.1 through 5.3, we believe that a one-size-fits-all approach is not appropriate for a digitalization project. In addition, digital transformation is an incremental effort rather than a one-time project. As businesses gain proficiency within each stage, their operations and supply chains become better-equipped to meet the demands of today's complex, networked and global business environment.

5.4 Business use cases

In this section, we present two case studies based on primary data derived from real-life experiences. One of these organizations is a beverage store and the other is a therapeutic drug manufacturing and distribution company. For both organizations, the cases we present are based on observations, interviews and data collection. We picked these two businesses to also demonstrate how digitalization can be a different journey for low and high digital maturity organizations.

Although digital transformation is inevitable for any organization, we believe that it will be a different process for different organizations. Smaller firms may have a completely different journey than that of larger ones. However, the size of an organization may not be a determining factor to assess the pace of digitalization: It is necessary to assess the digital readiness to understand the unique requirements of the transformation projects. The "digital maturity level" can be a more suitable measure, which represents the readiness for the transformation. According to Lockamy and McCormack (2004), the maturity model for companies can be broadly categorized in five, which are Ad Hoc, Defined, Linked, Integrated and Extended (see Table 6 for details). In this paper, we aim to shed light on how organizations with different maturity levels can start this transformation through case studies.

Table 6.
Summary of maturity levels for organizations based on Lockamy and McCormack (2004)

Maturity level	Characteristic
Level 1: Ad Hoc	Lack of structure and clearly defined process activities
Level 2: Defined	Communication exists between silos or departments in the organization, but there are no connections between them
Level 3: Linked	Clear lines of communication and collaboration exist, decisions are made unanimously
Levels 4 and 5: Integrated and Extended	Collaboration within and between companies is on the highest level

Source(s): Lockamy and McCormack (2004)

5.4.1 A beverage store. This is a small organization that can be classified as in Level 1 or Level 2 maturity (i.e. Ad Hoc or Defined) with approximately 500 employees. It used to run on a pen-and-paper-based process with no digital systems in place. Although this store didn't have much competition about 35 years ago when they first opened, over the last decade, this has changed. It is now vital that the store has a sound operation policy to keep their costs down. Decisions about business parameters and KPIs were all made based on past experience and intuition of business owners. Though the business was projecting increased revenue, there was significant profit leakage. The lack of a proper (digital) system made the integration within and between partners more challenging. There was no visibility into the operations or the supply chain, thereby providing no opportunity for collaboration or improvement.

Step 1 - Starting Small: The first action for this organization was to start digitizing their data collection process because the existing method was not efficient. As we outlined previously, getting all stakeholders on board is essential (Step 2 of digitalization) and demonstrating the impact of how transitioning from manual data tracking to a computerized approach is a simple and effective way to convince them. With this digitization, the company was able to start analyzing their data. For example, one of the business challenges they were facing was the presence of a large amount of inventory, which means cost and need for additional space for storage. Data analysis allowed the organization to identify and remove obsolete SKUs, generate more accurate counts of safety stocks, and reduce the overall holding cost by about 18%. This generated working capital to utilize and was helpful to convince the stakeholders. In addition to the financial aspects, the ability to maintain day-to-day records in an organized way enabled opportunities for collaboration with potential vendors and optimizes their processes.

Step 2 - Stakeholder Buy-in: In terms of logistics, the company owned their own trucks. The consultants proposed that by leveraging a third-party logistics (3PL) company and moving away from owning trucks, the business could generate up to 28% in cost savings. These savings included items such as driver salaries, truck service and maintenance, and depreciation of the trucks. Furthermore, by outsourcing to a transportation company, the team was able to gain real-time visibility into the movement of the products. With data-backed evidence, the consultants were able to convince the business stakeholders and the company was keen on investing in technology and systems to digitalize their operations.

Step 3 - Software Implementation: For this organization, the consulting team evaluated various systems and decided that the best suited for this business was an enterprise resource planning (ERP) system that integrates well with Microsoft Excel, generates end of day report documents (such as a PDF file), includes business intelligence tools to visualize the data, and offer capabilities in inventory and warehouse management. Finally, the consultants suggested creating a fully customized tool with barcode and RFID enabled capabilities to fully automate the processes. Since this is a small enterprise with a limited budget, the team recommended a low-code/no-code application for system customization.

5.4.2 A therapeutic drug manufacturing and distribution company. This organization has been operating for over four decades with some level of stability and digital maturity (Level 2 or Level 3). In the past, the management team made attempts to integrate ERP systems for digitalization and enable collaboration for improved decision making. However, the implementation was not successful and the software didn't meet their expectations. For example, a data entry corresponding to a doctor (i.e. a customer for this company) could be duplicated in the system to represent two separate entities. Sales representatives started projecting fake or duplicate medicine sales and customer acquisition in order to gain extra commissions. Once the lock-in period expired, the company had to send the unsold medicine back to the supplier if they hadn't already expired. The system had key flaws, which led to lost profits for the company.

Step 1 and Step 2 - Starting Small and Stakeholder Buy-in: Since this company was more digitally mature and had a unique business challenge, the "starting small" step looks different compared to the beverage store. The main obstacle was about convincing the stakeholders who lost confidence in digital systems due to the negative experience with the previous ERP software provider. The "real" first step for digitalization for this organization was to define the business challenge and set objectives. Then, by clearly defining the KPI and determining a performance measurement method, the consultants aimed to demonstrate the value that digitalization can bring to them. Table 7 provides the actions taken to obtain stakeholder buy-in.

In the example that Table 7 presents, the sales commission is the KPI to which having visibility is critical. The consultants made a case that the system could help identify observations with extremely high or extremely low commissions, which would prevent fraudulent activities. They could achieve this through digitalization, which allows collecting large amounts of KPI data. This systematic approach was successful to convince the stakeholders to pursue and invest in a digital system.

Step 3 - Software Implementation: After thorough review of the supply chain and setting up stringent processes in place, the stakeholders decided to replace the existing ERP system with a more tailored system to bring ease of implementation and increased support. After several rounds of request for proposals (RFPs) and request for quotes (RFQs), the organization decided to work with SAP as their end-to-end (E2E) implementation partner. This brought the necessary digitalization as well as subject matter expertise, which were both important to obtain stakeholders' approval.

In summary, considering these two business use cases, we want to emphasize that our recommendations are designed to be adaptable to various business scenarios and are not set in stone. Organizations should tailor these recommendations in a way that they align with their specific needs, challenges and goals.

6. Concluding remarks

Sooner or later, companies operating in a supply chain will become (more) digitalized to meet customer expectations. According to a report released by the World Economic Forum in 2022, the top four most digitally mature industry groups are semiconductors, electronics and pharmaceuticals, energy and chemicals. These industries are typically large-scale industries with high digital maturity. This report presents that, over the last three years, logistics industry has made progress to claim the fifth place, mainly due to two factors: Growth of online shopping and the emergence of e-commerce leaders such as Amazon, Alibaba and JD.com. With COVID-19 further fueling online shopping globally, digital transformation of the logistics industry is expected to accelerate in the coming years (World Economic Forum, 2022). We believe that this trend is going to impact operations and supply chains, which forces organizations to transform their operations.

In this study, we conduct a survey on 183 industry practitioners to understand their views and opinions about digitalization. The sample data includes executives, managers, consultants, analysts and other related professionals in the field. Based on the analysis,

Business challenge	Sales representatives make unearned commission due to a lack of system visibility
KPI to measure	Sales commission made by sales representatives, categorized by doctor and region
KPI measurement method	Unique identifier to be assigned to individual sales representative, doctor and sales transaction

Source(s): Table by author

Table 7.
An example for linking business use cases to KPIs

data analytics and real-time monitoring are viewed as the most important tools and capabilities by the participants: About 89% of the respondents' rate data analytics and 84% rate real-time monitoring very important for their organizations. Supply chain visibility and automation are the next two highest rated technology and capabilities (by 78% and 76% of the professionals, respectively). Blockchain and 3D manufacturing do not appear to be viewed as highly important technologies in our survey. An explanation for this can be the lack of information and successful business use cases of these technologies. We believe that as studies like ours become more widely available, this trend will change and companies will invest in technologies to digitalize their operations.

To identify the relationship between the survey responses, we present Cramer's V values and hypothesis tests. Based on Cramer's V values, the strongest association exists between responses for blockchain and 3D manufacturing. Relationships between visibility and data analytics, real-time monitoring and data analytics, visibility and real-time monitoring, and automation and analytics come next. Based on the hypothesis tests, there is no evidence to conclude that rating responses vary between leadership and other roles for the technology and capabilities we asked about. The same conclusion is true in terms of the annual revenue of the organizations. We also find that visibility ratings can vary depending on the experience level of the professionals. The proportion of those who view visibility very important is higher within the group of participants with more than 10 years of experience.

To understand the main barriers to digitalization, we examine the survey responses using text analytics and find that cost, failing to obtain stakeholder buy-in, and lack of evidence to provide its benefits for the organization are the top factors. Taking these results into account, we provide recommendations to practitioners that outline a successful path to digital transformation: We believe that starting small, focusing on stakeholder buy-in with a systematic approach, and implementation of software are the three steps the organizations must follow. We make a case that this transformation may look different for different organizations, and a one-size-fits-all approach is not appropriate. Our case studies demonstrate real-life applications of these steps for small enterprises compared to large organizations.

Future research can extend this study to new implementations of the proposed steps in various organizations. Examining the KPIs, cost savings and profit improvements can demonstrate the value added through digitalization. Further collaborations between academia and industry can increase awareness in digitalization. Specifically, applications in different industries can expand on our case studies and help organizations convince the stakeholders about the value that digitalization brings. Other tools and technologies such as AR, virtual reality and generative AI can be explored, as well.

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Supplementary material

Survey questions

(1) What is your current professional title? If "Other", please type your title in the space given below.

- Executive leadership (VPs, CXO's, directors)
- Manager
- Consultant
- Analyst
- Other

(2) How many years of experience do you have in operations and/or supply chain management?

- Less than 5 years
- 5 to 10 years
- 11 to 20 years
- More than 20 years

(3) Which of the below best represents your function?

- Procurement/Purchasing
- Supply/Demand Planning
- Operations
- Sales/Marketing
- Strategy

(4) What is the revenue ballpark for the company you are currently employed at?

- Less than $10M
- $10M - $50M
- $51M - $100M
- $101M - $500M
- $501M - $1B
- Greater than $1B

(5) How familiar are you with the benefits and impact of digital transformation for organizations?

- 1 (not at all) through 5 (highly familiar)

(6) In your opinion, on a scale from 1 to 5, how important are the below benefits of digital transformation for organizations? 1: least important, 5 most important.

- Supply chain visibility
- Data analytics
- Blockchain
- Real-time monitoring
- Automation

- 3D printing
- Internet of Things (IoT)

(7) Where is your organization in the digital transformation journey?

- Exploring and setting (developing the use case, Return on Investment (ROI), stakeholder views and sign off)
- Evaluation (pilot departments, budget, capital, project owners and timelines)
- Implementation and deployment
- Implemented and in continuous improvement phase
- Not pursuing at the moment
- Other:

(8) What would be the biggest barrier for your organization to start digit(al)ization or increase the scale of the existing digitization? Please check all that apply.

- High cost
- Unable to get stakeholder buy-in due to lack of business case objective
- Lack of infrastructure
- Not knowing where to start
- Lack of evidence to provide its benefits for the organization
- Other:

(9) Open ended question: In your opinion, what type of information would you need access to in real-time to improve supply chain performance?

Source(s): Supplementary by author

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