Digital Outcome Optimization:
Ensuring a Return on Investment From Digital Strategy

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Public sector organizations have difficulty avoiding cost or schedule variances that exhaust the resources of a project, and deploy digital initiatives to combat them without clear evidence of a quantifiable return on investment (ROI). This investigation determined if digital initiatives have a measurable ROI for major projects. A systematic review questioned, In public sector organizations, does the evidence suggest that the application of operational excellence ensures an ROI from digital initiatives? Scientific Management was the theoretical lens. The findings and conclusions of 43 peer-reviewed scholarly articles provided data on operational excellence, digitalization, synergy, and benefits. This research improves understanding of how to quantify and deliberately plan the impact of digital initiatives. The conclusion is that mangers should optimize digital outcomes by 1. Selecting the intended human outcome (customer value or staff effectiveness), then 2. Making five key management choices, 3. Choosing an operational excellence toolset, and 4. Implementing the appropriate Industry 4.0 technology.

Keywords: digital strategy, Industry 4.0, optimization, operational excellence, technology

INTRODUCTION

Management initiatives are seen throughout history in the public and private sectors. The New Deal was a series of policies and programs aimed to relieve the Great Depression, producing various effects. The Tennessee Valley Authority, Federal Housing Administration and the Securities and Exchange Commission were management initiatives on a grand scale. President Reagan signed the Productivity Improvement Program for the Federal Government, effectively making Total Quality Management the law of the land. Even the Roman Empire sought to improve project management.

In 2017, the Department of Homeland Security (DHS) launched their Digital Transformation policy. This was in response to the U.S. Digital Services Playbook. Montgomery County, Maryland's Digital Government Strategy was published in 2012. Digital initiatives are pervasive in the public sector.

In 2018, the Department of Defense (DoD) embraced digital management trends. DoD issued policies such as the DoD Digital Engineering Strategy, DoD Digital Modernization Strategy and DoD Data Strategy. These strategies must be echoed and implemented by each service, and their subordinate acquisition commands. However, there is no clear, direct evidence of a quantifiable benefit, leaving open to question if these digital initiatives are an efficient choice, management fashion, or fad.

The DoD acquisition enterprise aims to quickly buy products and services that satisfy user needs with measurable and timely improvements to mission capability. The National Defense Strategy states greater efficiency in procurement is a national priority. The National Defense Business Operations Plan declares that reforming the business processes is a key strategic goal.

In spite of this attention, the problems persist and the symptoms are measurable. The Government Accountability Office (GAO) provides a yearly Weapon Systems Annual Assessment that recount the status of major defense acquisition programs, and stated DoD experienced billions in cost growth over 15 years. Almost half of the programs still in development reported delays. Elworth et al. found cumulative cost growth among space programs was roughly 11% in only three years. Independent studies show similar cost and schedule failure are not restricted to the DoD.

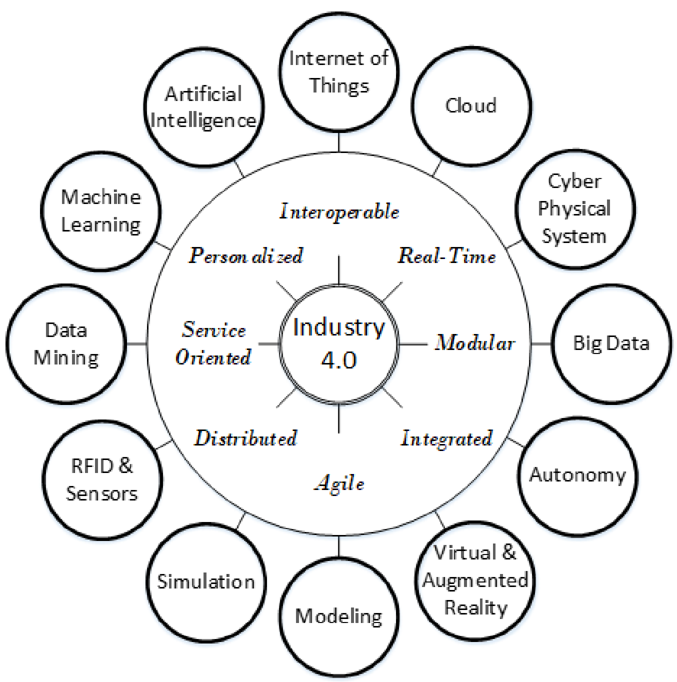
What is ‘digitalization’, and do classic methods of optimizing business operations apply?

Digitalization

Systems Engineering started as a document-based approach, but engineers advocated transforming to model-based systems engineering (MBSE) by leveraging software practices. One of the first papers to use the Systems Modeling Language (SysML) was published in 2004. Professor Azad Madni at the University of Southern California published eight of the over 7,000 peer-reviewed articles on ‘digital twins’. MBSE and SysML are used in the Introduction to Systems Engineering class taught by Johns Hopkins University. MBSE and SysML digitalized the underlying scientific principles and methods of engineering.

Industry 4.0 is a new term getting extraordinary use. It was introduced in a German press release in 2011, to describe a 4th revolution from a business, political and scientific perspective and differentiate it from the previous cycles. The 4th revolution would be cyber-physical systems that linked the real world to the virtual one, with machine-to-machine communication. Scopus reports that roughly 20,000 papers published since 2012 have used “Industry 4.0” in some manner or form. Scholars believe the term has utility, but a consistent definition is elusive. A systematic review that defined Industry 4.0 is now one of the top ten most cited Industry 4.0 sources because it identified the technology trends and principles, which subsequent authors modified. Figure 1 below is a summary graphic of those sources.

FIGURE 1
DIGITAL TECHNOLOGIES AND PRINCIPLES OF INDUSTRY 4.0



NOTE: ADAPTED FROM GHOBAKHLOO AND BUTT.

The digital world brought disruption as well as innovation. Digital transformation was a new phenomenon where disruption did not originate from small, lower-cost alternatives within an industry but from entirely different ones that offered such compelling alternatives that consumers would shift in droves, in only weeks. Digital transformation is now widely studied; Scopus reports that more than 70% of the over 9,000 papers that used 'digital transformation' in some manner were published between 2019-2021. One of the most cited sources is a review and research agenda that saw relationships between digital technologies, operational performance and ethics, potentially positive and negative.

Digital Engineering is a much less widely discussed topic. The DoD Digital Engineering Strategy drew considerable interest within the defense community, but the other industrial sectors have shown little attention. The DoD strategy is a policy document with goals, but fails to define it or differentiate 'digital engineering' from other branches of engineering, citing no distinct scientific principles, methods or unique products of it. No university grants an accredited degree in 'digital engineering'.

The term has not taken hold. Scopus reports that less than 150 papers published during 2019-2021 used the term. While trending upwards, the growth is orders of magnitude less than 'digital transformation'. Unless it is further explored, defined and real value identified, DoD may be relegated to forcing its management fashion onto its supply chain with little return.

There is no accepted authoritative term that encompasses these concepts. For this study, the term 'digitalization' will be used to describe the set of relevant technologies, principles, policies and implementations of things such as MBSE, digital transformation, Industry 4.0 in this vein.

Optimization

The history, number, and effect of business improvement schemes is encyclopedic. People committed to the art and science of improvement have followed the latest management fashion from quality to lean, six sigma, and beyond. Experts in this cornucopia of tools and methods refer to it as operational excellence. The literature surrounding several of these topics is discussed below.

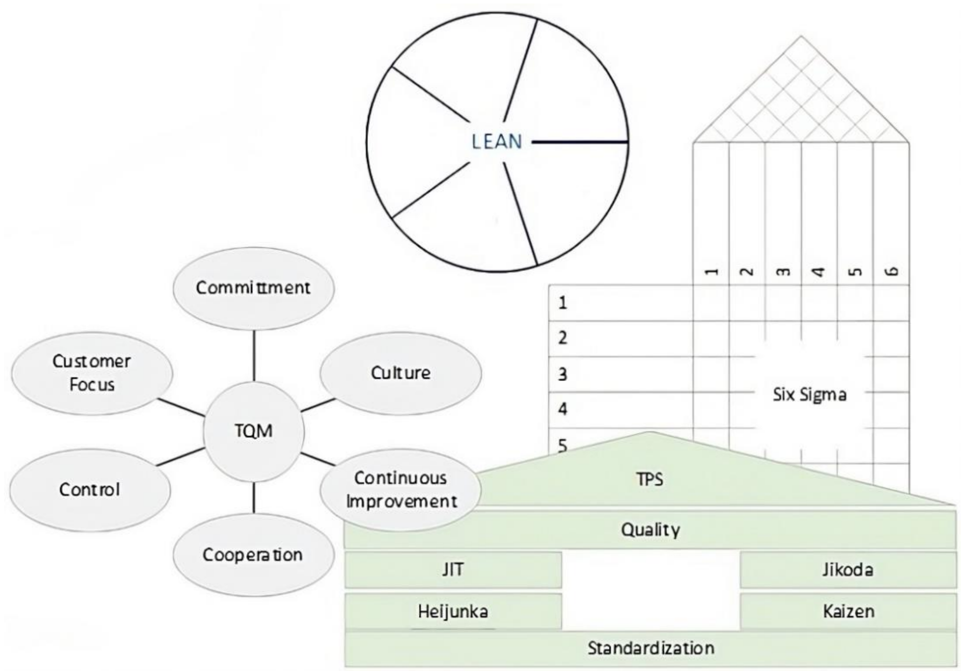
Perhaps the seminal business theory is Scientific Management that Taylor developed in the last decades of the 19th century, seeking the one best way to work. The observations became generalized principles for managing labor, and improving productivity at the lowest possible level. The academic study of scientific management continues, reexamining how to portray human nature, and the current implications for managing managers. The benefits of scientific management can only be achieved when both the labor force and the managers are working with good intent.

Implementation of management by objective (MBO) by setting objectives, cascading them downward, setting schedules, and reviewing progress was considered very successful. Research activity is stagnant, with little significant recent research on the topic. MBO works as an operational improvement tool, within its limits. Total Quality Management (TQM) was popularized during the 1980s. It requires a strong management commitment to focus on customer-driven improvement to processes and measures, which requires participation top to bottom including suppliers.

How Toyota executed production has become known as 'Lean'. Toyota Production System (TPS) integrated the social and technical aspects of production (respect for people with continuous improvement), and eliminated the obstacles of over-burden, inconsistency, and waste (muda). Just-in-Time (JIT), Jikoda (automation with a human touch) and Kaizen (continuous improvement) are part of TPS. The seminal book, The Machine That Changed the World demonstrated the benefits of TPS, and popularized the term 'Lean'.

Harvard Business Review called for outright obliterating the status quo, introducing the concept of business process reengineering (BPR). The BPR method was to assemble a fresh cross-functional perspective on a given process, then improve it. The excitement wore off: Scopus shows only 2,000 papers written on BPR since 1993, declining since its peak in 2011. For the purposes of this study, the term 'optimization' will be used to describe the set of relevant tools, methods and practices in this vein, such as the sample shown below in Figure 2.

FIGURE 2
SAMPLE OF OPTIMIZATION TOOLS



Research Purpose & Question

The research aims to determine if there is evidence that digital strategies have a measurable positive benefit to cost and schedule for major projects in the public or private sector. That evidence could be used to rationalize investment in digital initiatives at many levels. Leaders from around the world, in every sector, ask similar questions for a given project (how much should this program invest in digitalizing internal process or product), for a portfolio (is there a return on investment (ROI) across programs as they each digitalize), for a functional provider (how much should we digitalize our services), or for an infrastructure provider (should we invest in more digitalization tools, services and training). This research will improve understanding of how to quantify and make measurable the impact of digital initiatives, particularly on cost and schedule.

The research question is, "In organizations, does the evidence suggest that digital initiatives will produce measurable cost or schedule benefit?" This allows the broadening of the study from DoD to any entity, avoids management fashion traps, and targets a clear gap in the literature.

METHODS

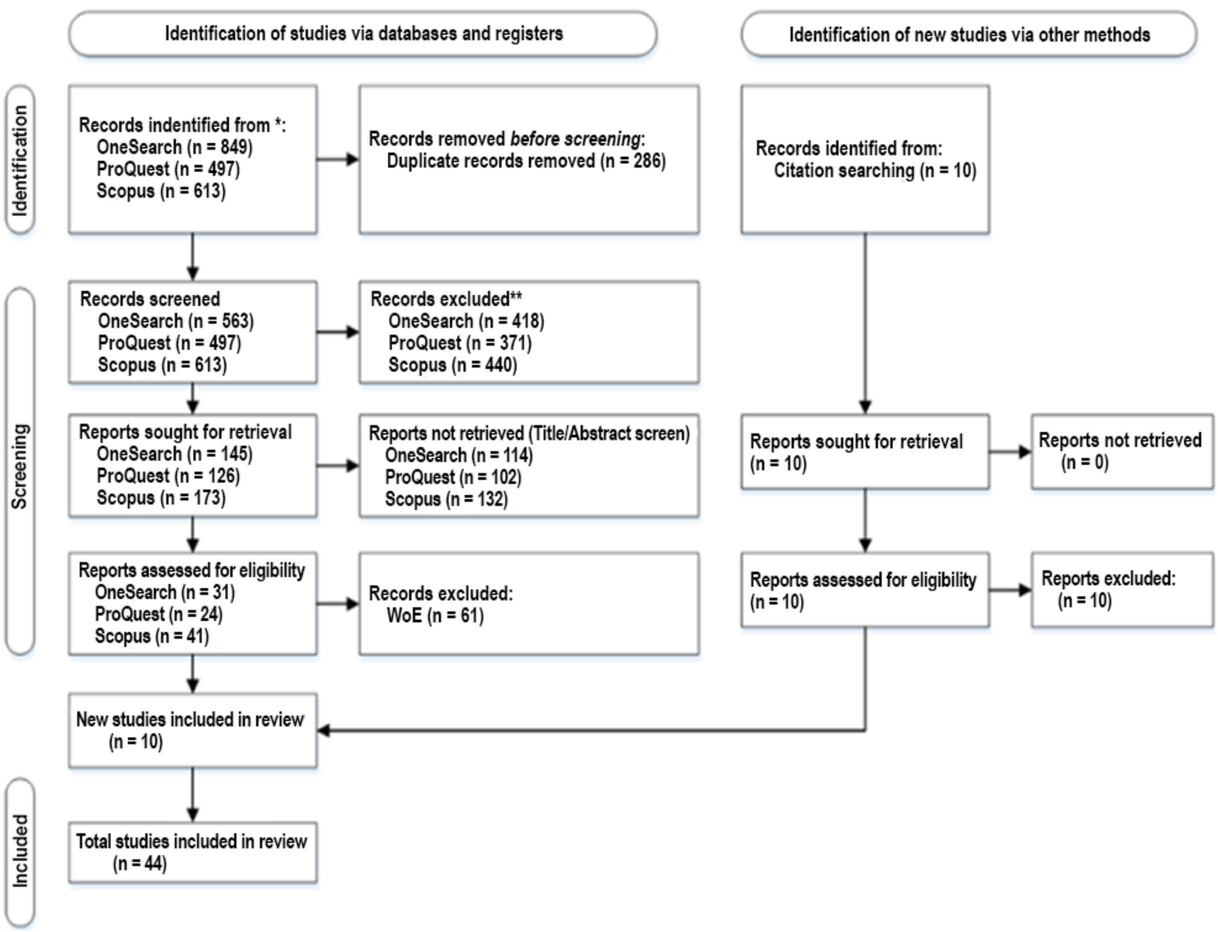
Three separate databases were used to help ensure that the search results were as comprehensive as possible. Consequently, the search was conducted identically three times, as was the duplicate removal, inclusion/exclusion application, title, and abstract screening. The databases were UMGC OneSearch, ProQuest, and Scopus, and the search string is below in Table 1.

TABLE 1
SEARCH STRING

Construct	Variable(s)
Intervention	digitalization OR digitalization OR "digital transformation" OR "digital engineering" OR "digital modernization" OR "digital initiative"
	AND
Mechanism	"quality improvement" OR "continuous improvement" OR "six sigma" OR lean OR "total quality management" OR "Toyota Production System" OR "Just in Time"

UMGC OneSearch system returned 583 results, ProQuest returned 497 and Scopus returned 613. Removing duplicates reduced the results to 1,673. Applying the inclusion/exclusion criteria (full text, 2013, journal, article, English) reduced that to 444 results. The titles and abstracts were screened to remove papers that were not directly relevant or were narrowly focused. A snowball search discovered several more. The process of narrowing the data pool via screening and inclusion/exclusion criteria from 1,673 to 96 sources is shown in Figure 3.

FIGURE 3
PRISMA DIAGRAM



The quality appraisal was executed systematically using Weight of Evidence (WoE). Six elements of each study (research question, design, population, findings, conclusions, and limitations) were examined to judge the appropriateness of the research methods, the appropriateness to the specific research question, and the appropriateness of the evidence. Eleven studies were graded highly but irrelevant to this study, so they were excluded. Four studies with an average WoE below 3.0 were retained for full review because they were directly on topic, such as a case study of applying Lean innovation to digitalize a customs administration procedure. Of the 43 retained studies, the overall average Weight of Evidence was 2.97.

During the second reading, unfamiliar acronyms and definitions used in each source were captured to build a glossary, if required. When the second reading was complete, every finding and conclusion from every source, 348 data points, were exported from Atlas.ti and inductive coding began.

Each data point was a complete sentence (either a finding or a conclusion) from a given source and individually reviewed for information related to the question, such as a particular technology, operational improvement technique, or measure of benefit. This enabled a grounded approach to coding. For example, this sentence was one data point:

"However, if a program only employed an MBSE approach for requirements management, advantages from finding defects early could not be leveraged in later phases, where the savings in cost and schedule from rework prevention is realized."

Key terms were coded, i.e., words such as 'cost'. Once a code was discovered, all 348 data points were searched and tagged for that code. This was done repeatedly, as each data point was reviewed and new codes were discovered, such as 'digital', 'sensors', 'RFID', 'big data', 'DMAIC', 'waste', 'reduce', and 'improve'. Of the 348 data points, 41 did not have relevant codes.

The codes were grouped into categories once the dataset had been fully coded. While it was expected that much of the codes would fall into categories like Digitalization, Optimization, and Benefits, it was also expected that other codes would emerge outside those categories, and they did. Codes such as 'manual', and 'synergy' emerged, and were grouped into the category of 'Other'. Coding the dataset this way opened the door to seeing unexpected relationships in axial coding.

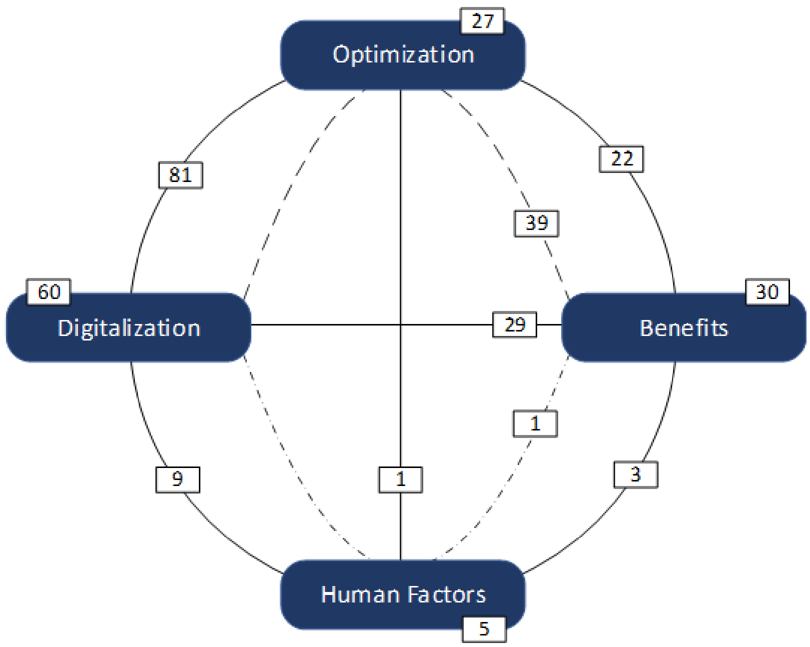
Counting the data points within a single category and those that bridged categories exposes themes and relations that may be unexpected. This also demonstrates which themes are dominant in the literature. 60 of the 348 data points exclusively discussed Digitalization, and did not refer to either optimization or effects. 81 data points demonstrated a relationship between Digitalization and Optimization. In the example above, the data point is coded for Digitalization, Optimization and Benefit. 39 of the 348 data points demonstrated this relationship. Table 2. Data Points Expose Themes, shows the data point distribution.

TABLE 2
DATA POINTS EXPOSE THEMES

#Sources	#Data Points	Themes
27	81	Digitalization - Optimization
20	60	Digitalization
24	39	Benefit - Digitalization - Optimization
15	30	Benefit
15	29	Benefit - Digitalization
11	27	Optimization
11	22	Benefit - Optimization
6	9	Digitalization - Human
2	3	Benefit - Human
3	3	Benefit - Digitalization - Optimization (Human)
1	1	Optimization - Human
1	1	Digitalization - Optimization (Human)
1	1	Benefit - Optimization (Human)

A complex set of relationships emerged between four elements, suggesting there should be findings on Optimization (27 data points), Digitalization (60 data points), and the relationship between them (81 data points). There can be findings on the benefits of Optimization (22 data points), benefits of Digitalization (29 data points), and the benefits of their combination (39 data points). Further, 19 data points exposed an important, though little discussed, Human Factor and its relationship to Digitalization, Optimization and Benefits. This is visualized in Figure 4. Data Points Supporting Relationships Map. The dataset is publicly available for independent subgroup analysis and review.

FIGURE 4
DATA POINTS SUPPORTING RELATIONSHIPS MAP



FINDINGS

Optimization and Benefits

The evidence showed operational excellence (hereafter, 'optimization') has tools that are well understood and used for many purposes. While some consider the operational excellence toolset to be confined to quality management tools, to the contrary, the evidence showed that the toolset is much broader and should be considered to contain all of the quantitative methodologies. The tools are well documented by a century of scholarly publications and modern programming languages. These tools improve quality, value, and effectiveness, largely by reducing waste, defects, and process complexity. Optimization tools have quantifiable effect.

The evidence showed optimization benefits are visible, particularly in quality improvement and the value orientation of the tools. Quality improvement benefits include faster execution, quality control, defect identification, customer acceptance, staff satisfaction, timely data, waste reduction and more. Value orientation focuses on the customer, driving improvements in performance and productivity and requires the ability to estimate appropriate levels of effort. Outcomes are more predictable with operational excellence tools.

Digitalization and Benefits

Digitalization refers to many concepts regarding digital technologies & principles and the evidence about their use and implementation. The term Industry 4.0 was coined by Kagermann et al., and is now used in tens of thousands of papers to describe a variety of digital technologies such as modeling and simulation, big data, and cyber-physical systems, as well as their principal attributes such as agility, interoperability, modularity, and integration. These digital technologies convert tacit knowledge to explicit knowledge, standardize activities, and speed work in every sector. A digitally transformed organization can share data, eliminate duplication, prevent transcription error, and seamlessly move from design to delivery. Digital transformation is complex but can succeed with structure, planning and buy-in.

The evidence showed the benefits of digitalization are specific to the implementation of the technology, were found in every sector, and can be difficult to estimate the secondary and tertiary benefits across the enterprise. Technology can benefit customer satisfaction, competitiveness, productivity, reduce tasks, improve health outcomes, and automate information exchanges, and more. As examples, this study documented benefits in architecture, engineering, construction, healthcare, manufacturing, and the public sector. The benefits depend on the complexity, environment and lifespan of the implementation.

Benefits of Combining Digitalization and Optimization

While the evidence showed that digitalization and optimization have benefits, they are compatible, complementary, and synergistic. The tools and technologies can work together, within a framework. The strengths of one adjusts for weaknesses of the other. The potential to support one another, particularly in the new conceptual model of Quality 4.0 has emerged. The combination is positively associated. They can be integrated. They are increasingly implemented in unison. Digitalization and optimization build on and enhance one another. Their combined impact is greater than the sum of the individuals. Optimization makes Digitalization testable during deployment.

The evidence showed the intentional combination of digitalization with optimization is successful when done deliberately in an integrated fashion, and the benefits are real, quantitative, and sustainable. They enhance one another, realizing additional savings, better quality, lower cost and faster production. Deliberate integration reaches higher levels of excellence, increases efficiency, and effectiveness, in sustainable development. The combination yields new flexibility, adaptability, greater performance, and reductions in waste. The combination has measurable effect on products and services.

Digital transformation does not have to be disruptive to the organization. Simulation-based LSS, modeling optimization, digital supply chain integration and using Big Data with Lean, are all options to the modern technical, quantitative organization. The integrated implementation makes digital gains stable, sustainable, and magnified. Integrated deployment is a real diffusion of innovation that positively impacts outcomes and every level of the organization. The evidence supports integrated implementation.

Human Factor

The evidence showed human factors in that combination, particularly with the social implications of digitalization. While digitalization may attempt to convert human experience to digital information, organizational culture can positively affect implementation by being human-centered on employee effectiveness or customer value. Organizations must consider the human fear of staff unemployment or customer privacy loss, encourage committed personnel, and safeguard sustainability. Digitalization and optimization are each compatible with both team-based and neo-Tayloristic office design.

Risks

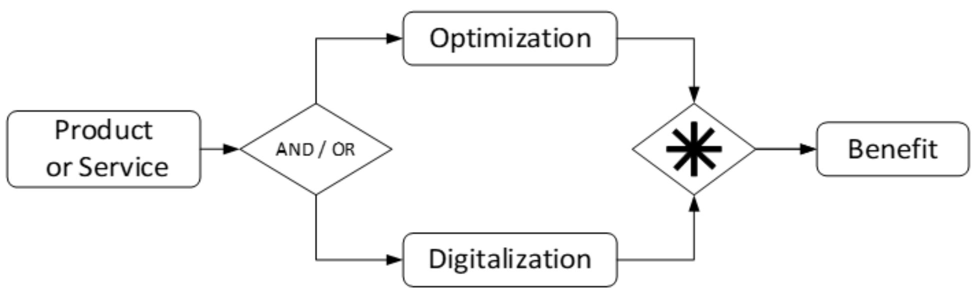
There are risks in optimization, digitalization, and their combination. Optimization has risk in standardizing bad processes, and does not guarantee sustainable benefit. Failing to understand the key elements for a given operational excellence tool, or using static tools in dynamic environments will be sub-optimal.

Digitalization needs to be carefully steered because following technology fashions may not realize tangible benefit, but instead may disrupt normal optimization and risk organizational cohesion. Digitalization is expensive and creates digital waste.

There is limited empirical evidence linking optimization to digitalization, however, one without the other may produce only small benefits. Digitalizing a bad process ensures bad outcomes. The human dynamic in a complex organization including the supply chain and customers is critical, and the fear of outsourcing and digital sweatshops can be real.

The findings support a conceptual model where managers may choose one path or the other. Still, the benefits are multiplied by combining digitalization with optimization, as shown below in Figure 5.

FIGURE 5
DIGITALIZATION ACTS WITH OPTIMIZATION FOR GREATER BENEFIT



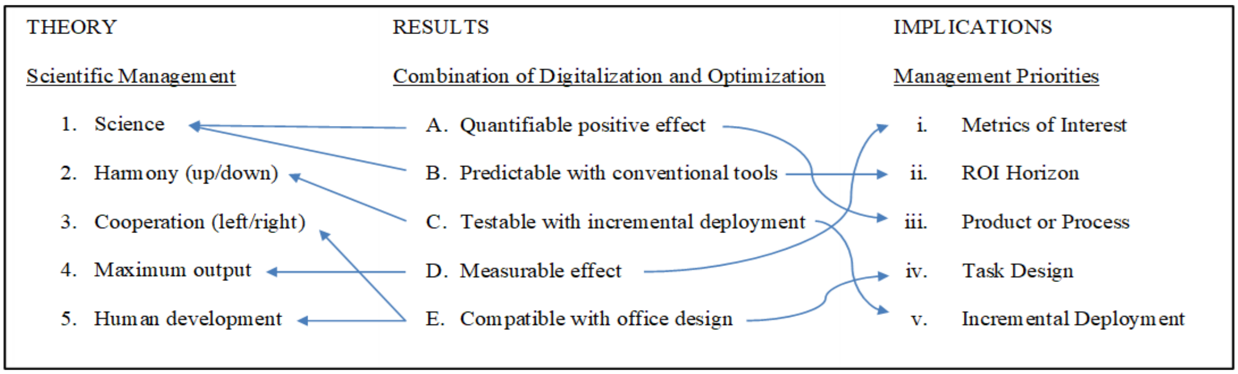
Key Results

1. The advantage is real. This approach has reduced process times by 3.76%, and increased output by 4.48% by removing manual steps based on digital studies. Hospital patients had shorter stays in smaller hospitals with electronic medical records. Optimization tools have quantifiable positive effect.
2. The complexity of digital transformation can be controlled. There are many frameworks for an organization to fold digital initiatives into an existing operational improvement toolset. A holistic architecture framework like Lean Enterprise Architecture Framework (LEAF) depicts the essence of a successful business in the circular economy. Digital outcomes are more predictable with conventional tools.
3. Optimization makes digitalization testable with early feedback and incremental deployment. Employing simulation-based optimization gives upper management incentive to selectively deploy. Optimized digital transformation is trialable.
4. The combination of digitalization and optimization makes the return on investment measureable. One integrated approach saw remarkable results, with critical to quality metrics improved 22%, standard deviation reduced 56% and overhead costs reduced 20% . In another case, the combination resulted in 9.45%-23.33% time. The benefits are observable.
5. Digital does not mean 100% structured. Customer expectations and satisfaction can be improved, reducing the likelihood of rejection in sectors as diverse as manufacturing and foods. Manual tasks can be digitally transformed, providing greater consistency and user experience, gaining support for automation within the organization. The combination of optimization and digitalization is compatible with both team-based and neo-Tayloristic office design.

DISCUSSION

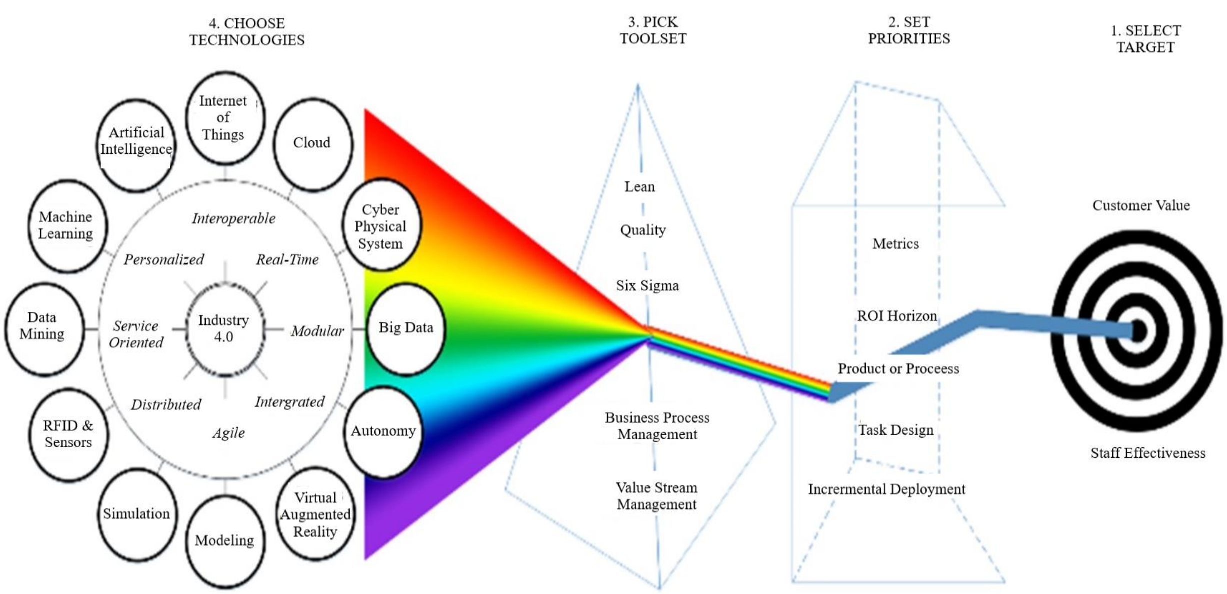
While the results link back to the theoretical lens, they also link to implications for management choices. As shown in Figure 6, management can set priorities about combining digitalization and optimization, such as the metric of interest, the horizon for return on investment, product or process focus, task design and incremental deployment.

FIGURE 6
RESULTS LINKS BACK TO THEORY, AND FORWARD TO IMPLICATIONS



However, these management choices do not mitigate all identified risks or address the integrated implementation of optimization and digitalization. The temptation is to follow technology fashions as they emerge and find applications for them. Instead, management needs to work backward from a target. Management needs explicit recommendations within a complete framework that selects the target improvement, sets management priorities for the combination, picks the optimization toolset, and then chooses the appropriate technology. Figure 7. The implementation strategy shows the four recommended steps, as supported by the evidence.

FIGURE 7
IMPLEMENTATION STRATEGY



Recommendation 1 – Select Target

Organizational culture must emphasize the human factor is paramount, by targeting either staff effectiveness or customer value. A major risk with implementing digital technology is the staff fear of outsourcing. That fear can be addressed by making it clear that the purpose of digitalization is to make staff more effective by reducing their burden and improving their user experience, what Taylor might call their greatest prosperity. Checks should be in place to prevent opportunistic management and protect staff privacy and security. Demonstrate that technology is subordinate to people. Trained staff are critical to design, implementation, and improvement. Committed staff are essential to innovation, implementation, and outreach. Staff are the best emissaries of technology within the organization and to the digital supply chain. People are the reason, not the problem.

Deliver value to the customer. Privacy and security must be protected throughout the digital supply chain. Elevate and involve customers to raise expectations and deliver value. Customers will appreciate better products and services more than new technology. Digital initiatives must be human-centered. The human target is either staff effectiveness (this will make the job less painful so you are more satisfied coming to work) or customer value (this will be difficult and expensive, but our customers are worth it).

Recommendation 2 – Set Priorities

Metric of Interest. What number needs to change? The chosen metric of interest will drive where the ROI is delivered. The metric of interest must directly connect to the selected human target, to achieve what Taylor would call the maximum output. For example, to achieve customer value management may prioritize cost compliance, schedule compliance, speed or innovation. Alternately, to achieve staff efficiency or effectiveness, management might prioritize workstation throughput, waste reduction, resource allocation or others. There is a limitless number of possible metrics.

ROI Horizon. How fast must it yield? The science of Taylor requires predictability. Digitalization is expensive and complex, so managers must declare how long they can wait for cost or savings benefits to be observed. While the outcomes are more predictable with operational excellence tools, the effects can be more timely or widespread, targeted or optimized. Management should consider that evolutionary change is a long-term commitment to a far horizon, with a journey of smaller but sustainable returns.

Product and/or Process. The science of Taylor also requires quantifiable, observable effects. Depending upon the metric of interest and the ROI horizon, the organization must choose whether focusing on products or processes will generate the desired impact. For example, if the target is customer satisfaction and the horizon is short, the organization may have more opportunities to affect processes. Similarly, if the organization focuses on process, they need not look for product data waste. Establishing the focus specifically on either a product or process will affect the analysis's priorities, methods and success.

Incremental Deployment. Digitalization and optimization are compatible, complementary and synergistic, but where are you starting? A testable, methodical deployment will provide what Taylor called harmony up and down the organization. Select a framework from the many available to orient and ground the deployment, such as the Demirdöğen et al. maturity framework, or the Liao & Wang Lean enterprise architecture framework (LEAF) or Barkobebas et al. framework for digitalization of premanufacturing phases, or some other. There are two kinds of transformation: disruptive or sustaining.

Task Design. How fluid or static is the task? Danielsson demonstrated that digitalization is generally compatible with team-based (flexible) office design, and neo-Tayloristic (structured) office design and encourages cooperation left and right in the organization as Taylor described. However, management must decide if the task being incrementally digitalized is one or the other. For example, digitalizing the task of taking a loan application might warrant a very structured design, and leverage tools that reliably produce repetitive performance, such as Lean Six Sigma tools and BPR technology. Team-based tasks such as drafting a procurement strategy with defined steps but indefinite content require different tools and technology. Management may want to make tasks as structured as possible, but needs to balance user experience, economic, social and environmental sustainability.

Recommendation 3 – Pick Toolset

The optimization toolset is robust. Complex, positive interactions exist between some operational excellence tools and digital technologies. Pekarčíková, et al. shows a complex interaction between some operational excellence tools and some digital technologies. The table lists Six Sigma, Kaizen, JIT, Jikoda, Heijunka, Standardization, TACT, Pull, Man-Machine, People & Teams, Reducing Waste as operational excellence tools, and relates their impact to eight technologies. While the matrix is valuable, it is incomplete because it misses Quality, Lean, BPM, VSM, MBO, and more mainstream improvement tools.

Some tools work better on products than services. Many operational excellence tools available in the optimization kit are quantitative and can be integrated, such as BPM, QM, SMS, TQM, VSM, Lean, and Six Sigma. Many tools are structured well documented, with common frameworks and ontologies, that allow shared understanding from executive to labor, such as the international standards for Business Process Model and Notation (BPMN), Value Delivery Modeling Language (VDML), System Modeling Language (SysML). They are not equally effective in every application.

Scientifically select the toolset, as Taylor might scientifically select the employee. Management should ask which toolset are they familiar with, and which toolsets can they access quickly. Then they can match the best tools to the selected target, and management priorities (metric of interest, product or service, task design). They have many purposes. They also have risks, such as standardizing a bad process.

Recommendation 4 – Choose Technology

Industry 4.0 is one listing of available digital technologies, even though the list expands daily. Digitalization is knowledge conversion and relies upon standardization as a precondition. Select the technology that is well aligned with the quantitative nature of your toolset, and the target metric, e.g., autonomous robotics to Lean, on production. Artificial intelligence (AI) sounds exciting, but autonomy for loan processing might result in massive numbers of equally bad loans, when modeling workflow with BPM might be better. It is what Taylor might call hearty cooperation between technology, tools, priorities and targets.

For each technology, prioritize design principles. Ghobakhloo identified twelve principles and Butt reduced that, though neither of the lists are complete or exhaustive. When considering design principles for digital technologies it is a balance between competing attributes. For example, it may be more important for integration of production line autonomous robotics than to be distributed, even though both may be required to some degree.

Summary

Select the target improvement, set management priorities for the combination, pick the optimization toolset, and then choose the appropriate technologies. If management keeps people as its purpose, has reasonable expectations of the resources required, and properly matches tools to the problems and solutions, cost and schedule benefit is likely. Carefully steering a digital transformation is much easier with a well-grounded framework that combines digitalization and optimization.

CONCLUSION

Leaders can make digital strategies have a predictable return on investment (ROI). By following the recommendations, they can make a digital initiative a true innovation.

1. Select the target human outcome: focus on either customer value or staff effectiveness.
2. Set priorities for: metrics of interest, ROI horizon, product or process, task design, and incremental deployment.
3. Pick the toolset: choose between the familiar tools or accessible tools for their applicability, given the priorities and target outcome.
4. Choose the technology: given the desired outcome, priorities, and tools, pick the technology that has the best opportunity for impact. Then decide its principles for implementation.

This new perspective is more than scientific management, it is ***Digital Outcome Optimization***. The value of this perspective is the ability to not just reliably predict, but proactively engineer a desired business outcome with the latest technology, using familiar tools. The familiarity of the tools will ease leadership tensions around the latest technology, and give them a clear approach to implementation. This approach is not limited to public sector organizations, private organizations of any scale could use it.

Project, portfolio and functional managers can ensure Digital ROI is predictable, by combining Optimization with Digitalization, and engineered to have targeted impacts supporting management priorities. Each of these four recommendations is valid, but are most impactful in sequence. Digital transformation is a necessary step in the 21st century, and is needlessly fraught with anxiety. Keeping each decision in context will make the impact laser-focused and enable an organization to realize rapid, significant benefit.

Limitations of the Study

This study has limited experimental evidence. The 43 sources included four systematic reviews, eight literature reviews, and 26 case study variations (single, multiple, longitudinal). Only six were primary research, some with some empirical evidence and some based on analysis.

There are several limitations common to systematic reviews. Publication Bias is the refusal to publish a study because its findings are unpopular. There are a limited number of databases & sources readily available to any researcher at any institution, such as a student at a university. The selection of inclusion and exclusion criteria may have been biased. The data in various studies will differ, as will the population, design, and methods, which is the heterogeneity of the data.

This study may have inappropriate subgroup analyses, or its findings may not be transferable given the context of its sources (Gopalakrishnan & Ganeshkumar, 2013). 15 of the studies were from the manufacturing sector, six were from healthcare, five were from engineering, two were of government agencies and several were unspecified. Of the 43 sources, 14 studied European organizations and 16 were unspecified.

Areas for Future Research

Future research should seek to adjust for the limitations of this study. Experimental evidence would be valuable as a confirmation of the findings and recommendations of this study. It could be collected in a quantitative constrained case study in an applicable context. For example, a side-by-side experimental implementation vs a control group could demonstrate selective deployment. It could confirm the impacts are measurable, and verify the impacts meet predictions.

A more inclusive, extensive qualitative study could correct or minimize typical systematic review limitations. A similar review conducted by multiple researchers would limit selection bias. More researchers with more time could have an order of magnitude increase in sources, use alternate databases, and employ mixed methods to seek and include quantitative studies. A large enough sample might detect a negative signal not present in these sources.

Most simply, an alternate researcher could code the same data set. Because coding is intensely personal and entirely dependent on the researcher's knowledge, experience and perspective, someone else is likely to see the data in a different light. Their grounded theory approach to subgroup analysis would certainly be different. It would be the least resource-intensive means to confirm or dispute these findings.

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