Do Advanced Technologies in ERP Systems Create Competitive Advantage?

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Introduction

The objective of this report is to ascertain the degree to which the value proposition of traditional Enterprise Resource Planning (ERP) systems can be augmented by the integration of advanced technologies. The list of advanced technologies that can be integrated into ERP systems today is quite long and includes blockchain, autonomous vehicles, robotic automation, and many more. To limit the scope of this report, focus is placed on artificial intelligence and machine learning, data analytics and big data, and the Internet of Things (IoT). Several supporting questions are researched to confirm or deny the central hypothesis that the integration of these advanced technologies into an ERP system provides a competitive advantage. Several underlying premises are key to this hypothesis.

1. Traditional ERP systems no longer provide a competitive advantage by themselves.
2. ERP systems can provide a competitive advantage if adequately enhanced or integrated.
3. An ERP system must be properly implemented and supported by sound business processes, a clear vision, and adequate user training to provide a competitive advantage.

What is ERP?

ERP systems are database-powered information systems that integrate data, business processes, and management practices across multiple business functions. With repeatable, systematic, operational practices, ERP facilitates better decision-making for enterprise employees at all levels and provides a management platform for better control and reporting. ERP systems were among the first integrated management information systems and grew out of inventory tracking systems and Material Requirements Planning (MRP) systems (Monk & Wagner, 2013). ERP originally extended the functions of MRP, and its core idea was effective supply chain management for manufacturers until service industries like healthcare and education began to adopt ERP systems (Perkins, 2020). Modern ERP systems extend beyond the boundaries of traditional enterprises to optimize communication and resource utilization across the entire supply (or service) chain to enhance the value-creating activities of modern enterprises and their partners. These systems enable management to optimally control resources and respond in an agile manner to changes in the business environment.

Many best practices for production or other business processes are embodied in modern ERP systems. Adopting process best practices and automating business processes are central to successful ERP implementation. Some people may think of ERP systems as end-to-end Business Process Management (BPM) systems because they encourage employees and managers to view their work activities as part of a cross-functional process rather than the traditional functional view that creates silos of information and activity (Monk & Wagner, 2013). Functional silos breed inefficiency and frequently result in departments unknowingly working against each other. When properly planned and implemented, an ERP system can profoundly influence company-wide collaboration and the continuous improvement of business processes across departmental boundaries, thereby enhancing the core competitiveness of the enterprise.

ERP systems encompass all the features that are necessary to run effective manufacturing and service operations. ERP systems also provide a single, centralized platform where the organization's most critical value-chain data are available in a shared database for use across multiple business functions and departments in real-time. Operations and finance are at the core of ERP because they directly impact the company's bottom line and management's ability to

wisely administer the firm's resources. But an ERP system can also incorporate the information systems used by many other business functions such as Customer Relationship Management (CRM), Human Capital Management (HCM), Project Management (PM), Transportation Management Systems (TMS), Warehouse Management Systems (WMS), Supplier Relationship Management (SRM), MRP, and more (Stanton, 2019; Monk & Wagner, 2013). ERP systems also ensure secure access to company information from a variety of client interfaces for employees at all levels and, in some cases, suppliers' employees too.

Core Functionality of ERP Systems

The primary goal of any ERP system is to standardize and integrate production-oriented processes and data in real-time across financial and operational functions with as much automation as possible (Perkins, 2020). On the financial side, all ERP systems integrate the general ledger (GL), accounts payable, accounts receivable, and standard reports (e.g., income statement, balance sheet, etc.). Depending on which optional modules are installed, other financial capabilities may include payroll processing, fixed asset depreciation, tax management, multi-currency reconciliation, and more. On the operations side, all ERP systems integrate the primary activities of the customer value chain. For a manufacturing company, this usually includes the core functions of procurement, production, warehousing, and distribution at a minimum. For a service firm, this might include demand management, outsourcing, and project management (Barker, 2013). According to Oracle, a complete end-to-end ERP system might also include:

- customer relationship management (CRM) data and functionality such as order history, quotes, orders, forecasting, commissions, deal profit margins, and sales ratios,
- marketing related data and functionality such as leads, campaigns, and customer activity,
- human resources (HR) / human capital management (HCM) data and functionality related to payroll, hiring, onboarding, compensation management, timekeeping, and deductions for taxes and benefits,
- project management, and
- supply chain data and functionality related to demand, raw materials inventory, finished goods inventory, manufacturing processes, logistics, purchase orders, work orders, transfer orders, product planning, sourcing raw materials, assembly management, bill of materials, shop-floor control, and product tracking (Biel, 12 Core ERP Features: Benefits and FAQ, 2020; Fisher, 2020).

The decision to include a business function in the ERP solution depends on the needs and maturity of the individual business. These factors are often influenced by the industry in which the business operates. The costs and benefits that are expected to accrue to each business function must also be weighed. According to the Panorama Consulting Group, the following seven business functions are available in most ERP systems (Panorama Consulting Group, 2021).

- Finance, Accounting, and Accounts Payable/Receivable
- Customer Service
- Supply Chain Management
- Order Processing
- Human Resources

- Project Management
- Customer Relationship Management

Current Adoption and Benefits of ERP Systems

Manufacturers are the largest users of ERP software followed by Information Technology (IT) companies, professional/financial services firms, and distributors/wholesalers (Panorama Consulting Group, 2020). The global market for ERP software was $145 billion in 2020 and projected to be $148 billion in 2021. The ERP market is expected to grow to $202 billion by 2025, which represents a compound annual growth rate (CAGR) of 8.1% (The Business Research Company, 2021).

For many companies, adopting an ERP system is an economic necessity. The complexity and scale of their operations make manual processes and unintegrated systems unfeasible. Some of the benefits of using an ERP system that drive companies to adopt such a system include:

- ease of scalability,
- complete visibility for faster company-wide collaboration,
- centralized storage/back-up for or all critical enterprise data,
- ability to integrate with Business Intelligence (BI) systems,
- business workflow and process automation,
- improved workflow and process management,
- cost efficiency,
- increased competitiveness,
- ability to calculate prices instantly,
- improved accuracy of cost comparisons across facilities,
- augmented electronic data interchange (EDI) with suppliers,
- better forecasts,
- fewer bottlenecks, and
- removal of duplicative procedures (InfoClutch, n.d.; Plotkin, 1999).

In a report by Beard and Sumner in 2004 that looked at the strategic advantages of ERP systems, several companies reported quantifiable improvements in their key performance indicators (KPIs) (Beard & Sumner, 2004). Table 1 reproduces some of these data.

Table 1

KPI Improvements due to ERP

Company	**Business Benefits**	**Source**
Fujitsu	• 90% reduction in cycle time for quotation from 20 to 2 days • 50% reduction in financial closing times from 10 to 5 days	(Jenson & Johnson, 2013)
IBM storage products company	• Time for checking customer credit upon receiving an order was reduced from 15-20 minutes to instantaneously	(Jenson & Johnson, 2013)

	• Responses to customer billing inquiries occur in real time versus 15–20 minutes • Entering pricing data into the system took 5 minutes whereas it took 8 days before • Shipping repair and replacement parts was done in 3 days compared to up to 44 days before	
Earthgrains	• On-time product delivery rate increased to 99% • Operating margins improved from 2.4 to 3.9%	(Bingi, Sharma, & Godla, 2006)
Par industries	• Delivery performance improved from 80% on-time to more than 95% • Lead times to customers were reduced from 6 to 2 weeks • Repair parts shipments were reduced from 2 weeks to 2 days • Work-in-process inventory dropped almost 60% • The lifespan of a shop order dropped from weeks to hours	(Bingi, Sharma, & Godla, 2006)

Another significant benefit of ERP systems is their ability to consolidate legacy systems. Historically, organizations have stored large amounts of data on dozens or hundreds of independent information systems. At one time, Owens Corning had 200 legacy systems, and Eastman Kodak had 2,600 software applications (Palaniswamy & Frank, 2001). Such isolation of data usually reflects similar isolation in the business teams and their workflows. The integrated foundation of ERP systems makes it possible for companies to migrate and consolidate data and processes from legacy systems spanning the business. The elimination of operations and maintenance (O&M) expenses associated with these legacy systems helps to justify the investment in an ERP system, but the real value comes from enabling the business in new ways that cannot be achieved with the legacy systems.

Recent Trends in ERP Systems

Like all businesses, ERP vendors are continually expanding the value proposition of their solutions to remain competitive. A comprehensive review of the evolving ERP landscape is beyond the scope of this report, but two trends are worth noting: cloud ERP and big data.

Cloud ERP

With the development of cloud computing and services permeating all aspects of business, the emergence of cloud ERP was inevitable. The cloud ERP market reached approximately $45 billion in 2020 (Emergen Research, 2021). In a 2018 ERP survey of CIOs in the United Kingdom conducted by Accenture, 77% said that over half of their infrastructure would be cloud-based by 2023 (Accenture, 2019). The authors assert that a cloud strategy as part of a larger digital transformation and new business model strategy is crucial to ERP evolution. In a report dated August 2019, Gartner analysts predicted 30% of large enterprises will move to a cloud ERP platform by 2022 (Tadepalli, 2021). Clearly, the general trend of migrating applications to the cloud applies to ERP as well. And cloud-based ERP offerings are expanding

the market for ERP systems by eliminating the acquisition costs and lowering the bar for in-house IT expertise. That puts ERP within reach of many small and medium-sized businesses that would otherwise not be able to afford and effectively manage these systems (Biel, 50 Critical ERP Statistics: 2020 Market Trends, Data and Analysis, 2020). In recent years, the cloud adoption rate of small and medium-sized enterprises has accelerated (Chang, n.d.).

Cloud ERP can simplify management (installation, maintenance, and support), improve remote access, accelerate implementation time for new installations, scale up the user base and supporting assets easier and larger than most on-premises solutions, reduce upgrade/update overhead, provide highly resilient storage and backups, and facilitate world-class disaster recovery (Hamilton, 2020; Fisher, 2020; Schoenborn, 2021). But there are trade-offs including reduced flexibility for customizations, potential security weaknesses due to vendor access to data, conflicts arising from vendor-mandated upgrade/update frequency and scheduling, heavy reliance on Internet connectivity, difficult migrations from on-premises systems, regulatory concerns related to data sovereignty and locality, and cultural resistance from internal IT staff (Hamilton, 2020; Fisher, 2020; McCue, SaaS ERP Explained, 2020). From a financial perspective, cloud ERP reduces or eliminates upfront capital expenditures and may also reduce total cost of ownership (TCO) depending on the deployment model (SAP, n.d.). With on-premises ERP systems, companies need to procure software packages that often have enterprise site license agreements. These licensing models are typically based on user count and paid annually, which means they do not allow for flexible cost control by reflecting fluctuations in the number of actual system users throughout the year (Monk & Wagner, 2013). They also have associated accounting requirements that record most of the total cost upfront (BDO, 2015). But with cloud ERP, companies can slowly or rapidly increase or decrease the number of active users and associated costs according to the current needs of the organization. The costs are flexibly expensed rather than depreciated according to a predetermined schedule.

Big Data in ERP

Since one of the core value propositions of all ERP systems is consolidation of data from previously disparate systems across multiple business functions, it is no surprise that big data is now intersecting with ERP as firms strive to leverage the value of non-traditional data. While the focus of ERP systems remains on transactional (structured) data consolidation, to effectively realize the full benefits of any ERP system, other forms of data must now be consolidated. This is most relevant in the realm of business intelligence typically deployed in a data warehouse. One approach is to build the data warehouse in the ERP environment, which can simplify the design of the data warehouse and reduce the difficulty of long-term maintenance (SAP, 2021). Another benefit is that analytics incorporate production data as they are generated in real-time. An example of this is SAP's BW/4HANA.

Alternatively, a traditional data warehouse can be established. Building the data warehouse outside the ERP environment might be advantageous for companies that do not have a complete ERP environment. In that scenario, the data warehouse may be able to more easily integrate non-ERP data from multiple systems with data from the ERP system (Kimball & Ross, 2013). One advantage of this framework is that the data warehouse can extract hidden value from all parts of the business no matter where the business is on its digital transformation journey. Another advantage is that the data warehouse does not interfere with the core performance of the ERP system, which typically has a direct impact on revenue and profits. This approach also provides

fault isolation in the event of a system outage; one system failure will not affect the uptime of the other system. The principal drawback of this approach is that the data in the data warehouse must be refreshed periodically from the ERP system and other systems. Thus, analytics are not real-time. However it is architected, a data warehouse is often the foundation of a data-driven decision support system (CSG Pro, 2020).

Significance

ERP systems were once considered cutting-edge technology that created competitive advantage (Kerimoglu, Basoglu, & Daim, 2008). The integration of departmental software enabled previously siloed departments of large businesses to act in concert, which put otherwise unattainable opportunities on the table (Thomson, 2020; Jacobs & Weston Jr, 2006). As ERP matured and adoption spread, integrated data and processes became more commonplace. In this context, a question arises regarding the competitive advantages afforded by ERP systems. Compounding this erosion of value, the democratization of the Internet has precipitated unprecedented change accompanied by an increase in the rate of change. To continue realizing competitive advantages from ERP systems, companies must differentiate their use of ERP and keep pace with the broader societal changes.

Competitive Pressures

Advances in transportation, communications, and computing have rapidly accelerated the globalization of economic activity. In turn, this has changed the competitive landscape and imposed new demands on companies to remain profitable. ERP systems play a critical role in this new landscape, but advanced technologies may be needed for ERP systems to remain as valuable as they have been.

Small and Medium-sized Business Considerations

An ERP system is mainly to help companies coordinate activities, make better decisions, and manage business processes effectively. At one time, most organizations believed that ERP systems were only needed by large manufacturing companies (McCue, The History of ERP, 2020). Smaller companies lacked the budget, expertise, and other resources to launch and support resource-intensive on-premises information systems initiatives. But times have changed. Though small companies may be relatively simple in terms of the scope and complexity of their business processes and operational needs, that does not spare them from the onslaught of new international competitors. Today, many small and medium-sized businesses that still use spreadsheets and stand-alone accounting software to run their organizations are choosing to implement ERP systems (Chang, n.d.). These businesses are eager to realize the benefits of ERP to improve their competitive capabilities and accelerate their digital transformation.

As previously discussed, for many small and medium-sized businesses, the decision to implement ERP is often compelled by the advantages of cloud computing and services. For these companies, software-as-a-service (SaaS) applications tend to be preferred. As ERP offerings become more broadly available via SaaS, they are enabling small and medium-sized businesses to cost-effectively respond to the changing competitive landscape. Another cost-effective option is to adopt an ERP package designed for small and medium-sized businesses. The ERP market has expanded “down market” to capture these new customers. Hundreds of vendors cater to

small and medium-sized businesses with less robust ERP solutions designed for the less complex operating environments of these businesses (Panorama Consulting Group, 2020).

The Data Age

For many organizations, big data has made a significant impact on business decision-making. In many industries, big data has made a disruptive impact (Wessel, 2016). Traditional corporate decision-making is often mired with procedural overhead, based on limited information, and shaped by office politics. However, the relentless competition of global markets demands faster and better decision-making to outpace and outmaneuver rivals. The future competition of companies may be largely based on decision-making competitiveness (Cheffah & Hanoune, 2017). Embedding big data capabilities and advanced data analytics into ERP systems may present a path to quicker, better decisions by enabling new data sources to inform production-oriented decisions (Thomson, 2020).

From Product-centric to Customer-centric

In the product-centric marketing model developed during the industrial age, companies focus their efforts on creating the best product they can. This effort may lead to adding features or technologies that seem valuable but do not actually increase utility for consumers (Wintermeier, 2020). An alternative view has been gaining mindshare in recent decades. The customer-centric model views all product development decisions from the perspective of the customer first. Focusing on the customer segments that have the highest customer lifetime value (CLV) and increasing their satisfaction and loyalty are more important than increasing product feature count or technological capability (Nox Solutions, n.d.).

Companies struggling to become customer-centric may be held back by their inability to share customer information across departments. In the product-centric model, business units had less need for the customer intelligence collected in other business units. However, a customer-centric view necessitates sharing of all customer intelligence across the organization in order to create the most complete and accurate understanding of the customer (Johansen, 2019). ERP systems inherently facilitate such sharing of customer data, but that may no longer be sufficient. As competition has increased, businesses have responded with more specialization in every business function. That has given rise to special purpose marketing information systems such as inbound marketing platforms and omnichannel communications platforms (HubSpot, n.d.; Foster, n.d.). ERP systems must integrate with these new platforms to paint a holistic customer picture. Advanced technologies may facilitate deeper integration.

Supply Chain Scale and Complexity

ERP systems have their roots in supply chain management. Even for many of the non-manufacturing industries that now use ERP systems, the supply chain capabilities of ERP systems are quite relevant. Consider a restaurant chain such as McDonald's. Restaurants are classified in the food service industry, and employees in this industry are counted in the service sector (Data USA, n.d.). But without an extensive and reliable supply chain for the foodstuffs they serve daily, McDonald's would succumb to competition and go out of business.

Straining the Limits of ERP

While global trade has created broader opportunities for companies, the impact on their supply chains has been increased complexity and risk (Gartner, 2021; GEODIS, 2017). The inherent

difficulty of managing a large network of suppliers and intermediaries is exacerbated by variations in legal systems, taxation requirements, Inco terms, customs processes, local labor issues, and local weather among other factors. The Chartered Institute of Procurement and Supply (CIPS) defines supply chain complexity as copiousness, interdependency, variability, variety and uncertainty (The Chartered Institute of Procurement and Supply, n.d.). Manual efforts to manage such complexity ultimately limit the scale and robustness of the supply chain.

ERP systems are necessary to be effective in this realm, but a traditional ERP system may not be enough in the modern economy. According to Martin Verwijmeren, CEO of MPO, "Trying to optimally operate in a highly complex ecosystem of partners and systems (ERP, WMS, CRM, APS) requires a smart cloud platform that manages orders, transport, and inventory across companies, processes, and systems (MPO, 2021)." MPO is a leading supply chain orchestration (SCO) vendor. Supply chain orchestration seeks to overcome the limitations of traditional supply chain management found in ERP systems by synchronizing the entire end-to-end supply chain and providing full visibility to upstream and downstream impacts across legacy systems and dynamic networks (Crane, Rainwater, & Rebello, 2019). Alternatively, companies could augment the supply chain capabilities of their existing ERP systems with advanced technologies. Either way, businesses that successfully meet this challenge are likely to enjoy a competitive advantage arising from improved resiliency and deeper transparency.

Long Lasting Disruptions

If the COVID-19 pandemic has taught society anything, it is that the global supply chains that power our daily lives are far more vulnerable to disruption that previously believed (Jain, 2021). This may be an unavoidable consequence of hypercompetition. As every business seeks to optimize operations and reduce costs, excesses are eliminated from processes, inventories, capital assets, headcount, and every other aspect of the business. While that drives down cost and capital requirements, it simultaneously increases reliance on accurate forecasts and perfect execution in the supply chain. This operating model is called just in time (JIT) and is used by both manufacturing and service businesses (Stevens, 2020).

With JIT, companies seek to reduce raw materials and finished goods inventories to minimize inventory carrying costs and spoilage by placing orders at the last responsible moment for the least responsible quantity. The underlying assumption is that the supply chain will reliably deliver on time day after day. When disruptions happen, stock outs follow. And when disruptions persist, unprecedented impacts are felt as the ripple effect unfolds across the countless, labyrinthine interdependencies of the modern global economy from raw materials providers to retailers (Rosenbaum, 2021; Egan, 2021; Keefe & Manley, 2021). Perhaps advanced technologies can improve forecast accuracies and uncover previously unknown dependencies on suppliers of suppliers, seaports, airports, fuel sources, labor sources, and other distant links in the supply chain.

Literature Review

To substantiate or refute the hypothesis of this report, one requires an understanding of competitive advantage, the role that information systems can play in achieving competitive advantage, the nature of the advanced technologies considered by this report, and the metrics commonly used to determine whether competitive advantage has been created (or lost). To that end, a review of the literature is provided.

Competitive Advantage Defined

A review of the literature reveals some ambiguity, impermanence, and disagreement around the concept of competitive advantage.

What is Competitive Advantage?

Competitive advantage is regarded as the critical element in strategic management since it explains the differences in the performance of various organizations (Ceglinski, 2017; Newbert, 2008). It takes into consideration many factors including cost leadership, how companies differentiate themselves from others, their defensive strategies, and the strategic alliances that help them reach better positioning in the market. The idea of competitive advantage is not new, and yet the definition is not universally agreed upon and has undergone change over time (Rumelt, 2003). Ansoff was among the first to attempt to formally define competitive advantage. In 1965, he described it as "the isolated characteristic of the particular properties of the individual product market which gives the firm a strong competitive position (Ansoff, 1965)." Many other definitions wholly or partially employ the notions of cost, profit, financial returns, or economic value. These definitions are somewhat problematic for various reasons (Rumelt, 2003). McGinnis and Vallopra define it as "the extent to which an organization is able to create a defensible position over its competitors (McGinnis & Vallopra, 2006)." While this definition avoids the problems associated with accounting-based definitions, it offers little insight to the sources of competitive advantage.

The resource-based view (RBV) of the firm asserts that the sources of competitive advantage are the resources and capabilities of a firm, both of which are unevenly distributed and imperfectly mobile among firms. Since all firms have resources and capabilities, emphasis is placed on the value and rarity of the resources and capabilities. A firm with such valuable and rare resources and capabilities can exploit them to attain a competitive advantage (Newbert, 2008).

Another view that has demonstrated staying power is Michael Porter's as described in his landmark book *Competitive Advantage* published in 1998 (Porter M. E., 1998). More of a framework than a simple definition, Porter's view employs a value chain concept focused on the sources of customer value. He posits that competitive advantage arises from the interrelationships of the value creating activities of the firm, its suppliers, and its customers. Porter identifies five competitive forces that apply to all industries in all parts of the world:

- the entry of new competitors,
- the threat of substitutes,
- the bargaining power of buyers,
- the bargaining power of suppliers, and
- the rivalry among the existing competitors.

He also provides three competitive strategies for responding to the five forces premised upon an understanding of the industry structure and the competition's behavior:

- cost leadership,
- differentiation, and
- focus (either cost focus or differentiation focus).

All of this boils down to two types of competitive advantage: low cost (which translates to lower customer pricing) and differentiation (which translates to higher customer value). Even before Porter's book was published, one could see evidence in the marketplace that his ideas were on the mark. Global competition began to accelerate in the 1980s. In 1993, Jack Welch, then CEO of General Electric, observed (Tichy & Sherman, 1993):

> The Value Decade has already begun, with global price competition like you've never seen. It's going to be brutal. When I said the 1980s was going to be a white-knuckle decade and the 1990s would be even tougher, I may have understated how hard it's going to get. … The enormous advantage we have today is that we can run GE as a laboratory for ideas.

Welch's comment on price competition foreshadowed Porter's "low cost" competitive advantage. Clearly, many of GE's competitors were taking this approach. And Welch's belief that ideation was key to competitive advantage was a nod to Porter's "differentiation" approach in which innovation creates new customer value. Today, GE still competes on value rather than price.

Does Competitive Advantage Vary by Industry?

In the abstract, competitive advantages themselves are similar across all industries. They might be generically described as anything that enables a business to deliver more value at the same price, the same value at a lower price, or more value at a lower price. Porter's assertion that the five forces of competition apply to all industries provides support for this position. However, the means to achieve competitive advantages are likely to vary across industries. This notion is reflected in Porter's three competitive strategies that require an understanding of the industry structure.

For example, some evidence exists that industry structure variables interact with organizational competencies in the hospital industry (Douglas & Ryman, 2003). Furthermore, one can intuitively see that core competencies in manufacturing do not apply to service firms. Thus, one can see that competencies required to drive down cost or increase value would be different for manufacturing industries than for service industries. For example, some evidence exists that product design quality, production quality, fast deliveries, and broad distribution (among other factors) are drivers of competitive advantage in the furniture industry (Droge, Vickery, & Markland, 1994). None of those factors are relevant to a service business such as tax preparation, but current and deep knowledge of tax law is.

Can Competitive Advantage be Sustained?

Porter suggests a firm's competitive advantage is sustainable only when the "firm's competitive advantage resists erosion by competitor behavior" (Porter M. E., 1998). The resource-based view (RBV) of the firm is consistent with Porter's position. To the extent that an organization's resources and capabilities are inimitable and non-substitutable, the firm's competitive advantage is sustainable. Empirical evidence supports this view (Newbert, 2008). Piccoli and Ives conducted a review of the literature on information systems, strategic management, and marketing in 2005 (Piccoli & Ives, 2005). They identified the following four barriers to erosion that contribute to the sustainability of a competitive advantage.

- IT Resources Barrier – "When a firm's IT-dependent strategic initiative leverages some preexisting IT resources, competitors who do not have ready access to the same or substitute resources find it costly and difficult to replicate." These IT resources encompass IT infrastructure, information repositories, technical skills, IT management skills, and relationship assets.
- Complementary Resources – These are other organizational resources and linked activities that must be mobilized for successful implementation of an IT-dependent strategic initiative.
- IT Project Barrier – The more time consuming and costly the project is to design, develop, and introduce the functionality, the more resilient this barrier is. Technology characteristics of visibility, uniqueness, and complexity plus implementation factors such as complexity and process changes contribute to barrier.
- Preemption Barrier – This barrier rests on the inability of competitors to threaten the competitive advantage even if they are able to imitate the sources of the advantage. Switching cost is one basis. If customers incur high switching costs, the competitor cannot merely imitate the leader but must offer compensatory value to customers to take market share from the leader. Another basis is the value chain. If any relationships in the value chain are exclusive or difficult to establish, or if any link in the value chain is unique, then competitors will struggle to threaten the leader. The underlying premise is that the leader's value proposition derives not solely from firm-specific competitive advantage but also from the value chain encompassing upstream and downstream partners. The degree to which the value chain enables realization of the competitive advantage influences the strength of this barrier to erosion.

Contrasting the view of inimitability, in Richard D'Aveni's book *Hypercompetition*, the author made the case that competition has become so ferocious that traditional sources of competitive advantage can no longer be sustained (D'aveni, 1994). He argues that businesses must now disrupt the status quo before the competition does. Only by continuously creating temporary advantages in one of the four arenas of competition can a business sustain its competitive advantage. The four arenas are price and quality, timing and know-how, creation/invasion/destruction of strongholds, and creation of "deep pockets" through alliance building. D'Aveni suggests static approaches to strategy derived from the structure of one's industry must be replaced by dynamic strategic planning driven by the competitive forces playing out within the industry.

The authors of *Built to Last* offer an insightful viewpoint that bridges the two aforementioned views (Collins & Porras, 1994). Collins and Porras researched 18 long-lasting companies they considered to be truly exceptional. All of the companies are at least multiple decades old with some centuries old. All have faced existential crises and displayed remarkable resilience. And they all embody core values that are timeless including having a purpose greater than merely earning a profit, seeing continuous renewal as a virtue, and consistency. These companies have thrived throughout many periods of change because they "distinguish their timeless core values and enduring purpose (which should never change) from their operating practices and business strategies (which should be changing constantly in response to a changing world)." This management philosophy of "to thine own self be true" has given these companies an unshakable self-identity as the basis for their sustainable competitive advantage without compromising their ability to rapidly pivot in D'Aveni's four arenas of competition.

The Role of Information Systems

Information systems have become permanent fixtures in professional and personal life. Given the costs and security challenges associated with implementing, operating, and maintaining such systems, the perennial questions for organizations are when, where, and how to use these systems for maximum benefit.

Deciding Where to Draw the Line

The presence of information systems in the modern business world is generally undisputed as both mandatory and critical, though the extent to which such systems are used varies widely from business to business. No responsible business decision maker would require all documents to be produced with pen and paper today, especially considering the availability of high quality, free office productivity software such as LibreOffice (LibreOffice, n.d.). But the decision to purchase or subscribe to an enterprise information system such as ERP, digital marketing, or telemedicine can be difficult for a variety of reasons. Numerous internal and external factors influence the decision to continue certain processes manually versus automating them including business size, capital structure, profitability, credit rating, internal IT capabilities, internal workforce readiness, internal culture, process maturity, solution cost/benefit analysis, prevailing trends within one's industry, macro trends, economic outlook, interest rates, the regulatory environment, and numerous other considerations (ABC of Marketing, n.d.; Almquist, Cleghorn, & Sherer, 2018; Monk & Wagner, 2013).

Relationship to Performance

Similarly, the impact of an enterprise information system on company performance is influenced by many factors. However, the relationship of information systems to organizational performance is long established and widely accepted. Bharadwaj established IT as an organizational capability with IT infrastructure, human IT resources, and IT-enabled intangibles driving outperformance on a variety of profit and cost measures (Bharadwaj, 2000). Piccoli and Ives concluded IT-dependent strategic initiatives contribute to sustained competitive advantage, but the long-term impact is determined by numerous factors that impede imitation (Piccoli & Ives, 2005). Building on the demonstrated tenet that IT capabilities are positively correlated with business performance, Lim et al. demonstrated empirically that the structural power of senior IT executives in large U.S. firms is positively correlated with the development of superior IT capabilities. They also found IT capabilities contribute more to a firm's competitive advantage in firms with comparatively powerful senior IT executives (Lim, Stratopoulos, & Wirjanto, 2012). With respect to traditional ERP systems, the business benefits are well understood and broadly accepted (Monk & Wagner, 2013).

Survey of Advanced Technologies

Given the objective of this report, some definitions of advanced technologies and context around the way they are used should illuminate the research.

Artificial Intelligence and Machine Learning

Artificial intelligence (AI) is a broad term that includes certain technologies plus the philosophical, social, and ethical aspects of understanding intelligence (Holzinger, n.d.; Oracle, n.d.). AI depends on underlying scientific theories of human learning. The most well-known technology under the AI umbrella is machine learning (ML), which encompasses deep learning

(DL) and natural language processing (NLP). Due to the practical nature of ML, many (if not most) business applications of AI today are actually ML implementations (Korolov, What is a chatbot?, 2021; Korolov, Making the most of sentiment analysis, 2021; Holzinger, n.d.). According to McKinsey & Company's 2020 global survey of AI usage, some of the most common use cases include enhancements of products, product feature optimization, service operations optimization, predictive service and interventions, customer service analytics, customer segmentation, yield/energy/throughput optimization, predictive maintenance, talent management optimization, talent performance management, logistics network optimization, inventory and parts optimization, risk modeling and analytics, fraud and debt analytics, capital allocation, and M&A support (Balakrishnan, Chui, Hall, & Henke, 2020). The U.S. National Artificial Intelligence Initiative Office lists many emerging benefits across a wide swath of the economy spanning agriculture, financial services, healthcare, COVID-19, pandemic response, national security and defense, science, transportation, and weather forecasting (National Artificial Intelligence Initiative Office, n.d.).

One example of ML used in an ERP system is Oracle's Fusion Cloud ERP and EPM suite. Oracle is augmenting its use of ML with several new features (Ghoshal, 2021). Procurement Spend Classification automatically categorizes unclassified procurement transactions to reduce reporting inaccuracies and labor expenses while improving category planning. Intelligent Document Recognition (IDR) scans transactions for financial reporting and identify inconsistencies. Enterprise Journals eliminates manually movement of journals by posting journals from Oracle EPM to Oracle ERP or any other ERP system. Fusion ERP Analytics is being enhanced with spend and procurement analytics including employee expenses. Intelligent Performance Management (IPM) Insights will enhance identification of patterns in large amounts of financial and operational data.

Data Analytics and Big Data

Most people likely recognize that data analytics have been around for a long time in one form or another. Perhaps more surprising is the fact that big data is not new either. The first documented instance of a big data problem occurred in 1888 when the U.S. Census Bureau commissioned a competition to find a new way to tabulate the 1880 census data because manual processing was no longer feasible (United States Census Bureau, n.d.). The world's first electro-mechanical tabulating device was created, which later contributed to the genesis of the International Business Machines (IBM) Corporation (IBM, n.d.). Our perception of big data has changed significantly since the democratization of the Internet. And modern big data is changing the nature of data analytics.

The concept of data-driven decision-making (DDDM) has garnered more attention in the age of big data. Tableau defines DDDM as "using facts, metrics, and data to guide strategic business decisions that align with your goals, objectives, and initiatives" (Tableau, n.d.). Due to the nature of big data, several challenges arise with DDDM when attempting to glean insights from big data. Big data was initially characterized by the volume, velocity, and variety (the so called "three Vs") of data that modern organizations must manage. Many other "Vs" have been applied to big data in recent years in an attempt to better describe the complete nature of the challenge and the implications for the toolset organizations use to glean insights. Two of the most common new descriptors are veracity and value (Oracle, n.d.). SAP explains some of the challenges of these five Vs as follows (SAP, n.d.).

- Volume: Potentially many terabytes of data need to be stored and organized for efficient retrieval. With Internet of Things (IoT) devices proliferating rapidly, the volume will grow much larger.
- Velocity: Though some manual data entry still occurs, most data are generated by automated means today. While this enables quicker utilization of the data, it also means the data are generated much faster than in the past. Information systems must be able to process and analyze these data as the data are generated.
- Variety: The data organizations collect and seek to analyze are no longer solely structured (i.e., tabular with well-defined data definitions) records created by transactional systems. They increasingly include unstructured and semi-structured data such as customer comments on social media sites, voice and video recordings, and images.
- Veracity: Data are valuable only if they are accurate, relevant, and timely. These characteristics were far more likely to be true in the past when dealing with just transactional data. Unstructured and semi-structured data introduce new sources of concern for data quality.
- Value: The data collected, stored, and analyzed must measurably improve the competitiveness and resilience of the business. Otherwise, the associated expenses would be better allocated elsewhere.

To overcome these challenges, businesses are increasingly reliant on new data analytics techniques and algorithms, with machine learning playing a prominent role. Improving forecast accuracy with predictive analytics, categorizing massive data elements with clustering algorithms, and uncovering hidden patterns and relationships to improve decision making are just some of the payoffs. Real-world examples of big data analytics include:

- root cause analysis in near-real time,
- faster and more accurate anomaly detection,
- rapid conversion of medical image data into patient insights,
- risk portfolio recalculation in minutes,
- preemptive fraud detection,
- personalized online shopping experiences,
- relevant recommendations from streaming media services,
- crop yield forecasts, and
- traffic congestion relief in cities (SAS, n.d.) (Bultin, n.d.).

ERP systems can leverage data analytics and big data in many ways. In transportation and logistics, a new term has been coined to describe the high bar for same-day/next-day/two-day delivery that customers now demand for all of their online orders. It is called the "Amazon Effect". As companies struggle with "last mile" logistics, they are turning to data analytics and big data to optimize route planning, load consolidation, and fuel efficiency (SAP, n.d.). As another example, SAP has an extension for capital projects and operations that harnesses structured and unstructured data such as documents to integrate it with the core SAP system. The extension associates key data attributes with documents to enable users to quickly find content about equipment, parts, and processes. The result is more time spent on operations tasks and less time spent searching for information (Forrester, 2020).

The Internet of Things

The Internet of Things (IoT) is driving explosive growth in the number of data sources businesses have at their disposal (Forrest, 2017; PSA Certified, n.d.; Loon, 2017). IoT is also broadening the data horizon with new types of data, new measurements, and new insights. The expected impact has been hyped in the media for several years, and many companies have already implemented IoT solutions. As Ronald van Loon puts it, "This increasingly connected culture presents businesses with an opportunity to harness digital connections to improve their products and services and ultimately, foster deeper human connections in order to improve customer experiences and relationships (Loon, 2017)."

Some define IoT to include all devices connected to the Internet (Monk & Wagner, 2013). An alternative definition excludes user-oriented devices and refers to a class of devices that communicate directly with other devices or a central application (Posey & Shea, n.d.; PSA Certified, n.d.). This was originally called Machine-to-Machine (M2M) communication. In an ERP context, many types of IoT devices can be used such as sensors, actuators, handheld radio frequency (RF) terminals, tablets, smartphones, wireless scanners, and wearables such as voice headsets, augmented reality headsets, and smart glasses. Modern IoT devices can be categorized from a hardware perspective as microcontrollers or microprocessors (Winter & Teebken, 2021). From a use-case perspective, they can be classified as consumer, enterprise, or industrial (Posey & Shea, n.d.). IoT devices and applications for industrial use-cases are called industrial IoT (IIoT) or Industry 4.0 and are designed to support production activities (Shea, Posey, & Rosencrance, n.d.). The concept of a "digital twin" plays a critical role here. According to the Digital Twin Consortium, "A digital twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity (Digital Twin Consortium, n.d.)." Most IIoT devices today are sensors and actuators. IIoT sensors:

- are often small and connected to or embedded in something else (e.g., machinery),
- are connected to the organization's network or to the Internet,
- generate new data by sensing something in the operating the environment,
- may locally store and/or transmit generated data, and
- are monitored and managed remotely (Behr Technologies, n.d.; Shea, Posey, & Rosencrance, n.d.).

ERP vendors have embraced Industry 4.0 to drive the evolution of smart factories (sometimes called digital manufacturing). For example, SAP's Business Technology Platform enables materials suppliers and manufacturers along a supply chain to automate "goods issue" and "goods receipt" by reading RFID tags as shipments pass by RFID gates. And by automatically sensing and recording the handling of shipping boxes fitted with IIoT sensors, the digital twin can be updated to document the conditions (such as temperature, humidity, or physical shocks) experienced by the boxes in real time. When adverse conditions occur, the logistics manager is notified and may even be provided proposed solutions such as create a return authorization, send a replacement, or contact the customer (Metzger, 2021). In production line settings, smart seals installed in valves are able to measure the seal wear as a percentage of usable life and automatically generate a service ticket in SAP's Field Service Management module when the seal wear reaches a predefined value (SAP, n.d.).

Measuring Success

The old adage, "What gets measure, gets managed" succinctly expresses why metrics matter. The topic of business metrics is very old and very extensive. At a macro level, metrics can be classified in a variety of ways:

- quantitative versus qualitative,
- internal versus external, or
- financial versus operational.

Metrics Models

Numerous models for collecting and presenting metrics have been devised. One of the most popular and enduring models is the Balanced Scorecard developed by Robert S. Kaplan and David P. Norton in 1992. The goal of the Balanced Scorecard is to blend traditional financial metrics that describe past performance with operational metrics that drive future performance (Hill, 2012). Organizations can tailor the scorecard to their needs, but the original format contained four "perspectives": customer, internal business, innovation and learning, and financial/shareholder. Management defines several goals within each perspective and develops specific metrics to support each goal. In addition to providing management with a way to manage and monitor the organization's overall performance, the scorecard also translates the organizational vision into measurable actions for employees.

By contrast, financial metrics alone were the traditional means by which management would track profitability, develop strategies, report value to shareholders, and comparatively assess competitors (Askar, Imam, & Prabhaker, 2009). A sole focus on financial metrics has several drawbacks. The true value of intangible assets such as intellectual property, research and development (R&D) capabilities, productive capacity of employees, brand equity, and customer loyalty is difficult to capture in traditional financial metrics. Many other non-financial metrics that are key to many businesses (e.g., customer intent to purchase, product quality, quality of management, market position, breadth and depth of strategic alliances, attainment of new capabilities, and innovativeness of the organization's culture) are difficult to incorporate into the traditional financial metrics model.

Accuracy and Clarity

Regardless of the model chosen, accuracy has always been a challenge with metrics. Quantifiable metrics are often based on estimates or forecasts, the reliability of which is highly variable. Qualitative metrics are often intuitively relevant but difficult to quantify accurately. Sometimes quantifying them is possible but at such a cost that the effort is not justified. Terminology introduces additional ambiguity. For example, one company's definition of "productivity" may differ significantly from another's even though they are operating in the same industry. Even within a firm, definitions of common terms may vary from department to department. A review of ERP surveys conducted by Oracle, Panorama Consulting, Accenture, and GEODIS reveals these challenges. Many of the metrics cited as evidence of business improvement or competitive advantage are estimated, subjective, or ambiguously defined. Table 2 presents some of these metrics.

Table 2

ERP-related Metrics Cited as Drivers of Business Improvements

Business Metrics	Challenge	Source
• "Users of AI within financial systems report an average improvement of 33% in productivity and 37% reduction in errors." • "88% of organizations leveraging IoT data in their financial systems are achieving or exceeding ROI expectations." • "78% of respondents agree that the ability to verify supply chain monitoring with blockchain will reduce incidents of fraud in their supply chain by 50% or more over the next five years." • "Emerging technology users are 6.8x more likely to describe their order-to-cash time as market-leading than those not using emerging technologies (38% versus 4%)."	• Definitions of productivity and errors • Expectations not quantified • Estimated • Subjective	(Oracle, 2020)
• ERP system satisfaction: 52.66% satisfied • Benefits realization: 65% realized operational efficiency they expected	• Subjective • Subjective	(Panorama Consulting Group, 2021)
• "This SAP Platform is their digital core: it strengthens their acquisition strategy, it provides agility to build new services … and it delivers stronger business value to end-customers." • "78% of UK CIOs believe that cloud is critical to their IT strategy and corporate strategy"	• Subjective • Subjective and benefits of cloud are undefined	(Accenture, 2019)
• "57% of firms consider their Supply Chain as a competitive advantage"	• Subjective	(GEODIS, 2017)

For these reasons, this report is not concerned with the selection of specific metrics or the rigor that companies employ when producing metrics. Metrics that reasonable and appropriate for the benefit being assessed are taken to be genuine and credible. The gamut of metrics reported is expected to include a mix of quantitative, qualitative, financial, and operational at multiple levels of specificity.

Research Methodology

A combination of questionnaires, interviews, and case studies was employed to explore the extent to which advanced technologies are being used in ERP systems across different industries. Where they are being used, metrics were identified to assess the impact on business performance.

Questionnaires

We developed two questionnaires to capture input from managers, IT engineers, and consultants with significant experience in ERP. Each questionnaire consisted of 10 questions. Though the questionnaires were materially equivalent, they differed in their wording to accommodate the

unique perspective of each audience. One questionnaire was targeted to employees of companies using ERP internally. The other questionnaire was targeted to consultants who design and install ERP systems for other companies. The questionnaires were loaded into Survey Monkey, and responses were recorded anonymously.

By leveraging our LinkedIn networks, we identified qualified respondents and solicited their participation via LinkedIn messaging. We also searched LinkedIn at large to identify additional qualified respondents and "cold called" them via LinkedIn messaging to solicit their participation. This method of sampling is not statistically rigorous as it provides no assurance the sample is representative of the population of ERP users. Furthermore, we were unable to compel participation, so the responses were given voluntarily, which introduced self-selection bias. We received three responses to each questionnaire.

Interviews

One of the consultants who responded to the questionnaire was eager to provide more information and contacted us via LinkedIn messaging. The ensuing discussion unfolded over several days and was allowed to go in the direction desired by the respondent. We consolidated his questionnaire responses with the discussion content and treated this as an interview. Some of the lower-relevance discussion content was omitted from this report.

We also conducted a live interview with a colleague in the construction industry. We used the employee questionnaire as the basis for the interview. As is common in interviews, deviations from the script were allowed. This enabled the interviewee to provide more insightful answers and raise related observations that we might have otherwise overlooked.

Case Studies

We searched academic journals, the trade and news media, and ERP vendor websites for case studies on individual companies. Not surprisingly, most academic journal articles were concerned with theory, empirical studies, and other intellectual explorations as opposed to practical application. The media dealt with the topics of ERP and advanced technologies, but most often the articles focused on each in isolation. Our quest to find quality discourse on the intersection of core ERP systems and advanced technologies from the perspective of real-world practice most frequently led us to vendor websites. Smaller ERP vendors rarely showcased advanced technologies, so the majority of the case studies came from market leaders: SAP, Oracle, and Microsoft.

Results

Questionnaires

Employee 1

Q1 - In what industry does your company operate?

Healthcare

Q2 - What are the most valuable benefits of using ERP/BPM in your company?

Centralizing multiple ministries in one centralized system.

Q3 - What are the primary drawbacks/challenges of using ERP/BPM in your company?

Limitation is based off state and city regulations

Q4 - What recommendations would you offer regarding information systems, techniques, or methodologies for a company adopting a new ERP/BPM system?

Work closely with your change management

Q5 - Does your company use advanced technologies (e.g., AI, ML, IoT, big data, data analytics) in your ERP/BPM system?

Yes

Q6 - If yes to question 5, which (if any) of these advanced technologies are you using at scale in your ERP/BPM system?

UKG analytics

Q8 - If yes to question 5, based on your metrics, do you believe using these advanced technologies in your ERP/BPM system has given your company a competitive advantage?

Yes

Employee 2

Q1 - In what industry does your company operate?

Healthcare

Q2 - What are the most valuable benefits of using ERP/BPM in your company?

Human resource management, role-based access, SSO, procurement, supply chain mgt

Q3 - What are the primary drawbacks/challenges of using ERP/BPM in your company?

Finding affordable IT talent, resistance from business operations to adapt processes to take advantage of the software and automation

Q4 - What recommendations would you offer regarding information systems, techniques, or methodologies for a company adopting a new ERP/BPM system?

Have clear goals with measurable outcomes for success. Don't underestimate the amount of time business users will need to commit to the project.

Q5 - Does your company use advanced technologies (e.g., AI, ML, IoT, big data, data analytics) in your ERP/BPM system?

No

Q9 - If no to question 5, why have you not implemented any of these advanced technologies in your ERP/BPM system?

Recently we replaced our VPs of Finance and HR so we're beginning to plan some of these initiatives. Old leadership wasn't interested in advancing.

Q10 - If no to question 5, are you planning to implement any of these advanced technologies in your ERP/BPM system?

Yes, in planning stages.

Employee 3

Q1 - In what industry does your company operate?

Networking equipment

Q2 - What are the most valuable benefits of using ERP/BPM in your company?

Sales, product mix, product partner mix and successful products

Q3 - What are the primary drawbacks/challenges of using ERP/BPM in your company?

Multiple systems need to interoperate

Q4 - What recommendations would you offer regarding information systems, techniques, or methodologies for a company adopting a new ERP/BPM system?

A cohesive system that easily coexist with each other

Q5 - Does your company use advanced technologies (e.g., AI, ML, IoT, big data, data analytics) in your ERP/BPM system?

No

Q9 - If no to question 5, why have you not implemented any of these advanced technologies in your ERP/BPM system?

In planning stages

Q10 - If no to question 5, are you planning to implement any of these advanced technologies in your ERP/BPM system?

Yes

Consultant 1

Q1 - What industries do you serve?

Wine

Q2 - What are the most valuable benefits of using ERP/BPM in each industry you serve?

Process effectiveness and consistency, enabled by technology

Q3 - What are the primary drawbacks/challenges of using ERP/BPM in each industry you serve?

Industry is late adopter and ERP concepts

Q4 - What recommendations would you offer regarding information systems, techniques, or methodologies for a company adopting a new ERP/BPM system?

Strong and experienced project manager

Q5 - Do any of your customers use advanced technologies (e.g., AI, ML, IoT, big data, data analytics) in their ERP/BPM systems?

No

Q9 - For your customers that have not implemented any of these advanced technologies in their ERP/BPM systems, why have they not?

Usefulness not understood

Q10 - Are any of those customers planning to implement any of these advanced technologies in their ERP/BPM systems?

No

Consultant 2

Q1 - What industries do you serve?

Consumer manufacturing distribution warehousing

Q2 - What are the most valuable benefits of using ERP/BPM in each industry you serve?

Consistency centralized data discipline

Q3 - What are the primary drawbacks/challenges of using ERP/BPM in each industry you serve?

Difficulty of implementation. learning required. data conversion and maintenance

Q4 - What recommendations would you offer regarding information systems, techniques, or methodologies for a company adopting a new ERP/BPM system?

Clearly define objectives. scope... effective governance.... delegation. Effective training. Most important adopt the best lowbrow inherent in the software

Q5 - Do any of your customers use advanced technologies (e.g., AI, ML, IoT, big data, data analytics) in their ERP/BPM systems?

No

Q9 - For your customers that have not implemented any of these advanced technologies in their ERP/BPM systems, why have they not?

Internal knowledge, inability to absorb change.

Interviews

LinkedIn

Q1 - What industries do you serve?

Too many to count. Primarily discrete manufacturers ranging from aerospace, automotive and furniture to big pharma. Some projects have been with continuous process operators.

Q2 - What are the most valuable benefits of using ERP/BPM in each industry you serve?

Effective order management and effective fulfilment thereof while keeping the supply-chain under control. ERP is about executing core business well.

Q3 - What are the primary drawbacks/challenges of using ERP/BPM in each industry you serve?

Incorrect perception of both companies and consulting firms regarding the purpose of ERP systems. If the core business is not operating well, no amount of dashboards and metrics will help.

Q4 - What recommendations would you offer regarding information systems, techniques, or methodologies for a company adopting a new ERP/BPM system?

Understand that ERP systems are about core business activity based on standards. The key to success is adopting behavior to meet these best practices. Avoid the urge to adapt standardized tools or expand project to cover weak practices; instead, rework the weakness. Additionally, ERP is a classic garbage-in garbage-out scenario, so attention to accuracy is crucial for: BOM, Inventory & Sales Forecasts. And don't ever set arbitrary go-live timing, the organization is ready when it is ready.

Q5 - Do any of your customers use advanced technologies (e.g., AI, ML, IoT, big data, data analytics) in their ERP/BPM systems?

No

Interviewee:

I'm perceiving a premise of your research that often leads to failure of effective management using ERP. Many design their ERP/BPM implementation projects with the icing in mind, leaving the cake to be baked with garbage ingredients. I've participated in more failed efforts than successes. I wish I could say that my experience has been circumstantially isolated, but that's not the case. Consulting firms and academia focus on the glossy add-on tools. It's sexy and helps the sell-cycle. But the only value of the ERP/BPM solution is effective, consistent management of core business. This ill-focus generates enough stress to force companies to abandon ERP efforts or worse close their doors. Organizations become less stable as a result of ERP implementations that don't contain scope to core behavior. Advanced tools are never implemented into ERP unless you want to destroy the business.

Many industries have specific needs that can't be derived from ERP without augmentation. That's where some adaptation of other tools, advanced or simple, supports competitive advantage. Advanced technologies and tools in of themselves, don't produce results. For stable organizations (those operating ERP/BPM effectively for at least a couple years), advanced tools beginning with good old OLAP (Business Intelligence) add value. OLAP is also useful in support of pricing determination by geography and/or customer demography. The vast majority of businesses are weak in sales and operation forecasting, which leads to concurrent excesses and shortages relative to market demand. Very few have operational stability and data quality that can drive any benefit from AI tools for elements like distribution optimization. Effective data mining is essential to drive truth into operational plans. It also requires honesty, which is rare. Determining shifts in market demand and fulfillment will provide an additional edge. Those with effective demand management then can benefit from "AI" tools like C3's for optimization of elements like distribution channels and transportation. Price and market-distribution analysis is also an easily

attainable path to improvement of overall profitability. But true competitive advantage is about being excellent at the basics (and industry specific behaviors) and ease of doing business with customers and suppliers.

The point is that the ERP/BPM focus should be on managing core business effectively. Doing the basics, not just well, but in outstanding fashion. Attention must only be paid to base metrics in opposition. Scorecards that put, for example, Customer Sat (fulfillment speed) against Inventory Turns drive the business to improve. In isolation, responses to both metrics will hinder success. The best ERP-driven measures reflect classic balanced scorecards. It usually takes client leaders weeks of effort to derive good ERP strategy.

Interviewer:

Throughout the course, we have discussed the many challenges of ERP implementation and the problems that result such as relatively high failure rate, lower than expected ROI, budget overruns, schedule delays, integration challenges, etc. Your commentary made me realize we need to refine our hypothesis to exclude poorly planned and implemented ERP systems. For those companies, it stands to reason they need to get the blocking and tackling fixed before they try anything fancy.

We are really interested in those companies with effective ERP deployments that have measurably improved their core operations and are now seeking ways to further exploit their ERP systems. One path is advanced technology (our focus), but that is certainly not the only path. We imagine various forecast accuracy improvements by replacing traditional statistical analysis with machine learning algorithms (e.g., sales, supply chain shortages, machine breakdowns, etc.) or perishable inventory spoilage reductions via IoT-powered environmental monitoring and response improvements.

Interviewee:

Advanced "knowledge tools" have their best use in forecast accuracy. Any ERP implementation effort will benefit there, assuming that the sales history is viable. Sadly, the reality is that most companies have process corruptions in the fulfillment cycle that muddy the data. If you can come up with reliable tools to identify historical data outliers, you'd have something. It's just that the drivers can be very strange. For example, sales orders entered that are false (not to be filled) with the intention to reserve capacity for a favored customer. These practices are common and completely blow out statistical models.

Maintenance, Repair, and Operations (MRO) activity ... Strict regimen well within tolerances typically drives a lower total cost of operation on critical capital than attempts to pinpoint failure forecasts. If there are a variety of failure points, algorithms over failure modes are useful in determining the aforementioned regimen. The theme being KISS otherwise it often becomes another tedium that drives instability.

With regard to perishables, be mindful in designs that many industries face independent unknowns and dirty political games to a point. A classic example is the Japanese lettuce story ... "If they aren't happy with a particular arrangement, well they just let the shipment sit on the dock a few days before customs inspection."

On the methodology front, the ERP implementation market is slow to change. There's a practice that on its face seems smart but often leads to driving bad practices into good projects. That's an over-use of current-state process documentation; it's better to acknowledge requirements and put the sage practice in the bottom drawer.

For transfer transactions, transfer documents and product identification (labeling, RFID, etc.) tend to be the weak point. The typical answer has been Advance Ship Notices to provide electronic support for the receiving cycle. There's definitely room for improvement, but it requires compliance from both transfer partners.

Live

Q1 - What industry do you work in?

Residential Building Construction

Q2 - What are the most important aspects of ERP/BPM (Business Process Management) in your industry?

a) The ability to drill through a set of information very easily within the ERP to track and understand the full story of any data recorded.

b) A customizable ERP to handle the specificities of the construction industry. For example, we need to have multiple levels of breakdowns of our cost and revenue (budget and actual) during the data processing and in the reporting.

c) Price management is an important aspect of our activity and having an ERP that can handle periodic regional pricing is an important asset.

Q3 - What are the most valuable benefits of using ERP/BPM in your company?

a) The efficiency of having a centralized financial system that can also be integrated with other 3rd party software like our custom construction-based software through API and SQL direct access.

b) Being able to quickly handle a large volume of accounting and financial tasks with a small staff. We process 10,000 invoices every month and weekly pay all our vendors with 5 Account Payables.

Q4 - What are the primary drawbacks/challenges of using ERP/BPM in your company?

a) The considerable time to allocate to the success of the ERP project by all the Key users is challenging.

b) Limited reports are available out of the box from the ERP, and even when some reports are available, they do not have the capability to drill through the data. We had to manage a reporting project to handle all our specific reporting.

Q5 - What recommendations would you make regarding information systems, techniques, or methodologies for a company adopting a new ERP/BPM system?

a) Before fully committing to a new ERP, I recommend requesting proof of concept that can be tested 1 to 3 months prior to the full commitment, and that includes:

i. the data migration of part or all the existing data,

ii. a request of a few customizations in the data processing form, pages, and reports of the ERP,

iii. 1 or 2 scheduled day-long workshops with a couple of members of each key department handling the daily tasks and their managers.

b) We used a hybrid approach between Waterfall and Agile methodology, we needed to scope out and plan most of the tasks but at the same time, we allowed and prepared for multiple new opportunities that will come up during the implementation until a specific date before going live.

Q6 - How does your company use AI techniques in ERP/BPM (e.g., sales or seasonality forecasting, procurement forecasting for order timing and sizing, audience targeting for marketing campaigns, etc.)?

We have not integrated AI in our ERP yet.

Q7 - Are you planning to implement any advanced technologies in your ERP/BPM system?

We are interested in having AI processing our matching invoices.

Case Studies

Mitsubishi Fuso

Mitsubishi Fuso Truck and Bus Corporation, part of Daimler Truck AG, is a manufacturer of trucks, buses, and industrial engines. They offer products ranging from light-duty to heavy-duty and also serve as a development center for electric and autonomous drive technologies for the Daimler Truck network (Mitsubishi Fuso Truck and Bus Corporation, n.d.). Fuso handles up to 20,000 parts shipments daily. They needed a way to streamline their warehouse operations and increase transparency of inventory and parts movements. To accomplish this, they decided to digitalize their warehouse management processes and connect their locations into a single warehouse management system (WMS). Fuso implemented SAP's Extended Warehouse Management (EWM) solution, which integrates with the core SAP ERP system and can control programmable logic controllers, direct the movement of items in automated systems, and manage conveyors. The results were faster order fulfillment, access to up-to-date parts availability across sites, earlier detection of issues, digitalized updates on shipments, and better data quality (SAP, 2021).

Dropbox

Dropbox develops online productivity tools such as smart content and collaboration products. Their mission is to design a more enlightened way of working so people can stay organized, focused, and in sync with their teammates. Dropbox has more than 700 million users around the world (Dropbox, n.d.). They needed a way to automate and cleanse high-volume monthly financial data and deliver the information quickly for finance teams to analyze. This would support resource allocation decisions. Dropbox embraced automation powered by machine learning across all finance operations to reduce manual labor. They integrated Oracle Analytics Cloud and Oracle Autonomous Data Warehouse with their Oracle Cloud ERP and Oracle Cloud EPM system to process big data for finance dashboards, data visualization tools, and self-service analytics. They also used prebuilt adapters and low-code automation in Oracle Integration Cloud

to take action on the information. Dropbox was able to cut processing costs and close their accounts receivable process four times faster (Oracle, 2020).

Clean Energy

Clean Energy Fuels provides low- and negative-carbon fueling solutions with renewable natural gas (RNG). They produce the fuel and operate fueling stations across the U.S. and Canada (Clean Energy, n.d.). The company's stations are fully automated and therefore not staffed. Service technicians are dispatched when equipment requires repair. High-turnover among service technicians combined with intensive training required to work on the high-pressure, high-voltage equipment posed a challenge. Clean Energy responded by integrating Microsoft Dynamics 365 Remote Assist and Microsoft HoloLens into their Microsoft Dynamics 365 ERP system. Senior engineers now coach junior technicians through troubleshooting and repairs remotely, leading to an 85% reduction in training expenses. The firm wants technicians to complete repairs as fast as possible, so they also integrated Microsoft Azure IoT Central. Data are collected from Azure IoT Edge devices connected to sensors on the equipment. The data are analyzed to determine the tools, procedures, drawings, and other information needed by the technician. The analysis is also stored in Azure Data Lake for management reporting and predictive analytics. Job satisfaction improved among technicians who no longer get up in the wee hours to drive long distances to inspect stations thanks to status data transmitted by the IoT sensors (Microsoft, 2021).

Faurecia

Faurecia S.A. is a top ten global automotive supplier with more than 300 industrial and R&D locations. The firm develops innovative solutions for seating, interiors, clean mobility, and electronics (Faurecia, n.d.). Faurecia implemented a single SAP ERP system across all its factories in 2010 to begin the company's digital transformation. They augmented the core system with SAP's Manufacturing Integration and Intelligence (SAP MII) and SAP's Manufacturing Suite. This enabled Faurecia to collect data directly from factory machines and analyze the machine data to identify process improvement opportunities. They have realized several benefits including reduced machine downtime, better alert reactivity, production line optimizations, and reductions in scrap. Faurecia estimates annual cost savings of more than €50 million (SAP, 2020).

Fedex

FedEx Corp. is a worldwide leader in package delivery. They provide a broad portfolio of transportation, e-commerce, and business services but may be best known for next-day and second-day express deliveries (FedEx, n.d.). With a long history of innovation in customer experiences, FedEx wanted to create equally innovative employee experiences in finance and supply chain functions. Management also wanted this effort to become part of their operating model and create breakthrough efficiency gains. They adopted Oracle Cloud ERP, Oracle Cloud EPM, Oracle Cloud SCM, Oracle Analytics Cloud, and Oracle Autonomous Database to standardized more than 220 operations. Now 3,000+ employees are making data-driven decisions and drilling into operations in near real-time with access to artificial intelligence, machine learning, and service automation. Time to market was cut in half for code deployments (Oracle, 2020).

Pack'n Fresh

Pack'n Fresh is a small, turnkey, food packager and consulting firm. They source ingredients and packaging material, productize food concepts, and prepare new products for mass production (Pack N Fresh, n.d.). During the early days of the COVID-19 pandemic, Pack'n Fresh experienced exponential growth. They ran their business on spreadsheets and QuickBooks with multiple departmental data sources, which led to data entry errors and data quality issues. They also manually tracked 1,050 products and 60 vendors to coordinate shipping, receiving, accounting, and production. The result was more than 7,000 SKUs representing the 1,050 products and dificulties in complying with FDA regulations. Pack'n Fresh decided to adopt Microsoft Dynamics 365 Business Central and contracted with Microsoft partners Power Central and Ingram Micro Cloud for the implementation. The data were de-duplicated using artificial intelligence in Microsoft Azure Machine Learning services and Microsoft Power BI in just two weeks. Six weeks later, accounting, sales, purchasing, warehousing, and inventory management were up and running on the new ERP system. The artificial intelligence was then used to analyze operations to maximize the ERP return on investment. The analysis revealed four key vendors contributed to the top thirty products that accounted for 85% of revenue. Refocusing the business improved quality control, inventory tracking, and timely delivery (Microsoft, 2021).

Evonik

Evonik is leader in specialty chemicals and seeks to create innovative, profitable, and sustainable solutions for their customers. Their products are incorporated into consumer goods to improve product quality (Evonik, n.d.). To fulfill their mission, Evonik must use complex materials data and packaging specifications provided by vendors. They process up to 10,000 product specifications per year. They chose to deploy SAP's Data Intelligence module with their core SAP ERP system. The solution reduces manual data entry and employs machine learning to trace errors in materials classification. Evonik was able to refocus staff on higher value tasks, reduce stock-outs arising from incorrect packaging, and reduce system maintenance time by 50% (SAP, 2020).

Noble Plastics

Noble Plastics is a small contract manufacturing company that specializes in product realization. They focus on design, manufacturing, and robotic integration to help customers turn ideas into reality (Noble Plastics, n.d.). Noble Plastics had issues with an old asset-monitoring system that was putting equipment and materials at risk. They often discovered a problem after making a bad part. Then they had to fix the problem and rebuild the production schedule. Employee morale was also impacted when problems occurred at night. Noble Plastics implemented Oracle Fusion Cloud Manufacturing, Oracle IoT Intelligent Applications, and Oracle IoT Service Monitoring for Connected Assets. The system pulls production data from robots and molding machines, applies anomaly-detection algorithms to optimize machine health, maintenance requirements, and parts quality, and sends alerts to employees when needed. Staff members now allocate more time to developing products and process improvements. Noble Plastics estimates the ROI took less than a year (Oracle, 2021; Banks-Louie, 2018).

Island Labs

Island Labs is a software developer specializing in holograms, mixed reality, artificial intelligence, and machine learning. They provide solutions for the interior and exterior design

and planning market (Island Labs GmbH, n.d.). The sales process for interior design projects can be stressful for customers because a large expenditure is decided based on two-dimensional, static drawings. Island Labs wanted to solve this problem while helping interior design companies improve customer engagements and increase revenues. They developed a collaborative, mixed-reality solution based on Microsoft Dynamics 365 Business Central and HoloLens 2 to provide an immersive experience for customers. Customers can now see a faithful representation of the design before spending any money. Sales consultants can add and remove cabinets, appliances, kitchen islands, windows, doors, walls, and more while the customer is viewing the virtual space. Kitchen builder küchenquelle says they can charge 20% more for projects when using this solution, and they close 15-20% more deals (Microsoft, 2020).

UPS

United Parcel Service of America (UPS) is the world's largest package delivery company delivering 24.7 million packages around the world each day. Their strategy is "Customer First, People Led, Innovation Driven" (UPS, n.d.). To optimize its logistics network, the company rolled out "Network Planning Tools" in 2018. The goals were to make better use of data and empower employees to make better decisions by leveraging advanced analytics and artificial intelligence on real-time data. Another core component of their internally developed ERP system is On-Road Integrated Optimization and Navigation (ORION). UPS updated the system to use big data in route optimization. ORION now continually factors in completed deliveries and dynamically optimizes routes as drivers complete deliveries throughout the day. The company says their use of big data is driven by the business case to improve our customer service, realize a return on investment, or improve other aspects of the business. Examples include meeting service commitments, reducing overall delivery miles, and reducing carbon emissions (Samuels, 2017).

Villeroy & Boch

Villeroy & Boch is a family-owned international lifestyle company. They are one of the largest producers of premium porcelain and ceramic products. They specialize in sophisticated tabletop and home décor products based on European designs (Villeroy & Boch, n.d.). Villeroy & Boch must respond to thousands of customer inquiries each year. They wanted to automate the simpler inquires along with repetitive tasks in finance and purchasing. They deployed SAP's Intelligent Robotic Process Automation solution to integrate with their core SAP ERP system. The solution uses artificial intelligence and enables them to create bots to respond to standard e-mail inquiries, make general ledger postings, and handle other routine but frequently occurring tasks. As a result, customer service staff can now focus on wholesale customers with complex inquiries, while finance and purchasing staff are free to focus on strategic tasks. The head of ERP Core Solutions believes the solution helps them "work more efficiently, serve customers better, and gain competitive advantage." Villeroy & Boch are now creating autonomous bots. They are also using SAP's AI Business Services to automate complex tasks like document classification and information extraction (SAP, 2020).

L'Oréal

L'Oréal is leading designer and manufacturer of cosmetics and beauty supplies such as makeup and skin cream. They have research, marketing, and production capabilities around the globe (L'Oréal, n.d.). With factories around the world, L'Oréal regularly sent experts to these factories

to service broken machines, perform maintenance, install new equipment, or conduct machine audits. Aside from being costly, the carbon footprint of these travel activities conflicted with the company's efforts to achieve its commitments on reduction of carbon emissions in industrial activity. L'Oréal implemented Microsoft Dynamics 365 with Remote Assist and HoloLens 2. This augmented reality IoT solution enables their experts in another part of the world to see what local employees see, react to the same image, use mixed reality annotations, and share information to perform machine repairs, maintenance, and audits. The firm has realized several benefits. Time required to diagnose and resolve issues was cut in half, operational and travel costs were reduced, and employee travel fatigue was reduced. They were able to reduce their carbon footprint in support of their climate goals (Microsoft, 2021).

Schaeffler

Schaeffler is a global automotive and industrial manufacturer of high-precision components, systems, and bearing solutions for engine, transmission, chassis, and industrial applications (Schaeffler, n.d.). By outfitting roller bearings used in power trains with IoT, they are able to leverage digital twins to optimize their R&D, design, and production. Taking high-speed trains as an example, they use the real-world load data (e.g., straightness of the track, temperature, vibration, torque, and other forces) in the design process to replace the artificial load data previously used. This, in turn, informs production process improvements. These real-world data are also used to optimize the functioning of trains in real-time and improve predictive maintenance. Load data are also sent to repair centers to facilitate quicker diagnosis and repair. For Schaeffler, digital twins provide traceability across the full product lifecycle and lead to new service opportunities and new digitized business models. For train passengers, this translates to increased safety at higher speeds (IBM, 2017).

Discussion

During our research, we came across many stories and case studies of failed ERP implementations. For some organizations, the implementation effort was abandoned prior to completion. For others, the project was eventually completed after being delayed by many months or years resulting in large budget overruns and sometimes a reduced scope (with an accompanying reduction in benefits). For others still, the deployment completed successfully, but the business struggled to use the new system effectively. Multiple causes contribute to failures including bad business processes that were not seriously analyzed for fitness pre-deployment; a reluctance to change business processes post-analysis; lack of adequate user training and support; challenges with integration of legacy systems and data; poor communication, cooperation, and transparency between the firm and external consultants hired to plan and implement the system; and/or lack of clear vision/purpose for the deployment. In keeping with the third premise of our hypothesis, these failed implementations were excluded from our results.

Questionnaires and Interviews

The seven questionnaires and interviews covered the healthcare, food & agriculture (wine), network hardware manufacturing, consumer goods manufacturing and distribution, aerospace manufacturing, automotive manufacturing, furniture manufacturing, pharmaceutical, and residential construction industries. The primary benefits of ERP were cited as data centralization, human resource management, security, supply chain management, sales and marketing analysis, order management, process automation and management, information drill-down, product price

management, integration with other systems, and scalability. The primary challenges were cited as compliance with local regulations, change management, IT skills required to support the system, getting the business to change processes, unclear goals, time required for training and for users to embrace the system, integration with other systems, appreciation for ERP concepts, strong project management, difficulty of implementation and data migration, ineffective governance, software complexity, and the difficulty of customizing processes and reports.

Only one participant indicated the use of advanced technologies with their ERP system: data analytics. However, no information was provided as to the specific technology used, how it is used, or the metrics to assess benefits. Among the other participants, the reasons for not using advanced technologies include lack of leadership interest, lack of understanding of the usefulness, inability to absorb change, weak processes, and unstable implementations. Half of these participants indicated interest in deploying advanced technologies into their ERP systems. The consultant who answered the questionnaire and then engaged in an interview revealed an oversight in our initial thinking. We added our third premise as a consequence of his input.

Case Studies

Among the 13 case studies, four are small and medium-sized business, and the other nine are global businesses. The industries covered include truck manufacturing, software development, energy production and distribution, automotive components manufacturing, shipping/logistics, food processing, specialty chemicals manufacturing, plastics manufacturing, porcelain/ceramic manufacturing, cosmetics manufacturing, and power train components manufacturing. All of the manufacturing firms engage in product design as well. Every advanced technology studied in this report is represented in one or more case studies as a critical piece of the solution. All of the organizations used subjective metrics like “production process improvements” or “reduced employee fatigue”, but many also produced quantitative metrics like “time required to … was cut in half” or “can charge 20% more”.

The extent to which the observed business benefits create a competitive advantage is difficult to determine. Harder still is establishing a case for sustainable competitive advantage. Many of the benefits derive from organizational resources and capabilities that are valuable but not rare suggesting any advantage gained is temporary. These firms would be wise to adopt D’Aveni’s viewpoint if they wish to maintain their competitive advantage. Some resources and capabilities, like UPS’s internally developed logistics systems, clearly had both value and rarity combined with technological complexity and scale that made them difficult to imitate and non-substitutable, thereby creating a sustainable competitive advantage. However, the contribution of the advanced technologies to this sustainable competitive advantage is difficult or impossible to quantify accurately. One may reasonably posit that continuous improvement of a firm’s resources and capabilities is necessary just to maintain their current value in the presence of competition. When viewed through that lens, the maintenance of ERP value could be attributed to the integration of advanced technologies.

Conclusions

Our research lacked the statistical rigor required to draw conclusions with high confidence. Additionally, the sources of our case studies, the metrics used to assess benefits, and the relationship of the benefits to competitive advantage cast further doubt on our conclusions. However, sufficient evidence was uncovered to suggest a positive correlation between advanced

technologies in ERP systems and competitive advantage. To increase confidence in our conclusions, broader primary research looking deeper into the firms is necessary.

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