Enterprise Resource Planning Systems

Technology Implementation for High-Tech Manufacturing Firms in the Year 2035

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Abstract

Enterprise Resourced Planning (ERP) systems are crucial to the operation of all multinational manufacturing firms today who remain the biggest users. In this paper, it is proposed that the characteristics of a high performing, high-tech manufacturers in the year 2035 would use a CAD-ERP-CRM (a modified S-ERP model) approach to sustainably and responsively bring manufacturing processes closer to the consumer allowing for better time-to-market product deliverables combined with (AM)-ERP systems to allow real-time consumption monitoring and procurement of 3D printing materials leading to less waste. Modes of operation include preventive analytics with ERP used to anticipate and avoid additional costs on equipment downtime and maintenance, as well as providing additional sources of revenue for the manufacturer during post-sale periods. From a framework centered around the manufacturer – analysis and responsiveness of ERP data will become the two prominent modes of operation. The use of Enterprise Partner Planning (EPP)-ERP systems will transform the way manufacturers approach alliances with other firms. Firms will be able to cocreate and collaborate with vendors, nongovernmental organizations (NGOs), customers, job seekers/agencies, and competitors while giving better clarity surrounding the nature of the relationships and goal alignment for all partners. The uncertainty surrounding costly and project management of ERP implementations; disruptive nature of technology which clouds foresight for manufacturing firms to understand and configure ERP systems; and a lacking cybersecurity framework for ERP integrations with the manufacturer's mode of operation; all pose as research challenges towards ERP-manufacturer implementations. Lastly, the use of Human Resource Information Systems (HRIS), providing virtual training to engineering job seekers, and other HRIS drone- and ERP-based tools to improve the flexibility and mobility of engineers, are all crucial for attracting the best talent to sustain and grow a high-tech manufacturing conglomerate in 2035.

1.0 Introduction

Enterprise Resource Planning (ERP) systems remain a backbone for many of the world's largest manufacturing corporations, yet, little is known about the importance of this technology for company day-to-day operations. As companies are faced with mounting pressures to behave sustainably, work to meet consumer needs, and generate profits for stakeholders; ERP systems integration continues to play a supportive and crucial role for organizations to run their daily operational activities.

ERP is simply defined as a software system that helps organizations manage and control activities and other functions on a holistic scale [1] [2]. The software is primarily used to control, track, monitor, purchase and plan for inventory and use financial and human capital management (HCM) systems to work other non-manufacturing processes [1]. It is also often see as an extension to manufacturing resource planning (MRP-II) which supports the control of inventory for manufacturing processes [3]. There are five areas of an organization which ERP systems are generally used in: sales, accounting, manufacturing, purchasing and scheduling inventories, and monitoring and controlling other business activities [4].

ERP systems improve manufacturing outcomes with, for example, the reduction in inventory for Toro Company that helped it achieve US$10 million/year in savings, and for Shanghai General Motors after sales warranty costs were reduced by 34% [1]. Another firm employing more than 100,000 employees across 60 countries which manufactures security and fire safety products saw inventory cost savings of more than US$8 million realized within two years of ERP implementation [4]. The adoption of ERP forces companies to look at their processes and systems from a holistic perspective and this means centralizing data, restructuring their organizations, changes to workplace culture and other operational processes [1]. For high-tech manufacturing companies, ERP becomes the vital organ which keeps the company alive as data integration into manufacturing processes is essential for its survival - from backend operations to the end consumer - everyone throughout this value chain must be satisfied either from using, or arising from the usage, of ERP systems. For example, manufacturing firms will need to attract, manage and retain talent; for operations, waste is eliminated throughout the manufacturing chain sometimes with the aid of radio frequency identification (RFID) tags (allowing manufacturers to monitor the movements of their materials); and for the average consumer they want their products at the right place, price, time and with the correct features [5] [6]. Some manufacturers have opted for engineering methodologies like Design for Manufacturing and Assembly (DFMA) that are integrated with ERP Supply Chain Management (SCM) processes to expedite time-to-market deliveries and cut production costs [7].

Since the early 1980s, ERP systems have been readily integrated with a variety of Manufacturing Resource Planning (MRP) packages that aided companies in the transition to plant process automation [8] and have dominated the manufacturing landscape [9]. Data for the high-tech factory will become crucial in order for smarter products, planning and scheduling, equipment process monitoring and quality controls to be made [10]. Using this data, ERP systems support the elimination of waste and process improvements for organizations, underpinning further developments in lean (or the Toyota Production

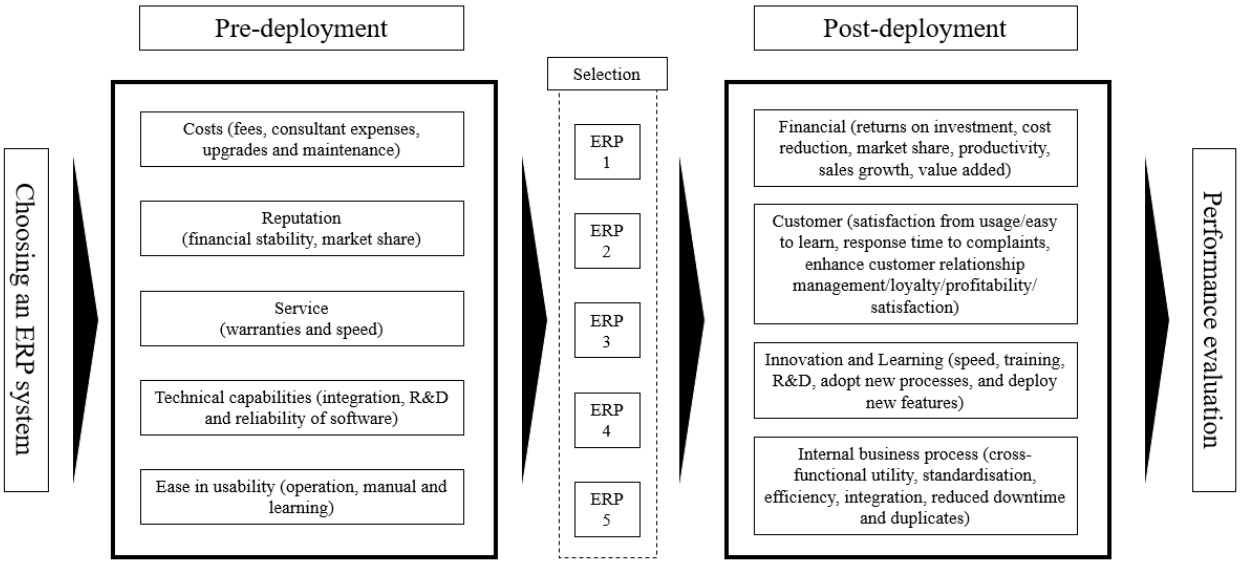

Figure 1: Pre-deployment from Lee et al. [53] and post-deployment taken from Chofreh et al. [52] of ERP systems for firms.

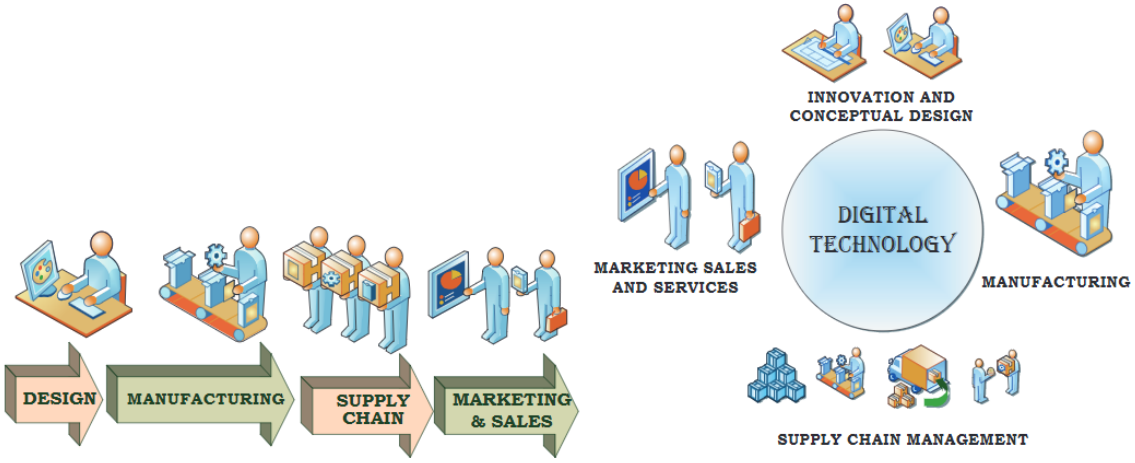

Figure 2: Conventional (left) and digital (right) manufacturing processes taken from Paritala et al. [11].

System) [11] [12] and agile manufacturing techniques [4]. Mass customization of products are growing in popularity and are becoming the preferred manufacturing business model over mass production, design cycles are now made shorter and a holistic, digital view of the product are a key driver for digital manufacturing adoption [11]. The move towards predictive analytics has allowed manufacturing firms to source data from machinery [13] and predict faults in equipment before they happen allowing fewer downtime disruptions across manufacturing processes [14] [15] [16], leading to potential cost improvements of between 20-26% [17]. Furthermore, the use of predictive data analytics can aid large manufacturing firms to provide aftersales maintenance services maintenance, adding further sources of revenue [18] [19]. Without ERP systems: inefficiencies, process mismatches and disorder, design and engineering problems, wastages, increased expenses, delivery delays, greater customer dissatisfaction, heightened workforce turnover, poor talent attraction and onboarding, reduced market responsiveness time, poorer customer relationship management, would all arise that will become detrimental and even fatal to a high-tech manufacturing company.

ERP types can be separated into several functions [20]:

- ***Production Planning*** – optimize manufacturing processes (inventory, forecasting and recording data)
- ***Purchasing*** – streamline procurement of raw materials with suppliers, can be automated
- ***Inventory Control*** – stock management
- ***Sales*** – order scheduling, shipment, invoicing and placement
- ***Marketing*** – lead generations and market campaigns
- ***Financial*** – balance sheets and financial statements
- ***Human Resources*** – employee databases/records

2.0 High-Tech, High Performance Manufacturing Companies in the Year 2035

Global consulting firm Accenture predicts that in the coming decades: data, user experience, the use of cloud systems, and integrating machine learning across ERP systems will drive business performance through real-time monitoring of problems, trends and key performance indicators [21]. No doubt that all of these trends will continue well on into the next couple of decades, with the advent of intelligent virtual and digital manufacturing methods that drive down development time and costs [11].

2.1 CAD-ERP-CRM Model for Sustainability

Action for climate change becomes increasingly dire at this point, high-tech manufacturing companies would use systems which promote sustainability and transparency across their manufacturing operations. The traditional role for ERP systems to help companies make profits would also complement the need to drive sustainable engineering processes throughout the entire organization's processes. An improved model of Sustainable ERP (S-ERP) systems is needed.

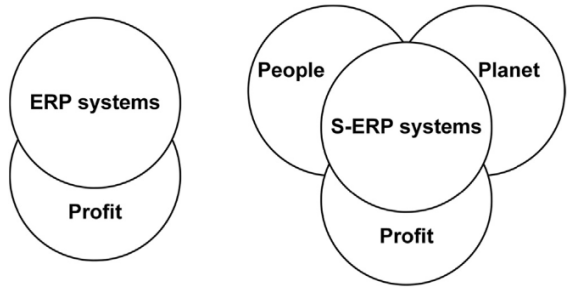

Figure 3: Traditional ERP and S-ERP models from Chofreh et al. [52].

S-ERP model suffices people, planet and profits for organizations. With growing sustainability concerns and consumers demanding better products tailored to their needs, an S-ERP model that brings production processes and designers all closer to the consumer in a supply chain will help minimize prototyping time and, within the context of Industry 4.0, help provide real-time data to aid in decision making that holistically integrates and measures all sustainable aspects of the company's operations [22].

For example, a virtual model chassis for an electric vehicle is made using computer aided design (CAD) software, shown to the customer with virtual reality interactivity, material savings and pricing of the part is determined and issued from this interaction, negotiations can be made at this point with the cycle repeating by having the product redesigned in CAD or a contract signed confirming the purchase. At this point, a computer via ERP would have recommended all the trusted suppliers of the materials and parts that have the highest positive sustainability and reliability ratings. Ultimately, this setup would expedite product-to-market time frames, minimize waste, help companies understand their customers better in-sync using customer relationship management (CRM) tools, and reduce complexities surrounding engineering to customer requirements and thus, boosting company-user experience. This is visualized in Figure 4.

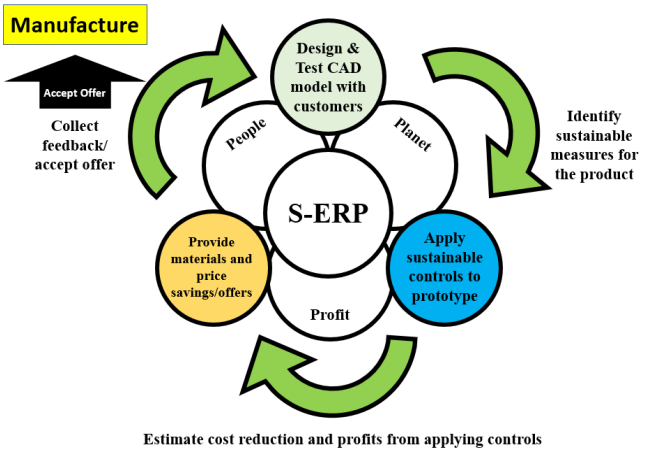

Figure 4: Modified S-ERP layout for the future high-tech manufacturer using a CAD-ERP-CRM operating model.

2.2 Additive Manufacturing Integration with ERP Systems

Rapid Prototyping (RP) through Additive Manufacturing (AM) has allowed manufacturers to quickly identify defects within their products and refine them through customer feedback before mass production. Complex parts can be produced at the fraction of the time compared to traditional manufacturing processes which can sometimes take weeks [23]. However, AM still requires raw materials in the form of photopolymeric resins and thermoplastic polymers.

An integration of AM processes with ERP systems can improve monitoring and control of raw materials during production. Automatic orders can be placed when inventory for 3D printers runs low, eliminating the need for engineers to manually order and make forecasts over the different types of 3D printing materials there are available. It is considered best practice for manufacturing firms to have both flexible production systems and a centralized data center for improved competitiveness [24]. Incorporating AM into production processes improves the level of flexibility that manufacturers have over their processes (giving them the freedom to make changes before committing production), and centralizing 3D printing raw material inventory data improves transparency throughout the entire company. Automatic orders of 3D printing materials would free up human resources so that more important engineering tasks

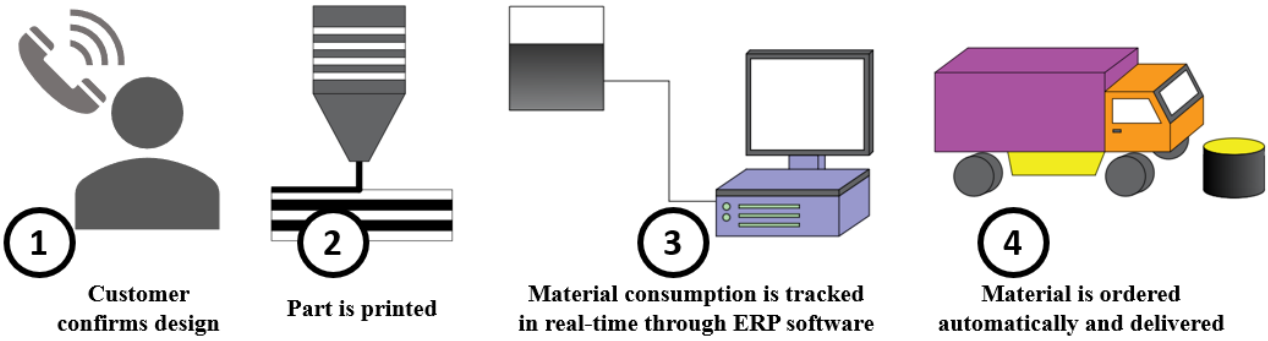

Figure 5: AM integration with ERP systems for effective inventory control.

can be prioritized. This focus is what will drive a high-tech manufacturing firm towards the path of greater operational performance (e.g. design activities). Shown in Figure 5, a customer requests and confirms the design of a prototype or part, the part is then created and real-time data on its material consumption is presented within the ERP system itself. This system would then order the part if inventory is low enough from a trusted supplier, ensuring that the manufacturing firm has a stable supply of input for such operations. Therefore, disruptions to engineering manufacturing processes are minimized and financial losses in terms of dissatisfied customers and downtime could be averted.

4.0 Mode of Operation for High-Tech Manufacturing Firms – ERP Perspective

Policy drives through Industry 4.0 in Germany, Industrial Internet in the United States, and China's Made in China 2025 initiative would have made high-tech manufacturers dependent on data to sustain their competitive advantage [1] [10]. The operation of ERP systems off the cloud will make system implementation faster and cheaper, turning the company into a cloud manufacturing one where data and work can be done online [25]. ERP systems contribute significantly to adding business value for manufacturing firms [26] and with proper alignment to its competitive strategy and country's policies [24], manufacturing firms will thrive in this digital era. A study conducted on five global manufacturing firms derived ERP benefits primarily from the availability of information, ease of ERP integration, customizability, and financial management [27]. The flow of data will only grow bigger when high-tech manufacturing companies become increasingly reliant on it to operate smart factories. Figure 2 contrasts conventional against digital manufacturing models for smart production firms where the entire process of marketing and finance, engineering, supply chain management and design revolve around the use of digital systems.

Manufacturers need to be extremely responsive to changes in the market and real-time data can aid in this, where inventory levels and manufacturing processes can be changed with very little notice [10]. In Figure 7 for a data driven cloud manufacturer multiple types of information from production processes are collected. This problem is translated into data which is then shared across an entire

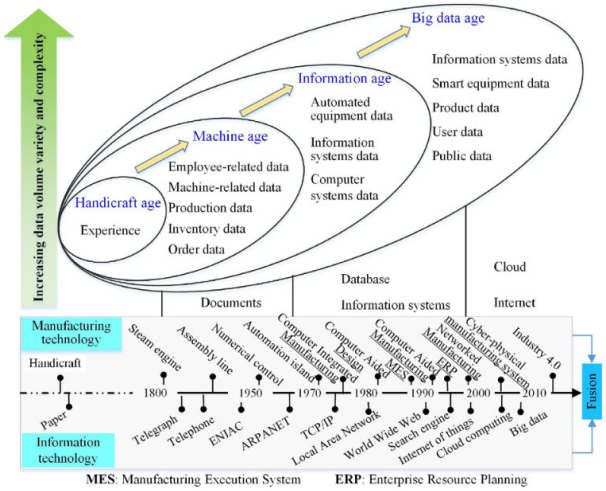

Figure 6: Eras of data management across manufacturing firms, taken from Tao et al. [10].

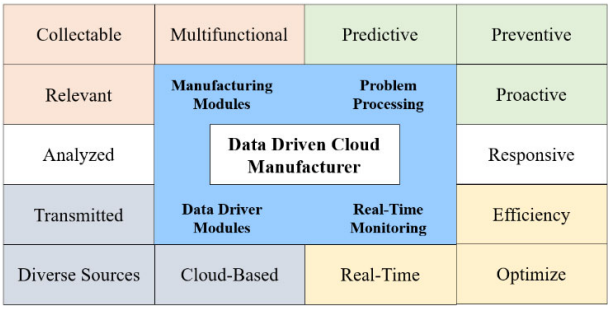

Figure 7: A data-driven model for smart manufacturing summarised and modified from Tao et al. [10].

organization. Problems and other data points from manufacturing processes and customer preferences are monitored and optimized in real-time. Once this data is recorded, proactive action is taken to prevent and predict problems. This mode of operation for a high-tech manufacturing company will help minimize downtime and adjust manufacturing processes a lot more quickly against any sudden changes to both the internal and external working environment. Most importantly, the two significant elements to this framework is that data is *analyzed* and rapid *response* to this is taken. The use of ERP technologies that are cloud based which aid personnel in the analysis and response of real-time data will increase firm resilience, productivity and customer satisfaction rates - leading to strong performing and high-tech manufacturing firms in the year 2035.

5.0 Partnerships to be Formed with High-Tech Manufacturing Firms

5.1 Cocreation-Collaboration with Vendors, Implementation Consultants, Customers, Non-Government Organizations, and Competitors

The use of ERP supports manufacturers to readily source suppliers and form new partnerships which gives them many options to purchase and bid for materials [1] [28]. As technology becomes more advanced, the importance of understanding customers means high-tech manufacturers need to develop even stronger relationships with their own buyers at both the business-to-business (B2B) and business-to-consumer (B2C) level. The process of cocreating and co-owning processes with customers, partners and other vendors has been explored within the context of ERP systems by Sarker et al. [29]. Sarker et al. [29] proposes three ways in which value can be created alongside partners: exchanging (sharing knowledge and resources to serve clients), addition (parties build on each other's contributions) and synergistic integration (mutual trust and relationship investment). Trust is the cheapest form of mechanism enforcing partnership responsibilities between each other but however, contracts are still in place to financially enforce this. Collaboration leads to the innovation of both ideas and products between partners and vendors [29]. This model should be extended to include manufacturers as they play an important role in this ecosystem, and not-for-profit organizations who have influential power throughout society for enforcing the triple bottom line of organizations – complementing the modified S-ERP model seen in Figure 4. Cocreation between implementation partners, ERP providers, vendors, non-government organizations (NGOs), manufacturers and to a limited extent, competitors, expands the reach of high-tech manufacturing firms beyond their natural sphere of influence and broadens the perspectives of their ideas.

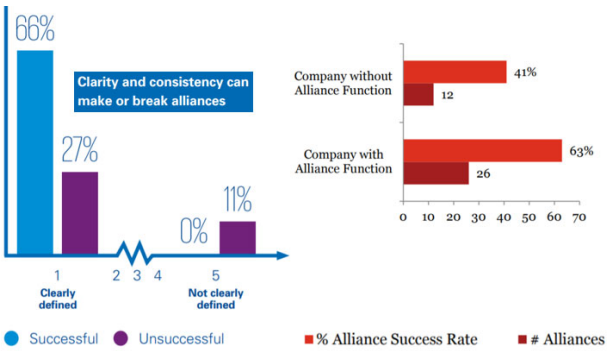

Figure 8: (Left) KPMG survey results comparison between organisations that have similar and dissimilar goals in mind when collaborating [30]. (Right) PricewaterhouseCoopers study comparing the success rate of organisations that have and do not have alliance functions [54].

A survey done by KPMG [30] found that only around 30% of working professionals cited that their strategic alliances were highly successful, with both a lack of clarity and a misalignment of goals and ambitions being the key driver in most of these failures. Companies with dedicated alliance functions (have dedicated personnel in managing and overseeing corporate alliances within their organizations) have success rates of 70% as opposed to firms without one (at 40%) [31], indicating that manufacturing firms may begin to adopt specialist alliance directors and partners within their organizations to forge effective and productive relationships with stakeholders. Manufacturing firms can also expect to have contingency plans in place to foster cocreation rather than co-destruction [29]. Hence, a stakeholder ecosystem where manufacturers, supply vendors, implementation partners, ERP providers, and competitors are all aligned on the same goals will lead to greater innovation, success rates and growth.

5.2 And the Supportive Role of ERP Systems in this Manufacturer-Centric Stakeholder Model of Collaboration

ERP systems will have the role of facilitating knowledge creation and transparency in this collaborative ecosystem of interested parties. Jahantab and Garcia-Perez [32] found that in order for this to work on manufacturing companies, such systems should involve a team of interested experts who can collate a variety of solutions who have a problem stake in which they want to solve. ERP systems can host this information which can be linked to a centralized database that is selectively authorized for sharing with other interested parties required to successfully complete tasks. This would effectively turn ERP systems into Enterprise Partner Planning (EPP) platforms for manufacturing firms. Vasilev and Stoyanova [33] found that sharing data between upstream vendors and manufacturing firms would prevent

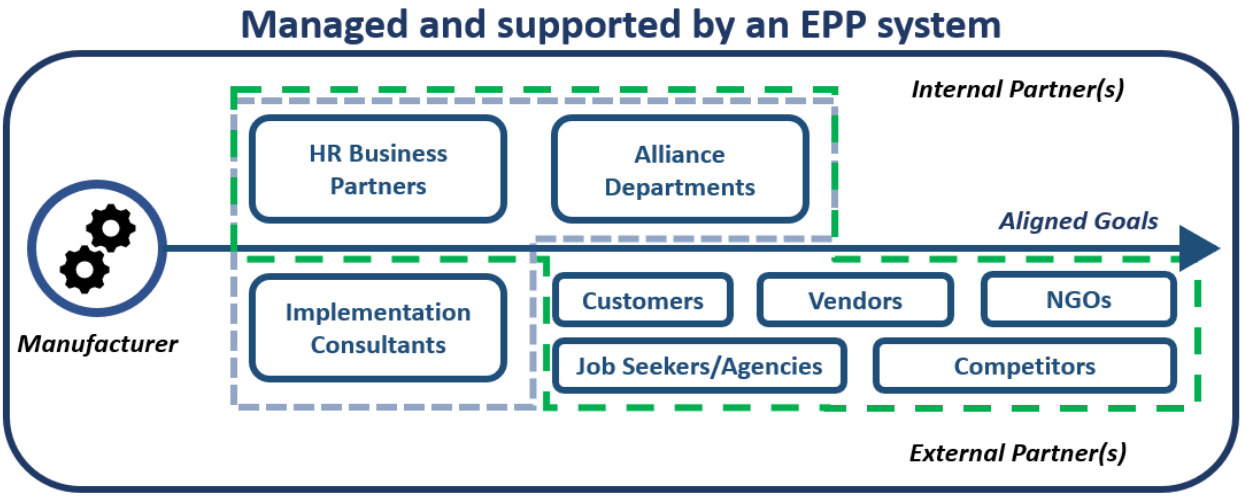

Figure 9: The partnership model for high-tech manufacturing firms using EPP add-ons integrated with ERP systems.

bullwhip effects, stockouts, inaccuracies in planning, and lead to improved performance evaluation of a customer's business. Individual costs were also shown to be reduced when information was shared across a supplier-warehouse-retailer network, however, mechanisms surrounding the need to encourage information dissemination are lacking [34]. Applications of ERP systems for knowledge management in new product development settings across manufacturing firms, found in the study of Gao and Bernard [35], that sharing information through digital systems allowed speedier time-to-market, efficiency and quality of products to be made. Skippari et al. [36] determined that firms most comfortable with the relationships they had with other collaborators were more likely to be more actively involved in collaboration activities. The use of product lifecycle management (PLM) technologies helped overcome barriers such as distance, inaccessibility, lack of institutional memory and poor awareness [37]. ERP technologies could facilitate this relationship with manufacturing firms and other partners by setting out clear goals and ways of working to build confidence and clarity for innovative collaboration to work. ERP technologies in the next decade could make real-time collaboration even more user-friendly and help minimize the risks associated with growth alliances. Shown in Figure 9, when the EPP-ERP systems are being implemented, consultants, alliance personnel and human resource practitioners work together to configure the software to the manufacturer's requirements so that it is streamlined with the sort of talent a manufacturing firm would want to attract and onboard and the objectives of what the nature of the partnerships with suppliers, NGOs, and competitors would be like. Once configuration is completed (blue), the next phase (in green) is to forge effective relationships through EPP systems to help improve the success rates of high-tech manufacturing firms collaborating with other interested partners. Customization is important as each partner has differing interests, however, they should all be aligned with the same goals as the high-tech manufacturers. For example, a partnership with suppliers will be different as stock orders and planning will be a high priority. While partnerships with competitors might stress more on how knowledge is shared, the goals and outcomes of the alliance, work patterns, and distribution of other resources. Ultimately, all of these partners during the post-configuration phases of EPP-ERP implementation should all be moving towards the same goal (for example, to produce cost-effective and leaner solutions for customers and clients), all with the support of EPP systems from the high-tech manufacturer.

The full maturity of EPP systems in the year 2035 will match high-tech manufacturers with reliable supply vendors, other manufacturers and competitors to deliver final products assessed based on their potential to contribute with similar goals in mind. Therefore, the application of EPP with these mechanisms could support greater transparency across partner ecosystems leading to reductions in costs, increases in higher-than-normal innovative outputs and elevated levels of successful competitive-collaborative alliances. More importantly, it could also transform the way manufacturing companies perceive their own competitors as opportunities, rather than as threats.

6.0 Research Challenges

6.1 Predicting the Unpredictable

Organizations implementing new ERP systems in an era of high-tech competitiveness will need to accept new methods of using the software as historically, there has been a culture of resistance to its adoption [28]. Knowledge acquisition for new ERP usage will pose a significant and future challenge for high-tech manufacturers. Manufacturers today continue to be the number one buyers and users of ERP systems which have now long replaced the older MRP packages, and nearly 50% of all companies currently have or are planning to implement ERP systems [38]. The upward trend in ERP usage means high-tech manufacturers will need to become more familiar with their own operational processes and this could mean identifying their own key performance metrics or learning to make sense of large quantities of centralized data from their own operations. Despite this, as disruptive technologies continue to appear on the market, smart

manufacturers and other factories may have a harder time predicting what their needs will be in the future, let alone in the present. Being familiar with processes is one of the most important factors determining the success or failure of ERP implementation projects [39]. The strength in predictive analytics today are limited to current problems facing manufacturers with existing capital, but once better equipment or ways of doing things materialize, previous predictive approaches could be rendered obsolete. Digital disruptions will continue to challenge the way high-tech manufacturers approach and become familiar with their own processes in areas that predictive analytics would not be able to. Further research could be done to examine the resilience of predictive analytics towards technological disruptions.

6.2 ERP Integration could be a Barrier, Not Facilitator, for Manufacturing Collaborations

There are limitations to how information technology can facilitate greater knowledge creation between teams and firms. Reliable hardware and software efficiencies continue to stand as barriers to this collaborative ecosystem [32]. Scalability, flexibility and integration of ERP systems will remain as the biggest challenges for companies, with the average ERP implementation taking 30% longer than expected, and 3-4 times the budget estimate [38]. Apart from budget and project forecasts; effective change strategies, systems that must be compatible with the manufacturer's technical, involvement by leaders and cultural requirements, are also needed for ERP systems to be successfully implemented [1] [39]. Forecasting and reliably predicting the costs and integration timelines for ERP systems will continue to remain a challenge for companies for the years ahead as each manufacturing company must understand its own budgetary and timeline requirements, processes, adoption practices and its own unique sociotechnical needs.

Besides project difficulties, the connectivity of ERP systems with manufacturing assets for this smart, high-tech factory could in fact become disconnected [13]. Manufacturers devour and use the most amount of data compared with any other industry annually making it the most attractive industry for Big Data solutions [13] [40] and if this data is not collected and integrated centrally both physically and digitally with say, ERP systems, inefficiencies and extra unnecessary costs could be added to production processes. The use of ERP systems also requires that physical upgrades to physical capital are made onto the ERP cloud. A disconnected factory would prevent it from attaining a high-performance status where a cost advantage is lost.

Little is also known about the use of information systems to cocreate value between manufacturers and partners. Sarker et al. [29] believes that there is a gap in the studies done demonstrating the use of information systems to cocreate value between organizations [29]. This cocreational void is hoped to be filled by the functionalities delivered through EPP-ERP systems. However, implementing ERP systems into manufacturing organizations that are becoming increasingly complex, disrupted and challenged by the business environment poses a barrier to taking the first step towards better collaboration between manufacturers and its partners. Manufacturers, therefore, may need to conduct a cost-benefit analysis between the length of time and costs required for ERP implementations with the benefit of working better with its partners.

6.3 Who Needs a Firewall – A Lack of a Secure ERP Manufacturing Framework

Another present limitation is the lack of a secure framework for the implementation of ERP systems with cloud based engineering and manufacturing functions to safeguard work from malicious attacks [13] [41]. Using ERP systems to build partnerships and alliances is not without risks, where cybersecurity attacks on this network can lead to significant loss of proprietary data to hackers. Attacks on ERP systems will continue to pose a threat for not just high-tech manufacturing companies, but every organization that uses data as part of their daily operations. Future research examining the relationship between the effectiveness of a cybersecurity framework, number of breaches and whether social engineering was involved in these attacks can help determine best practices for maintaining ERP systems and improve confidence in such systems across the high-tech smart manufacturing industry.

7.0 Technologies Needed to Support Employees of These Firms for Global Competitiveness

7.1 Using Human Resource Information Systems (HRIS) to Manage and Onboard Talent

HRIS functions as a module from the ERP suite of technologies that are available. The features that HRIS systems perform covers remuneration, timesheets, benefits, learning and development, Human Capital Analytics (HCA), recruitment, self-service, and mobile telecommuting [42]. HRIS systems have been shown to improve the performance of Human Resource (HR) staff members across manufacturing firms [42] and their adoption will help recruiters for these companies attract and retain the best engineers [43]. Indeed, the future of shared data across the organization is paramount for this to work [44], the automation and self-service of administrative processes from HR practitioners will give them more time to focus on employee engagement and benefits. Most importantly, according to Mercer's 2018 Talent Trend Study for 2018, 68% of employees believe that state-of-the-art digital systems are important for their success at work. Nonetheless, digital HRIS will play an even bigger role for high-tech manufacturing organizations in the year 2035.

7.2 The Changing Demographics and Expectations of Work

According to the ManpowerGroup report from 2016, surveying 700 engineers and 70 employers within this same industry, found that 95% of employers planned on hiring in that year, while less than 25% believe they will find people with the right sufficient experience or technical skillsets [45]. With Deloitte anticipating that in the future, more than one-thirds of the world's population will be Generation Z [46] and the role of engineering may soon have to change with this generational tide. From this report, workforces will also become more multigenerational, gender diverse and educated [46] with for example, more than 3.5 million STEM jobs required by 2025 as predicted by the National Association for Manufacturing and Deloitte with a push to increase the number of women in science, technology, engineering and mathematics (STEM) up from 28%. LinkedIn's 2020 report found that 89% of companies believed that a multigenerational workforce made the organization more successful, 82% believe in internal hiring, 73% of HR leaders believe data is very important for their work and 96% say that employee experience is crucial [47]. The values of Generation Z can be regarded as being focused more on individual pursuits, independent work, financial security and career development [46]. With the experience-deficiency plaguing certain engineering industries, companies have resorted to virtual internships to give job seekers an insider look at how large companies work without incurring salary expenses. Companies like InsideSherpa deliver virtual internships to clients like General Electric, KPMG and Deloitte, giving job seekers experience before choosing to apply. With the war for scarce engineering talent hitting the manufacturing sector, high-tech firms in the future can expect to offer insider programs both digitally and physically to train and attract the best talent around using add-ons to HCM systems.

7.3 Predictive Analytics for Workforce Management

Indeed, predictive analytics within manufacturing firms has had tremendous successes with minimizing costs by preventing rather than curing symptoms during operations. Analytics are now being used to anticipate potential leavers of a company [48]. An ERP system featuring predictive analytics will help minimize equipment downtime and retain top talent across the organization. However, a study done by Mercer found that only 12% of companies today are using predictive analytics for workforce management, while digital organizations are 5.8 times more likely to see Human Resources (HR) as being important to the agile change management and implementation process of digital systems [48]. The application of predictive analytics for workforce management for example, has reduced labor intensities for management, improved training, better scheduling plans, and flexibility [49] [50], however, this increases the amount of temporary workers being used in manufacturing settings, risking further issues raised on industrial relations matters.

7.3 The Remote and Creative Engineer

Increasingly, younger generations have favored work environments that are highly entrepreneurial and support worker flexibility [48]. Unfortunately, only 9% of HR leaders from manufacturing organizations believe their company is offering flexibility benefits, with 51% of employees wanting and 45% believing it would negatively affect their chances of a promotion [51]. The features that support employee flexibility from these systems could revolutionize the traditional idea that engineers must be on-site to work and deliver designs, simulate work and reports. With ERP software moving mostly onto the cloud, engineers can work with real-time data anywhere and anytime, while possibly being remotely present at the factory working through the eyes of a drone. HRIS will work to provide the benefits of flexibility to engineers working within high-tech manufacturing firms.

8.0 Conclusion

High-tech manufacturing firms face an uncertain and difficult future ahead, not due in lack of work, but having to navigate through the disruptive and changing landscape of the business environment, labor market, and technological innovations. A modified S-ERP model and bringing AM processes closer to ERP systems holds the promise to supporting more sustainable and leaner production activities, better responsiveness for products to market, and reduced buffer stock throughout supply chain systems with automatic procurement. The mode of operation is one of cloud based which primarily analyses and responds to manufacturing problems using a preventive approach guided by predictive analytics. Partnerships formed with customers, vendors, NGOs and competitors through EPP-ERP systems will fundamentally change the way manufacturers approach and perceive alliances, with such systems providing greater clarity and better success rates by aligning all partners to a single clear goal. The disruptive nature of technological innovations which makes the familiar processes unfamiliar; the uncertainty surrounding ERP integrations from risks such as costs, poor project implementations and unconnected data that is antithetical to that of a smart and connected factory; and a near-absent cybersecurity framework to protect manufacturers who are the largest users of data; all pose as research challenges to ERP implementation for high-tech manufacturers. Finally, workers are demanding state-of-the-art systems to perform at work. The use of HRIS to reflect the changing demographics and expectations of job seekers will become important for manufacturers to appeal to applicants from all backgrounds. Predictive analytics can also be extended to assist HR practitioners with administrative work, giving room focusing on employee engagement. While the future engineer in this scenario will

be able to work flexibly using drones and cloud-based ERP systems. Nonetheless, without ERP systems, high-tech manufacturers today would not be able to function.

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