

Student Name: Lois Harris

Student ID Number: 1907505

Employer: Bisley F. C. Brown (Steel Equipment) Limited

Role: Strategic Buyer

Programme: MSc Advanced Manufacturing (Industry 4.0)

Module: Master's Project

Module Code: ACFA7003

Project Supervisor: Alan Mumby

Assignment Title: *The relationship between industry 4.0 and procurement strategy within the context of a manufacturing organisation*

Word Count: 15,000 words

Submission Deadline: Report submission: 31st January 2024

Viva presentation: 16th February 2024

Abstract

The purpose of this report is to explore the relationship between industry 4.0 and procurement strategy within the context of a manufacturing organisation. The objective is to explore the concept of procurement 4.0, considering how traditional best practices can be enhanced using industry 4.0 technologies.

Industry 4.0 is introduced and defined according to its four pillars, along with additional key concepts. The organisational values are presented as well as the wider trends for the future of the manufacturing sector. Procurement best practices are identified according to the Chartered Institute of Procurement and Supply - CIPS.

The literature review has three major elements: procurement 4.0, improving the value chain and redefining the supply chain. This presents the opportunities, challenges, and barriers; lean manufacturing and value chain analysis; and knowledge sharing and KPIs for decision-making.

Procurement plays a significant role in the value chain, and in creating and sustaining competitive advantage. Disruptive procurement relies on strategic sourcing, supplier management and using technology-driven processes. Value chain analysis, shortening the value chain and pareto analysis are fundamental. The challenges are departmental, managerial and employee related.

There is a clear relationship between the pillars of industry 4.0, and the four segments of procurement strategy:

1. Vertical networking and people / process development
2. Horizontal integration and supplier relationship management
3. Through-engineering and supply chain management
4. Exponential technologies and strategic sourcing

The future of procurement data analytics depends on the availability and integrability of various data types. This can support decision-making in a reactive or proactive way. There are a number of applications and potential benefits to leveraging procurement data; and this can ultimately be used in procurement data ecosystems.

Procurement AI encompasses machine learning and natural language processing. Although, the challenges must be considered simultaneously to the potential outcomes / benefits. The AI roadmap should include the immediate, short-term, and long-term vision. Successful management of change and innovation covers the entire organisation.

This manufacturing organisation, Bisley, will need to improve its knowledge and understanding of industry 4.0 concepts, technologies and opportunities and challenges. A procurement policy needs to be deployed before potential use cases for procurement data analytics and AI can be identified and presented as a business case.

Acknowledgements

I would like to acknowledge my gratitude to several individuals during the completion of not only this dissertation, but across the entire MSc program and previous part-time studies I have undertaken.

Firstly, to Alan Mumby, my project supervisor and innovation management lecturer, for his help, support, and guidance throughout the course. His experience, understanding and approachable character has been invaluable. I would also like to extend my thanks to the wider MADE Cymru team for their dedication to making the program the success that it is.

Secondly, I would like to thank all of my colleagues and mentors at Bisley F C Brown (Steel Equipment) Limited. A special thank you to both Paul Brown (Head of Procurement) and Dave Gawthorn (Purchasing Manager), for all of their guidance and expertise along the way. I am extremely grateful to Bisley for the opportunities that they have afforded me during my career thus far.

And finally, to my other half, Samuel, for his reassurance and belief in me throughout this stage in my academic and professional development.

Declaration Statement

I declare that the work in this dissertation was carried out in accordance with the regulations of UWTSD. The work is original except where indicated by special references in the text and no part of the dissertation has been submitted for any other degree.

Any views expressed in the dissertation are those of the author and in no way represent those of the UWTSD.

The dissertation has not been presented to any other University for examination either in the United Kingdom or overseas.

I hereby give permission for my work, if accepted, to be available for photocopying and inter-library loan, and for the title and summary to be made available to outside organisations.

Signed: *L. Harris*

Date: 19/12/2023

Table of Contents

Abstract.....	2
Acknowledgments.....	3
Declaration statement.....	4
List of figures and tables.....	7
1. Introduction.....	Pages 8 - 11
1.1 Introduction to the author.....	8
1.2 Bisley procurement department and categories of spend.....	8
1.3 History of the manufacturing organisation.....	8
1.3.1 Post Covid era: diversification.....	9
1.3.2 Business model, strategy, and innovation.....	9
1.4 Research problem: purpose, context, and rationale.....	9
1.4.1 Aims and objectives.....	10
1.4.2 Hypothesis and phenomenon.....	10
1.5 Research limitations.....	10
1.6 Structure and methodology.....	11
2. Setting the scene.....	Pages 11 - 15
2.1 What is industry 4.0?.....	11
2.2 What are the pillars of industry 4.0?.....	12
2.3 Industry 4.0 – definitions, themes, characteristics, and concepts.....	12
2.4 Bisley values – procurement goals, strategy, objectives, and techniques.....	13
2.5 Trends for the future of manufacturing.....	13
2.6 What does procurement best practice look like according to CIPS?.....	14
2.7 Strategic challenges and opportunities.....	15
3. Literature Review.....	Pages 15 - 22
3.1 Procurement 4.0.....	15
3.1.1 Opportunities, challenges, and barriers to implementation.....	15
3.1.2 Conceptual framework.....	17
3.1.3 Benefits in terms of financial, innovation and circular economy.....	17
3.2 Improving the value chain.....	18
3.2.1 Industry 4.0 in the context of lean manufacturing philosophy.....	18
3.2.2 Value adding – value chain model analysis.....	19
3.2.3 Digital readiness and change management.....	19

3.3 Redefining the supply chain.....	20
3.3.1 Implementation of industry 4.0.....	20
3.3.2 Ethics of digitalisation.....	21
3.3.3 Knowledge sharing and collaboration.....	21
3.3.4 KPIs for supply chain performance.....	22
4. Discussion.....	Pages 23 - 26
4.1 How has the procurement function evolved?.....	23
4.1.1 Value chain analysis and shortening the value chain.....	23
4.2 Procurement – current state.....	24
4.2.1 Detailed spend analysis, pareto analysis, and major suppliers.....	24
4.2.2 Findings.....	25
5. Implementation.....	Pages 26 - 34
5.1 How does industry 4.0 influence the procurement strategy?.....	26
5.1.1 Vertical networking and people / process development.....	26
5.1.2 Horizontal integration and supplier relationship management.....	27
5.1.3 Through-engineering and supply chain management.....	27
5.1.4 Exponential technologies and strategic sourcing.....	28
5.2 Future of procurement data analytics.....	28
5.3 Procurement AI – business case.....	31
5.4 Examples of procurement analytics software.....	33
5.5 Managing innovation and change.....	34
6. Conclusion.....	Pages 35 - 38
6.1 Summary of findings.....	35
6.2 Recommendations and future work.....	37
6.3 Evaluation.....	37
7. References.....	Pages 39 - 55
7.1 List of references.....	39
7.2 List of figures.....	44

List of tables and figures

Tables:

Reference	Title
1.1	Key aspects of value
2.1	Bisley values
4.1	Bisley financial statement figures 2022
4.2	Kanban value by category
5.1	Components of procurement data ecosystem
5.2	Procurement AI benefits and challenges

Figures:

Reference	Title
1.1	Procurement organisational chart
1.2	Annual steel consumption
1.3	% balance of change in orders
1.4a	Order intake report home market vs. export market
1.4b	Order intake report by cost centers
1.5	Components of business models
1.6a	Managerial pillars of innovation
1.6b	Technical pillars of innovation
2.1	Three key elements of Industry 4.0
3.1	Framework investigating values proposed by industry 4.0 in procurement
3.2	Digital Economy and Society Index (DESI) 2020 Ranking
3.3a	DESI UK Ranking 2018-2020
3.3b	DESI UK Ranking 2020 – Relative Performance by dimension
3.4	Digital Economy and Society Index (DESI) 2022 Ranking
4.1	2022 Spend Graph
4.2	Top 10 of 257 Supplier Expenditure 2022
4.3	Spend Analysis by Category 2022
4.4	Kanban Value by Category 2022
5.1	Procurement 4.0 Objectives
5.2	10 types of innovation
5.3	Category management cycle
5.4	Types of procurement data
5.5	Procurement data analytics categories
5.6	Components of a procurement data ecosystem

1. Introduction

1.1 Introduction to the author

The author of this report is employed as a Strategic Buyer within the procurement department at Bisley F. C Brown (Steel Equipment) Limited, based in Newport, South Wales. Beginning as an Engineering apprentice in 2014, the author has nine years of experience with the organisation within various departments including production / quality engineering and new product development. The author was promoted from technical buyer in September 2023, following the appointment of a new Head of Procurement in January 2023. This experience has developed an in-depth understanding and a well-rounded, unique perspective of the processes and systems currently used within this manufacturing organisation. Conversely, the author has no prior experience within the manufacturing industry, hence comparative reference to theoretical best practices and academic published research.

1.2 Bisley procurement department and categories of spend

The terms procurement and purchasing are often used interchangeably; whilst they are similar, there are differences between the two. The latter focuses on transactional functions whereas procurement focuses on the strategic process of product sourcing.

Purchasing is the act of acquiring goods or services and typically involves the immediate day-to-day transactions between sellers and buyers. The purchasing process involves:

- Spend requests and purchase approvals.
- Creation of a purchase order.
- Passing the completed purchase to the accounts payable team.

On the other hand, procurement is the process of sourcing and purchasing the goods and services a company needs to fulfil its business objectives, usually from an external source, like a third-party vendor or supplier. The procurement process involves:

- Sourcing activities and tactical sourcing.
- Negotiation and vendor management.
- Strategically selecting goods and services.

Purchasing is typically more focused on the short-term and purchasers are often looking to get items for the best price rather than the best overall value. Procurement is a more long-term, strategic approach to acquiring goods and services for the business. Unlike purchasing, procurement considers the total cost of ownership, not just the price. It's focused on building mutually beneficial partnerships with suppliers (Procurify, 2023).

Historically, the department has been *purchasing* and *operationally* focused ([figure 1.1](#)). It is a support function to manufacturing, with cross-departmental responsibilities to support sales, design, customer services and logistics. The largest categories of spend for the organisation include raw material - steel and melamine faced chipboard, powder paint, packaging, locks, and fixtures/fasteners.

1.3 History of the manufacturing organisation

Bisley is a manufacturer of office storage, established in the 1940s. Traditionally specialising in manufacturing steel office products, more recently the organisation expanded its capabilities to manufacture wooden products too. This ventured into market segments including healthcare, residential and hospitality as well as the office landscape. The organisation has just one manufacturing location but uses various processes and equipment including sheet metal laser cutting,

CNC routing and electrostatic powder coating to manufacture products for its customers. The organisation sells and distributes products all over the world including the UK, Ireland, North America, and Dubai, as well as European countries including France, the Netherlands and Germany.

1.3.1 Post Covid era: diversification

Market trends have seen a decline in demand for traditional steel storage over the past decade, (figure 1.2), combined with the recent global pandemic, Brexit, ongoing international conflict, and the energy crisis – times have been challenging for the organisation, and the UK manufacturing industry as a whole (figure 1.3). Customer demands continue to evolve at an exponential rate. Mass customisation of products must allow for a combination of finishes, materials, and technologies to be utilized to provide domesticated work environments built for collaboration and flexibility. Post-global-pandemic, now more than ever, the workspace is ripe for reimagination (Bisley, 2023). Historically, predominant sales channels included furniture dealers, wholesaler networks and sales directly to corporate clients. However, largely due to the influx of working from home – the organisation now sells directly to individual customers via its own e-commerce platforms and retail partner John Lewis (figure 1.4a & 1.4b).

1.3.2 Business model, strategy, and innovation

The business model has and needed to evolve in order to remain competitive, but as a manufacturing organisation innovation must be continuous. A business model describes the rationale of how an organisation intends to create, deliver, and capture value (Ibarra, 2018). It underpins value proposition, market segments, structure of value chain, value capture mechanisms and how these elements link together (figure 1.5). A business strategy is required to create and appropriate value from the organisation's systems, processes, resources, and competencies (Kohtamaki, 2020). According to most literature (Grabowska, 2022), (Ibarra, 2018), (Muller, 2018), and (Platform Industrie 4.0, 2019) value can be broken down into four key aspects:

Value creation	Activities, resources, and partnerships
Value delivery	Products and services
Value distribution	Communication, sales channels, customer segments and customer relations
Value capture	Monetisation - cost and revenues gained

Table 1.1 – Key aspects of value

In order to win the global race for competitive advantage and create new value propositions; innovation needs to be centred around managerial (figure 1.6a) and technical (figure 1.6b) pillars simultaneously.

1.4 Research problem: purpose, context, and rationale

The traditional manufacturing industry is in the throes of a digital transformation that is accelerated by exponentially growing technologies. This widespread adoption is paving the way for disruptive approaches to product / process development, manufacturing, and the entire logistics chain (Deloitte, 2021). Whilst there is potential for great opportunities as part of this transformation, there remains ambiguity regarding the relationship between industry 4.0 and strategy at departmental level. The purpose is to explore the relationship between industry 4.0 and procurement strategy within the context of a manufacturing organisation.

1.4.1 Aims and objectives

The main objective is to explore the concept of *procurement 4.0*, considering how traditional best practices can be enhanced using industry 4.0 technologies. It is perceived that alignment of the procurement and industry 4.0 strategies can provide added value to the manufacturing organisation. It is intended that the research can be used as a roadmap for future development of the procurement strategy and function.

Subsequently, the aim is to address fundamental issues including:

- The societal pressure placed on manufacturing organisations to reduce lead times and costs, driven by changing customer habits and therefore expectations.
- The development and management of partnerships with an increasing number of third-party vendors or suppliers as a direct result of globalization, and risk management due to economic and environmental instabilities.
- The impact of market saturation and increased competition – ensuring adequate processes and resources are in place to facilitate development in prioritized areas of business growth.
- Identification of ways to adapt the business model so that best practices are adhered to – on a pathway to a greener and more circular future.

1.4.2 Hypothesis and phenomenon

The hypothesis is that without a procurement strategy, which has been developed with consideration to industry 4.0 implementation, fundamental mistakes will be made, and opportunities missed concerning the procurement function. This includes process development, supplier relationship management, supply chain management and strategic sourcing.

This could result in losing a competitive advantage over other manufacturing organisations within the industry. The organisation could lose their grasp on understanding the wants and needs of the customer, and waste valuable resources developing over-complicated solutions which are difficult and expensive to source and manufacture (Nicholas, 2018). In addition to an unclear business strategy, limited innovation, and poor product development, this could also bring negative connotations socially and environmentally.

The strategy for industry 4.0 adoption and procurement strategy must be aligned and utilized to enhance and improve decision making within management of the supply chain. There are opportunities to be realized from a financial, industrial, social, and environmental perspective.

1.5 Research limitations

It is necessary to introduce research limitations in order to define the scope of the work undertaken. The first non-negotiables were the word count limitation of 15,000 words and the ability to complete all work before the deadline of January 31st, 2024. Furthermore, the research has been undertaken within the context of a manufacturing organisation – namely Bisley F. C Brown (Steel Equipment) Limited. This is a manufacturer of furniture – manufacturing solely within the UK, the organisation operates as a small medium enterprise with a total of 354 employees at the Newport factory. There are a further 35 employees across the UK showrooms and approximately 100 employees across the subsidiaries. The organisation is also a private limited company. The research is limited to the relationship between industry 4.0 and the *procurement* strategy.

1.6 Structure and methodology

The structure and methodology of the research will be outlined by the following sections:

Setting the scene – this section will provide a holistic view of the research background including defining the concept of industry 4.0, Bisley's organisational values and trends for the future of manufacturing. Procurement best practice will be discussed, and strategic challenges and opportunities identified.

Literature review – the literature review can be categorised into three major elements: procurement 4.0, improving the value chain and redefining the supply chain. The first predominantly looks at opportunities, challenges, and barriers to implementation. The second element reviews lean manufacturing and value chain model analysis. The section ends with the ideologies of knowledge sharing and KPIs for decision making.

Discussion – this section reflects upon how the procurement function has evolved and defines the current state within the manufacturing organisation.

Implementation – how does industry 4.0 influence the procurement strategy? This section considers the future of procurement data analytics and provides a business case for procurement AI, with examples of procurement analytics software. Managing innovation and change is also discussed within this section.

Conclusion – to finalise there is a summary of the research with recommendations for future work and an evaluation of the work undertaken.

2. Setting the scene

2.1 What is industry 4.0?

The traditional manufacturing industry is undergoing a digital transformation that is being accelerated by exponentially growing technologies. The term industry 4.0 is commonly interchanged with the Fourth Industrial Revolution – and represents production networking and the digitalized connectivity between suppliers and customers. Three key elements of industry 4.0 are: high grade digitalisation, smart manufacturing through cyber-physical systems and inter-company connectivity between the value chain (figure 2.1).

Many academics, including (Powell, 2021) suggest that digitalisation of manufacturing is the essence of industry 4.0 realisation. It presents a new era in the organisation and the control of the industrial value chain. The first industrial revolution saw the introduction of mechanisation through steam engines and water/steam power. This transformed iron production, mining, and the textile industry amongst others. The second industrial revolution brought further technological advances as well as electrification. This introduced the production line, globalisation, and mass production. Next came the third industrial revolution which rapidly increased productivity using the internet, digital manufacturing technologies and digitisation. Industry 4.0 emphasises networks of machines, operating autonomously as cyber-physical systems (Tjahjono, 2017).

2.2 What are the pillars of industry 4.0?

1. Vertical networking of smart or cyber-physical production systems: smart factories, products, services, and marketing; with strong needs-oriented, individualised, and customer-specific production operations. This enables a rapid reaction to change in demand or stock levels. Not only autonomous organisation of production management but also maintenance management. Maximisation of resource efficiency including materials, energy, and human resources.

2. Horizontal integration by means of new global value-creation networks, including integration of business partners and customers, and new business and co-operation models. These networks enable both real-time optimisation and integrated transparency. Offering a higher level of flexibility and better global optimisation; in terms of financial, social, environmental, and sustainable benefits.

3. Through-engineering throughout the entire value chain, taking not only the production process but also the end product – the entire product life cycle. New synergies created between product development and production systems. Data and information are available at all stages of a product's life cycle, enabling new more flexible processes to be defined from data, via modelling to prototypes and product stage.

4. Acceleration through exponential technologies that allow for individualised solutions, flexibility, and cost savings.

- Internet of Things (IoT) and cloud computing
- Simulation and augmented reality
- Additive manufacturing (3D printing)
- Big data analytics
- Cyber security
- Artificial intelligence (AI) and robotics

(Deloitte, 2021)

2.3 Industry 4.0 – definitions, themes, characteristics, and concepts

A previous tertiary literature review of industry 4.0 conducted by Lemstra (Lemstra, 2023) found that articles based on a content analysis could be presented in three categories: industry 4.0, enabling technologies and operations management. The first sub-categorised by concepts, technologies and applications, and the latter on production planning and control, supply chain management and predictive maintenance. Other authors such as Galati (Galati, 2019) classified their results into four clusters: business, operations, technologies, and training. Most literature agreed with Sony's (Sony, 2020) characterisation of industry 4.0 into five main attributes including: a) digitalisation, optimisation, and customisation of production, b) automation and adaptation, c) human-machine interaction, d) value-added services and businesses and e) automatic data exchange and communication.

Chauhan (Chauhan, 2020) showed that most research in industry 4.0 is directed to manufacturing and logistics and that the digitisation of supply chain management (SCM) is a topic of growing interest. The topics found during their review of industry 4.0 in supply chain management studies included:

- Conceptualisation of I4.0 for SCM
- Principles for implementing I4.0 in SCM
- Digitalisation outcomes
- Performance of digitised supply chains

- Managing digitised supply chains
- Drivers and barriers of I4.0 in SCM
- Digitised supply chain practices and
- Collaborative engineering and customisation

Industry 4.0 has rapidly grown over the past few years, accompanied by exponential growth in literature on its many enabling technologies (Buchi, 2020). However, only a few economic and management studies exist and these focus on primary topics including “improving the value chain” and “redefining the supply chain”.

2.4 Bisley values – procurement goals, strategy, objectives, and techniques

In the latest Bisley strategy document for 2023/24, the organisation has five core values: integrity, pioneering, sustainability, creativity and connected (Bisley, 2023).

Integrity	Honesty and transparency are paramount. Long-term reputation will not be sacrificed for any short-term gain.
Pioneering	Relentless and considered in the approach to innovation, using the latest sustainable manufacturing processes and technologies.
Sustainability	Continue to invest in people, processes, manufacturing, talent, and leadership, for long-term benefit.
Creativity	Constantly seeking to improve and innovate, operating with agility.
Connected	Relies on loyalty and connection with customers and suppliers.

Table 2.1 – Bisley values

In line with values of the overall organisation, the goals of the procurement department are to make operational improvements through people and process development, manage risk through supplier relationship management, promote commercial growth by supply chain management and reduce the total cost of ownership by strategically sourcing.

2.5 Trends for the future of manufacturing

According to the 2022 world manufacturing report, (World Manufacturing Foundation, 2022) the following six disruptive trends for the future of manufacturing were presented as sources of great opportunity to deliver solutions of excellence. These trends are likely to play out simultaneously and not alternatively.

Cognitive manufacturing

- Promote AI to support resilient supply networks.
- Utilise AI to track and respond to supply network disturbances.
- Exploit AI to improve daily operations.

Circular manufacturing

- The circular economy (CE) is acknowledged as a way to minimise impact and encourage firms to look into new circularity prospects.
- Enable cooperation among relevant stakeholders in building circular value chains.
- Facilitate information sharing in the value chain.
- Track the flow of materials and/or products in different stages of the value chain.

Global risk-resilient manufacturing

- The goal of a globally competitive and resilient manufacturing system will be realised via the combined efforts of several players from different sectors and across various governance levels.
- Prior to redesigning global supply chains, it is important to understand the actual problems that businesses encountered during the COVID-19 pandemic and the policies that can address such problems.
- Build resilient global value chains through effective policies.
- Diverse sourcing and digitisation are key to building stronger and smarter supply chains.
- Utilise new demand management strategies to create robust supply chains.

Hyper-personalised manufacturing

- Hyper-personalisation commands a certain closeness with, and to, the customer.
- The post-COVID future of customer involvement in retail is hyper-personalisation¹⁸⁰.
- Customize for Local and Global Markets.

Rapidly responsive manufacturing

- Speed has become more significant than scale on a number of fronts, including time to market, time to gather input and learn from it, and time to make and carry out decisions.
- Flexible supplier bases enable businesses to better withstand unexpected events that disrupt the supply chain.

Inclusive manufacturing

- Inclusive supply networks are a key tool the manufacturing sector may use to make a lasting and beneficial impact.
- An inclusive supply chain will lead to a resilient economy.

2.6 What does procurement best practice look like according to CIPS?

The Chartered Institute of Procurement and Supply is a global membership organisation driving positive change across the procurement profession. They are a voice and standard, defining and amplifying best practice (CIPS, 2023).

Value generation: Procurement has shifted in focus from tactical and reactive to strategic and proactive. The opportunity to generate added value has increased, due to technology automating many of the more procedural aspects of the function. Value is the regard that something is held to deserve; importance or worth, whereas added value is the difference between a particular product's final selling price and the direct and indirect input used in making that particular product (CIPS, 2023).

Total cost of ownership is a methodology whereby in addition to the price of a purchase, other purchase-related costs are incorporated. TCO approach has become increasingly important as it helps organisations to look for ways to understand and manage their costs better (CIPS, 2023).

Collaborative working: requires companies and employees to engage with each other to enhance the effectiveness and value within the supply chain. The basis is around sharing needs, expertise, experience, resource, and risk to promote cost reduction, added value and innovation. Through open communication and strong teamwork ideas can be increased, time to market reduced and the overall

expenditure significantly reduced without compromising quality. It is essential to engage with all key stakeholders to ensure buy-in and long-term commitment (CIPS, 2023).

Supplier performance management: Most organisations rely on timely deliveries, price reductions and service quality offered by suppliers to make more profit. Supplier performance management is the business process that includes the methods and systems used to collect and provide information in order to measure, rate, or rank suppliers on a continuous basis. The monitoring criterion should be agreed in the contract or service level agreement to ensure standards are adhered to, and room for improvements are identified (CIPS, 2023).

2.7 Strategic challenges and opportunities

CASME is a global membership community which inspires procurement excellence with market insights, benchmarking studies and events. A RoundTable meeting on the strategic challenges and opportunities for indirect procurement were held globally between August 2018 and June 2019. The following main topics were discussed: business challenges, adapting procurement's organisational structure, developments in strategic sourcing, increasing the strategic value of procurement, the impact of technology on procurement and procurement personnel and skills development (CASME - Market Focus Research Limited, 2017).

3. Literature Review

3.1 Procurement 4.0

Procurement can be defined as the “business management function that ensures identification, sourcing, access, and management of the external resources that an organisation needs or may need to fulfil its strategic objectives”. It is the arrangement and interpretation of consumers' needs and prerequisites extended in the process of obtaining the right goods at the right time at the right cost (Jerome, 2022). There are four major disciplines which include:

1. Financial performance – planning company finances regarding the acquisition of goods / services.
2. Supply chain risk mitigation– operational, financial, customer, contract and vendor risk, or any kind of disruption which might hamper profitability.
3. Transparency and visibility – leading to better communication, accountability, and healthy competition.
4. Strategic decision making – efficiency in the supply chain and building trust across the value chain.

3.1.1 Opportunities, challenges, and barriers to implementation

In the era of digitisation, procurement will grow its corporate price as an innovation “catalyst” by way of linking crucial external understanding and competencies with internal business elements to make their supply chains more efficient and transparent. With the help of industry 4.0 technologies, it is becoming easier to analyse, predict, visualise, and trace plus it will refine the capability of real-time decision making.

Business optimisation has emerged as a key driver for ensuring the sustainability of businesses globally, and it must include supply chain optimisation along with other business functionalities. It becomes extremely important that the right product reaches the right customer at the right time. Elements affecting the total cost of ownership are also important such as quality, efficiency, delays, stock outs, obsolescence, and conveyancing costs. In the context of the supply chain, resilience can be defined as

“the ability to return to its original state or move to a new, more desirable state after being disturbed.” Resilience can be achieved through the collaboration between the organisation and its network of suppliers. The application of industry 4.0 concepts into the procurement activities of an organisation can make it more resilient and efficient.

The major challenge remains that managers, practitioners and decision-makers have still not grasped the concepts of industry 4.0 due to the low level existing technological infrastructure. Small, medium, and micro-enterprises have limited resources, which drives them to invest only if benefits are visible. Through the review of existing literature, eleven barriers have been identified by (Jerome, 2022):

1. Organisational and employee inertia
2. Lack of interdepartmental communication
3. Lack of resource for training
4. Cultural change
5. Data security and confidentiality
6. Lack of supplier willingness and capabilities
7. Lack of information technology and information system infrastructure
8. Lack of understanding of requirements, capabilities, and benefits
9. High and unclear investments
10. Perceived ease of use and usefulness
11. Lack of support from management due to uncertain return on investments

The study focuses on the concept of mutual growth of the supply chain as a whole through leveraging industry 4.0 beyond the boundary of the organisation. When the initial review of the literature was conducted, it was seen that studies that related directly to the implementation of industry 4.0 to procurement were less. This type of implementation differs from other domains, as there is an inherent need for co-operation and co-ordination between the organisation and its network of suppliers for procurement 4.0 to succeed. While the traditional supplier management techniques such as on-boarding, negotiations and evaluations have been the reason for the development of procurement in the past, the usage of these technologies provide opportunity to automate these repetitive tasks and would give scope for resource allocation for other purposes.

“High and unclear investment” is one of the most restrictive barriers to adoption. This can be attributed to the fact that the pandemic has put organisations in a weak position when it comes to liquidity and cash flow. As a result, organisations are trying to hold onto more cash, thus reducing investments. However, when considering the medium- and long-term survival of an organisation, investment in emerging technologies becomes important for increased agility. There is a need to maintain liquidity whilst also investing for survival in the future.

Cultural change is inevitable when there is a new disruptive technology coming into play. The culture of the organisation must evolve into one where risks are taken after proper calculation and risk analysis. Top management must ensure the presence of a clear and long-term strategy to achieve goals. Cognitive flexibility, (which refers to the mental ability to switch between various concepts), has proven to play a positive role in reducing inertia (a tendency to do nothing or to remain unchanged). Inertia can be overcome through strong communication and collaboration. There is a tendency to invalidate technology due to fear of loss of job and also to the thought that a machine can never be greater than man. For cultural change to be effective and smooth, good support and leadership from management are imperative (Jerome, 2022).

3.1.2 Conceptual framework

Procurement 4.0 is a component of industry 4.0, which introduces connecting all supply chain upstream partners and enables dynamic and quick co-operation and co-ordination beyond organizational frontiers. The main and most significant problem is relating to the cost of the implementation. To put it another way, the organisation needs to know how the investment in technology can bring the required value to overcome new challenges they may face.

A conceptual framework is developed to classify different value propositions provided by the different applications of industry 4.0 technologies in procurement process. Results reveal nine value propositions that can provide a better understanding for the department to analyse the benefits of these technologies. Primary values that the procurement department offer include pricing, supplier performance management, reducing the relevant costs, developing sustainability, risk management, data-security improvement, data-sharing management, purchasing performance management and cross-functional activity (Figure 3.1).

Hereof, the conceptualised framework indicates that managing purchasing operations and the process associated with supplier selection and evaluation are the most attended values in procurement management. Additionally, big data analysis, the internet of things and blockchain technology are the most frequent procurement 4.0 applications to propose these values (Jahani, 2021).

To begin, managers need to focus on building technological resources in their companies. Second, procurement 4.0 should be applied to enhance operations productivity. Next, the proposed values in this study should be aligned with the supply chain performance measures and strategies. The significant role of managers is to integrate big data analysis, artificial intelligence, and the internet of things to form the supply chain performance architecture. Finally, practitioners must emphasise the procurement 4.0 policy for every operation in the supply chain to be able to pursue and adhere to the added values (Jahani, 2021).

3.1.3 Benefits in terms of financial, innovation and circular economy

Simultaneously to the deluge of information on emerging technologies, procurement professionals are also motivated to embark on circular procurement as well as industry 4.0 to generate more value. Today, the procurement function is more than a support activity within manufacturing organisations. Instead, today's managers engage in a strategic procurement view and seek to align this procurement activity with sustainability goals while including digital technologies (Rejeb, 2022). Organisations that are strategically prepared to implement procurement 4.0 are also those that have a higher level of competitiveness in the context of the circular economy. This is because the openness of managers to the circular economy has proven to be an element that also positively influences the competitiveness of the organisation, and this influence is enhanced by the level of strategic procurement 4.0 performance (Corbos, 2023).

However, in the context of digitalisation and procurement 4.0, the level of strategic training of the organisation is the one that has a decisive influence on the achievement of superior performance. Therefore, strategic thinking becomes critical. Strategic thinking regarding procurement 4.0 works on three levels: a) procurement 4.0 strategy, b) procurement 4.0 planning and c) procurement 4.0 performance review (Corbos, 2023). Constant evaluation brings continuous improvement of the system – with consideration to both the long-term and short-term vision. The competitiveness of the organisation does not only refer to financial performance, but also the capacity for innovation, know-how and level of co-operation. Based on the findings of this study, it can be concluded that there is a need for greater understanding of the benefits of procurement 4.0; because it offers advantages such

as increased supply chain collaboration, the use of hard data in decision making and improved employee skills. These are all essential in the context of circular economy and achieving the organisation's sustainability goals (Rejeb, 2022).

3.2 Improving the value chain

(CIPS, 2023) Michael Porter first introduced the concept of 'The Value Chain' in his influential book *Competitive Advantage* in 1985. He argues that understanding how your company creates value and looking for ways to add more value are critical elements in developing a competitive strategy. The value chain describes the activities that are involved in delivering value to your customers. Value creation is the way in which you can create added value for the customers of your product. Adding value creates higher profitability for an organisation. Higher profitability through introducing added value is the basis of competitive advantage.

3.2.1 Industry 4.0 in the context of lean manufacturing philosophy

Industry 4.0 affects nearly every aspect of life by making it more technologically advanced, creative, environmentally friendly, and ultimately more interconnected. Concerns about globalisation are connected to a variety of issues. They harness the potential to allow for greater integration of developing countries, eradication of poverty and the introduction of new possibilities for manufacturing, innovation, employment, large scale industry and value chains - which are essential to global commerce. Industry 4.0 technologies are now more widely available, which lowers entry barriers, virtualises the global value chain, and increases the potential of lean processes (Kliestik, 2023). According to Rogers (Rogers, 2021), industry 4.0 integration would increase global trade productivity by 6% to 8% yearly. However, with creation and incorporation at a rate that has never been higher, there is a fundamental question to consider – where does man fit into such a society?

One of the major challenges in implementing industry 4.0 is standardisation. Womack (Womack, 1994) claimed that automated systems can integrate lean production through the following techniques: beginning with the customer, establishing corporate excellence, determining what is important to the customer, determining how value flows, and ensuring that the process is operational. Liker (Liker, 2004) then expanded on this idea by supporting a way of thinking that aims to ensure the continuous flow of product, through the process of introducing a culture wherein everyone aspires to development, and the balancing of the customer's demand against the movement of the product throughout the entire manufacturing process is such that what is taken away by the subsequent activity is replenished at irregular intervals.

The highest possible quality of the products travelling down the automated assembly line must be ensured through "Jidoka". This is regarded as a philosophy – automation with a human touch. Lean manufacturing lines typically use "Poka-Yoke" components to cut down on human error. In accordance with the "Genchi Genbutsu" concept, the whole authorised team of employees gather at the location of the quality failure when the "Andon" signal is activated and collaborates to find the root-cause. However, in the current market, a one-piece flow does not currently offer "just-in-time (JIT)" production. "Heijunka" is necessary to sustain output, since customer demand is frequently irregular – it is used to determine a type of mix that must be made in each time period in order to satisfy all of the customer's long-term requests without using overtime. The Toyota Production System (TPS) philosophy aims to eliminate waste and achieve the best possible efficiency (Kliestik, 2023).

It is evident that parallels can be drawn between lean manufacturing principles and the fundamentals of industry 4.0. Powell (Powell, 2021) implies that it is important to prioritise the lean manufacturing philosophy first, before even considering industry 4.0. Technologies cannot assist in achieving better

efficiencies if the task is ultimately waste. Whilst considering lean principles as a prerequisite to industry 4.0 implementation is logical, it is difficult to understand in practice how to determine when a business is 'ready' for industry 4.0 – as lean is commonly associated with continuous improvement. The question is where does this improvement plateau?

3.2.2 Value adding – value chain model analysis

Competition brings many challenges for companies operating on the market, moreover, today competition can be considered in a global sense. It is necessary to change business models and value chains in organisations so that they can integrate technological innovations supporting the creation of value, which is mainly based on the use of available data. It is claimed that half of industrial enterprises in Germany are involved in this concept already and by 2030 German enterprises should operate on the internet industry system. The challenge for organisations is to find a workforce that has the knowledge needed to implement such a production flow. This process will change the relationship between organisations, suppliers, and customers – the entire value chain. Production will be more flexible, adapted to customer needs (Kohnova, 2023).

Due to the influence of industry 4.0, value chains are able to change from mass production to products tailored to the customer. The customer is perceived as a partner and can choose which material will be used in the production of the product and also which technology will be used (Weking, 2020). The product contains new functionalities, are more reliable, usable, and better than traditional products. The new nature of products disrupts traditional value chains and forces organisations to react and reorganise processes (Porter, 2014). Digital transformation affects the overall reengineering of organisations. Technologies build vision across the value chain and are the foundation for automation to enable efficiency and competitiveness.

When building a business strategy, the organisation must therefore consider the alignment of digital and information systems. The premise of a virtual value chain is data generation. Therefore, it is important for companies to analyse the impact of digital transformation on the value chain from a data cycle perspective. In general, research results point to a stronger importance of supporting activities for companies, in context of coping with industry 4.0 challenges than that of primary activities. Companies that do not conduct many activities in automation and digitalisation do not see the high level of future risks, as well as the inevitable need for constant progress. University-industry collaboration offers knowledge, up-to-date information, and support in the implementation process (Kohnova, 2023).

3.2.3 Digital readiness and change management

Digital readiness of the population can be measured using the DESI index (Digital Economy and Society Index). The index's goal is to evaluate how EU nations are faring in terms of the digital economy and society. The five categories of the ranking system are: connection, human capital, internet use, integration of digital technology and digital public services.

Since the UK left the EU in 2020, they are no longer included in the DESI index, however the results from the 2020 ranking show that the UK was considered 8th place out of the 28 EU Member States – (Figure 3.2) (European Commission, 2020).

Whilst the overall score improved over the period between 2018 and 2020, 53.5 to 60.4 respectively, the overall ranking of the UK fell year on year (figure 3.3a), suggesting that other countries were improving their digital readiness at a faster rate than the UK. The poorest dimension was digital

connectivity, despite the best performance dimension being the use of internet services (Figure 3.3b) (European Commission, 2020).

Germany ranked 12th out of 28 EU Member States in the 2020 edition of the Digital Economy and Society Index (DESI). On the connectivity dimension, Germany leads the EU on 5G readiness and has a high take-up of overall fixed broadband. In March 2016, the Federal Ministry for Economic Affairs and Energy presented the Digital Strategy for 2025. In March 2018, a new state minister for digitisation was appointed, reporting directly to the Chancellor's Office.

In November 2018, the federal government published its implementation strategy 'Shaping Digitalization'. The objective was to continue improving the quality of life for everyone in Germany while also leveraging economic and ecological opportunities and securing social cohesion. The strategy comprises five specific pillars: (i) Digital competence; (ii) Infrastructure and equipment; (iii) Innovation and digital transformation; (iv) Societal shift towards digitalisation and (v) the Modern state (European Commission, 2020).

By 2022, Germany's rank had slipped to 13th place, being overtaken by Austria, Slovenia, and France (figure 3.4). This is arguably surprising as the term "industry 4.0" was first reputedly made in 2011 when the German government coined this term to announce a new high-tech economic strategy, proclaiming the dawn of a "new industrial age" (European Commission , 2022).

3.3 Redefining the supply chain

A supply chain is a network of individuals and companies who are involved in creating a product and delivering it to the consumer. Links on the chain begin with the producers of the raw materials and end with delivery of the finished product to the customer. Supply chain management is a crucial process because an optimised supply chain results in lower costs and a more efficient production cycle. Organisations seek to improve their supply chains so they can reduce their costs and remain competitive (Hayes, 2023).

3.3.1 Implementation of industry 4.0

Technology Transfer (TT) is the movement of data, designs, inventions, materials, software, technical knowledge, or trade secrets from one organisation to another or for one purpose or another. The technology transfer process is guided by the policies, procedures and values of each organisation involved in the process (TWI Global, 2023). The application of industry 4.0 technologies in traditional supply chains are stated as being guided by six value drivers (Luiz da Silva, 2018):

1. Supply chain planning: will be influenced by technologies such as big data, advanced analytics, and automation of knowledge work.
2. Physical flow: through better connectivity between supply chain stages, additive manufacturing, advanced automation, autonomous and smart vehicles aim to reduce costs.
3. Performance management: control systems, performance indicators, big data and data mining techniques and machine learning aim to identify dysfunctions in the processes.
4. Order management: the processing of orders can be performed by digital means, and re-planning, if necessary, in real-time, aims to reduce costs and improve the reliability of the consumer.
5. Collaboration: cloud technologies create digital platforms between suppliers, industry, and customers and;
6. Supply chain strategy: customised products provide most value for the consumer and help reduce costs through big data and other technologies and strategies.

According to Schrauf (Schrauf, 2016), supply chain 4.0 basically consists of nine main elements: integrated planning and execution of operations, logistic visibility, smart storage, efficient management of inputs, autonomous logistics, prescriptive supply chain analysis, flexibility of processes, reduction of delays and efficiency and cost reduction.

3.3.2 Ethics of digitalisation

The basis for the adoption of new business models, production processes, development of intelligent technologies and new curriculum in academia, centres around the challenge to find human talent with the capacity to develop analytical algorithms that lead to the development of self-learning intelligence, taking advantage of the current infrastructure. An essential characteristic to perform industry 4.0 include the socio-technical environment as well as physical object virtualisation. The need for human talent-sociotechnical integration is fundamental (Saucedo-Martinez, 2018).

In 1943, Abraham Maslow, a pioneer in motivation research, defined the basic needs that drive all human beings. He put these needs into a hierarchy in a way that he claims, that, once the needs of one level are fulfilled, the fulfilment of the next level is the next goal. Human beings, whose fundamental physiological needs are satisfied will seek to establish a safe and protected environment. Once this environment is assured, he or she will seek to satisfy the love needs. In 1970, Maslow further detailed the hierarchy of needs by adding two additional classes of needs between the love needs and esteem needs – cognitive needs and aesthetic needs. Additionally, on top of his hierarchy, Maslow added transcendence needs, which is the desire to help others to achieve self-actualisation (Maslow, 1943).

Human needs are an important motivator – industry 4.0 will change the way we live and work, and individuals will be required to acquire new competencies. The key is to engage those people in the new process as soon as possible – so that they increase their ownership in the process design. Communication, expression, connectivity, morale, and willingness are fundamental to develop new solutions, strive for continuous improvement and create success within the organisation (Kinzel, 2016).

3.3.3 Knowledge sharing and collaboration

Given the potential advantages afforded by adopting industry 4.0 technologies, especially in increasingly competitive environments, many organisations remain hesitant to implement these technologies more comprehensively. Instead, most organisations still tend to confine themselves to experimenting with stand-alone industry 4.0 approaches for individual machines and in-house production steps, meaning they do not harness the full potential. Collaboration is vital not only for optimising the affordances of industry 4.0 in the supply chain but also for facilitating large-scale adoption.

Knowledge sharing can enable manufacturing organisations to learn from the experience of others. By diminishing intra- and inter- organisational boundaries, digital integration can further help strengthen supply chain partners' collaborative relationships. As multiple studies have shown, an effective way of obtaining external knowledge is through the adoption of voluntary knowledge-sharing with other supply chain "actors" such as direct suppliers and customers (Eslami, 2023).

Types of knowledge can include explicit or tacit information. The first refers to codified knowledge such as fact and symbols that can be stored and accessed in different ways and is thus easily transferrable. Tacit information is knowledge possessed by the organisation's employees that is difficult to codify, complicated to understand and challenging to transfer. The major challenges associated with knowledge sharing within the supply chain are *maintaining the effectiveness of partnerships over time*

– continuity of mutual benefits and minimising intentional and non-intentional knowledge leakage. *Self-interest* – relationship-specific knowledge tends to nurture a long-term perspective. Trustworthiness needs to be developed and takes time to build. *Relational challenges* – transferring internal knowledge to suppliers or customers tends to be a highly sensitive issue.

Some of the factors influencing knowledge sharing within the supply chain include *relationship-related modifiers* – mutual trust plays a significant role in this process as a key driver for effective knowledge sharing and for building complementary capabilities across supply chain “actors”. Commitment has also been shown to influence the success of knowledge-sharing initiatives by positively influencing “relationship performance” (Eslami, 2023). Power balance in knowledge-sharing partnerships needs to be carefully considered to avoid the coercion of weaker parties. *Company readiness* – the willingness of companies to share knowledge is often people dependent. Knowledge-sharing with supply chain members has been shown to help organisations compensate for the lack of internal expertise. Such knowledge asymmetry need not be an impediment however; and can be overcome if organisations with greater industry 4.0 maturity share their knowledge and best practices with less experienced partners to enable industry 4.0 adoption across organisational boundaries and combine expertise from different perspectives. Proactive approaches to knowledge-sharing can accelerate the process of trust building amongst supply chain partners in adopting industry 4.0.

3.3.4 KPIs for supply chain performance

Supply chain performance has evolved towards other dimensions considering social and environmental perspectives to guarantee efficiency; not only from economic perspective but ensuring sustainable organisations and making eco-friendly products. As a result, transparency across the supply chain is becoming increasingly important. Chamola (Chamola, 2020) claimed that agility and collaboration are powerful enablers to lead industry 4.0 transformation. Supply chain challenges are structured around business, technology, sustainable development, collaboration, and management strategies. This methodology is based on the decision-model and key performance indicators that allow individuals to quantify the needs of industry 4.0 technologies and the current status of implementation.

Supply chain resilience has been proven to be improved (Spieske, 2021) thanks to big data adoption in priority of other technologies such as additive manufacturing, which still lacks proof of effectiveness. Internet of things, artificial intelligence and big data are the most frequently quoted technologies – these can improve KPIs regarding intra- and inter- organisational costs and create more value for organisations. Currently it is difficult for organisations to choose the most appropriate technology for their needs. Very often, the optimisation concerns one department disregarding the others.

It is important to consider the steering levels referring to different decision horizons. Different departments and different decision granularities lead to differentiation in levels:

1. Strategic (horizon 3-5 years)
2. Tactical (horizon 1-6 months)
3. Operational (horizon 1-2 weeks)

Strategic levels include decisions focusing on long term goals; tactical level on medium term decisions focusing on means to implement and reach goals and operational decisions focusing on short term decision aiming to use these means (Kihel, 2023).

4. Discussion

4.1 How has the procurement function evolved?

There has been a growing recognition of the critical role that procurement plays in creating and sustaining competitive advantage as part of an integrated logistics process. There is a major opportunity for leveraging the capabilities and competencies of suppliers through closer integration of the buyers and suppliers' processes. In this way, procurement plays a significant role within the value chain. Procurement can use value chain analysis to understand suppliers' costs. Having this information is invaluable when negotiating and partnering with suppliers to understand real value drivers, find innovation and generate cost reductions (CIPS, 2023).

Disruptive procurement relies on three pillars (Kearney, 2020):

- Strategic sourcing – effective strategic sourcing determines what to buy and from where through effective use of supply and demand power.
- Supplier management – ensures what is contracted for is what is delivered and then collaborates with the supplier to bring in more supply-market expertise. Ultimately, the goal is to drive the supplier-behaviour that you need.
- Orchestration of the procurement engine – using technology and processes to provide a frictionless, compliance-based buying experience. Procurement must respond to stakeholders' demand for more user-friendly approaches to buying.

4.1.1 Value chain analysis and shortening the value chain

Value chain analysis is a strategic tool used to analyse internal business activities and recognise which activities are the most valuable. The value chain model breaks down an organisation's activities into strategically relevant pieces, so that a fuller picture of the cost drivers and sources of differentiation can be seen, and then appropriate changes can be made. Primary activities relate directly to physical creation, sale, maintenance, and support of a product or service. Secondary activities, including procurement, support the primary functions (CIPS, 2023).

You can add value by improving operational effectiveness and shortening the value chain. Differentiation through expertise, through re-thinking a standard approach to market, offers another route for competitive advantage. For example, direct customer relationships can help to become more responsive and to better sense and satisfy preferences for personalisation and co-creation (CIPS, 2023).

In a 2011 paper, Dr Porter and Mark Kramer introduced the concept of creating shared value, which is a framework for creating economic value while simultaneously addressing societal needs and challenges. Shortening the value chain fundamentally changes the economics of value creation in a market by eliminating or shifting stages of the value chain.

In the report, *Patterns of Disruption*, shortening the value chain was identified as one of nine patterns of disruption (Deloitte, 2016) (Deloitte, 2015). The other patterns include:

- | | |
|------------------------------------|------------------------------------|
| • Expanding marketplace reach | • Connecting peers |
| • Unlocking adjacent assets | • Unbundling products and services |
| • Turning products into platforms | • Aligning prices with use |
| • Distributing product development | • Converge products |

In terms of the procurement strategy, Market Dojo (Market Dojo, 2023) suggest consideration of four new rules for procurement engagement; rule one – reimagine the strategy – challenge the past to define the future, rule two – re-evaluate sourcing – transform market access and performance, rule three – reshape supplier relationships – connect experiences and insights, rule four – redefine value creation – revolutionise continual innovation.

4.2 Procurement – current state

As discussed, historically the department has typically been more focused on the short-term cost of acquiring goods and services rather than considering the total cost of ownership as part of a more long-term, strategic approach. As the traditional manufacturing industry is in the throes of a digital transformation that is accelerated by exponentially growing technologies, procurement has an important role to play in working towards the organisational vision of manufacturing profitable, innovative, and high-quality products. The procurement strategy for the following three to five years emphasises people/process development, supplier relationship management, supply chain management and strategic sourcing.

4.2.1 Detailed spend analysis, pareto analysis, and major suppliers

In order to provide context to the spend-analysis conducted, a summary of the organisation's profit and loss account for the financial year ending 31st July 2022 is shown below. The financial results for the year 2022/23 are yet to be published, but the organisation will be recording a financial loss for this period.

Bisley Financials	Value
Turnover	£52,882,000.00
Cost of Sales	£42,466,000.00
Gross profit	£10,416,000.00
Operating profit	£1,399,000.00
Profit for the financial year	£1,365,000.00

Table 4.1 – Bisley Financial Statement Figures 2022

It is important to note that the organisation's financial year runs from 1st August to 31st July. However, due to data confidentiality reasons, the spend-analysis conducted for this report is based on the calendar year from January – December 2022. The data is also based on direct category purchases only, and does not include indirect expenses such as transport, utilities, and maintenance.

The total expenditure in the calendar year of 2022 equated to £30,049,192.00, averaging approximately £2.5 million every month (figure 4.1). This expenditure was made across 257 different suppliers (figure 4.2). The major category of expenditure for the organisation is raw material. Steel is purchased as coils, sheets, and blanks in various gauges. Melamine faced chipboard, compact grade laminate and medium density fiberboard are also purchased as part of this category. Other large categories of expenditure include electrostatic powder paint, packaging, locks and fixtures and fasteners such as hinges, handles, drawer slides and adjustable feet (figure 4.3).

Pareto analysis is a technique used for business decision-making, but it also has applications in several different fields. It is premised on the idea that 80% of problems can be traced to 20% of the causes. Pareto analysis is a powerful quality and decision-making tool. In the most general sense, it is a technique for getting the necessary facts needed for setting priorities (Kenton, 2022).

Considering this technique, 80% of the total annual expenditure (£24,039,534.00) comes from the eighteen suppliers with the highest annual expenditure. This equates to just 7% of all of the suppliers being used. Five of these eighteen suppliers are steel suppliers, as approximately 35% of the total annual spend is on steel. Historically, quick moving stock is held on a Kanban system – this is an inventory control system, developed by Taiichi Ohno (Halton, 2022), whereby an exact quantity is purchased and replenished according to the Kanban cards. Goods on kanban include powder paint, packaging, small plastic injection-moulded parts, locks, and shutters. The Kanban value is currently £158,270.00 and over half of this value is in powder and packaging (figure 4.4).

Kanban Type	Spend	Percentage
Powder	£ 47,921.84	29%
Packaging	£ 37,736.18	23%
Locks	£ 28,974.00	18%
Shutters	£ 27,360.64	17%
Plastics	£ 17,825.12	11%
Misc.	£ 2,961.00	2%
Total Spend	£ 162,778.78	

Table 4.2 – Kanban Value by Category

As product complexity increases, and customers expect more customisability, the sale of non-standard products continues to increase. This means the price and availability of non-standard bought-out elements needs to be managed. Procurement from relatively new categories such as electrics, fabrics, and complete third-party products such as chairs, lamps and acoustic booths can be challenging as they can be considered irregular purchases. Often, procurement struggles to drive value from tail spend and can be criticised by other departments, such as product development, for slowing down innovation by using complex and administrative processes.

4.2.2 Findings

The business model and strategy for the manufacturing organisation needed to, and is beginning to, change in order to remain competitive. Likewise, the function of the procurement / purchasing department is also beginning to evolve, and there is emphasis on a greater alignment between the organisational and departmental strategy. As with any goal setting, it is important to set objectives which are S.M.A.R.T, to ensure that they are specific, measurable, achievable, relevant, and time-bound. Change does not happen overnight and should not be irrational, but long-term success can be achieved through commitment to incremental but frequent continuous improvement.

With this being said, many of the challenges and barriers to the implementation of industry 4.0, or more specifically procurement 4.0, identified within the literature review are true of the manufacturing organisation at focus. These can be categorised as departmental, managerial and employee related:

The department must become more strategically focused, and consideration should be given to the total cost of ownership of goods or services, rather than just the price. Decisions must be made with respect to the long-term, as well as the short-term impact and made proactively rather than reactively where possible. There is currently no mechanism for supplier performance management and the organisation is lacking supplier contracts with agreed service levels– causing exposure to increased business risk. Historically, there has been a lack of co-ordination with suppliers resulting in few mutually beneficial partnerships and difficulty maintaining relationships over time. The organisation

needs a procurement / procurement 4.0 policy to pursue and instruct adherence to best practices to gain added value. Currently, there is little consideration given to sustainability, and key performance indicators need to be developed to monitor personal performance, and drive development plan metrics. The procurement processes are perceived as being outdated, slow and difficult to use. At present, there is fragmentation of expenditure in certain purchasing categories, which adds to the difficulty of managing irregular, ad-hoc purchases.

There is a lack of understanding of the concepts of industry 4.0 amongst management, in part due to the lack of technological infrastructure and resource- including personnel and financial. Many of the investments are perceived to be too high and unclear, particularly post-pandemic where management of cash flow is increasingly important. Clear and long-term goals need to cascade from the very top of the organisation, across all levels of the hierarchy – there needs to be ongoing support, leadership, and engagement from the management team. There is a lack of clear process and governance / adherence to best practice across the whole organisation. Commercial nous needs to be improved; the organisation operates a basic costing model, meaning budgeted vs actual cost analysis is difficult to execute. There is limited sales forecasting and volume data analysis, which would be beneficial during supplier contracting and for ongoing supply chain management.

Generally, there is limited stakeholder engagement, communication, and collaboration across departments within the organisation. There is a lack of willingness to change – employee inertia. Organisational processes need to be optimised and waste removed, but employees do not necessarily have the required skills or authority to implement such process changes. Motivation and inspiration to change should cascade down through the organisation. Some development initiatives are pursued in a silo, diminishing their chances of success. Opportunities are missed as data analysis is not used to strengthen decision-making. Procurement is also not yet seen as a department to drive innovation and sustainability. The organisation may benefit from university / collaborative research funding opportunities, but to my knowledge these options have not been explored.

5. Implementation

5.1 How does industry 4.0 influence the procurement strategy?

As discussed in section one, a strategy is required to create, and appropriate value from the organisation's systems, processes, resources, and competencies (Kohtamaki, 2020). In section two, the four pillars of industry 4.0 were considered as vertical networking, horizontal integration, through-engineering throughout the entire value chain and acceleration through exponential technologies including big data analysis and artificial intelligence. In section four, a review of the procurement - current state revealed that the strategy for procurement was developed around four key principles: people/process development, supplier relationship management, supply chain management and strategic sourcing (figure 5.1).

5.1.1 Vertical networking and people / process development

The goal is to deliver operational improvements through people (personal development plans) and processes / systems (whereby collaboration is key). There is trust and empowerment within teams which creates a sense of psychological safety. The focus is on guiding, supporting, upskilling, and providing constructive feedback. There is care and connection with processes and the wider team.

Industry 4.0 will generate enormous quantities of data. Gathering, analysing, and processing such big data will generate new insights, support decision-making, and create a competitive advantage. The

manufacturing organisation will need to develop new specialist skills in the areas of analytics and efficient data management and put new business processes in place on the basis of the insights that this analysis reveals. If the organisation can set themselves apart from their competitors in this respect, they will overtake existing market leaders.

5.1.2 Horizontal integration and supplier relationship management

The goal is to manage risk through supplier evaluation, contract management, risk mapping, as well as sustainability and corporate social responsibility. Traditional techniques shall be executed such as quarterly/annual reviews, benchmarking, and value engineering for “greener” purchases. Risks must be identified, mapped, analysed, and removed/mitigated. With regards to technology, innovation and new product development exchanges, non-disclosure agreements can be used to protect positions.

There will be a particular focus on new models that are tailored more closely to individual customer needs and enable new co-operative models with business partners. However, this will place new demands upon the supply chain. The digital transformation provides the opportunity to create a single database, making supply chains smarter, more transparent, and more efficient at every stage – beginning at customer needs through to product delivery. Design and new product development, procurement and purchasing, production and sales functions need to become more closely aligned as digitalisation advances. The organisation needs to use better communications to integrate suppliers and customers’ needs into value-creation activities.

5.1.3 Through-engineering and supply chain management

The goal is to facilitate commercial growth through delivery, quality and inventory management of goods and services. In order to achieve this, the introduction of new products needs to be managed and provisions need to be made to ensure compliance with health and safety regulations, legislations, and guidelines. Traditional approaches include quality and claims management, consignment stock engagement and review of suppliers’ key performance indicators, like defective parts, H&S records, and deliveries made on-time, in-full, invoiced correctly (OTIFIC).

Industry 4.0 can enable integrated and cross-disciplinary engineering throughout the value chain and throughout product and customer life cycles. Industry 4.0 applications should be designed to help ensure that innovation is not limited to the traditional areas of product innovation. Traditionally, innovation has related predominantly to product offerings, but its major potential lies in the areas of company structures, processes, networks, and profit models, together with customer-facing functions, such as new services and distribution channels. Empirical research shows that companies deploying more than just two types of innovation performs better on the stock exchange – and that top innovators deploy five or more types of innovation (Deloitte, 2021) ([figure 5.2](#)).

Industry 4.0 and digital transformation presents opportunities to make it possible to provide relevant data for life cycle management at any time and from anywhere. This data will comprise not only information and reports but also results of big data processing to generate relevant early indicators through the use of artificial intelligence. AI can use global cross-checking and assess the plausibility of generating relevant bases for decision-making supported by data. If implemented successfully, it will enable the organisation to understand and meet the customers’ needs better, as well as customise product cycles.

5.1.4 Exponential technologies and strategic sourcing

The goal is to reduce the total cost of ownership through strategic sourcing. This incorporates, but is not limited to driving cost savings, making working capital improvements, understanding the whole life costs and implementation of the category management process (figure 5.3). Fundamental is laying the foundation via the procurement policy, providing complete governance to aid the objectives and goals of the department and ultimately the organisation as a whole. Traditional techniques such as category segmentation, pareto analysis, RFX process (requests for information, proposal, and quotes) and total cost of ownership methods (savings, days payable outstanding and whole life costing) can be implemented.

Corporate venturing offers an organisation a good opportunity for investing in new trends at an early stage and for benefiting from disruptive innovation and exponential technologies. For example, investing in start-ups enables organisations to be involved in developing innovations and to secure their long-term competitiveness. Such investments allow early and convenient insight into new technologies. The organisation needs to give itself more freedom to *look around the next corner*. There is potential that a new business area can be created that can become the new centre of the business in the future. If such opportunities are missed, the survival of the organisation could be at risk.

The manufacturing organisation needs to become a “learning organisation” if they are to make full use of the potential exponential technologies in achieving the digital transformation to industry 4.0. The use and integration of such technologies needs to be gradual but steady. Learning is the key to sustainable organisational development. Change that is too rapid can be counterproductive. New ideas, processes and business segments are most successful when they start off as a niche where learning goes on, and then gradually migrate to the centre of the organisation to establish themselves as a new leading segment.

5.2 Future of procurement data analytics

According to Sievo (Sievo, 2021), there are two dimensions of procurement data: first, procurement data can be internal or external. Secondly, procurement data can be structured or unstructured. When combined, these dimensions make up four distinct types of procurement data (Figure 5.4): internal structured, internal unstructured, external structured, and external unstructured.

Internal structured data is the core foundation of procurement data. The clearest example of this is supplier master data: basic information such as contact details and transaction history. This data is stored and created within the existing corporate software and is easy to access and is already completely integrated into the organisation’s systems.

Internal unstructured data is the data within the organisation, which is stored and generated locally, but is difficult to integrate. Examples of this data type are purchase agreements and meeting minutes. This is difficult to manage and analyse without human oversight because they may exist in many versions and places, in different file formats and the content is generally unstructured.

External structured data is procurement data that comes from outside the organisation’s own databases. For example, supplier specific sustainability scores. This type of data has some barriers to access but has been designed to be easy to integrate. This type of data is usually purchased from third party data providers.

External unstructured data is the most challenging type of procurement data in terms of access and integrability. This type of data can be very useful for analytics and forecasting – such as with

commodity market outlook reports for example. However, this requires a lot of work to integrate with existing internal data. As we have seen from the research, managers are often skeptical regarding the return on investment – in terms of time as well as any financial investments in such processes.

Procurement can use data to support decision-making and data analytics to describe, predict or improve business performance. Data analytics can influence all activities from strategic sourcing to category management. On a broad level, analytics can fall into four categories (Figure 5.5):

1. *Descriptive* – what happened in the past?
2. *Diagnostic* – why did something happen in the past?
3. *Predictive* – what trends and patterns tell us? What will happen?
4. *Prescriptive* - what decisions procurement should take?

Traditionally, procurement analytics has focused on understanding past procurement spend and supplier performance – this is descriptive and a reactive approach, whereas increasingly the focus is shifting towards AI-driven prescriptive decision making – a more proactive approach.

Procurement data analytics can have applications in a variety of ways including:

- Category management - identify savings opportunities, market segments, and prioritise suppliers, address risks, and facilitate innovation.
- Strategic sourcing - identify the best times and areas to run sourcing events and requests for proposal, as well as which suppliers to include.
- Contract management - provides value across contract lifecycle management. It can alert when contracts need to be renegotiated or provide data for supplier negotiations.
- Procure-to-pay - measure purchase order cycles and improve payment terms. You can evaluate payment accuracy, discover rebate opportunities, and benefit from currency fluctuations.
- Sustainability and corporate responsibility - can uncover the environmental or social impact of procurement decisions and identify opportunities for more sustainable alternatives and improvement.
- Risk management - analytics can unravel the complex relationships between supply, price, the environment, corporate social responsibility initiatives, and risk, while identifying opportunities for mitigation.
- Performance management - identify savings realised, which are directly relevant for profit and loss (P&L) reporting for finance.

There are a number of benefits to leveraging procurement data – it can help in identifying changes in spending which can influence negotiating better contracts in terms of pricing, level of service and payment terms. Procurement data can improve forecasting and budget management, through collaborative working with other departments such as sales and finance, this can lead to risk mitigation and disruption coverage. The data can gain insights into the quality and performance of products and processes – this can improve prioritisation and strategic focus not only for the procurement department but across the organisation, in communications and marketing for example. Procurement data can be used to discover opportunities for consolidation and benchmarking performance.

Once the organisation has learned to efficiently gather, analyse, and process its procurement data to generate new insights and support proactive decision-making, procurement data ecosystems can be utilised. These ecosystems are collections of networked systems and applications that together manage all procurement's knowledge and data, bringing visibility to information, relationships, and institutions (Figure 5.6). The elements of the procurement ecosystem have always existed. However,

in procurement these components have generally been siloed and disconnected. The four major components of these data ecosystems are information-related, relationship related, institution related and knowledge. Examples of these types of knowledge and data can be found in the table below.

Information related	Relationship related	Institution related
<i>Spend data</i> : the core element of the procurement ecosystem is spend data. This is the fabric that connects suppliers, materials, services, categories, and markets.	<i>Commercial relationships</i> : a valuable source of market knowledge that feeds innovation and competitive advantage. These include vendors, market players, partners, and subcontractors.	<i>Market networks</i> : global and regional collectives of businesses and organisations connected to the supply chain.
<i>Third party data</i> : external data on supply chain risk, diversity, sustainability, market commodities, and more.	<i>Stakeholder relationships</i> : the extended sphere of strategic relationships. This includes relationships with shareholders, customers, and partners.	<i>Economic networks</i> : the economies that are built up of markets.
<i>Strategic information</i> : the strategy, processes, and direction of the organisation that guides procurement.	<i>Internal relationships</i> : the processes and relationships of departments in the organisation. For example, between category managers, operations, and finance.	<i>Governmental institutions</i> : regulatory bodies that impact procurement, concerning data policies (e.g GDPR), trade, and sustainability.
<i>Socio-economic information</i> : relevant information on legislation, governance, politics, the environment, and social values.	<i>PR and media relationships</i> : relationships with the society media, influencers, and public at large.	<i>Advisory networks</i> : academia, industry, consultants, and NGOs* which provide valuable insights and have influence over certain networks.
<i>Knowledge</i> : the implicit knowledge, skills and expertise of the organisation and its people, as well as the external knowledge of industry leaders and visionaries.		

*NGOs – non-governmental organisations

Table 5.1 – Components of procurement data ecosystem.

As discussed during the findings in section four, procurement processes can be perceived as time-consuming and outdated. It is important for the procurement department to be dynamic in its function, particularly when supply chain and market environments are ever-increasing in complexity. Speed and agility are fundamental in keeping up with market changes and addressing evolving stakeholder needs. Throughout the research, there have been several references to the evolution of the procurement function. Sievo (Sievo, 2021) described the change in approach from operational, to waterfall to lean-agile. From 1980-2000, the major technological enabler was enterprise planning software and with this the focus was operational reporting and tactical cost savings. The waterfall approach between 2000 and 2020 used the internet and multitenant software to digitalise and streamline enterprise procurement processes. The approach of today should utilise artificial intelligence, powered analytics and ecosystems through cloud computing and robotic process automation. The focus: faster routes to sustainable profit through automation and spend culture.

5.3 Procurement AI – business case

The basic definition of artificial intelligence (AI) is an algorithm which exhibits any behaviour considered to be “intelligent” (Sammalkorpi, 2019). AI is a branch of computer science for which the umbrella term is used to describe technologies that enable machines to exhibit human-like behaviour. Commonly, AI is divided into weak or strong AI. Weak AI is the type we most often interact with in our daily lives. Its focus is on one narrow task, and it does what it is designed to do. Strong AI can present flexible and skilful behaviour and can focus on several tasks. This type of AI should feel like interacting with a conscious human, and therefore must have human-like cognitive abilities and the ability to solve unfamiliar problems, without human intervention.

There are several ways to distinguish weak AI from strong AI. In the field of AI research, the Turing test, developed by Alan Turing in 1950, became an accustomed way to distinguish whether machines were “intelligent”. This test was initially made to determine whether a machine is able to exhibit intelligent behaviour that is indistinguishable from that of a human being. Whether AI has ever been able to pass the Turing test is debated.

Artificial intelligence encompasses machine learning and natural language processing. The definition of machine learning is an algorithm that detects patterns and automatically improves through experience. This is a class of different methods commonly used in AI applications – the machine is not given specific step-by-step instructions but learns from the data by itself. Once the initial settings and data have been provided, it processes the data by itself and improves its performance over time. There are three different types of machine learning: supervised, unsupervised and reinforcement learning (Sammalkorpi, 2019).

1. *Supervised learning* – the machine is given a pre-defined set of training examples which help it learn and come to its own conclusions in the future when provided with new pieces of data. In this case, the data sets are labelled in a way that the machine can detect patterns. In other words, the machine uses past data to predict future cases. This type of machine learning has become more accurate as technology and training continues to improve – it is most commonly used in businesses cases currently.
2. *Unsupervised learning* – the goal is to distinguish possible groups on its own. In this case, the data sets are neither classified nor labelled. Instead, they are sorted according to their differences and similarities. The most well-known example of this is Netflix’s recommendation system. AI helps in making suggestions about series or films that a user might like. This type of machine learning is unable to label the different clusters, despite being able to identify them.
3. *Reinforcement learning* – Here, the machine is trained to make specific decisions on its own by continuously learning from its environment based on a trial-and-error method. They are constantly fed negative or positive feedback based on how they have performed, which enables them to reach the desired goal. The machine learns from the past in order to make better decisions in the future.

Deep learning is a class of machine learning methods where advanced artificial neural networks progressively improve their ability to perform a task. At the moment, deep learning is used in technology including facial recognition, personalised shopping, and driverless cars. However, in most business cases, deep learning is neither necessary nor able to bring about the desired results. This type of machine learning can be advantageous when data is unstructured and very diverse, however this requires a considerable amount of computing power which could make applications more expensive, complex, and unnecessarily slow in some cases.

Natural language processing is an algorithm which can interpret, transform, and generate human language. The objective is to read and understand human language in a valuable manner. Well-known examples include Google Translate and personal AI assistants like Apple's Siri and Amazon's Alexa. They are beneficial to make a quick summary and quick language translation and use data patterns to improve understanding. One major challenge for this type of AI is human-perception and context, for example sarcasm. Technology is evolving quickly in this area, providing more intuitive approaches.

The table below presents some of the potential outcomes of implementing procurement AI as well as the benefits they could bring at both organisational and personal levels. It is important to evaluate the potential outcomes/benefits against the challenges of procurement AI.

Potential outcomes of AI	Benefit of AI	Challenges of AI
Minimised manual tasks	Employees can focus on creative and less monotonous tasks	Errors made by AI may require fixing by human intervention – taking time and effort to understand / correct
Increased efficiency	Discover savings opportunities and organisational optimizations	Opportunities discovered might be erroneous or not substantial enough
Improved forecasting	Better predictions on price, maintenance needs and market indexes	Flawed data might cause forecasting inaccuracy. As with any data, garbage in = garbage out
Faster response times	Identify anomalies as soon as they occur, minimizing the impact of disruption	Risk of false positives – greater during earlier stages of implementation
Increased accuracy	Boost accuracy and certainty in decision-making	To train the AI to gain a desired level of accuracy is difficult and requires a sufficient data set
Greater strategic focus	Allowed due to minimization of manual monotonous tasks	AI needs guidance and retraining – initial phases can be demanding
Lower cost	Identify savings opportunities to lower costs – allows for corporate venturing / learning	AI is a large investment initially, and must be trained to understand saving significance

Table 5.2 – Procurement AI benefits and challenges

In general, most literature agrees that the implications of implementing industry 4.0 – including data analytics and artificial intelligence – are centred around three major aspects: people, processes, and resources (financial investment and employee skills). Employees can be reluctant to such change due to fear of job loss, lack of understanding of technology and poor guidance from management. Processes will evolve and change over time, which can be difficult and stressful to begin with, due to lack of existing infrastructure. Individuals will need to be creative in their innovation and committed to long-term improvements.

In terms of the procurement strategy, the first step is challenging the past to redefine the future (Market Dojo, 2023). In order to unlock trapped value, the organisation must face the challenges, embrace environmental social governance, tackle talent shortages, think strategically and show the

return on investment. Next, the organisation will need to dismantle the outdated silos by engaging with stakeholders, focusing on user-centric processes, and remaining connected through communication. Exemplifying strategy-driven, technology-informed agility requires focus on people first, then process and technology. Supplier intelligence and closing the supply chain loop will follow. The future of the procurement strategy will protect the planet, leverage AI and automation, expedite digital transformation and enable disruptive innovation. This type of strategy is essential for the procurement department to function effectively, particularly in a manufacturing environment whereby disruptive trends are playing out simultaneously – as identified in section 2.5.

According to Sammalkorpi (Sammalkorpi, 2019), there are two common business cases for procurement AI; the first applying AI over data sets to identify new sources of value, new opportunities, new suppliers, and new risks. Secondly, using AI to make existing processes more efficient – for example reducing the manual work and reducing operating costs.

In their potential AI roadmap, there are three fundamental milestones concerning the immediate, six-month, and three-to-five-year period. At the first milestone, it is suggested that the organisation should identify key use cases and review possible pilot projects. The best practices should be reviewed, and key partners and providers evaluated. At the second milestone, pilot projects can be initiated, and the organisation can focus on any further developments. Adjustments to applications may be required according to the learning of the initial period. It is important that the findings of the pilot are utilised to create a coherent AI strategy. At the final milestone, the overall implementation results should be reviewed. Whilst the AI performance can be reviewed at regular intervals, a more thorough review of the AI strategy should be driven by the findings and used for the development of the corporate AI strategy. Here, long term decisions regarding AI software and personnel investments need to be made.

5.4 Examples of procurement analytics software

Machine learning and AI are already present in the growing number of procurement software applications currently available. Due to the present capabilities and developments, they tend to be focused on quite narrow applications. Whilst adept at repetitive data and forming patterns, they cannot do everything. At the moment, this is resulting in different procurement software being required for different areas of the procurement cycle.

For example, Keelvar may be used for strategic sourcing with software designed to drive better sourcing outcomes for strategic, tactical, and tail spend (Keelvar, 2023). Tealbook is used for supplier information management, it aims to boost procurement efficiency with trusted supplier data (Tealbook, 2023). Sievo is another procurement analytics software - it has various products for product benchmarking, spend analytics and savings lifecycle. In addition to this, it can analysis environmental data such as CO₂, diversity, and sustainability analytics (Sievo, 2023).

With the variety of options available, organisations struggle with where to start on the implementation journey. One of the major risks is misunderstanding the complexity, which can lead to wasting time and resources. In order to assess the readiness for implementation, the organisation should first consider if there is a sufficient amount of data available, and whether this is the correct type of data to realise the benefits of procurement data analytics and AI – ease of integration and access. Is there a business case to articulate the benefits? This may be applying AI to existing datasets or using AI to increase efficiency of existing processes. Next, the organisation will need to consider if a third-party software application can facilitate the requirements, considering data-integration, timescale, financial investment, data security, accessibility, IT support, etc. Finally, how will the human-machine collaboration work on a day-to-day basis?

According to a conceptual framework considered as part of the literature review in section 3.1.2, it was suggested that the added value for procurement would reside within pricing, purchasing performance management, reducing relevant costs, and cost-functional activity (logistics); all of which would benefit from both big data analytics and artificial intelligence. However, the starting point for implementation is identifying key use cases and reviewing possible pilot projects. This should engage key stakeholders such as the finance, commercial and IT departments. A prerequisite to being able to identify use cases is an understanding of the requirements, capabilities, and benefits of such technologies. Hence, the organisation needs to first tackle the talent shortage – investing in people with the required skills to implement, and as importantly, communicate this vision for change.

With a lack of understanding of requirements, capabilities and benefits, high and unclear investments and concerns regarding data security and system infrastructure, the exponential rate of change simultaneous to the deluge of information on emerging technologies, the strive towards procurement 4.0 can feel overwhelming. This only increases the importance of managing innovation and change, to develop a culture of organisational learning and corporate venturing.

5.5 Managing innovation and change

Successful management of innovation takes in the entire organisation and covers strategy, project portfolio and product development. Industry 4.0 will make it possible to further improve the efficiency of innovation management in all of these areas. Interactive and tailored curricula make individualised learning possible, thereby accelerating strategic implementation and organisational development. In project portfolio management, industry 4.0 solutions make it easier not only to track the return on investment (ROI) in innovation, but also identify risks by using global comparative project data for monitoring and remedial purposes. In terms of product development, information technology can be used to accelerate research and development. This transforms the sharing of information between existing technologies within global networks.

According to Satell (Satell, 2017), innovation can be classified across three horizons in terms of capabilities and markets – those existing and already deployed/served, those existing but not yet deployed/served and new markets / capabilities. Huthwaite says that most organisations struggle due to their return to conventional thinking (Huthwaite, 2007). Within the innovation matrix, Satell references four different types of innovation: sustaining, breakthrough, disruptive and basic research. An innovation can be categorized depending on how well defined the problem is and how well the skills domain is defined. The majority of innovations of SME's falls within the umbrella of sustaining innovation, with a small amount of breakthrough and disruptive innovation (Satell, 2017). He suggests implementation of the 70/20/10% rule whereby the majority of the focus is on investment into the core business. The remaining innovation capacity involves exploration into adjacent markets and capabilities (Satell, 2021).

As depicted in (figure 5.2), there are various types of innovation including configuration, offering and experience. Procurement can influence innovations within the configuration category as these include the profit model, structure, network, and processes within the organisation. In a similar way, the business model canvas and (figure 1.5) suggest key partners, activities, and resources as a source of innovation. Industry 4.0 technologies including procurement data analytics and AI can enable knowledge-sharing and collaboration outside the boundaries of the organisation.

6. Conclusion

6.1 Summary of findings

It is clear that the outlook for the procurement function is changing – from one that has a short-term perspective, is best-price driven and operationally reactive to one that takes consideration for the long-term impacts of decision-making, the total cost of ownership of products and services and is strategically proactive to accommodate the organisational requirements. The challenge is to create, deliver, distribute, and capture value from systems, processes, resources, and competencies and seek to provide added value to gain a competitive advantage. Traditional procurement best practices can be enhanced using industry 4.0 technologies: with respect to people and process development, supplier relationship management, supply chain management and strategic sourcing.

The pillars of industry 4.0 were found to include vertical networking, horizontal integration, through-engineering and exponential technologies. Whilst there is growing academic-published research surrounding industry 4.0, studies outside of the “production” domain remain in their infancy. Trends such as resilience, circularity, customisation, responsivity, and collaborative manufacturing are likely to play an important role in the future of the industry. This only increases the importance of strategic long-term decision making for manufacturing organisations, as it is anticipated that these trends will play out simultaneously. Proactive approaches are critical for the success of the organisation.

Industry 4.0 can help to improve financial performance, identify, and mitigate risk, improve transparency across the entire value chain and provide data to support decision-making. The total cost of ownership of goods and services considers more than just the price, but also considers the bigger picture such as ongoing operational costs, maintenance, and training. It is also focused on building mutually beneficial partnerships with other supply chain “actors”, which can improve the resilience of the supply chain and enhance collaboration overall. Despite these opportunities, the major barriers to implementation are high and unclear investments, poor knowledge and understanding and organisational inertia. The research found nine areas of value for procurement including management of purchasing operations and the processes associated with supplier selection and evaluation. As well as financial benefits, industry 4.0 has been found to increase success in terms of sustainability goals and movement towards a more circular economy.

Understanding how the organisation creates value and looking for ways to add more value are critical elements in developing a competitive strategy. Adding value creates higher profitability for an organisation. Higher profitability through introducing added value is the basis for competitive advantage. The research found that parallels can be drawn between lean manufacturing principles and the fundamentals of industry 4.0, therefore it is important to ensure that work is standardised, and processes are evaluated to identify and remove waste. The value chain must be extended beyond the organisation and also include customers and suppliers. Transparency can be built using available data and also through the knowledge of the workforce. To ensure success, there must be an organisational culture which is ready to embrace such changes to the methods of working.

Industry 4.0 technologies allow the transfer of knowledge between entities within the supply chain. However, on an individual level, employees must be engaged to be receptive and giving of various types of knowledge including both tacit and explicit. Organisational departments must break the conventional tendencies to operate in a silo, as there is a greater potential for successful industry 4.0 implementation through collaboration. For example, organisations can share learnings of previous experiences. There is reluctance to share such knowledge due to data sensitivity, and knowledge

leakage, which could compromise the organisation's position within the industry. However, transparency is fundamental for improving supply chain performance towards other dimensions including social and environmental perspectives. Different decision horizons can impact the choices being made.

Disruptive procurement refers to strategic sourcing (what to purchase and who from?), supplier management (behaviour in terms of contracted service level agreements) and processes to allow for innovation and compliance to manufacturing requirements. Value chain analysis is a tool to analyse business activities and challenge traditional methods of working – identify opportunities to add value and remove waste – be innovative! The department has been stagnant for a number of years, there is fragmented spend in various purchasing categories – which is difficult to manage and opposes the ideologies of long-term supplier partnerships. There is a lack of supplier contracts with agreed service levels and thus it is difficult to monitor and improve performance. Systems for non-standard ad-hoc purchases are slow and outdated. There are challenges from a departmental, managerial, and individual standpoint, but the organisation needs to improve its financial state by driving operational efficiencies and cost reductions.

In order to implement procurement data analytics, there are various types of data which need to be accessible and integrable. Data analytics can describe (descriptive and reactive) or predict and improve (prescriptive and proactive) business performance. Unfortunately, at present this organisation, Bisley, is lacking in anything other than internal structured data. The research identified various applications for procurement data analytics and a number of benefits to leveraging this data. One of the major advantages is the ability to strategically focus on data-driven insights from across the organisation, in a methodical, evidence-based manner. This prevents work being siloed and disconnected. The results proved that the data needs to be understood (informative) in order to become organisational knowledge. There are opportunities to gather socio-economic information, commercial relationships, and Governmental and advisory institutional information from procurement data ecosystems.

The premise of AI is machine learning and natural language processing – and fundamental to this is pattern recognition through available data sets. Human intervention and guidance are required for the initial implementation phases to ensure the potential outcomes and benefits to AI are realised. It is evident that a prerequisite to this implementation is the availability of people, processes, and resources to implement and drive these changes. Whilst this is difficult to overcome, in the long term it is necessary to meet the evolving needs of the manufacturing sector. An implementation roadmap should see development for the immediate, short term (6 months) and long term (3-5 years). According to the continuous improvement cycle, by Dr William Deming, plan, do, check and act – learn from mistakes along the way as they are inevitable and necessary for learning.

There are various procurement analytics software available depending on the application requirement, for example supplier information management, strategic sourcing, or environmental data analysis. The organisation needs to determine the objectives for the software in order to determine which is most appropriate for them. Data availability, integration, timescale, cost, data security and IT support are influential factors in the decision-making process. Procurement needs to engage with other departments, including IT and finance, however the first step is tackling the talent shortage necessary to understand the capabilities of such software.

Management of innovation and change is important for commitment to a long-term vision. Innovation can be categorised according to new capabilities and new markets. Considering how well defined the problem and skills domains are, can determine what type of innovation is being undertaken. The major struggle for small-medium organisations is the temptation to revert back to conventional thinking and the perception of innovation in the more traditional “product” sense.

6.2 Recommendations and future work

Upon the completion of this study, there are a number of recommendations and possibilities for future work to be undertaken. The organisation should consider these for the future development of the procurement function and strategy, but also for the wider organisational strategy for industry 4.0 implementation.

Step 1: The organisation will need to improve the knowledge and understanding of industry 4.0 concepts, technologies, opportunities and challenges. It is suggested that this should begin with the Senior Management Team, before cascading down to employees at departmental level. This could involve training sessions, and collaborative workshop events. Engagement and promotion of collaborative working across departments is fundamental to success.

Step 2: The organisation needs to introduce a procurement policy to promote and ensure adherence to best practices. Procurement needs to engage with key stakeholders including the Chief Executive Officer and Chief Financial Officer to ensure commitment to compliance with the new processes. Procurement needs to listen to feedback from stakeholders and provide information surrounding the advantages to following such practices.

Step 3: Procurement will need to identify potential use cases for procurement data analytics and AI using the available data (predominantly internal structured data). They can engage in conversations with key suppliers regarding their knowledge and implementation of industry 4.0 technologies. It may be prudent to also explore the opportunities for knowledge transfer partnerships, as this can assist with resource allocation and expertise.

Step 4: On the basis of the identified potential use cases, investigate which of the available procurement software would be most appropriate for the organisation. Considerations need to be made with regards to the financial cost, timescale for data availability and integration, the objectives that need to be met by the software and also the Governmental and Industrial regulations surrounding data security and use of data analytics / AI in the procurement context.

Step 5: Present a business case for implementation of industry 4.0 – procurement data analytics / AI to the Board of Directors and wider Senior Management Team. The decision-making process must be conducted in a transparent, engaged, and collaborative manner to ensure buy-in from key stakeholders across the organisation.

6.3 Evaluation

The purpose of the paper was to explore the relationship between industry 4.0 and the procurement strategy within the context of a manufacturing organisation – namely Bisley F C Brown (Steel Equipment) Limited. The research limitations were such that this is a manufacturer of furniture, manufacturing solely within the UK, operating as a small medium enterprise. The organisation is also a private limited company.

The manufacturing industry is in the throes of digital transformation which is paving the way for disruptive approaches to traditional manufacturing functions, including procurement. Whilst there is

potential for great opportunities as part of this transformation, there remains ambiguity regarding the relationship between industry 4.0, and strategy at departmental level.

The main objective was to explore the concept of procurement 4.0, considering how traditional best practices can be enhanced using industry 4.0 technologies. It was perceived that alignment of the procurement and industry 4.0 strategies can provide added value to the manufacturing organisation. Upon completion of the research, various examples of this have been demonstrated and therefore, this is a statement that is believed to be true. The research has addressed some of the fundamental challenges currently faced by procurement including:

- The pressure to reduce lead times and costs, driven by changing customer habits and therefore expectations.
- The development and management of partnerships with an increasing number of third-party suppliers as a direct result of globalisation, and risk management due to economic and environmental instabilities.
- The impact of market saturation and increased competition – ensuring adequate processes and resources are in place to facilitate development in prioritised areas of business growth.
- Identification of ways to adapt the business model so that best practices are adhered to – on a pathway to a greener and more circular future.

At the beginning of the paper, the hypothesis was that without a procurement strategy, which has been developed with consideration to industry 4.0 implementation, fundamental mistakes would be made, and opportunities missed. The organisation could lose their grasp on understanding the wants and needs of the customer, and waste valuable resources developing over-complicated solutions which are difficult and expensive to source and manufacture. The research has proven this hypothesis to be true because the potential outcomes of procurement AI include increased efficiency, improved forecasting, greater strategic focus, and lower cost through identification of savings opportunities.

One of the fundamental learnings from this research is that, as well as the potential for financial improvements for the organisation, there are greater opportunities to leverage procurement data analytics and AI to benefit environmentally and socially as well. As a result, this research can and should be used as a roadmap for the future development of the procurement strategy and function. In addition to this, it will support the organisational implementation of industry 4.0 strategy as a whole.

So, how does industry 4.0 specifically influence the procurement strategy? *Vertical networking* will create a production environment which is more individualized and customer-specific hence heavily reliant upon the gathering, analysing, and processing data. Individuals will need to develop new skills in order to generate new insights from this data processing, and also make process improvements on the basis of these insights. *Horizontal integration* will drive business models which are co-operative, transparent, and more efficient. Individuals will need to execute traditional techniques, as well as utilise new technologies to improve supplier relationship management. A fundamental aspect of this is improved communication across the entire value chain. *Through engineering* can facilitate commercial growth, enabling innovation outside of the traditional product domain. Transparency and data from across the entire lifecycle of products or services can influence decision-making to ensure sustainability. Supply chain management can control end-to-end product lifecycle performance from raw material to end-of-life – driving more circular thinking. Finally, *exponential technologies* can enhance strategic sourcing through identifying cost savings opportunities and making working capital improvements. Corporate venturing and learning allow for sustainable organisational development.

7. References

7.1 List of references

- Bisley. (2023, May 10th). <https://www.bisley.com/>. Retrieved from We are Bisley - Our Story: <https://www.bisley.com/co/our-story/>
- Buchi, G. C. (2020). Smart factory performance and Industry 4.0. *Technological Forecasting & Social Change*, Article 119790.
- CASME - Market Focus Research Limited. (2017). *Logistics*.
- Chamola, V. H. (2020). A Comprehensive Review of the COVID-19 Pandemic and the Role of IoT, Drones, AI, Blockchain, and 5G in Managing its Impact. *IEE*, 90225-90265.
- Chauhan, C. S. (2020). A review of Industry 4.0 in supply chain management studies. *Journal of Manufacturing Technology Management*, 863-886.
- CIPS. (2023, June 17th). *About us*. Retrieved from Chartered Institute of Procurement & Supply: <https://www.cips.org/about-us>
- CIPS. (2023). *Adding Value to the Supply Chain - Porters Value Chain*. Retrieved from CIPS/Documents/Knowledge: <https://www.cips.org/Documents/Knowledge/Procurement-Topics-and-Skills/Members-only-content/Adding%20value%20to%20the%20supply%20chain%20-%20Porters.pdf>
- CIPS. (2023). *Category Management Cycle*. Retrieved from CIPS/Intelligence Hub/Category Management: <https://www.cips.org/intelligence-hub/category-management/cycle>
- CIPS. (2023). *Collaborative Working*. Retrieved from CIPS/Documents/Knowledge: https://www.cips.org/Documents/Knowledge/Procurement-Topics-and-Skills/6-Efficiency/Collaborative-Working/1/Shared_services_in_procurement_and_supply_chain_management.pdf
- CIPS. (2023). *Supplier relationship management*. Retrieved from CIPS/Intelligence Hub: <https://www.cips.org/intelligence-hub/supplier-relationship-management>
- CIPS. (2023). *Total cost of ownership*. Retrieved from CIPS/Intelligence Hub/Finance: <https://www.cips.org/intelligence-hub/finance/total-cost-of-ownership>
- CIPS. (2023). *Value Generation*. Retrieved from CIPS/Documents/Knowledge: https://www.cips.org/Documents/Knowledge/Procurement-Topics-and-Skills/6-Efficiency/Value-Generation/1/Value_Generation.pdf
- Corbos, R. B. (2023). The Effects of Strategic Procurement 4.0 Performance on Organisational Competitiveness in the Circular Economy. *Logistics*, 13.
- Deloitte. (2015). *Patterns of Disruption: Anticipating disruptive strategies in a world of unicorns, black swans, and exponentials*. Retrieved from Deloitte/Insights/Articles: https://www2.deloitte.com/content/dam/insights/us/articles/anticipating-disruptive-strategy-of-market-entrants/DUP-1098_Patterns-of-disruption_vFINAL.pdf
- Deloitte. (2016). *Shorten the value chain: Transforming the stages of value delivery*. Retrieved from Deloitte/Insights/Articles:

https://www2.deloitte.com/content/dam/insights/us/articles/disruptive-strategy-value-chain-models/DUP_3057_Shorten-the-value-chain_v2.pdf

Deloitte. (2021, October 29). *Industry 4.0 Challenges and solutions for the digital transformation and use of exponential technologies*. Retrieved from Deloitte Manufacturing Industry 4.0: <https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/manufacturing/ch-en-manufacturing-industry-4-0-24102014.pdf>

Eslami, M. A. (2023). Knowledge-sharing across supply chain actors in adopting Industry 4.0 technologies: An exploratory case study within the automotive industry. *Technological Forecasting & Social Change*, 122118.

European Commission . (2022). *Digital Economy and Society Index 2022*. European Commission.

European Commission. (2020). *Digital Economy and Society Index (DESI) 2020*. European Commission. Retrieved from <https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2020>

European Commission. (2020). *Digital Economy and Society Index (DESI) 2020 Germany*. European Commission.

European Commission. (2020). *Digital Economy and Society Index (DESI) 2020 United Kingdom*. European Commission.

Galati, F. B. (2019). Industry 4.0: emerging themes and future research avenues using a text mining approach. *Computers in Industry*, 100-113.

Grabowska, S. S. (2022). Business models in the industry 4.0 environment - Results of web of science bibliometric analysis. *Journal of Open Innovation*, 8-19.

Halton, C. (2022, September 28). *What is the Kanban system?* Retrieved from Investopedia: <https://www.investopedia.com/terms/k/kanban.asp>

Hayes, A. (2023, March 28). *The Supply Chain: From Raw Materials to Order Fulfillment*. Retrieved from Investopedia: <https://www.investopedia.com/terms/s/supplychain.asp>

Huthwaite, B. (2007). *The Rules of Innovation*. Michigan: Institute for Lean Innovation.

Ibarra, D. G. (2018). Business model innovation through industry 4.0: A review . *11th International Conference Interdisciplinary in Engineering, INTER-ENG 2017* (pp. 4-10). Tirgu-Mures, Romania: Procedia Manufacturing.

Jahani, N. S. (2021). Application of Industry 4.0 in the Procurement Processes of Supply Chains: A Systematic Literature Review. *Sustainability*, 7520.

Jerome, J. S. (2022). Procurement 4.0 to the rescue: catalysing its adoption by modelling the challenges. *Benchmarking: An International Journal*, 217-254.

Kearney. (2020). *The Future of Procurement: Rediscovering the Fundamentals*. Kearney.

Keeley, L. P. (2013). *Ten Types of Innovation - The discipline of building breakthroughs*. Wiley.

Keelvar. (2023). *Home Page*. Retrieved from Keelvar: <https://www.keelvar.com>

- Kenton, W. (2022, December 30). *What is Pareto Analysis? How to Create a Pareto Chart and Example*. Retrieved from Investopedia: <https://www.investopedia.com/terms/p/pareto-analysis.asp>
- Kihel, Y. A. (2023). Methodology combining industry 4.0 technologies and KPI's reliability for supply chain performance. *International Journal of Computer Intergrated Manufacturing*, 1128-1152.
- Kinzel, H. (2016). Industry 4.0 - Where does this leave the Human Factor. *27th Annual Conference of Human Dignity and Humiliation Studies*. Dubrovnik, Croatia.
- Kliestik, T. N. (2023). Global Value Chains and Industry 4.0 in the Context of Lean Workplaces for Enhancing Company Performance and Its Comprehension via the Digital Readiness and Expertise of Workforce in the V4 Nations. *Mathematics*, 601.
- Kohnova, L. S. (2023). Impact of Industry 4.0 on Companies: Value Chain Model Analysis. *Administrative Sciences*, 35.
- Kohtamaki, M. P. (2020). The relationship between digitalisation and servitization: The role of servitization in capturing the financial potential of digitalization. *Technological Forecasting & Social Change*, 151-159.
- Lemstra, M. M. (2023). Industry 4.0: a tertiary literature review. *Technological Forecasting & Social Change*, Article 122204.
- Liker, J. (2004). That's What Toyota Does: 14 management principles of the world's largest manufacturer. In J. Liker, *That's What Toyota Does: 14 management principles of the world's largest manufacturer* (pp. 30-35). Praha, Czech Republic: Management Press.
- Luiz da Silva, V. K. (2018). Technology transfer in the supply chain orientated to industry 4.0: a literature review. *Technology Analysis & Strategic Management*, 546-562.
- Make UK. (2022). *Manufacturing Outlook - 2022 Quarter 4*. BDO.
- Market Dojo. (2023). *The New Rules of Procurement Strategy: Rule 1 Reimaging Strategy*. Retrieved from Market Dojo - The New Rules E-Books: <https://marketdojo.com/new-rules/?rules=reimagine-strategy#ruleResources>
- Maslow, A. (1943). A theory of human motivation. *Psychological Review*, 370-396.
- Muller, J. M. (2018). Fortune favours the prepared: How SMEs approach business model innovations for industry 4.0. *Technological Forecasting & Social Change*, 2-17.
- Nicholas, J. (2018). *Lean Production for Competitive Advantage: A Comprehensive Guide to Lean Methods and Management Practices*. Productivity Press.
- Platform Industrie 4.0. (2019, November 20). *Digital business models for Industrie 4.0*. Retrieved from Platform Industrie 4.0: <https://www.plattform-i40.de/IP/Redaktion/EN/Downloads/Publikation/Digital-business-models.html>
- Porter, M. H. (2014, November). *How Smart, Connected Products Are Transforming Competition*. Retrieved from Havard Business Review: <https://hbr.org/2014/11/how-smart-connected-products-are-transforming-competition>

- Powell, D. M. (2021). Lean First... the Digitalize: a standard approach for Industry 4.0 implementation in SMEs. *Advances in Production Management Systems. Artificial Intelligence for Sustainable and Resilient Production Systems* (pp. IFIP Advances in Information and Communication Technology, vol 631 pp31-39). Springer, Cham.
- Procurify. (2023, October 19th). *Procurement vs Purchasing: What's the Difference?* Retrieved from <https://www.procurify.com/>: <https://www.procurify.com/blog/procurement-vs-purchasing>
- Rejeb, A. A. (2022). The Nexus of Industry 4.0 and Circular Procurement: A Systematic Literature Review and Research Agenda. *Sustainability*, 15633.
- Rogers, S. Z. (2021). Big Data-driven Algorithmic Governance in Sustainable Smart Manufacturing: Robotic Process and Cognitive Automation Technologies. *Analysis and Metaphysics*, 130-144.
- Sammalkorpi, S. T. (2019). *AI in Procurement*. Tallinn, Estonia: Printon AS.
- Satell, G. (2017). *Mapping innovation: A playbook for navigating a disruptive age*. New York, NY: McGraw-Hill Education.
- Satell, G. (2021, March 22nd). *Mapping-innovation-playbook*. Retrieved from www.gregsatell.com: <https://www.gregsatell.com/wp-content/uploads/2018/04/Mapping-Innovation-Playbook.pdf>
- Saucedo-Martinez, J. P.-L.-S.-F. (2018). Industry 4.0 framework for management and operations: a review. *Journal of Ambient Intelligence and Humanized Computing* , 789-801.
- Schrauf, S. B. (2016). *How Digitization makes the supply chain more efficient, agile and customer-focused*. pwc.
- Sievo. (2021). *Procurement Loves Data*.
- Sievo. (2023). *Home Page*. Retrieved from Sievo: <https://sievo.com>
- Sony, M. N. (2020). Critical factors for the successful implementation of Industry 4.0: a review and future research direction. *Production planning and control: The management of operations*, 799-815.
- Spieske, A. B. (2021). Improving Supply Chain Resilience Through Industry 4.0: A Systematic Literature Review Under the Impressions of the COVID-19 Pandemic. *Computers & Industrial Engineering*, 107452.
- Tealbook. (2023). *Home Page*. Retrieved from Tealbook: <https://www.tealbook.com>
- Tjahjono, B. E. (2017). What does Industry 4.0 mean to Supply Chain? *Manufacturing Engineering Society International Conference 2017* (pp. 1175 - 1182). Vigo (Pontevedra), Spain: Elsevier Procedia Manufacturing.
- TWI Global. (2023). *What is technology transfer? (Definitions and examples)*. Retrieved from TWI Global: <https://www.twi-global.com/technical-knowledge/faqs/what-is-technology-transfer>
- Weking, J. S. (2020). Leveraging industry 4.0 - A business model pattern framework. *International Journal of Production Economics*, 225-241.

- Womack, J. J. (1994). *From Lean Production to the Lean Enterprise*. Retrieved from Harvard Business Review: <https://hbr.org/1994/03/from-lean-production-to-the-lean-enterprise>
- World Manufacturing Foundation. (2022). *The World Manufacturing Report 2022: Redesigning supply chain in the new era of manufacturing*.

7.2 List of Figures

Procurement Team 2024

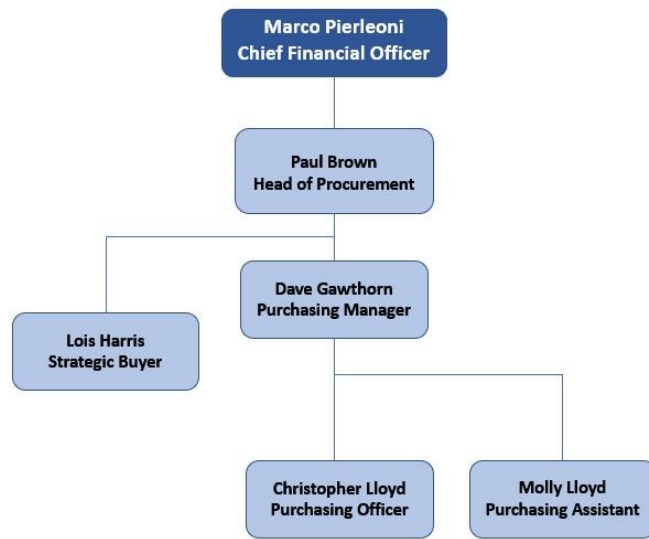


Figure 1.1 - Procurement organisational chart (Bisley, 2023)

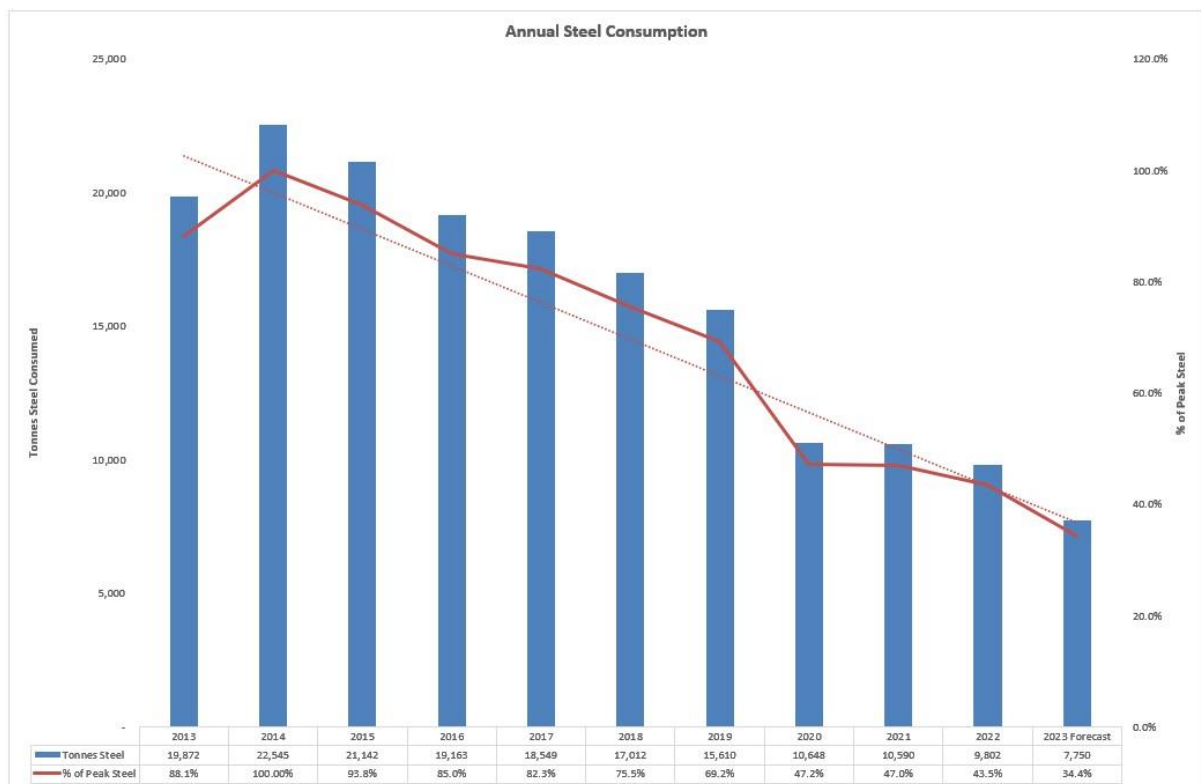
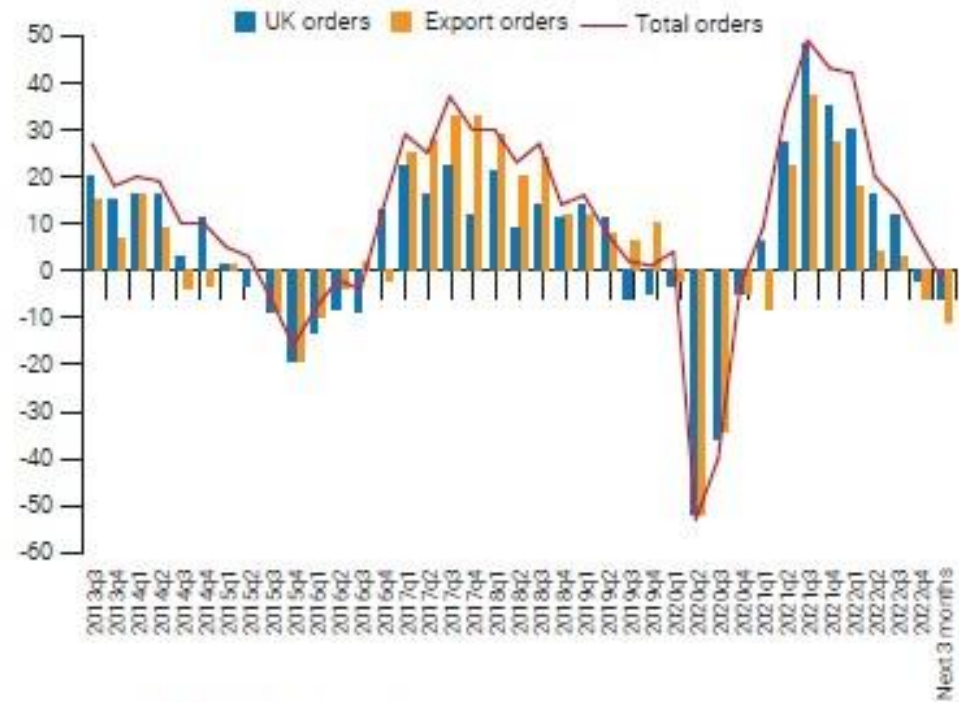


Figure 1.2 – Annual steel consumption (Bisley, 2022)

All measures of orders growth are losing momentum

% balance of change in orders



Source: Make UK Manufacturing Outlook Survey

Figure 1.3 – % balance of change in orders (Make UK, 2022)

BISLEY Order Intake Report



Figure 1.4a – Order intake report – home market vs. export market (Bisley, 2023)

BISLEY

Order Intake Report by Cost centres

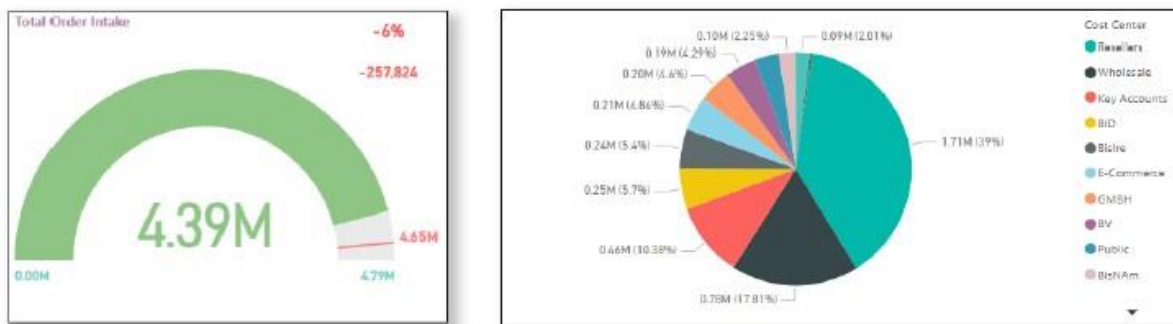


Figure 1.4b – Order intake report by cost centres (Bisley, 2023)

Components of business models.

Foss and Saebi (2017), Saebi et al. (2017)	Teece (2010)	Osterwalder and Pigneur (2010)	Gassmann et al. (2014)
Market segments	Customers	Customer segments	Who is the target customer?
Value proposition	Value	Value proposition	What does the customer value?
Structure of the value chain	Value creation, Value delivery	Key partners, Key activities, Key resources, Customer relationships, Channels	How is the value proposition built and distributed?
Value capture mechanisms	Value capture mechanisms	Revenue streams, Cost structure	Why is the BM financially viable?

Figure 1.5 – Components of business models (Weking, 2020).



Figure 1.6a – Managerial pillars of innovation (Grabowska, 2022)

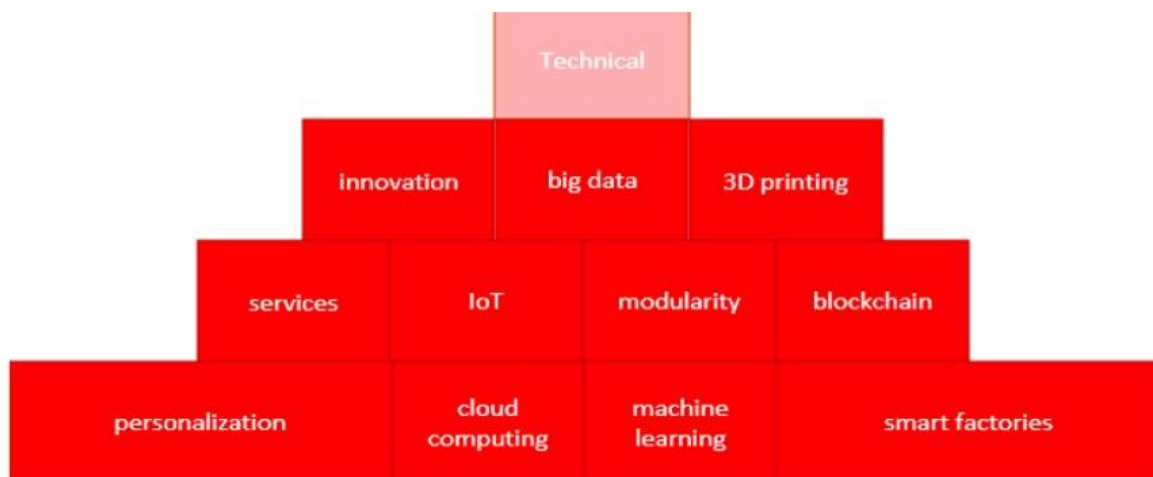


Figure 1.6b – Technical pillars of innovation (Grabowska, 2022)

Industry 4.0		
<i>High grade digitalisation</i>	<i>Smart manufacturing</i>	<i>Inter-company connectivity</i>
Transformation of ecosystems and value chains within manufacturing companies.	“Smartness” is the ability to communicate and co-operate in real-time (Weking, 2020).	Working together more effectively within a range of operational technologies.
Changing how companies interact across firm boundaries upstream and downstream.	“Smartness” refers to autonomous decision making to steer oneself based on information obtained.	“Interoperability” is the ability to communicate, share digital assets and data (Grabowska, 2022).
Improving supplier and customer interactions and enhancing data acquisition, warehousing, big data analytics and implementation.	Cyber – physical systems (CPS) are composed of physical hardware, software, and human intervention (Grabowska, 2022).	Ambidextrous approach: optimisation of existing core markets to ensure they are being served efficiently.
An ecosystem is a web of mutually beneficial relationships brokered by a digital platform that enhances economic value for all (Deloitte, 2021).	Each of these elements are integrated closely and networked to deliver some global behaviour.	Simultaneously, develop a digital vision that focuses on individual needs of new market segments.

Figure 2.1 – Three key aspects of Industry 4.0 (Muller, 2018), (Kohtamaki, 2020)



Figure 3.1 – Framework investigating values proposed by implementing industry 4.0 in procurement (Jahani, 2021).

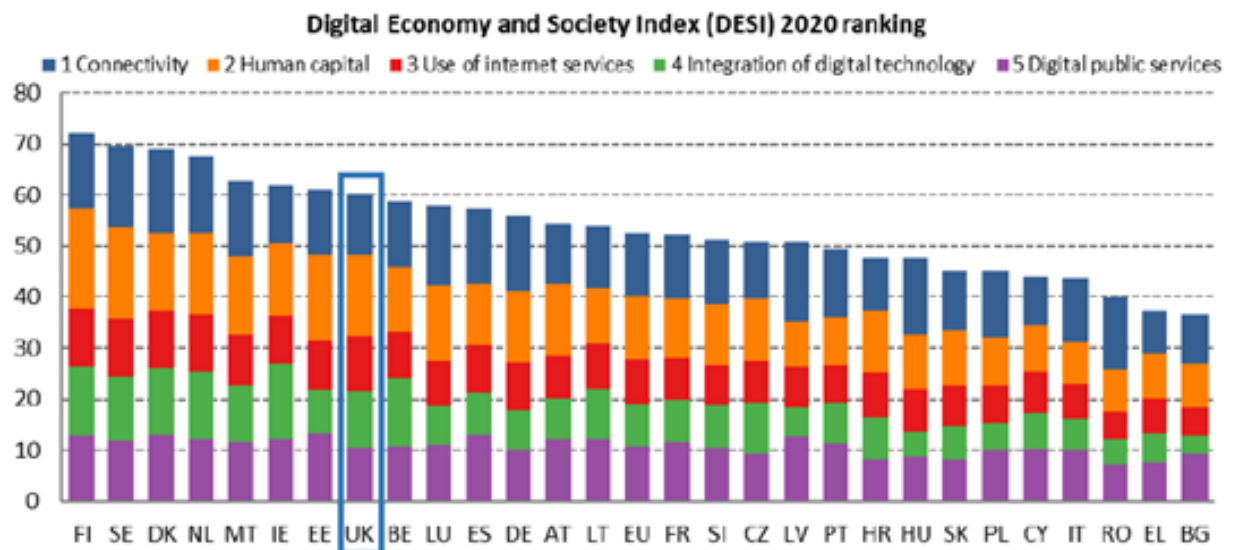


Figure 3.2 – Digital Economy and Society Index (DESI) 2020 Ranking (European Commission, 2020)

	United Kingdom		EU
	rank	score	score
DESI 2020	8	60.4	52.6
DESI 2019	7	56.6	49.4
DESI 2018	6	53.5	46.5

Figure 3.3a – DESI UK Ranking 2018-2020 (European Commission, 2020)

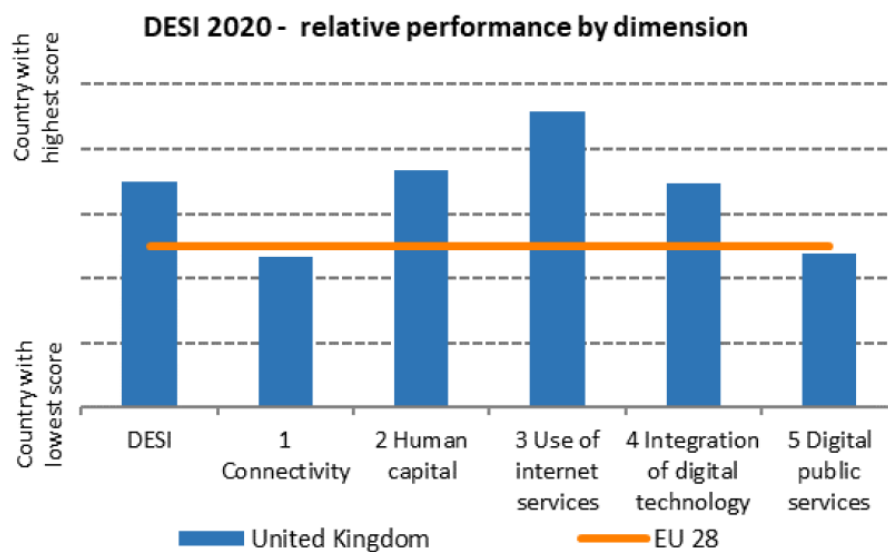


Figure 3.3b - DESI UK Ranking 2020 – Relative Performance by dimension (European Commission, 2020)

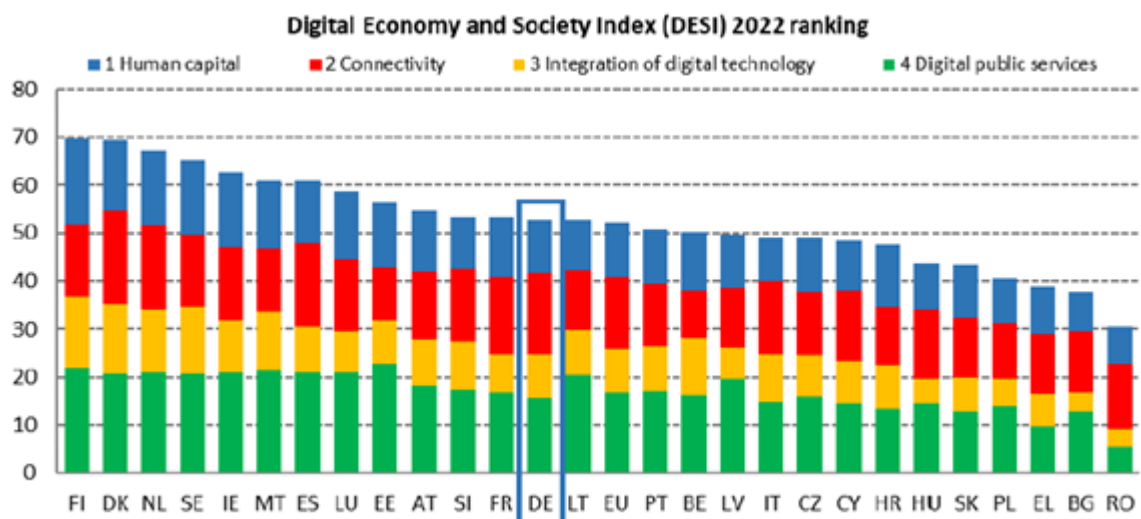


Figure 3.4 - Digital Economy and Society Index (DESI) 2022 Ranking (European Commission , 2022)

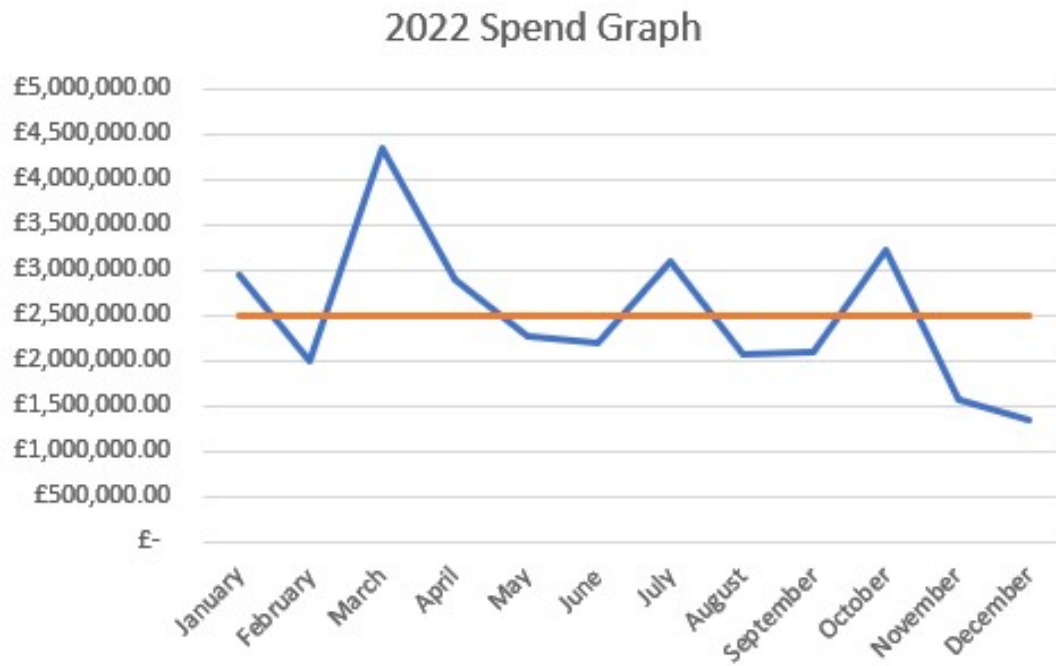


Figure 4.1 – 2022 Spend Graph

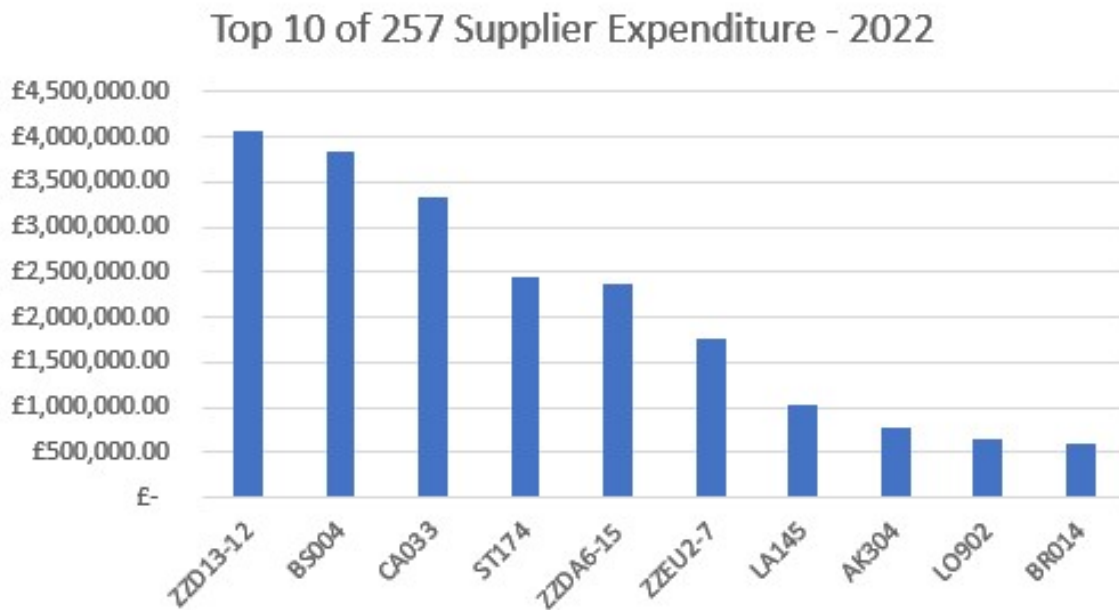


Figure 4.2 – Top 10 of 257 Supplier Expenditure 2022

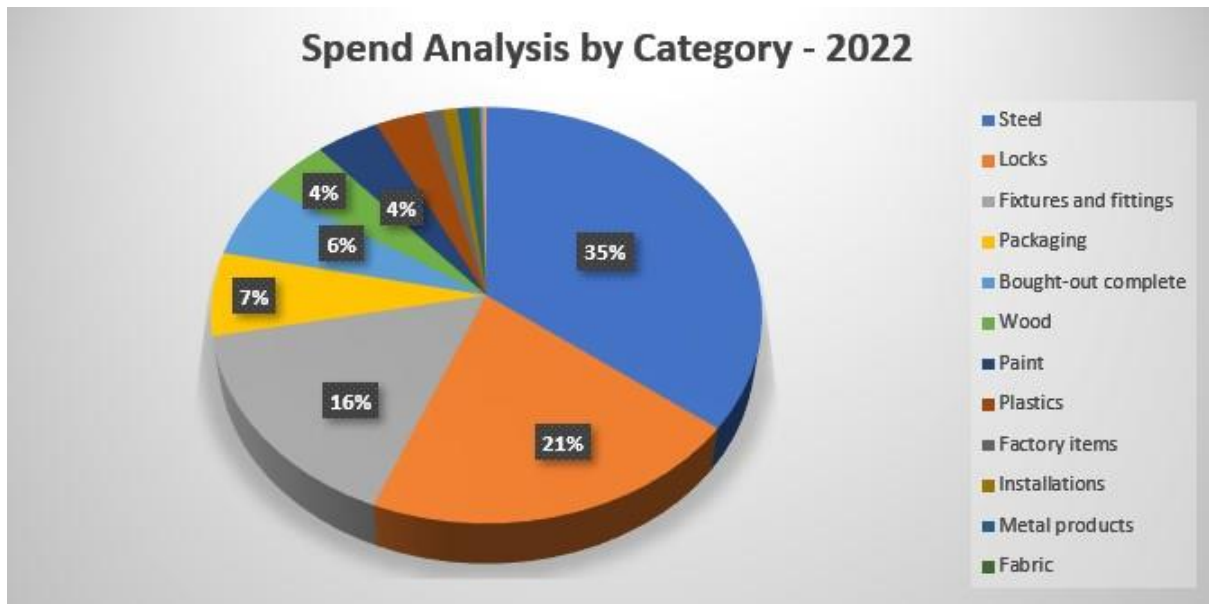


Figure 4.3 – Spend Analysis by Category 2022

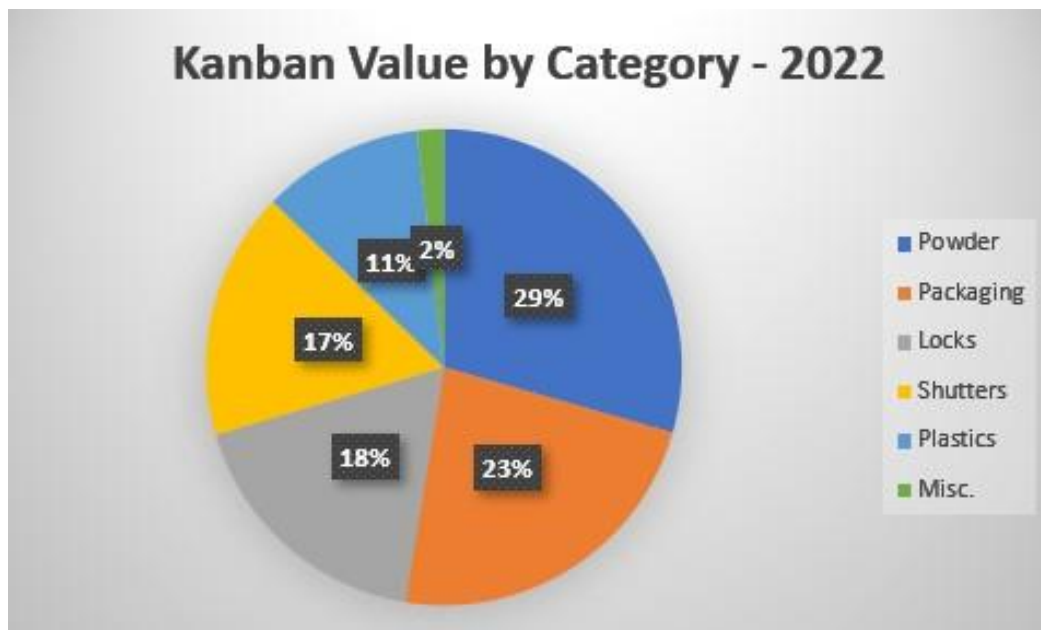


Figure 4.4 – Kanban Value by Category 2022

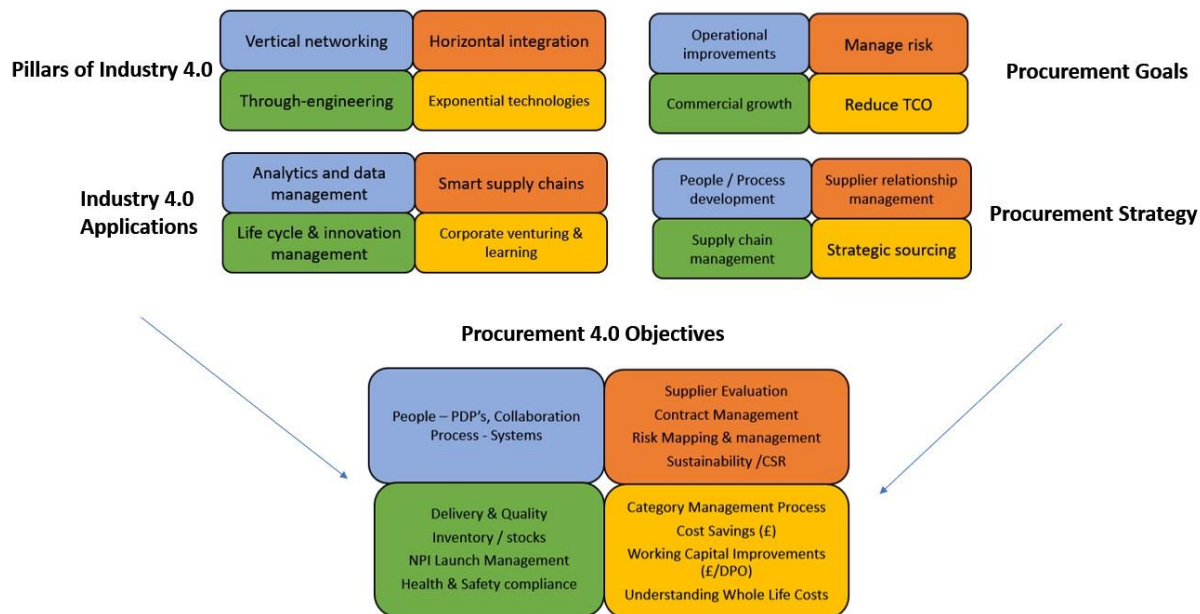


Figure 5.1 – Procurement 4.0 Objectives





Figure 5.2 – 10 types of innovation (Keeley, 2013)

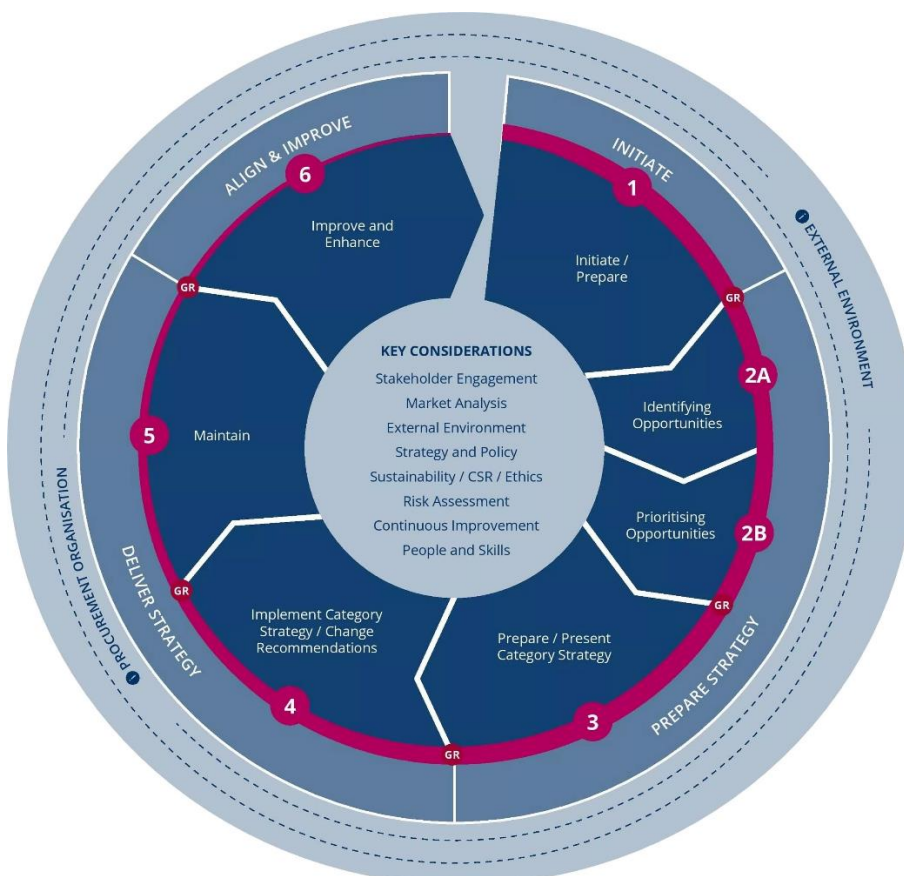


Figure 5.3 – Category management cycle (CIPS, 2023).

Dimensions of procurement data & their ease of access and integration

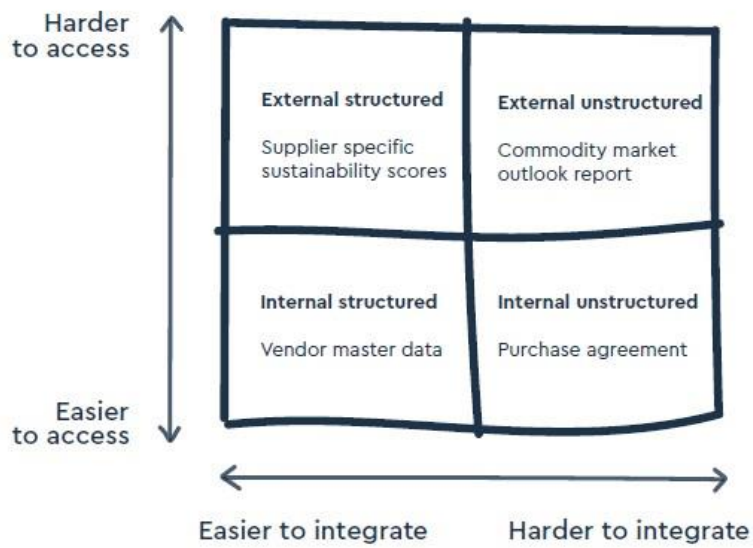


Figure 5.4 – Types of procurement data (Sievo, 2021).

From insights to action: the four types of analytics

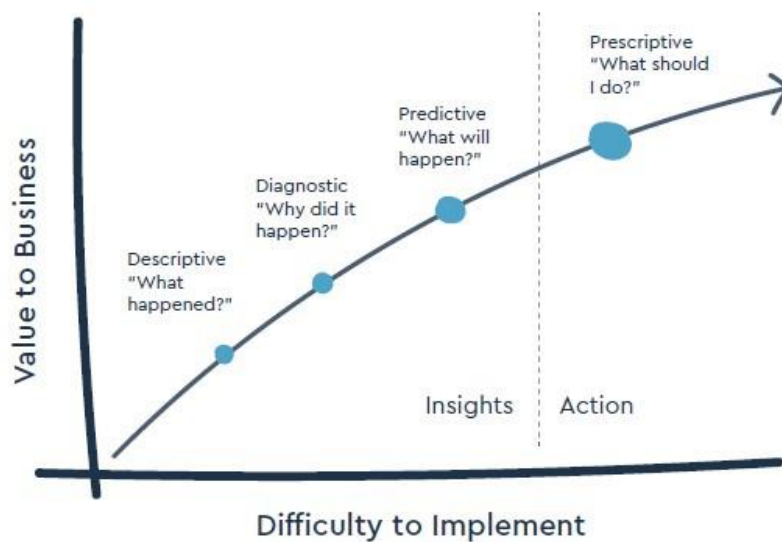


Figure 5.5 – Procurement data analytics categories (Sievo, 2021).

The components of a procurement data ecosystem

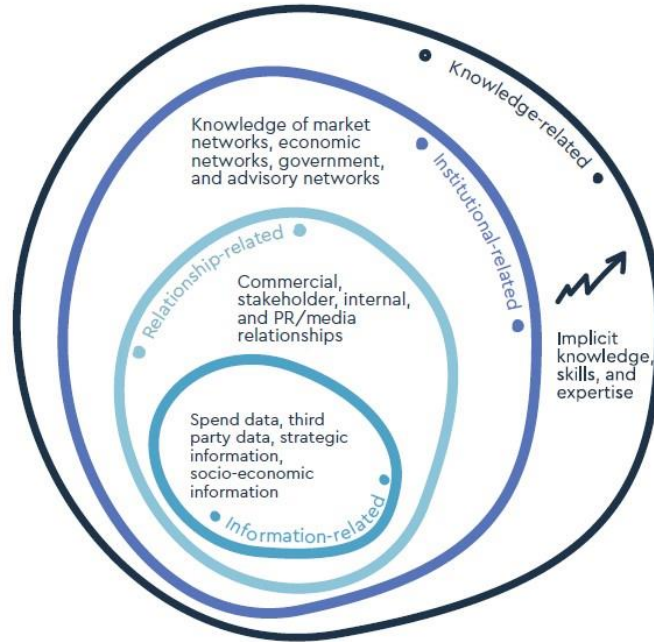


Figure 5.6 – Components of a procurement data ecosystem (Sievo, 2021).