TOOLKIT

Industrial digital technology adoption in UK manufacturing SMEs

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The toolkit provides guidance on potential improvement opportunities from implementing industrial digital technologies (IDTs), ranks business functions by potential impacts from IDT adoption, offers prioritisation of IDTs for a firm's stated focus area and signposts users to the optimum digital solutions. The toolkit allows UK SME manufacturers to benchmark their level of IDT adoption against the industry standard to identify which specific IDTs will have the most significant impact on improving their business performance across a number of indicators and which are most relevant to their needs, thereby simplifying the process of IDT adoption.

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1. Introduction

Industrial digital technologies (IDTs) are transforming the manufacturing landscape. The integration of IDTs into manufacturing promises to yield a production ecosystem that is drastically more flexible, efficient, and responsive. This new industrial revolution has been dubbed 'Industry 4.0'.

Industry 4.0 digital technologies comprise technologies that allow real-time monitoring, remote control of devices, and production machinery through networked infrastructure, and eventually realising a more direct integration and synchronisation between the physical and the virtual world.

The adoption of IDTs has already had a big impact on UK manufacturers and will impact the global economy as a whole, offering promising opportunities to improve the position of UK manufacturers within global value chains.

However, these new opportunities also come with their fair share of challenges and confusion for UK manufacturers, specifically around which IDT to adopt, which supplier to use, and how best to implement IDT adoption.

This toolkit aims to support UK manufacturers in maximising the potential of Industry 4.0 by providing guidance on the complexities, benefits, and challenges of IDTs and digital technology adoption. Additionally, user guidance is provided for the IDT adoption toolkit, a free-to-use software designed to radically simplify and clarify the process of IDT adoption and to allow firms to benchmark their level of digital adoption against their peers.

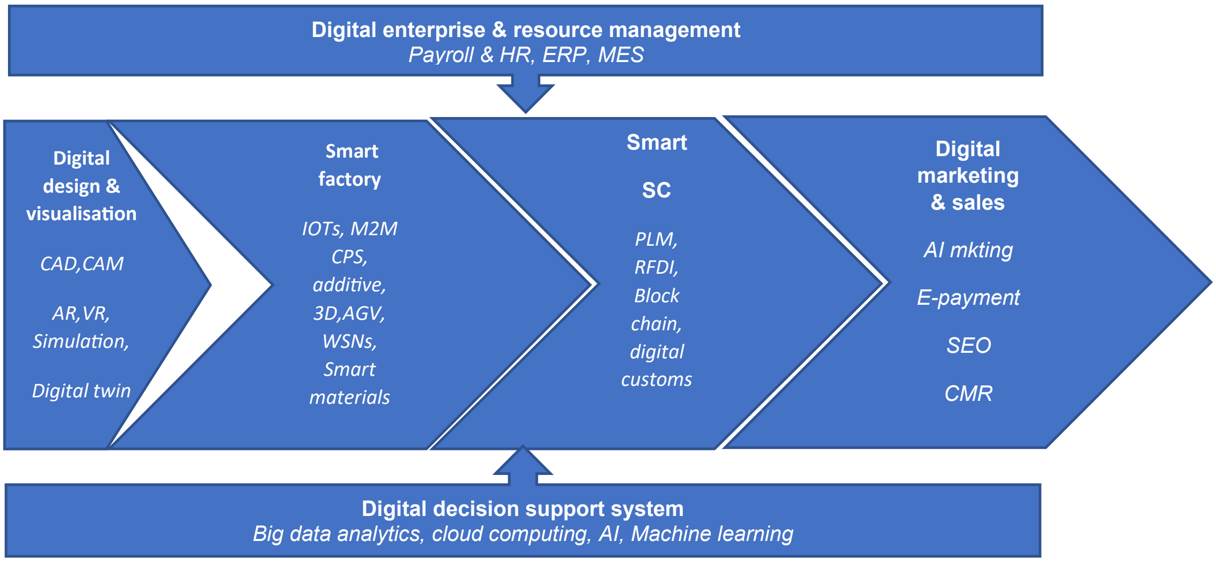
The toolkit was developed based on the results of a research project on the adoption of IDTs in UK SME manufacturers conducted in 2023. The toolkit consists of two parts: (i) the toolkit guide and (ii) the toolkit program. This document is the toolkit guide. The toolkit program requires expert knowledge to run and produce specific results for a particular firm case based on the detailed data of the firm. If you are interested in finding the results for your firm, you can contact the lead researcher, Dr Hanh Pham.

2. IDTs used in the UK manufacturing sector.

IDTs encompass a wide range of software, hardware and tools that allow real-time monitoring, remote control of devices, and production machinery through networked infrastructure, which has the potential to realise a more direct integration and synchronisation between the physical and the virtual worlds.

IDTs have been developed to serve a firm's business processes. They can be categorised based on business functions: digital enterprise & resource management, decision support system technologies, digital marketing and sales technologies, smart supply chain management and smart manufacturing technologies. Figure 1 shows the list of IDTs employed in UK manufacturing firms. The list has been developed based on our survey of UK SME manufacturers conducted in June 2023.

Figure 1: The links across digital technology categories



The full name and application of each specific technology can be found in Appendix 1.

3. Drivers for IDT adoption.

In general, increasing efficiency, reducing cost or solving other business problems to enhance competitiveness are drivers for technology adoption and organisational changes. In particular, the results of our survey of UK SME manufacturers conducted in June 2023 show the top 5 motivations for their IDT adoption to be the following:

- Responsiveness.
- Quality/Accuracy.
- Efficiency.
- Flexibility.
- Transparency.

4. Top ten benefits of IDT adoption

The results of our survey of UK SME manufacturers conducted in June 2023 show the top ten benefits of IDT adoption for UK SME manufacturers to be the following:

- Shorten delivery time.
- Increase profit.
- Reduce production cost.
- Enhance production volume.
- Increase export sales revenues.
- Increase production flexibility.
- Enhance product range.
- Increase number of foreign customers
- Enhance product quality.
- Enhance sales price.

5. Top five challenges of IDT adoption.

The results of our survey of UK SME manufacturers conducted in June 2023 show the top five challenges in IDT adoption among UK SME manufacturers to be the following:

- Disruption of business process due to long training times.
- Employees reluctant to learn and adapt to the new technology.
- Being locked in with the vendor's technology and unable to change in the future.
- Being ripped off by the IDT vendor.
- Poor after-sale support by the vendor.

6. The three stages of the IDT adoption process.

Adopting an IDT consists of three main stages in which you need to answer different strategic questions.

Stage (1): Identify your business concerns.

What is your main business concern? Are they related to:

- Overall business performance: sales or profit growth?

- Operational performance: product quality (product safety, product defective rates and product reliability) or service quality (on-time deliveries, order accuracy and order flexibility) ?
- Environmental performance (e.g., reusable packaging, material efficiency, wastewater reduction, waste reduction for recycling, overall impacts and energy consumption)?
- Customer-related performance: customer satisfaction and customer loyalty?
- Employee-related performance: employee satisfaction, employee commitment and low employee turnover?

Stage (2) Develop a vision and goals to be achieved in digitalisation.

At this stage, you must ask yourself what you want to achieve from IDT adoption.

Stage (3) Identify a relevant IDT and select the best digital solution.

Which digital solution can help you to achieve the goal that addresses your business concern? To answer this question, you need to implement three tasks: (i) identify relevant IDTs that will help to achieve these goals, (ii) develop IDT adoption criteria, and (iii) select a digital solution vendor.

7. Top ten IDT adoption criteria.

Building IDT adoption criteria is crucial in stage 3 of the IDT adoption process. Although your specific criteria for IDT adoption may depend on your firm's unique circumstances, it may be helpful to see what popular IDT adoption criteria are used by UK firms.

The results of our survey of UK SME manufacturers conducted in June 2023 show the top ten criteria for IDT adoption used by UK SME manufacturers to be the following:

1. Data security and control.
2. Maintenance cost.
3. User-friendliness.
4. Adaptability for the future.
5. Setup costs.
6. Licence cost.
7. Interoperability.
8. Post sales support.
9. Fit of technology.
10. Connections to community.

8. The IDT adoption decision-making tool.

This toolkit was developed in the form of an Excel-based program. It allows users to clarify and simplify their decision-making processes around identifying the types of IDTs relevant to their firm's needs and to select the best IDT solution through a comparison of different specific IDT solutions (Stage 3 of the IDT adoption process).

In particular, the toolkit allows UK SME manufacturers to compare their level of IDT adoption to the industry standard and identify which specific IDTs will have the greatest impact on improving their business performance across several indicators. Then, the toolkit allows the firms to determine the best choice among several competing technologies offered by the digital solution providers they may engage with in their adoption process based on their specified goals and selection criteria (e.g., investment cost, sale growth and environmental sustainability performance).

The toolkit includes two tasks. Task 1 is to identify relevant IDTs, and Task 2 is to decide on the best digital solution based on comparing different specific IDT solutions.

Two case firms, A and B, were used as examples to feed into the IDT decision-making tool. Case firms A and B are anonymised versions of two SMEs that participated in developing the toolkit. In this section, the results of these tests will be briefly outlined to demonstrate the features and use cases of the decision-making model.

Case firm A is a small SME (10-49 employees) which operates on a B2C model. It is a relatively older firm (in existence for >10 years) with a reasonable amount of exporting experience, selling to customers in the EU, US, and Japan.

Case firm B is a medium SME (50-249 employees) operating on a B2B model. It is a new firm (established <5 years ago) with limited exporting experience, selling mainly to domestic firms but also a small number of firms based in the EU.

8.1 and 8.2 set out the results of applying the decision-making tool for the case firms.

8.1. Identifying relevant IDTs

This task includes three steps as below.

Step 1: Describe the business size.

Step 2: Describe the business needs.

Step 3: Describe the current stage of IDTs in use.

The toolkit will then calculate:

- Scores against the average scores from the survey.
- Improvement potential against the average score.
- Potential improvement opportunities for each IDT.
- Business functions ranked by the potential impact on performance.
- Prioritisation of IDTs for the focus area stipulated by the user.
- Which available digital solution providers are relevant to the user's needs?

8.1.1. The use of the IDT adoption toolkit to identify relevant IDT for firm Case A

After inputting information on the firm's size, age, business model, and exporting status in the first section of the toolkit, information on priorities for digitalisation can be inputted. Firstly, information on which business function is the highest priority for improvement through IDT adoption is entered, following on from which information on the relative weights attached to the following goals of IDT adoption can be inputted:

- Quality.
- Responsiveness.
- Transparency.
- Efficiency.
- Flexibility.

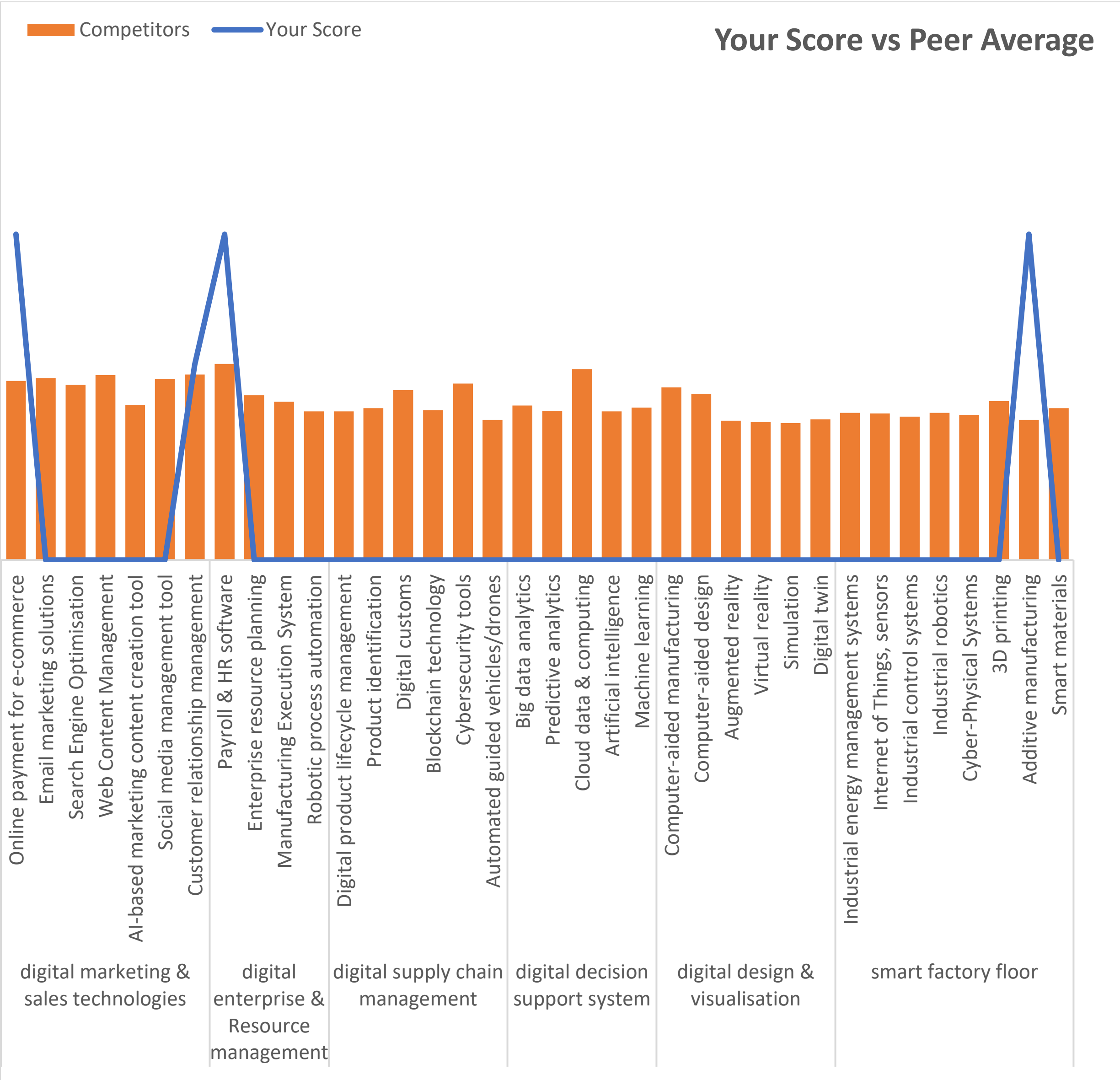
In firm A, the business function identified as most needed improvement was digital marketing and sales technologies, and the goals ranked as being the first and second highest priorities were improved responsiveness and efficiency, respectively.

The following section of the model asks the user to select from a list of IDTs which are currently in place and how satisfied they are with them across the following business functions:

- Digital marketing & sales technologies.
- Digital enterprise & Resource management.
- Digital supply chain management.
- Digital decision support system.
- Digital design & visualisation.
- Smart factory floor.

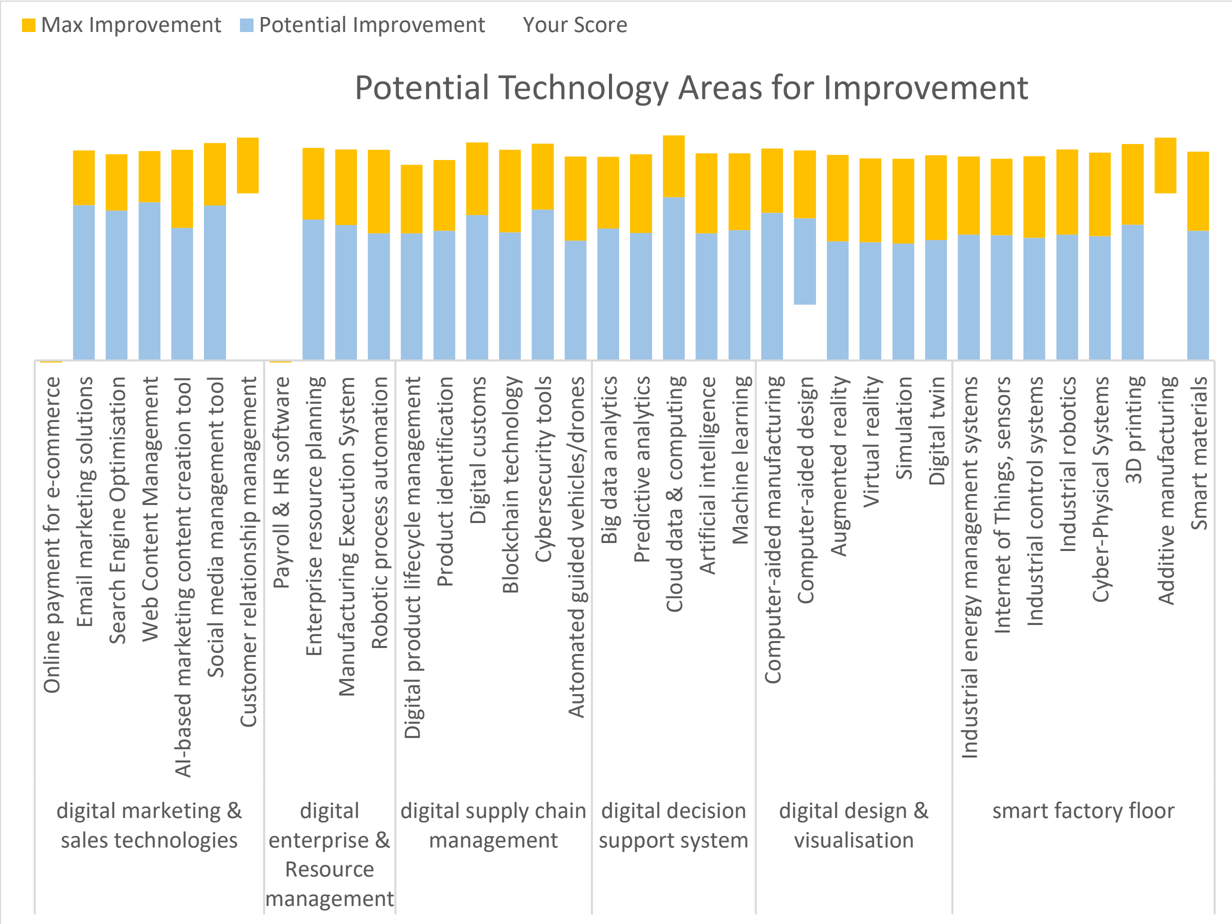
Case firm A has relatively few IT solutions in place but is, for the most part, satisfied with its performance. Specific examples include online payment for e-commerce, payroll & HR software, and CAD. The decision-making tool then provides a score based on the inputted data and additionally benchmarks the user's score with the average score of the user's peers (based on the survey data discussed in section 3.2). The results for case firm A can be seen in Figure 2.

Figure 2: IDT implementation score for Case firm A.



Following this, the decision-making model provides guidance on areas for improvement in terms of technology implementation. Figure 3 shows this output for firm A.

Figure 3: Potential technology areas for improvement for case firm A.



The decision-making model also ranks specific IDTs and business functions by their potential to improve performance. Examples of these outputs for case firm A can be found in Figures 4 and 5.

Figure 4: IDTs ranked by opportunity for case firm A.

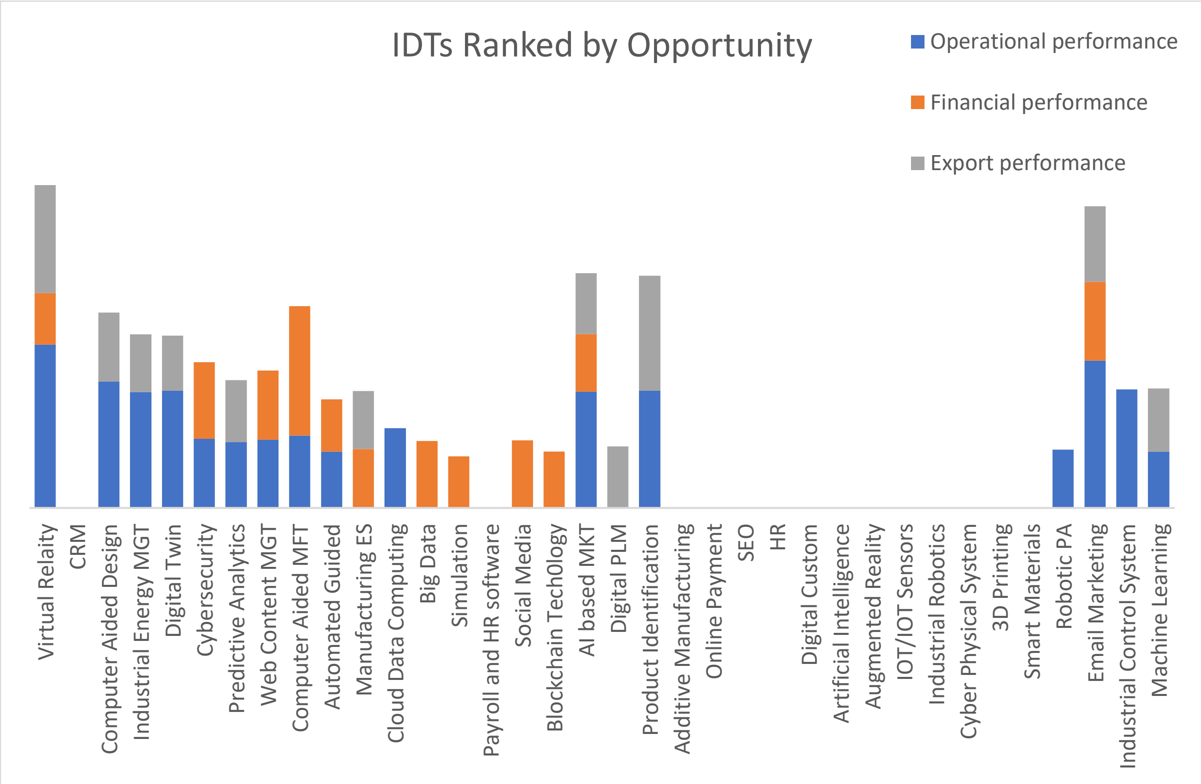
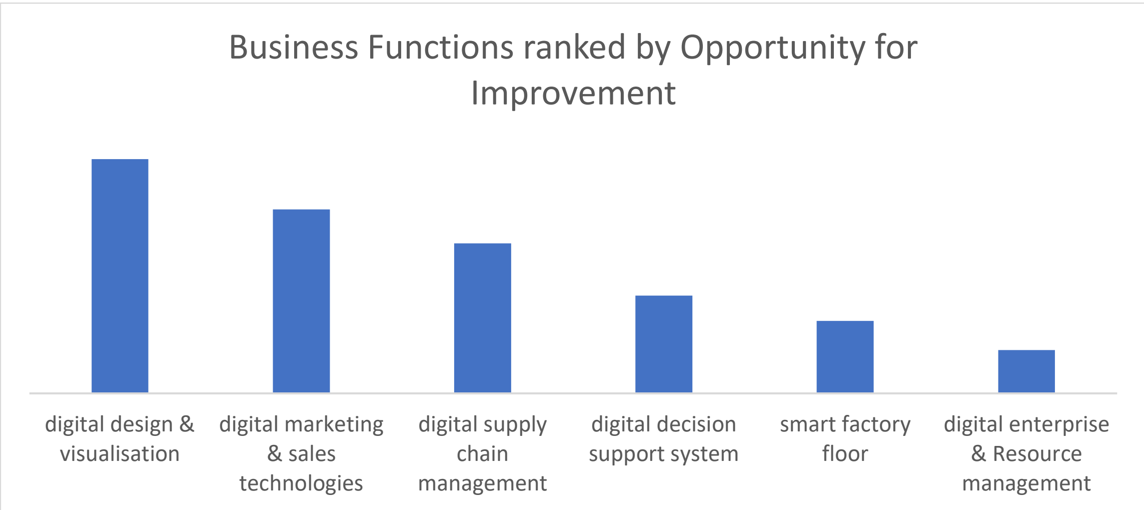
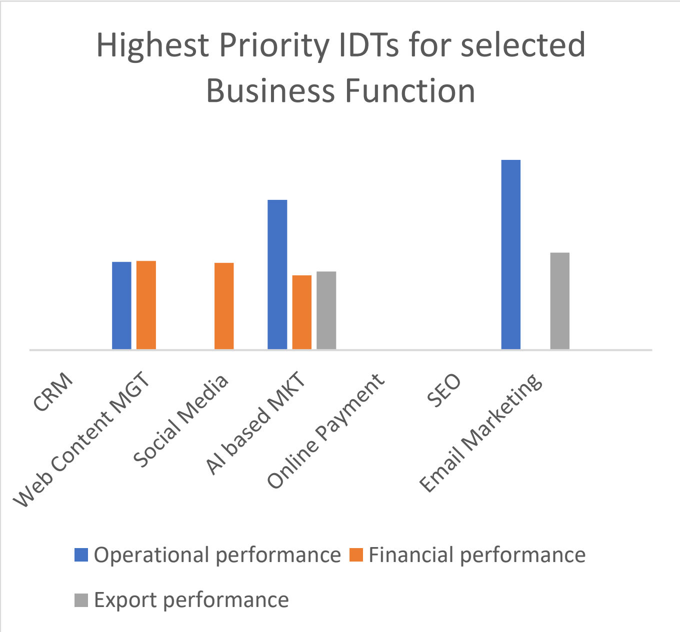


Figure 5: Business functions ranked by opportunity for improvement for case firm A.



Finally, the decision-making model also provides outputs related to the specific business function highlighted by the user as most important in section 2 of the model (described above). For case firm A, this was digital marketing and sales. Figure 6 shows the highest priority IDTs for case firm A.

Figure 6: Highest priority IDTs for Case firm A's selected business function.

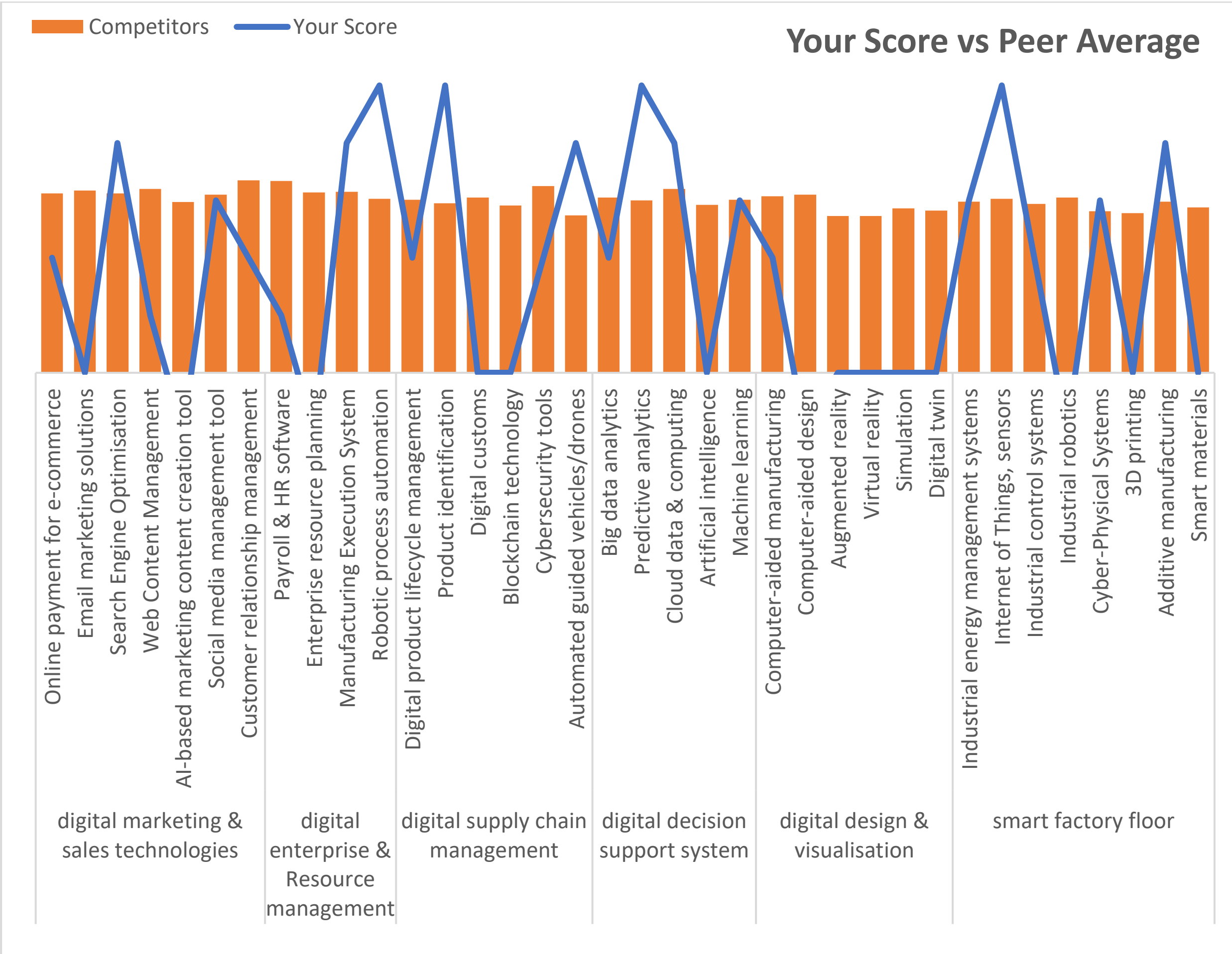


8.1.2. The use of the IDT adoption toolkit to identify relevant IDT for *case firm B*

Compared to case firm A, firm B is more advanced in its adoption of IDTs but has targeted digital supply chain management as the business function it most seeks to improve. Regarding case firm B's rankings, transparency was rated as the highest priority, followed by efficiency.

Specific IDTs already implemented by firm B include robotic PA, industrial control systems, digital product life cycle management, ERP software, and machine learning. IDTs in which Firm B has yet to invest include VR, digital twins, and blockchain technologies. Figure 7 shows the IDT implementation score for case firm B. As expected from their differing backgrounds, the results show that firm B is much more advanced in its digitalisation journey and performs better against the average peer score than firm A.

Figure 7: IDT implementation score for case firm B.



Figures 8 and 9 show the opportunities for improvement that can be gained from implementing specific IDTs. One interesting result is that Figure 9 identifies VR as the IDT, which represents the greatest opportunity for case firm B. This demonstrates the usefulness of the toolkit, as the firm on which B is based did not note this technology as representing a priority in the interview as they were focussed on an ongoing project implementing IDTs aimed at improving transparency; using the toolkit therefore, can provide a fresh perspective by suggesting appropriate IDTs that have not yet been identified by management as a priority. The result for Figure 10, 'business functions ranked by opportunity', similarly identifies data design & visualisation technologies as promising opportunities where case firm B had previously only identified digital supply chain management as a priority.

Figure 8: Potential technology areas for improvement for case firm B.

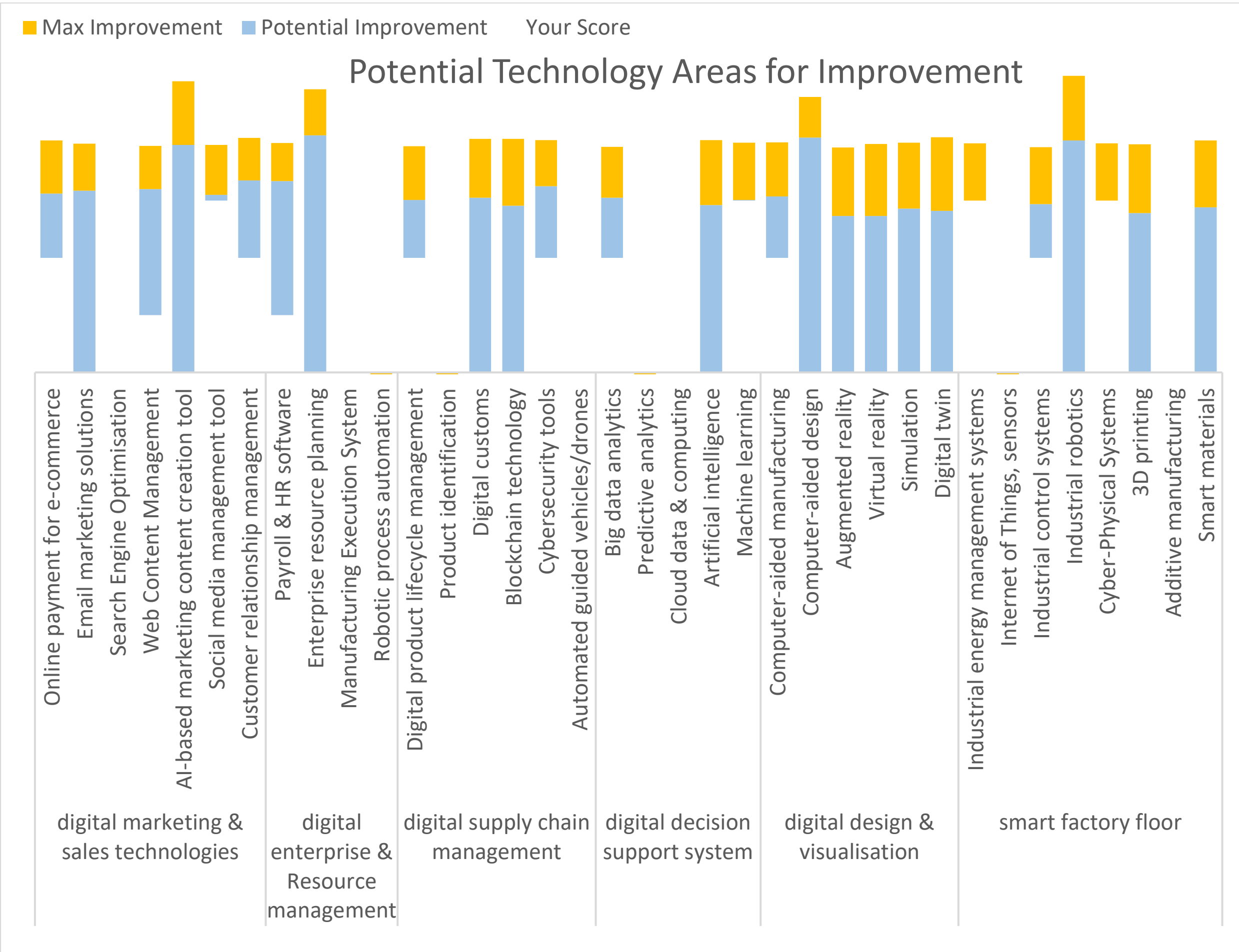


Figure 9: IDTs ranked by opportunity for case firm B.

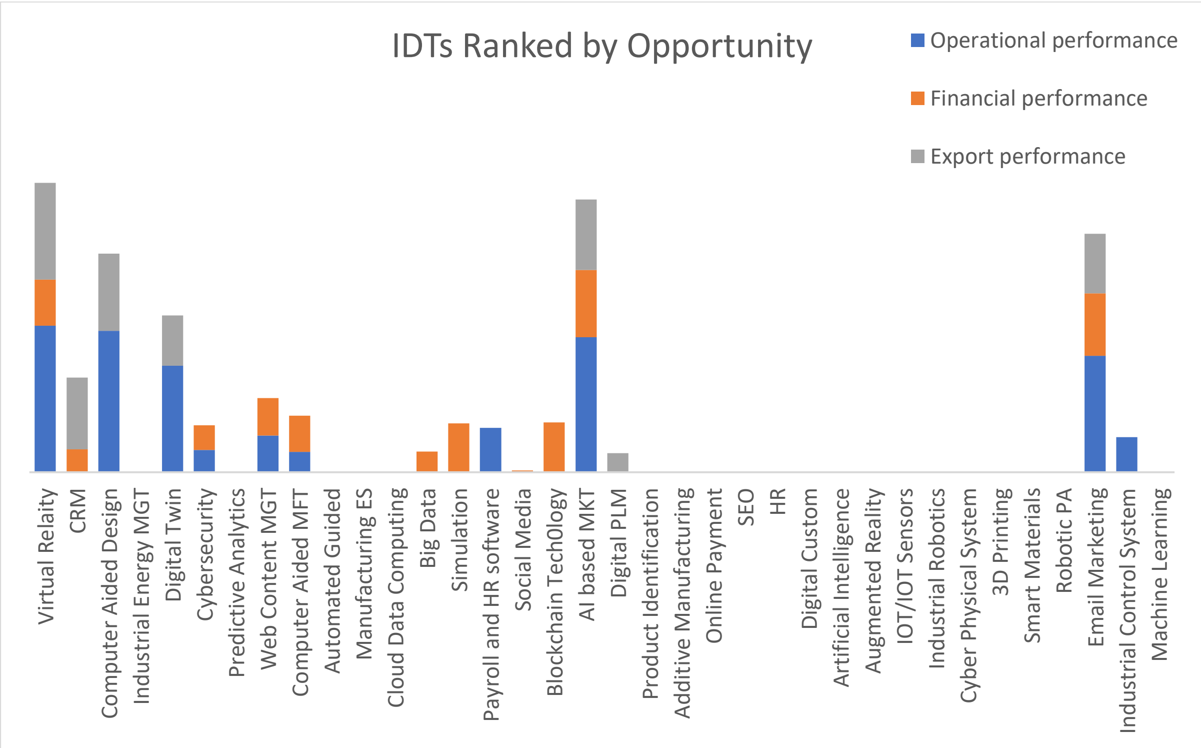


Figure 10: Business functions ranked by opportunity for improvement for case firm B.

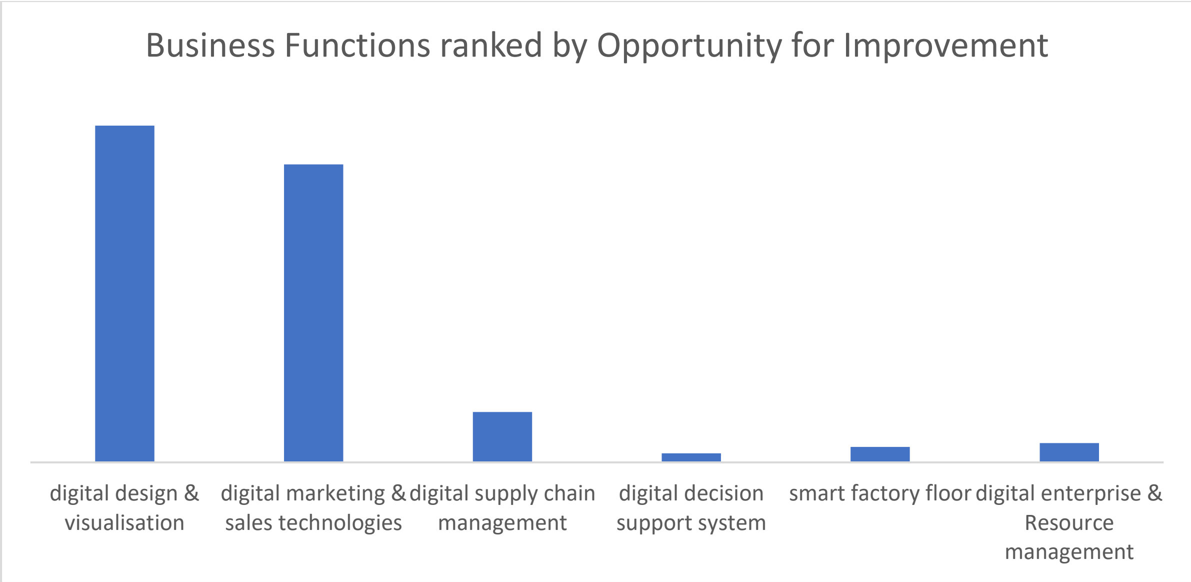
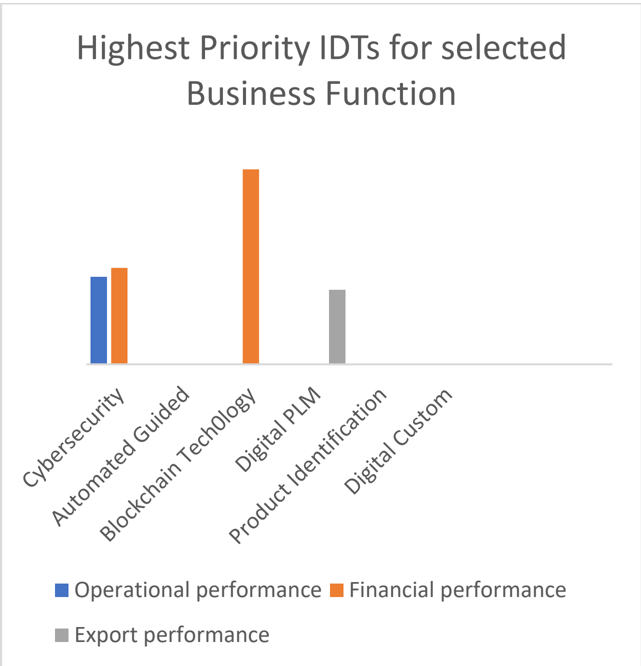


Figure 11 shows the most important IDTs for case firm B within their indicated highest priority business function, digital supply chain management. As can be seen, the decision-making model identified cybersecurity, blockchain, and digital product lifecycle management as the IDTs most likely to have a positive impact on operational, financial, or export performance.

Figure 11: Highest priority IDTs for case firm B's selected business function.



8.2. Select the best digital solution.

After identifying relevant IDTs, the IDT adoption decision-making toolkit can be used to identify the ideal solution(s) for the firm based on the specific objectives of the company and quotations that a firm may get from digital solution providers. Every company is going to have a unique set of criteria on which to base their decision, and the following process allows them to identify and use these in the selection process. The following section will demonstrate this aspect of the decision-making model's functionality, once again using the examples of case firms A and B discussed previously.

Note that in this toolkit, we use two different decision-making methods in each case to demonstrate two different methods to model the decision. Specifically, we use SURE for case A and AHP-TOPSIS (AHP for the weights and TOPSIS for the decision calculation) for case B. SURE, AHP and TOPSIS are the main technical methods used in decision-making science. To understand these methods, see the book entitled "Smart Decisions" ISBN: 9781119309338. Below, we present the IDT decision-making outcomes for case firm A (using the SURE method) and case firm B (using AHP-TOPSIS).

8.2.2 The use of IDT adoption toolkit to select the best digital solution for case firm A

Case firm A identified digital design and visualisation and digital marketing and sales technologies as the most important IDTs. From this, the company needs to identify specific technologies or suppliers of a single technology to invest in. To showcase the decision functionality, three alternative IDTs from different suppliers were selected for analysis: (1) a VR headset and VR developer to develop product demonstrations, (2) a Solidworks (a CAD software package) licence and CAD engineer to do FEA (Finite Element Analysis, a method of analysis to predict how a product will be impacted by real-world forces), or (3) a social media management tool and social media marketing training for their staff.

The user can start the decision process by inputting the aforementioned technologies and reviewing quotes from relevant suppliers. It should be noted that while in this example, multiple different technologies from different suppliers are compared, it is also possible to compare different technologies from the same supplier or the same technology from different suppliers.

Having inputted the IDTs, the user needs to identify suitable criteria on which to make their decision in the next step. For this example, the criteria used are the investment cost, measuring the value for money of the IDT, the IDT's sustainable impact, measuring the IDT's impact on performance indicators of environmental sustainability (such as energy use), and sales impact, measuring the impact of IDT adoption on sales growth. This data can either be inputted directly from the prospectuses provided by the IDT supplier (in which Case the user can input 'No' in the 'Subjective?' box) or can be based on an estimate (in which Case the inputted data can be marked as such using the 'Subjective?' option). Using the 'Min/Max' option the user can then indicate whether for the inputted criteria minimisation or maximisation is preferred; for example, in the Case of investment cost 'Min' is selected as here the criterion is cost minimisation, whereas for sustainability 'Max' is selected as a higher value indicates a more sustainable product. Figure 12 shows the interface for inputting selection criteria.

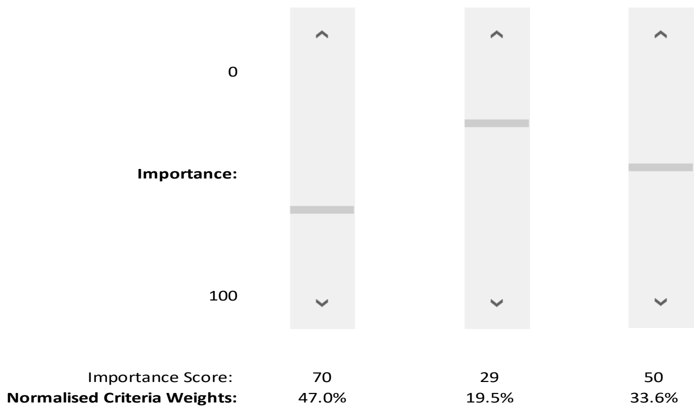
Figure 12: IDT toolkit selection criteria.

Identify Criteria:				
	Name:	Investment cost	Sustainable impact	Sales impact
	Units:	£	/10	/10
	Subjective?	No	Yes	Yes
	Min/Max?	Min	Max	Max

	Investment cost			Sustainable impact			Sales impact		
	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max
Virtual reality	80000	100000	120000	8	9	9	6.5	7	7
Computer-aided design	115000	120000	130000	4	5	6	6	6	7
Social media management tool	50000	60000	62000	1	3	3	8	8	8.5

From here, the user can input information on the importance of each of the criteria by applying a weighting score from 0-100% importance using a sliding bar. Figure 13 shows the criteria importance of the weighting interface.

Figure 13: IDT toolkit importance score interface.

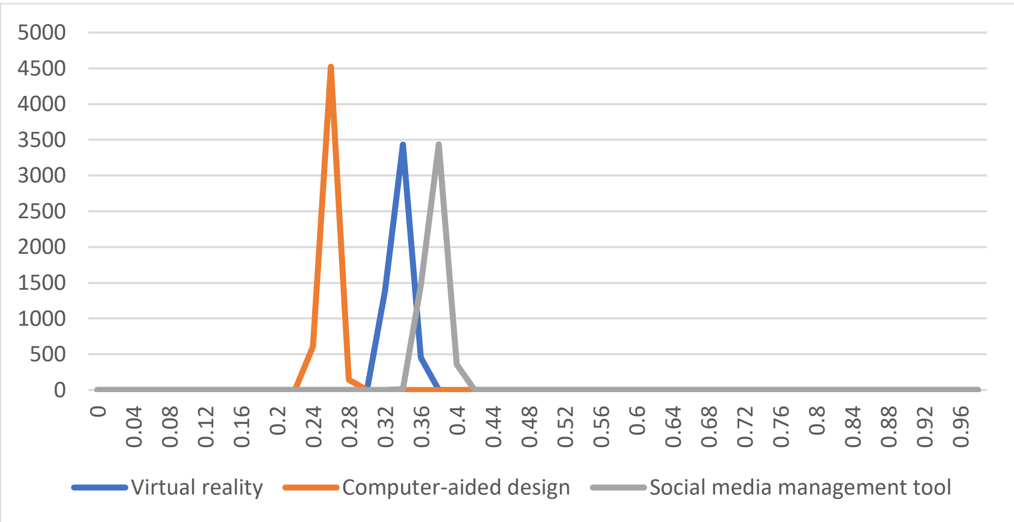


As can be seen, for firm A, investment cost was rated as the most important criterion (importance score=70) and was therefore assigned the largest weighting (47%), while sustainable impact was assigned the lowest importance score (29) with a weighting of 19.5%. Sales growth was assessed as being moderately important, with an importance score of 50 and a weighting of 33.6%.

Finally, the user needs to input information for each alternative with respect to each criterion. The method used in this case study allows for uncertainty, so the user can provide three values for each: a minimum, most likely, and maximum value. The inputs are shown in Figure 12.

Once the criteria have been inputted and the weights assigned, the decision-making model's outputs are ready for interpretation. The model's outputs are provided in a graphical form. The results for case firm A can be found below in Figure 14. The output's X axis represents the overall preferability score, whereas the Y axis represents the intensity of the score. For Case firm A, therefore, it can be seen that the best IDT adoption decision would be to implement the social media management tool. However, there are scenarios where VR could perform better as the distributions overlap.

Figure 14: Case firm A - IDT adoption toolkit model outputs.

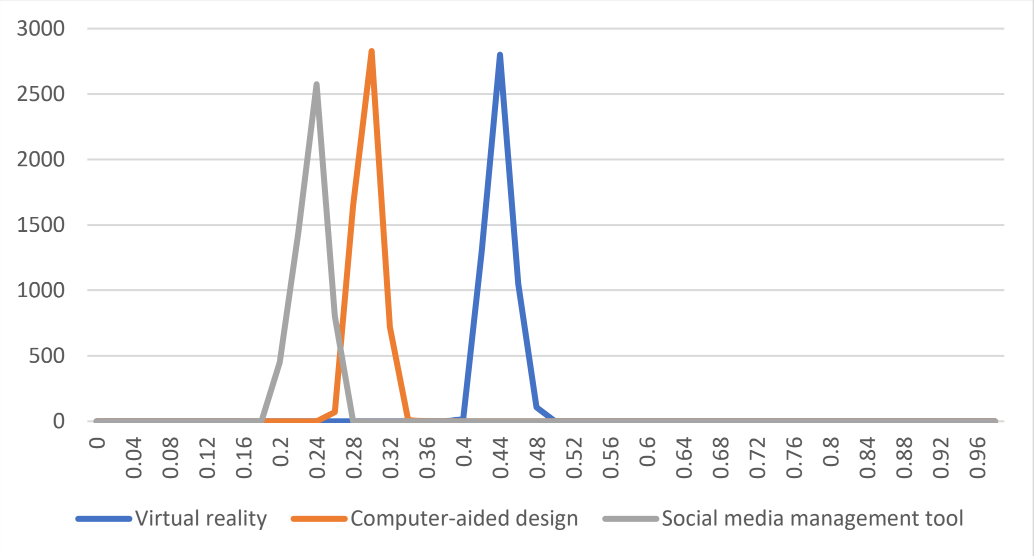


The next step is to perform a sensitivity analysis to determine how the alternatives perform with different inputs.

For example, Figure 15 presents the model outputs when the importance weightings are changed so that no importance is attached to investment cost as a decision criterion (importance score = 0), and the importance scores for the other criteria remain unchanged. As can be seen, the model outputs change drastically, placing VR as the best option, not overlapping with any other alternative.

At this point, the company can do further research or investigations to narrow down the uncertainty of the problem or make a call on which IDT/supplier to invest in.

Figure 15: Case firm A IDT adoption toolkit model outputs with altered importance scores.



8.2.3 The use of IDT adoption toolkit to select the best solution for case firm B

Case firm B requires support in selecting between 4 IDTs: CAD, SEO to improve the firm's marketing, email marketing solutions, including training for staff on how email marketing techniques, and predictive analytics, including hiring a predictive analytics professional to construct a predictive dashboard.

In contrast to case firm A, for case firm B, the main decision-making criteria are investment cost, value for business (measuring the costs and benefits to the business from a holistic perspective), and company values (measuring alignment of the IDT with the firm's values). Figure 16 presents the selection criteria inputted for case firm B.

Figure 16: Case firm B selection criteria.

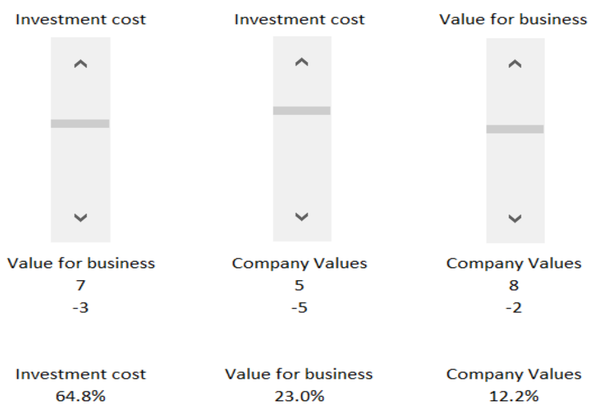
Identify Criteria:	Name:	Investment cost	Value for business	Company Values
	Units:	£	/100	/10
	Subjective?	No	Yes	Yes
	Min/Max?	Min	Max	Max

	Investment cost	Value for business	Company Values
Computer-aided design	85000	7	9
Search Engine Optimisation	10000	8	3
Email marketing solutions	25000	6	4
Predictive analytics	50000	7	7

Unlike case firm A, we are going to use a pairwise selection methodology for assessing the criteria weights. This means each criterion is compared directly with each other, with the user inputting this information using slider bars. The weights are calculated for case firm B. Figure 17 shows the criteria importance weighting interface for case firm B.

In terms of importance weighting, for case firm B, the criterion assigned the highest weighting is investment cost (64.8%), followed by value for business (23%), with alignment with company values assigned the smallest weighting (12.2%).

Figure 17: Case firm B importance score interface.

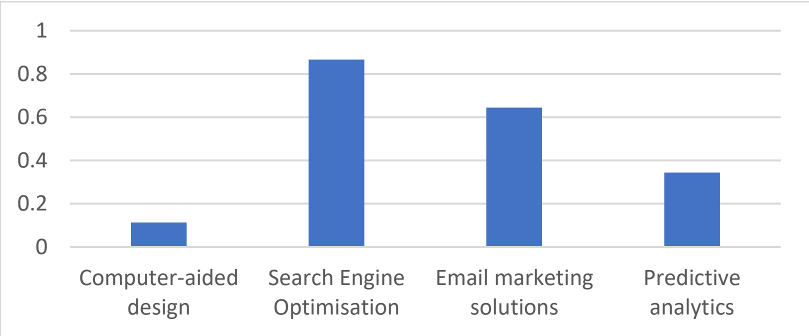


Note that the decision-making model used in case B differs from case A; in this method, only one value is needed for each alternative concerning each criterion. This means uncertainty ranges are not considered, but uncertainty can be assessed afterwards using a sensitivity analysis.

The outputs of the decision-making model are presented in Figure 18. As can be seen, the results indicate that SEO is the optimal IDT for case firm B to adopt, given the firm's criteria and preferences. As before, the visual presentation of the outputs is configured slightly differently than in the example of case firm A. In Figure 18, overall preferability scores are displayed on the Y-axis.

It would be advised that a sensitivity study is subsequently used to assess how changes to the weights and alternative scores impact the results. This can be achieved through a local or global sensitivity analysis, a local analysis being where 1 value is updated, the model assessed and then returned to the original values and a global analysis being where multiple values are updated, and the model is assessed before returning to the original values.

Figure 18: Case firm B IDT adoption toolkit model outputs.



8.2.3. Decision-making method selection.

There are many different decision-making methodologies available for modelling decision problems. It's a personal preference which one you prefer. Some people like giving direct weights, while others prefer pairwise comparisons. Similarly, some people like to see what the overall uncertainty is in the results, while others prefer to explore uncertainty with a sensitivity analysis.

We have demonstrated different methods so that users are aware of a wider range of the methods available and can select the method they prefer. If users want to learn more about what methods are available, we recommend reading Smart Decisions by Richard Hodgett, Sajid Siraj, and Ellen Louise Hogg (ISBN: 9781119309338). This book shows how to model the methods used in the 2 cases along with other popular methods in Excel (and the statistical programming language R).

9. Conclusion

Digital adoption is clearly the way of the future. Adapting to new technology and fully leveraging its features is imperative to the modern organisation and is what leads to digital transformation.

While it might seem natural that organisations of all sizes should absolutely adopt and leverage new technology, the truth is that there are many different challenges that they have to face before they can truly adopt them.

However, with good training and onboarding, great support and a great digital adoption strategy, you can make a massive difference to the success of your organisation.

Acknowledgement

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Appendix: Glossary of Industrial Digital Technologies with Applications

	Application
Digital marketing & sales technologies	**Technologies that assist with the integration and automation of company sales & marketing**
Online payment for e-commerce	Used to make and receive payments via the Internet, including debit/credit cards, wire transfers, net banking, and digital wallets.
Email marketing solutions	Used to create, send, and track emails to their list of subscribers. Using software makes it easier to create well-designed emails and allows users to see key metrics, e.g., open rates and click-through rates.
Search Engine Optimisation (SEO)	Used to optimise a website's technical configuration, content relevance and link popularity so its pages can become easily findable, more relevant and popular towards user search queries, and hence, search engines rank them better.
Web Content Management	Used to create, manage, store, and display content on webpages. It is often used to manage the integrity, revisions, and lifecycle of information and the content that is specifically destined for the web.
AI-based marketing content creation tool	Used for various purposes, such as generating ideas, writing copy, editing, and analysing audience engagement.
Social media management tool	Used to enable the users to effectively manage their presence on social media, facilitating more effective marketing and communication with clients.
Customer relationship management (CRM)	Used to manage, track, and store information related to your company's current and potential customers. By keeping this information in a centralised system, business teams have access to the insights they need the moment they need them.
Enterprise & resource management	**Technologies that assist with the integration and automation of company accounting, payroll, HR, process scheduling**
Payroll & HR software	Used to improve the efficiency of the users' HR processes, enabling cost reductions and freeing up managerial resources.
Enterprise resource planning (ERP)	Used to manage and integrate the essential parts of their businesses in order to increase the efficiency and transparency of their operations.
Manufacturing Execution System (MES)	Used to manage and optimise production processes, raising outputs and increasing efficiency.
Robotic process automation (RPA)	Used to automate various supply chain processes, including data entry, predictive maintenance and after-sales service support.

Digital supply chain management	**Technologies that assist with the integration and automation of information tracking & traceability of raw materials, work in progress, and finished goods.**
Digital product lifecycle management (PLM)	Used in manufacturing to manage a product and its associated data through all stages of the product lifecycle.
Product identification (e.g., RFID, RTLS)	Used to enable the automatic identification and tracking of parts and products, allowing operational processes to become more transparent, efficient, and secure.
Digital customs declaration	Used to check if the goods are allowed into the country and to determine the taxes and duties needed to pay.
Blockchain	Used to record transactions and share information in a secure, transparent, and tamper-resistant manner.
Cybersecurity technologies	Designed to combat threats against networked systems and applications, including theft of sensitive data by hostile state and non-state actors.
Digital decision support system	**Technologies that assist with the integration and automation of company data analysis and decision-making process**
Big data analytics	Used for planning and forecasting, predictive maintenance and simulation in manufacturing, supply chain management and maintenance. The data can come from IoT systems connected to the productive layer (e.g., with sensors and associated equipment) or the exchange between IT systems for production and warehouse management.
Forecasting/predictive analytics	Used for continuous adjustment of forecasts to help the company identify new opportunities and risks early and grow profitably.
Cloud data and computing	Used to enable ubiquitous, convenient, on-demand internet access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
Artificial intelligence (AI)	Used to perform functions including, but not limited to, speech recognition, machine vision or machine learning, e.g., speech recognition, machine vision using sensors and software, and machine learning, which uses statistical software and data to "learn" and make better predictions without reprogramming.
Machine learning	Used in internet search engines, email filters to sort out spam, websites to make personalised recommendations, banking software to detect unusual transactions, and apps on mobile phones such as voice recognition. To handle large amounts of data using the same customer segmentation processes for improving marketing.
Digital design & visualisation technologies	**Technologies that assist with the integration and automation of design and new product development practices**
Computer-aided manufacturing (CAM)	Used to enable manufacturers to create better parts with increasingly more control over the entire process.
Computer-aided design (CAD)	Used to create better quality designs and greater efficiency in the design process.
Augmented reality (AR)	Used for various purposes, including gaming, product visualisation, marketing campaigns, architecture and home design, education, and industrial manufacturing. For example, AR can be used to promote products or services, launch novel marketing campaigns, and collect unique user data.
Virtual reality (VR)	Used in entertainment applications such as video games, 3D cinema, amusement park rides and social virtual worlds.
Simulation	Used to tune up performance, optimise a process, improve safety, test theories, train staff and even for entertainment in video games
Digital twin technology	Used to monitor equipment at all times and analyse performance data that shows how a particular part or the entirety of the plant is functioning.
Smart factory floor	**Technologies that assist with the integration, automation, quality, and safety of manufacturing processes.**
Industrial energy management systems	Used to monitor energy consumption
Internet of Things (IoT/IIoT), sensors	Used in manufacturing applications and many others (housing and construction, automotive sector, environment, smart city, agriculture, health, etc.).

Industrial control systems (PLS, SCADA)	Used to control industrial processes such as manufacturing, product handling, production, and distribution.
Automation and industrial robotics	Used to replace manual labour and increase efficiency, speed, and overall performance.
Cyber-Physical Systems (CPS/CPPS)	Used to develop the processes, networking and technology needed to seamlessly integrate cyber and physical systems.
Additive manufacturing	3D Printing finds application in prototyping (to support the product development process, static simulation and wind tunnels, etc.), manufacturing (direct production of products), maintenance and repair, and modelling phases, e.g., drugs, medicine, dentistry, automotive sector, construction, customised tools and components.
Machine to Machine (M2M) technologies	Used to capture and transmit data according to specific applications through multiple wireless technologies
Automatic guided vehicle (AGV)/Drones	Used in various applications, including manufacturing, warehousing, inspection, exploration, transportation, and military.
Wireless sensor networks (WSNs)	Used to respond and detect some input from both physical and environmental conditions.
Smart materials	Used to create more efficient and responsive sensors, actuators, and similar devices.