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Section 1: Introduction

1.1 Business model definition: There are a number of key business models that are implemented within industry 4.0. A business model describes the rationale of how an organisation intends to create, deliver, and capture value (Ibarra, 2018). It can be presented as the design and undertaking of activities, methods, and timescales, using resources to create the highest value for the client, by interacting with suppliers and partners, to secure its position to take over the market share (Grabowska, 2022). A business model underpins value proposition, market segments, structure of value chain, value capture mechanisms and how these elements link together (fig 1).

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?

Fig 1 - (Weking, 2020)

1.2 Difference between business model and strategy: A business strategy is required to create and appropriate value from the organisation's systems, processes, resources, and competencies (Kohtamaki, 2020). Operational adjustments can be made to identify new avenues and sources of value. The business model reflects the implementation of the strategy in terms of economic effects. Current and future revenues are generated by products offered and a competitive approach to market. This results in revenue stream, return on investment, combination of profit and appropriate cost structure.

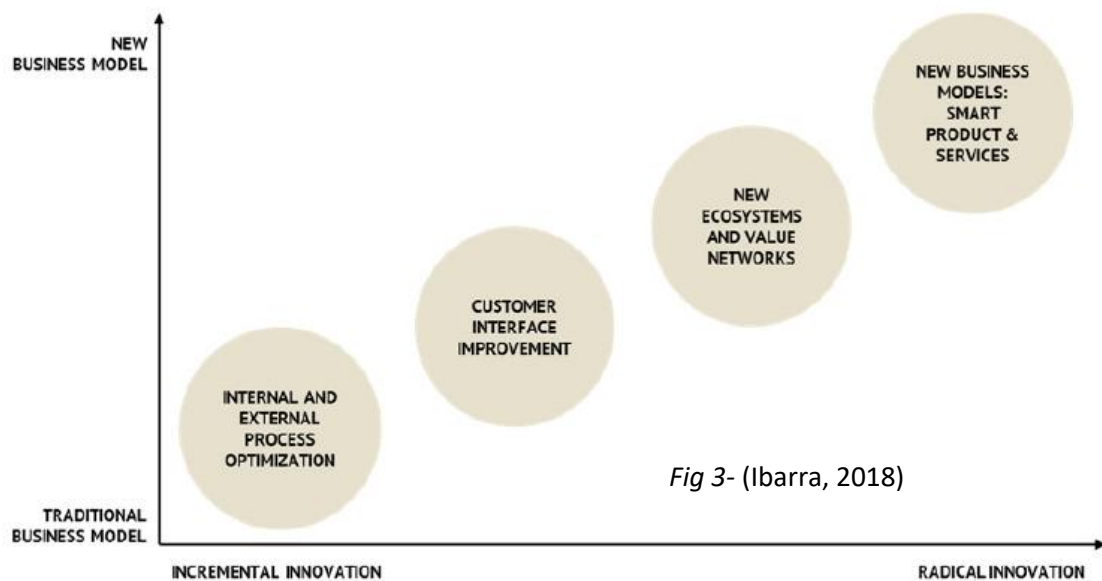
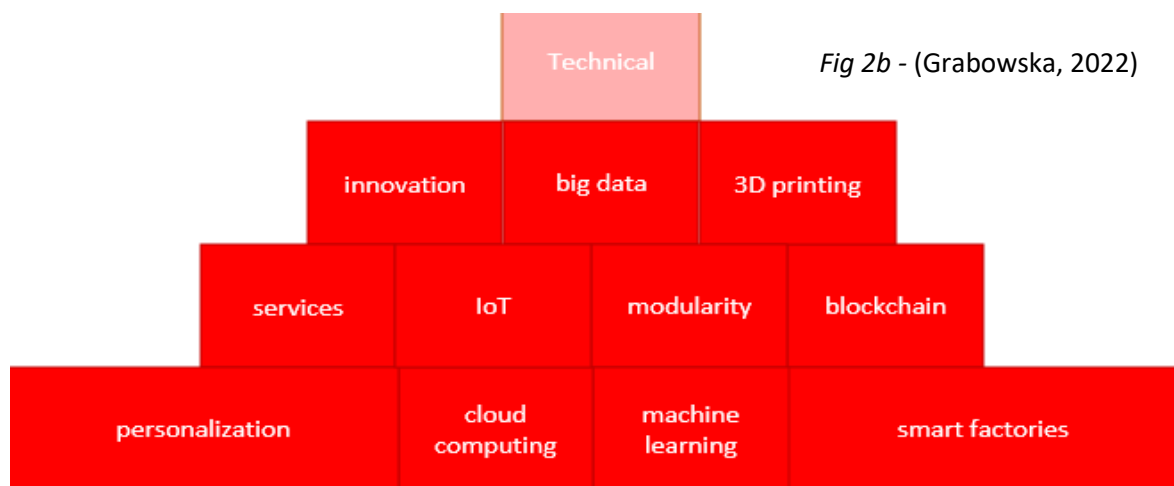
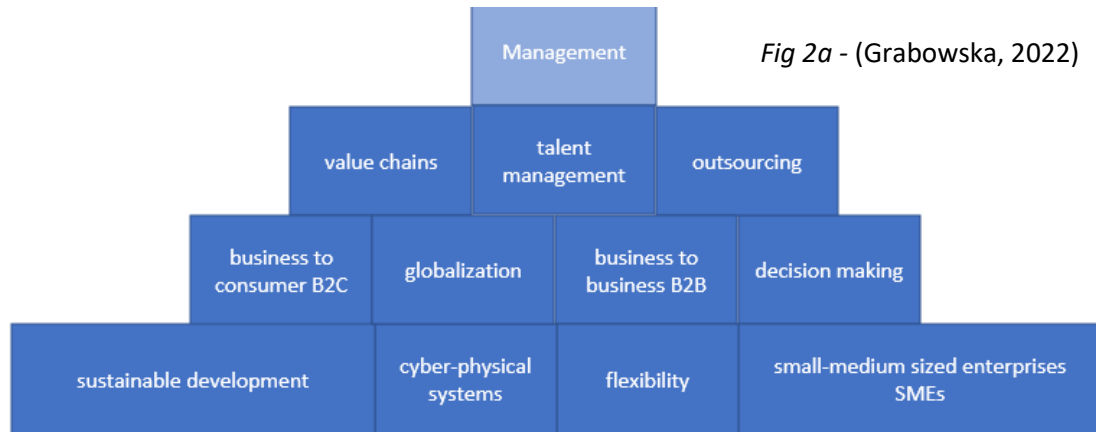
1.3 Importance of value: Value is a key phase in business model innovation, industry 4.0 and lean manufacturing (Powell, 2021). According to most literature (Grabowska, 2022), (Ibarra, 2018), (Muller, 2018), and (Platform Industrie 4.0, 2019), value can be broken down into the four key aspects:

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

1.4 Business model innovation: This represents the designed, novel, non-trivial changes to key elements of an organisations' business model and/or the architecture linking these elements (Muller, 2018). In order to win the global race for data-driven business models and create new value propositions; innovation needs to be centred around managerial (Fig 2a) and technical (Fig 2b) pillars simultaneously. It is suggested that there are four main steps of business model innovation (Fig 3). This begins with identifying the flaws within the current business model before implementing incremental innovation for improvement. There is a period where there is parallelisation of the old

and new business models, whilst new ecosystems and value networks are established. A new business model can then be seen as disruptive or radical innovation for the business.

Data needs to be assessed and made commercially viable. These should complement the approaches to increase the value in current procedures and practices. Both existing and emerging technologies can impact the extent to which these opportunities can be explored and exploited.



Section 2: Business models for industry 4.0

2.1 Defining industry 4.0: Industry 4.0 represents production networking and the digitalised connectivity between suppliers and customers across the complete value chain. Three key elements are shown in (fig 4) below.

1. High grade digitalisation
2. Smart manufacturing through cyber – physical systems
3. Inter-company connectivity between the suppliers and customers within the value chain

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.

Fig 4 - (Muller, 2018), (Kohtamaki, 2020)

2.2 Industry 4.0 – Existing and emerging technologies: (Platform Industrie 4.0, 2019) explores five drivers and enablers of digital business models, those being:

1. **Availability of core technology** – Increasing levels of interconnectedness of machines, people, products, and logistics allows different data sets to be combined. Companies can monitor and align different processes from one central location. The industrial internet of things (IIOT) enables this, and falling costs allows greater and scalable use of this technology and cloud capacity.
2. **Digital elements for achieving operational excellence** – Innovation can make products efficient across the entire lifecycle. Digital twins and cyber physical systems collect data in real-time, increasing efficiencies and leading to better utilisation of manufacturing capacity.
3. **Big data** – Data can be stored, analysed, and effectively used to drive decision-making. One key tool for creating value from data will be artificial intelligence (AI). This enables learning and pattern recognition from large data sets. It can reduce scrap, downtime and even make predictions to avoid overproducing. Data autonomy and privacy needs to be considered for the sharing and trading of data.

4. **Focusing on customer experience** – The focus is no longer on the product, but on providing a solution that solves a problem. As customers' buying criteria changes, companies need to adopt a multi customer-management strategy. Companies which are able to quickly and accurately identify how to create added value for their customer will gain a competitive advantage. Innovation needs to optimise the total customer experience.
5. **Marketing** – Interconnectedness means greater complexity. This means that companies need broader strategies and to learn to understand market participants who are located outside their core market segment. An interconnected industry could provide profitable value propositions, but companies need to adapt their way of thinking. This also enhances the strive towards a more circular economy and is more environmentally beneficial in terms of reduced waste, energy conservation and dependence on raw materials.

2.3 Categorisation of business models for industry 4.0: Generally, business models for industry 4.0 can be classified into three main categories: product service systems (servitization), networked eco-systems (expertization) and customer-driven (integration).

1. **Product service systems (servitization)** – This business model is often described as a transition where the company moves from providing pure stand-alone products and add-on services, to maintenance contracts and operational services and finally to an outcome, solution, or platform-based offering (Kohtamaki, 2020). The premise is that companies must offer the function of the product, not the product itself. The purpose of this is to serve the real needs of the customer, who do not necessarily want to own things, but what to benefit from using them. Businesses must utilise cyber-physical systems, smart factories and IoT to achieve this.

Product service systems can be sub-categorised further as life-long partnerships, product-as-service, or result-as-service (Weking, 2020). The first capitalises by using IoT-connected devices to add continuous revenue streams, throughout the entire product life-cycle, with subscription based, long-life service contracts. The second focuses on renting product rather than selling and offering them for a use-based fee. Customers pay for product usage and availability rather than ownership or service. Finally, the latter sells the output or result of the product. Customers pay for full-service packages as well as eliminating their own responsibility of safe operation and compliance.

2. **Networked eco-systems (expertization)** – This model proposes the idea of sharing information and data through the networked eco-system. Through the means of big data, cloud computing and artificial intelligence (AI), the business is more transparent with all stakeholders in the value chain (Ibarra, 2018). The concept of an eco-system rather than a value chain is that the data flow is circular rather than unidirectional. An example of this is a data trustee model which enables trading of data. Companies that provide part of their data to a data trustee not only receives payment but can also gain access to a more extensive database with pre- analysed data (Platform Industrie 4.0, 2019). There are opportunities to support the transition to a circular economy within this business model. There are environmental benefits too as supply and demand is synchronised to minimise waste.

Other examples of expertization include product and process consulting and platformization (Weking, 2020). Essentially, companies use their internally built expertise in products or processes, and make more of it, and offers it as a new consulting service or a new platform-

based product. SMEs in particular can benefit from joining such networks. Partnerships are formed as companies with complementary capabilities can use the expertise of others to monetize value from new market segments outside of their own capabilities and experience.

3. **Customer – driven (integration)** – This type of business model encompasses the desire to be innovative with new capabilities to explore new market segments. According to (Satell, 2017) innovation matrix (fig 5), this type of innovation is more breakthrough and/or disruptive as generally either the problem or the domain is not well defined. With increasing pressures from globalization, companies wanting to gain a competitive advantage need to understand and finely execute their customers' requirements.

Innovation Matrix

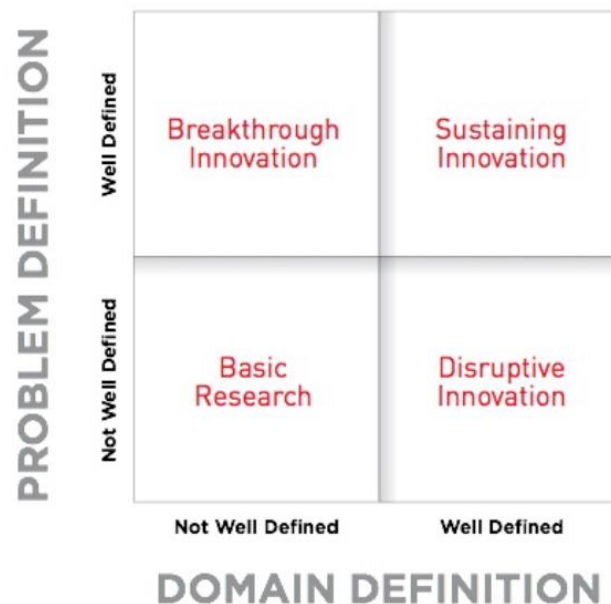


Fig 5

Crowdsourced or open innovation strategy is a new product development process whereby a community of potential or existing customers present ideas directly to the company (Weking, 2020). New manufacturing techniques including 3D printing, digital twins and AI allow fast production and on-demand feedback from customers (Platform Industrie 4.0, 2019). Iterations can be made before time and money is wasted developing over-engineered solutions, that do not add customer perceived value. Production as a service can build on transforming product ideas into physical products. This enables mass-individualized, user-designed products which are widely accessible to a large customer base. Finally, mass customization enables customers to adapt the final product to their individual taste by choosing from a range of options. Smart production enables profitable production of small lot sizes.

Section 3: Conclusions and recommendations

3.1 Opportunities presented by industry 4.0: The aim of any business is to serve its customers; in order to achieve this value must be created, distributed, delivered, and captured (Muller, 2018). A business model defines what to do, a business strategy how to do it and so business model innovation is a change in this regard. The paper has presented how the various existing and emerging technologies can be utilised to define new business models to create a customer-driven, service orientated, networked eco-system environment for industry 4.0 to develop.

Some of the opportunities shown in (fig 6) below can be categorised by financial, industrial, environmental, and social opportunities.

Financial Data driven decisions Knowledge Optimization Exploitation	Industrial Competitive advantage Globalization Flexibility Agility
Environmental Waste elimination Circular economy Frugal innovation Lifecycle management	Social Innovative culture Problem solving Dynamic Long term thinking

Fig 6

3.2 Identification of risk and its management: Digitalisation paradox refers to the high investment, challenging implementation and integration faced by many SMEs. Investment is needed to reduce the cost of data processing by automizing. Whilst this can improve customer engagement and development of product service systems, the relationship between digitalisation and performance are non-linear and complex. Complementary capabilities and organisational practices may also need investment in terms of finance and time. Return on investment relies upon value creation and value appropriation (Kohtamaki, 2020).

Sociotechnical perspectives refer to the entanglement between technologies and society. Complexity requires a higher level of competency. It can be costly to train employees and takes time for change to become imbedded within an organisational culture. Considerations need to be made towards this when calculating the investment and payback period (Platform Industrie 4.0, 2019), (Kohtamaki, 2020).

3.3 Recommendations: There needs to be a fundamental shift, particularly within the manufacturing industry to migrate towards an eco-system. This is where all parties mutually benefit from the relationship that enhances economic value (Deloitte, 2021). Currently, transparency is feared and as a result data and knowledge sharing is limited for risk of detrimental effect (Platform Industrie 4.0, 2019).

Assistance is needed from Government and other regulatory bodies to ensure that laws such as civil, product liability and data protection laws are updated as technology advances and becomes more accessible. In addition to this, support is needed to help SMEs in particular devise a pro-active but realistic approach to exploring and exploiting the opportunities of industry 4.0. (Powell, 2021), (Platform Industrie 4.0, 2019).

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