THE INSTITUTE OF
CHARTERED ACCOUNTANTS OF SRI LANKA

BL 8 Digital Business Strategy

Supplement for

Revised Chapter 1 & 2

Changes to the BL 8 Digital Business Strategy under Curriculum 2020

With reference to the communication dated 31st October 2022, the following changes to the Curriculum 2020 will take effect from March 2024 onwards, as part of our ongoing efforts to align the CA Curriculum with professional standards.

<table>
<tr><th></th><th>EXISTING SYLLABUS</th><th>NEW SYLLABUS</th></tr>
<tr><td colspan="2">Chapter</td><td>Change</td></tr>
<tr><td>1</td><td>Business Management Process and Technology</td><td rowspan="3">These three chapters will be removed and two new chapters will be included as follows;
1. Management of Technology
2. Digital Transformation and Artificial Intelligence</td></tr>
<tr><td>2</td><td>Managing Technology in Organisations</td></tr>
<tr><td>3</td><td>Digitalization of Business and Commerce</td></tr>
<tr><td>4</td><td>Role of information Systems in Business</td><td>Parts 3 - IT Infrastructure and Emerging Technologies and 4 - Communication Technology in Information Systems will be removed.</td></tr>
<tr><td>5</td><td>Enterprise Resource Management Systems (ERP)</td><td rowspan="7">No Change</td></tr>
<tr><td>6</td><td>Introduction to E-Business</td></tr>
<tr><td>7</td><td>E-Business Environment</td></tr>
<tr><td>8</td><td>E-Business Applications</td></tr>
<tr><td>9</td><td>Marketing Practices for Digital Platforms</td></tr>
<tr><td>10</td><td>Mobile and Social Media Marketing</td></tr>
<tr><td>11</td><td>Content Marketing</td></tr>
</table>

Note :
This supplement covers two new chapters which are the replacements for previous syllabus first three chapters.

Learning outcomes

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
A. Management of Technology (10%)	**1.1 Introduction to Management of Technology**	1.1.1 Identify the key concepts of Technology Management	Definition of technology, what is management of technology, why manage technology, components of technology,	1
		1.1.2 Explain the concept of technology S-curve	Technology S-curve, stages of S-curve	1
	1.2 Strategic Management of Technology	1.2.1 Explain the concept of strategy in the context of technology management	What is a strategy	1
		1.2.2 Discuss the alignment of technology strategy with Business Strategy	Levels of strategy competitive advantage, determination of competitive advantage, what is technology strategy.	1
		1.2.3 Technology Development	What is technology development, generic business strategies, positioning strategies	1
	1.3 Knowledge Management & Technology Transfer	1.3.1 Identify the concept of technology transfer	Technology transfer, channels of technology flow,	1
		1.3.2 Explain the modes and routs of technology transfer	Mechanisms for the technology transfer, phases in technology transfer	1
		1.3.3 Identify the formation and importance of knowledge	Definition of knowledge management, drivers of technology management, benefits of technology management	1

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
B. Managing Information in Business and Digital Transformation (35%)	**2.1 Digital Transformation Management**	2.1.1 Explain the concept of digital transformation in the context of a digital era	Digital business, digitization and digitalization, Digital Maturity, Process of Digital Transformation	2
		2.1.2 Demonstrate the understanding of business process management lifecycle and their impacts to a business	What is Business Process Management, BPM lifecycle, BPMN 2.0	2
		2.1.3 Describe how a firm engages in business model transformation	Business model transformation, Domain Transformation, Cultural & Organizational Transformation	2
	2.2 Big Data and Artificial Intelligence	2.2.1 Explain the concept of Industry 4.0 and its impact to the business world	Industry 4.0	2
		2.2.2 Describe the concept of Big Data	Big data and performance management, What is Big Data, Big Data Attributes	2
		2.2.3 Explain AI, Data Sciences and demonstrate the understanding of supervised machine learning process	Artificial Intelligence, Data and Algorithm, Data Analytics, Data warehousing and improved reporting capabilities, Predictive Analytics	2
	2.3 Role of information systems in businesses	2.3.1 Distinguish basic concepts for IT/IS management and examine the role of information systems in business processes	Business processes and information systems	3

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
		2.3.2 Compare and contrast different types of information systems adopted by business organizations	Types of information systems	3
	2.4. ERP	2.4.1 State systematically the planning mechanisms in an enterprise	The basic concepts of ERP systems	4
		2.4.2 Identify all components in an ERP system and the relationships among the components	The basic concepts of ERP systems	4
		2.4.3 Compare and contrast the nature of different resource planning systems and possible applications in business process	MRP, MRP II and ERP systems	4
		2.4.4 Recognise the principles of ERP systems adopted by modern business organisations	The principles of ERP systems	4
		2.4.5 Identify major components of ERP systems	Major components of ERP systems	4
		2.4.6 Discuss the advantages and limitations of implementing ERP systems	Advantages and limitations of implementing ERP systems	4

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
C. Nature and Scope of E-Business 30%	**3.1 Introduction to E- Business**	3.1.1 Compare and contrast features and scope of e-commerce vs e- business	E-commerce vs e-business	5
		3.1.2 Explain types of EC transactions adopted by modern businesses	Types of EC transactions	5
		3.1.3 Discuss the nature and applications of different e-business models	E-business models	5
		3.1.4 Identify the elements of e-business models and integration of the elements for developing value proposition to the customers	Elements of e-business models	5
		3.1.5 Recognise the benefits and limitations of e-commerce and e-business	Benefits and limitations of e-commerce and e-business	5
	3.2. E-Business environment	3.2.1 Explain trends in business environment in 21st century and their impacts on businesses	Trends in business environment in 21st century	6
		3.2.2 Identify e-marketplace types, functions and features	E-marketplace types, functions and features (auctions, portals etc.)	6
		3.2.3 Discuss consumer online behaviour and behaviour display in technology adoption	Consumer online behaviour and technology adoption	6

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
		3.2.4 Explain profile of digitised consumer. Identify the specific behavioural indicators over traditional customer	Profiling digitised consumer	6
	3.3. E-Business applications	3.3.1 Discuss the ways of using e-business fundamentals to ensure the integration among key business functions of organisation	Integrating e-business fundamentals into organisational functional management	7
		3.3.2 Identify technology application in supply chain management (SCM) for business value creation	Technology application in SCM (e- procurement systems/supply chain information system etc)	7
		3.3.3 Recognise the technology application in HRM and possibilities of adopting to HR analytics for productivity of human resources	Technology application in HRM/HR analytics	7
		3.3.4 Identify technology application in operation management for enhanced operational performance	Technology application in operation management (lean manufacturing, total quality management, business process re- engineering)	7

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
		3.3.5 Discuss alternative payment systems to provide the payment solutions and order fulfillment e-business environment	E-payment system (payment solutions and order fulfillment)	7
		3.3.6 Identify issues related to e-business applications for finding appropriate solutions	Issues related to e-business applications	7
D. Marketing Strategies in the Digital Age 25%	**4.1. Marketing Practices in Digital platform**	4.1.1 Compare and contrast features and scope of e-marketing vs traditional marketing	E-marketing vs traditional marketing	8
		4.1.2 Recognise components of e-marketing adopted by modern business firms	Components of e-marketing	8
		4.1.3 Explain e-marketing tools and their possible applications	E-marketing tools	8
		4.1.4 Discuss the process of e-tailing products and services	E-tailing products and services	8
		4.1.5 Identify the benefits and limitations of e-tailing in both organisation and customer perspectives	E-tailing products and services	8
		4.1.6 Identify the new digital avenues adopted by marketers to deliver creative messages to their customers	E-marketing communication	8

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
		4.1.7 Discuss the possible applications of search engine optimisation for businesses in strategic perspectives	Search engine optimisation	8
		4.1.8 Identify the customer relationship management applications in digital environment	Customer relationship management	8
	4.2. Mobile and Social Media Marketing	4.2.1 Recognise the application of social media business in different perspectives	Nature and scope of social media business	9
		4.2.2 Examine the nature and specialties of social media marketing compared to common e-marketing applications	Introduction to social media marketing	9
		4.2.3 Discuss basic building blocks of the social media platform	Basic building blocks of the social media platform	9
		4.2.4 Examine application of social network analysis for finding new business opportunities	Social network analysis	9
		4.2.5 Discuss the possibility of using viral marketing for building the brands of business	Viral marketing	9

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
		4.2.6 Identify possible tools and techniques for analysing and monitoring of social media	Analysis and monitoring of social media	9
		4.2.7 Discuss the application of social media management tools for developing competitive advantages to business	Application of social media management tools	9
		4.2.8 Recognise specific marketing applications of mobile technology over other e-marketing applications	Mobile applications in marketing strategy	9
	4.3. Content Marketing	4.3.1 Examine the nature and scope of content marketing	Introduction to content marketing	10
		4.3.2 Discuss the application of content marketing as a strategic communication tool	Content marketing and strategic communication	10
		4.3.3 Identify different content marketing business models in strategic perspectives to find best model for the business	Content marketing business model	10
		4.3.4 Discuss the possible application of content maturity model for identifying challenges and opportunities around created content	Content maturity model	10

Syllabus Area	Knowledge Component	Learning Outcomes	Specific Knowledge	Chapter
		4.3.5 Identify principles of content marketing in practical perspectives	Principles of content marketing	10
		4.3.6 Examine the special features and attributes of email marketing, paying special attention to its costs and benefits	Nature and scope of email marketing	10
		4.3.7 Recognise the possibilities of using email marketing for enhancing the effectiveness of content marketing	Application of email marketing in content marketing	10

CHAPTER 01

Management of Technology

Knowledge Component			
1.1	**Introduction to Management of Technology**		
	Management of Technology	**1.1.1**	Identify the key concepts of Technology Management
		1.1.2	Explain the concept of technology S-curve

1.1.1 Introduction to Management of Technology

What is Technology?

There are a number of definitions and views on technology that could be used to understand this multifaceted, dynamic and evolving nature of subject. Technology can be thought as the society's pool of knowledge regarding the industrial arts. This includes the knowledge of the industry on the principles of physical or social phenomena and application of the above principles to production processes. Also, it includes the industry knowledge on day-to-day operations (Mansfield, 1968). Dahlman & Westphal (1981) define technology as the translation of technological knowledge into a set of production methods. Technology can be anything (technical knowledge, the skills, the experiences, the equipment, the information, and the processes) that it requires to convert resources or materials into products and/or services. According to Betz (1993), broadly the technology is the knowledge of the manipulation of nature for human needs.

Technologies are classified based on their competitive advantage given to a particular firm. A firm must master *base technologies* to be an effective competitor in its chosen product-market mix. Base technologies are necessary, but not sufficient, to gain a competitive advantage. Majority of base technologies are widely known and readily available. (e.g.: Electronic ignition technology for automobiles). On the other hand, *key technologies* can provide a firm competitive advantage. Key technologies enable a firm to embed differentiating features in the products or services or to increase its production process efficiencies (e.g.: food-packaging technology that enables the purchaser to use microwave cooking). *Pacing technologies* are the technologies that can become tomorrow's key technologies. However, only a few firms in the industry can afford to invest in pacing technologies or *emerging technologies*. Such firms can differentiate themselves from others by becoming leaders.

Management of Technology

Definitions and Scope

The US National Research Council (1987) defines the MOT as knowledge area that links Science, Engineering, and Management disciplines. MOT enables a firm to plan, develop and implement its technological capabilities to shape and achieve strategic, tactical and operational level objectives. So, it is clear that technology management deals with the decisions such as acquisition and utilization of technological assets, acquisition of technological capabilities and their impact on firm level, industry level and national level to provide the competitive edge. For example, at firm level, MOT integrates technology change with business strategy to continuously improve business performance and competitiveness.

Why Manage Technology?

Traditional products and services would no longer be adequate for firms to secure their existence due to the current market dynamics. Product, service and process innovations have become new norms for long-term success and for achieving sustainable competitive advantage. It appears that MOT can response to both intense competition among firms and the rate of change of technologies seen in many sectors of the economy. Still, there is no simple answer to the question of how to use technology for competitive success. Technology is multidimensional and multifaceted and technological change can contribute to both positive and negative consequences, unless it is managed in a systematics manner.

Components of Manufacturing Technology

Manufacturing technology creates value through the production of goods and services and therefore it has a high price attached to it. As a result, transferring technology from the developed nations, the Newly Industrialising Countries (NICs) and industrially advanced developing nations (such as Brazil, China and India) to the firms in developing countries may not occur as an altruistic manner. Many international technology transfer arrangements to developing nations often face difficulties due to their lack of capability in the following: identifying technology needed, scanning the international technology sources; assessing the offered technologies, negotiating and selecting the suitable transfer mechanisms (Godkin, 1988). The manufacturing technology transfer involves the flow of product technology or process technology or both between nations and/or firms. The absence of a generic framework specifying the elements of product and process technology also can contribute to failures in technology transfer.

Generally, manufacturing technology transfer refers to process technology transfer and product technology transfer. Process technology comprises of four elementary and interacting components.: (1) technoware: an object-embodied form, (2) humanware: a human-embodied form, (3) inforware: an information-embodied form and (4) orgaware: an institution-embodied form called (Ramanathan, 1994). Under, product technology transfer, it is crucial that product-related inforware to be transferred. Product related inforware relates to product design and product usage.

1.1.2 Technology S Curve

Technology forecasting is important for nations and firms (public and private) to make smart decisions. The relationship between technology performance parameter and time / effort can be constructed after a several rounds of observations on changes of technology over a period of time. It gives us an s-shape diagram known as 'Technology S-curve' (example: evolution of computer hard-disk capacity or aircraft speed during the last 50 years). **Figure 1.01** shows the technology S-curve where the technology has three major stages in its life cycle.

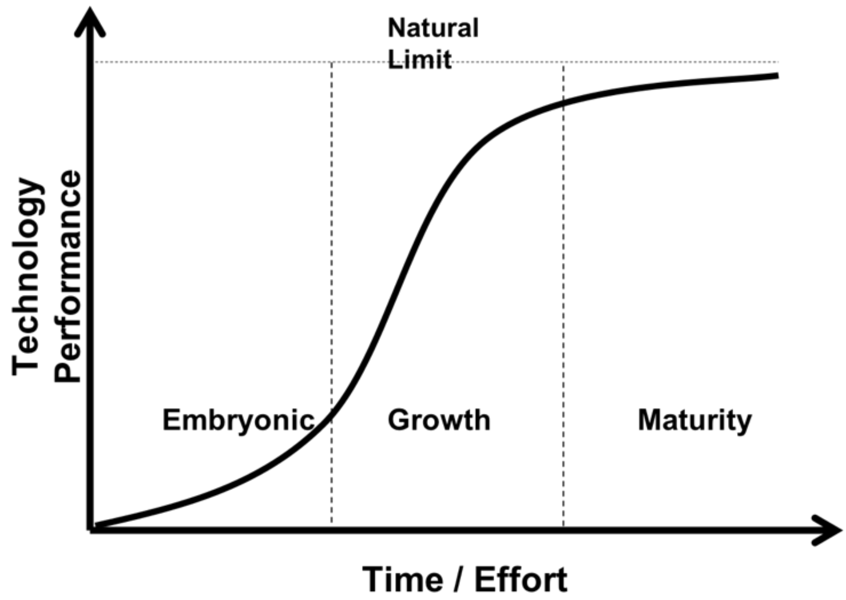


Figure 1.01: Technology S – Curve

Embryonic stage

A new technology is born in this stage. There is a slow growth of an emerging technology which may not be visible to outsiders in full scale. Firms engage in eliminating technology related issues such as debugging and improving the rate of performance. It requires a substantial effort and time to do a marginal improvement of the product / service. Firm's cash flow may be negative due to relatively high investment on R&D.

Growth stage (technology improvement period):

A successful invention leads to an introduction of the technology to outsiders and there will be an increase in demand. Technology transfer will help the firm to further improve its technology based on transferee feedback. Transferor's revenue increases but additional investment is required to secure the growth and survival of technology. Firms focus on process innovations rather than product innovation during this stage. Progress of the technology is visible, and measurable.

Maturity period (mature technology period):

During this stage, technology reaches its natural and/or physical limit and there is less avenue for further improvements. Obviously, firm's cash flow shows a declining trend.

Note: The factors such as the amount of effort put into the development and the nature of the technology determine the rate of improvement and the natural or physical limits of the curve.

Additional References

Betz, F. (1993), Strategic Technology Management, McGraw-Hill, New York, NY.

Dahlman, C. J., & Westphal, L. E. (1981). The meaning of technological mastery in relation to transfer of technology. The Annals of the American Academy of Political and Social Science, 458(1), 12-26.

Godkin, L. (1988). Problems and practicalities of technology transfer: a survey of the literature. International Journal of Technology Management, 3(5), 587-603.

Harrison, N. and Samson, D. (2002), Technology Management: Text and International Cases, McGraw-Hill Inc,

Khalil, T. (1998), Management of Technology: Future Directions and Needs for the New Century, A Report of the Workshop on Management of Technology, National Science Foundation, Arlington, September 14-15.

Khalil, T.M. (2000), Management of Technology: The Key to Competitiveness and Wealth Creation, McGraw Hill.

Mansfield, E. (1968), Industrial Research and Technological Innovation, W.W. Norton & Company Inc. New York.

McGinn, R. E. (1991), Science, Technology, and Society, Englewood Cliffs, N.J.: Prentice-Hall.

Ramanathan, K. (1990), Management of Technology: Issues of Management Skill and Effectiveness, International Journal of Technology Management, 5(4), pp. 409-422.

Ramanathan, K. (1994), The Polytrophic Components of Manufacturing Technology, Technology Forecasting and Social Change, 46, pp. 221-258.

Knowledge Component			
1.2	**Strategic Management of Technology**		
	Strategic Management of Technology	**1.2.1**	Explain the concept of strategy in the context of technology management
		1.2.2	Discuss the alignment of technology strategy with Business Strategy
		1.2.3	Technology Development

1.2.1 What is Strategy?

The following citations provide a good definition on strategy.

"*Strategy is a rule for making decisions under conditions of partial ignorance, whereas policy is a contingent decision. Business strategy is the broad collection of decision rules and guidelines that define a business's scope and growth direction*" (Ansoff, 1965).

"*Strategy is the pattern of objectives, purposes or goals and major policies and plans for achieving those goals stated in such a way as to define what business the company is in or to be in and what kind of company it is or is to be*" (Christensen et al, 1973).

"*Strategy formulation involves the interpretation of the environment and the development of consistent patterns in streams of organisational decisions*" (Mintzberg, 1979).

"*Strategy is a broad-based formula for how business is going to compete, what its goals should be, and what policies will be needed to carry out those goals. The essence of formulating competitive strategy is relating a company to its environment*", (Porter, (1980).

1.2.2 Strategic Decisions and Management

Strategic decisions refer to the scope of a firm's activities, how to match firm's activities to its environment and resource capability, resource allocation, values & goals that influence organizational strategy and the long-term direction that the firm moves. On the other hand, strategic management involves developing the goals and strategies of an organization and implementing organizational strategy. Strategies are in 3 levels: corporate strategies, business strategies and functional strategies (see Figure 1.02).

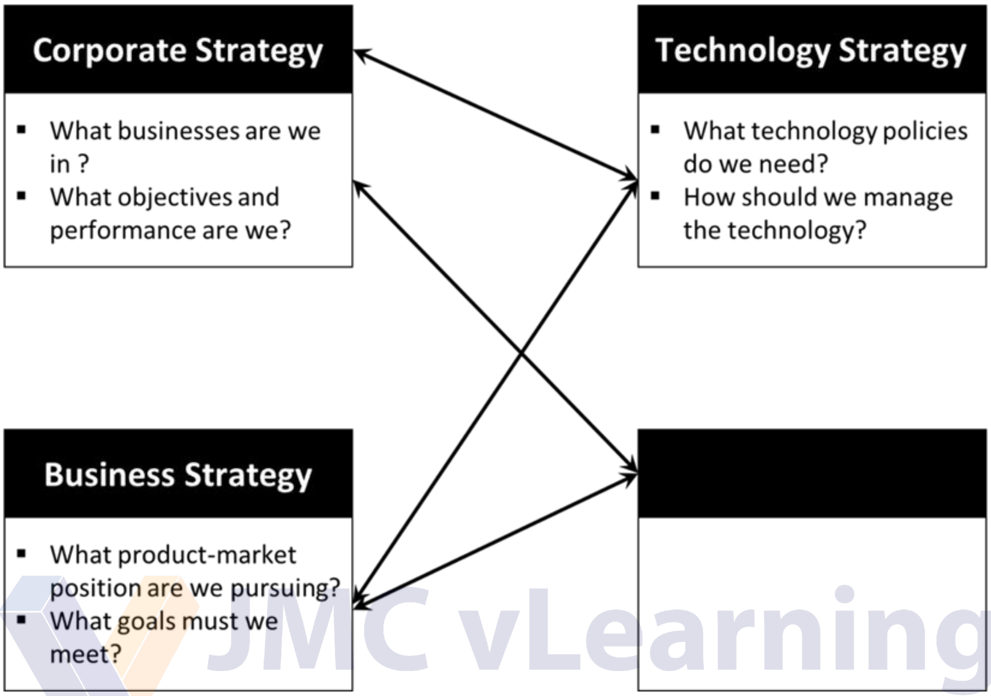


Figure 1.02: Levels of strategy

Business strategy development requires thorough understanding of vision, mission and values of an organization. Organization's vision refers to what it wants to achieve in the future (example: 5 years, 10 years). Mission defines the type of business a company is in and how it engages stakeholders. Values reflect firm's beliefs in its commitments and ethics towards stakeholders. One can perform a strategic analysis after gaining a deep understanding of the above (see Figure 1.03).

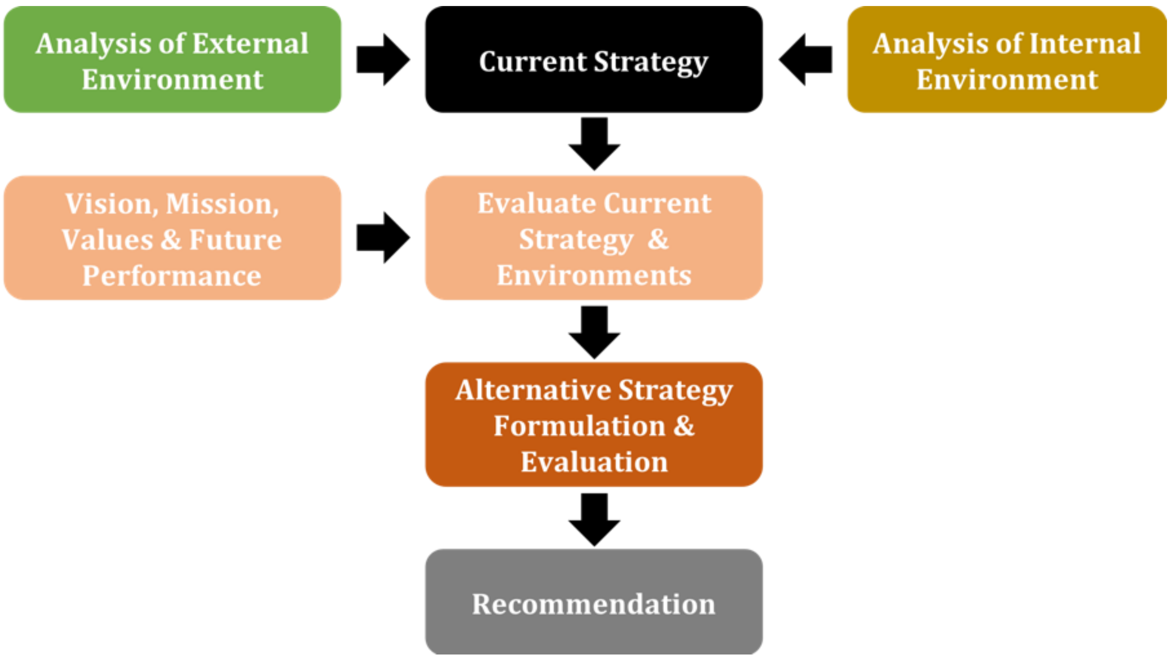


Figure 1.03: Strategic Analysis Process

The above strategies can help an organization to create a competitive advantage over its rival firms.

Competitive Advantage

Industrial Organization (IO)

Competitive advantage can be assessed using both external and internal factors of a firm. Industrial Organization (IO) model (example: Porter's Five Forces Model of Competition) explains the competitive advantage by determining the factors outside firm. IO focuses on industry structure & attractiveness. According to Porter's Five Forces Model of Competition, theoretically, factors affect *all firms* in industry *equally*. Prospects for all companies in the industry remain unchanged. Porter's five forces model can be used to perform industry analysis to select the right industry (refer to Figure 1.04).

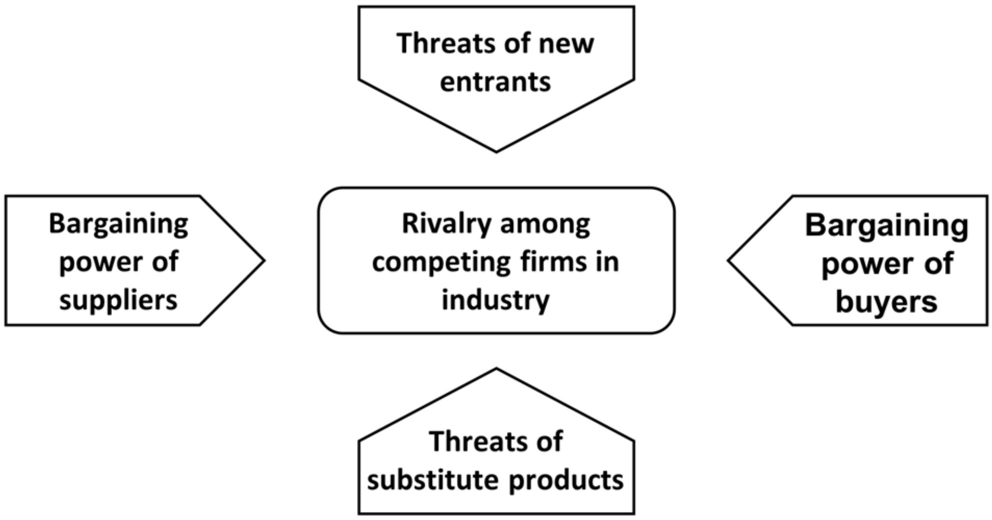


Figure 1.04: Porter's Five Forces Model of Competition

This model is widely used to analyze an organization's industry structure in strategic planning processes. The above forces determine the intensity of competition and assess the attractiveness of an industry. The objective of corporate strategy is to improve the position of the organization by assessing these competitive forces.

Bargaining power of buyers or customers:Customers look for quality products at lower prices. For example, in a perfectly competitive market setting, buyers bargaining power will force to lower the prices which can negatively impact on the organization's profitability. The bargaining power of customers depends on one or more of the following: buyer concentration to firm concentration ratio, bargaining leverage, buyer volume, buyer switching costs relative to firm switching costs, buyer information availability, ability to backward integrate, availability of existing substitute products, buyer price sensitivity and price of total purchase.

Bargaining power of suppliers: Suppliers can influence the market under the following circumstances: supplier switching costs relative to firm switching costs, degree of differentiation of inputs, presence of substitute inputs, supplier concentration to firm concentration ratio, threat of forward integration by suppliers relative to the threat of backward integration by firms, cost of inputs relative to selling price of the product and importance of volume to supplier.

Threat of potential or new entrants: New entrants can increase the competition among players by bringing additional volumes with respect to the type of industry. This depends on the existence of barriers to entry, economies of product differences, brand equity, switching costs, capital requirements, access to distribution, absolute cost advantages, learning curve advantages, expected retaliation and government policies.

Threat of substitute products: A substitute product satisfies the same customer / buyer needs fully or partially but produced by a different industry (example: tea versus coffee).

Still, a substitute will influence the price that one can charge from firm's customer. The level of threats of a substitute depends on the following factors: buyer propensity to substitute, relative price performance of substitutes, buyer switching costs and perceived level of product differentiation.

Intensity of competitive rivalry: The profitability of the industry mainly depends on the intensity of competitive rivalry amongst existing firms. In a perfectly competitive market setting, at least in the short run, firms will increase their marketing budget to sustain their market share contributing negatively to their bottom-line. However, firms could still see a market growth, if the demand can be stimulated by the competition. The factors such as number of competitors, rate of industry growth, intermittent industry overcapacity, exit barriers, diversity of competitors, informational complexity and asymmetry, brand equity, fixed cost allocation per value added, level of advertising expense, brand switching customers and strategic importance.

Resource Based View Model (RBV)

Resource Based View Model (RBV) uses internal factors of a firm to determine competitive advantage. The main idea behind the RBV is that competitive advantage is a function of the resources and capabilities of the firm (Wernerfelt, 1984; Conner, 1991). RBV is a 3-step framework.

Step 01: Identify the firm's key resources

Step 02: Evaluate whether the above resources fulfill VRIN criteria (Valuable, Rare, Imperfectly imitable, Non-substitutable).

Step 03: Develop and secure resources that pass Step 01 and Step 02.

For example, competitive advantage of a firm depends on its resources, capabilities and competencies (See Figure 1.05).

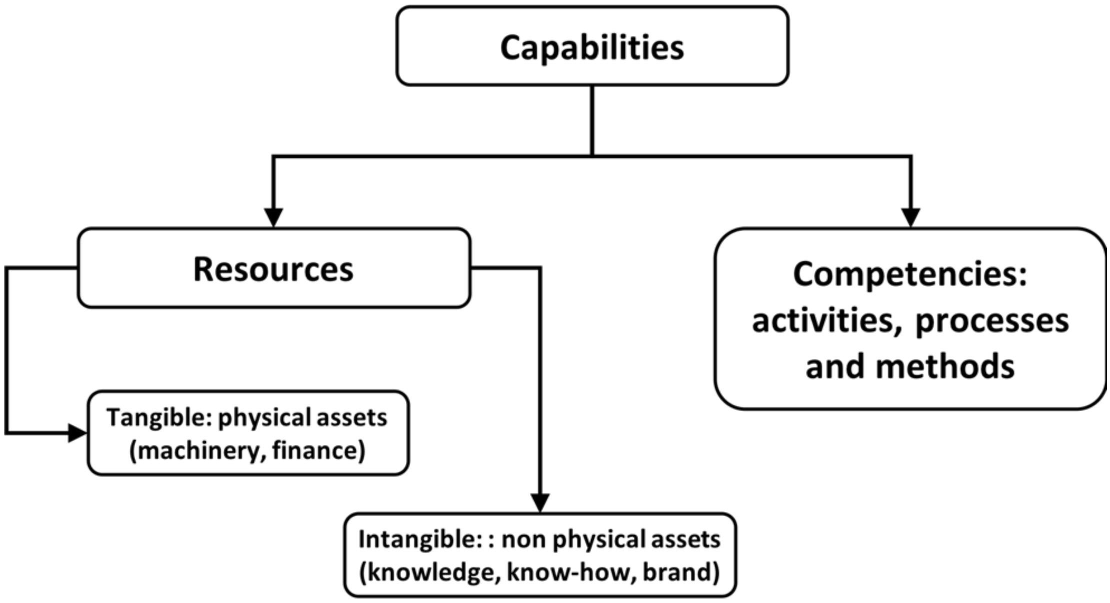


Figure 1.05: Resources, Capabilities and Competencies

Resources are *relatively* easy to imitate, and often tangible resources are available for purchase on open market. A firm could develop intangible resources. On the other hand, capabilities are not visible outsiders and deep rooted in a firm. Capabilities are hard to imitate.

Capabilities can be exploited using competencies. This can be achieved by external collaborations (forge alliances for technology access) and consolidating internally (blend skills, technologies). Table 1.1 shows a resource appraisal of a typical firm.

Table 1.1: Resource, Characteristics and Indicators – RBV model

Resource		Characteristics	Indicators
Tangible Resources	Finance	Borrowing capacity, Internal fund generation, Market value	Debt/Equity ratio, Credit rating, Net cash flow
	Physical	Plant & equipment: size and location, Land & buildings, Raw materials	
Intangible Resources	Technology	Patents, Copyrights, Know-how, R&D facilities, Technical & scientific employees	Number of patents, Royalty income, R&D expenditure, R&D staff

	Reputation	Brands, Customer loyalty	Brand equity, Price premium, Recognition
Human Resource		Training, Experience, Adaptability and Commitment	Employee qualifications, Pay rates, Labour turn-over

Technology Strategy

In general, a technology strategy focuses on the issues such as the type of distinctive technological capabilities that can be sources of the firm's competitive advantage, level at which a firm should invest in technology development, sources of technology (internal or external), timing of introducing new technologies to market place and managing and organizing technology and innovation.

Content of Technology Strategy: BMW Framework

BMW framework identifies 4 major elements of technology strategy: Competitive strategy stance, Value chain stance, Resource commitment stance and Management stance.

Competitive strategy stance focuses on the technology decisions that essentially support the corporate and business level strategies of the firm (example: technologies to support a firm's product-market strategy, technologies to enable a positioning / differentiation).

Table 1.2: Technology decisions under competitive strategy stance

Technology Decision	**Orientation**	**Explanation**
Technology choice	Differentiation related	Choice of technologies to be included within the firm's products or services
	Cost related	Choice of technologies used internally within the firm, to reduce cost of its operations
Technology leadership		Leader / follower on each technology
Technology entry timing		Timing of a new technology into the market
Technology licensing		Technology commercialization or offer under license

Value chain stance refers to the use of technology across various activities and functional entities of a firm. Porter's value chain model (Figure 1.06) decomposes activities of a firm into 2 categories:

- Activities that directly add value for the firm's customers
- Activities that support above value adding activities

The value chain stance can be used to decide the kind of activity and the level of technology capabilities need to be developed.

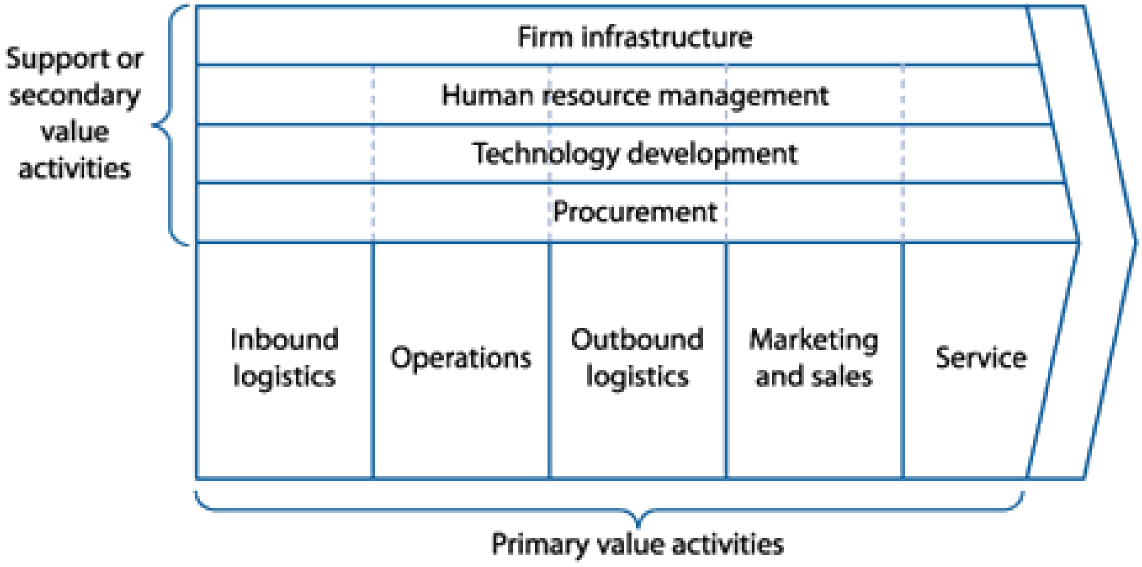


Figure 1.06: Porter's Value Chain (source: Porter, 1985)

Primary activities in **Figure 1.06** refer to inbound logistics (example: deliver materials to warehouse, material handling, storage and stock control), operations (example: convert resource inputs such as materials and people into final products), outbound logistics (example: handling the passage of finished goods to distributors, retailers and consumers), marketing and sales (example: advertising, promotions and other marketing activities), services (example: customer services and after sale services). Support activities are required to support the primary activities of a firm. They are firm infrastructure, human resources management, technology development and procurement.

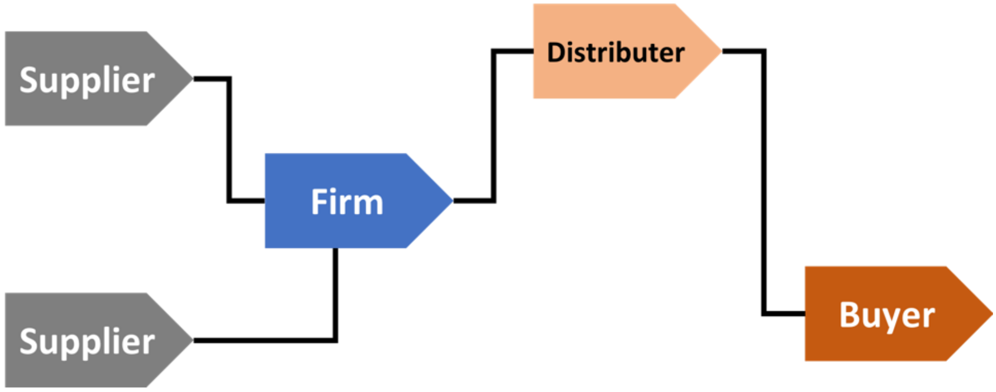


Figure 1.07: Value Networks

In addition, a firm's value chain exists within a value chain network. The inbound logistics is connected to upstream firms / players in the value chain (one or more suppliers) and the outbound logistics is connected to the downstream firms / players (distributors, retailers) in the value stream (see Figure 1.07).

Resource commitment stance determines the amount of resources committed to enhance technological capabilities as a part of the technology strategy.

Management Stance is about the organisational structure, management systems and leadership styles.

1.2.3 What Technologies to Develop?

What technologies to develop is one of the important questions to be answered in technology strategy development exercise. There is an inter-link and inter-play between the technology strategy and the business strategy. Business strategy aims to achieve sustainable competitive advantage. Technologies to be develop is in line with the business strategy.

A firm's relative position within its industry is determined by comparing its profitability against the industry average. This average profitability reflects a firm's competitive advantage in the long run. Porter's generic business strategy model (Porter, 1985) provides a set of processes that can be used to gain a competitive advantage at the business strategy formulation (see Figure 1.08).

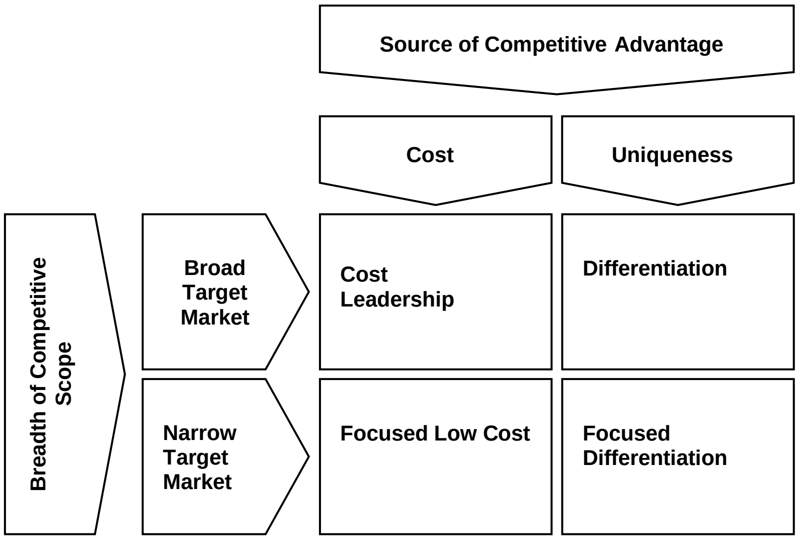


Figure 1.08: Generic Business Level Strategies

Generic Business Strategies

Cost leadership strategy refers to a firm striving to be lowest producer. A firm operates at lowest costs (production and distribution) and it becomes the price setter in the market.

Differentiation strategy is where a firm creates unique products or services for the broader market segments. For example, product differentiation includes high performance / quality, fast delivery, customization and added service.

Focus strategy targets a specific market segment (example: niche market) and the firm tailors its products / services meet the needs of a specific market segment.

Table 1.3 below shows how product and process technological changes respond to each generic strategy discussed above.

Table 1.3: Product and Process Technology and the Generic Strategies
(Source: Perera, 2008)

	Cost Leadership	**Differentiation**	**Cost Focus**	**Differentiation Focus**
Product Technological Change	Reduce product cost by lowering material content, low cost manufacture, simplify logistical requirements.	Enhance product quality, features, deliverability, or switching costs.	Design in only enough performance for the target segment's needs	Product design to meet the need of a particular segment better than broadly targeted competitors.

Process technological Change	Learning curve process improvement to reduce material usage or lower labour input Process development to enhance economics of scale	Process development to support high tolerances, greater quality control, more reliable scheduling, faster response time to orders, and other dimensions that raise buyer value	Process development to tune the value chain to a segment's needs in order to lower the cost of serving the segment	Process development to tune the value chain to segment need in order to raise buyer value.

Later, Porter introduced his activity positioning strategies. These include the paths that a firm can take in order to gain competitive advantage within its value chain. His positioning framework contains four activity positioning strategies: variety-based, need-based, access-based and variety and need based (Porter, 1996)[14].

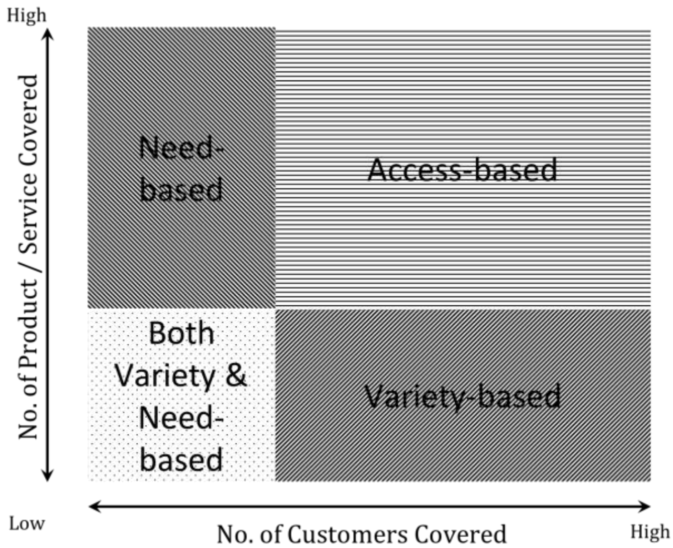


Figure 1.09: Porter's Activity Positioning Strategies

Variety-based strategy (see **Figure 1.09**) refers to a firm producing a subset of product portfolio covering an entire industry's products or services. This strategy helps firms to deploy their resources to specific areas to cater demand at a lower cost.

Need-based positioning strategy targets a particular customer segment to fulfill their needs. A firm has to orient its full value chain to understand customer needs and to create value to its customers to ensure maximum customer lifetime value (CLV).

Access-based positioning is about targeting customers that have similar needs. However, these customers do not have similar access routes to the product or service.

Additional References

Andrews, K. R., Christensen, C. R., Andrews, K. R., & Bower, J. L. (1973). Business policy: Text and cases. Homewood, IL: RD Irwin.

Ansoff, H. I. (1965). Corporate strategy: An analytic approach to business policy for growth and expansion.

Conner, K. R. (1991). A historical comparison of resource-based theory and five schools of thought within industrial organization economics: do we have a new theory of the firm? Journal of management, 17(1), 121-154.

Johnson, G., Scholes, K., & Whittington, R. (2008). Exploring corporate strategy: Text and cases. Pearson education.

Mintzberg, H. (1989). The structuring of organizations (pp. 322-352). Macmillan Education UK.

Porter, M. E., & Strategy, C. (1980). Techniques for analyzing industries and competitors. Competitive Strategy. New York: Free

Porter's, V. C. M. (1985). What Is Value Chain. E-Commer., 1-13.

Porter, M. E. (1996). What is strategy? (https://dms.uom.lk/s/ZxfC4y3bbfDafjc)

Wernerfelt, B. (1984). A resource-based view of the firm. Strategic management journal, 5(2), 171-180.

Knowledge Component			
1.3	**Knowledge Management &Technology Transfer**		
	Technology Transfer	1.3.1	Identify the concept of technology transfer
		1.3.2	Explain the modes and routs of technology transfer
	Knowledge Management	1.3.3	Identify the formation and importance of knowledge

1.3.1 Introduction

Technology transfer is a series of processes that enables the flow of technology from a source / transferor (example: owner or holder of the knowledge) to a receiver / transferee (example: the beneficiary of such knowledge). Transferor and transferee can be an individual, a company, or a country. Technology transfer as a "*process by which science and technology are transferred from one individual or group to another that incorporates this new knowledge into its way of doing things.*" (Jain and Triandis, 1990).

Technology transfer can be divided into the following categories:

- *International technology transfer*, in which the transfer is across national boundaries. (example: technology transfer from industrialized countries to developing countries).
- *Regional technology transfer,* in which technology is transferred from one region of the country to another.
- *Cross-industry or Cross- sector technology transfer,* in which technology is transferred from one industrial sector to another (example: transfer of technology from the space program to commercial applications such as Space-X project).
- *Interfirm technology transfer,* in which technology is transferred from one firm to another.
- *Intrafirm technology transfer,* in which technology is transferred within a firm from one location to another.

Over the last few decades, the Least Developed Countries (LDC) have changed their attitude towards technology transfer due to substantial contribution from private sector to economy, increased liberalisation, globalisation trends, and the success of newly industrialised countries (NICs) such as Korea, Singapore, Taiwan and Hong Kong. Many firms in LDCs have acquired know-how from the firms in developed nations. As a result, firms can build upon the imported know-how using their own scientific and technological capabilities.

Today, the concept of international technology transfer is thought as an international technology trade and it has become a simple commercial transaction. In some cases, know-how is even given features of a commodity where it is available in the international market. As a result, instead of "donor" and "recipient", there exists only "buyers" and "sellers" or alternatively be known as "transferees" and "transferors". However, the policy-makers in LDCs are continuously debating over issue of striking a balance and harmony between importing technologies and developing locally.

Channels of Technology Flow

Technology is an intangible asset and given the channels of flow are available, it can flow easily across boundaries of countries, industries, departments, or individuals.

General channels of technology transfer make a transfer unintentionally and sometime without the involvement or knowledge of the source / transferor. This is because sometimes information is made freely available in the public domain with any restrictions to access. General channels of technology transfer are education, training, publications, conferences, study missions, and exchange of visits.

In reverse-engineering channels a traditional receiver of a technology breaks or attempts to break the code of a technology and develops the capability to duplicate it in some form. In most cases, transfer occurs with no active contribution from the transferor. Technology transfer through reverse-engineering channel is feasible if the transferee has the knowledge to perform the re-engineering and there is no violation of laws of intellectual or property rights.

Planned channels of technology transfer is performed intentionally where there is an established agreement between the technology owner and receiver.

1.3.2 Mechanisms for the Transfer of Technology

There are two transfer mechanisms to transfer technology from a transferor to a transferee. Market-oriented technology transfer mechanisms have a profit motive and market forces dominate in determining growth, competitiveness and profitability of stakeholders. For example, Purchases of plant, equipment and products, International joint ventures, Licensing (Franchise), Subcontracting, Turnkey contracts, Management contracts, Production sharing, Foreign direct investment (FDI), Expert services and Technical information services.

Non-market-oriented mechanisms have less focus on financial considerations and not always driven by the market forces (example: Books, academic journals, business magazines, sales literature, Industrial fairs and exhibitions, Informal personal contacts, and participation in conferences, seminars and workshops, Training).

Phases in Technology Transfer

Key steps of technology transfer are as follows:

Step 01: Recognizing the Need of Technology
Step 02: Identification of Technology Needs / Gaps

> This is the most important step in the process of technology transfer. This may be performed either at country level or firm level. For country level technology transfer, transferring technologies should be able to meet the development goals of the country. Firm level technology transfer will make the firm more competitive by improving its products and processes.

Both product technology and/or process technology can be transferred. The transferee should define the complete specifications of the product and/or process technology (Ramanathan, 1997).

Step 03: Identification of Technology Options and Sources of Technology

Step 04: Selection of Technology Transfer Mechanism

Step 04: Technology Evaluation and Selection

Typical criterion of technology evaluation and selection includes development benefits, environmental benefits and market potential.

Step 05: Negotiation

After selecting the suitable technologies, the transferee will engage in a negotiation process with the transferor. Outcomes of a negotiation process depends on the bargaining power of parties. In general, they will agree on the following:

- An acceptable basis for the valuation of the technology
- Payment terms and intellectual property protection
- Contribution and responsibilities towards the technology transfer project
- Methods related to the transfer of technology and training.
- Suitable mechanism(s) for transferring the technology components.
- Preparation of technology transfer agreement.

Step 06: Technology Acquisition

Technology acquisition phase is the stage where the technology is transferred from the transferor to the transferee through the selected transfer channel. Transferee identifies the changes to be made to the organizational structure and its policies to accept the new technology. She formulates a technology transfer project implementation plan with payment schedules. Transferee conducts user training with the support of transferor. organizational infrastructure of the transferee will be upgraded to accommodate new technology.

Step 07: Technology Adaptation

After the phase of technology acquisition, the transferee is required to create a suitable operating environment to harness the maximum benefits of the technology. It is also required to focus on other factors such as level of human skills, organizational practices, socio-economic conditions, culture, process of technological learning within the organization. As a result, training has become an essential element for proper adaptation of technology.

Additional References.

Jain, R. K., & Triandis, H. C. (1990). Management of R&D organizations: Managing the unmanageable. New York, NY: John Wiley&Sons.

Ramanathan, K. (1994). The Polytrophic Components of Technology, Technological Forecasting and Social Change, 42(3), pp. 221 258.

Ramanathan, K. (1997). An Analytical framework for technology transfer, In: Contemporary Issues in Technology Transfer, Ed. Gougeon, P and Gupta, J. Eska Publishing.

UNIDO (1993). Prospects and Dimensions of International Transfer of Technology, Proceedings of the Regional Workshop on Integration of Science and Technology in the Development Planning in the ESCWA Countries, Amman, Jordan.

1.3.3 Knowledge Management

Definitions of Knowledge Management

In the absence of a standard definition for Knowledge Management (KM), KM can broadly be defined as a business model incorporating knowledge as an organizational asset. Literature identifies several strategic levers of KM: Customer Knowledge, Knowledge in Processes, Knowledge in Products (and Services), Knowledge in People, Organizational Memory, Knowledge in Relationships, Knowledge Assets and Competitor Knowledge.

Drivers of Knowledge Management

There are several reasons why firms are interested in knowledge management. One of the main divers is continuous advancement of technology (example: e-commerce linking with c-commerce). Value of tangible assets in an organization is decreasing and on the other hand intangible assets are valued more. In particular, new organizational dynamics such as global customers, suppliers and partners, virtual firms with cloud computing, redefined employment contracts and firms striving for talents have become normal in post Covid era. As a result, KM is increasingly becoming a concern of the senior management of firms.

What Benefits can Companies Expect from KM?

Benefits of KM practice may be difficult to quantify. However, a good KM programme will help a firm to foster innovation (using free flow of ideas), reduce customer churn (improve customer services by analyzing the response rate), reduce employee churn (recognize and reward employee's knowledge) and business process optimization. In addition, ignoring human knowledge will lead to loss of knowledge of organizational best practices, harm clients or supplier relationships and loss of income.

How does KM Create Value?

KM creates value to improve product / service leadership, customer intimacy, employee capability and operational excellence (see Figure 1.10).

Figure 1.10: KM Value Creation

KM practice can help firms to attain product / service leadership by delivering the best products and services offerings to customers breaking own performance boundaries. KM leverages human intellectual capital in product / service design to enhance employee capabilities. KM helps firms to strive for operational excellence by delivering products / services at best prices with less hassle to their customers. KM effectively manages customer knowledge to ensure firm's customer intimacy.

Understanding Knowledge: Constituents of knowledge-based assets

All information may not create equal value to a firm. Firms individually determine the type of information that fall into the category of intellectual or knowledge-based assets. Knowledge-based assets are two types: explicit knowledge and tacit knowledge. Patents, trademarks, business plans, customer databases and technical manuals are some examples for explicit knowledge. Explicit knowledge refers to anything that can be documented, archived and codified using IT or otherwise. The concept of tacit knowledge is not straight forward. Tacit knowledge refers to the know-how of employees of an organization (example: cognitive skills such as beliefs, images & intuition and technical skills such as craft and know-how). Unlike explicit knowledge, it is difficult to recognize, generate, share and manage tacit knowledge.

"*The strength of Japanese manufacturing industries is at the technologies (based on) tacit knowledge. With the progress in Information Technology (IT), tacit knowledge is converted into explicit knowledge. Still, we need tacit knowledge. To build a car, we have to build people*" (Hiroshi Okuda, Chairman of Toyota).

A firm cannot simply replace a firm specific high-quality tacit knowledge by outsourced explicit knowledge. Absence of high-quality tacit knowledge will challenge the survival of a firm in the long run. KM process (knowledge creation, capturing, organizing and storing, transferring, sharing and using) enables a firm to recognize tacit knowledge embedded in people scattered across firm's hierarchy. By synthesizing tacit and explicit knowledge and successfully integrating it with organizational activities can make learning and innovative organizations.

Knowledge Management Use Cases

Use Case 01: Knowledge Sharing

KM for knowledge sharing and retention can be used to minimize the loss of tacit knowledge that eventually walks out of the organization. Alfa PLC, a large banking and financial institution, recently devised multi-facet knowledge transfer instruments to facilitate both direct and indirect KM. These instruments can handle knowledge sharing either one-to-one, one-to-many or many-to-many.

Use Case 02: Onboarding and Learning

Onboarding and learning are everything that an employee need to perform, from day one of her employment through the entire tenure of her employment. Effective onboarding and learning help employee retention and job satisfaction.

Beta PLC designed and implemented an internal web-based interactive platform that integrates all aspects of learning and performance ecosystem. This enables employees devise their self-learning under close supervision of supervisors at different levels in the organization.

Additional References

Awad, E.M. & Ghaziri, H.M., 2003. Knowledge Management, Pearson Education, Inc.

Perera, H.S.C., 2002. Knowledge Management: Tools and Technology, Paper Presented in the APO Study Meeting on Knowledge Management in Colombo, Sri Lanka, July 2002

Perera, H.S.C. 2004. Development of Knowledge Infrastructure: Role of Consultants, Sri Lanka Country Paper Presented in the Conference 'Development of Knowledge Infrastructure: Role of Consultants' New Delhi, India, October 2004

CHAPTER 02

Digital Transformation and Artificial Intelligence

Knowledge Component			
2.1	**Digital Transformation Management**		
	Digital Transformation Management	2.1.1	Explain the concept of digital transformation in the context of a digital era
		2.1.2	Demonstrate the understanding of business process management lifecycle and their impacts to a business
		2.1.3	Describe how a firm engages in business model transformation

2.1 Digital Transformation Management

2.1.1 Digital Business

Digital business is the use of digital technologies and strategies to transform traditional business processes, models, and operations. It involves leveraging digital technologies, such as the internet, mobile devices, cloud computing, big data analytics, artificial intelligence, and social media, to create new opportunities, improve efficiency, enhance customer experiences, and drive innovation.

Digital Transformation, Digitization & Digitalization

Developing a digital transformation (DT) strategy is essential for organizations seeking to leverage digital technologies to drive innovation, improve efficiency, and stay competitive in today's digital age. Digital transformation can be described as the process of adopting digital technologies and strategies to fundamentally change how businesses operate, deliver value to its customers, develop potential into drive significant business growth, unlock new revenue streams and create a competitive advantage in today's digital economy.

Digitization and digitalization

Digitization and digitalization are two related but distinct concepts in the realm of digital transformation. Digitization converts analog information or physical assets into a digital format. For example, scanning paper documents and converting them into electronic files is a form of digitization. Digital versions of analog information are easier to store, access, and manipulation.

On the other hand, digitalization covers strategic, tactical and operational levels of an organization. It involves transformation of business processes, models, and operations using digital technologies. Digitalization leverages digital tools & technologies (example: automation, data analytics, artificial intelligence, and cloud computing), and data to create new business models, improve efficiency, enhance customer experiences, and drive innovation.

Digital Maturity

Digital maturity refers to the level of an organization's capability and readiness to effectively leverage digital technologies and strategies to drive business success. It reflects the organization's ability to integrate digital technologies into its operations, culture, and overall strategy, and to derive tangible benefits from those digital investments.

Digital maturity model developed by Deloitte (www2.deloitte.com), has 5 core business dimensions and a set of sub-dimensions as shown in Figure 2.01.

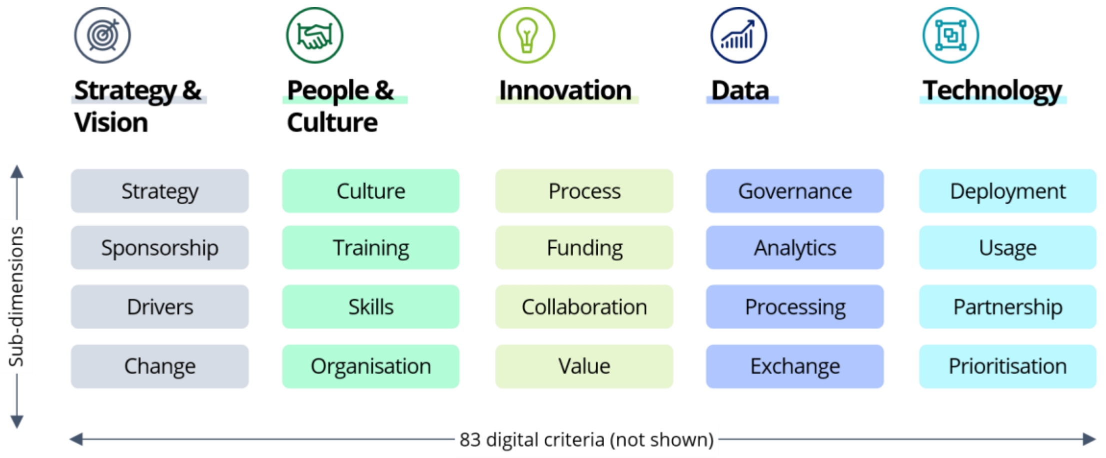


Figure 2.01: Digital Maturity Dimensions

(Source: www2.deloitte.com)

Process of Digital Transformation

The DT process involves a series of steps to guide organizations through the adoption of digital technologies and the integration of digital strategies. While the specific approach may vary depending on the organization's needs and context, the following gives a general outline of the DT process (Figure 2.02):

Figure 2.02: Digital Transformation Process

2.1.2 Business Process Management

What is Business Process Management?

DT involves reimagining and optimizing business processes to increase efficiency and effectiveness. Automation, digitization of workflows, and eliminating manual or paper-based processes are key strategies to streamline operations. This leads to improved productivity, reduced costs, and faster time-to-market.

Business Process Management (BPM) refers to the discipline of managing and improving an organization's business processes to enhance efficiency, productivity, customer satisfaction, and overall performance. BPM involves the systematic design, execution, monitoring, and optimization of processes to achieve operational excellence and drive business success (Dumas et al, 2008). There are a number of software tools to perform BPM and process automation (example: http://bizagi.com)

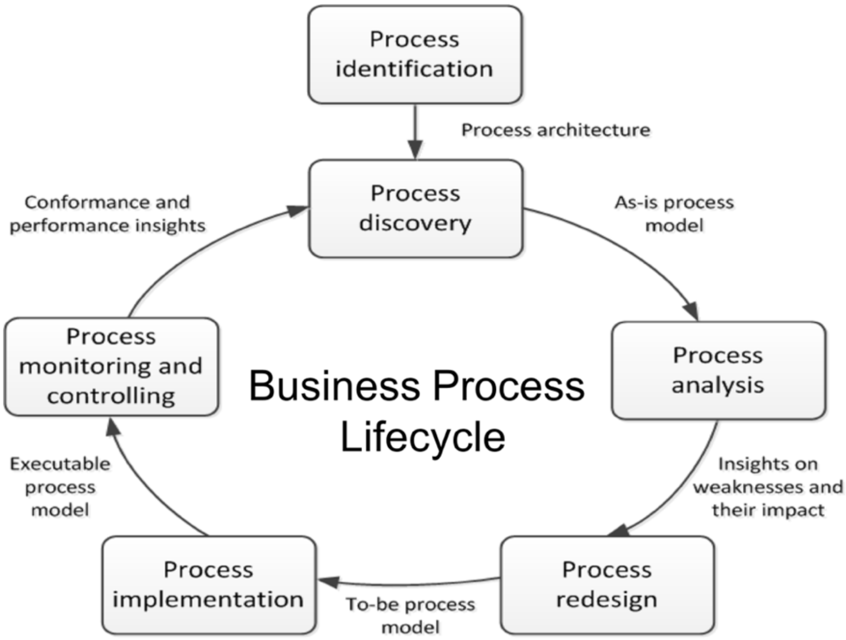


Figure 2.03: Business Process Cycle
(Source: Dumas et al., 2008)

Process Discovery

Identify and document the current business processes within the organization. This involves mapping out the activities, tasks, roles, and interactions involved in each process. Process discovery helps gain a comprehensive understanding of existing processes and their interdependencies.

Process Modeling and Design

Create process models that visually represent the sequence of activities, decision points, and flow of information within a process. Process modeling techniques such as flowcharts, swimlane diagrams, or BPMN (Business Process Model and Notation) diagrams can be used. This step allows for a clear visualization of the process and helps identify inefficiencies or bottlenecks.

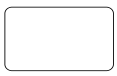
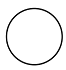
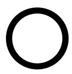
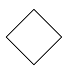
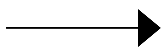
Illustration 01: Let us consider an order-to-cash process in a firm. This can be broken into the following steps for us to understand.

- An order-to-cash process in a firm is triggered by the receipt of a purchase order from a customer.
- A worker checks the purchase order against the inventory levels to determine if the requested item(s) are available.
- Depending on stock availability, a relevant worker either confirms or rejects the purchase order. Latter will be communicated to the customer.
- If the purchase order is confirmed, an invoice is raised and sent, and the goods requested are shipped.
- Finally, the process completes by archiving the order.

Let us draw a process model for the above using Business Process Modelling and Notation (BPMN 2.0) (Dumas et al., 2008)

Declaration of Symbols / Elements

Table 2.1:

Element	Label
	Activity
	Start an event
	End an event
	Gateway
	Sequence flow

Process Model

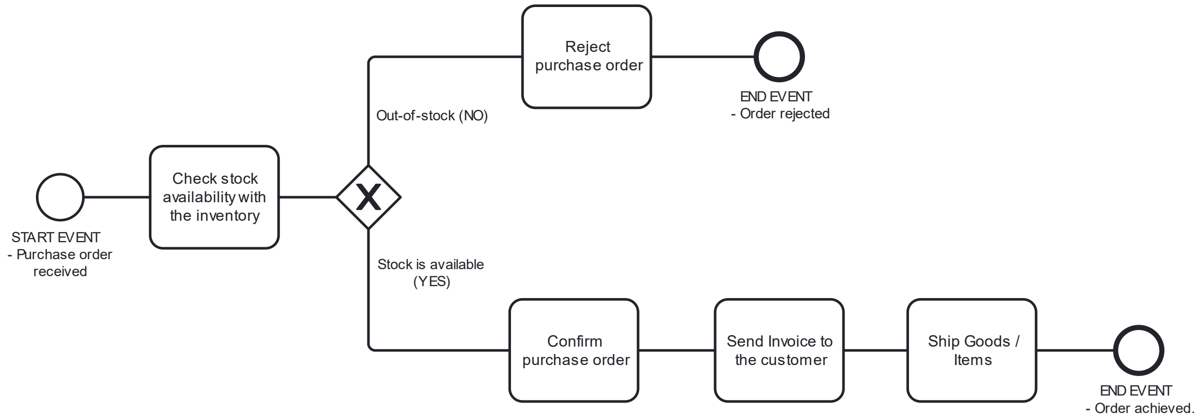


Figure 2.04: Order-to-Cash Process Model

In addition to the above, BPMN 2.0 has the capability to include organizational elements into the process model. This is known as 'swimlanes'. BPMN 2.0 uses a 'pool' to show the resource class (example: company) and a 'lane' to show the resource sub-class (example: finance department) for the above purpose.

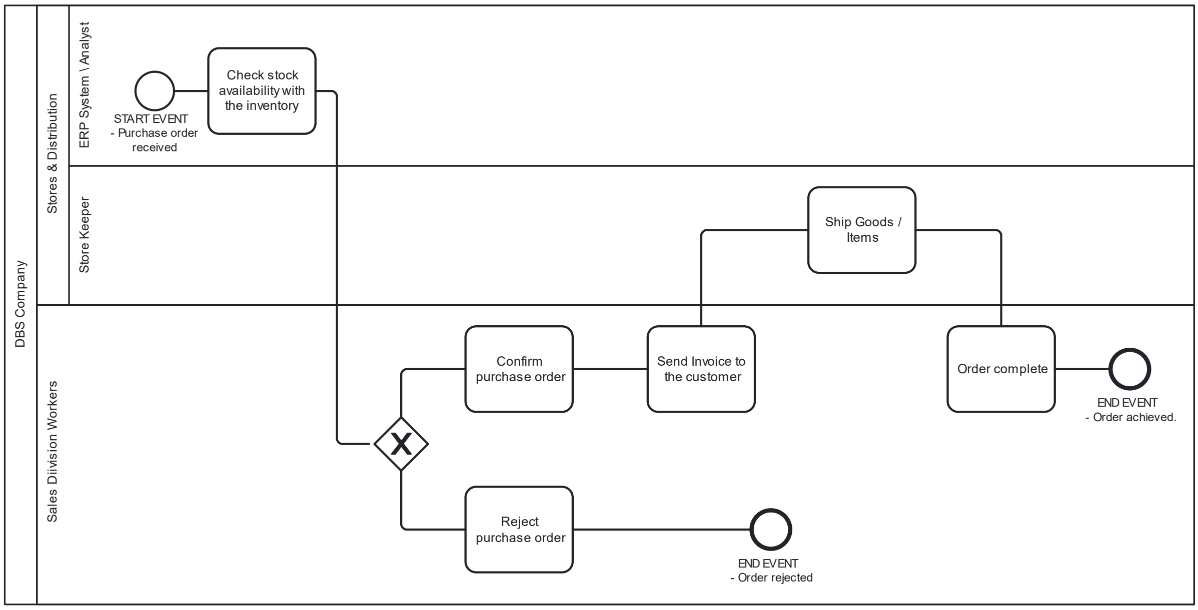


Figure 2.05: Process Model with Swinlanes

Process Analysis

Analyze the documented processes to identify areas for improvement. This can involve evaluating process performance metrics, such as cycle time, throughput, error rates, or customer satisfaction. Identify pain points, redundancies, or areas of low efficiency that can be targeted for improvement.

Process Redesign

Based on the analysis, redesign the processes to optimize performance and address identified issues. This may involve simplifying steps, eliminating non-value-added activities, automating manual tasks, or reorganizing process flows. The goal is to streamline processes, reduce costs, enhance quality, and improve customer experience.

Process Automation

Implement automation technologies to streamline and accelerate process execution. This can include workflow automation, robotic process automation (RPA), or integration with enterprise software systems. Automation reduces manual effort, eliminates errors, and improves process efficiency. Some commercially available RPA platforms are shown below (see **Figure 2.06**).

Power Apps | Power Automate | UiPath™ | WorkHub24

Figure 2.06: Commercially Available Process Automation Platforms

Low-code No-code Developments of Robotic Process Automation

No-code and low-code robotic process automation (RPA) platforms are tools that enable users to create and automate workflows and processes without extensive programming knowledge or traditional software development. These platforms provide visual interfaces and pre-built components that allow users to design, deploy, and manage automation tasks

No-Code RPA: No-code RPA platforms require minimal to no coding or programming skills. They typically provide a drag-and-drop interface and pre-built automation components that users can combine to create automated workflows. These platforms focus on simplicity and ease of use, allowing users to automate repetitive tasks quickly

Low-Code RPA: Low-code RPA platforms offer a balance between visual, drag-and-drop interfaces and the ability to add custom code or scripts if needed. While coding skills are not mandatory, users with some coding knowledge can extend the functionality of the automation workflows by adding custom logic or integrating with external systems through code snippets

Both no-code and low-code RPA platforms aim to democratize automation by enabling non-technical users to automate their business processes.

Process Execution and Monitoring

Implement the redesigned processes and execute them consistently. Establish clear roles, responsibilities, and guidelines for process execution. Monitor process performance in real-time, capturing data and metrics to assess adherence to predefined performance standards. Implement dashboards or reporting mechanisms to provide visibility into process performance.

Continuous Improvement

Foster a culture of continuous improvement by establishing feedback loops and mechanisms for capturing insights and lessons learned. Encourage employees to identify opportunities for process optimization and innovation. Regularly review and refine processes based on feedback and changing business needs.

2.1.3 Business Model Transformation

Business model transformation is about the fundamental changes made to an organization's existing business model to create new value propositions, revenue streams, and competitive advantages over its rivals.

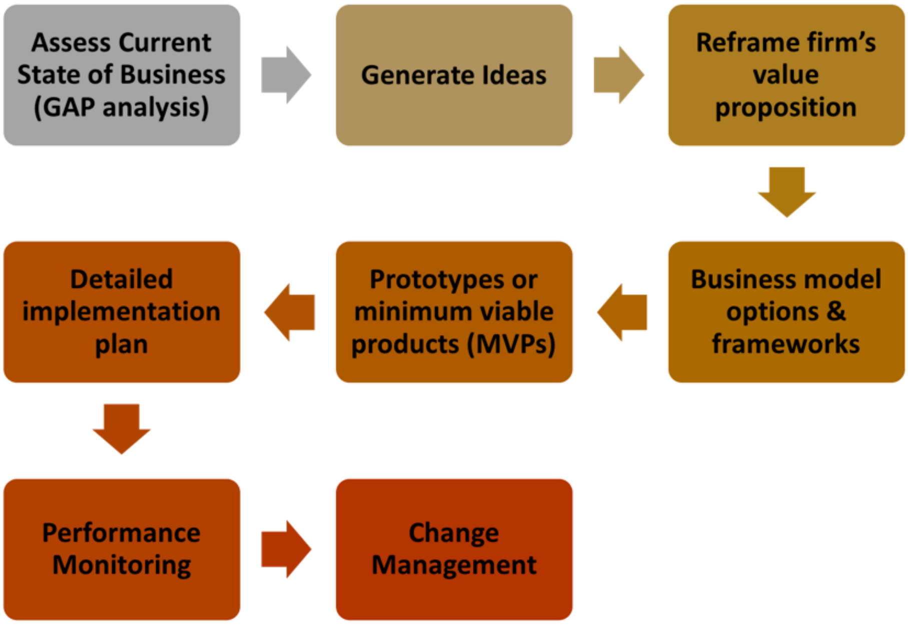


Figure 2.07: Business Model Transformation Process

Business model transformation is a complex and dynamic process that requires strategic vision, innovation, and the ability to adapt to market changes. It enables organizations to stay relevant, create new revenue streams, and unlock long-term growth opportunities in a rapidly evolving business landscape.

Domain Transformation, Cultural & Organizational Transformation

In the context of digital transformation, domain transformation enables firms to leverage the opportunities presented by digital technologies. Domain transformation is about the restructuring of various aspects of an organization's operations, processes, and business models. One of the main focus is the cultural and organizational transformation (example: leadership & vision, agile and adaptive culture (adoption of agile methodologies such as Scrum and Kanban), digital skills & capabilities, communication & collaboration, change management, customer-centricity and collaboration with external partners).

References

Dumas, M., Reichert, M., & Shan, M. C. (2008). Business process management. Springer Berlin/Heidelberg.

Knowledge Component			
2.2	**Big Data and Artificial Intelligence**		
	Big Data and Artificial Intelligence	2.2.1	Explain the concept of Industry 4.0 and its impact on the business world
		2.2.2	Describe the concept of Big Data
		2.2.3	Explain AI, Data Sciences and demonstrate the understanding of supervised machine learning process

2.2.1 Industry 4.0

The Fourth Industrial Revolution (Industry 4.0) refers to the ongoing transformation of traditional manufacturing and industrial processes via digital technologies and automation. This will shift the existing systems to smart and inter-connected systems.

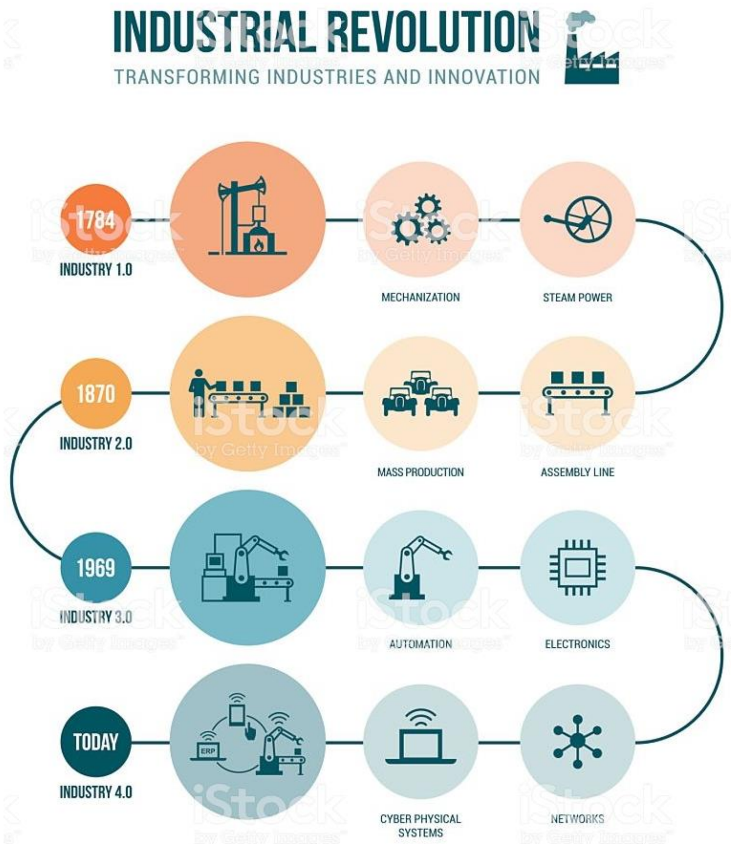


Figure 2.08: Industrial Revolutions

Source (Thinkstock.com)

As shown in Figure 2.08 above, the fourth industrial revolution (analytical revolution) has started in the 20th and 21st century. In particular, an integration of advanced technologies developed as a result of Industry 4.0, into various industries helps to improve efficiency and productivity by enabling connection, communication and collaboration with others. Figure 2.09 shows key technologies associated with Industry 4.0.

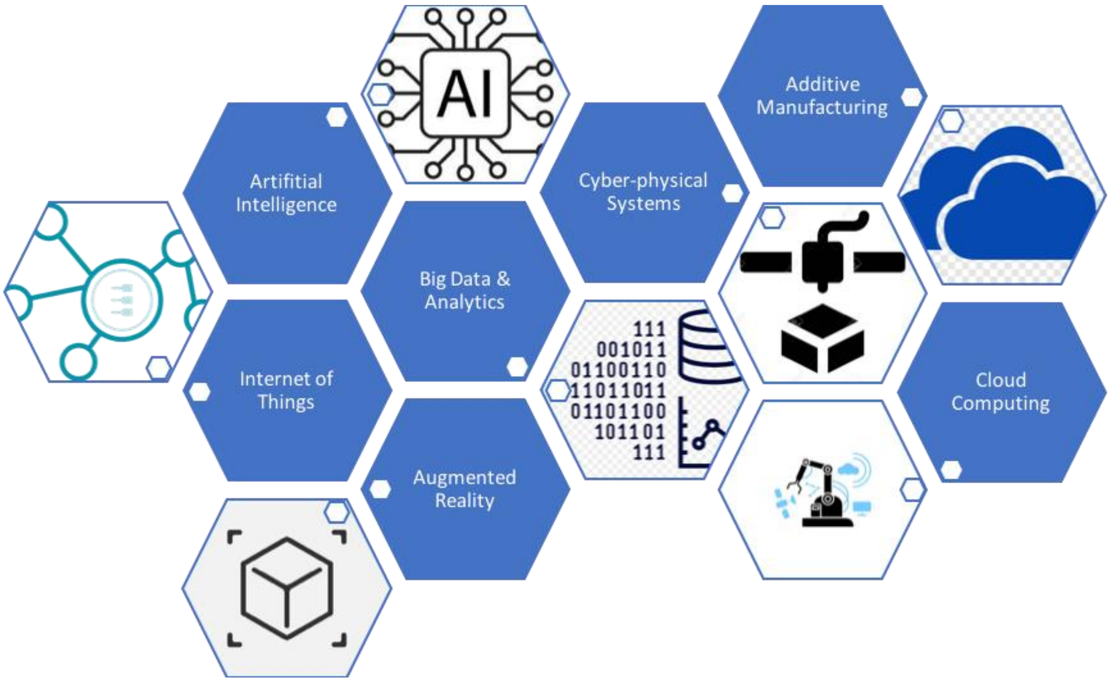


Figure 2.09: Industry 4.0 Technologies

Industry 4.0 links the production processes and products with intelligent information and communication systems that can handle large amounts of data (Big Data).

Smart Manufacturing

The main objective of smart manufacturing is to effectively and efficiently use the advanced information and manufacturing technologies to provide greater flexibilities in physical processes to cater complex and dynamic consumer demands. Smart manufacturing uses the following technologies:

- Industry 4.0
- Cyber physical systems
- Internet of Things (IoT)
- Digital manufacturing and Additive manufacturing
- Advanced robotics and simulation
- Cloud computing and Big Data
- Augmented Reality

Smart Manufacturing Use Cases

Use case 01: Remote monitoring of manufacturing operations

IoT devices can be used for remote monitoring of manufacturing processes by connecting machines and devices to the internet. In particular, maintenance engineers and sometimes production engineers are able to collect real-time data on equipment performance and condition (example: Temperature, Pressure, Vibration, Energy consumption, Input/output quantity, Production process duration).

With the help of remote accessibility, engineers can detect issues using predictive analytics, make adjustments, and optimize process.

Refer the following link to read the above use case:
https://dms.uom.lk/s/np97ba84Jcow4zp

2.2.2 Big Data

Big data and performance management

The amount of data available to organisations is increasing ever more rapidly, and big data – with its characteristics of volume, velocity, veracity, variety and value – highlights both the opportunities and the challenges which new sources of data present to organisations.

The ability to analyse large, and unstructured, data sets and to uncover previously hidden patterns of information could be an important element of an organisation's competitive advantage. However, as a prerequisite for this, organisations need to have the capacity to store and – more importantly – to analyse these data sets.

One of the key themes in this chapter and the previous one has been the way organisations collect and use information to support their strategic, tactical and operational decision making. Crucially, though, organisations today have more transactional data than they have ever had before – about their customers, their suppliers and their operations.

What is Big Data?

In a report looking at big data's potential to drive innovation, competition and productivity, McKinsey Global Institute (2011) defined big data as 'datasets whose size is beyond the ability of typical database software to capture, store, manage and analyse'.

However, the most widely cited definition of big data is that given by the technology research firm, Gartner:

Big data is 'high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation'.

Development of digital technologies has led to the generation and storage of large volumes of data (petabytes, 10^{15} B). Big Data refers to a large volume of structured, semi-structured and unstructured data. Big data is generated as a result of transactions, interactions and observations.

Due to its massive volume and complex nature, the traditional data processing applications (example: relational databases) find it hard to handle. As a result, specialized technologies and frameworks like Apache Hadoop, Apache Spark, NoSQL databases and distributed & parallel computing, that can handle big data have emerged. Figure 2.10 shows data uses, growth and complex nature.

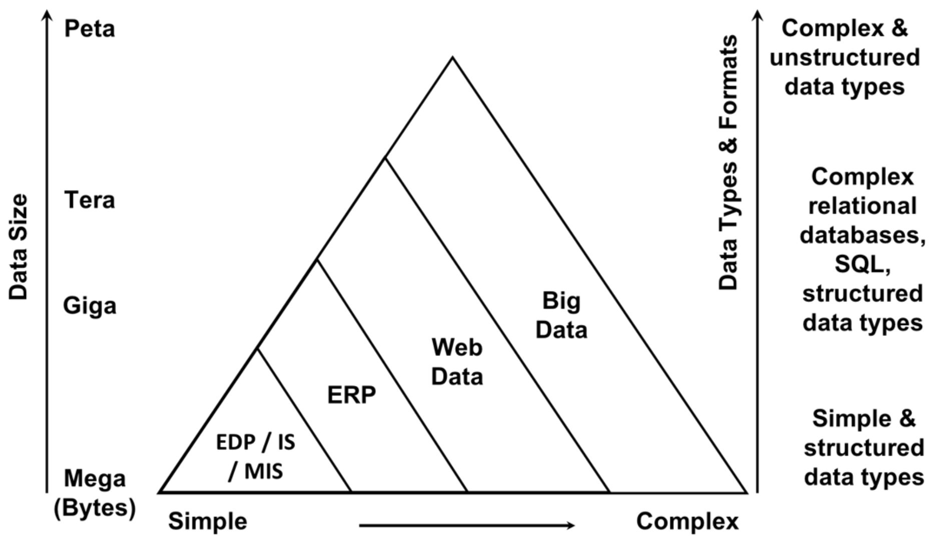


Figure 2.10: Evolution of Big Data and their attributes
(Source: Kamal & Saxena, 2019)

Big Data Attributes

Volume – A massive volume of data is one of the main attributes of Big Data. These volumes are ranging from terabytes to petabytes or even more (example: exabytes). For example, as most customers use the internet, smartphones and social media in their everyday lives, these can now also be sources of data for organisations alongside any data they may capture internally – for example, from customer loyalty cards or the transactions recorded in EPOS tills.

Velocity – Big Data is generated, collected, and processed at high speeds and real-time (example: social media, financial transactions, sensor outputs). Online retailers are able to compile records of each click and interaction a customer makes while visiting a website, rather than simply recording the final sale at the end of a customer transaction. Moreover, retailers who are able to utilise information about customer clicks and interactions quickly – for example, by recommending additional purchases – can use this speed to generate competitive advantage.

Variety – This refers to the formats and types of Big Data. This includes structured (relational databases, spreadsheets), semi-structured (JSON, XML) and unstructured data (text, images, videos). For example, keywords from conversations people have via social media (for example, Facebook or Twitter), and content they share through media files (tagged photographs or online video postings), could be sources of unstructured data.

However, this variety presents a challenge to organisations, as they need to find ways of capturing, storing and processing the data. If data is too big, moves too fast, or doesn't fit with the structures of an organisation's existing information systems, then in order to gain value from it an organisation needs to find an alternative way to process that data.

In this respect, 'big data analytics' is likely to be crucial to making use of the potential value of big data.
Veracity – This means the quality and reliability of the data. Sometimes data could be noisy, incomplete and/or erroneous.

Use Case

Logistics providers, such as DHL, manage a massive flow of goods around the globe, and at the same time create vast data sets; for example, from recording the origin and destination, size and weight of millions of shipments every day, and then from tracking their location across global delivery networks.

Big data can also provide a number of potential benefits to logistics providers, and this case example highlights three of these (DHL, 2013).

Last-mile optimization

A major constraint on the levels of operational efficiency in a distribution network is the so-called 'last mile' – the final stage of a supply chain in which goods are handed over to the recipient. This final stage can often be one of the most expensive in the supply chain (for example, if a delivery driver becomes stuck in a traffic jam, or if a recipient is not present when a courier attempts to deliver their package, and so the delivery has to be rearranged).

However, analysis of big data can help to increase last-mile efficiency, through route optimisation aimed at saving time in the delivery process. Rapid processing of real-time information assists route optimisation in several ways.

When the delivery vehicle is loaded and unloaded, sensors detect the destinations of the packages and the optimal delivery sequence is then calculated for the driver.

Once the delivery vehicle has begun its journey, telematics databases are used to automatically change delivery routes according to current traffic conditions. For example, if heavy traffic is causing delays on the route originally scheduled, a revised route is generated for the driver to avoid those delays.

In addition, routing intelligence makes use of availability and location information posted by recipients in order to avoid unsuccessful delivery attempts.

The 'big data' aspects of this scenario are that the driver's control systems make use of a number of different optimisation procedures, fed by correlated streams of real-time events, to dynamically reroute vehicles while they are on the road. As a result, each driver receives instant driving direction updates from their onboard navigation system, guiding them to the next best point of delivery.

Capacity planning

Effective capacity planning can be an important competitive advantage for logistics providers. Excess capacities reduce profitability, while capacity shortages affect service quality and potentially jeopardise customer satisfaction (eg by increasing delivery times).

Resource planning is therefore an important consideration for logistics planners at both strategic and operational levels. At a strategic level, the topology (links, nodes etc) and the capacity of the distribution network need to be adapted according to anticipated future demand. The results from capacity planning often lead to capital expenditure, such as investments in warehouses, distribution centres and vehicles. Therefore, more precise capacity demand forecasting can increase efficiency and lower the risks attached to investing in storage and fleet capacity (either by overinvesting or underinvesting).

Big data can support such capacity planning by analysing data about the historical capacity and utilisation rates of transit points and transportation routes. In addition, it can take account of seasonal factors and emerging freight flow trends (which are affected by external economic information, such as industry or regional growth forecasts).

As well as identifying potential under-capacity, planners can expose any potential overcapacity, and identifying this should provide a trigger to try to increase sales volumes – for example, by using dynamic pricing mechanisms.

Risk evaluation and resilience planning

Business to business logistics providers know their customers' supply chains in detail, and customers rely on the providers' predictive risk assessment.

In order to be able to identify potential threats to the supply chain, logistics providers need to maintain a model which not only describes all the elements of the supply chain topology but also monitors the forces which could affect the performance of that supply chain – for example, local developments in politics, the economy, or events in the natural environment.

Data on these environmental factors can come from a number of sources (eg weather forecasts, new sites, social media and blogs) but must then be aggregated and analysed. Much of this data stream is unstructured and continuously updating, so the power of big data analytics in dealing with velocity and variability could be invaluable in detecting supply chain risks. For example, if there is a tornado warning in the region where a transhipment point is located, the logistics company will need to alert its customer to this risk, as well as suggesting suitable counter-measures to mitigate against potential disruption (for example, either re- planning the transport route, or else increasing substitute supplies from another area).
(Based on DHL, 2013)

The value of big data

The case study above (about big data in the logistics industry) illustrates some of the ways big data can help an organisation, but more generally, DHL's report 'Big Data in Logistics' (DHL, 2013) suggested that one of the main ways in which big data can create value for organisations is through improving operational efficiency. Data can be used to make better decisions, to optimise resource consumption and to improve process quality and performance. In this respect, big data provides similar benefits to automated data processing, although big data can increase the level of transparency in the data.

McKinsey's '*Big Data*' report (McKinsey, 2011) also highlights its ability to create transparency as one of five broad ways in which big data can create value for organisations:

(a) Creating transparency – Making data more easily accessible to relevant stakeholders, in a timely manner, can create value in its own right – for example, by revealing insights from data which had previously been too costly or complex to process. This transparency could relate to data within an organisation as well as external data – through better integration and analysis of data produced by different parts of an organisation. For example, within a manufacturing company, integrating data from research and development, engineering and manufacturing units to enable concurrent engineering could significantly reduce time to market as well as improving quality.

However, in many cases the increased transparency resulting from big data is likely to relate to external data. For example, analysing shoppers' transactions, alongside social and geographical data, can reveal peer influence among customers – ie the extent to which shoppers' choices are shaped by their friends and neighbours as well as by the marketing efforts of the company itself.

Another important context in which transparency can be valuable for an organisation is in relation to fraud. For example, having real-time information available from a variety of sources could help an organisation expose fraud and irregular business practices among customers, employees, suppliers or other partners more quickly than it would otherwise have been able to do.

(b) Performance improvement – The increasing amount of transactional data they store in digital form provides organisations with an increasing amount of accurate and detailed performance data – in real or almost real time. By analysing variability in performance – and the causes of that variability – organisations then manage performance to higher levels. For example, identifying what customers are saying on social media about an organisation's products or its customer service could help the organisation identify how well it is meeting customers' needs. Customers' conversations could help the organisation identify potential changes which are needed to its products, or the way they are delivered, in order to meet customers' needs more effectively – and thereby to increase sales.

In addition to increasing revenues, cutting costs is also likely to be a key component of increasing profits. Having a complete picture of operational activities – and a detailed picture of costs – can help an organisation identify patterns that indicate wasteful or inefficient processes. Similarly, understanding the dynamics of the supply chain in more detail could help an organisation optimise its costs, capacity and inventory levels, as well as the service it provides customers (for example, through improved product availability).

(c) Market segmentation and customisation – The volume and variety within big data enables organisations to create highly specific segments within its markets and to tailor its products and services precisely to meet those needs.

The idea of market segmentation is already an important concept within strategic marketing. However, big data could facilitate the real-time micro- segmentation of customers for targeted promotions and advertising – for example, by sending tailored recommendation to customers' mobile devices while they are in the right area to take advantage of the offers.

The ability to perform precise customer segmentation and targeting could be used to help organisations improve customer loyalty and retention, as well as in attracting new customers.

McKinsey's (2011) report highlights that big data could also be valuable in segmenting public sector markets. Traditionally, public sector markets have not segmented citizens (service users) in the same way that private sector companies have segmented customers and potential customers. However, big data could enable public sector organisations to also tailor products and services more effectively.

2.2.3 Artificial Intelligence

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think and learn like humans. It is a multidisciplinary field of computer science that encompasses various subfields such as machine learning, natural language processing, computer vision, robotics, and more (See Figure 2.11).

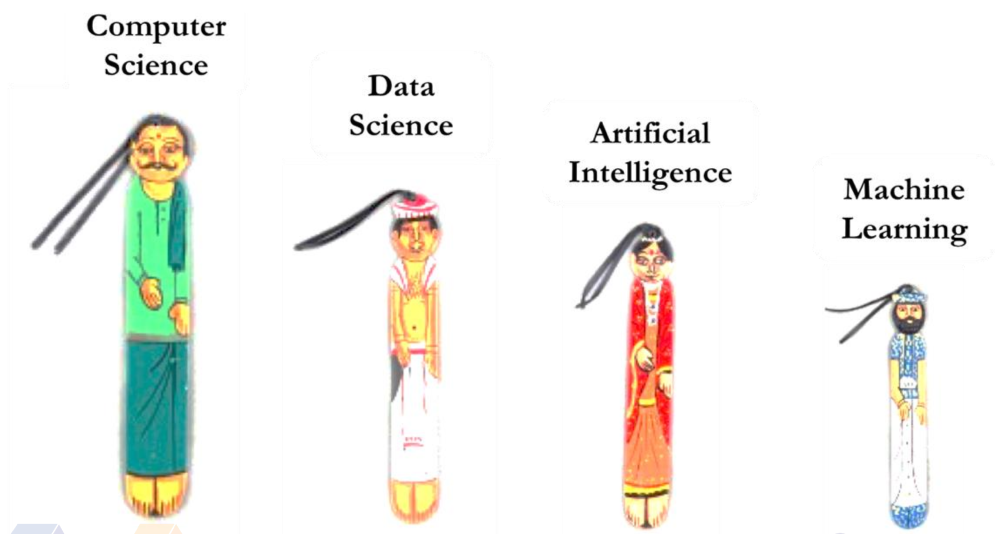


Figure 2.11: Family of ML

Data science is a broader and interdisciplinary field that has roots to statistics, mathematics, computer science, application domain expertise and other related disciplines. Data analytics is a sub-field of data science that focuses on analyzing data using statistical and computational techniques to unveil patterns, trends and meaningful information to understand historical data to answer some specific issues and solve business problems.

AI involves developing algorithms and intelligent agents & systems that can perceive, reason, learn, and make decisions based on data. An intelligent agent is a system or entity that perceives its environment, processes information, and takes actions to achieve specific goals or objectives. It is an entity that exhibits intelligent behavior and can make decisions autonomously.

AI encompasses various subfields, including:

- Machine Learning (ML) algorithms enable machines to learn from the input data and make predictions, recommendations and decisions without being explicitly programmed.
- Deep Learning (DL) is a subset of machine learning. DL deploys artificial neural networks with multiple layers to process complex data. DL extracts high-level representations from data.
- Natural Language Processing (NLP) focuses on enabling computers to understand, interpret, and generate human language (example: text analysis, sentiment analysis, machine translation, and chatbots).
- Computer Vision is about enabling machines to understand and interpret visual information from images or videos (examples: image recognition, object detection, and image generation).
- Robotics creates intelligent machines that can physically interact with the physical environment.

AI technology applications can be found in disciplines such as healthcare, finance, transportation, customer service, manufacturing, and more. AI is capable of automating repetitive tasks, provide recommendations, detect patterns or outliers, support decision-making, and increase efficiency and productivity.

Data and Algorithm

Datum, Data, Information and Knowledge

Datum refers to a single measurement or value within a dataset. It represents a single data point. Datum is the singular form of the word ‘data’. Data is raw facts, observations, or measurements that are typically collected or recorded. Data can be in various forms, such as numbers, texts, images, audio, or video. It is often unorganized and lacks context or meaning on its own. Data can be structured, where it follows a specific format, or unstructured, where it doesn't adhere to a predefined structure. For example, a list of numbers representing daily sales figures, a collection of customer names and addresses, or a set of survey responses are all examples of data. Data is broadly categorized into qualitative and quantitative.

Illustration 02: List both qualitative and quantitative data of Figure.

Qualitative	Quantitative
Orange colored skin with black stripes	Four legs
White colored paws	Two ears
Scary look	

Algorithm

An algorithm is a step-by-step procedure or set of rules designed to solve a specific problem or perform a specific task. Algorithms have certain attributes or characteristics that define their behavior and performance.

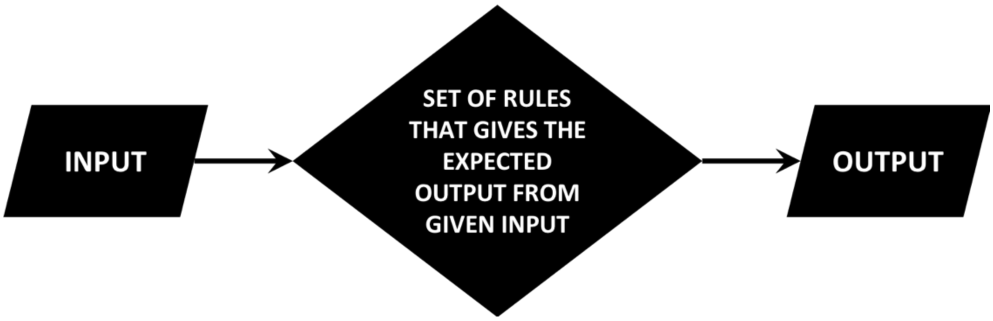


Figure 2.12: Algorithm Explained

An algorithm has well-defined input(s) and it produces well-defined output based on the given input(s). An algorithm produces consistent/same output for a given set of inputs every time it is executed. An algorithm is executed for a finite number of iterations. An algorithm, itself is precisely defined with no ambiguity in its instructions. The efficiency of an algorithm depends on the level of utilization of computational resources (time and memory). Accuracy of an algorithm is decided by the accuracy of instructions and validity and accuracy of inputs. Modularity is an important design concept in algorithm development that provides reusability, maintainability, and easier testing and debugging. Scalability helps an algorithm to handle a problem irrespective of its dimensionality and adaptability refers to provisions to redesign to face different scenarios.

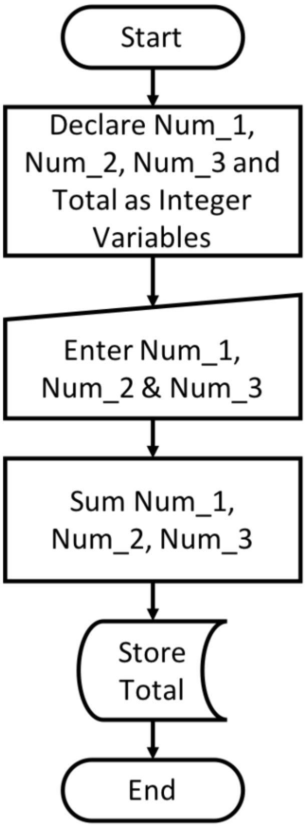
Algorithm Design

Step 01: Pre-requisites

Define the problem and identify the inputs and the expected outputs.

Step 02: Algorithm Design

This can be done using flow charts or pseudo codes.



$Initialization$

$Declare\ x_i, z \in \mathbb{Z}^+\ for\ i = 1,2,3$

$z \leftarrow \sum_{i=1}^{3} x_i$

$Print\ z$

End

Figure 2.13: Flow Chart and Pseudo Code.

Step 03: Testing and Implementing.

Testing the algorithm and python programming language implementation is as follows:

This is a simple python language code to compute the sum of 3 integers entered by a user.

The following line requests for the first number?

```
x = int(input("ENTER ANY INTEGER:"))
```

```
ENTER ANY INTEGER:3
```

The following line requests for the second number?

```
y = int(input("ENTER ANY INTEGER:"))
```

```
ENTER ANY INTEGER:4
```

The following line requests for the third number?

```
z = int(input("ENTER ANY INTEGER:"))
```

```
ENTER ANY INTEGER:5
```

Next line calculates the sum of the above 3 integers

```
sum = x+y+z
```

Below line displays the answer

```
print('The total is:',sum)
```

```
The total is: 12
```

Data Analytics

Descriptive Analytics

Descriptive analytics is used to understand historical data and summarize it to gain insights into past events and trends. The primary goal of descriptive analytics is to answer the question of "what happened?" by examining data and presenting it in a way that is easily understandable and interpretable.

The initial step of descriptive analytics is the data processing. This includes collection (gathering data from various sources, such as databases, files, surveys, sensors, or web scraping), manipulation, and transformation of data into a useful format for analysis, interpretation, and decision-making. It involves various operations, such as capturing, validating, sorting, organizing, summarizing, and presenting data. Data validation is important to verify the accuracy, completeness, and consistency of the collected data. This may involve data cleansing, eliminating duplicates, and removing errors or outliers. Next, data sorting arranges the data in a particular order based on specific criteria, such as alphabetical, numerical, or chronological order. Data transformation phase converts the data into a standardized format or structure suitable for further processing. This may involve data normalization, formatting, or aggregation

Finally, descriptive statistics combines multiple data points or records to create summary statistics or higher-level representations. Aggregation can involve calculations like sum, average, count, or other statistical operations. Data reporting, visualization and storytelling is communicating the findings and results of the data analysis to stakeholders through reports, presentations, or interactive tools (see Figure 2.14).

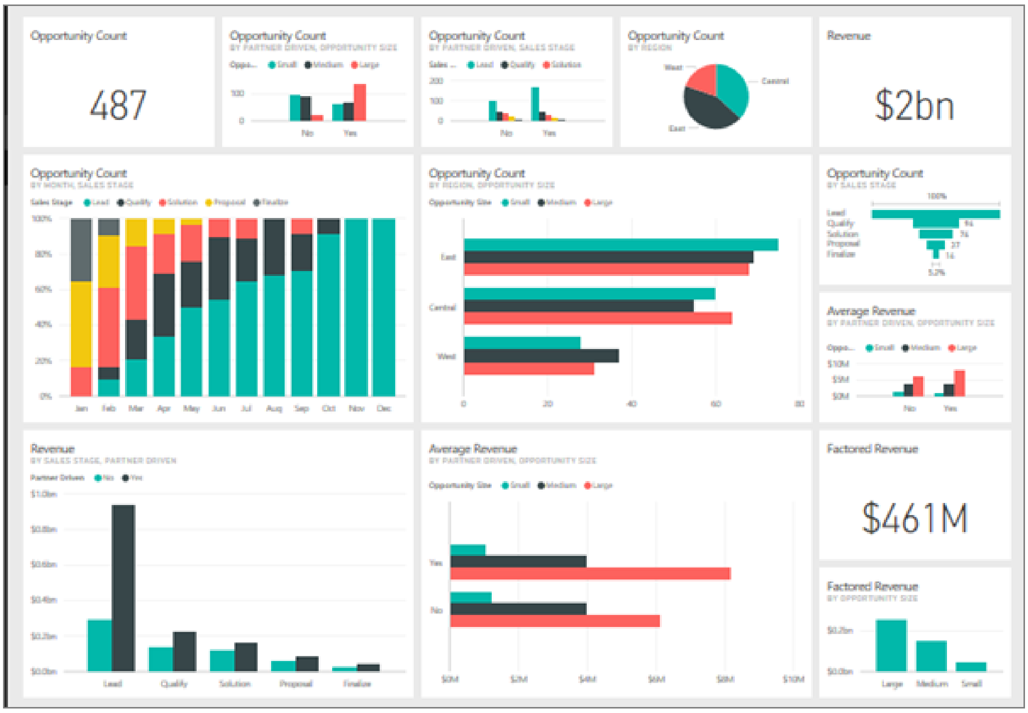


Figure 2.14: Sample Data Visualization Dashboard using Microsoft Power BI (Source: https://learn.microsoft.com/en-us/power-bi/create-reports/service-dashboards)

Microsoft Excel, Microsoft Power BI, QlikView and Tableau are some examples for popular data visualization tools.

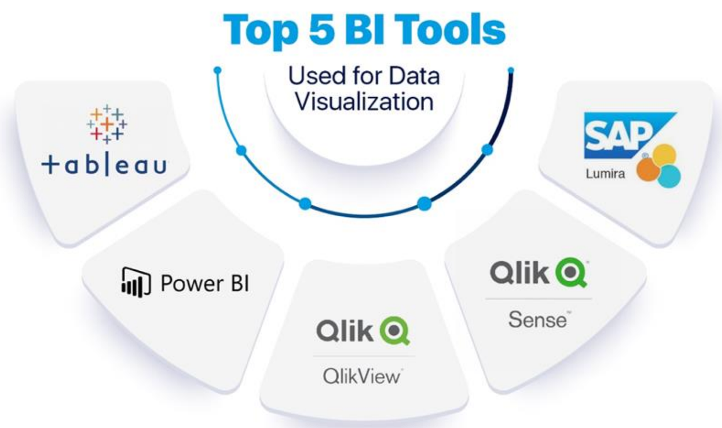


Figure 2.15: Data Visualization Commercial Packages (Source: www.dasca.org)

Increasingly, companies are looking at ways of reducing the number (and size) of paper reports which are produced, and of providing the necessary information to decision makers in an easy to read manner. One of the ways of doing this is through the use of 'Executive Dashboards' which show current data, pictures, graphs and tables to illustrate how a business is performing and to help managers make better decisions. For example, if a retail chain is expanding, and preparing to open new stores, it could use dashboards to monitor the progress of the new stores. The dashboards could display geographical areas and the new stores that are being developed. By clicking on an individual store, executives can see details of how the new stores are being constructed and if any are being delayed. Once the new stores have opened, the executives could then also use the dashboards to see how well each store is performing – for example, when sales are in line with expectations.

Historically, there have been criticisms of information systems and reports that people were getting tied in knots trying to produce the reports they wanted from the systems available. Reporting tools tended to be rigid and had lots of requirements about the way reports were produced. However, current reports offer a lot more flexibility, and thereby allow managers to get the reports they actually need or want.

Drill-down reports

Dashboards are often also combined with drill-down reports. Drill-down reports provide users with the capability to look at increasingly detailed data about a situation. For example, the sales managers could first look at data for a high level (such as sales for the entire company) and then drill down to a more detailed level (such as sales for individual departments of the company) if they are concerned about sales performance. The manager should then also be able to drill down to a very detailed level, possibly to look at sales for an individual sales representative. In this way, the manager can dictate the level of detail and information presented and can avoid being overloaded with too much detail initially.

Exception reports

Another way of managing the amount of information being presented, and thereby preventing information overload, is through the use of exception reports. Exception reports are reports that are only triggered when a situation is unusual or requires management action. For example, the parameters could be set so that exception reports are generated for all capital projects which exceed budget by greater than $100,000.

However, the key to using exception reports successfully is setting the parameters carefully. The aim of an exception report is only to highlight the situations which require management action. If the parameters are set too low (for example, all capital projects which exceed budget by over $100) then the manager will end up looking at too many items. Conversely, if the parameters are set too high (for example, capital projects which exceed budget by over $10 million) then situations which should receive management attention will not do so.

Because the aim of exception reports is to highlight situations which require management attention or action, they are best used to monitor aspects of performance which are important to an organisation's success. In this respect, exception reports could be used to report against key performance indicators (KPIs), or other aspects of an organisation's performance relating to its critical success factors.

Finally, in relation to the outputs of information systems as a whole, users need to get involved when scoping what they require from their information systems. If an MIS has immense capacity but does not give users the data they need individually, then the system is making life harder for the user.

The presentation of reports

Although organisations may be able to use dashboards and exception reports to help improve the suitability of the management information they produce, there are also some more basic factors which can affect the quality of their output reports.

Presentation. Taking care with presentation can make a significant difference to the professionalism and appearance of a report. For example, a well-presented report, which is clearly structured and written in a logical order, is more likely to be well received than one which isn't.

Standard format. Some organisations have 'house style rules' which determine the format and style of reports. This might be to promote a corporate image within the organisation. However, it might also be to allow ease of comparison between reports, or to ensure that the managers do not miss key pieces of information because they do not know where to look for them.

Length. The length of a report should be appropriate to its purpose. So, for example, a summary report should be concise, but a detailed review should be comprehensive. However, whatever the length of the report, it is important that the material contained in it should be relevant.

- Data Storage: Archiving and organizing processed data for future retrieval and reference. This may involve storing data in databases, data warehouses, or cloud storage systems

Data warehousing and improved reporting capabilities

A data warehouse contains data from a range of internal (eg sales order processing system, nominal ledger) and external sources. One reason for including individual transaction data in a data warehouse is that if necessary, the user can drill down to access transaction-level detail.

The warehouse provides a coherent set of information to be used across the organisation for management analysis and decision making. The reporting and query tools available within the warehouse should facilitate management reporting and analysis.

The reporting and query tools used within the warehouse need to be flexible enough to allow multidimensional data analysis, also known as online analytical processing (OLAP). Each aspect of information (eg product, region, price, budgeted sales, actual sales and time period) represents a different dimension. OLAP enables data to be viewed from each dimension, allowing each aspect to be viewed in relation to the other aspects. So, for example, information about a particular product sold in a particular region during a particular period would be available online and instantly.

Organisations may build a single central data warehouse to serve the entire organisation or may create a series of smaller data marts. A data mart holds a selection of the organisation's data for a specific purpose.
A data mart can be constructed more quickly and cheaply than a data warehouse. However, if too many individual data marts are built, organisations may find it is more efficient to have a single data warehouse serving all areas.

Advantages of setting up a data warehouse system include:

(a) Decision makers can access data without affecting the use of operational systems.

(b) Having a wide range of data available to be queried easily encourages the taking of a wide perspective on organisational activities.

(c) Data warehouses have proved successful in a number of areas:

  (i) Quantifying the effect of marketing initiatives

  (ii) Improving knowledge of customers

  (iii) Identifying and understanding an enterprise's most profitable revenue streams

(d) Information can be made available to business partners. For example, if customer sales order information is in the data warehouse, it could be made available to customers and even suppliers. Internal information on products and services could also be provided.

Example:

'Clubcard' is Tesco's loyalty card, and customers earn loyalty points whenever they make purchases using their Clubcard.

However, by rewarding customers with Clubcard points when they make purchases using their card, Tesco is not solely rewarding customers for their loyalty. At the same time, the Clubcard programme provides Tesco with insight into millions of customer transactions.

From this, Tesco can develop tailored ranges, promotions and marketing by country or region. Perhaps even more valuably, Tesco can tailor its marketing, right down to individual customers, via its Clubcard mailings.

Loyalty card programmes (such as Tesco's Clubcard) are also linked to data warehouses, and the data stored in them can be analysed to provide retailers with valuable information about individual customers' spending patterns. This information enables retailers to send personalised marketing messages to customers with offers relating to products which they have bought previously or may be likely to buy in the future.

- It's important to note that data processing methods can vary depending on the specific requirements, domain, and technologies involved. Organizations often employ specialized tools, software, and programming languages to streamline and automate data processing tasks, such as using SQL for database operations, spreadsheets for data manipulation, or programming languages like Python or R for more advanced data processing and analysis.

Predictive Analytics

Predictive analytics is the practice of using historical and current data, statistical algorithms, and ML techniques to analyze patterns and make predictions about future events or outcomes.

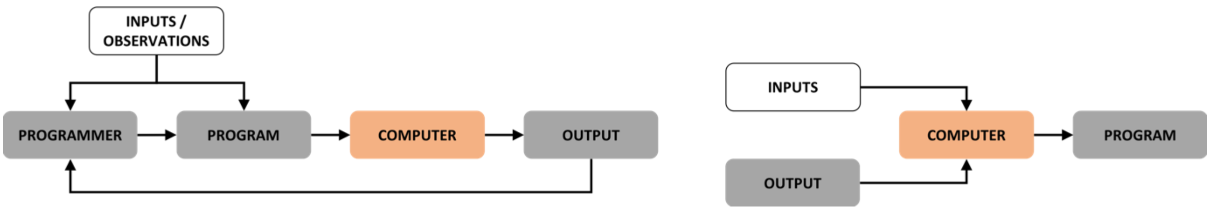


Figure 2.16: Classical programming vs ML

The above figure shows the difference between traditional programming and ML. ML makes computers learn from data without explicitly having to program the computer. Then, ML improves computers learning over time in autonomous fashion. Feeding data can be in the form of observations and/or real-world interactions. ML involves extracting insights from data to forecast trends, behaviors, and probabilities, helping organizations make informed decisions and take proactive actions. Popular applications of machine learning include the following: Email spam detection, Face detection and matching (e.g., iPhone X, Windows laptops, etc.), Web search (e.g., DuckDuckGo, Bing, Baidu, Google), Sports predictions, Post office (e.g., sorting letters by zip codes), Credit card fraud, Product recommendations (e.g., Walmart, Netflix, Amazon), Language translation (Google translate), Sentiment analysis, Self-driving cars (e.g., Uber, Tesla).

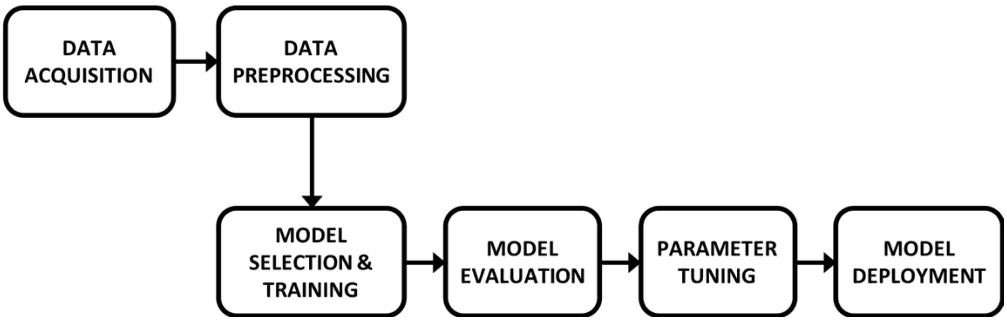


Figure 2.17: Machine Learn Modeling Life Cycle

- Data Acquisition

  Gathering relevant data from various sources, such as databases, sensors, social media, or customer interactions. This data may include structured data (e.g., numbers, categories) and unstructured data (e.g., text, images)

- Data Pre-processing

  Cleaning and preparing the data for analysis. This step involves tasks such as data cleaning, handling missing values, data transformation, and feature engineering (creating new variables or features that may enhance prediction accuracy)

- Exploratory Data Analysis (EDA)

  Analysing and visualizing the data to gain insights, identify patterns, and understand the relationships between variables. EDA helps in selecting relevant features and understanding the data's characteristics.

- Machine Learning (ML) Model Selection

  Choosing the appropriate predictive modeling technique or algorithm based on the problem and data characteristics.

  Machine learning is a subset of artificial intelligence (AI) that focuses on the development of algorithms and statistical models that allow computers to learn from and make predictions or decisions based on data, without being explicitly programmed for each task. The main objective of machine learning is to enable computers to improve their performance on a specific task through experience and exposure to relevant data

  ML can be broadly categorized into three main types: supervised learning, unsupervised learning and reinforcement learning. This study text briefly focuses only on supervised learning models.

  Supervised learning and unsupervised learning are two main types of machine learning paradigms used to train models and make predictions from data. They differ in their approach, data requirements, and the nature of the learning process

  Unsupervised learning, on the other hand, deals with unlabeled data. In this type of learning, the algorithm explores the underlying structure or patterns within the data without the guidance of explicit output labels. The goal of unsupervised learning is to identify meaningful patterns, groupings, or representations that may not be apparent to the human eye. Unsupervised learning is outside the scope of this study text.

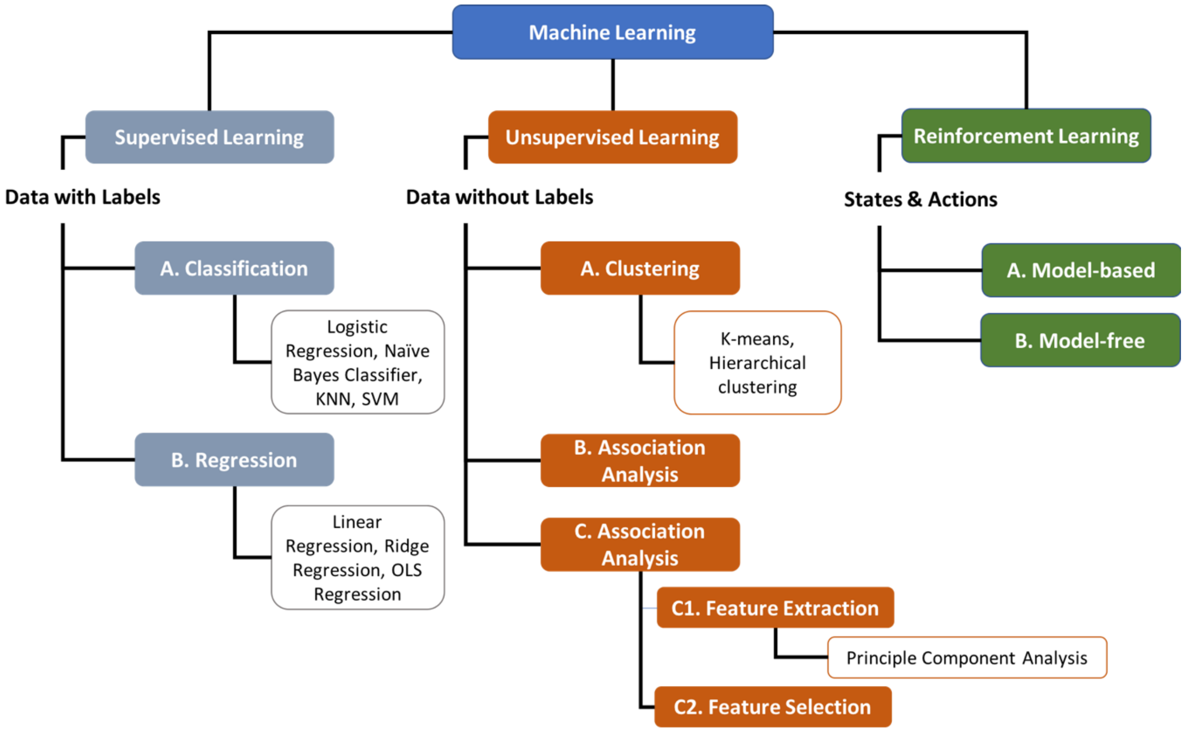


Figure 2.18: Overview of ML Algorithms

- Model Training: Training Data vs Test Data of Supervised Machine Learning Models

Supervised learning is a class of ML that works on input instances such as predictor features (independent variables, feature variables, predictor variables) and associated labelled variables / target values (dependent variable, predicted variable). Labelled data means that each input sample in the training dataset is associated with a corresponding output label, also known as the target or ground truth. That is for every set input features the output/response/label is available in dataset.: $(x_1, y_1), (x_2, y_2), (x_3, y_3), \ldots\ldots, (x_n, y_n)$.

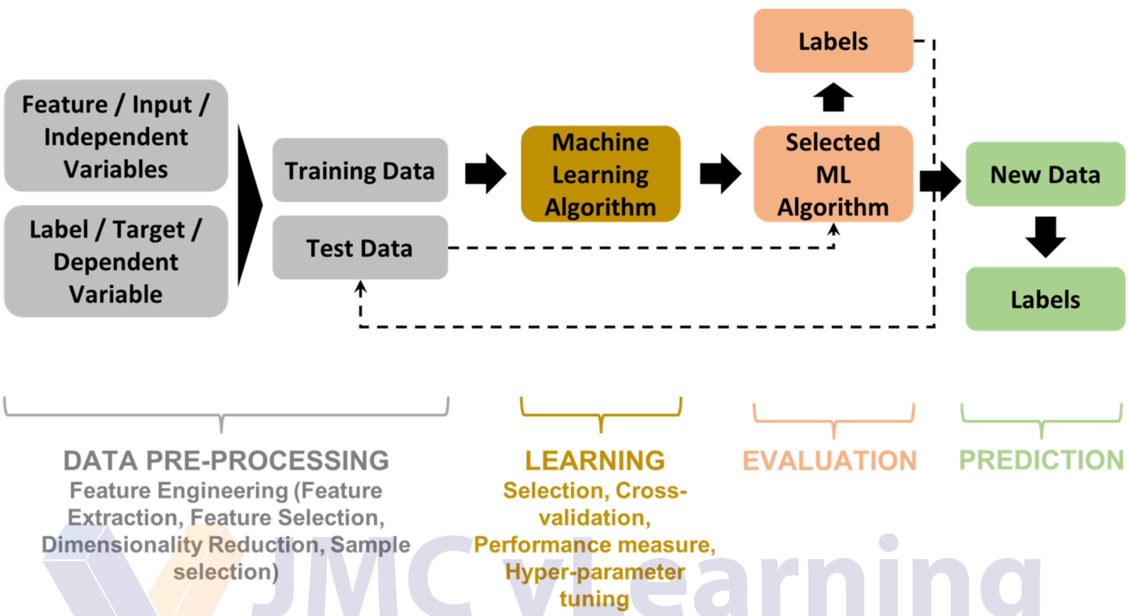


Figure 2.19: Supervised ML Process

Training data refers to the sample data points that are used to train the ML model. Test data is used to test the performance of the trained ML model. The learning process in supervised learning involves presenting the algorithm with a set of input-output pairs and adjusting the model's parameters iteratively until it can predict the correct output for new, unseen data examples.

Classification Algorithms

A classification algorithm classifies data into predefined groups. This works only for discrete categories or the data that can be tagged or separated Output depends on what the model has learned in its training phase using training data. Support Vector Machine (SVM), decision trees, *k*-nearest neighbor (KNN) and Naïve Bayes are some commonly used classification ML algorithms.

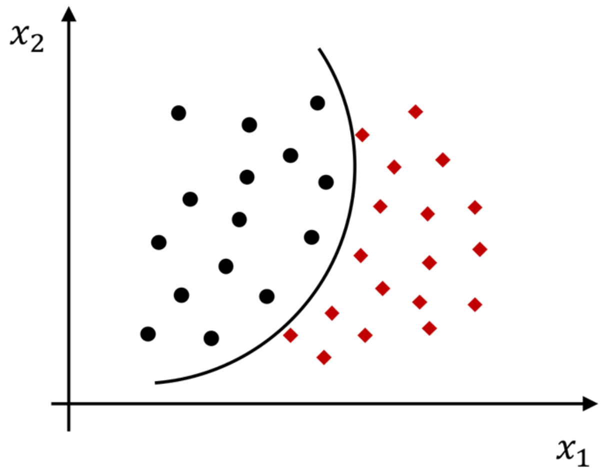


Figure 2.20: Classification Model

Illustration: Simple email classification problem

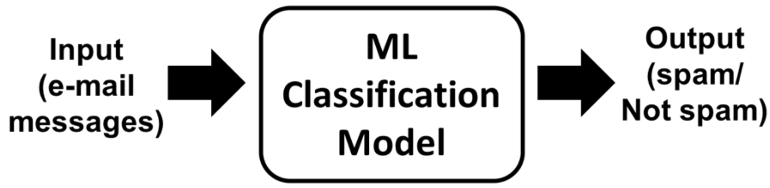


Figure 2.21: Supervised ML Classification Model

As shown in Figure 2.21, a classification ML model can be trained using many input/output pairs. The goal of this classification algorithm is to classify incoming email messages into spam and non-spam categories.

Input: e-mail messages

Features to be defined in some feature space $\subseteq \mathbb{R}^d$

$x \in \mathcal{X} \subseteq \mathbb{R}^d$

Output: Spam / Not spam

Spam / Not spam to be represented as $\{+1, -1\}$

$y \in \mathcal{Y} = \{+1, -1\}$

The machine learning model is fed with n number of input / output pairs:

$\mathcal{D} = \{(x_i, y_i)\}_{i=1}^{n} \in (\mathcal{X} \times \mathcal{Y})^n$

Here $\mathcal{D} = \{(x_i, y_i)\}_{i=1}^{n}$ is called the "training data".

Figure 2.16 shows the model learning process using the training data set.

Figure 2.22: Training of Classification Model

Training

Input: Training data $\mathcal{D} = \{(x_i, y_i)\}_{i=1}^{n}$

Aim: Learn a model $h: \mathcal{X} \rightarrow \mathcal{Y}$

Test data set ($\hat{\boldsymbol{x}}$) is fed into the trained classification model as shown in Figure 2.17. So the model is expected to make a prediction $\hat{\boldsymbol{y}} = h(\hat{\boldsymbol{x}})$.

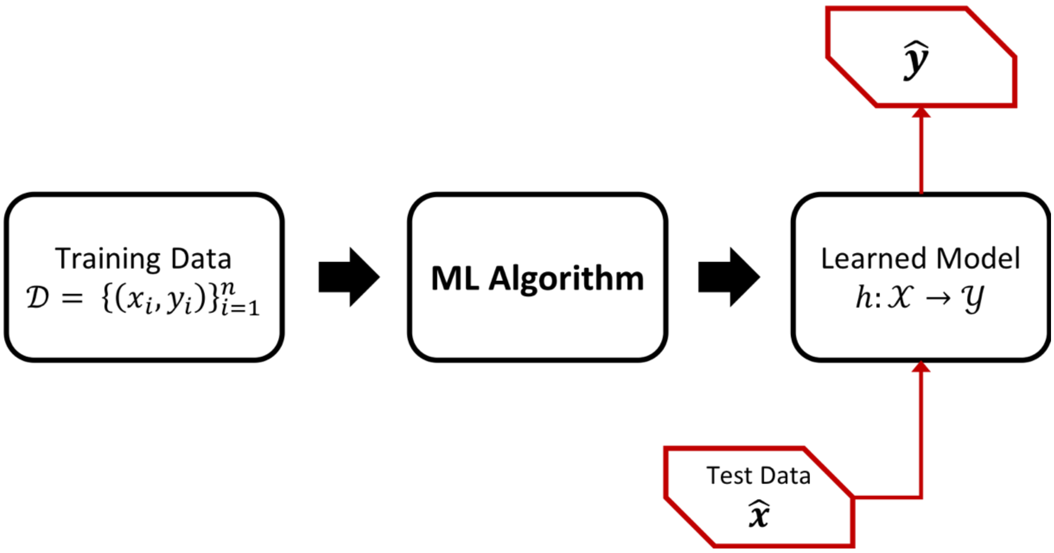


Figure 2.23: Evaluation of Classification Model

Testing

Given: $\hat{\boldsymbol{x}}$

Predict: $\hat{\boldsymbol{y}} = h(\hat{\boldsymbol{x}})$

Regression Models

In contrast to classification algorithms, regression algorithms predict continuous values.

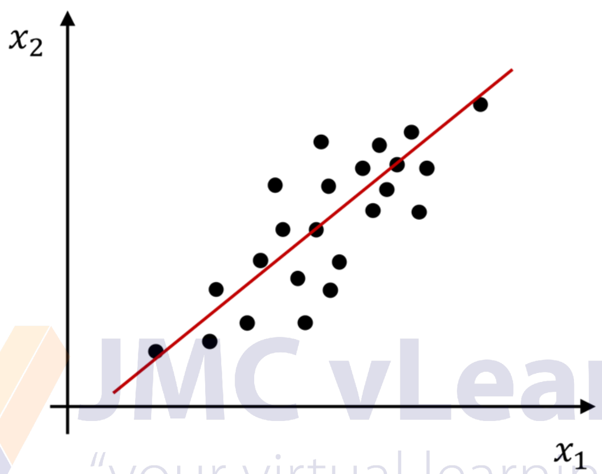


Figure 2.24: Example of a Linear Regression Model

Here the training data set $\mathcal{D}$ is in the form of a set of pairs: $\mathcal{D} = \{(x_i, y_i)\}_{i=1}^{n}$ where x_i is the input / feature and y_i is the output to be predicted or target value. The aim of a regression problem is ultimately, given a new input feature x_i^{n+1}, to predict the value y_i^{n+1}.

- Model Evaluation
  Assessing the performance of the trained model using evaluation metrics such as accuracy, precision, recall, F1-score, or area under the curve (AUC). This step helps determine the model's effectiveness and potential for prediction
- Model Tuning
  Iteratively adjusting the model's parameters or configurations to optimize its performance. Techniques like cross-validation, hyperparameter tuning, or ensemble methods can be used to enhance the model's accuracy and generalization capability
- Predictions and Deployment
  Applying the trained model to new or unseen data to generate predictions or forecasts. These predictions can be used for various purposes, such as customer behavior analysis, risk assessment, demand forecasting, fraud detection, or personalized recommendations. The model is then deployed in a production environment to make real-time predictions
- Monitoring and Maintenance
  Continuously monitoring the model's performance and retraining it periodically with new data to ensure its accuracy and relevance over time. This step helps to identify model decay or drift and address any issues that may affect prediction quality

Predictive analytics has applications in numerous industries, including finance, marketing, healthcare, manufacturing, and supply chain management. It helps organizations optimize processes, improve decision-making, identify opportunities, mitigate risks, and enhance overall operational efficiency.

It's important to note that predictive analytics is not about providing absolute certainty or precise future predictions. Instead, it aims to provide probabilistic insights based on historical data and patterns. The accuracy and reliability of predictions depend on the quality of the data, the chosen modeling techniques, and the assumptions made during the analysis

References

Kamal, R., & Saxena, P. (2019). Big Data Analytics: Introduction to Hadoop, Spark, and Machine-Learning. McGraw-Hill Education.

Schwab, K. (2017). The fourth industrial revolution. Currency.

Theobald, O. (2017). Machine learning for absolute beginners: a plain English introduction (Vol. 157). London, UK: Scatterplot press.