Creating Value with Industry 4.0

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ABSTRACT

We are in the age of Industry 4.0. Evolution and advancements in information and communication technology, sensors, Big Data, the Internet of Things, 3D printing, cloud computing, robots and mobile internet are some of the key technology areas that will digitize the value chains in various industries. The benefits are expected to be enormous along all value dimensions: efficiency, flexibility, quality, larger product selection and unique customer experience.

The goal of this thesis is to understand and explore how adoption of Industry 4.0 technologies will impact and transform the functions of a value chain. Research consists of extensive study of industry case studies from leading providers, research papers, industry reports and journals. This thesis analyzes current applications and benefits of Industry 4.0 technologies and their impacts. It also explores risk and barriers of technology adoption by researching industry examples.

The outcomes of the thesis are-

- A "Benefit-Impact Mapping Framework" to capture the how implementation Industry 4.0 technologies can impact organizations.
- A "Conceptual Framework" to assist in strategic decision making for adoption of Industry 4.0.

Thesis Supervisor: David Simchi-Levi

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Chapter 1: Introduction

Industrial Revolution has gone through different phases, starting from transition from hand production methods into machines during the eighteenth century, to modern day digital and Internet technologies. In this chapter, we introduce the Industry 4.0 or the Fourth Industrial Revolution; what Industry 4.0 means to organizations and motivation and objectives behind this research.

1.1: Industrial Revolutions

Industrial Revolutions that have occurred in the past served as major turning points in history; they have impacted almost every industry and affected almost every aspect of their operations and functions.

The First Industrial Revolution occurred in Britain in the period from about 1760 to 1830[1]; during this period there was transformation of manufacturing processes from manual production methods to machines and mass production.

The Second Industrial Revolution occurred in the latter half of the 19^{th} century; it was characterized by expansion of electricity, petroleum, transportation and steel in UK, USA and Germany. The Second Industrial Revolution also witnessed growth in some industries of huge economies of scale and throughput(Mokyr, 1998).

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1 *http://www.britannica.com/event/Industrial-Revolution*

The Third Industrial Revolution, also known as Digital Revolution, started in the latter part of 20th century marking the application of digital computers and computing power. The main players in the beginning of this phase are the US based IT and Internet companies.

Although all the three Industrial Revolutions occurred in different times in the history, some of the impacts in the manufacturing industry were similar – they led to increase in production volume, production and operational process change, reduction in production times, automation, reduced growth rates of labor income, lower cost of manufacturing among others. We are now at an age of the Fourth Industrial revolution or the Industry 4.0, which marks the next phase of digitization of manufacturing and operations.

1.2: Defining Industry 4.0

Definition: The term Industry 4.0 stands for the fourth industrial revolution. Best understood as a new level of organization and control over the entire value chain of the life cycle of products, it is geared towards increasingly individualized customer requirements. This cycle begins at the product idea, covers the order placement and extends through to development and manufacturing, all the way to the product delivery for the end customer, and concludes with recycling, encompassing all resultant services.

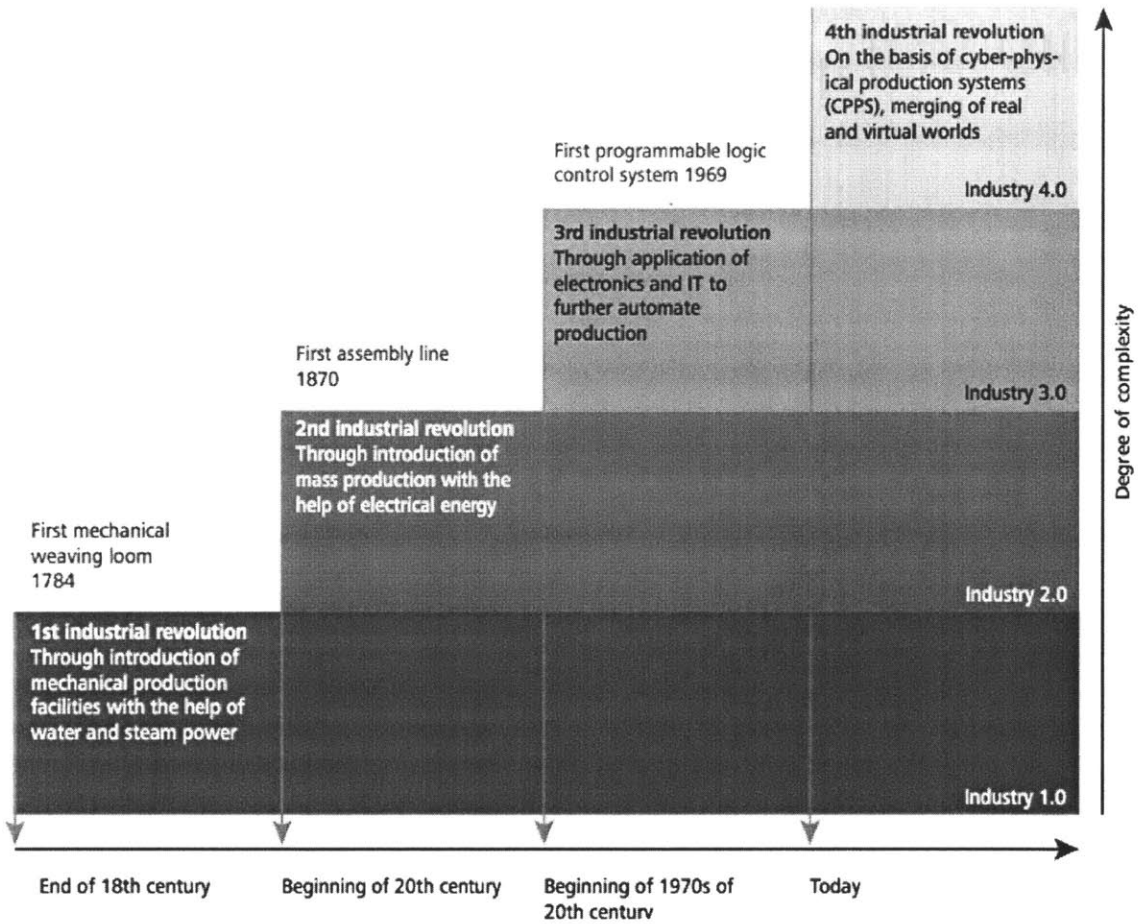

Figure1: Industrial Revolutions [2]

The basis for the fourth industrial revolution is the availability of all relevant information in real time by connecting all instances involved in the value chain. The ability to derive the optimal value-added flow at any time from the data is also vital. The connection of people, things and systems create dynamic, self-organizing, real-time optimized value- added connections within and across companies. These can be optimized according to different criteria such as costs, availability and

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[2] *Jochen Schlick, Peter Stephan and Detlef Zühlke: Produktion 2020. Auf dem Weg zur 4. industriellen Revolution. IM – Fachzeitschrift für Information Management und Consulting. August 2012. Retrieved from Deloitte Report - Industry 4.0 Challenges and solutions for the digital transformation and use of exponential technologies*

consumption of resources (Platform Industry4.0, retrieved from PwC report - Koch, 2014).

1.3 Literature Review

1.3.1: Current state of Industry 4.0

Industry 4.0 involves increasing digitization and interconnection of products, value chains and business models (Koch et al., 2014). The traditional methods of manufacturing is in the cusp of digital transformation that goes beyond application of IT and automation but creating intelligent networks connecting entities or stakeholders along the entire value chain.

A BCG report names nine pillars of technology advancement in Industry 4.0 viz. Big Data and Analytics, Autonomous Robots, Simulation, Horizontal and Vertical System Integration, The Industrial Internet of Things, Cybersecurity, The Cloud, Additive Manufacturing and Augmented Reality (The Boston Consulting Group, 2015). These technologies will create huge volume and variety of data; it will be critical that there is secure interconnection between systems that would generate these data and information. Some of these technologies have existed for many years but in recent times there has been advancement in their applications and such applications are gradually changing the way several industries operate and functions. Another report released by McKinsey identifies four disruptions that drive Industry 4.0 as below (Safire, 1991):

- The astonishing rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks
- The emergence of analytics and business-intelligence capabilities
- New forms of human-machine interaction such as touch interfaces and augmented-reality systems
- Improvements in transferring digital instructions to the physical world, such as advanced robotics and 3-D printing.

The manufacturing industry is going through transformations. Machine learning and analytics powered manufacturing operations will have the capability of predictive maintenance, mass production, intelligent and customized customer support, automation etc. For example, using 3-D printing complex and intricate designs can be manufactured with precision and speed that was not possible before. Predictive analytics can forecast errors before they even occur and catch them before it stops operations in a factory floor, reducing equipment downtime and improving safety of workers.

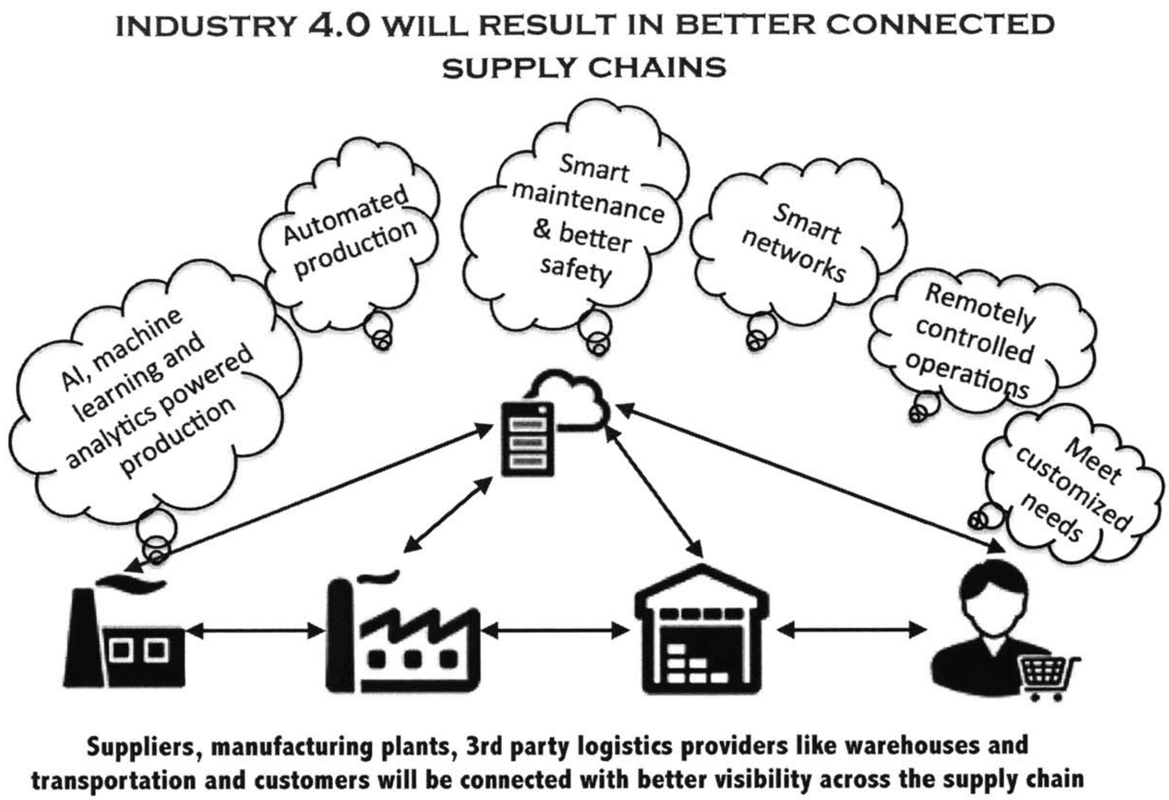


Figure 2: Smart manufacturing and connected supply chains

As Industry 4.0 technologies mature to attain more business readiness for application, their adoption would have the potential to change the global competitive environment at a massive scale. Accenture's analysis in collaboration with Frontier Economics estimates that it could add US$14.2 trillion to the global economy by 2030(Accenture, 2015). Another study by GE and Accenture states 73% of the companies surveyed said that Big Data analytics comprised of more than 20% of their overall technology budget(Accenture & GE, 2015). One of the key findings of a recent PwC study states Industrial Internet occupies a leading position on the agenda of directors and managers of industrial companies, it must be a part of the CEO agenda(Koch et al., 2014). According to a recent research by Accenture Strategy "most C-suite executives want to follow the trend rather than lead in the journey to the Industrial Internet". In certain sectors of the industry being a follower may be the favorable strategy but in some companies being late in adopting industrial internet will also put them at risk of losing out to competitors. Industry 4.0 can rapidly disrupt value chains and change business models challenging existing players in the market. Hence, it is critical that executives pay close attention to this phenomenon and evaluate the course of action to adopt the right strategy in the age of fourth industrial revolution.

1.3.2: Three main Classifications

The various outcomes and benefits of application of Industry 4.0 technologies can be classified into three categories (Professor David Simchi-Levi, MIT) – New Business Models, Operational Efficiency and Customized Offerings.

- *New Business Models* – New technologies can introduce new business models and sometimes also disrupt the value chain. Rolls-Royce implemented sensors and used big data analytics to provide monitoring capabilities and spot problems before they occur thus improving safety and performance. Customers were offered to monitor their engines and were charged based on usage time, thus changing from a fixed cost to a variable cost service based model. Rolls-Royce handles repair, maintenance and replacement responsibilities. As a result service revenue accounted for 70% of the civil-aircraft engine division's annual revenue. Uber, Netflix, Airbnb are examples of disruptions in business models using technology.

- *Operational Efficiency-* New technologies are improving operational efficiency by building capabilities such as predictive maintenance, automation, dashboards, better supply chain visibility, asset monitoring and helping in faster decision making. Big data analytics enabled Rolls Royce to predict future failures of components between 10 to 15 days before failure would occur. The company could cut cost and downtime by 90 to 99 % relative to fixing problems after they occur. Airlines, utilities, freight shipping companies are using IoT to improve fuel efficiency and drive down overall fuel costs. Amazon Robotics (formerly Kiva Systems) is another example where use of robots and data analytics helps in operational efficiency.

- *Customized offerings* – The third category is the capability to offer customized services and experiences to customers. New technologies help companies learn about their customers and receive real time feedback. This helps companies improve marketing efforts and tweak campaigns real time based on behavior of targeted customer. Amazon, Netflix, Spotify offer customized recommendations based on their past behavior.

1.4: Primary Research Objectives

Technology in itself cannot achieve results if not implemented correctly. According to a 2015 report released by McKinsey, only 48% of the 300 manufacturing leaders surveyed consider themselves ready for Industry 4.0. Implementation of Industry 4.0 technologies for majority of organizations would involve an extensive transformation process that cannot be attained in a short period. Such changes not only involve the company but a lot of times they impact other stakeholders in the value chain. It is a company wide transformation process involving considerable amount of time and investments and hence it requires top management to understand its importance and have the right strategy in place for its adoption.

It is still early stage for Industry 4.0 technologies and the objectives of this research are two fold. The first objective is to explore the use and application of current Industry 4.0 in various industries such as manufacturing, utilities, automotive, high tech. This analysis will help in deriving key insights about impacts of adoption of the technologies involved. Second objective is to propose a conceptual framework for adoption of Industry 4.0. To attain the objectives mentioned above, we will use insights from interviews with companies conducted by MIT and PricewaterhouseCoopers, industry case studies and extensive literature review.

Chapter 2: Technologies of Industry 4.0

2.1 Industry 4.0 environment:

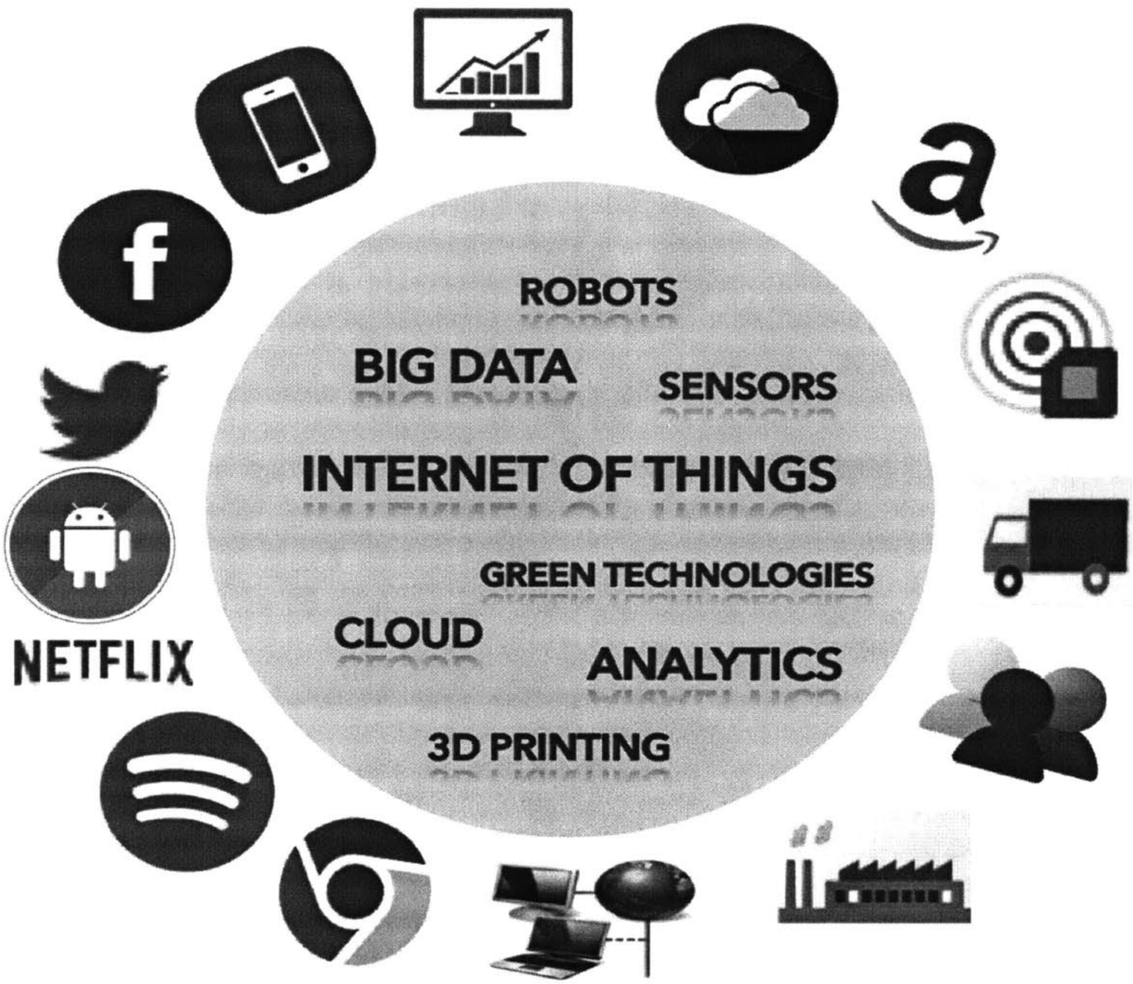


Figure 3: Industry 4.0 Environment

In an Industrial 4.0 environment, automation, operational efficiency, new business models, predictive maintenance, more efficient supply chains, and better network visibility will characterize business functions in various industries. More and more products will become connected and intelligent and in turn help add value at different nodes of processes and operations. Following sections explores various technologies of Industry 4.0 and their capabilities.

2.2 Technologies of Industry 4.0

2.2.1 Internet of Things

Definition: Internet of Things can be defined as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies(International Telecommunication Union, 2012).

The numbers of objects that are connected to the Internet are increasing and the world is moving towards a more connected future. There have been several predictions about the number of connected devices - Cisco predicted that about 50 billion devices would be connected by 2020, which are twice as many devices predicted by Gartner.

Table 1: Internet of Things Units Installed Base by Category

Category	2013	2014	2015	2020

Automotive	96.0	189.6	372.3	3,511.1
Consumer	1,842.1	2,244.5	2.874.9	13,172.5
Generic Business	395.2	479.4	623.9	5,158.6
Vertical Business	698.7	836.5	1,009.4	3,164.4
Grand Total	**3,032.0**	**3,750.0**	**4,880.6**	**25,006.6**

Source: Gartner (November 2014)

A report from McKinsey Global Institute report predicts that linking of the physical and digital worlds has the potential to generate $11.1 trillion a year in economic value by the year 2025. To analyze application and impact of IoT in various industries, we researched industry case studies from leading IoT providers. Some of the case studies and key findings are discussed in detail in the subsequent chapters.

2.2.2 Big Data

Definition: Big data is a broad term for a large volume of data – both structured and unstructured generated on a day-to-day basis in a business. Big data can be captured and analyzed to gain insights to make strategic and intelligent decisions to add value to business. Gartner analyst Douglas Laney introduced the 3Vs concept – Volume, Velocity and Variety.

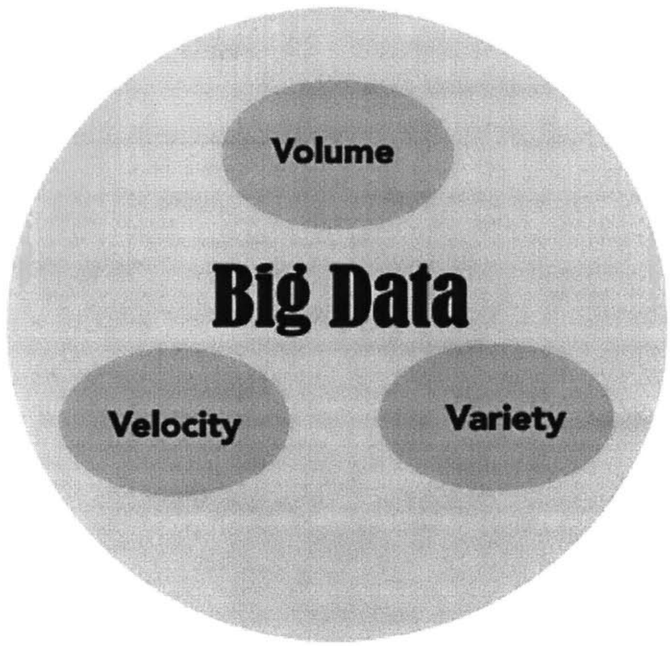
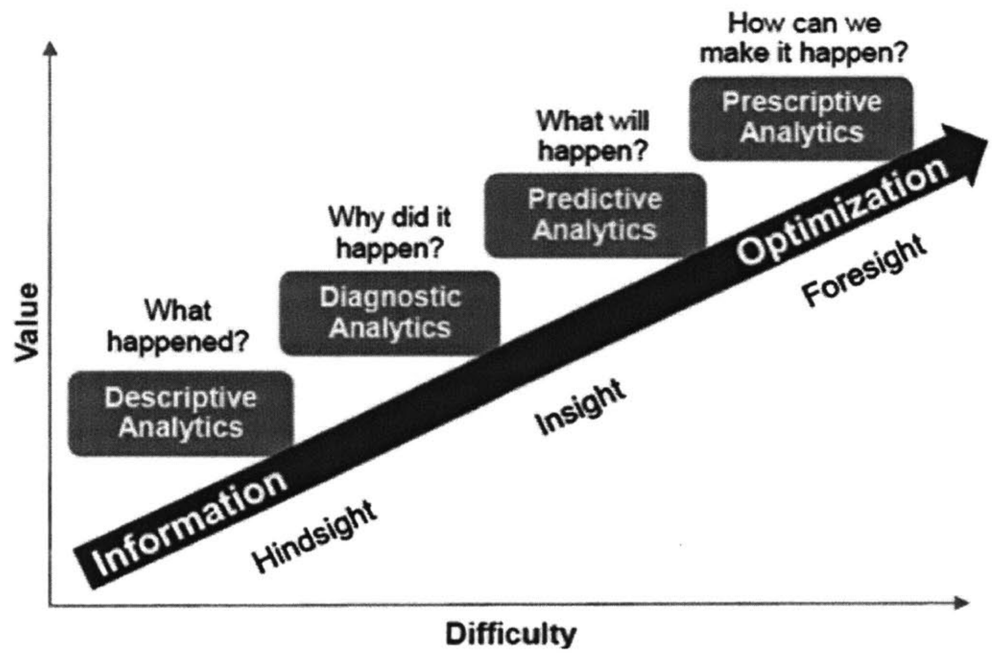


Figure 4: Big Data – 3Vs

With the increase of connected objects the amounts of data produced are increasing. Huge volumes of data are created from various sources like sensors in machines (e.g. manufacturing plants, turbines in power plants, tractors used in agriculture), wearable devices (e.g. Fitbit, Jawbone), social media (e.g. Facebook, Twitter), e-commerce sites (e.g. Amazon, eBay), Video on Demand services (e.g. Hulu, Netflix), music streaming services to name a few. Companies are gaining valuable insights by synthesizing and analyzing these data, which help them add more value to their business in various ways such as improving sales and marketing functions through customer insights, preventive maintenance etc.

2.2.3 Analytics

Definition: Analytics can be defined as the method of uncovering and identifying meaningful trends and patterns in data. Analytics involves application of statistical methods, programming and operation research[3] and often supported by data visualization to present findings.



Source: Gartner

Figure 5: Four stages of Analytics

Descriptive analytics: This is analytics that use data mining techniques on historical data to provide information and insights into what happened in the past. Descriptive analytics is widely used in various industries in the form of dashboards,

[3] https://en.wikipedia.org/wiki/Analytics

graphs etc. to provide information to different stakeholders. For example, in a warehouse management system application such a dashboard can have historical and real-time inventory data located in different parts of the warehouse as well as the supply chain, combined with other metrics to help decision making for warehouse operations.

Diagnostic analytics: This is a form of advance analytics, which examines data or content to answer the question "Why did it happen?" and is characterized by techniques such as drill-down, data discovery, data mining and correlations (Gartner). This type of analytics will be used to determine the root cause of an event. If in the warehouse example, if there is a particular inventory update error occurring at random occasions, the type of analytics used to determine it the root cause of the error is diagnostic in nature.

Predictive analytics: Predictive analytics is the use of data, statistical algorithms and machine-learning techniques to identify the likelihood of future outcomes based on historical data (SAS). This type of analytics goes beyond descriptive and diagnostic analytics to provide the best assessment of when an event will occur again. This type of analytics has been applied in manufacturing to predict a failure before it occurs and fix in advance.

Prescriptive analytics: This is the final phase of analytics that goes beyond descriptive, diagnostic and predictive analytics to provide information, which would assist in better decision-making. This is characterized by techniques such as graph analysis, simulation, complex event processing, neural networks, recommendation engines, heuristics, and machine learning (SAS). E-commerce sites such as eBay, Rue La la and airline sites use such analytics for dynamic pricing.

Internet of Things, Big Data and Analytics are interconnected. Sensor data from IoT has no value if analytics is not applied to data to derive meaningful insights. Increase in number of connected objects will also drive big data analytics adoption.

INTERNET OF THINGS NEEDS BIG DATA ANALYTICS

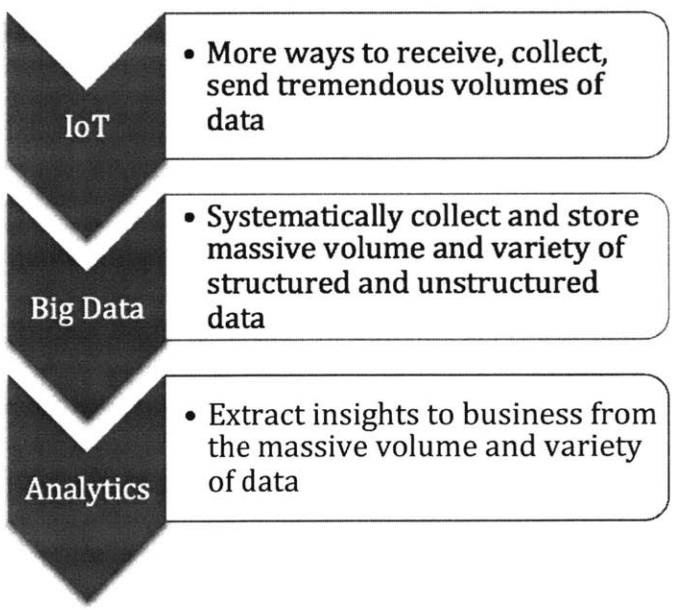


Figure 6: IoT and Big Data Analytics

2.2.4 3D Printing

Definition: 3D printing also known as additive manufacturing refers to the various processes of manufacturing three-dimensional solid objects from a digital file. In additive process an object is built by depositing layers[4] of material successively until the entire object is manufactured[5].

3D printing can be used to combine parts and also create intricate parts with better quality. This technology is already used in numerous industries such as in manufacturing healthcare devices, aerospace and defense, dental devices, consumer electronics, jewelries etc. According to Harvard Business Review, 3-D printing application has gone beyond basic prototyping, rapid tooling, toys(D'Aveni, 2015). Business executives should realize the potential impacts this technology can have on their businesses. The cost of 3D printers has decreased dramatically, the machines that used to cost $20,000 in around 2010 now costs less than $1,000(Bilton, 2015). These developments and capabilities of the 3D-Printing technology call for organizations to evaluate their manufacturing and operations and explore if processes can be optimized through application of this technology.

[4] *http://www.eos.info/additive_manufacturing/for_technology_interested*

[5] *http://3dprinting.com/what-is-3d-printing/#whatitis*

2.2.5 Robots

Robots have been in use for a long time in various forms. Ever since the first Industrial Revolution factories used industrial robots in the form of machines capable of performing tasks in production floor without or with little need of human assistance. Today robots, which are far more sophisticated and powered by software and artificial intelligence, are beginning to replace labor work in various industries such as military, medical and surgery, manufacturing processes like welding, assembly, material handling equipment etc. Amazon's warehouses rely heavily on Kiva System's (now Amazon Robotics) AI powered robots for their operations. As robots will continue to get more sophisticated with new capabilities, their costs will also reduce and will see more applications in future. According to BCG, worldwide spending on robotics is expected to reach 67 billion dollars by 2025.

2.2.6 Augmented Reality

(Note: Virtual Reality is beyond the scope of this research)

Definition: An Augmented Reality system supplements the real world with virtual (computer-generated) objects that appear to coexist in the same space as the real world. It consists of following properties(Wu & Tanphaichitr, 2002):

- Combines real and virtual objects in a real environment;
- Runs interactively, and in real time; and
- Registers (aligns) real and virtual objects with each other.

In manufacturing sector, Augmented Reality (AR) has been implemented in warehouse operations for picking operations. Pickers use AR equipped headsets which displays information such inventory locations and other SKU details necessary to perform picking operation. This increases accuracy and bringing down error rates and it is convenient for pickers to perform operation with both hands free. AR systems also have applications in assembly lines and factory floors.

In the following chapter we explore few of the case studies that we researched which involves above mentioned technologies.

Chapter 3: Industry Case Studies

3.1 Introduction

We researched and analyzed many industry case studies involving technologies of Industry 4.0 environment such as Big Data Analytics, Internet of Things, 3D printing and Robots. Below sections provides summary of few selected case studies with an analysis of their benefits and impact.

3.2 Two Main Outcomes

The objective of this exercise of researching industry case studies is to understand the impact of implementation of these technologies. During our research it emerged that adoption of Industry 4.0 technologies resulted in outcomes that can be grouped into two main categories:

- Growth Impact
- Productivity Impact

Growth Impact – Organizations were able to grow by generating more revenue through introduction of new business models, new customer acquisitions, new revenue streams, better/dynamic pricing etc. They were able to build new capabilities through adoption of technologies, capabilities that would facilitate such growth.

Productivity Impact – On the other hand organizations could improve productivity by cutting cost and attain better operational efficiencies and asset utilization by achieving automation capabilities, data availability/visibility, predictive maintenance, higher product yield, waste reduction, improved safety, better forecasting among many others. This results in better utilization of resources and assets thus leading to better productivity.

3.2.1 Case Study 1: Manufacturing at Intel – Predictive Maintenance

Source: Intel

Industry: Manufacturing

Business Challenge:

This case study is about application of Internet of Things and Big Data Analytics to one of Intel's manufacturing facilities to show how these technologies helped bring operational efficiencies and cost savings to manufacturing processes. Sensors and factory equipment generated huge sets of varied data types –

- *Structured data* such as manufacturing data stored in relational databases, and data from manufacturing execution systems and enterprise systems.

- *Unstructured data* such as images, texts, machine log files, human-operator-generated shift reports etc.

Table 2: Data size examples:

DATA TYPE	DATA SIZE (per week)
Machine parameters and error logs	~5 GB per machine
Machine events	~10 GB per machine
Defect images from vision equipment	~50MB per unit or 750 GB per lot

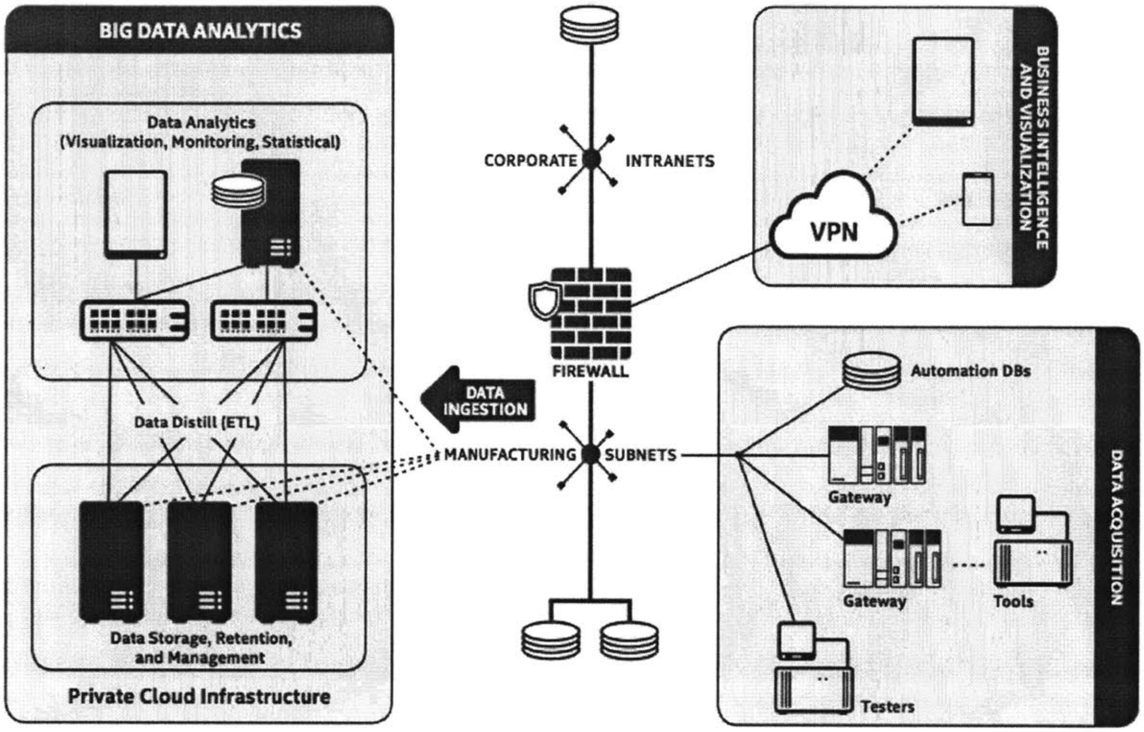
Source: Intel

These massive data files limited the ability to store and analyze the data using conventional methods. There lay a big opportunity to extract business value from these large sets of data that was getting generated from Intel's manufacturing plant.

Solution:

Intel implemented IoT and Big Data analytics in its manufacturing facility with industry collaboration from Cloudera, Mitsubishi Electric, Dell and Revolution Analytics. A high-level architecture of building blocks for end-to-end infrastructure enabling manufacturing intelligence from factory floor to data center is shown in Figure 7. With the use of these big data technologies, it was possible to gather and manage huge sets of data from manufacturing shop floor and the manufacturing network. By running analytics on these data sets, Intel was able to gather meaningful insights and present data using visualization platform to assist in decision-making and operational efficiencies.

Addressing the challenge: IoT pilot using big data analytics server and IoT gateway in Intel manufacturing



Source: Intel

Figure 7: High level Architecture of IoT implementation

Benefits:

- *Predictive maintenance:* Analytics capability predicted up to 90% of potential failures in a particular use case. By replacing machine parts before they fail, Intel was able to reduce non-genuine production yield loss and sudden equipment downtime, which resulted in higher efficiency in production.

- *Automation:* Using image analytics Intel was able to inspect units that were screened as marginal units and segregate the ones that had to be rejected. This method identified defects roughly 10 times faster than manual method.

Impact:

Use of IoT and big data analytics in such use cases, which leads to automation and predictive maintenance as in the above mentioned case, results in cost savings and *productivity improvement.* In this specific case, Intel was able to improve operational efficiency through predictive maintenance, avoid equipment downtime, reduce manual work and provide remote and easy access to data via visualization tools. This led to cost reduction in their manufacturing facility. According to the report, this IoT big data analytics project was forecasted to save millions of dollars annually along with additional return on investment business value.

Case Studies 2-5 are referred from Real Time Research & SAP.

3.2.2 Case Study 2: Adobe Systems- Targeted Marketing

Company: Adobe Systems is a publisher of desktop publishing and graphics editing programs and other wide array creativity and marketing software products.

Industry: High tech

Business challenge:

Analytics teams and data were fragmented across the company. Different groups produced different numbers and because executives relied on IT to retrieve data, on-demand analytics and number crunching was not possible as a result slowing down decision making. Aggregating structured and unstructured data from multiple sources was a challenge. Access to real-time data to respond to customer activity was another challenge. Time delay can be a huge disadvantage for a cloud-based business with subscription based model where access to customer's second-by-second activity can provide valuable insights.

Solution:

Adobe implemented fully integrated and real-time customer profiles across channels. Adobe implemented predictive analytics and data visualization tools to anticipate customer needs and develop more personalized programs.

Benefits:

- *Faster decision making-* Adobe was able quickly analyze customer acquisition and usage patterns to tweak promotions immediately to improve results.
- *Customized offering* – By having faster access to aggregated customer data from multiple sources, Adobe was able to provide more personalized customer interactions as opposed to a generic interaction.

Impact:

Offering personalized customer interactions and tweaking promotions when needed can improve customer retention and customer acquisition. This will in turn impact revenue, we categorize this impact as *growth*.

3.2.3 Case Study 3: Alliander (2013) - Predicting fluctuating energy demand

Company: Alliander is a regional grid operator for gas and electricity in Netherlands.

Industry: Power and Utilities

Business Challenge:

With the increase in the number of energy hungry devices such as plug-in electric vehicles (PEVs) every year, it became critical for Alliander to be able to forecast peak load and unusual demand quickly and accurately. Inability to do so could lead to customer demand not being met on time, which could result in higher operating costs and network outages that would leave customers angry and dissatisfied.

Solution:

Alliander expanded network to 22,000 sensors spread across 400 substations and set up wireless mobile telecommunications network. The company used analytics capabilities to draw insights from massive amounts of data that was generated and make data driven decisions.

Benefits:

- Improved customer relationships
- More accurate forecast of energy demand
- Automation of manual tasks
- Improved auditing and reduced energy costs for customers

Impact:

Benefits listed above would result in cost savings through better operational efficiency. Better customer relationships would lead to customer retention and hence help grow revenue. This will result in both improved *productivity* and *growth*.

3.2.4 Case Study 4: ARI - Improving operational efficiency

Company: A fleet management services company

Industry: Automotive

Business Challenge:

ARI's data volumes were doubling every 14 months, every vehicle collected 14,000 data points. This increase in data volume also increased the time it took to run reports and queries. Managers needed real-time data to make faster decision and improve efficiency.

Solution:

ARI used big data and analytics to integrate data from disparate systems and provide faster access to data so that insights can be drawn for faster decision making. Faster access to data and reports helped better customer service. In the future ARI planned to use big data analytics for predictive maintenance i.e. recommend a repair before failure occurs, discover hidden trends, for eg: discover link between fueling locations and accidents.

Benefits:

- *Automation*- when customers needed more granular data, it involved a lot of manual work, after technology implementation they were able to reduce manual work and also improve transaction time by a little more than five percent

- *Trend spotting*- Real time access to data helped to draw correlations and spot trends better

- *Customer Service*- A majority of ARI's employees use the system daily, which helped them make faster decision making. Select customers run their own queries using the customer portal empowering them to make better decisions.

Impact Analysis:

The impact of technology adoption in ARI's case clearly falls under *productivity* improvement through automation and easier access to data.

3.2.5 Case Study 5: ConAgra- Better pricing and supplier relationships

Company: ConAgra is an American packaged food company. The company makes and sells food[6] under various brand names such as Healthy Choice, Marie Callender's, among others.

Industry: Food processing

Business Challenge:

The challenge that ConAgra was facing was to figure out the optimal pricing for its products in an environment where consumers are hypersensitive, while coping with the ever- fluctuating costs for 4,000 raw materials used in some 20,000 products. ConAgra needed access to variety of data and analytics capabilities to gain meaningful insights into customers and make faster decision-making.

Solution:

ConAgra implemented big data analytics to speed data analysis, gather new sources of data about customer behavior and share data driven insights with retailers.

[6] https://en.wikipedia.org/wiki/ConAgra_Foods

Benefits:

- *Faster decision making through real time data* – ConAgra was able to speed collection of data related to commodities purchases from 9 hrs to 20 minutes and to reduce its month-end forecasting process by three days.

- *Insights from new sources of data, respond to consumer needs and stronger ties with retailers*- The company uses more types of data than it did before; it gathered shopper specific data that it gets directly from retailers. Insights from such customer data helped better product merchandizing. For example, people who bought one type of single-serving frozen food tended to buy several other single-serving varieties at the same time. As a result of this insight, ConAgra suggested that retailers group the packages with smaller portions together, instead of stocking single-serve pizzas with family-size pizzas. This in turn also strengthened ties with its retailers by making recommendations that would improve their operations.
- *Pricing decisions and better merchandizing*- Using external data, such as consumer data provided by retailers, delivers real-time insight into how to merchandize products more effectively and increase margins.

Impact Analysis: All of the benefits listed above will have impact on revenue and hence *growth.*

3.2.6 Case Study 6: Israel Electric Corporation-Improving Safety

Source: IBM, 2013

Company: Israel Electric Corporation (IEC) generates 95 percent of Israel's electricity.

Industry: Utility

Business Challenge:

IEC had to meet the needs of 2.5 million consumers in an era when Israel's demand for electricity was growing at more than three percent per year. It was needed that IEC keep its 17 power stations online and operating efficiently at all times.

Solution:

The company used big data and analytics to gain meaningful insights from data collected from sensors located in their complex machines. These sensors collected huge amounts of data – in one case their control system collected 500 data-points from analog sensors, and another 700 from digital sensors. Such data was mined to perform predictive maintenance.

Benefits:

- *Cost savings*- The need to restart turbines after an outage was an expensive process. By predicting and fixing a problem before an outage occurred avoided the need of such restarting of turbines. By doing this IEC estimated to reduce costs by up to 20 percent. IEC also saved approximately USD 75,000 in fuel costs per turbine by identifying inefficient fuel usage.

- Efficiency- IEC increased the efficiency of maintenance schedules, costs and resources, resulting in fewer outages and higher customer satisfaction.

- Preventive maintenance - Provides early warning of certain types of failure up to 30 hours before they occur, instead of 30 minutes.

- Improved safety- Since IEC was able to predict a major failure 30 hours in advance instead of 30 minutes, they had much more time to intervene and make sure that all their employees were out of harm's way.

Impact Analysis: The benefits mentioned above would result in improved *productivity*.

3.2.7 Case study 7: JCB India-New Business Model

Source:(IDC Manufacturing Insights, 2015)

Company: JCB India is a leader in earthmoving and construction equipment manufacturing in India.

Business Challenge:

JCB had a requirement to keep its customers informed of status of their machines at all times. JCB needed to gather vital parameters of machine performance and its exact location at all times.

Solution:

JCB India implemented IoT as an end-to-end application by involving several vendors to take care of different functions such as communications, map services, cloud based platform among others. Customers we able to monitor equipment usage, status and health, fuel consumption and idle time. Customers would receive alerts if machine went outside the defined boundary of operation.

Benefits:

- Enhanced customer experience- At the beginning of 2015, the platform handled 60,000 transactions per day for a fleet of 1,300 machines, with plans to add 2,000 new machines each month. The Company was able to provide prompt service to its customers – to ensure all issues be resolved within 72 hours of reporting.

- New business model – They launched IoT program known as "LiveLink" as a value-added-service along with the machine. They could implement product-as-a-service model with no revenue leakage.

Impact:

JCB India was able to introduce new business models by allowing customers to remotely monitor their machines. This avoided any revenue leakage. We categorize this impact as *growth*.

3.2.8 Case Studies- 3D Printing

Several case studies from leading 3D Printing companies such as Stratasys Ltd., Materialise NV, ExOne etc. were analyzed. In the table below we grouped the benefits that were mentioned in the case studies we researched. It is evident from the benefits mentioned in the table that their resulting impacts fall under the same two categories mentioned earlier in this chapter, *growth* and *productivity.*

Table 3: 3D Printing Benefits Grouping

Common Benefits	**How benefits were realized**
Flexibility-design & manufacturing process	Dramatic time and cost savings allow more flexibility to make fast adjustments throughout design cycles
	Capable of geometric complexity otherwise

	unachievable through conventional methods
	Parts manufactured in house instead of service bureaus
	Removes human error
	Less tools required/ Tool less
Saves time	Reduced product design cycle time
	Reduced testing time
	Automated- printer can work unattended
	Inhouse Vs outside supplier
	Frees up other machines (CNC m/c) that would otherwise be doing the job for longer
	Reduced lead time
Saves Cost	Reduced prototyping cost
	In house Vs outside supplier
	Reduced scrap rate
	Cuts tooling cost
Quality	Intricate shapes can be obtained
	Fine details and high accuracy can be achieved
	Cost effective and high quality prototype in early stages of design cycle
	Can be printed for added strength that is not achievable by traditional manufacturing
Time to market	Shorter concept and proof of concept phases

	Streamline prototyping process
	Reduced testing time and others mentioned under "time"
Customer communication	Prototypes easier to understand by customers-enables customer and company to agree more quickly on design changes avoiding any misunderstandings

Chapter 4: Mapping Technology Benefits & Impact

4.1 Introduction:

In order to gain a better understanding of benefits of Industry 4.0 technologies and how these benefits impacted organizations, several case studies involving these technologies such as IoT, Big Data Analytics, 3D printing among others were researched. It was observed that irrespective of the technologies deployed, benefits and impact could be grouped into few common categories.

4.2 Methodology

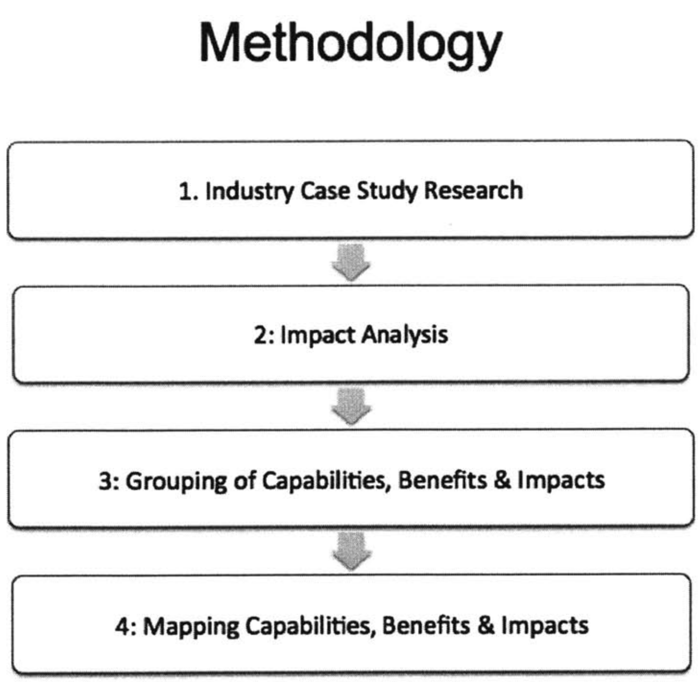


Figure 8: Methodology – Benefits and Impacts Map

4.3 Two Main Impacts - Growth & Productivity

To develop our impact mapping framework we consider the final objective of adoption of technologies in Industry 4.0 environment as increasing shareholder value. Shareholder value can be maximized in various ways. In this context we consider *Growth* and *Productivity* as two factors among many that creates shareholder value.

Figure below represents the basic building block of our mapping framework.

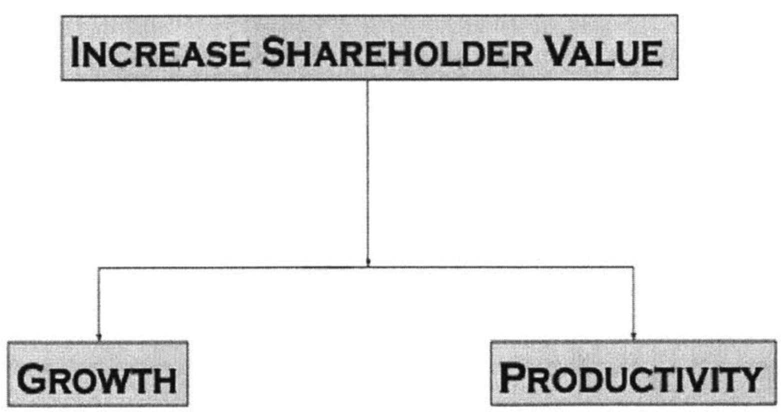


Figure 9: Growth & Productivity approach

Productivity: We define productivity as improvement of performance in any function that involves cost cutting achieved through operational efficiency and asset monitoring.

Growth: By growth we refer to growth achieved through increase in revenue.

Revenue: We categorize revenue into revenue generated from existing streams and revenue generated from new streams, for example introduction of new business models and products.

Cost: We categorize costs into fixed and variable.

Fixed costs are those costs that do not fluctuate with changes in production volume or sales and services; for example- rent, insurance, salary, equipment etc.

Variable costs involve costs that change when there is a change in production output or sales and services. Variable costs may involve hourly wages, raw materials etc.

4.4 Step 1: Industry Case Study Research

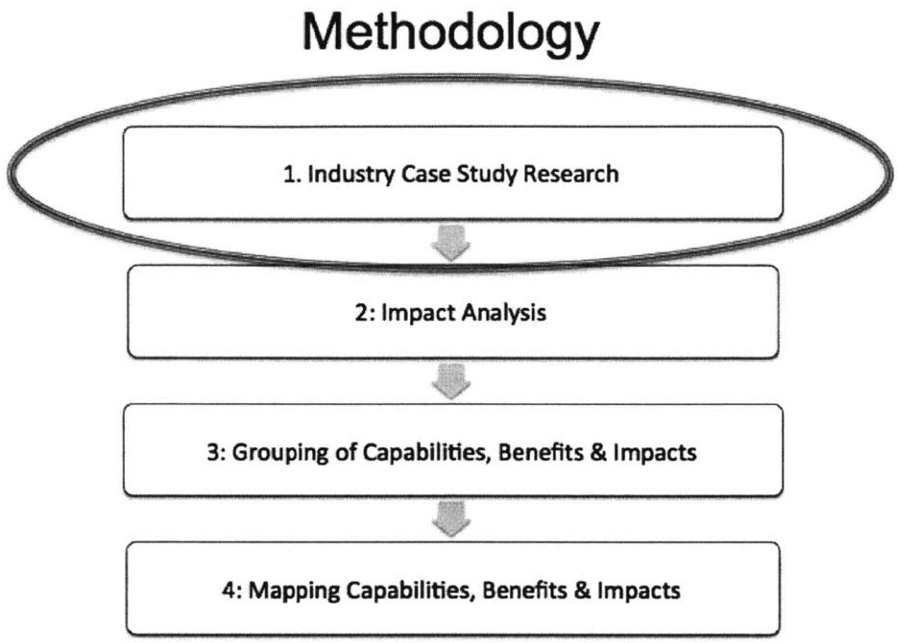


Figure 10: Step 1 - Industry Case Study Research

Researching case studies involving Industry 4.0 environment was our first step. Our objective was to understand how and why various technologies were adopted and their many benefits. Results of this research have been covered in detail in chapter 3. In our research we saw that in the various case studies, although the technologies used were different, the benefits and outcomes were similar. For example, implementing 3D printing and IoT in two different scenarios led to reducing time to market, similarly robots and IoT coupled with Big Data Analytics led to automation and operational efficiency. And finally impact of the benefits achieved through adoption of technologies could be categorized into two categories - growth impact and productivity impact.

4.5 Step 2: Impact Analysis

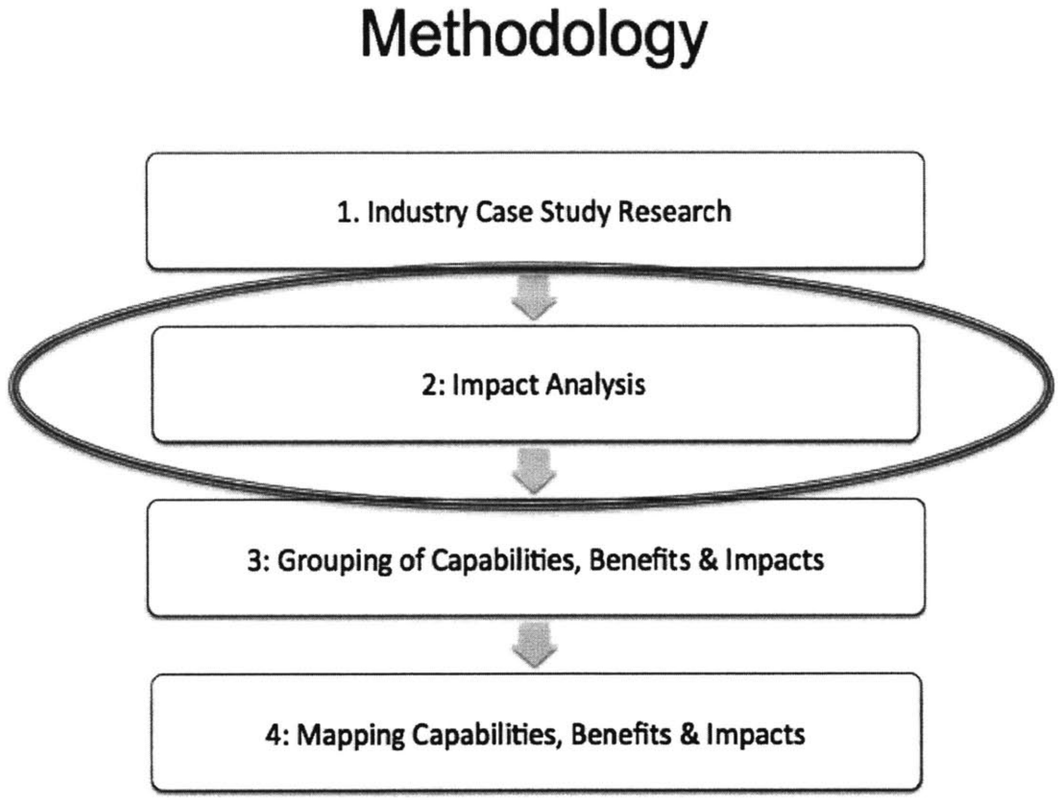


Figure 11: Step 2 - Impact Analysis

During our research we saw that revenue can be generated in various ways as a result of adoption of technologies. Examples of these include creation of new business models, offering customized service/experience to customers, improving targeted marketing that would impact sales and retention of existing customers. We categorize revenue impact into two categories

- *Existing Revenue Streams* – We define this as the impact on revenue streams that already exist in the organization. For example, in a supermarket or an online store data analytics can be used to gain better understanding of customer behavior and based on insights, actions such as changing layout of items, better pricing and recommendations, can be taken to improve sales.

- *New Revenue Streams* – This is the revenue generated from new revenue streams introduced as a result of technology adoption. For example, offering subscription model or pay-as-you-go model instead of one time lump sum payment to attract different segment of customers.

From our research on industry case studies we found that *Cost* can be reduced in various functions. We categorized them into fixed and variable costs–

- *Fixed Cost* – Examples of this type include cost reduction due to improvement in asset utilization as a result of asset monitoring capabilities, safety improvement as we saw in the case study about Israel Electric Corporation, better space utilization, workforce monitoring and employee utilization etc.

- *Variable Cost* – Examples of this are cost savings as a result of building capabilities like predictive maintenance which would help in reducing yield loss, equipment downtime in a manufacturing plant, fixing of customer issues remotely which will reduce travel cost, automation and reduction of testing times and other operational efficiencies achieved through technology adoption.

4.6 Step 3: Grouping of Capabilities, Benefits and Impacts

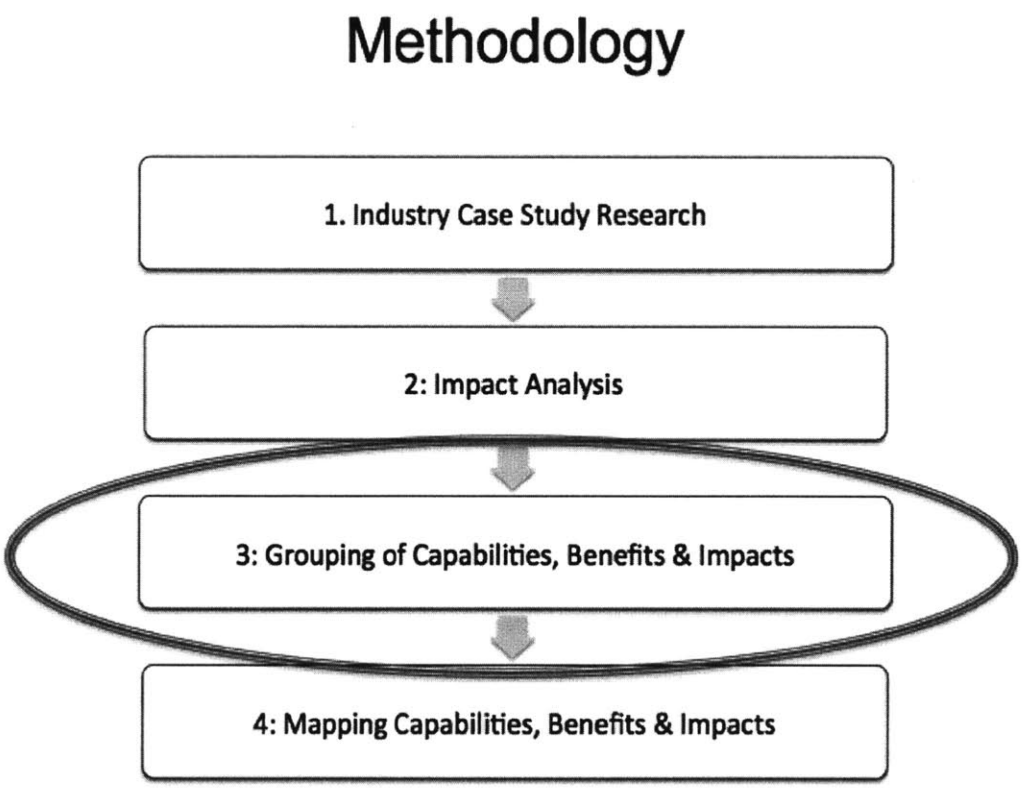


Figure 12: Step 3: Grouping of Capabilities, Benefits & Impacts

Before grouping the benefits and impacts of adoption of Industry 4.0 technologies, we define the three terminologies used - capability, benefit and impact. We will refer to the Intel Case that was mentioned in the previous chapter under section 3.2.1 while defining these terms.

Capability: We define capability as a feature that is added to a system or a process as a result of which particular function or task can be performed in a new improved fashion.

Example: In the Intel Case, few of the capabilities that were built through implementation of IoT and Big Data Analytics technologies are Preventive Maintenance and Automation.

Benefit: In this context, we define benefit as a desirable outcome of the capability that is built through technology adoption.

Example: In the Intel Case, the benefits that were achieved because of capabilities that were built. Capability "Preventive Maintenance" led predicting failure before it actually occurred and taking corrective measures in advance. This led to the "benefit" of reducing yield loss or sudden equipment downtime. Similarly by building "Automation" capabilities Intel was able to achieve the benefit of reducing testing time by 10x.

Impact: In this context, we define Impact as the effect on growth and productivity as a result of technology adoption. Growth is related to revenue impact and productivity is derived from cost impact.

Example: In the Intel Case, adoption of IoT and Big Data Analytics mainly resulted in improvement in operational efficiency. The impact here is *cost* as a result of cost savings through reduction of yield loss and reduced testing times.

Table 4: Capability, Benefit & Impact in Intel Case (refer section 3.2.1)

CAPABILITY	BENEFIT	IMPACT
Preventive Maintenance Automation	Reduced yield loss Avoid sudden equipment downtime Reduced testing times	Cost savings

Similarly capabilities, benefits and impacts in numerous case studies were analyzed. Figures below show examples of some common capabilities and benefits that were achieved through technology adoption and their corresponding impact of revenue and cost.

Table 5: Example - New Revenue Streams impact

CAPABILITY	BENEFIT	IMPACT
Remote process monitoring Remote access to machine data Real time updates Remote customer support	New business model innovation New products/ services New market/geo	New revenue streams

Table 6: Example - Existing Revenue Streams impact

CAPABILITY	BENEFIT	IMPACT
Dynamic pricing Targeted and customized marketing Automated customer assistance	Competitive pricing Empower sales and customer support Better sales Customized product/service Time to market	More revenue from existing revenue streams

Table 7: Example - Fixed Cost impact

CAPABILITY	BENEFIT	IMPACT
Asset monitoring Workforce utilization automation Prototyping of intricate designs Preventive maintenance Automation	Improved asset utilization Improved workforce utilization Utilities Safety Reduced design cycle time Quality/Accuracy Operational efficiency Prototyping cost	Fixed cost reduction

Table 8: Example - Variable Cost impact

CAPABILITY	BENEFIT	IMPACT
Preventive maintenance	Faster decision making	Variable cost reduction
Automation	Time to market	
Remote customer support	Efficiency	
Automated logistics planning	Quality	
Automation	Flexibility	
	Visibility	
	Reduced testing times	
	Avoid equipment downtime	

4.7 Step 4: Mapping Capabilities, Benefits & Impacts

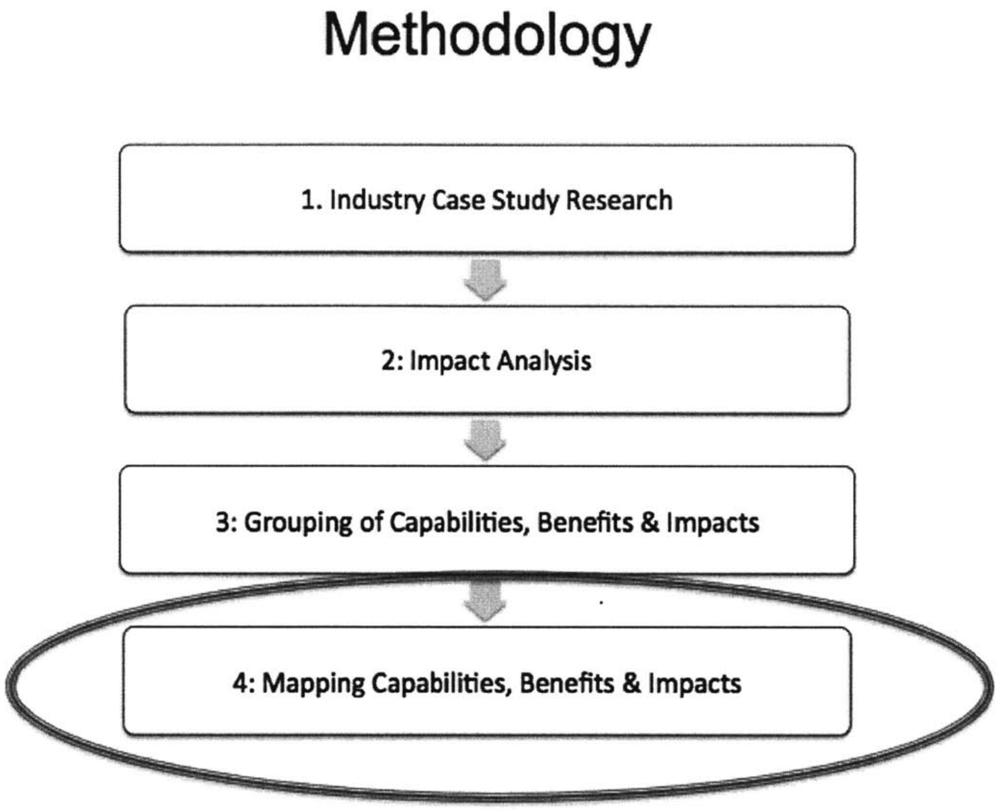


Figure 13: Step 4: Mapping Capabilities, Benefits & Impacts

In our final step of building a framework, we analyzed of capabilities, benefits and impacts described in the previous sections. The impact of the benefits are grouped into Growth and Productivity, which in turn helps in increasing shareholder value. Figures 14(a) represents a summary of the results of our research of industry case studies.

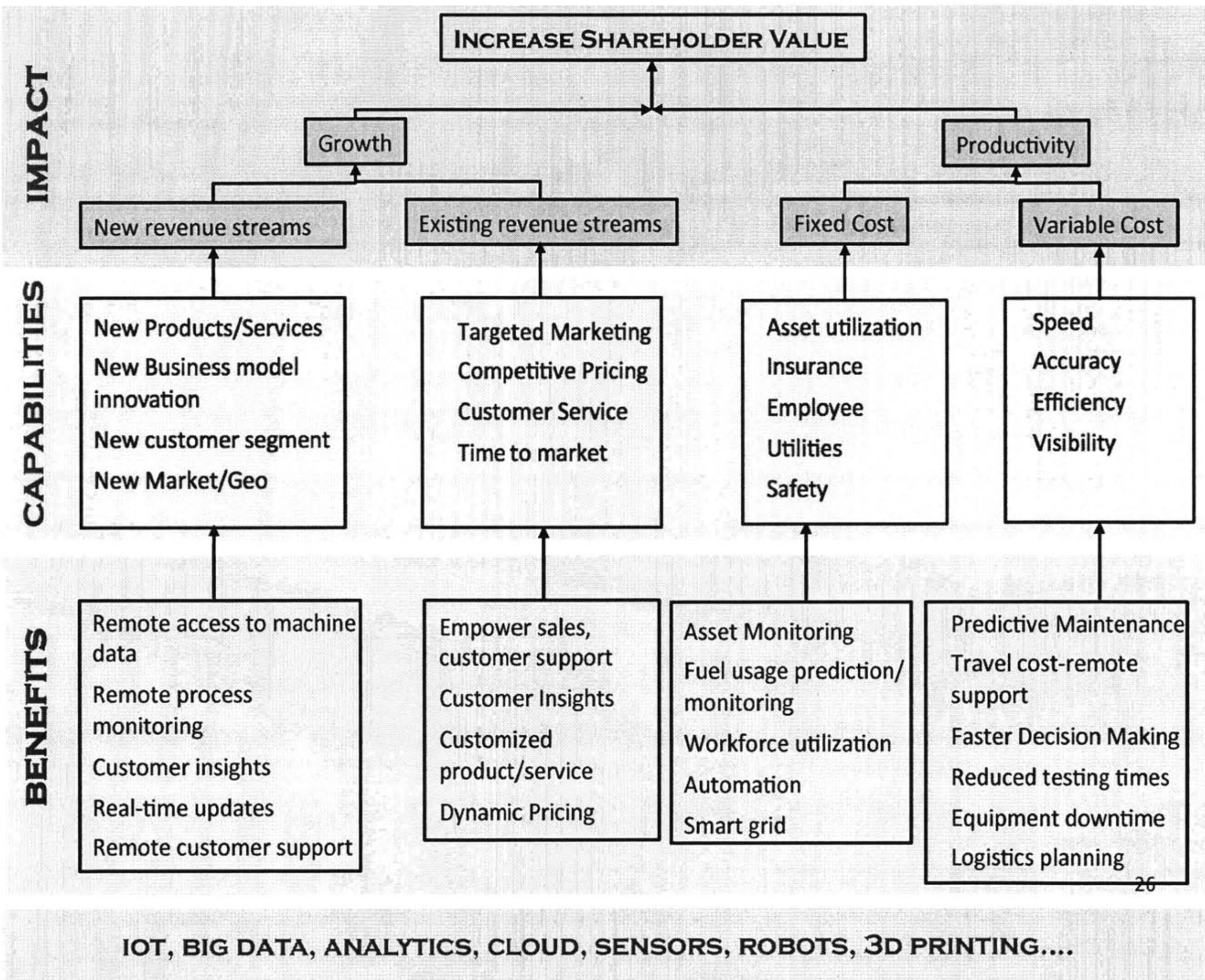


Figure 14(a): Benefit Impact Mapping Summary

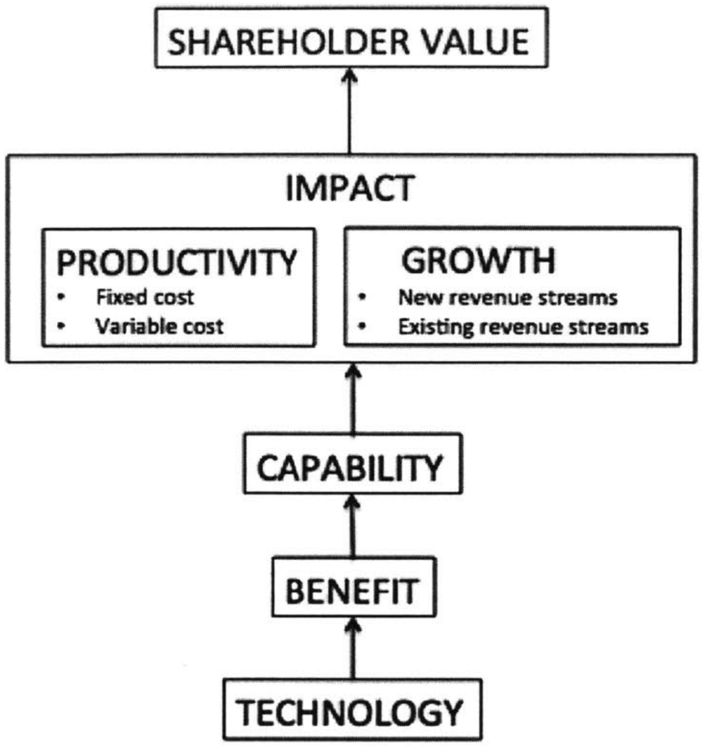


Figure 14(b): Benefit Impact Mapping Framework

4.8 Benefit Impact Mapping Framework & Model Building Block

The objective of this exercise is to understand how technologies can add value to the various business operations and functions in an organization. Figure 14(b) represents the final summary of our Benefit-Impact Mapping Framework.

Technology is just a tool or instrument to achieve larger goals and objectives. Organizations need to first decide what these objectives are. From discussions in this chapter we identified two such objectives that can be achieved through technology – growth and productivity. This is the first building block of our final model.

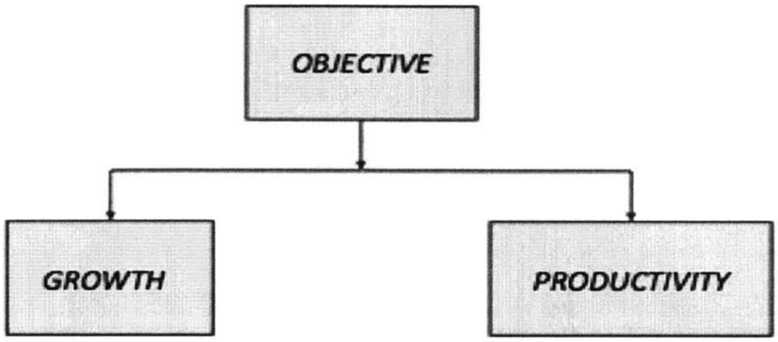


Figure 15: Model Building Block - Objective

Chapter 5: Technology and Value Chain Disruption

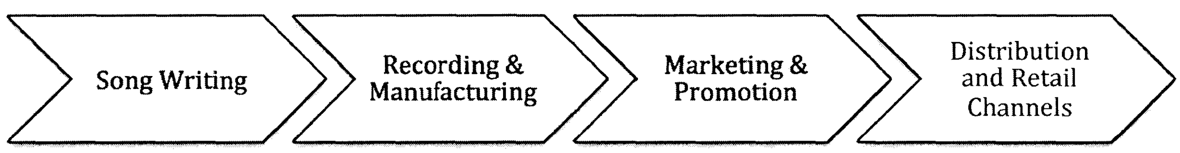
5.1 Introduction

Technologies in the digital age have impacted various industries massively sometimes even disrupting an entire value chain. Some of the recent examples of such disruptions are Uber disrupting the taxi industry, Airbnb challenging the Hotel industry and Netflix taking away business from cable companies. No other industry has been as frequently disrupted by new technologies as the Music Industry. In this chapter we will explore how the music industry has been transformed in the past few decades.

5.2 Value Chain Disruption Example – Music Industry

Technology has impacted every aspect of music starting from the way music is created to the way music is consumed. Internet technologies triggered the disruption in the Music Industry. With advancement of recording technologies musicians were able to record music at a much lower cost and sometimes even in their basement. Through digital platforms, musicians who are not backed by a record label, can now market their music at almost zero cost and reach an audience directly. The way consumers listen to music changed over the years from Vinyl Records, CDs and Albums to file sharing & download and to present day streaming and subscription services. This has hugely impacted revenue generated from recorded music and licensing. Because of the massive transformation the music industry has gone through due to the impacts of rapidly changing technologies, we picked this industry for our study.

5.2.1 Stakeholders in Music Industry



Source: Adapted from (Prof. Bruno Cassiman and Pablo F. Salvador, 2007)

Figure 16: Processes in Recorded Music

The figure above is a simplified representation of processes involved in creation to consumption of recorded music in the traditional music industry before digitization. There are many stakeholders involved in the processes that are involved in music creation and distribution. They are[7]:

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[7] *Stakeholders were identified from PwC paper by Prof. Bruno Cassiman and Pablo F. Salvador, 2007 and the book All You Need to Know About the Music Business by Donald S. Passman.*

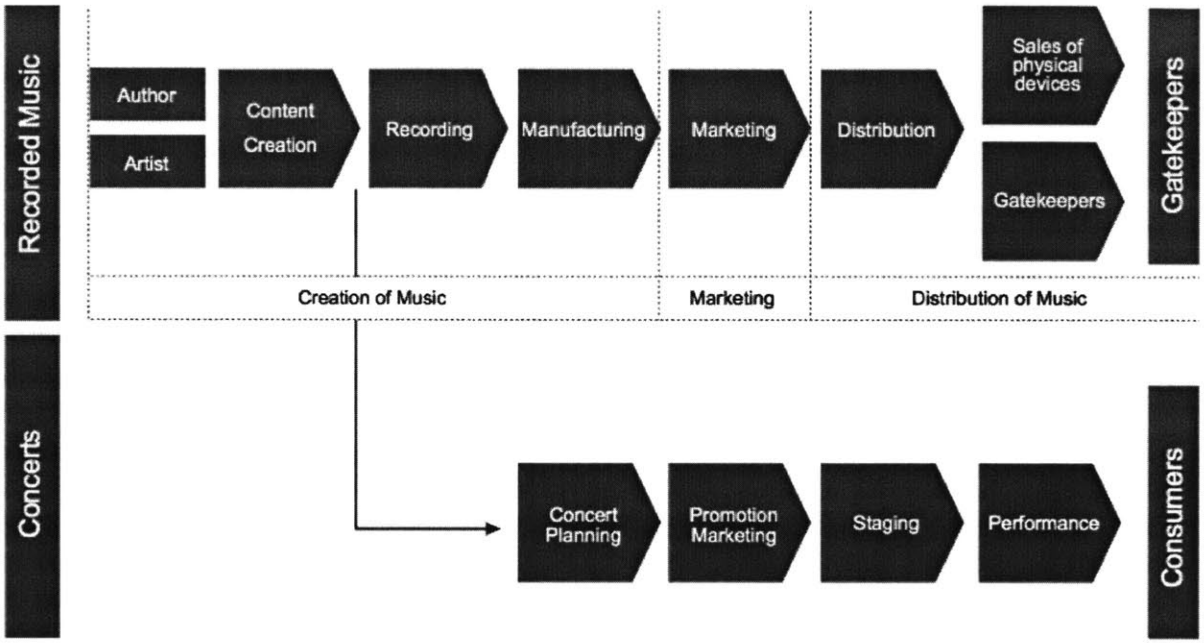
- *Artists* – Artists compromise of those who create music - songwriters, singers, instrumentalists etc.
- *Authors* – These are the people who create music without performing them.
- *Personal Managers* – These are the people who help the artist to expand his/her career and looks after almost every aspect artist management from music creation to business decisions.
- *Business Managers* - The business manager is the person who handles all the finances of the artist.
- *Attorneys* – They are the ones who structures deals, look over contracts, advise clients about the law and helps shaping artist's business lives.
- *Agents* – Music agents are the ones who book live personal appearances, concerts, commercials and other areas.
- *Musical ensembles* – They are the groups of musicians that meet to perform music.
- *Music Publisher or publishing houses* – They manage and administer author's copyright and promote the work of musicians.
- *Writers' copyright collectives and performance rights organizations* – they are responsible for collecting royalty payments.
- *Tour promoters*- Those who publicize and promotes tours
- *Music producers* – They are the talent scouts (A&R) who invests in artists.
- *Recording studios* – This is the facility equipped with everything necessary to record music.

- *Artistic producers* – They are in charge of completing and putting the final touch to a master recording.
- *Wholesalers* – They deliver music to retailers and final consumers.

In addition to stakeholders in traditional stakeholders, digital music industry has following stakeholders added to value chain-

- *Streaming services* – These comprises of providers like Spotify, Pandora etc.
- *Video streaming* - Examples are Vimeo, YouTube etc.
- *Social Media* – Social media is a huge platform for marketing and connecting with the audience.
- *Analytics services* – There are several analytics powered service that partner with record labels and streaming providers. Example – Next Big Sound, Audiokite etc.
- *Music search engines* – These are services that help listeners find music when they don't know the name of the artist or track. Example – SoundHound, Shazam etc.

5.2.2 Traditional Music Value Chain



Source: PwC Report - (Prof. Bruno Cassiman and Pablo F. Salvador, 2007)

Figure 17: Traditional Music Value Chain

The above figure shows the traditional value chain of the music industry. The music industry value chain can be divided into two categories (Libro Blanco de la Música en España, 2005- Retrieved from (Bruno, 2007)) –

- Recorded Music
- Live Music

The first phase of Recorded Music business is "Creation of Music"; in this phase authors and artists composes the music. Once this phase is completed, the recording process starts. This happens in a recording studio. Artists, producers, A&R,

technicians and other musicians are present in studio recording sessions. Marketing, strategy for creating a brand for the artist or album also starts simultaneously. After recording phase, manufacturing process starts. This phase involves manufacturing cover posters, CDs, Vinyl records etc. Marketing and promotion efforts for live music performance also start simultaneously. In the last phase, distribution of music involves logistics networks, retailers and wholesalers, chain stores etc. Apart from this, music publishing comprises of other streams through which revenue can be generated through royalties. This may involve collaborated advertisements with brands, TV shows, Movie scores etc.

5.2.3 Characteristics of Traditional Music Industry

Traditional Music Industry went through major transformation when digital music came into play. Some of the characteristics of traditional music value chain are –

***"Push" in nature*:**

Traditional Music Industry was "push" in nature and there weren't adequate means of learning about its consumers such as where consumers discovered their music, how a song became popular, what consumers are doing while listening to music, what other kinds of music a particular consumer listens to etc. Record labels will often decide on who would be the next big star. They would decide this on their gut and groom and package them to "push" them on to the listeners.

Role of Record Labels:

Prior to digital music, most record artists was hugely dependent on major record labels for music production, promotion, live shows, music publishing etc. Independent labels (often artist-owned) were not as popular as they are today.

Asset heavy

Prior to digitization music was consumed through physical Vinyl Records, Cassettes and CDs. The right supply chain strategy was very crucial. Contracts were drawn between labels and retailers on how much inventory had to be kept at stores and who would be liable if sales did not meet forecasts.

Revenue sources

Recorded music sales peaked in 1999 just when file sharing services (Napster et al.) started getting popular. Revenue has been on a decline ever since with the exception of 2012 when the industry saw slight growth in digital sales[8]. Revenue was driven by sale of CDs, which was proceeded by Cassettes and Vinyl Records.

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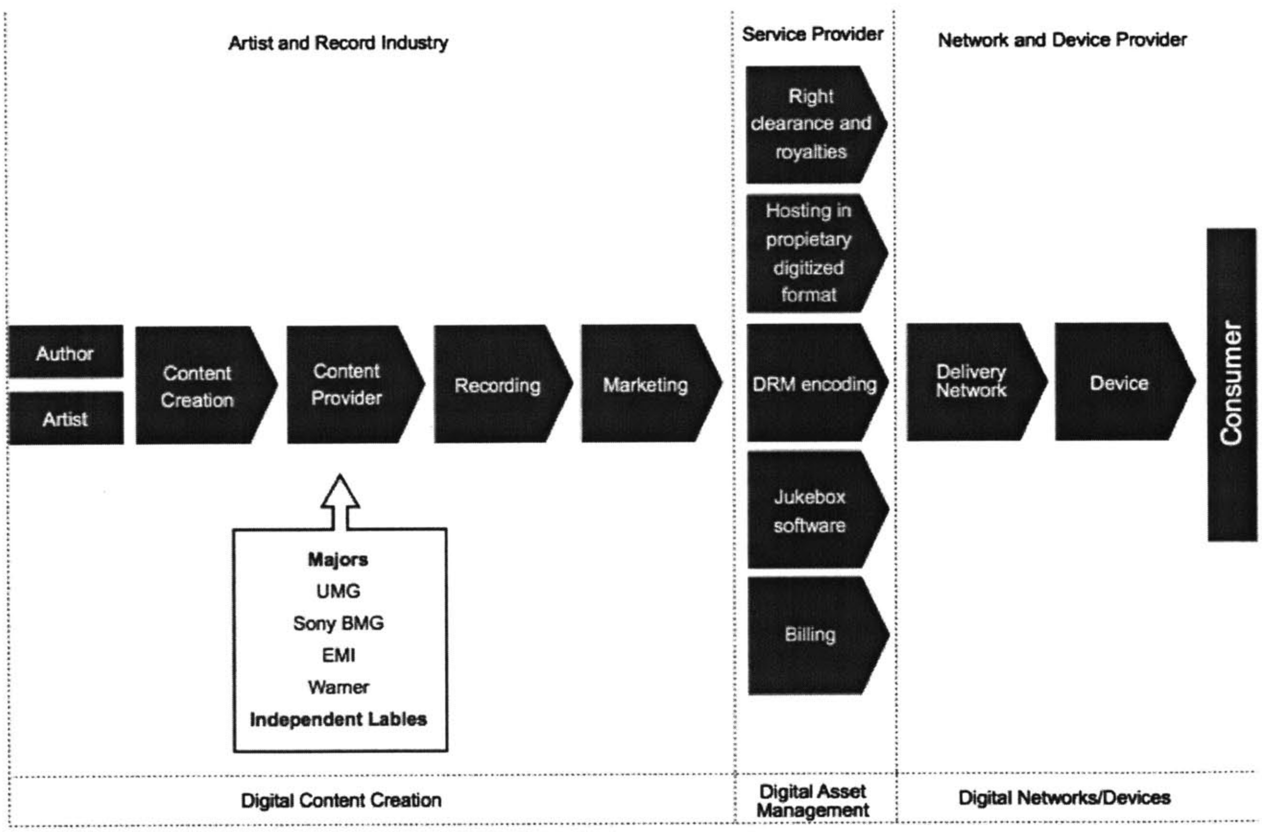
8 *http://www.billboard.com/biz/articles/news/digital-and-mobile/1549915/ifpi-digital-music-report-2013-global-recorded-music*

Marketing and Promotion

Marketing and promotion was mainly through radio, TV channels and other traditional methods. There was little avenue for artists to constantly connect to fans directly.

5.2.4 Digital Music Value Chain



Source: PwC Report - (Prof. Bruno Cassiman and Pablo F. Salvador, 2007)

Figure 18: Digital Music Value Chain

Digital music changed the way music is created, distributed and the way listeners consume music. It changed the traditional value chain and created new business models. It consists of following forms-

- Physical CD/ Vinyl record sales through online retailers
- Downloaded Music
- Streaming/Subscription services
- Illegal downloads and shared files

Prior to digitization, music revenue was driven by physical album sales. Rise of digital music sharing in the nineties also led to increase of piracy and illegal downloads. Napster was created in 1999 and it made music available for free. There existed lot of other such sites where users could download music for free. This led to declining sales in recorded music. Then came iTunes, which facilitated purchase of singles further reducing sales of full albums. Streaming services like Spotify, Pandora, Tidal, YouTube etc. are slowly replacing downloaded music.

5.3.5 Characteristics of Digital Music Industry

New platforms for music consumption

Technology has changed the way listeners consumes music. Listeners can listen to or watch music videos, on demand through their devices.

Moving away from asset heavy value chain

Before digitization Vinyl Records, Cassettes, CDs constituted the supply chain. Now the market is moving away from ownership of music and towards streaming. If we do not consider devices in which consumers are accessing their music (devices have other functions apart from playing music) the value chain is less asset heavy. Music can be directly released to listeners online skipping the logistics network. Although recently vinyl records have seen an upward trend it is still very small compared to streaming and digital sales.

New Business Models

New business models were created as a result. The two primary business models in digital music are:

- Pay-per-download model
- Subscription model

Subscription model may have ad supported models, limited ad models or ad free paid subscription.

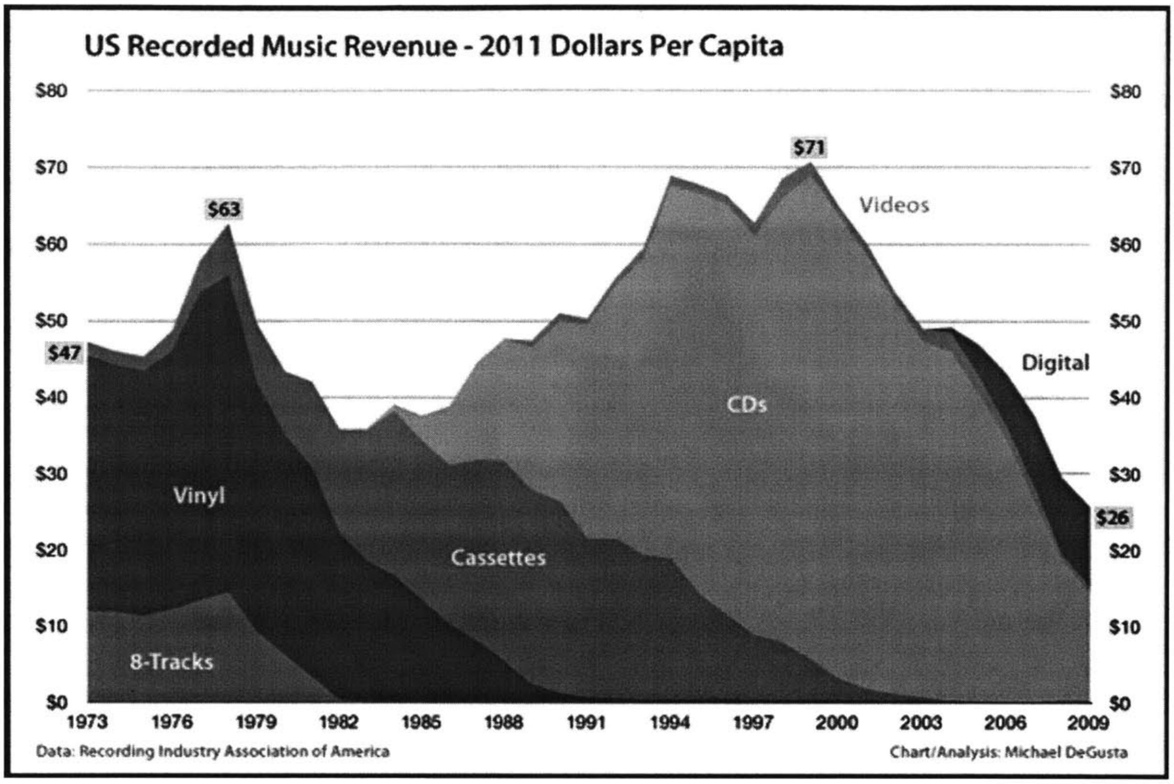


Figure 19: Revenue Plot of Music Industry[9]

Revenue loss to digital platforms

Music industry lost revenue to various legal and illegal digital platforms. Record labels' profit shrunk and consumed each other. Figure 19 shows revenue plot from 1973 – 2009, plot shows total revenue of US recorded music revenue has almost been on a continuous decline.

Many Record Labels merged

Digital music also saw falling of record labels and resurgence of independent labels. Table 8 below shows how the number of big players in the industry reduced with

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9 *Retrieved from http://www.businessinsider.com/these-charts-explain-the-real-death-of-the-music-industry-2011-2*

years. PolyGram got absorbed into Universal Music Group (UMG). Sony and BMG merged and later came to be known as Sony Music Entertainment (denoted by SME in the Table 8). Warner Music Group (WMG) also absorbed other labels such as Atlantic Records and Parlophone Records.

Table 8: Number of major Record Labels since 1988 - 2016[10]

1988–1999 (Big Six)	1999–2004 (Big Five)	2004–2012 (Big Four)	Post 2012 (Big Three)
WMG	WMG	UMG	UMG
EMI	EMI	Sony BMG	SME
Sony	Sony	WMG	WMG
BMG	BMG	EMI	
UMG	UMG		
Polygram			

Moving towards "Pull"

In today's age, musicians can directly reach an audience by simply uploading their music online on digital platforms. Such uploads have helped launch artists, who may not have the backing and resources provided by a label, reach and audience and again popularity. Sometimes such artists go "viral" and gain a considerable amount of online following that helps them get noticed by labels. Unlike before when labels used to risk launching a completely unknown artist, labels in digital age have the

[10] *Adapted from Wikipedia*

luxury of testing their artists first. Listeners are now picking their artists or in other words the industry is moving towards "pull" in nature.

New Strategy for labels -360 deals

Because of declining revenues, record labels had to look into other sources of revenue streams. They had to find a new label strategy, which led to the creation of 360 deals between the label and the artist. These types of deals would entitle the label percentage of the earnings that an artist earns through other avenues such as live performance, event appearances, merchandizing and endorsements.

Marketing and Promotion

Digital marketing constitutes an important factor in marketing and promotional strategy. Artists can now directly connect with their fans through social media such as Twitter, Facebook and YouTube channels.

Consumer Insights – Big Data and Analytics heavy

Streaming services creates huge amounts of data that can provide valuable insights about their customers. They can now know who is listening to their music, for how long/number of times, which location and so on. Services like Spotify uses such data for improving their recommendation engines and help listeners discover new music catering to their taste. Spotify also uses data to predict Grammy award winners. Data from Shazam can give insights into how and where a particular track got popular. Services like Soundout, AudioKite etc. also claim to predict which music track will be a hit.

Future projections:

While music revenue from physical and download sales are on a decline, streaming revenue has shown an upward trend.

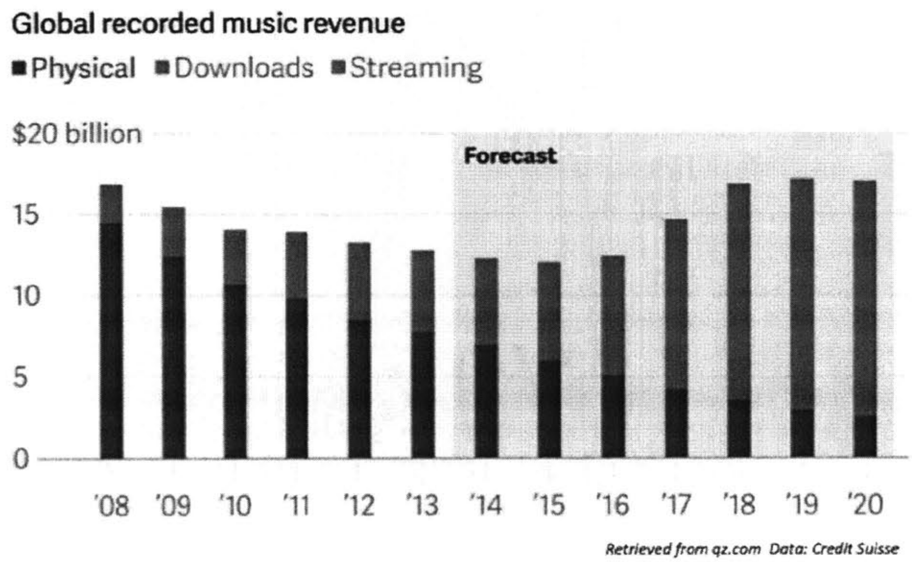


Figure 20: Recorded music revenue forecast

International market will drive revenue

Vevo's CEO Eric Huggers says, out of 17 billion music videos they delivered in January 2016, 80% of the consumption is international. From my interactions at a major record label in Los Angeles, an A&R executive confirmed that they do believe that as streaming takes over, international markets will be a major source of revenue.

Table 9: Traditional Vs. Digital Music Industry

TRADITIONAL MUSIC INDUSTRY	DIGITAL MUSIC INDUSTRY
"Push" in nature – Labels picked artists	Moving towards "Pull"- listeners pick their artist
Several Record Labels existed	Many Record labels merged
Asset heavy (CDs, Vinyl Records, Cassettes)	Digital files and New business models
Ownership model- Revenue driven by physical sales	Streaming model- Projected that streaming will drive revenue
Traditional Marketing and Promotion	Digital Marketing and social media forms an important component
360 deals were absent	New Business Strategy - 360 deals
Not much consumer insights	Big Data and Analytics heavy

5.3.6 Model Building Blocks

Table 10: Music providers and adoption drivers

	Disrupt Value Chain	No Value Chain disruption
Innovation driven	First mover *Example- Napster, Rhapsody*	First mover *Example- Internet radio*
Market driven	Fast Follower *Examples – Amazon Prime Music Vs. Amazon's online CD, Vinyl Sales*	Fast Follower *Example- Youtube Red, Google Play Music*

Digital disruption on Music Industry has created many players in the market. Table 10 classifies some of the music providing services in categories - market (or competition) driven, Innovation driven, first mover, fast follower and value chain disruption. Napster was one of the first file sharing services that made music available for free. Although it hampered the industry by depriving artists and labels off their revenue, it was one of the first movers of the industry. Pandora and Rhapsody innovated the streaming model. These services disrupted the value chain by providing music to listeners "on-demand" without having to own a CD. Napster, Rhapsody and Pandora are innovation driven companies.

Other services such as Amazon Prime Music and Google Play Music followed soon. These are services that are driven by competition and current consumer trends. Amazon sells CDs and Records online. By launching Amazon Prime Music provided a streaming model, in a way disrupting its own physical CD sales. YouTube was always a popular source of music video streaming destination. YouTube Red, the company's newly launched music streaming service is an example of market driven adoption. It did not disrupt its existing music video streaming service but added an extra feature.

From above analysis of Music Industry we identified following key aspects or building blocks of our model:

- Value Chain Disruption
- Market driven strategy
- Innovation driven strategy
- Push-Pull market trend

Chapter 6: When Technology Adoption Fails

6.1 Introduction

There have been many examples in the past where big technical projects have failed catastrophically, sometimes even challenging the every existence of the company. On average large IT projects run 45 percent over budget and 7 percent over time, while delivering 56 percent less value than predicted (HBR, 2011)[11]. This chapter explores examples of some of the biggest failures of such projects and impact of their failures.

6.2 When Technology failed organizations

Sources of examples below: (Gross, 1999), (SCDigest, 2006), (Wailgum, 2011)

6.2.1 Hershey's ERP Implementation

In 1996, Hershey's started work on upgrading and revamping its legacy IT systems into an integrated ERP environment using solutions from SAP, Manugistics and Siebel. Due to business demands Hershey's had to implement several modules of software under very tight deadlines. The go-live schedule overlapped with Hershey's busiest period of business – around the same time when orders for Halloween and Christmas starts coming in. There were several problems with the

[11] *Retrieved from McKinsey article http://www.mckinsey.com/business-functions/business-technology/our-insights/delivering-large-scale-it-projects-on-time-on-budget-and-on-value*

systems that tracked orders and fulfillment as a result of which despite having inventory in stock, the Hershey's could not fulfill orders from several customers.

Impact: This failure resulted in a stock dip of 8 percent, suffered revenue loss of at least $150 million and drop of profit of 19%. Apart from this there is also loss from resources, time and cost of implementation of the ERP project. The company suffered bad press.

6.2.2 Toys R Us.com Christmas delivery

Toys R Us.com is a toy and children's product retailer. In 1999 when online retailing was getting popular, the company received thousands of orders after heavy advertisements of guaranteed Christmas delivery of any order placed by Dec 10 that year. The volume of orders they received after national advertisements were much more than their prediction.[12] Although they mostly had stocks in place the company could not pick, pack and ship orders in time. Two days before Christmas they sent out thousands of sorry emails to customers whose orders they could not fulfill in time.

Impact: The company suffered negative PR and backlash from unhappy customers. Their reputation in the public eye took a huge hit. They offered 100$ gift certificates

[12] *http://www.clearspider.com/supply-chain-management-disasters-toys-r-us/#.VwxRGGQrKRs*

to customers as compensation for the inconvenience. The company later outsourced its fulfillment to Amazon.

6.2.3 Nike's supply chain system

Nike is a renowned athletic wear company. In 2000 the company started implementing a bold ERP, CRM and supply chain project that aimed to upgrade their systems. In February 2011 they went live with this new and complex system. As a result of various issues such as software bugs, system failures, lack of training etc., they faced major challenges in forecasting demands that created significant inventory shortages and excesses.

Impact: Nike suffered $100 million revenue in loss sales and 20% stock dip and a collection of class-action lawsuits.

6.2.4 Foxmeyer Drug

Foxmeyer was the second largest wholesale drug distributor in the U.S. in 1996. An ambitious project to revamp its IT systems and distribution facilities, involving a new ERP system implementation and a highly automated DC that would automate order picking and product movement, failed to perform as expected. There were bugs in the systems and additional hundreds of workers had to be deployed to work around issues. Shipping errors cost tens of millions of orders.

Impact: The company suffered huge sales losses. Foxmeyer filed for bankruptcy and was later bought by its rival company McKesson. There were several lawsuits between the company and several technology and consulting companies.

6.2.5 GM's Robot failures

In the 1980s GM embarked on massive automation effort by implementing robots in GM factories. GM at that time had 300 robots. They planned to implement 14,000 new robots by 1990 which would involve investments of billions of dollars. The robots did not work as expected and the project was a huge failure.

Impact: Introduction of robots reduced productivity and operational inefficiency incurring additional costs. The project was later scrapped; GM's cost increased and market share shrunk. They lost sales to competitors like Toyota and Nissan.

6.3 Impacts of failures

We research several such examples where adoption of new technologies or transformation projects failed. From our research and as seen in our examples above, it can be seen that when such projects fails it can be mapped to the same two categories of impacts identified in previous chapters but here the impacts are not favorable in nature –

- *Loss of Revenue (or Growth):* Companies suffered loss of revenue because of loss in sales, lawsuits, loss of customers, shrinking market share, inability to fulfill customer orders, bad PR among others.
- *Cost Overturn (or Productivity):* When such projects fail to meet expected performance the company incurs additional costs to fix issues. Such costs may involve money spent in deploying additional workforce, replacement technologies and corrective measures taken such as giving out coupons and discounts to customers and so on. Project that goes over time often goes over budget as well.

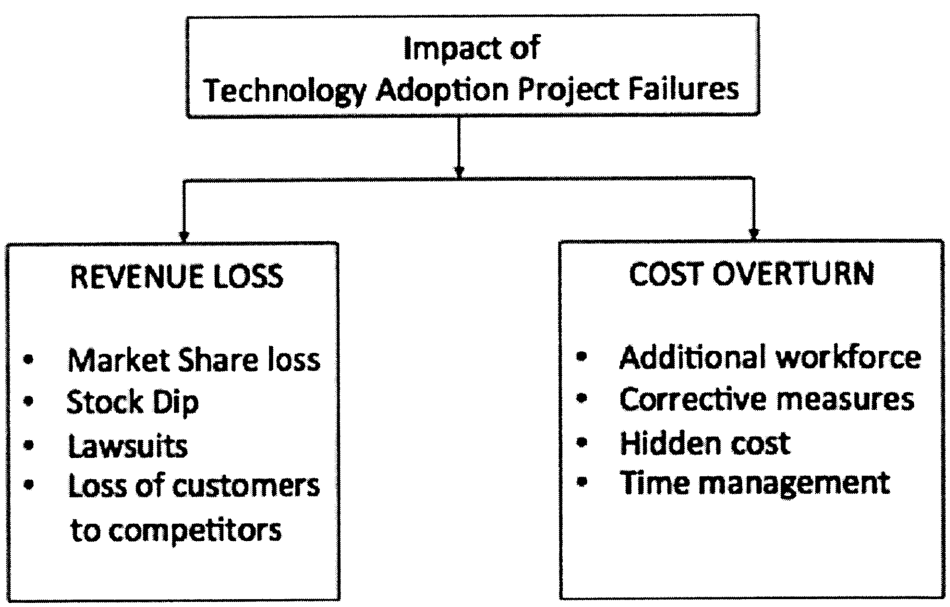


Figure 21: Benefit Impact Mapping Framework

6.4 Summary

From above discussion it can be concluded that just adopting technology is not guarantee for success. If not implemented correctly, failure of a large scale project can have undesirable impact on cost and revenue. In the next chapter we explore why such projects fail and what are the barriers that limit adoption of technology.

Chapter 7: Barriers of Technology Adoption

7.1 Introduction

As technologies of Industry 4.0 environment will become an important differentiating factor and competitive advantage. Organizations that do not act on time will lose out on opportunities. At the same time as we saw examples in the previous chapter, if not implemented correctly, such projects can produce undesirable results. Organizations must evaluate their current state and check if there are any barriers exists that might hinder adoption. This chapter reviews barriers that hinder successful implementation of technologies.

7.2 Challenges and Barriers

Even if right strategy is in place, barriers that exist in an organization can limit from attaining a project's goal. From extensive literature review consisting of academic papers, industry reports and journals, we identified following barriers to technology adoption:

- Organizational/Cultural
- Resources and Skills
- Time and Budget management

- Data Privacy & Security Concerns

Organizational/Cultural barriers:

Implementation of large complex projects involves transformation throughout the organization. A look at data below from industry studies indicates that organizational capabilities play a big role in success of such projects-

- In a study of 40 large-scale industrial change projects, it was found that ROI for such projects was 143% of the expected return when paired with excellent change management programs, compared with only 35% when change management was poor or absent (McKinsey, 2002).

- 61% of executives highlight culture and change management as a critical skills gap in their business(Fenwick, 2015).

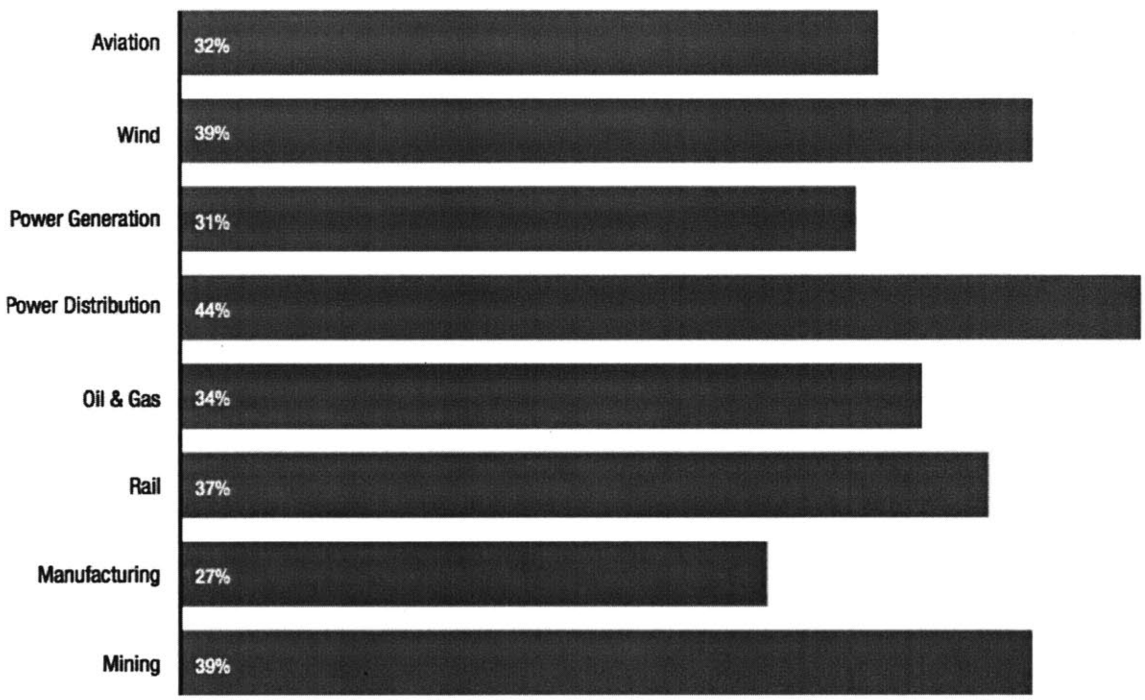
- Change fatigue is a major obstacle to transformation efforts, 65% percent of survey respondents in a PwC study cited change fatigue, and only about half felt their organization had the capabilities to deliver change(Aguirre, Von Post, & Alpern, 2013).

- Two- thirds of employees believe functional departments are too fixed in their ways, while 68% of business-unit leaders believe the functional teams in their companies act as barriers to effective coordination(Fenwick & Gill, 2014).

We define organizational barriers as any internal factor that hinders or delays decision-making process. Such barriers may involve communication barriers between teams and different divisions, redundant policies or processes that needs to be followed for making decisions, resistance to change from higher management or individual group attitudes and other cultural barriers.

Resources and Skills: In Industry 4.0 environment technologies and their applications are rapidly changing. In such an environment organizations struggle to keep up with the resources and skills necessary for successful implementation of large complex transformational projects. A Forrester study reports while 74% of the companies surveyed had digital strategy but only 15% of business executives believed their organizations had the skills to execute the strategy (Fenwick & Gill, 2014). Even if the strategy is in the right place and organizations provide training for their employees, skills can become obsolete in no time in such a fast paced environment. Losing talents to competitor firms can be another hurdle.

Time and Budget Management: It takes considerable amount of time and budget to implement large scale projects in Industry 4.0 environment. The returns may take a long time to realize. There are several projects that go over budget and fail to meet deadlines. Sometimes projects fail because of ambiguity in scope and scope changes frequently in the duration of the project. This throws the initial project plan off track. On other occasions, people who are making the project management plan are not the same people who would be actually working on the projects; this leads to errors in estimation of time and effort required for project implementation. To get approval for project plan, sometimes project managers tend to be over optimistic about the estimated benefits of project, goals and timelines.



Source: (Accenture & GE, 2015)

Figure 22: Percentage of companies that named security as top challenge to implementing Big Data initiatives.

Data Privacy & Security: Data privacy and security is one of the top concerns about Industrial Internet. Any leak in data security and data breach can cost an organization. Sensors, mobile Internet, IoT and other such technologies create huge volumes of data. While Big Data can provide insights which can create value to organizations, but at the same time it also puts a company at security risks. Figure 22 shows results from an Accenture and GE study on Industrial Internet; it can be seen that security is a serious concern that organizations face when adopting Big Data.

7.3 Model Building Block

From our research of risks and barriers of technology adoption we conclude that organizations need to evaluate their existing capabilities, strengths and weaknesses before embarking upon a complex technology adoption project. Sometimes skills and resources needed for such a project may be outside their core capabilities. They need to first invest time and resources to build those capabilities or partner with providers of those capabilities.

We identify "Organizational Evaluation" as one of the key building blocks of our model.

Chapter 8: Research Findings and Summary

8.1 Introduction

	Value Chain Disruption	No Value Chain Disruption
Innovation driven	First mover *Example- Netflix, Amazon AWS*	First mover *Example- Amazon Robotics*
Market driven	Fast Follower *Examples – Walmart online*	Fast Follower *Example- Youtube Red*

Table 11: Adoption drivers and value chain plot

In the previous chapters we explored the impacts of technologies and drivers/objectives for their adoption. During our discussions we identified key building blocks for our model. The table above is a plot of organizations on the basis of adoption drivers and impact on value chain. In this chapter we propose a conceptual framework consisting of the key building blocks that were identified through our research and discussions in the previous chapters.

8.2 Conceptual Framework

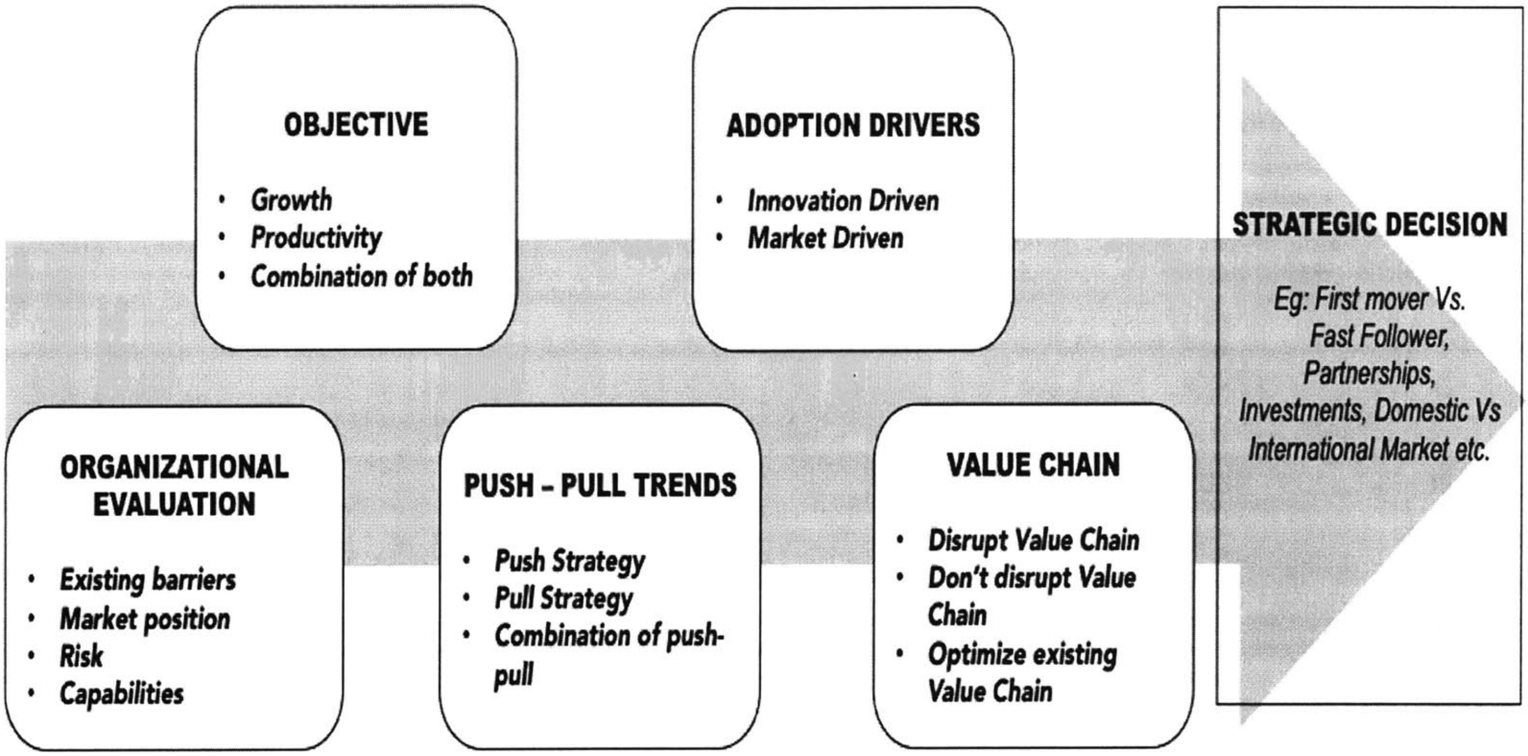


Figure 23: Conceptual Framework

From our research and discussion we have identified the key building blocks for our framework. Figure 23 represents our conceptual framework for assisting in strategic decision-making during adoption of technologies. The key aspects of this framework are summarized below:

Value Chain: Organizations should continuously innovate to optimize their value chains. Technology disruptions can reduce/eliminate the stakes of certain entities in a value chain. In our analysis of the music industry, we saw that unlike in traditional music industry, the final consumer in digital age can directly access music without having to buy a physical copy from a retail store. In this specific case, a retail store in the value chain is replaced by a streaming service or digital download. Music can be released to millions of listeners globally at once in a single digital platform. Value chain disruption can also create new business models. In our research of industry case studies we saw examples of transition to cloud technologies. This removed the need to own physical storage space and also helped in introducing new service models. Evaluation of current value chains and innovation of business models is a crucial step to technology adoption.

Adoption Drivers: We classify adoption drivers into two categories–

- *Innovation driven adoption:* This type of strategy leads to creative use of technology and resources to execute a business in new ways often creating new business models and new product offerings. They are often among the first adopters of new technologies. An example of innovation driven technology adoption is Amazon's acquisition of Kiva Systems, now known as Amazon Robotics. They deployed mobile robotic fulfillment systems in their warehouses, which helped in reduction of manual work and human errors, increasing utilization of warehouse space and operational efficiency. This helped in reducing their order lead times. This is an example of innovation driven adoption without disrupting the value chain.

- *Market driven adoption:* We define this as the type of strategy adopted in order to keep up with competition, retain market share or when forced to adoption by customers/other stakeholders in the value chain. Services like Netflix, Hulu and Amazon Prime are threats to the existing cable TV networks. Networks are forced to take action to avoid losing out market share to these players. An example of market driven adoption is HBO's OTT subscription on-demand service.

Objective (Growth Vs. Productivity Vs. Both): As discussed in the previous chapters, our research showed that adoption of technology has two major impacts – growth and productivity. Organizations should evaluate carefully the objectives of technology adoption. Sometimes instead of immediate profit margins, objective of technology adoption is growth in terms of maximizing market share. An example of such adoption is Amazon.com, Uber and Spotify; these companies are focused on growing their market share. In other cases technology can help in improving operational efficiencies and increasing profit margins.

Push-Pull Trends: In our discussion about music industry we saw that the industry is moving away from push and towards pull. Previously labels would pick artists based on their gut and launch them. Now listeners are picking their artists. There are several examples of viral artists, who after gathering online followers, are successful in getting signed onto a label. Such "pull" trends call for investments in Big Data Analytics and machine learning. Labels and media companies such as

Billboard are collaborating with analytics driven services like Next Big Sound to predict next hits. Radio services use analytics to decide on airtime for music tracks. Amazon patented "Anticipatory" shipping, i.e. to start shipping orders even before customer orders them. Organizations should continuously seek to explore hidden market trends and changing consumer behaviors to adopt the right push or pull strategy.

Organizational Evaluation (Risk, Barriers, Capabilities, Market position etc.):
This is a very crucial step in our framework and has been discussed in detail in Chapters 6 & 7. Even after having adequate funds and the right strategy in place, the process of technology adoption can fail if existing barriers are not removed. Growing and retaining a talented workforce is crucial to success of complex technology adoption projects. Such projects may involve transformation across the organization. It is critical that leadership is aligned and action is taken to remove any cultural and communication barriers that may exist.

8.3 Conclusion:

This study shows that in a rapidly changing competitive landscape brought about by Industry 4.0, organizations should be aware of their current capabilities, where it stands with respect to competitors and ever changing customer behavior and market needs. This study provides insights into the opportunities offered by Industry 4.0 technologies through a Benefit-Impact Mapping Framework. To assist in technology adoption strategy, this study identifies key areas that organizations need to explore in order to develop the right strategy. These key areas are presented in a form of a conceptual framework that can help to capture the potential of technological advancements of Industry 4.0. The next step would be to research deeper into each of these key areas of the conceptual model by gathering latest data from organizations.

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