

Human-Robot Collaboration in Warehousing: A Cloud-Powered Revolution

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Abstract:

This case study aims to understand the challenges faced by bigger warehouses in verticals such as logistics and warehousing, in the supply chain. It deconstructs the Warehouse Automation Management (WMS) technology and how it has evolved since its inception. It delves deeper into the problem statement that is majorly focused on the impact of COVID-19 on warehouse operations. Challenges such as labor shortage, capacity restrictions, health and safety protocols, and large inventory management became more prominent and affected the business operations. Additionally, this case study analyzes the solution i.e. Warehouse Management System in a holistic approach. It is a user-centric and human-driven solution, rather than being solely robot-oriented. Furthermore, It talks about the collaboration of the latest technologies such as Artificial Intelligence, IoT (Internet of Things), Automated Guided Vehicles (AGVs), Blockchain, etc. The culmination of all these technologies and keeping the user-centric approach in mind was an innovation of a new technology called Cobots i.e. Collaborative Robots. These robots are automated by nature and are close to humans for their operations, not for the physical aspect of a task but for the strategic aspect of it. In addition, extensive Primary Research was conducted for this case study through various research methods such as in-depth interviews and surveys of the core stakeholders of the industry.

Keywords: Warehouse automation, Automation, Collaborative Robots; Iot, Data

2. Introduction:

We live in a dynamic world, where technological advancements are at bullet speed. Today, by just using such technologies, we can replicate a human's way of doing things, in fact, with more efficiency. One such technology is Warehouse Automation. Warehouse automation or formerly known as Automated Storage and Retrieval System (ASRS) was designed and built by German heavy equipment manufacturer Demag, whose system consisted of racking mounted from the ceiling. ASRSs at this time were giant cranes that traversed large columns of shelves to store and retrieve raw materials. (Team Hopstack, 2023) Since then, the warehouse operations have changed quite drastically. Companies increasingly turn to automation technologies to address labor shortages, the rise in customer demand, and the need to optimize processing times.

For example, It is safe to say that warehouse automation was and is an operations revolution. Additionally, it leads to reduced risks, cost reduction, increased efficiency, accurate data analysis by incorporating cloud computing, and a lot more benefits that we will discuss further. (Accenture, 2019) Earlier, robots were

used to replace humans, but in today's world, we use robots to increase the efficiency of our human resources.

To set some context, a modern technology called cobots (collaborative robot) is a robot intended for direct human-robot interaction within a shared space, or where humans and robots are in close proximity. Cobot applications contrast with traditional industrial robot applications in which robots are isolated from human contact. This technology is used in warehouse automation where robots are in close contact with humans to perform tasks that are repetitive, tedious, and risky for a human. By doing so, it saves up time, increases efficiency, and reduces risks of any harm to humans. Through the advent of cloud computing, especially cloud-native software platforms, supply chain managers can more easily track inventory and take action to address supply/demand imbalances. (Fersman, 2020)

How did Cobots come into existence:

In 1999, Colgate and Peshkin were engineering their ways to come up with an easier and more efficient way to improve ergonomics for human workers without posing any risks of robotics. After quite a lot of ideations and iterations, they came up with an idea where humans and robots could collaboratively work on tasks, contributing to what they are best at.

Initially, this technology was called a "programmable constraint machine," because the robots contributed to the work being done under a computer constraint control.

Later, when the collaboration between humans and robots became more relevant and a key requirement, they came up with the term Collaborative Robot or Cobot. The term was then filed for a patent, in 1999.

Earlier, the Cobots could help guide the motion of a worker to ensure greater precision, while supporting a load against gravity, but it did not work up to the expectations of Colgate and Peshkin.

Later, they realized that the Cobots could drive around and carry heavy loads by themselves. With a good interactive design and speed control of the Cobots, they proved to be an operational revolution in warehouses. (Pittman, 2016)

In this case study, we will break down how warehouse automation is an operations revolution that is collaborative between humans and robots, and understand the impact of various technologies such as IoT (Internet of Things), Artificial Intelligence, AGVs (Automated guided vehicles) and robotics in modern day warehouses.

Furthermore, for this case study, primary research was conducted through a combination of interviews and surveys. The target audience was mainly factory and warehouse owners or workers, aimed at understanding and receiving first-hand insights regarding the operational challenges faced in warehouses and their take on warehouse automation. Adding to this, an Emerging Technologies Canvas was made for the Warehouse Automation technology. It mapped out every detail of the technology from its opportunity, impact, technical feasibility, and the future. This canvas serves as a visual depiction, highlighting emerging trends, potential solutions, and areas of innovation that have the potential to greatly impact

warehouse operations in the future. As the case study folds, the primary research and Emerging Technology Canvas will be detailed in depth.

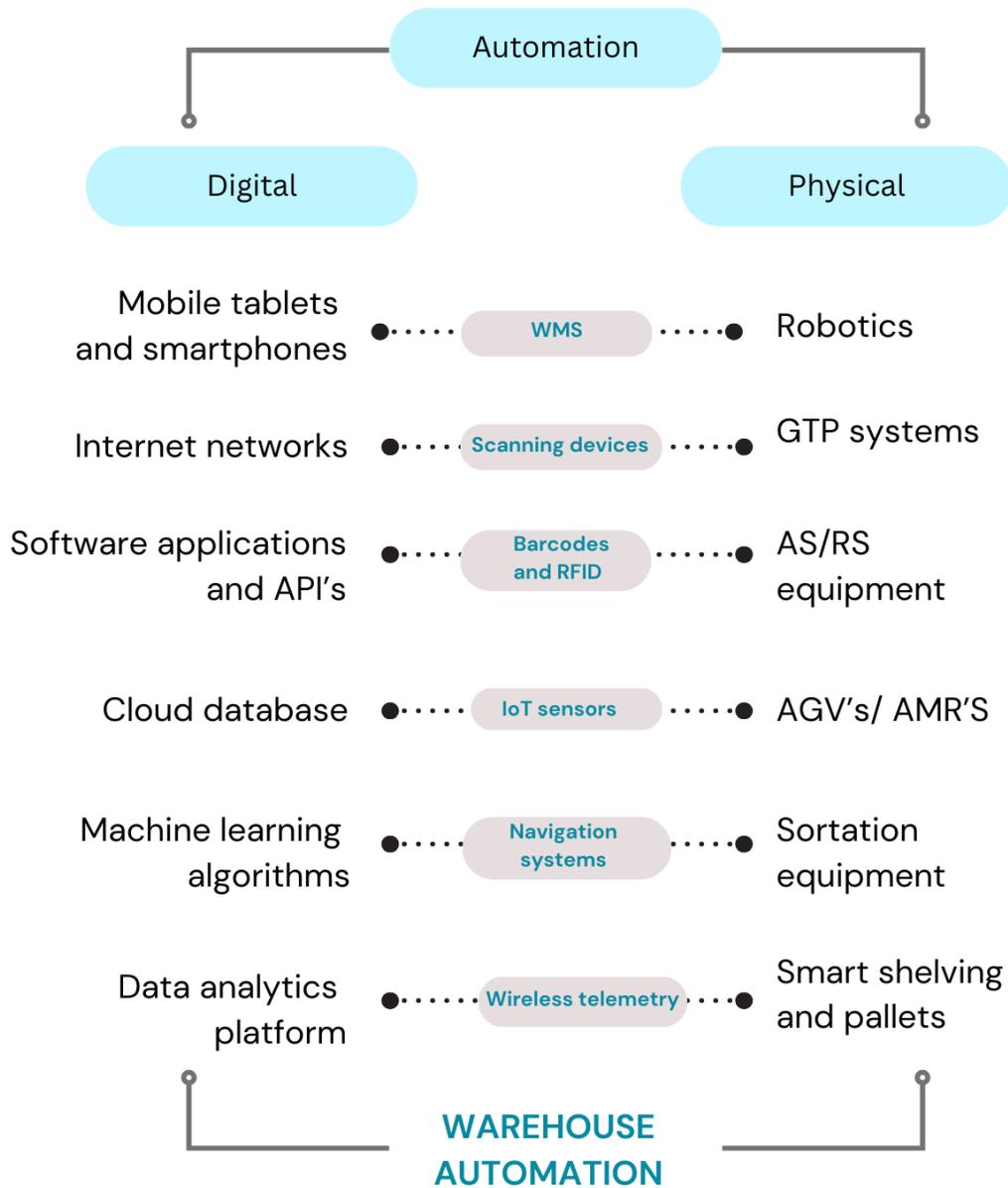


Fig.1 The Making of Warehouse Automation

3. Problem statement:

Warehouse automation has been around since the early twentieth century. Previously, conveyor belts and simple mechanization were used to move goods within warehouses. This did help with the problem of

labor shortages or workplace hazards, but it still required supervision and people on one end. It wasn't entirely automated.

In the wake of the Coronavirus pandemic, several firms in the import and export markets were impacted by challenges such as:

- **Labor shortages** - during covid 19, there was an increased labor shortage as they started to move to their hometowns seeking shelter the pandemic.
- **Health and safety protocols** - measures like social distancing, regular sanitizing, and wearing masks had to be taken to maintain health and safety protocols by the government to fight the COVID-19 pandemic. This made it difficult to conduct daily operations and added up to costs.
- **Capacity restrictions of employees and staff in warehouses** - as social distancing had to be strictly maintained, certain capacity constraints (of labor and workforce) were issued by the government, which were mandatory to adhere to.
- **Inventory management** - inventory management had become difficult and chaotic as the E-commerce industry surged during the pandemic. Still, the warehouse infrastructure was all over the place due to above above-listed reasons.
- **Order fulfillment delays** - consumers were unhappy with delayed deliveries and missing items in their orders. This was causing trouble for businesses. Many businesses had to shut shop or face major losses during the pandemic due to these reasons.

Almost every industry took a hit on their businesses due to a disturbed supply chain and the above-stated factors. Companies across the globe started to adapt to different types of solutions to meet the demand. Nike's distribution, third-party manufacturing, and logistics activities were severely impacted by the pandemic. According to its July annual report, net income before taxes for 2020 decreased 40% from the previous year to \$2.9 billion. Following the pandemic, which compelled Nike to close stores first in its strong China market and subsequently around the world, inventory increased 31% to \$7.4 billion at fiscal year-end on May 31, compared to \$5.6 billion at the end of fiscal 2019. Reduced shipments to wholesalers, manpower shortages, and other "supply chain effects" hampered Nike's ability to balance supply and demand, raising production and distribution costs. Automating the warehouses and digitally transforming the business operations turned out to be a favorable solution for them. (Silver, 2021)

McKinsey's report on "India's post-pandemic logistics sector: The need for technological change" states that India's warehousing industry may enjoy higher demand as producers shift their focus away from China and toward other Asian countries, including India itself. Considering this, it suggests that warehouses will have to reduce human contact in their daily operations and automate them for increased efficiency and better productivity.

In November 2020, a Business Insider report stated that A recent investigation by Reveal found that the serious injury rate of manpower at Amazon's warehouses in 2019 was 7.7 per 100 employees, or "33% higher than in 2016 and nearly double the most recent industry standard". (McKinsey, 2021)

With the passage of time and significant technological improvements, we now see a bigger picture of massive warehouses in the import and export marketplace, with goods and products being shipped in bulk.

Furthermore, the increasing rise of e-commerce and the necessity to meet consumer needs has resulted in significantly larger production and even larger warehouses.

This was a wake-up call for those in the warehouse industry to digitally alter their warehouses rather than simply automating jobs using conveyor belts and enormous cranes to move items. It is not only about adopting automation, but also about transforming warehouses into more efficient, flexible, and 24/7 operational epicenters. (Jane, 2022)

According to an Accenture study, the main drivers of this include labor shortage (61%), higher work volume for staff (55%), and solving new business challenges(34%). (See Illustration 1). (Accenture, 2022)

3.1 Lack of due diligence to assess automation requirements and warehouse complexities:

“If you’re a fast-growing company, the answer might be to invest as soon as possible, because you can be more confident in realizing the sales to justify it, and you’ll continue growing,” said Kulp, who is EVP of MHI’s Solutions Community and managing partner at MHI member St. Onge Company. (DOW & Lamerson, 2023)

When we look at the current state of the marketplace and the huge scale of warehouses and operations, it is important to assess the requirements and complexity of a business’s warehouse operations to correctly inculcate automation in it. An aspect that a lot of companies don’t understand is due diligence. Making a quick move in the market by adapting to the latest technology is not the solution to all the warehouse problems. If due diligence is not done in aspects of scalability, complexity, and the need for it, the adoption of technology could then be the downfall of the company. Additionally, having blind faith in technology, especially in a business that is solely about innovation and creativity, having longer payback time, is not ideal.

Brian Poveromo, director of facilities and maintenance at Solutions Community member of American Eagle Outfitters, and end-user chair for the Solutions Community, said "We’ve turned to automation to help us with labor. But in the long run, we’re also finding that automation is helping us with efficiency. Now 10 people can do the job of probably 50, he said. But it’s not just about replacing people with robots. It’s about finding other things for those people to do. It’s also about helping people be more ergonomic, removing risks, and reducing injuries.”

In this case study, we will look at how present-day warehouse automation, along with cloud computing, cobots, RFID tagging, etc has helped the sector eliminate the problem of reliance on factors such as labor and technical hurdles.

3.2 Proposal:

Backing this up, Accenture’s 2020 Supply Chain Survey shows that warehouse automation is the third biggest investment priority for senior supply chain executives.

Investing in the right amount of automation and cobots that are also cloud computed, will help the supply chain executives be faster, safer, and more efficient and cut costs in the daily warehouse operations. Additionally, it may also help the businesses scale up and grow. This is not just about being on pace with

technology advancements, but also planning and strategizing the way through business challenges. (Accenture, 2019)

Further in the case study, we will investigate and discuss emerging technologies in the automation business, as well as their impact on it.

4. Solution:

The intervention of technology in warehousing has been a game changer for warehouse operations. Automating the warehouses is cost-efficient, sustainable, and an effective solution for warehousing challenges. In today's scenario, where E-commerce is at its peak in the market and accessible to the public throughout, warehousing has become one of the most important parts of the supply chain. To meet the demand of the consumers, the warehouses had to be well equipped for such an operations revolution, Thus warehouse automation played a crucial role.

3.1 The most important technologies for warehouse automation are: (Sunol, n.d.)

A) Internet of Things:

The IoT (Internet of Things) is a sensor-embedded network that is interconnected with physical objects from computers to non-computers as well. They are interconnected to derive real-time data and generate insights from them.

The wave of IoT has given organizations an upper hand in understanding every facet of the supply chain in a better way. Having real-time data insights has also improved customer experience and allowed transparency.

The working of Iot in warehouse management looks like this:

Sensors and hand-held, voice-activated IoT devices form a network. Information is transferred into a warehouse management system to track and trace inventories. Data is delivered in real-time to analytics programs. The analytics assist managers in identifying warehouse bottlenecks and determining how to resolve them.

The floor is patrolled by driverless forklifts and inventory-carrying robots, which move heavy packages from one spot to another. This minimizes worker fatigue. Testing medicines and perishable foods for safety and freshness to prevent spoilage.

Inventory management with IoT:

Digital barcodes and RFID tagging are helping warehouses reduce time and enhance efficiency in their operations. Warehouses use both 1D and 2D barcodes for tagging. Generally, 1D barcodes are used for UPC labels as they are handy and can be easily changed. 2D barcodes are used for more complex product categories such as chemicals, medical or pharmaceuticals. Such barcodes contain more information and cannot be changed easily.

B) Business Intelligence and Predictive Analytics

Business intelligence is one such technology that gathers, analyses and synthesizes historical and current data in an easy-to-read and visual format.

This technology makes decision-making easier and less risky as it is backed up with data insights from the past. On the other hand, Predictive Analytics is a technology that predicts possible outcomes and recognizes patterns and trends using techniques such as statistics, data mining, predictive modeling, machine learning, and artificial intelligence. As warehouses have Big data that needs to be segregated and analyzed, these technologies help in doing so with greater accuracy.

C) Robotics and Automation

Robotics is one such aspect of engineering that deals with the design, construction, operation, and use of robots that can be programmed to perform manual processes in the warehouse. Inculcating robotics in warehouses can replace human jobs that are repetitive, tedious, and monotonous.

On the other hand, automation is a technology that uses robotics to perform a set of operations with minimal time and increased efficiency, with very less to no human assistance. Investing in both technologies is your first step to achieving warehouse automation.

As we all are aware, warehouses are full of repetitive, risky, and process-oriented operations. Robotics can take over such operations from humans, leading to increasing efficiency and reducing time to fulfill customer demands. This directly relates to the enhanced user experience of the customer in E-commerce, in terms of quicker process and delivery of the products. Additionally, this improves the employee retention rate by replacing their repetitive and monotonous tasks with interesting and skill-oriented tasks such as customer experience, data analysis, site planning, etc.

Robotics and automation will also allow the warehouse to continue 24/7 operations and lead to increased productivity and returns of the business, with reduced cost and mitigating workforce risks.

D) Automated Guided Vehicles (AGVs)

Amazon might be the market leader of warehouse automation with 45,000 Amazon (Kiva earlier) Automated Guided Vehicles (AGVs) in its warehouse army, but it is not the only company that uses autonomous vehicles in warehouse management. Currently, beyond large-scale warehouses, even mid-sized businesses are moving gradually toward driverless vehicles. (Sunol, 2023)

An AGV is a portable robot that navigates itself around the warehouse through floor markers (stickers), wires, magnets, lasers, or cameras. This technology has been around for more than 4 decades but in a very rudimentary form. In today's scenario, AGVs are of various types such as automated stackers, forklifts, pallet trucks, and small rack-carrying robots such as Kiva and Fetch. They use machine learning and deep learning to conduct operations. These portable vehicles have proven to be safer than the human workforce to move around the warehouse facility.

UAVs such as drones have also started marking their presence in the warehouse and logistics sector, but only in the prototype stage as of now from giants such as Amazon.

As AGVs evolve, even the smallest of warehouses will be able to afford them, suggests MHI View. Four factors that can be advantageous for warehouses by using AGVs are:

1) Reduced Costs:

As we all know, AGVs are automated vehicles that do not require human workforce or any human

intervention. By using them, the warehouses will cut costs of hiring and training the workforce. Also, AGVs can operate 24/7, unlike humans, which would be advantageous for the warehouse in terms of productivity.

2) Safety:

AGVs are proven to be the safest for handling material around the facility, saving the warehouse workforce from performing tasks that can cause physical injuries, exhaustion, or product damage. There are designated safe paths for the vehicles. The AGV sensors can sense a highly used path or traffic in the facility and direct the vehicle accordingly to avoid any accidents.

3) Flexibility:

Autonomous vehicles can be integrated with warehouse management systems, Automated Storage and Retrieval Systems, conveyors, etc. Also, their mobility prevents them from being a permanent obstacle.

4) Increased Productivity and Precision:

The ability to integrate with AS/RS, WMS, and sensor technology makes these vehicles accurate. They work at a consistent speed, thus making material handling time efficient, consistent, and less prone to errors.

E) Mobile and Wearable Technologies

Mobile and wearable technologies are nothing new or emerging in the market of technologies, but the way they have evolved in a sophisticated way has marked their new presence in the market!

As a result, quite a lot of warehouses are adopting these solutions as they progress towards warehouse digitalization. Here's where the differentiation of adopters and enablers of technology play a role. Many warehouses have adopted digitalization, but are all of them able to adopt it efficiently? This question is a make-or-break deal for warehouses.

F) Blockchain

Warehouse automation, as we all know, is the process of automating the movement of merchandise into, within, and out of warehouses to consumers' hands with little to no human guidance. This not only streamlines processes but also increases efficiency and reduces error. While warehouse automation offers numerous benefits, there is room for improvement in key areas such as enhancing transparency, increasing security measures, and optimizing efficiency across various processes. This can be achieved through the implementation of blockchain technology. But what exactly is blockchain? (Kirbac & Tektas, 2021)

The way blockchain stores transaction information is how it gets its name, in blocks that are chained together. The blockchain expands as the number of transactions gets added to it. Blocks record and confirm the time and order of transactions within a private network that is governed by rules agreed upon by network users. These blocks are then added to the blockchain. Each block contains a distinct hash (a unique identification), timestamped batches of recent transactions, and the hash of the previous block. Therefore, each successive block verifies the previous block's transaction, and hence the entire network. (Sunol, 2023)

What are cobots and how will they impact the future of manufacturing?

Today, we are in an era of automation and robotics in the manufacturing and warehousing industry. Since the invention of robotics, it has been an ever-evolving technology.

Today, artificial intelligence has marked a strong presence in the industry and is taking over quite a lot of technological aspects. In the manufacturing and warehousing industry, AI can now train robots, analyze data, provide historical data, and simply do a lot more operations in much less time than human resources.

Industry cobots or Collaborative robots are developed and designed in such a way that they are in close proximity to humans and collaborate with them to go about the daily operations of the warehousing industry in a smart, digitized and safe manner.

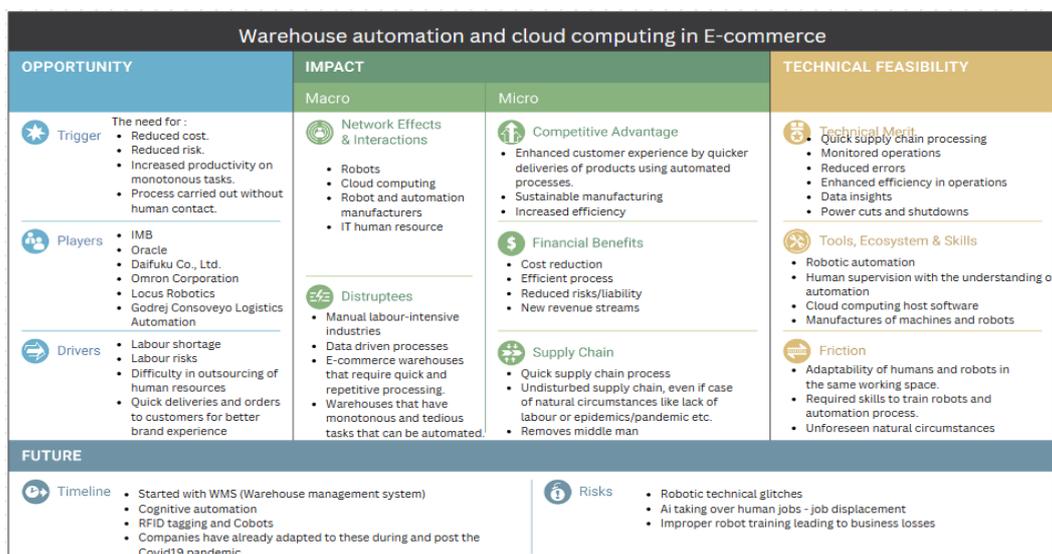
As we talk about the rapid evolution of robotics and automation in the logistics and supply chain industry, robots are just a tool to go about the operation. This realization came very late to developers and manufacturers. Robots can perform tasks that are repetitive and monotonous and the technology of cloud computing can connect them all and provide data insights as well. But to train the robots, analyze the outcomes and strategize the operations, human intervention is important. Robots cannot be solely relied upon as strategy is a human train. (Fersman, 2020)

How do we define cobots?

Collaborative robots and robots that are designed for collaborating with humans. This collaboration was invented to inculcate human abilities with the robots, for enhanced results. Furthermore, They can be programmed in such a way that the robots stop when a human enters the facility. This, in turn, leads to unwanted delays in operation or production, which can be avoided through the use of cobots. Collaborative robots are capable of monitoring the environment and co-existing in the same facility together with humans without sacrificing performance or safety.

4.2 Emerging Technology Canvas:

An Emerging Technology Canvas is a visual representation of the framework of an Emerging Technology. It is made to understand the overall landscape of the technology for bigger organizations, researchers, investors, and various industry stakeholders. The canvas consists of four main verticals, namely Opportunity, Impact, Technical Feasibility, and Future. In this case study, every section and its sub-section is thoroughly detailed with a visual representation of the canvas.



(Fig.2 Emerging Technology Canvas)

OPPORTUNITY

The Opportunity section in the Emerging Technology Canvas reflects the possibility and opportunity of Warehouse Automation as an Emerging Technology in the market. It captures the problem and solution by stating the key triggers, players, and drivers that positively affect the technology.

Trigger - The potential for significant labor cost savings is one of the key reasons for using warehouse automation. Automation reduces human errors in areas like order picking and inventory management, which can be expensive to correct. By replacing or supporting humans in dangerous tasks, automation minimizes the likelihood of workplace accidents and injuries. Heavy lifting and repetitive chores can be handled by machines, reducing the risk of strain and damage.

Players - IBM offers a variety of solutions to optimize supply chain and warehouse operations, including AI-powered analytics and IoT platforms. Their technology assists firms in improving supply chain efficiency, visibility, and decision-making. Oracle offers a suite of supply chain management solutions, including warehouse management systems (WMS) and cloud-based applications. Daifuku is a key player in material handling and warehousing process automation. Conveyor systems, automated storage and retrieval systems (AS/RS), and robotic solutions are available to assist businesses in optimizing their warehouse operations and increasing production. Locus Robotics' robots are designed to work collaboratively with human workers to improve order fulfillment in warehouses and distribution centers.

Drivers - Labour shortage occurs when there is a lack of available workers with the necessary skills to meet the demands of a particular industry or region. The obstacles and uncertainties associated with the human workforce, such as worker safety, health, compliance, and labor conflicts, are referred to as labor risks. Due to issues such as increasing labor costs, regulatory difficulties, and the requirement for specialized expertise, outsourcing human resources, such as hiring temporary or contract workers, can be difficult. Consumers anticipate swift deliveries and order fulfillment in today's competitive industry. Brands that can provide a consistent and quick consumer experience gain a competitive advantage.

IMPACT

The Impact section mainly talks about various factors such as political, economic, sociocultural, technological, legal, and environmental that are subject to changes in the market. This section is divided into two subsections, Macro and Micro.

IMPACT - MACRO

Network effects and interactions - NetRobots developed from cloud computing improvements because they can use the cloud's processing power and storage for increasingly powerful AI and data analytics. Manufacturers of robots and automation research and construct robots that integrate with cloud-based systems to expand their capabilities and functionalities. Cloud computing is being used by manufacturers to provide software-as-a-service (SaaS) solutions for robot users, enabling remote management, performance tracking, and predictive maintenance. IT personnel are essential for manufacturers in order to develop and maintain cloud-based platforms, software applications, and data analytics tools that complement their robot capabilities. The presence of IT specialists can assist organizations in maximizing the potential of robotics and cloud technologies, allowing them to compete effectively in the market.

Robots, Cloud Computing, Robot and Automation Manufacturers, and IT Human Resources interact to form a dynamic ecosystem in which breakthroughs in one area can promote improvements and innovations in others. The interaction of these factors is critical for the successful adoption and integration of developing technologies across sectors.

Disruptees - Automation technologies such as robotics and artificial intelligence (AI) pose a threat to manual labor-intensive industries such as manufacturing, agriculture, and construction. Automation in these industries can reduce labour requirements, lower manufacturing costs, increase efficiency, and improve safety. However, it is possible that some manual labor workers would be displaced, needing reskilling and workforce change. Data-driven automation can result in speedier order processing, fewer errors, better demand forecasts, and better customer experiences. Warehouses that do not react to technological advances risk losing competitiveness and client happiness. Automation is an ideal solution for warehouses that have monotonous, repetitive tasks like order picking, packing, and inventory tracking. Traditional manual operations can be disrupted by technologies such as autonomous robots, conveyor systems, and automated storage and retrieval systems (AS/RS).

IMPACT - MICRO

Competitive advantage - Faster deliveries offer a considerable competitive advantage, particularly in areas such as e-commerce and retail, where fast and dependable shipment is a crucial customer expectation. Order processing, packing, and shipping can all be automated, resulting in faster delivery times. In today's business scenario, sustainability is becoming increasingly crucial. Sustainable manufacturing entails minimizing waste, saving resources, and lowering environmental consequences during the manufacturing process. Streamlining operations, minimizing waste, and optimizing procedures all result in increased efficiency. Automation plays an important part in increasing efficiency. Businesses that leverage these advantages effectively can differentiate themselves in the market, attract and retain customers, and achieve long-term success.

Financial benefits - Cost-cutting measures include identifying and reducing unnecessary costs as well as discovering more cost-effective ways to operate. It is a fundamental financial benefit that has the potential to considerably increase profitability. Increasing efficiency involves optimizing workflows and processes to get better results with the same or fewer resources. By boosting productivity and decreasing waste, efficiency has a direct impact on financial success. Reducing risks and liabilities means reducing the likelihood of financial losses as a result of unexpected events, compliance concerns, or legal battles. Creating new revenue streams involves identifying and capitalizing on opportunities to generate income beyond the core business activities.

Supply chain - Quick supply chain processes refer to the ability to transport goods and materials from suppliers to customers as quickly as possible. This entails shortening lead times, decreasing bottlenecks, and optimizing various logistics and distribution tasks. Technologies such as automation and AI can help mitigate the impact of labor shortages by automating key tasks, and ensuring uninterrupted operations. Removing intermediaries from the supply chain involves dealing directly with suppliers and customers, reducing the reliance on middlemen or third-party distributors.

TECHNICAL FEASIBILITY

The Technical Feasibility evaluates the probable technical possibilities of Warehouse Automation. The subsections Technical Merit and Friction discusses the technological breakthrough as well as technological limitations.

Technical merit - Automation and digital tools can reduce lead times dramatically, allowing organizations to adapt to market developments more quickly. Monitored operations involve following up on and keeping track of numerous supply chain processes and activities in real-time. By automating repetitive operations and incorporating error-checking procedures, technology can drastically reduce human errors in supply chain processes. Technology-driven efficiencies involve improving supply chain processes to reduce waste, boost resource utilization, and lower costs. Huge volumes of data are collected and analyzed by technology, providing important insights into supply chain performance, trends, and possibilities.

Tools, ecosystem, and skills - The adoption of robotic automation requires skills related to robot programming, maintenance, and integration with existing systems. These skills are in high demand in the job market. Human operators and supervisors in these ecosystems need skills in human-robot interaction, real-time monitoring, and the ability to intervene effectively when necessary. Additionally, understanding automation and its limitations is essential for decision-making. Cloud computing is a foundational component of the modern technology ecosystem, supporting a wide range of applications, including IoT, AI, and big data analytics. Skills related to cloud computing are essential for managing and optimizing cloud-based services. These skills include cloud. The manufacturers require skills in engineering, design, production, and quality control. Their expertise drives innovation and the development of advanced automation solutions. design, security, data management, and scalability.

Friction - If not handled appropriately, integrating robots into a workstation alongside human labor might cause friction. Human-robot collaboration necessitates changes to workplace design, safety regulations, and employee training. Employees may first dislike working with robots due to concerns about job displacement or unfamiliar technology. Creating a collaborative culture between people and robots may take time and effort to overcome resistance and inspire acceptance. The skills gap required to effectively train robots and manage automation processes might cause organizational friction. A lack of competence might cause implementation issues and delays. Unexpected natural phenomena, such as harsh weather, pandemics, or supply chain disruptions, can disturb the smooth operation of technologies and cause friction.

FUTURE

The Future section talks about the key possible milestones in advancements of the technology and the number of years required for its standardization.

Timeline - WMS adoption began before the COVID-19 outbreak and has been a continuing trend in supply chain and logistics management. Artificial intelligence (AI) and machine learning (ML), for example, are increasingly being integrated into WMS and supply chain management systems. This integration enables smarter decision-making and the automation of repetitive operations. There has been a greater emphasis on technology that increases safety, efficiency, and flexibility in warehouse and industrial operations

during and after the COVID-19 outbreak. RFID tagging and Cobots have gained popularity during this time. The COVID-19 pandemic hastened the use of these technologies as businesses tried to improve supply chain resilience, reduce human touch, and optimize operations in the face of disruptions. The lessons learned during the pandemic have influenced long-term strategies. Companies continue to invest in technology to ensure preparedness for future disruptions and to improve overall supply chain efficiency and flexibility.

Risks - Unexpected faults or errors in robotic systems are referred to as robotic technological glitches. These flaws have the potential to disrupt operations, cause delays, and result in costly downtime. Concerns about job displacement may arise as a result of the increasing adoption of AI and automation technologies, in which computers replace human labor in a variety of tasks. Power outages and shutdowns can cause havoc in companies that rely largely on technology and automation. Inadequate robotic system training can result in inefficiencies, errors, and financial losses. Poorly taught robots may not perform to their full capacity, resulting in lower production.

Summary:

The Emerging Technology Canvas for Warehouse Automation captures the very essence of the technology. It positively suggests that the technology is Emerging and also criticizes its fallbacks. The canvas is an easy visual representation for all stakeholders to understand the technology and gain insights at a glance. Additionally, the canvas serves as a secondary research tool for this case study along with research reports and case studies.

4.3 Primary Research:

This case study's backbone is the extensive primary research conducted through a combination of targeted surveys and interviews of factory and warehouse owners or workers. The research aimed at delving into the critical operational challenges in the warehouse which included inquiries about common issues such as inventory inaccuracies, order fulfillment delays, and manual data entry errors. Additionally, the impact of COVID-19 was investigated by inquiring about the problems faced during the pandemic, in the factories and warehouses. The interviews were aimed at understanding how the factory and warehouse owners tackled such difficult times, with or without implementing automation. The survey also assessed the extent of awareness about Warehouse Automation and Cobots, with specific questions about the implementation of automation technologies in their processes. The respondents provided deep insights into their pain points faced in warehouse operations and the mindset of adapting to emerging technologies to get an upper hand. On inquiring further, it was understood that the majority of the warehouse owners lack the understanding of automation and such emerging technologies due to their complexity.

Research Methodology:

Interviews:

As a part of the primary research, 4 in-depth interviews were conducted with key industry stakeholders. Four factory and warehouse owners in various fields were interviewed: Mahaveer Jain, the owner of M AASHI; Raj Tileshra, the owner of Tileshra Diamonds; Kaushik Jain, the owner of Rajkamal Enterprises; and Rajesh Kariya, the owner of Gayathri Plastics. They were chosen for their considerable experience and different responsibilities in the warehouse and logistics sector, making it a holistic approach to

understanding the industry's difficulties and prospects in person. The interview questions were designed in a way to gain relevant insights into their warehouse operations, inventory management experiences, insights into order fulfillment processes and delays, worries about labor shortage, their affordability and mindset on automation, and the impact of the COVID-19 pandemic. Additionally, the respondents were inquired about their understanding of Warehouse Automation and Collaborative Robots, to which the respondents provided their candid insights and interpretations from their experience.

Surveys:

Survey forms were designed in-depth with questions that aimed to gain particular facets of operational challenges in warehouses, the impact of COVID-19, and assessing the understanding of emerging technologies involved in Warehouse Automation such as IoT, Cobots, and cloud computing. The survey consisted of 12 niche questions that were a combination of MCQs and short answer type questions. It was targeted and distributed to a group of warehouse and factory owners or workers, all above the age of 20, and received 25 responses.

A particular group of people was targeted to be part of this survey because of their relevant experience in the field of manufacturing and warehousing and their widespread understanding of the industry.

Primary Research Summary:

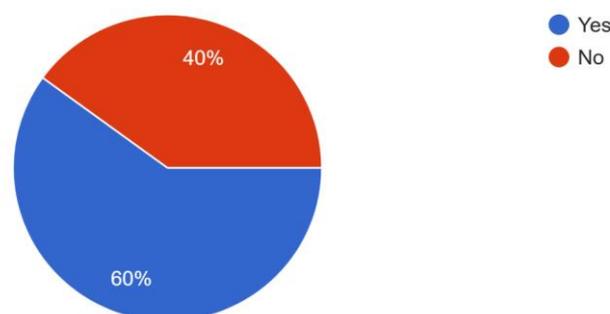
Both the interviews and surveys were a mix method strategy to understand the intricacies of operational challenges faced in warehouses and the depth of Warehouse Automation. This strategy provided both qualitative and quantitative insights which then led to validating the secondary research.

A common pattern that was observed in all interviews was the problem of labor shortage in warehouses. All the respondents seemed to highlight this as their major concern and a reason why they would switch to automation any day, as they wouldn't be solely dependent on labor to fulfill their tasks. On the other hand, some respondents who had already implemented automation into their warehouses were not aware of the emerging technologies like Cobots, IoT, and Cloud Computing and how they could be incorporated into their warehouse operations to make their tasks more efficient.

Results:

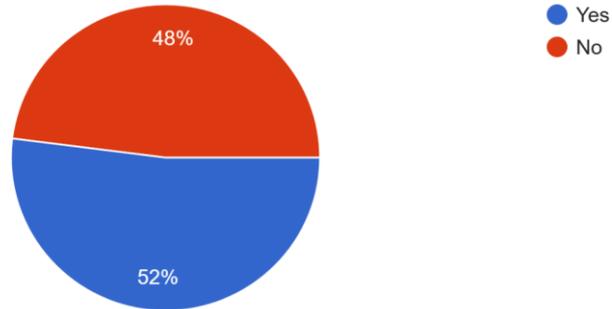
Do you encounter inventory inaccuracies in your warehouse operations?

25 responses



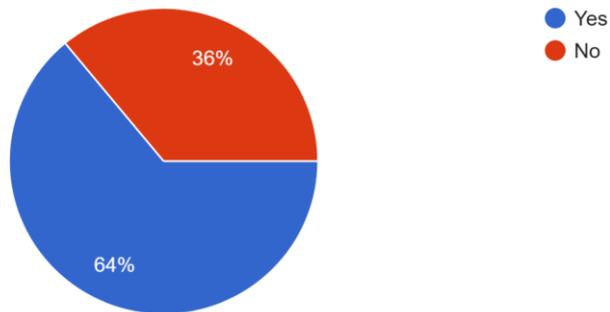
Are order fulfilment delays a common issue in your warehouse?

25 responses



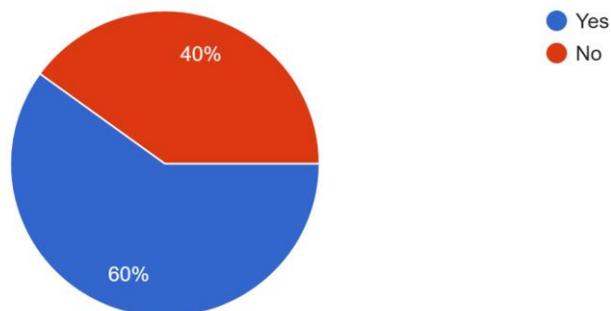
Are manual data entry errors a concern in your warehouse processes?

25 responses



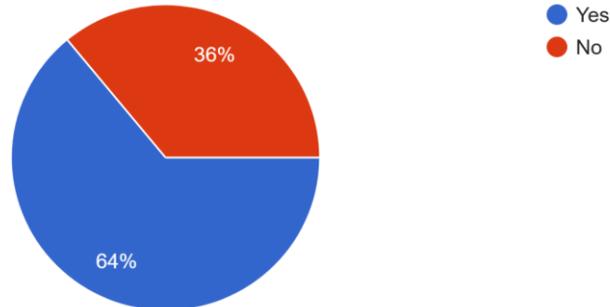
Did the Covid-19 pandemic impact your warehouse operations?

25 responses



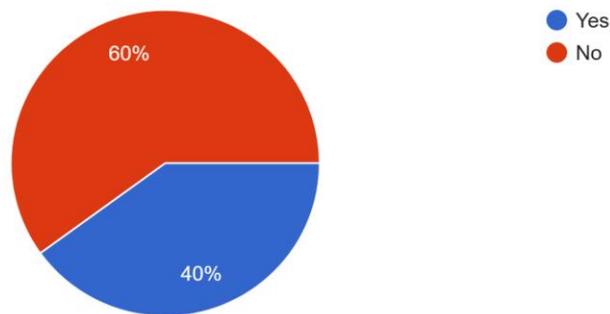
Are you familiar with the concept of warehouse automation?

25 responses



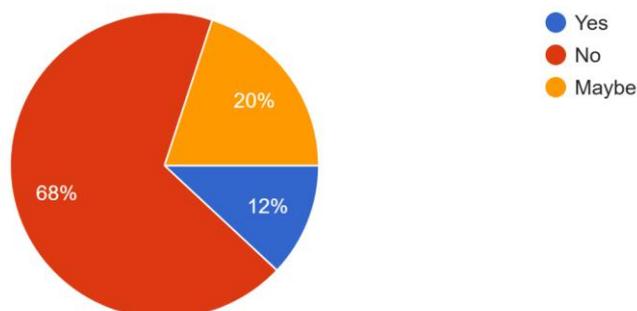
Have you implemented any form of automation in your warehouse processes?

25 responses



Are you aware of a technology called Cobots (Collaborative robots) that are used in warehouses?

25 responses



Insights:

From the Primary Research conducted, quantitative and qualitative insights were deduced. The insights were majorly focused on the operational challenges faced by warehouse and factory owners and their

understanding of Warehouse Automation. The following stated below will explain the insights and personal reflections in-depth.

Quantitative insights:

- 60% of the respondents face inventory inaccuracies in their warehouses because there is a lack of constant monitoring in the warehouses as the staff and employees are not available throughout.
- Order fulfillment and timely deliveries were agreed upon as a problem by 52% of the respondents. This was the case without Warehouse Automation, whereas the rest who had implemented it did not face such issues.
- A common issue faced by 64% of respondents was that of manual data entry. This conveys that manual data entry is still being done which eventually causes inventory inaccuracies. On inquiring the rest about why they don't face this issue, they mentioned that they have implemented automated software that is connected to their inventory through sensors.
- 67.5% of respondents were aware of Warehouse Automation and only 32.5% have implemented it. The reasons for not implementing Warehouse Automation were majorly the high cost and lack of understanding.
- Majority of the small factory and warehouse owners lack the understanding of Warehouse Automation and Cobots due to its complexity.
- Almost all respondents agree that labor shortage was a major issue during Covid-19 and without automation, some tasks were impossible to execute.
- Out of 25, 15 respondents claim the expense of adopting automation in their factories and warehouses is exorbitant.
- Only 12% of the respondents are aware of Cobots. This conveys the lack of awareness of such emerging technologies in the industry.

Validation:

A recent report by Gartner, predicts that by 2026, 75% of large enterprises will have adopted smart intralogistics robots in their warehouse operations. Smart intralogistics robots are robots that specialize in cyber-physical automation which mainly focuses on solving operational challenges in warehouses by incorporating smart robots. Additionally, Dwight Klappich, vice president analyst with the Gartner Supply Chain practice, mentions in the report that labor availability constraints, rapidly rising labor rates, and the residual impacts of COVID-19 will compel most companies to invest in cyber-physical systems, especially intralogistics smart robots. Furthermore, the report suggests that cyber-physical automation solutions will address important challenges by adding intelligence, guidance, and sensory awareness, making them independent of human workforces. Addressing the challenge of heavy cost, the report mentions that many flexible robotic use cases are inexpensive and can be implemented and scaled according to the enterprise's needs. (STAMFORD, Conn, 2022)

Reflections:

From the research insights, it is evident that there is quite a lot of scope for Warehouse Automation and Cobots in the industry. The quantitative insights directly relate to the problem statement in this case study.

It is worth noting that the prevalence of inventory inaccuracies (60%) is a crucial aspect and is happening due to a lack of constant monitoring of the inventory as the warehouse staff are not available throughout the day/night. Hence, this highlights the need for real-time tracking solutions for the inventory.

Secondly, the effectiveness of Warehouse Automation is validated in an insight where 52% of the respondents face order fulfillment and timely delivery challenges whereas the rest 48% don't face such issues as they have already incorporated Warehouse Automation.

The fact that manual data entry error is still an issue for 64% of the respondents highlights the prevalence of obsolete practices in the industry. On the other hand, people who are using automated software for data entry are saving on time, and cost and increasing their efficiency.

Warehouse automation awareness and adoption rates (67.5% aware, 32.5% deployed) highlight a gap in the industry. The major reason is the complexity of the technology which requires a well-educated team. This also emphasizes the fact that 15 out of 25 respondents find the expense of adopting automation exorbitant, indicating a potential barrier to wider adoption.

Lastly, almost all respondents agree that labor shortage was a huge issue during and after the Covid-19 pandemic. This emphasizes the fact that automation should be adopted as early as possible to avoid such problems in the uncertain future.

5. Conclusion:

In conclusion, this case study summarizes warehouse automation and how it has evolved over the years into becoming an operations revolution. It has valuable insights into the problems faced in warehouses daily and also focuses on providing an accurate solution for the same. Furthermore, it has focused on the huge impact of warehouse automation in logistics and supply chains.

Warehouse automation has not just simplified operations that are repetitive and monotonous, but also provided an entire ecosystem by inculcating cloud computing with it and alleviating the process by giving deeper data insights into the supply chain. In this process, robots (collaborative robots) and humans work in close proximity to make the operations much more productive and enhance the customer's experience.

The case study also speaks about Automated Guided Vehicles (AGVs) and its impact in the warehouses such as reduced risk and ease of moving goods in huge warehouses. During and after the impact of COVID-19, quite a lot of warehouses have chosen to fully automate and digitize their warehouses by implementing robotics, AGVs, Artificial Intelligence, Cloud computing, and many such emerging technologies.

The insights provided in the case study have quite a lot of relevance currently and in the future as we all know, digitalization is the new normal. The early adopters of emerging technologies in warehouse automation will now have to become enablers to keep up their game in the market. There is a high probability that if warehouses don't fully automate their operations, they might lack in providing a good customer experience and fall back in the market.

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Appendix

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