Journal of Supply Chain Management Systems
11 (1 & 2) 2022, 24-37
http://publishingindia.com/jscms/

A Conceptual Market Analysis of Automated Vehicles for Logistics in Future

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Abstract

Ever-changing consumption demand and industry 4.0 has drastically revolutionized the logistics chain and operating efficiency of the production plants. Material handling poses to be a key task for the growth of any business. Whether it is the distribution picking process or on the factory floors, a higher percentage of distribution executives, logistics, and manufacturing facilities are nowadays, facing the challenges of increasing labour costs. With the rising number of distribution centres, and increasing labour cost pressures, businesses are thereby emphasizing on the integration of automated solutions and processes on floors. Implementation of automated guided vehicles (AGVs) in warehousing and distribution centres of the industries is expected to improve the overall productivity with minimal costs. This article focuses on the market analysis and forecasting of revenue for the forecast period of 2019–2028. Further, the article briefly emphasizes the determinants such as drivers, restraints, challenges, and trends impacting the market for AGVs in different application segments.

Keywords: Industry 4.0, Automated Guided Vehicle, Warehouse, Distribution, Material Handling

Introduction

Customizability and modularity of smart industry solutions accelerate the digital transformation of businesses as per different strategies and models to pave their way in the competitive market. Digital renovation of industries with reverence to the digitalization of manufacturing processes is becoming a custom in terms of future sustainability aspects (regardless of the company's size or industry) as well as for enterprise expansion scenarios (Anasoft, 2019). To compete in today's competitive business environment, supply chains need to be sustainable, agile, and efficient, with digitalization being one of the most essential factors to attain these. Advancements in digital technologies are projected to impact the expansion of new models, principles, and paradigms, in the supply chain processes and its management (Ivanov, 2021). Digitalization of logistics defines itself in three key areas: distribution logistics, in-plant logistics, and warehousing management. Implementation of unmanned solutions is gaining traction owing to the rising demand for improved operational efficiency and productivity in businesses.

Manufacturers nowadays are significantly embracing the new period of communication by leveraging wireless technologies and integrating newer automotive equipment to enhance efficiency and productivity. An increase in competition is significantly expected to cause a shift towards new architypes in the fields of manufacturing and logistics sector. Incorporating the latest concepts and usage of digital technologies offers holistic control to the communication processes of businesses and helps strategize their models, along with value-producing opportunities as well (Insights).

Innovativeness in technologies is significantly used for continuous and consistent improvement, along with the key emphasis on previous trends in businesses as well (Galli, 2019). With the growing demand for digitalization in industrial intelligence and automation sectors, automated guided vehicles (AGVs) are gaining traction in the manufacturing spaces, automotive, intralogistics, food & beverage, and other industries. Over the years, AGVs have been considered a vital part of the digital sector. The abilities of AGV systems have witnessed an exponential rise with improvement in terms of the sensor as well as software technology. AGVs pose to be one of the pioneering solutions in times of industry 4.0 and digitalization to offer an efficient flow of goods in intralogistics (GmbH, GEBHARDT Automated Guided Vehicle, 2018).

The increasing popularity of these guided vehicles can be attributed to the explicit adaptability of technology with minimal disturbances for the adjustment of physical blockades. These vehicles offer benefits that make routing decisions based on real-time feedback from the environment. The incorporation of AGVs has increasingly enabled industries to enhance their work efficiency in distribution centres, warehouses, and factory outlets.

These vehicles are designed to enhance the performance and distribution processes of materials both outdoors as well as indoors (Solutions, 2021). AGVs enable efficient communication with control systems offering a live stream of video and data along with the usage of a dedicated network to open the doors. Transportation of products poses to be labourious, and a repetitive task, wherein, usage of the driverless computer-controlled vehicles helps save time, with minimal risk of damaging the components and enhanced overall productivity. Integration of flexible automated vehicle fleets in businesses thereby enabling the workplace to witness a noteworthy transition (Gafert).

Increasing diversification, coupled with demand for higher reliability of the appliances inventory, adds to a long-term value for the storeroom/warehouse managers. This, in turn, enables the businesses to enlarge their product portfolio, with a substantial increase in product sales as well.

Research Questions

- What is the market size (market estimates and forecasts) for the AGVs market in terms of revenue for the forecast period 2019–2028?
- Which vehicle segment accounted for the largest market share?
- Which application segment dominated the AGV market?
- What are the growth opportunities, and factors impacting as well as hindering the growth of AGVs in the market?
- What are the competitive strategies and market share analysis of different segments?

Purpose of the Article: The article illustrates how the integration of automated solutions poses to be an essential factor in increasing the overall profit of any business, by minimizing the delivery time and production costs and enhancing the quality of work. The paper in particular focuses on a market analysis of AGVs, with key areas of discussion being the different market determinants impacting the growth of the AGV industry over the forecast period. In addition to these, the paper also discusses the future implementations of these vehicles, thereby empowering the existing players and the new entrants to accordingly strategize their plans to attain the goal of seamless and better performance.

Key Findings in the Research: The article provides in-depth global AGV market-related data, with a key analysis of opportunities and trends for the same. With constant technological innovations, to expand the manufacturing facilities and integrate the latest automated solutions in warehousing facilities, the market for automated vehicles is projected to witness a substantial rise in growth over the forecast period. The study is a market research-based study that outlines and forecasts the AGV market on basis of regions across the world, applications, and products. The article presents a wide range of market statistics with an in-depth categorization and market sizing for each of these segments.

Literature Review

Over the past few decades, the logistics businesses have undergone incredible variations. Automation and digitalization have been significantly shaping the logistics and supply chain processes and are expected to witness profound acceleration over the forecast period as well. The concept of digitalization is becoming essential and an unavoidable approach for several businesses to remain competitive. For the logistics sector, digitalization is certainly a demanding issue. Digitalization acts as economic, technological, and social opportunities for any logistic business nowadays. Most of the manufacturing businesses are significantly planning to embrace the concepts of Industry 4.0 in their strategic analysis and models to stay competitive (Yilmaz, 2021). Industry 4.0 is expected to comprehensively impact the entire value chain processes (from raw materials to incomplete goods to manufacturing shop floor to distribution and warehousing facilities to packing to transportation of the product to the end-user). With every stage being leveraged to present automation in the next, the supply chain processes are thereby becoming smarter with every advanced stage. Since automation is considered to be an essential part of Industry 4.0, robots are expected to play a key role in the manufacturing industry (Hub, July 24, 2019). Industry 4.0 offers an amalgamation of digital and physical systems. It is engaged in altering the overall planning, product designs, supply chain, and production processes in the businesses by the introduction of connected systems.

The application of Industry 4.0 technological know-how for reconfiguration and reconstruction of supply chains across the globe cannot be overlooked (Publishing). The technologies offer advanced levels of manufacturing efficiencies with the potential to intensely impact environmental and social development (Bai, November 2020). Implementation of technologies has empowered businesses to revolutionize hybrid supply chain models into collaborative, agile, open, and flexible digitalized models. The functional strategies of supply chain processes are gradually witnessing a shift, to cater to the advancement in planning processes which includes the incorporation of analytical and digital solutions. The supply chain industries have been witnessing an upsurge of connected technology throughout the distribution and manufacturing segments in the value chain. Disruptive technologies such as autonomous vehicles and next-generation robotics are increasingly being integrated with sensors, big data analytics, blockchain, and a few different applications.

Material flow management in business environments poses to be one of the most significant features of the logistics systems. Optimization of the material flow, whether in manufacturing or retail, is expected to enhance the overall reliability and productivity (Group). The introduction of a smart material handling approach is expected to minimize the work-related time, thereby maximizing the work precision and accuracy. In today's scenario, distribution and warehousing facilities are engaged in minimizing their costs by bolstering their efficiency and productivity with the inclusion of technologies such as automated storage and retrieval, AGVs, and robotic arms.

AGV-enabled automation of manufacturing facilities helps cater to the requirements relevant to material handling capability, improvement of repeatability and accuracy, ensuring high output volumes, along with minimization of human error.

The history of AGVs goes back several years, with the technology gaining significant traction and becoming a standalone concept nowadays (Rooks, 2001). With the growth of automated solutions in assembly lines and manufacturing facilities, AGVs are becoming a vital element in integrated systems (Hollingum, 1991). AGVs are automated or driverless vehicles that are capable of performing material handling procedures and functions in both traditional and flexible facilities (Hoff). The term "driverless" is used to describe industrial trucks that are mainly used in the distribution and manufacturing settings, which otherwise in a conventional scenario would have been driver operated. Automated vehicles or smart transport systems are largely designed for various logistic solutions and systems which owe some capability to integrate automatically with palletizing robots, conveyor belts, cranes, and others (Systems). These vehicles are gaining prominence in various end-user segments owing to the fact, that they are engaged in the reduction of damage to the inventory and worker requirements. They also make the production scheduling highly flexible, thereby propelling their sales in the market.

The market growth for these vehicles is primarily driven by automation in material handling and the rising adoption of industrial robots. Moreover, increasing wastage due to product damage, along with the delays caused by accidents are also expected to favourably contribute to the adoption of AGVs in material handling processes. Furthermore, unavailability of the workforce, halt of manufacturing operations, and lockdowns imposed by the government in the ongoing COVID-19 pandemic have also substantially boosted the AGV market.

Confluence of Autonomous Vehicles and the Internet of Things (IoT)

The availability of cloud computing platforms and machine-to-machine (M2M) communication have significantly led to the era of IoT. Shared advancements in IoT, autonomous technologies, and robotics, have significantly formed an ideal environment for the implementation of connected autonomous vehicles across varied industries. New-generation of AGVs are smart and capable of working with humans. Technologies such as computer vision augmented reality (AR), low-cost sensors, wearables, IoTs, robotic prehensility, human-robot safety, analytics, and high-performance computing have reduced wastage and increased productivity. With the implementation of automated solutions and technologies, connected industrial vehicles are engaged in changing the overall landscape of industries.

In the manufacturing industry, the robots navigating through the shop floor can easily gather necessary statistics/information from the production line regarding the availability of tools, calibration needs, inventory, and identification of potential hazards. These autonomous robots owe the capability to work continuously and are connected to a back-end system, either to the cloud-based or on-premises systems, which processes the data provided by these machines and consequently performs the tasks.

The flexibility offered by these vehicles has enabled manufacturers to switch from an in-floor conveyor-based or fixed overhead assembly line to the continuously moving AGVs that move along with the component car body on the assembly line. Additionally, with the implementation of these vehicles, the production rate increases, thereby offering room to adjust the workflow. The explicit adaptability of AGV technology is expected to increase its popularity of these among warehouse managers. These autonomous systems offer benefits to making routing decisions on a real-time feedback basis with easier navigational adjustments. Hence, to attain their productivity goals, vendors are engaged in the deployment and integration of solutions that can cope with the changing operational needs and requirements.

Global Market Overview

In the past, AGVs were generally considered luxuries on the factory floor; however, in today's scenario, due to the advancements in battery and sensor technology, these vehicles are considered to be an important part of the new-generation robotic workforce which helps in assisting human labourers to attain momentous levels of profitability and productivity. Rising industrialization has significantly led to constant prerequisites for customized transport and material handling solutions with improved efficiency.

Various manufacturers nowadays are shifting to flexible and automated solutions to attain higher production capacity and efficiency. The few latest applications of AGVs in manufacturing plant location include the employment of a one-directional controller-path for vehicle routing (Egbelu, 1986). One of the collective reasons for the shift towards automation and modernization in the warehouse management are greater capacities for varied types of goods, overstocked warehouses, and grim access to appropriate information (expiration dates, complaints and claims, inventory records, and returns) (Digitalization of Logistics and Intelligent Management of Supply Chain, 2019). It is very much essential for businesses to optimize their warehouse management processes, to stay competitive and relevant in the market. Setting up automation in the warehousing services enables businesses to necessitate the usage of customized equipment and machinery along with the fleet of drones or AGVs. The incorporation of AGVs enables transmitting the tasks generated by systems such as processing demands based on predictive models and big-data analysis along with the real-time demands.

AGVs are increasingly being integrated among the various manufacturing and warehousing/distribution segments of food & beverage, retail, automation, pharmaceutical, chemical industries, and many more. However, the purchase, as well as the implementation of these systems, is based on economic considerations. Usage of AGVs can be segregated into the following end-user areas:

- Production-integrated application of AGV trucks as assembly platforms;
- Disposal and supply at the production and storage areas; and,
- Recovery, particularly in the wholesale trade.

These vehicles are considerably simple machines for performing varied light-weight and heavy-duty tasks. An AGV poses to be a standard for the expansion of intelligent logistics (Shihua Li, 2018). Reduction in labour costs, scale for backing the automation processes, along with enhanced productivity are expected to bolster the need for this business equipment. The incorporation of AGVs in the businesses has thereby significantly transformed the movement of materials within the distribution and manufacturing facilities.

Factors Bolstering Market Growth

- *Increasing Demand for Automation in Material Handling Processes*

Automation in the material handling processes is considerably one of the solutions, which most businesses are focusing upon nowadays, for productivity increment, better standards of safety, floor space optimization, and proper allocation of workers to different activities (Melo, 27th June 2020). Easy connectivity, e-commerce, urbanization, and mass personalization are expected to reform the overall landscaping businesses in logistics and manufacturing material handling equipment and systems. Supply chains across industries for distributors and manufacturers are facing enormous challenges across talent shortages, multichannel fulfillment, and improved analytics, along with the usage of newer technologies such as AR, M2M, robotics, and wireless systems. In addition to these, there is a continual focus on sustainability and cost reduction.

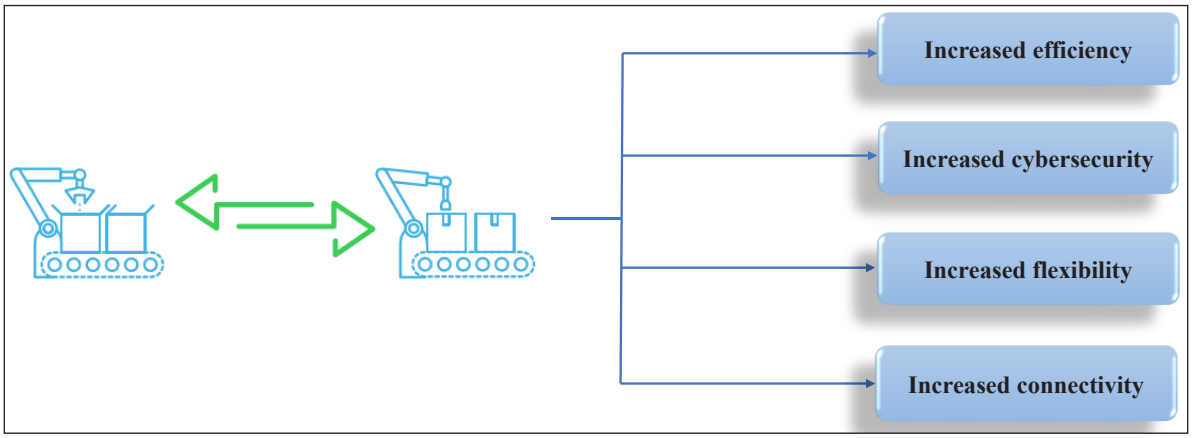
The Industrial Internet of Things (IIoTs) is augmenting major transformation, as these increases the interconnection between analytics and connected devices (Schneider Electric). Smart manufacturing enterprises are expected to take hold of these opportunities to maximize

safety and efficiency via intuitive collaboration and networking with their users. Implementation of a smart and automated approach for material handling processes in businesses enables enhanced accuracy, reduced downtime, and increased productivity. Hence, processes across the supply chain system, including material handling systems, are required to grow to accommodate flexible needs and requirements with predictive planning.

Latest automation technologies and solutions are gaining significant traction and hence, becoming one of the essential tools. One of the major buying influences for the end-users includes an increase in system throughput requirements with the flexibility of proposed systems. The flexibility of automated solutions is paving the way towards "enhanced and latest configurations of workflow" such as the way packages, parcels, and items move across the warehousing system (Corporation, 2021).

Automation in material handling processes confirms efficient transportation of material within the same bay, or from one place to another in manufacturing areas or two different buildings. The automated approach is significantly one of the key approaches being incorporated by the companies to attain their goals relevant to optimization of floor spaces, productivity increment, allocation of workers with value-added services, as well as higher standards for the safety of factories.

In addition to these, factors such as variability and environmental uncertainty of the processes and products are expected to have bolstered the demand for flexible solutions in various industries. Administrative automation, manufacturing automation, and design automation are the key steps for flexible manufacturing processes. AGVs, along with industrial robots, are gaining prominence in the automated material handling processes. The AGVs are widely used for automated material handling, retrieval, and storage systems, thereby enabling easy transport of materials from unloading as well as loading stations. AGV technology is considerably versatile, intelligent, and flexible and offers flexible solutions to the integration process of automated transportation lines. Few benefits offered by the implementation of smart and automated solutions such as AGVs in material handling are illustrated in the figure mentioned below:



Source: Electric (2018).

Fig. 1: Benefits Offered by the Implementation of AGVs in Material Handling

Hence, the implementation of smart technology solutions for any material handling areas such as automated warehouses, conveyor systems, retrieval and storage systems, or sorting and picking up facilities enables to quickly build more connected, efficient, and safer systems.

- *Replacement of Traditional Batteries with Lithium-Ion Batteries*

The emergence of new generation equipment and batteries by various global manufacturers emphasizes that lithium-ion batteries owe the capability to compete with the performance of petrol, with no hassles. Preference for automated equipment or technically advanced equipment or tools is expected to open various avenues for the manufacturers. With increasing necessity and emphasis of the warehouse managers on reduction of costs and enhancement of operational efficiencies, the AGVs are gaining significant traction in demand. The Lithium-Ion battery technology for these AGVs is being increasingly preferred over the traditional lead-acid batteries. In addition to these, the incorporation of the Li-ion batteries enables the companies to provide the terminals operating the AGVs, with the following benefits (Konecranes, 2021):

- Recharge up to nearly three times more than the lead-acid batteries;
- Enhanced efficiency with lesser deadweights;
- Faster charging time.

The upgraded and advanced equipment operates autonomously and quietly, thereby proving to be cost-efficient as well as time-efficient. With such benefits and features, lithium-ion batteries have proven to be a tested and preferred choice among businesses, thereby impacting their overall productivity in warehouses and distribution facilities, hence driving the demand for AGVs in the future.

- *Implementation of High Safety Standards at Workplaces*

The concept of driverless vehicles might be in the far-off future for consumers, however, in the manufacturing industries, these automated vehicles are increasingly gaining traction to enhance manufacturing flexibility and increase the productivity. In addition to the efficiency factor, automated solutions are also about safety. Moving the goods and items in a controlled way in warehouses, manufacturing, and distribution facilities result in a lesser number of injuries and damages to the pallets, goods, as well as racks. One of the key visions is to minimize the number of accidents, i.e., reach the level of zero accidents (Andersson, 2018). To address the increasing number of workplace accidents, manufacturers have started implementing various safety protocols in production units and warehouses such as safety in transportation, explosive safety, chemical safety, radiation safety, machine safety, as well as a checklist for inspections and training aids. Usage of AGVs is considered an important part of the safety measures being implemented by the manufacturers to assure a safe working environment for the workers.

AGVs which are associated with the manufacturing execution systems, and enterprise resource planning systems, are engaged in using cutting-edge navigation procedures, thereby becoming an essential part of make-to-order and synchronized manufacturing processes (Lydon). The innovative safety features offered by these vehicles imply that there would be no damage to the machinery, buildings, or products. In addition to these, the AGVs help in enhancing the material handling efficiency, productivity, and consistency. Hence, these approaches prove to be significant for hazardous areas, repetitive tasks, and longer distances, with enhanced worker safety.

Market Restraints

- *High Initial Investment Cost of AGV*

One of the significant factors restraining the AGV market growth includes the high cost of these vehicles. Despite increasing the bottom line of operations, the upfront cost of programming, manufacturing, and engineering a free-range system is expected to be significantly high. Purchasing an AGV is considerably more expensive than hiring workers or personnel or using any other type of equipment which includes forklifts. The savings are particularly realized in the long term by the businesses opting for the same. The initial investment is expected to pose as a hindrance in cases of small-sized businesses or operations which do not owe the capability of having access to such expensive capital.

- *Restrictive Environment Requirements*

The unmanned guided vehicles essentially cater to the highly specific working environment. With the presence of unfavourable environmental conditions, the performance of AGV is expected to be restricted. A few of the environmental constraints include factors related to flooring, abrasion resistance, ambiance light and dust, levelness, and flatness (Network). To have a smooth and longer running of the warehousing and distribution facilities, it is thereby essential to cater to such challenging environmental requirements. The presence of a restrictive environment in the warehousing facilities is thereby expected to hinder the efficient working of autonomous robots, thereby negatively impacting the overall market growth of the same.

Market Opportunities

- *Increasing Demand for Artificial Intelligence (AI) in Factories*

AI is one of the latest trends in various business segments of the industrial sector companies. With the implementation of the correct combination of AI technologies, manufacturers are expected to improve flexibility, bolster efficiency, enable self-optimizing operational processes, and accelerate manufacturing processes (Daniel Küpper, April 18, 2018). The inclusion of AI in different industries is projected to minimize conversion costs by nearly 20 per cent. Usage of AI in the factories enables the producers to produce and develop innovative tailor-made products and distribute the same in a shorter lead time.

AI offers machine learning to perform operating tasks more smartly. The implementation of these enables producers to decide on the best sequence of events, thereby achieving goals in a shorter duration and managing the operations remotely on a real-time basis.

To cater to the changing competitive scenario, it is becoming increasingly important for the manufacturers to understand the analytical capabilities and completely transform their businesses as per the AI culture. The incorporation of AI technology is expected to completely transform different aspects of businesses such as the business support functions, research & design to project management.

Technologically advanced economies with higher per-capita GDP are projected to significantly rely on AI-based automation over the next decades, to power the output gains, to attain the GDP targets. For instance, In Germany, it is expected that AI will enable significant mechanization, thereby yielding nearly 4 per cent of the additional GDP by the year 2030 (Matthias Breunig, October 2, 2017).

AI-based machinery is expected to create solutions for complex problems within the given space. In the manufacturing sector, AI can detect maintenance time for robots and other machinery by tracking operating conditions and the performance of the factory-based tooling. Developments in computing power enable machines to learn from past experiences, recognize patterns, and organize as well as understand unstructured data, thereby improving the overall future performance. For instance, machine vision is one of the recent developments that enable robots to see the objects, analyze them, and then take the required action or decision (machine vision includes the usage of cameras that are more sensitive). The inclusion of AI enables robots to achieve a proper understanding of the environment, thereby attaining higher workforce productivity gains.

Incorporation of these intelligent solutions is thereby expected to offer businesses with a comprehensive range of solutions, and a complete guarantee of new scaleups and technologies. Hence, over the next few years, the concept of AI is expected to enable autonomous vehicles to gain majority of demand in the manufacturing and distribution facilities.

Impact of COVID-19 on AGVs Market

The prevailing pandemic crisis has led to economic turmoil across the globe. COVID-19 has led to an unparalleled situation for the manufacturing sector, due to several restrictions being imposed to contain the situation. Due to disruptions in the supply chain, the flow of finished goods and materials had come to a standstill across different regions in the world. With the impact of the situation being challenging, the manufacturing industries incurred great losses during the pandemic in terms of both revenue and profit gains. Small and medium enterprises (SMEs) have been considered the worst hit due to financial losses and substantial layoffs. With the immediate impact of this global crisis being unprecedented, the manufacturing sector is completely emphasizing on imposing essential steps for survival and prosperity post the pandemic situation.

Advancements in technology are expected to play a vital role in maintaining business continuity. Increasing digitalization and deployment of automated solutions are projected to bolster a quantum leap in the overall manufacturing business framework over the forecast period. The companies with robust digital capabilities have proven greater resilience, with the pandemic offering further evidence of such resilience, particularly in cases of supply-chain operational segments and employee engagement examples. Segments gaining significant momentum post this crisis are expected to focus on the incorporation of smart and connected technologies in businesses. For instance, cognitive technologies, quantum computing, analytics, robotics, the Internet of Things, AI, additive manufacturing, and a few more are expected to be gaining substantial traction (Deloitte, June 2020).

Further, the COVID-19 pandemic is projected to offer several opportunities for the AGVs market, because incorporation of such solutions in the industries owes the capability to cope up with the scenario, thereby enabling the industries to upscale their production operations. Hence, the adoption and integration of advanced technologies into businesses would essentially pose as a significant success factor for the same.

Research Methodology

This study entails a detailed market research-based study with a key analysis of market dynamics impacting the AGVs for logistics along with market sizing and forecasts over the projected period. The research focuses on different market drivers, trends, challenges, opportunities, regulatory policies, and strategies impacting market growth over the forecast period. The forecast analysis will be in terms of revenue at the global and regional levels, with the key trends varying for 2019–2028 (forecast period).

Research Objectives

The objectives of the research study can be illustrated as:

- To study the evolution of autonomous vehicles, with a major focus on recent technological trends in the market;

- To emphasize on the future aspects, challenges, and implications of automated guided/autonomous vehicles in the market;
- To recognize the factors bolstering the growth of AGV businesses across different industry verticals over the forecast period; and,
- Impact of COVID-19 on the autonomous guided vehicles market.

Inclusions

- Tow vehicles, unit load vehicles, forklift trucks, pallet trucks, AGCs, and others (light-load and assembly line);
- Automotive, retail, F&B, healthcare, aerospace, and others; and,
- North America, Europe, Asia Pacific, Latin America, and Middle East & Africa.

Scope of the Study

The article contemplates the current scenario of the Global AGV market for the forecast period of 2019–2028. The study focuses on regional as well as segment revenue for assessing the overall market scenario. It further emphasizes on the competitive strategies and market share analysis.

Description

Enclosed aspects comprises of market size and estimates of the autonomous vehicles market in terms of revenue over the forecast period; as well as segmentation based on regions covering North America, Europe, Asia Pacific, and the rest of the world.

There are several methods for forecasting the data. A few of these include the market share method, market survey method, market tests, statistical methods, and a few more. The statistical method further comprises of exponential smoothing, extrapolation, and regression analysis. The extrapolation method is termed a trend projection method, which poses to be a bit more complex than the simple projection method. The method includes plotting the revenue same, for the historical years, and then stretching the same for the next few years. Extrapolating the numbers provides analysis of data for the future period. In this study, the top-down approach has been used to estimate the data, wherein, the data was analyzed for the state of the global economy and detailed further to different segments.

The process of market size estimation and forecast can be explained as follows:

Market Size Estimation and Forecast

- Valuation of historical market revenues based on secondary data insights;
- Projecting market recast by assigning weightage to market forces (opportunities, restraints, and drivers);
- Freezing historical data and forecasting the market size estimations based on strategies, outlook, and trends;
- Consideration of region-specific, geography-specific revenues, vehicle-specific demand for market segmentation; and,
- Consideration of product demand outlook for segmentation by application type.

The overall evaluation further helps in determining the insights about the factors which are engaged in propelling the market growth and the factors which pose to be restraining its growth and development. The given statistics are consequently attained from secondary sources via various company annual reports, investor documents, journals, and statistics published by various market leaders. The data can be analyzed owing to the below-mentioned factors:

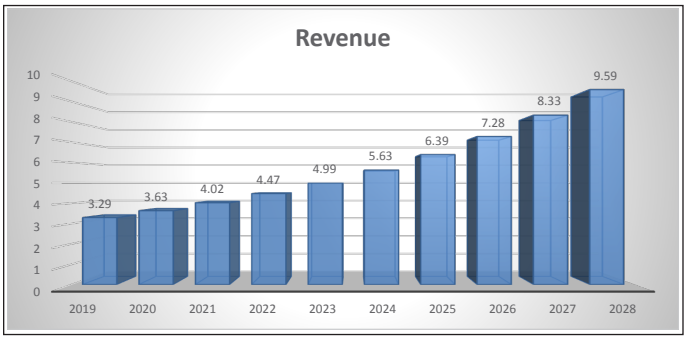
- Demand and supply estimates;
- Market developments and trends; and,
- Future aspects and opportunities offering insights on product commercialization as well as expansion in different regions.

Findings and Market Analysis

Global Market Overview

The global AGV market was valued at $3.29 billion in 2019 and is expected to reach $9.59 billion by 2028, growing at a CAGR of 12.62 per cent. Profound usage of automated vehicles in the distribution centres, warehouses, and manufacturing facilities follows configurable tracks for easy optimization of picking, storage as well as transportation of products. The distinguished advantages being offered by these vehicles enable the logistics and transportation firms to install AGVs to bolster operational efficiency.

The market is witnessing a significant rise in growth due to the presence of vendors such as Daifuku, JBT Corporation, Toyota Industries, and Kion Group, among others, which offer a diversified range of products in different verticals.



Source: Results of the analysis.

Fig. 2: Global AGVs Market 2019–2028 ($ Billion)

The above-mentioned graph illustrates the overall revenue for AGVs market for the forecast period 2019–2028.

Based on the end-user segment, the global AGV market was dominated by the automotive segment, which accounted for a 32.15 per cent share in 2019.

Based on the vehicle segment, tow vehicles and unit load vehicles accounted for nearly 30.81 per cent and 26.42 per cent in 2019, respectively.

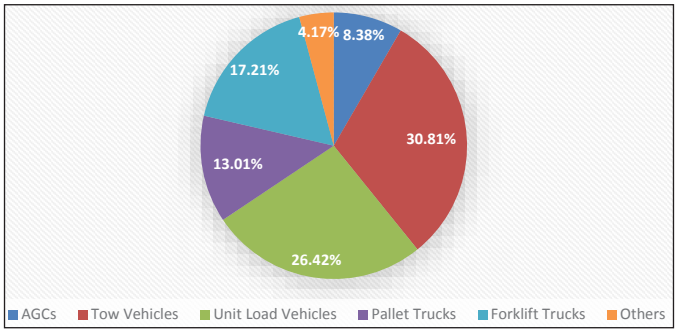
North America accounted for the largest market share in the global AGV market in 2019 and is expected to continue its dominance over the forecast period owing to the growth of industries such as online retail and automotive, among others. In Europe, the presence of major AGV manufacturers such as Dematic, Daifuku, JBT Corporation, AGVE, Milvus Robotics, KUKA Robotics, and Seegrid Corporation makes it a strong market.

Segment Analysis

- *Based on Vehicle Type*

Based on the vehicle segment, the market can be segmented into tow vehicles, unit load vehicles, forklift trucks, pallet trucks, AGCs, and others.

Growing usage of tow vehicles can be attributed to the fact that this offer significantly more economical solutions than other solutions, wherein, more than one load can easily be moved. These vehicles are used in industries such as aerospace, automotive, food and beverages, and retail, for the movement of products over long distances, sometimes in the outdoor areas, in between buildings, and in larger distributed systems wherein the runs are usually longer. Further, these vehicles also help in the movement of approximately 16 pallet loads at a given time, thereby eliminating the usage of manual trains or fork trucks.



Source: Results of the analysis.

Fig. 3: Vehicle Segment Analysis of Global AGVs Market (In Terms of Market Share)

Unit load vehicles are used in environments that involve the execution of specific tasks just like mission assignments. These vehicles are usually used along the conveyors with storage retrieval systems or assembly/ manufacturing operations. The unit load AGVs are the most viable option for the longer distances, repetitive types of tasks, or in hazardous areas. Since these AGVs are autonomous, they help in improving worker safety because of the reduced operated forklift traffic, reduction of human labour, and the reduction of potential product defects because of the unit's controlled and precise movements. Usage of these AGVs also enables trackable product timing and delivery. In addition to these, ease of reprogramming is also possible based on the navigation type, which proves to be cost-efficient when compared to relocating the conveyor.

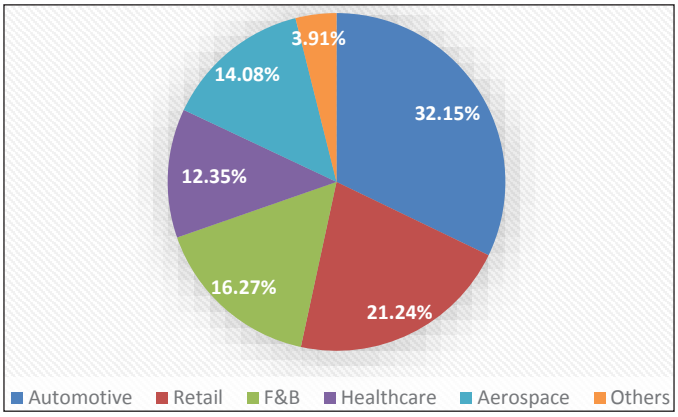
- *Based on Application Type*

Automated vehicles are used to increase the efficiency of manufacturing processes as well as the material handling industry. These vehicles are gaining prominence in the medical-industrial segment, particularly in hospitals. AGVs are increasingly becoming popular in the healthcare industry since they can efficiently complete repetitive tasks in a shorter period. In healthcare facilities, these systems are gaining traction for pharmacy medicines, central transportation, supply of food, laundry, and wastes, handling of bulkier materials, as well as biomedical instruments (Gregor, December 2017). The inclusion of automated solutions is expected to reduce the workload, control the costs, as well as streamline the traffic flow of materials in the hospital. Hospitals are increasingly

engaged in the fulfillment of these requirements with the usage of modern logistics systems, which are hence anticipated to impact the operations of the entire facility along with its economy. Factors expected to bolster the adoption of AGVs by healthcare businesses include:

- Rising floor plate related to the latest hospital builds, due to enhanced circulation space along with the larger ratio of single-patient rooms.
- Advancement in sensor technology is anticipated to have impacted the performance of AGVs in different areas. These include environment recognition and collision avoidance, material tracking, fleet management, and navigation, along with the capability to maintain individual vehicles and conduct detailed diagnostics.
- An increasing need for enhanced disinfection and sanitation facilities in the hospital areas to reduce the chances of hospital acquired infections.
- Growing focus on the minimization of workplace injuries for the hospital staff, doctors, and patients.

Hence, the implementation of AGVs in hospitals helps in reducing the burden on hospital employees, thereby enabling them to dedicate more time to the care of patients. These vehicles thereby help in minimizing job accidents, tracking the movement of materials, and prioritizing the tasks to increase the productivity factor in healthcare settings.



Source: Results of the analysis.

Fig. 4: Application Analysis of Global Automated Guided Vehicles Market (In Terms of Market Share)

The above-mentioned graph illustrates that the automotive sector accounts for the largest market share in the AGV market in 2020. The automotive sector was projected to be valued at $1.16 billion, and the retail sector was valued at $0.77 billion in 2020.

In addition to the healthcare segment, technologies such as AGVs are considered one of the most intelligent automated equipment being widely used in the automotive industry as well. The automakers are engaged in completely deserting the obstinate conveyor belts with the belts which make the production processes more efficient (Intelligence, 2017). Implementation of such vehicles in the automotive industry allows the manufacturers to respond quickly to a varied number of product specifications. For instance, these vehicles can easily cater to the customization request from a customer without making major alterations in their assembly and manufacturing line. As per the specifications of fitment order in the vehicle, along with custom parts, these vehicles can be easily programmed to avoid delays at the individual workstations. Further, the flexibility offered by these enables the manufacturers to switch from an in-floor conveyor-based or fixed overhead assembly line to the continuously moving AGVs which can easily move along with the component car body on the assembly line. Hence, with such benefits, market demand for AGVs in the automotive industry is expected to witness substantial growth over the forecast period.

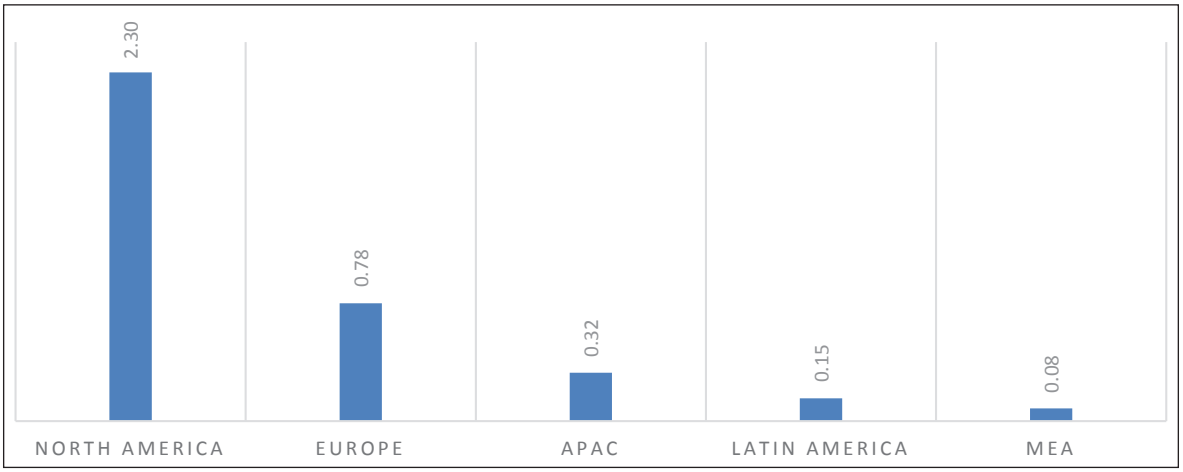
- *Based on Regional Segments*

Based on region, North America reported the largest share in the AGVs market. In 2020, the AGV market in North America and Europe was valued at $2.30 billion and $0.78 billion respectively.

North America is considerably one of the first and major markets to have adopted AGVs in warehouses, distribution centres, and production environments. In today's scenario, unlike the traditional AGVs which follow a predetermined bidirectional path, the latest and most innovative automated vehicles nowadays are being well designed for packaging and picking the goods in an organized and efficient manner.

Europe is expected to witness substantial demand for AGVs during the forecast period. Companies such as AVT Europe are engaged in offering tailored applications which ranges from handling heavy loads to lightweight transport systems (NV). Other application areas such as aerospace and healthcare are adopting AGVs to cater to the improvement in quality of their operational services. For instance, in 2018, Swisslog (a subsidiary unit of Kuka Robotics) announced a contract to build an automated high-bay pallet warehouse for Kühne (one of the largest

logistics providers in Europe). Warehousing & distribution facilities of the company are largely engaged in the implementation of integrated automation solutions for various distribution centres and warehouses.



Source: Results of the analysis.

Fig. 5: Geographical Analysis of Global Automated Guided Vehicles Market in 2020 ($ Billion)

Developing Asian countries such as China and Japan are also expected to witness an increase in market penetration owing to the rising expansion of automotive industries and e-commerce sectors in the region.

Discussion

Theoretical Implications

According to Hoff, AGVs are automated vehicles that owe the capability to execute the material handling operational activities in various facilities. In today's scenario, the automated solutions are anticipated to traction in growth, owing to the factors such as increasing automation in the material handling processes, replacement of traditional batteries with lithium-ion batteries, and implementation of high safety standards at workplaces. According to Lydon, automated vehicles focus on cutting-edge navigation procedures, and play a vital role in manufacturing and warehousing facilities. Explicit adaptability of the AGV technology is expected to increase the popularity of these among warehouse managers by the removal of barriers. However, factors such as the high initial investment cost of AGV, and restrictive environment requirements are expected to restrain the market growth over the forecast period.

Analysis used in the article offers a detailed description of the factors impacting the overall market. The information for studying the market was gathered from secondary sources such as company annual reports, press releases, market journals, as well as government and non-government agencies, and websites. Key objective of the study was to evaluate the current scenario of the market and estimate the forecasts for 2019-2028.

The market has been segmented based on vehicle (AGCs, tow vehicles, unit load vehicles, pallet trucks, forklift trucks, and others) application (automotive, retail, food & beverage, healthcare, aerospace, and others), and regions (North America, Europe, Asia Pacific, Latin America, and Middle East Africa).

Key Takeaways from this Study

The global market has high growth potential. The study conducted by Hollingum, focuses on various applications of AGVs in the industrial sector, with a major focus on the free-ranging automated solutions and their expanding usage. In today's scenario, these vehicles are gaining significant traction among various end-user segments such as food & beverage, retail, aerospace, automotive, healthcare, and others. The profitability potential is driving vendors to invest in the market.

A rising number of mergers & acquisitions, along with collaborations among the leading market players helps maximize varied economic and environmental benefits and thereby, offers enhanced profitability and operational efficiency to their businesses.

Segment-wise takeaway includes:

- Tow vehicles segment account for the largest market share and is projected to gain a significant rise in demand in comparison to the other product segments.
- The retail sector in the application segment accounts for nearly 21.24 per cent in 2019 and is anticipated to witness a substantial rise over the forecast period. This can be attributed to the fact that integration of these vehicles in retail businesses offers efficient operational flow in warehouses and distribution centres, thereby transforming their overall material handling capacity.
- APAC is expected to witness strong potential in the market over the forecast period 2019-2028, owing to:
  - Rapid expansion of the e-commerce sector;
  - Paradigm shift in the automotive industry; and,
  - Constant technological innovations, to expand the manufacturing facilities and deployment of the latest automated solutions in warehouses, and manufacturing facilities.

The global AGV market is highly concentrated with many local and international players in the market. Major market players in the industry include Toyota Industries, Kion Group, JBT Corporation, and Daifuku. These players are engaged in introducing newer and advanced technologies in their product segments, thereby posing considerable competition to their counterparts in the market.

Practical Implications

The paper is a market research-based study, wherein regional and global estimates, and forecasts have been discussed. Market forecasting and share analysis enable both small-size and large-size businesses, to cater to the strategic decision-making processes and assess the overall industry positions in terms of different market segments. Forecasting and evaluating the future opportunities and trends of data serves as the first step for all the business activities of any small-sized or large-sized firm. The forecasting process enables the firm to:

- Identify the position of key players in the market;
- Identify the resource requirement in terms of labour, money, and raw materials;
- Helps to identify the factor responsible to boost the overall market demand and accordingly strategize their models and plans to compete in the market; and,
- Enables both large-sized and medium-sized businesses to understand and get idea about customers' tastes, requirements, and preferences.

Major companies in the market are engaged in differentiated distribution approaches to cater to customer requirements across the different regions of the world. Understanding why and how the customers decide on products enable the businesses to accordingly launch their products in the market. This article emphasizes on different market-related information which thereby helps the vendors gain a competitive edge and profitability in the industry. The complete market analysis enables the businesses deploying autonomous vehicles across, to discover their potentialities to compete in the market.

Conclusion

Growing industrialization has led to continuous want for customized transport and material handling solutions for fueled proficiency. Logistics- and retail-related businesses are increasingly engaged in the implementation of robotic solutions and analytics for the improvement of workflow, reduction in costs, and enhanced flexibility. To boost productivity and margins, businesses are engaged in the adoption of data analytic tools for the identification of improvement areas, particularly in warehousing and logistics operations.

In today's scenario, the market is engaged in placing larger requests on AGVs, owing to their critical role in manufacturing processes with different lot sizes. The solutions and components in such vehicles work flawlessly and seamlessly thereby accelerating the overall production processes, and making it more cost-effective and safer (AG).

In addition to this, the AGVs are considered, to be valuable collaborators when they interface with the planning, management, and execution of the software. Integration of AGVs in the warehousing and distribution channels of industries is expected to yield better and seamless performance. In addition to these, these vehicles enable maximized output and productivity, minimal inaccuracy in the workflows, as well as waste products.

The AGVs market demand is expected to foresee a huge rise globally over the forecast period. Technological advancements coupled with the expansion of product line-up and new developments act as key strategies

for vendors, thereby propelling the demand for these vehicles in the market. Key vendors across different regions are thereby expected to increase their investments with the introduction of various innovative techniques and solutions, hence, enabling the professionals and warehouse managers to perform their operational tasks with ease and efficiency.

Limitations

The study includes an in-depth evaluation and analysis of secondary research. Primary research was not conducted.

Future Research Directions

With the rising competitiveness in order fulfillment, manufacturing facilities, distribution, and retail sector, it becomes essential for businesses to emphasize on the ways to differentiate themselves and enhance their supply chain processes. Increasing automation demand enables the manufacturers to add a fleet of AGVs to their production line, to increase their profitability in business.

AGV poses to be a long-term and cost-effective solution for completely transforming the reliability, efficiency, and accuracy of businesses. The AGVs are projected to expand with a significant CAGR of 12.62 per cent over the forecast period of 2019–2028. Deployment of AGVs in operations is anticipated to result in minimal picking error and efficient processing time, thereby catering to the future goals of businesses. With the growing demand for AGVs, it thereby becomes essential for the market players to emphasize more on developing customer-centric solutions and platforms for their business segments to increase profit margins and sales.

Increasing market demand for AGV can further be analyzed, for the forecast period of 2020–2030. Sales of major AGV providers can be aggregated to arrive at an estimate of the market size in terms of volume as well. The same approach was used to calculate the market size in terms of revenue. Segmental volumes can be calculated via the bottom-up approach, which involves the analysis of segment-wise financials of the key market players. Further, work can be done concerning the in-depth analysis of every segment in detail region wise.

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