Advances in Consumer Research
https://acr-journal.com/
Volume-3 | Issue-4 |April 2026
Original Researcher Article

Study of the use of material handling equipment in Warehouses in Delhi NCR

Rajesh Chander [1], Dr. Bhakti Pawar [2], Dr. Shilpa Arora[3]
[1]Research scholar, School of leadership and management, Manav Rachna international institute of research and studies,
Email ID: Rajeshchander1@gmail.com
[2]Associate Professor, School of leadership and management, Manav Rachna international institute of research and studies,
Email ID: Bhaktipawar.slm@mriu.edu.in
[3] Associate professor, Mittal school of business, Lovely professional university,
Email ID: Shilpa.34467@lpu.co.in

ABSTRACT
In any industry, supply chain is crucial for efficient management of raw materials and timely completion of production process. But in mid-sized companies, businessmen have little knowledge about the type of machinery used, skills required, and efficiency of manual, semi-automatic, and fully automatic. This research aims at systematic literature review of supply chain management. To develop a knowledge base of selecting a machinery type most suitable and help in protecting businessmen from marketing and lack of knowledge problems. Here, 66Research papers are considered from the year 1999, from Scopus database to arrive at conclusion about the Themes, trends, type, area, keywords most frequently used in this subject..
Keywords: Supply chain Management, raw materials, machinery type, manual, semi-automatic and fully-automatic.

INTRODUCTION:

Moving things from start to finish - turning basic stuff into what people buy - that's what managing the chain covers. This work means organizing how a business gets products made on purpose, aiming to give better worth while standing out somehow. Overseeing the path of goods and services includes every step needed to build something ready for sale. When companies fine-tune these steps, waste drops and delivery speeds up without slowing down. What results is smoother handoffs from supplier to shopper through smarter coordination behind the scenes.

Smooth handling of supplies helps companies stay quiet in public view while avoiding expensive product takebacks and legal trouble. A plan forms first, followed by finding where to get parts needed for making things. Making products comes next, after which they move to stores or customers through delivery networks. Getting items back when necessary completes the cycle. Watching expenses closely matters just as much as ensuring materials do not run short during operations. People managing these steps must pay attention to both spending and availability.
Things move thanks to one sort of mechanism. Yet shifti ng happens in a separate way using another.
A completely different approach handles the task in a thi rd case.
A few systems operate without any human help at all. No tably powerful, they rely on current Robotictechnology.
Machines moving items bring sharper accuracy, quicker movement, plus safer conditions indoors.Special adjustm ents appear often, built around how each warehouse func tions differently. In motion,
these zones sometimes feature robots that roll freely - kn own as AMRs. Objects big and small travel faster thanks to these units. Their paths come preloaded, allowing self-guided movement across zones. Machines moving on their own might just save money while making fewer mistakes during tasks involving physical items. Where gear runs loud or chemicals linger in the air, these robots keep working without putting humans at risk. Shifting roles comes naturally to them - rewriting their job takes little time, even when daily patterns change unexpectedly.Top modules fit onto AMRs depending on what the job needs them to do. Starting with tools that handle specific tasks, these additions change how the robot works. A different piece attaches here when sorting packages versus moving carts. Each setup adjusts for one kind of work only. Some robots carry lifts; others get arms. Whatever the task demands shows up in which part sits on top. Function follows form every time.

One step beyond manual work, semi-automated tools rely on an operator yet run on power sources - gas, diesel, or batteries. Moving goods inside warehouses happens through machines instead of hands alone. Think conveyor belts, cranes, or hoists - they're common picks for shifting heavy loads. Efficiency gets a boost when these systems go live, especially where size or weight slows things down. Setting them up isn't quick - it takes effort, money, and careful planning. Once built, changing their layout brings trouble; they stay put, fixed in place. Should workflows shift, rigid setups could become problematic. Under those conditions, tearing out or rearranging the transport line moving items from storage to repair might be needed - costing both time and money.

Moving things by hand happens when people carry out tasks without machines. Workers shift items across warehouse floors using their strength alone. This approach shows up often where operations stay small or loads weigh little. Tools like trolleys, hand carts, or walkie stackers help make lifting easier. Online shopping keeps

expanding, so more storage sites pop up near rail lines and highways. Being close to roads cuts down delivery delays and fuel bills. But drawing workers from nearby areas grows harder every year. Some places struggle to hire enough hands on short notice. Adjustments in how work gets done may ease pressure behind the scenes.

Research methodology

This section is divided into three subparts:

Collection of data.

For the collection of data, this study adopted the three-step process.

Figuring out the search terms.

Relevant keywords like "Forklift, Reach Truck", "Battery Operated Forklift", "Warehouse for storing materials", "Operators qualifications and their skills", "AGVs used in the warehouse" and "AGVs cost effectiveness as compare to Forklift", "Reach Truck", "Battery Operated Forklift" which are driven by operators and "The maintenance difficulty of managing MHE in the warehouse"

Articles having any of the above keywords in their title or central to their discussion were selected for this study.

Setting up the boundaries/filters for the search.

We took January 1995 as the Starting year for this review. Subjects were management, accounting and finance, Economics and Operations management. Full text and open Access articles were taken into this study.

Assessing the quality of the papers.

Scopus database was used for collection of articles. Books were not the part of them.

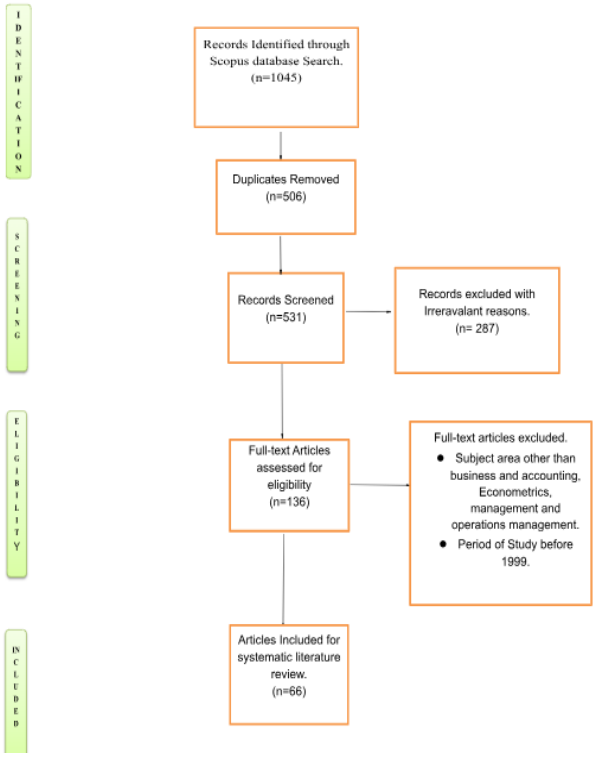

Figure 2.1 Data Collection Process

3. Data analysis and Synthesis

Out of that initial sweep, once duplicates got filtered out, researchers pulled together sixty-six unique studies. Each one made it into the final review without being left behind. In the end, patterns began to emerge when they grouped findings differently, showing results through charts and visuals that mapped things clearly.

3.1 Keyword Analysis

Keywords most commonly used by the researchers are identified with a minimum 5 co-occurrence of each word. Here in this study, 979 keywords were found but only 20 of them meet the threshold of 5 keywords.

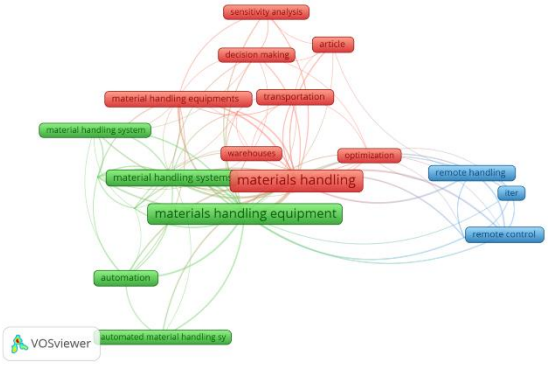

Figure 3.1 Keyword analysis

Keyword with highest occurrence is Material handling with 44 occurrence and 120 link strength, followed by material handling equipment with 38 occurrences and 105 link strength, then material handling system with 11 occurrences and 42 link strength. Followed by material handling equipment with 9 occurrences and 29 link strengths. Then article, automation and remote handling with 8 occurrences (each) and 9, 24 and 27 link strengths respectively. Then manufacture, remote control and transportation with 7 occurrences each and 31, 27 and 11 link strengths respectively, then automated material handling system, material handling system, remote handling system with 6 occurrences each and 14, 13 and 23 link strengths respectively, and finally decision making, genetic algorithms, material handling system, optimization, sensitivity analysis and warehouses with occurrences 5 each and link strength 15, 19, 19, 22, 14, 11 and 17 respectively.

Research over the years

To know the research trend, we have analyzed the numbers of research papers done over the years in the subject. Table and Figure will give a clear description of it.

Table 3.2.1 Relative Growth Rate (RGR) and Doubling Time (DT)

Year	Annual Records	Total Records	ln(W_1)	ln(W_2)	Growth Rate (RGR)	Doubling Time (DT)
2009	5	5	0	1.6094	–	–
2010	1	6	1.6094	1.7918	0.1918	3.6139
2011	3	9	1.7918	2.1972	0.4072	1.7018
2012	2	11	2.1972	2.3979	0.2079	3.3334
2013	6	17	2.3979	2.8332	0.4432	1.5636
2014	4	21	2.8332	3.0445	0.2145	3.2304
2015	8	29	3.0445	3.3673	0.3273	2.1174
2016	3	32	3.3673	3.4657	0.1057	6.5541
2017	4	36	3.4657	3.5835	0.1235	5.6105
2018	4	40	3.5835	3.6889	0.1089	6.3648
2019	4	44	3.6889	3.7842	0.1042	6.6513
2020	2	46	3.7842	3.8286	0.0486	14.2471
2021	3	49	3.8286	3.8918	0.0718	9.6491
2022	5	54	3.8918	3.989	0.099	7.0011
2023	2	56	3.989	4.0254	0.0454	15.2806

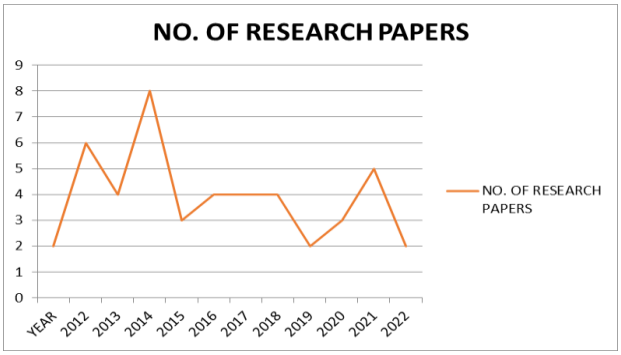

Figure: 3.2.1 No of research papers.

The Highest no of Papers (8) were published in the year 2015, followed by 2013 with (6) papers, then in 2009 and 2022 (5), then in years 2014, 2017, 2018, 2019 (4) in each year, then in 2011, 2016 and 2021 (3) each, then in years 2012, 2020, 2023 (2) each. The relative growth rate is highest in the year 2013 at 0.443213 rate and lowest in year 2021 at 0.07182 rate.

Table: 3.2.2 Annual ratio of growth /annual growth rate/compound annual growth rate.

ANNUAL RATIO OF GROWTH /ANNUAL GROWTH RATE/COMPOUND ANNUAL GROWTH RATE				
YEAR	NO. OF PUBLICATION	ARoG	AGR	CAGR
2009	5			-1.37333
2010	1	0.2	0.8	-2.86667
2011	3	3	-2	-1.62222
2012	2	0.666667	0.333333	-1.93333
2013	6	3	-1	-1.31111
2014	4	0.666667	5.333333	-1.46667
2015	8	2	2	-1.23333

2016	3	0.375	0.625	-1.62222
2017	4	1.333333	1.666667	-1.46667
2018	4	1	0	-1.46667
2019	4	1	3	-1.46667
2020	2	0.5	3.5	-1.93333
2021	3	1.5	0.5	-1.62222
2022	5	1.666667	1.333333	-1.37333
2023	2	0.4	4.6	-1.93333

The biggest jump in yearly ratios happened in 2011 and 2013, each hitting 3, yet actual growth during those time s fell by 2 and 1. After that, things change by 2015 - both numbers land at 2. Then comes 2022: the first drops near 1.67, yet the second hits around 1.33. Then 2021 appears with a ratio of 1.5 and a small rise of 0.5 in growth. After that, 2017 holds a ratio near 1.33, though the rate edges up to around 1.67. In contrast, 2018 and 2019 share a flat ratio of 1, but differ sharply - one logs zero change, the other gains 3. Following them, 2012 and 2014 bring lower ratios, both close to 0.67; their rates spl it widely - 0.33 versus over 5.33. Later, 2020 dips further with a hal f-point ratio, even as its rate surges to 3.5. By 2023, ratio drops below half to 0.4, yet rate jumps again, nearin g 4.6. Back before that, 2016 sits low - ratio just above 0.37, rate under 0.63. Finally, the earliest point, 2010, opens at 0.2 for ratio and ends slightly higher at 0. 8 for growth.

3.3 Most- influential authors.

Contribution of various authors in the subject is an important factor to be studied, here is the table for top 10 most cited authors in the subject over the years.

Table: 3.3.1 Most-Influential authors.

Authors	Year	Reformulated Title / Study Focus	Citations
Carlo H.J., Vis I.F.A., Roodbergen K.J.	2014	An extensive survey of transportation operations in container terminals, highlighting classification systems, recent developments, and potential research directions	207
Tuzkaya G., Gülsün B., Kahraman C., Özgen D.	2010	Development of a hybrid fuzzy multi-criteria decision-making approach for identifying appropriate material handling equipment	126
Sujono S., Lashkari R.S.	2007	A multi-objective decision framework for selecting material handling systems and allocating tasks in flexible manufacturing environments	72
Lommen S., Mohajeri M., Lodewijks G., Schott D.	2019	Use of discrete element method-based scaling techniques to examine particle interactions in large-scale bulk material systems	39
Meng C., Nageshwaraniyer S.S., Maghsoudi A., Son Y.-J., Dessureault S.	2013	Creation of a data-driven simulation system to improve material flow management in coal mining operations	36
Choe P., Tew J.D., Tong S.	2015	Analysis of how cognitive automation influences flexibility in production systems involving material handling	36

Cortés P., Gómez-Montoya R.A., Muñuzuri J., Correa-Espinal A.	2017	Route optimization in distribution centers using tabu search while accounting for varying equipment and inventory constraints	34
Pratap S., Nayak A., Kumar A., Cheikhrouhou N., Tiwari M.K.	2017	A decision-support model for berth allocation and unloading processes in bulk cargo port operations	34
Andriolo A., Battini D., Persona A., Sgarbossa F.	2015	A sustainable procurement model for materials using shared transportation concepts supported by numerical analysis	30
Welgama P.S., Gibson P.R.	1995	Integration of expert systems with optimization methods for automated selection of material handling systems	29
Rahman H.F., Nielsen I.	2019	Strategies for scheduling automated transport vehicles in distribution and handling systems	26
Torres-Carrasco M., Reinosa J.J., de la Rubia M.A., Reyes E., Alonso Peralta F., Fernández J.F.	2019	Comparative study of rice husk ash and nano-silica for controlling reactive silica in cement-based materials	22
Faber G.S., Koopman A.S., Kingma I., Chang C.C., Dennerlein J.T., van Dieën J.H.	2018	Application of wearable sensors and motion tracking technologies for continuous monitoring of manual material handling activities	21

Right off the bat, Carlo H.J., Vis I.F.A., and Roodbergen K.J.'s 2014 study pulls ahead its citation number hits 207. Focusing on how containers move inside terminals, their paper maps out what's already been studied while pointing toward new paths forward - not just listing ideas but sorting them into clear groups. Back before that, in 2010, Tuzkaya G., Gülsün B., Kahraman C., and Özgen D. dug into picking the right gear for moving materials; scholars kept coming back to it, racking up 126 mentions. Jumping further back, Sujono S. and Lashkari R.S. looked at both assigning tasks and choosing handling setups in 2007. Seventy-two citations point to the impact of their contributions. Work from 2019 by Lommen S., Mohajeri M., Lodewijks G., along with Schott D. looked into DEM-based methods for scaling particles - picked up 39 times since. Back in 2013, a team including Meng C., Nageshwaraniyer S.S., Maghsoudi A., Son Y.-J., and Dessureault S. built a model driven by data, shaped around simulations for moving materials in coal mines. That one shows 36 references behind it. Around that time, Choe P., Tew J.D., together with Tong S. explored automated effects on adaptability inside these systems, appearing just as often - also at 36 mentions. A technique using tabu search for solving item collection routes came from Cortés P., Gómez-Montoya R.A., Muñuzuri J., along with Correa-Espinal A. back in 2017 - this one picked up 34 references. That same year saw Pratap S., Nayak A., Kumar A., working together with Cheikhrouhou N. and Tiwari M.K. build a combined tool aiding decisions about dock usage and crane placement at large cargo docks, adding notable insight into port operations. Sustainability angles within buying raw materials became the spotlight when Andriolo A., Battini D., Persona A., joined by Sgarbossa F. explored it in 2015; scholars referenced that piece thirty times. Long before these works, Welgama plus Gibson P.R. tackled how to choose systems moving goods automatically through factories - a base-layer paper from 1995 now pulled 29 citations. Later on, Rahman H.F. teamed up with Nielsen I. in 2019 to examine timing strategies for driverless hauling machines across facilities - its impact seen in 26 citation counts. Moving beyond earlier work, Torres-Carrasco M., Reinosa J.J., de la Rubia M.A., Reyes E., Alonso Peralta F., and Fernández J.F. (2019) looked into how reactive silica is managed, building understanding in that area. Not long before, Faber G.S., Koopman A.S., Kingma I., Chang C.C., Dennerlein J.T., and van Dieën J.H. (2018) examined ways to track hand forces during movement, a paper now referenced 21 times.

3.4 Top Contributing Journals

The most important contributing journals in the subjects are identified in the table and figure.

Table: 3.4.1 Top Journals.

Year	Journal Title	Number of Publications
2012	European Journal of Operational Research	2

2012	Measurement: Journal of the International Measurement Confederation	2
2014	Applied Radiation and Isotopes	4
2014	Computers and Operations Research	4
2015	Simulation Modelling Practice and Theory	8
2015	Applied Soft Computing	8
2016	International Journal of Production Economics	3
2016	Fusion Engineering and Design	3
2017	Fusion Engineering and Design	4
2017	Applied Soft Computing	4
2018	Construction and Building Materials	4
2019	Journal of Biomechanics	4
2020	Resources Policy	2
2020	Omega	2
2021	Annals of Nuclear Energy	3
2022	Energy	5
2022	European Journal of Operational Research	2
2023	Transportation Research Part E: Logistics and Transportation Review	2

Figure3.4.1 Journals.

Looking at where studies appeared, two outlets stood out in 2015: Simulation Modelling Practice and Theory alongside Applied Soft Computing Journal, both putting out eight pieces that year. For that period, their output topped the list among all sources included. By 2022, Energy had reached five entries, marking its growing role in the field. Several others maintained activity without high volume - titles like Applied Radiation and Isotopes, Computers and Operations Research, Fusion Engineering and Design, Construction and Building Materials, and Journal of Biomechanics stayed present but quieter. Over time, the International Journal of Production Economics kept showing up, dropping one paper each in 2014, 2017, 2018, and 2019. In addition, journals such as Fusion Engineering and Design and Annals of Nuclear Energy recorded three publications each during the period spanning 2016 to 2021. Furthermore, several journals

contributed smaller yet significant numbers of articles. These include European Journal of Operational Research, Measurement: Journal of the International Measurement Confederation, Resources Policy, Omega, and Transportation Research Part E: Logistics and Transportation Review, each publishing two papers during the years between 2012 and 2023.

3.5 Co-authorship

Table 3.5.1 Co-authorship Index.

Year	Single Author	CAI (Single)	Two Authors	CAI (Two)	Multiple Authors	CAI (Multiple)	Total Publications
2009	1	1040.91	2	90.51	19	96.47	22
2010	0	0	0	0	4	111.71	4
2011	0	0	0	0	11	111.71	11
2012	0	0	4	995.65	0	0	4
2013	0	0	0	0	24	111.71	24
2014	0	0	1	33.19	29	107.98	30
2015	0	0	4	497.83	4	55.85	8
2016	0	0	0	0	23	111.71	23
2017	0	0	0	0	24	111.71	24
2018	0	0	2	99.57	18	100.54	20
2019	0	0	2	104.81	17	99.05	19
2020	0	0	2	181.03	9	91.4	11
2021	0	0	0	0	11	111.71	11
2022	0	0	4	306.35	9	77.34	13
2023	0	0	2	398.26	3	67.02	5
Total	1	—	23	—	205	—	229

From the table it can be seen that Single authors was only in the year 2009, and co-authorship index for it is 1040.91, two authors were in 2012, 2015 and 2022 with 4 different authors and co-authorship index 995.6522, 497.8261, 306.3545, in years 2023, 2020, 2019, 2018 and 2009 with 2 different authors and co-authorship index 398.2609, 181.027668, 104.805492, 99.56521739 and 90.51383 respectively and only 1 author in years 2014 with co-authorship 33.18841. Multiple authors in maximum in year 2014 with 29 different authors and co-authorship index 107.98, followed by 2013 and 2017 with 24 different authors each and co-authorship index 111.70 each, followed by 2016 with 23 different authors and co-authorship index 111.70, followed by 2009 with 19 different authors and co-authorship index 96.47, followed by 2018 with 18 different authors and co-authorship index 100.53, followed by 2019with 17 different authors each and co-authorship index 99.95, followed by 2011 and 2021 with 11 different authors for each and co-authorship index 111.70 each, followed by 2020 and 2022 with 9 different authors each and co-authorship index 91.39 and 77.36 respectively, followed by 2010 and 2015 with 4 different authors and co-authorship index 111.70 and 55.853 and lastly 2023 with 3 different authors and co-authorship index 67.024.

3.6 Co-authorship of Countries

Minimum number of documents from a country are taken 5 and 6 countries meet the theresold.

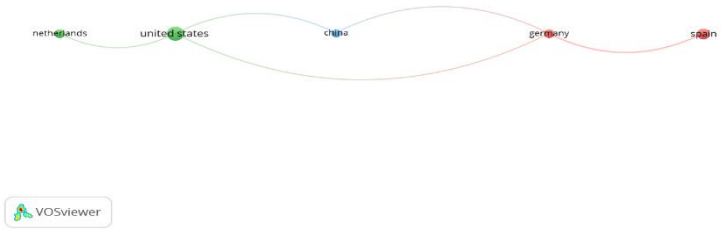

Figure 3.6 Co-authorship of Countries.

From the figure, it can be seen that Netherlands is most co-occurred country with 6 documents, 292 citations and 1 link strength, followed by United statedwith 14 documents, followed 214 citations and 34 link strengths, followed by Spain with 9 documents, 144 citations and 2 link strength, followed by Hong kong with 6 documents, 109 citations and 0 link strengths, then China with 5 documents, 53citaions and 2 link strength.

3.7 CO-AUTHORSHIP OF AUTHORS

Minimum 2 occurrence of authorship was taken and only 11 meet the theresold.

Table: 3.7 Co-authorship of authors.

Co-Authorship of authors			
Author	Documents	Citations	Total Link Strength
Mattila J.	2	12	5
Semeraro L.	2	12	5
Siuko M.	2	12	5
Ferreira J.	2	16	4
Ribeiro I.	2	16	4
Vale A.	2	16	4
Irving M.	2	14	3
Kakudate S.	2	21	2
Takeda N.	2	21	2
Lau H.Y.K.	3	33	0
Lin J.T.	2	37	0

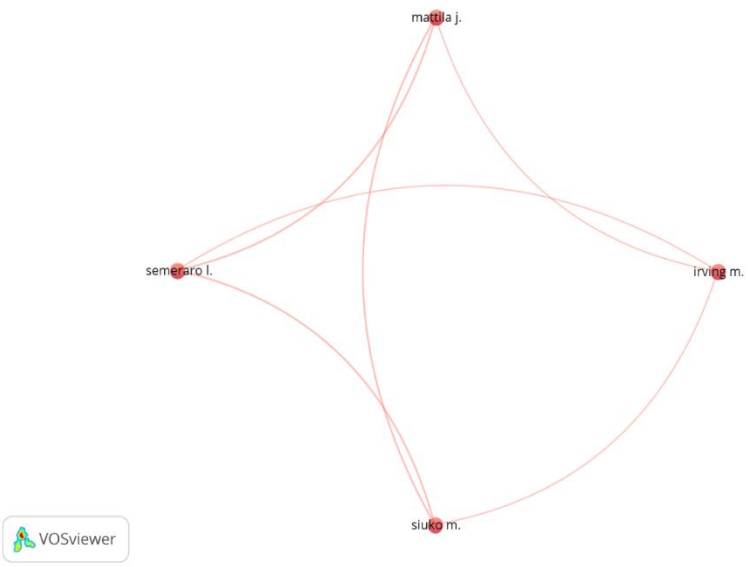

Figure: 3.9 Co-authorship of authors

.

From table and figure it can be seen that most occurred authors are Mattila J., Semeraro L. and Siuko M. with link strength 5 each, citations 12 each and documents 2 each. Followed by Ferreira J., Ribeiro I. and Vale A. with link strength 4 each, citations 16 each and documents 2 each, then Irving M. with 3 link strengths, 14 citations and 2 documents. Followed by Kakudate S. and Takeda N. with 2 link strengths, 21 citations and 2 documents each.

3.10 Dominance factor

Table: 3.10.1 Dominance Factor Analysis of author

Author	Total Publications	Co-authored Papers	First Author Contributions (in Co-authored Papers)	Dominance Factor (DF)
1	50	40	10	0.25
2	40	40	0	0
3	30	15	15	1
4	15	10	5	0.5
5	20	5	15	3

The most dominant author is 1 with 50 total papers, 40 total joint papers, 10 as first author and dominance factor 0.25, followed by author is 2 with 40 total papers, 40 total joint papers, 0 as first author and dominance factor 0, then author 3 with 30 with total papers, 15 total joint papers, 15 as first author and dominance factor 1, followed by author 5 is with 20 total papers, 5 total joint papers, 15 as first author and dominance factor 3, finally author 4 with 15 total papers, 10 total joint papers, 5 as first author and dominance factor 0.5.

3.11 Average authors per paper

Table: 3.11.1 Average authors.

Average authors per paper				
Year	**Total article**	**No. of author**	**AAPP**	**PPA**
2019	4	19	4.75	0.210526
2020	2	11	5.5	0.181818
2021	3	11	3.666667	0.272727
2022	5	13	2.6	0.384615
2023	2	5	2.5	0.4

Looking at the numbers, authors per paper plus papers each researcher produced appear clear. The period covers five recent years. In 2020, researchers saw a peak - average contributors reached 5.5 on one publication, though output per person dipped to 0.1818. That dropped next in 2019: team size shrank slightly to 4.75 while individual productivity rose to 0.215. Three years ago, things shifted further; collaboration fell near 3.67 yet articles per scholar climbed toward 0.2727. Moving into 2022, group sizes narrowed more - to just 2.6 names per study - with personal volume reaching about 0.3846 pieces. Most recently, in 2023, teams hovered around two and a half individuals per work while writers managed nearly 0.4 publications apiece.

3.12 Publication Efficiency

Table 3.12 Publication efficiency index

Publication efficiency index			
Year	Publication	Citation	PEI
2019	4	104	2.795698925
2020	2	7	0.376344086
2021	3	12	0.430107527
2022	5	22	0.47311828
2023	2	0	0
TOTAL	20	186	1

This table shows publication efficiency in the last 5 years. Highest publication efficiency was in the year 2019 with 104 citations and 2.795, followed by 2022 where citations were 22 and publication efficiency index 0.473, then 2021, where with citations 12 and 0.4301, then 2020 where citations were 7 and publication efficiency index 0.3763.

3.13 Country wise science production index.

Table 3.13.1.Science production

Science production index		
Country	output	SPI
India	100	8.547009
China	200	17.09402
UK	230	19.65812
USA	450	38.46154
Canada	190	16.23932
total	1170	100

From table 3.13.1, it is concluded that USA is on the top with SPI 38.46, followed by UK with SPI 19.65, then China with SPI 200, then Canada with 16.24, then India with SPI 8.54..

REFERENCES

1. Tuzkaya, G., Gülsün, B., Kahraman, C., & Özgen, D. (2010). An integrated fuzzy multi-criteria decision making methodology for material handling equipment selection problem and an application. Expert systems with applications, 37(4), 2853-2863.
2. Adenipekun E.O., L. V. (2022). The impact of transportation optimisation on assembly line feeding. Omega (United Kingdom) , 170.
3. Alp O., T. T. (2022). Transitioning to sustainable freight transportation by integrating fleet replacement and charging infrastructure decisions. Omega (United Kingdom) , 109.
4. Andriolo A., B. D. (2015). Haulage sharing approach to achieve sustainability in material purchasing: New method and numerical applications. International Journal of Production Economics , 164, 10.
5. B.M., B. (1999). System reliability and congestion in a material handling system. Computers and Industrial Engineering , 36 (3), 11.
6. Babiceanu R.F., C. F. (2009). Distributed and centralised material handling scheduling: Comparison and results of a simulation study. Robotics and Computer-Integrated Manufacturing , 25 (2), 7.
7. Barletta D., B. R.¬r.-G. (2015). Assessment on bulk solids best practice techniques for flow characterization and storage/handling equipment design for biomass materials of different classes. Fuel Processing Technology , 138, 14.
8. Bassily H., S. R. (2007). A mechatronics educational laboratory - Programmable logic controllers and material handling experiments. Mechatronics , 17 (9), 8.
9. Bedell P., S. J. (2012). Topological arrangements of M/G/c/K, M/G/c/c queues in transportation and material handling systems. Computers and Operations Research , 39 (11), 19.
10. Beschorner A., G. D. (2003). MaxFlow theory for availability calculation of automated material handling systems. Robotics and Computer-Integrated Manufacturing , 4, 4.
11. Carlo H.J., V. I. (2014). Carlo H.J., Vis I.F.A., Roodbergen K.J. European Journal of Operational Research , 236 (1), 12.
12. Choe P., T. J. (2015). Effect of cognitive automation in a material handling system on manufacturing flexibility. International Journal of Production Economics , 170, 8.
13. Corts P., G.-M. R.-E. (2017). A tabu search approach to solving the picking routing problem for large- and medium-size distribution centres considering the availability of inventory and K heterogeneous material handling equipment. Applied Soft Computing Journal , 53, 12.
14. Cugini U., D. P. (1996). Design and simulation of non-rigid materials handling systems. Mathematics and Computers in Simulation , 41, 6.
15. Dai J.B., L. N. (2012). Economic feasibility analysis of flexible material handling systems: A case study in the apparel industry. 36 (1), 8.
16. Demetgul M., Y. K. (2014). Fault diagnosis on material handling system using feature selection and data mining techniques. Measurement: Journal of the International Measurement Confederation , 55, 9.
17. Erkayaolu M., D. N. (2016). A comparative life cycle assessment of material handling systems for sustainable mining. Journal of Environmental Management , 174, 5.
18. Faber G.S., K. A. (2018). Continuous

ambulatory hand force monitoring during manual materials handling using instrumented force shoes and an inertial motion capture suit. Journal of Biomechanics , 70, 6.

19. Falkenberg S.F., S. S. (2022). The role of novel data in maintenance planning: Breakdown predictions for material handling equipment. Computers and Industrial Engineering , 169.

20. Ferreira J., V. A. (2013). Localization of cask and plug remote handling system in ITER using multiple video cameras. Fusion Engineering and Design , 88, 4.

21. Fransen M.P., L. M. (2021). Application of DEM-based metamodels in bulk handling equipment design: Methodology and DEM case study. Powder Technology , 393, 13.

22. Grimes S.M., M. D. (2020). Assessment of priorities in critical material recovery from Waste Electrical and Electronic Equipment. Resources Policy , 68.

23. Haneyah S.W.A., S. J. (2013). Generic planning and control of automated material handling systems: Practical requirements versus existing theory. Computers in Industry , 64 (3), 13.

24. Hydrogen fuel cells: Commercially viable solutions in material handling operations. (2011). Fuel Cells Bulletin , 12, 2.

25. Irving M., T. J. (2007). Irradiation and testing of off-the-shelf seal materials for water hydraulic applications in ITER remote handling equipment. Fusion Engineering and Design , 82, 4.

26. J., M. (2009). Materials handling equipment for the compounding plant. Plastics, Additives and Compounding , 11 (5).

27. Johnstone M., C. D. (2015). Simulation-based baggage handling system merge analysis. Simulation Modelling Practice and Theory , 53, 14.

28. Josseaume F., C. J.-J.-P. (2018). Development and qualification of the ITER port plug handling process. Fusion Engineering and Design , 136, 5.

29. Kivel T., S. H. (2011). Calibration and compensation of deflections and compliances in remote handling equipment configurations. Fusion Engineering and Design , 86, 3.

30. Larriba T., G. R. (2013). Fuel cell early markets: Techno-economic feasibility study of PEMFC-based drivetrains in materials handling vehicles. International Journal of Hydrogen Energy , 38 (5), 10.

31. Lau H.Y.K., W. V. (2009). A cooperative control model for multiagent-based material handling systems. Expert Systems with Applications , 36 (1), 14.

32. Lau H.Y.K., Z. Y. (2006). Joint scheduling of material handling equipment in automated air cargo terminals. Computers in Industry , 57 (5), 13.

33. Leung C.S.K., L. H. (2018). A hybrid multi-objective AIS-based algorithm applied to simulation-based optimization of material handling system. Applied Soft Computing Journal , 71, 14.

34. Li J.-Y., G. L.-S.-P.-F.-J.-W. (2020). The development of spallation target and fuel handling system for China initiative accelerator driven system. Annals of Nuclear Energy , 149.

35. Lin J.T., H. C.-J. (2014). A simulation-based optimization approach for a semiconductor photobay with automated material handling system. Simulation Modelling Practice and Theory , 46, 24.

36. Lin J.T., W. C.-H.-W. (2013). Dynamic vehicle allocation control for automated material handling system in semiconductor manufacturing. Computers and Operations Research , 40 (10), 10.

37. Lindsay C., B. G. (2000). Advanced material handling system for computer integrated manufacturing. Robotics and Computer-Integrated Manufacturing , 16 (6), 4.

38. Lommen S., M. M. (2019). DEM particle upscaling for large-scale bulk handling equipment and material interaction. Powder Technology , 352, 9.

39. Madzharov V., M. M. (2015). Development of a zonal applicability tool for remote handling equipment in DEMO. Fusion Engineering and Design , 4.

40. Meinert T.S., D. T. (1999). Modular simulation approach for automated material handling systems. Simulation Practice and Theory , 7 (11), 15.

41. Meng C., N. S.-J. (2013). Data-driven modeling and simulation framework for material handling systems in coal mines. Computers and Industrial Engineering , 64 (3), 13.

42. Mital P., G. M. (2015). Robust material handling system design with standard deviation, variance and downside risk as risk measures. International Journal of Production Economics , 170, 9.

43. Muhammad A., E. S. (2009). Combined application of Product Lifecycle and Software Configuration Management systems for ITER remote handling. Fusion Engineering and Design , 84 (4), 10.

44. Nakahira M., M. Y. (2009). Design progress of the ITER blanket remote handling equipment. Fusion Engineering and Design , 84, 4.

45. Nguyen R.T., I. D. (2019). Anticipating impacts of introducing aluminum-cerium alloys into the United States automotive market. Resources, Conservation and Recycling , 9.

46. Ojha S., D. M. (2021). Knowledge of Handling the Personal Protective Equipment by Frontline Allied Health Professionals in COVID-19 Outbreak?A Web-Based Survey Study. Journal of Radiology Nursing , 40 (2), 4.

47. Poon T.C., C. K. (2011). Effective selection and allocation of material handling equipment for stochastic production material demand problems using genetic algorithm. Expert Systems with Applications , 38 (10), 8.

48. Prasad K., Z. E. (2015). A software prototype for material handling equipment selection for construction sites. Automation in Construction , 57.

49. Pratap S., N. A. (2017). An integrated decision support system for berth and ship unloader allocation in bulk material handling port. Computers and Industrial Engineering , 106, 13.

50. Rahman H.F., N. I. (2019). Scheduling automated transport vehicles for material distribution systems. Applied Soft Computing Journal , 82, 26.

51. Roozbahani H., A. M. (2021). Coordinate-based control for a materials handling equipment utilizing real-time simulation. Automation in Construction , 122.

52. Saito M., K. H. (2017). Irradiation tests of radiation hard materials for ITER blanket remote handling system. Fusion Engineering and Design , 124, 5.

53. Schulz A., S. Y. (2023). An efficient heuristic for the fixed-route vehicle-refueling problem. Transportation Research Part E: Logistics and Transportation Review , 169.
54. Siikanen J., T. T.-E. (2014). A solid target system with remote handling of irradiated targets for PET cyclotrons. Applied Radiation and Isotopes , 94, 7.
55. Sujono S., L. R. (2007). A multi-objective model of operation allocation and material handling system selection in FMS design. 105 (1).
56. Torres-Carrasco M., R. J. (2019). Critical aspects in the handling of reactive silica in cementitious materials: Effectiveness of rice husk ash vs nano-silica in mortar dosage. Construction and Building Materials , 223, 7.
57. Tuzkaya G., G. B. (2010). An integrated fuzzy multi-criteria decision making methodology for material handling equipment selection problem and an application. Expert Systems with Applications , 37 (4), 10.
58. Vale A., F. D. (2013). Flexible path optimization for the Cask and Plug Remote Handling System in ITER. Fusion Engineering and Design , 88, 3.
59. Wang C.-N., L. Y.-H.-P.-H. (2016). The heuristic preemptive dispatching method for convey-based automated material handling system of 450 mm wafer fabrication. Computers and Industrial Engineering , 96, 8.
60. Welgama P.S., G. P. (1995). A hybrid knowledge based/optimization system for automated selection of materials handling system. Computers and Industrial Engineering , 28 (2), 12.
61. Wutthisirisart P., S. M. (2015). The two-warehouse material location selection problem. International Journal of Production Economics , 170, 9.
62. Xie L., L. H. (2023). Formulating and solving integrated order batching and routing in multi-depot AGV-assisted mixed-shelves warehouses. European Journal of Operational Research , 17.
63. Yamazaki Y., (. S. (2017). Design method of material handling systems for lean automation?Integrating equipment for reducing wasted waiting time (Vol. 66).
64. Yun L., L. L. (2022). Demand response for manufacturing systems considering the implications of fast-charging battery powered material handling equipment. Applied Energy , 310.
65. Zajac P., R. T. (2022). Energy consumption of forklift versus standards, effects of their use and expectations. Energy , 239.
66. Zhou Q., Z. B.-H. (2016). A deadlock recovery strategy for unified automated material handling systems in 300 mm wafer fabrications. Computers in Industry , 75, 11.
67. Zielinski J., A. R. (2018). Prospects for meeting the corporate average fuel economy standards in the U.S. Resources, Conservation and Recycling , 136, 6.

.