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Delivering Smart Warehousing in Australia

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ABSTRACT

Smart warehousing continues to advance - particularly for larger strorage supply-demand chain facilities. Such embedded digital, real-time AI engagement storage solutions often involve intelligent autonomous place, track, pack resource orchestration solutions targeting towards direct multi-consumer and marketplace rapid distributions, and into the future further linking towards retailing. This literature researched paper frames a research agenda to determine the relative smart warehousing pathway effects of supply side input competencies and of demand side actioned interactive capabilities in determining the sustainability of intelligent, lower-cost warehousing into the immediate future.

Keywords: Artificial intelligence (AI), Digital technologies, Warehouse management system, Artificial intelligence, Robotics, Machine learning, Autonomous smart warehousing, Internet of everything, Communications connectivity, Software solutions.

INTRODUCTION

Over-time warehousing has developed from community storerooms to multimillion-dollar facilities. However, its purpose remains the same. Warehousing remains a place to temporarily store goods within the supply-demand chain network, with all processes effectively connected to maintain a smooth flow of goods (Kumar et al. 2021).

The concept of smart warehousing emerged from Industry 4.0 (the fourth industrial revolution), a German government hi-tech strategy showcased at the Hannover fair of 2011 (Kumar et al. 2021). Industry 4.0 refers to how automation, data, and computers interface and process desired information. The blending of this interface between the physical and the digital domain – including: AI, IoT, and automation, now impacts on societies and their everyday lives (Kumar et al. 2021).

In 2018 around 90% of warehousing worldwide was either manual, or engaged only low-levels of automation across the specific storage's operations. Firms utilizing warehousing are increasingly deferring towards incorporating advanced technologies, and automation, into their business plans. Over-time this enhances ongoing costs, makes better use of funds and of infrastructures, and builds IT (Information Technology) knowledge (Pontius, 2018). For example a consequence of the increasing demand for e-commerce (along with processing cost savings), the demand for still smarter warehousing is emerging. Smart warehousing links process stages in real-time. It can handle rapid multi-item processing, and depending on scale can deliver up to millions of items (or products) either daily or weekly. Consequently, as their use rises smart warehouses must continually upgraded their digital systems(Immerman, 2019). Accordingly, mobile, autonomous, compact, and/or collaborative systems are increasingly being applied into the systems within these smart warehouses (called Warehousing 4.0) (Mahmut, 2022).

Smart warehousing is reportedly thee most effective and efficient way of raising the firm's ROI (Return on investment) by improving precision and performance and reducing manual labour costs (Kumar et al. 2021). The global supply chain's rapid growth, improvements in automation, communication technologies (ICT), and Industry 4.0, warehousing along with it's embedded digital systems, have brought integtration and real-time changes into warehousing practices and processes.

Warehousing is also moving from traditional (supply-store-ship) warehousing towards a digitally-connected, automated and integrated warehouse management system. Warehousing remain under considerable stress, and scalability. This is partly due to increasing demand for items. When expanding their warehousing requirements, industry actors and their firms recognise it is better to adapt to changing competitive business environments, by enlisting smart digital and integrated warehouse management systems (Kumar et al, 2021).

LITERATURE REVIEW

Existing State of Play for Warehouse Space in Australia

The current vacant warehouse lease space availability in Australia is low, but demand remains record-high. As a result, the market is led by pre-commitments and speculative lease deals, with 2023 leasing take-up approximating 3.4M m2 (Henderson et al. 2023).

Across 2022 modern, efficient warehouse lease space in Australia was lacking, and fewer assets were entering the marketplace. In addition, supply was at historically low levels as post-Covid-related new project developments and project completions became available. As a result, occupier warehouse demand was buoyant, and in 3Q 2022, gross take-up space was 988,410 m2. In contrast, 4Q 2022 gross take-up space fell to 684,160 m2.

Long-term average warehouse take-up space of 692,330 m2 suggests macroeconomic drivers in Australia may lower occupier demand. Less available take-up space in Melbourne (27%) and Brisbane (47%) is particularly restricting take-up space levels within these two capital cities (Ballantyne & McFarlane, 2022).

E-commerce growth is another driver of warehousing floor space in Australia. As E-commerce increases, firms increase their stock holdings and seek further warehouse-related efficiencies. As a result, over the past ten years, the average floor space has increased from 12,000 m2 to 25,000 m2 today, and within Melbourne, the average floor space today is 45,000 m2.

There has been a 29% increased demand for take-up spaces above 30,000 m2. This exposes a trend where smaller businesses slow in warehouse take-up, but larger Australian companies, or occupiers, are moving forward, incorporating long-term logistics and business strategies (Henderson et al. 2023).

Australian retailers are currently planning and constructing smart, automated warehousing and fulfilment centres. Major Australian retail and logistic players investing millions of dollars in their supply chains and smart warehousing include Amazon, Coles, Woolworths, Australia Post, Booktopia, and online specialists Temple & Webster and Kogan. (DHL Logistic of Things, Insites, 2023).

Across 2024 and 2025, demand in Australia is likely to remain elevated as the nation's population and general consumption grow. At the same time, a pick-up in development-ready land availability, particularly in select capital cities, is likely to support other pre-commitment and speculative lease take-up space activities (Henderson et al. 2023).

Considering competitiveness, Australian firms or occupiers with less-efficient supply chains, are likely to continue migrating toward newer facilities, and to employ automation, or even migrate toward autonomous warehouse processing. Across 2023 such shifts are increasing the demand for take-up space and driving further pre-commitments regarding take-up space. Thus, Australian smarter warehousing is a likely driver for take-up warehouse lease space in the future.

Smart Warehousing

The development of robotics, autonomous systems, edge technologies, and other collective intelligence interfacing with smart warehouse management systems likely offers near-real-time control and movement of goods in and out of the warehouse in logistically smart, fast, and efficient ways.

In addition, the information flow across the central (AI) platform offers machine learning and virtual reality (twinning learning). This likely assists the workforce in fault finding and in improving overall storage to marketplace servicing (Severns, 2022). As part of the automation process, robotics, advanced AI, cameras, and sensors can add communication channels between each automated machine or device, and the relevant members of the workforce. This likely assists in providing optimal location and status positioning, which can be then tracked directly through an integrated online control portal.

Using software to replace manual tasks minimises human assistance, and minimizes labour-intensive duties – especially those requiring repetitive physical activity, and/or manual data analysis (Jenkins, 2020). Zunic et al (2018) present a warehouse management system as a key directional component that simplifies, optimizes and drives efficiencies across item storage and item logistical transmission complexities. Warehouse managment systems typically include digital automated, real-time: stock item planning, tracking, placement, picking, transfer, and logistical transport aspects of warehousing. Integrated warehouse management systems can make: anonolies (or risks) easier to detect, process improvements easier to find and fix, and deliver a more efficient entire digitally-driven interconnected and integrated digital management system.

Zhang et al. (2021) show Alibaba's smart warehousing solutions as an integrated 'resource orchestration' delivering value from collectively managed AI technologies, workforce personal, and input-to-ouput processes. They find when relevant key AI resources including: data, AI/ML algorithms, and robotics, are orchestrated to include coordinated, leveraged, and deployed solutions that operate in conjunction with other in-situ resources (including facilities, information systems, and workforce ingenuity), then still stronger AI capabilities can be generated.

Further smart warehousing advantages can be achieved where the AI systems can real-time project/forecast and learn – particularly by interacting efficiently with the workforce and its ingenuity, plus space, position, distance digital optimizations, and also with other productivity drivers (including error reduction and communivative connectivities. Thus smart warehousing requires a new skills-set for both the firm, and its workforce.

Smart Warehousing - Future Enablers

Into the future smart warehousing will likely involve a suite of critical enablers, including continual growth in e/m-commerce, demands for instantaneous high-quality data, further strategic advantages, greater operational agility, less external threats, greater risk mitigations, more warehouse complexities, and new customer instantaneous demands (Ballantyne & McFarlane, 2022).

Consumer online transactions, or e/m-commerce solutions, are likely to require faster logistical interpretations and solution, and expanded consumer demands for specific information. This ideally helps rectify and/or reduce supply chain delays. In addition, such solutions may enlist smart digital network connectivities complete with new capabilities systems that together may simplify operations, reduce the needed workforce, and help overcome specific new-skills requirements.

Thus, the smart warehouse creates an environment of ongoing, accelerated, innovations. These then mesh with the latest relevant creative technologies, and together can support autonomous or advanced intelligent machine sensing operational systems - capable of improving and aligning smart warehouse productivity and associated logistics towards better meeting marketplace and consumer expectations (Burston et al. 2023).

Today instant connectivity systems require real-time information, near-instant response time, accuracy, and precision. This also applies to smart warehousing and its embedded logistics systems. In addition, the marketplace and consumers expect rapid deliveries. This stems from efficient and effective distribution centres, with enhanced digital warehouse management systems that link backward and drive responses throughout current supply chains. Today many warehouse management systems still remain susceptible to human input/output errors. However, merging warehouse systems with supply chain participant actors also requires the ability to process and interpret vast amounts of data.

To facilitate order picking and batch-handling efficiencies, goods-movement digital systems can now capture all warehousing aspects, from receiving to restocking to picking, packing, and shipping. Furthermore, all data and digital sensor inputs are network interfacing with management systems to provide rapid and reliable controls of processing (van Geest et al. 2021).

Hence today, automated smart warehouse systems are becoming a normative pathway towards improving overall storage responsiveness, agility, and flexibility, and to solve human error issues throughout the warehousing processes. These networks also bring advanced technologies complete with integrated Internet of Everything (IoE) solutions.

Into the future smart warehouse processing is likely to rely on increased order volumes, accurate order picking, digital dispatch logistics, ongoing workforce skills certainty, and collective intelligence (Celik & Sural, 2019). Warehouses adopting automation, smart robotics, and autonomous systems likely offer new pathways to transition from fixed equipment operations toward fast, fully-robotic random order processing, and possibly within workforce-free facilities (Burston et al. 2023).

Smart Warehousing - Barriers

Besides the initial smart warehousing development cost, various supply chain members often utilise digital, legacy, and non-standardized programming language systems. Such occurrences raise prices of interfacing and networking such member systems. In addition, the ongoing cost of maintenance and operating across such disparate member systems can be prohibitive. Hence the trend is towards migrating these disparate systems across standardised supply-demand chain systems.

The reliability of remote hardware, the limits of robotic technology, and robots' inability to identify, pick and pack everything, and especially irregularly-shaped items must improve to ensure reliable operations. In addition, technology continually changes as sensor, tracking, movement and engagement systems become more autonomous. However, this too remains a strategic and cost challenge (Tikwayo, L. N., & Mathaba, T. N. (2023). Applications of Industry 4.0 Technologies in Warehouse Management: A Systematic Literature Review. Logistics, 7(2), 24.).

A current human upskilling challenge remains the ability of the workforce to strategically deal with: system complexities, potential competing competitiveness positions, operational flows, and/or instantaneous decision requirements. Hence smart warehouse systems must also be human and workforce friendly, and incorporate resistance to human error.

There is a lack of knowledge in warehousing adoption of IoE strategies to robotics and AI/ML intelligences. Warehouse management systems are often limited to select parameters of set configurations, and to restrict big data adaptive requirements. Furthermore, not all systems can interact with different supply firm actors, as supplier programming languages often differ and so remain unstandardized and possibly incompatible to the programming languages used within the warehouse. This creates challenges and costly remedies to link different systems together.

Hence, building a smart warehouse is more expensive than traditional warehouses, and transitioning to a smart warehouse requires both effort and cost. In addition, there remains an inherent risk to data security, to privacy, and to confidentiality across all data collection systems (van Geest et al. 2021).

Smart Warehousing - Study Motives

A decade ago warehousing worldwide was primarily a manual storage and movement operation. However, competition and customer expectations of shorter, or same-day delivery times, necessitated the transformation manually-dominated workforce storage and movement operations, towards digital, hi-tech, autonomous, smart warehousing. The development and implementation of automation across storage systems, robotics rather than manual handling and picking, and intelligent information systems is assiting in facilitating this change to smart warehousing. (Chung, 2021)

The compounding effects of customer demand, along with greater informative expectations have caused warehousing operations to become more complex. The prime motivations identified are external threats, competitive advantages, increased data processing speed, warehouse complexity, operational speed, and customer demand. As a result, warehousing continues to become more complex, and customers have become more demanding (Ding, 2013). Hence, traditional warehousing is no longer suitable to satisfy the increasing demand of customer expectations. Instead, fast response time, accuracy, and real-time data information are necessary (Wang et al. 2015).

Retailers need efficient distribution centres supported by informative warehouse management systems that work in-hand with intelligent automation technologies that competitively manage a warehouse operation and the associated supply-demand chain. Retailers also continue to press for supply of goods at lower prices, in faster timeframes, and across shortest logistics supply-demand chains. This also engages the use of identification technologies –especially those linked to further enabling efficiencies and performance optimizations (Cheng et al., 2015). This requires the warehouse management system to intelligently seek-out and link efficiencies in management and operations - especially those that can reduce overall operating costs. However, because most warehouse management systems typically rely on human inputs rather than automated real-time data, there is room for inaccuracies, and these add to supply-demand chain complications (Zhou et al. 2017).

To solve such human error issues, warehouse and supply-demand chain actors likely need to merge and integrate their vast amounts of data capture. This data intelligence likely stimulates increasing needs for much more automated smart warehousing. Automated smart warehousing offers retailers another area of competitive advantage. It reduces human error, introduces well-organized picking, batch handling, and delivers better more responsive consumer servicing.

Recently the implementation of digital automation into warehousing has increased in-tune with emerging advances in robotics, electronics, connectivities, and computer technologies. This results in: better warehouse functionalities, the ability to communicate with other devices, greater ease-of-use, and greater affordability (Culler et al. 2016).

Smart Warehousing - Solution Progressions Towards Automation

Figure 1a shows Jenkins' (2020) smart warehousing blends stagewise digital process automation components - related to embedded information technologies, with related physical process automation stages to stagewise deliver the integrated and networked components that support warehouse automation. Figure 1b highlights process flows within smart warehouses.

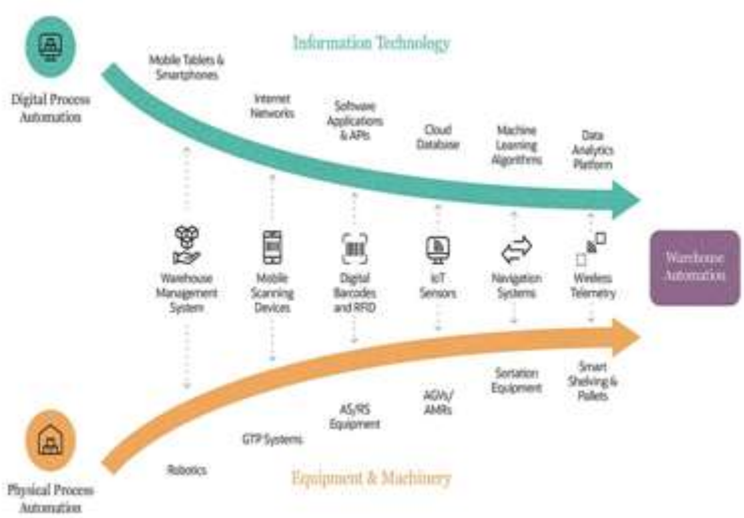

Figure 1a: Smart Warehouse automation (Jenkins, 2020)

Figure 1b: Smart Warehouse (https://vakoms.com/)

Automation at the digital process level begins with the programmed inclusion of mobile devices connected by wifi into the warehouse network and its warehouse management system. Software development applications and API's are added to expand intelligence and functionality of storage systems and associated robotics. This increase in data capture makes digital security increasingly important, and requires the introduction of secure cloud database storage systems. As robotic devices expand in function and intelligence machine learning algorithms are introduced and then the entire warehouse management system and its overall data analytics platform is continually recalibrated to deliver required solutions (Jenkins, 2020).

Digital inclusions constitute the middle stagewise increasingly complex transitions. These are matched to above digital process automation stages and to the below physical process automation systems. Digital development inclusions flow from warehouse management systems, to mobile scanners, to digital RFID bar code readers, to IoT/IoE sensors to navigation GPS systems to wireless telemetry directional movements.

Automation at the physical level is again stagewise presents. It begins with the introduction of warehouse management system supported by hardware interfaces collecting and transferring data and robotics control. Goods-to-person fulfilment systems (GPT) increase the warehouse efficiency and reduces congestion by using conveyors, carousels, and vertical lift systems. In high-volume reduced space warehoused, automated storage and retrieval systems (AS/RS) add components to the GTP system by incorporating further automated systems and equipment. This system is best utilised with high-volume reduced space warehouses. Then automatic guided vehicles (AGVs) and autonomous mobile robots (AMRs) provide equipment accessible to operational process routes and typically use laser-guided systems to detect obstacles when navigating these dynamically changing environments and human workforce traffic. Next pick and sort automation is introduced and then smart shelving and pallets provide moveable and changeable solutions (Jenkins, 2020). Thus by 2020 smart warehousing attained considerable advantageous change improvements across autonomous and robotic capabilities.

Today warehousing can operate as a fully-integrated, intelligent, decision-making-by-machines process, that blends suppliers into to warehouse storage requirements and projections, and links though to completion of consumer demand/order requirements. Today smart warehouses can add AI/ GPS tracking/IoE to plot process solutions, digital twinning capabilities to assess and modify storage, 3D/360 degree/mixed realities inestigative solutions to define and remedy overall processes and maybe digital systems too, warehouse meshing/advanced planning/ML/predictive analytics to project likely future requirements, dynamic learning and warehouse mesh visualization to describe future solutions. Thus a smart warehouse of th future likey possesses an overall system that understands in a microsecond, manages an unplanned event assesses past experiences uses marketplace intelligences, and ensures value-over-volume.

Summary: Australian Smart Warehousing

Australia has experienced a dramatic increase in e-commerce post the Covid 19 pandemic. Spending reached USD 49 billion in 2021, compared to USD 38 billion in 2020. Seventy-five percent of Australian businesses now earn part of their revenue from online sales, and e/m-commerce accounts for 10 percent of all Australian online sales (DHL Logistics of Things, Insites, 2023).

Online shopping continues to grow as more shoppers shop from their living rooms, with this demand expected to create 490,000 square metres of additional warehouse space per-year for the next few years. This growing trend, has lifted total retail sales thirteen percent (from nine percent in 2020), and sales are expected to rise over twenty percent by 2025 (Schlesinger, 2021).

In today's demand-driven retail economy, online transactions have promoted expansion of both warehousing and distribution centres, and this has pushed a shift towards warehouse automation (JLL Australia, 2021).

The increase in e/m-commerce sales, and the transition from bulk orders, towards single items sales is driving a shft towards more efficient warehousing operations, along with faster process times for online orders. These imperatives have helped secure and retain consumers (DHL Logistics of Things, Insites, 2023).

In 2021 the average consumer expected less than 4.5 days delivery time, compared to 5.5 days in 2012. With online shoppers showing increased expectations of faster deliveries, retailers have quickly recognised the need for smart automated warehousing. consequently, warehouse automation is expected to grow globally by 14 percent by 2026. (JLL Australia, 2021).

Australian retailers are planning and constructing smart, automated warehousing and fulfilment centres. Major Australian retail and logistic players investing millions of dollars in their supply chains and smart warehousing include Amazon, Coles, Woolworths, Australia Post, Booktopia, and online specialists Temple & Webster and Kogan (DHL Logistic of Things, Insites, 2023). Kogan is planning to build an automated warehouse, and Booktopia has invested $12 Million in an automated Sydney warehouse (JLL Australia, 2021). The supermarket chain Woolworths has announced plans to build two automated warehouses with robotic pickers. Coles is also developing two data fulfilment centres in Melbourne and Sydney to be completed in late 2022 (DHL Logistic of Things, Insites, 2023). Amazon is now operational in Western Sydney with its 200,000 square metres, four-level robotics fulfilment centre. It has been equipped with cutting-edge technology, supported by 1,500 support associates. By incorporating robotics to drive moving inventory pods to associates for picking, packing, and dispatch (Cummins, 2021).

To transition into smart, automated warehousing within its ever-changing Australian marketplaces, warehousing requires broad digital information, operational precision, and ongoing flexibility. The warehouse management system deployed likely features radio-frequency identification (RFID), Internet of Everything (IoE), connectivities, and other digital robotic integrations, activated in real-time, and item tracking across the supply-demand chain (Van Geest et al., 2021). Warehouse management system integration of higher levels of intelligence/assessment software can further: automate the supply-demand chain process, reducing human error, and speed processing. This then increases bottom-line revenue per square meter of warehouse-space by between 10 and 20 percent within an actioned e/m-commerce warehouse management system facility (DHL Logistics of Things, Insites, 2023).

Although the Australian logistics industry has utilized automated/guided vehicles for decades, only recently have necessity-driven innovative developments (including: advanced autonomous driving technologies, flexible picking and manipulation systems, smart storage-wide automation, and capable intelligent robots) been operationalized in warehousing. Robotics systems controlled by machine learning (ML), and incorporating sensor feedback circuits are now easier to utilize. This allows rapid logistical changes to changing supply-demand environments. (DHL Logistic of Things, Insites, 2023).

Thus smart warehousing, from a literature perspective in Australia, still remains limited. However inherent problems remain across the current supply-demand chain networks and fully-integrated warehouse management systems tend to be firm or site-specific. Hence today larger firm warehouses in Australia are pursuing more efficient, lower cost automated models strategically-aimed at advancing, enhancing, and restrategising their current warehousing systems.

Proposed Research Agenda: Approach, Methods, and Techniques

This Post Covid study considers challenges, opportunities, innovations, technologies, connectivities, and risks to enhance and grow future Australian business' commercial (storage/specialist/autonomous) warehousing. It considers smart warehousing a pathway to integrate and coalesce supply/value chain networks by designing fit-for-purpose warehouses offering rapid storage, remixing, and distribution).

Smart warehousing - the centrepiece of Figure 2, encompasses future strategic factors for inbound materials, smart storage, and the outbound remix/repackaging into smart logistical downstreaming.

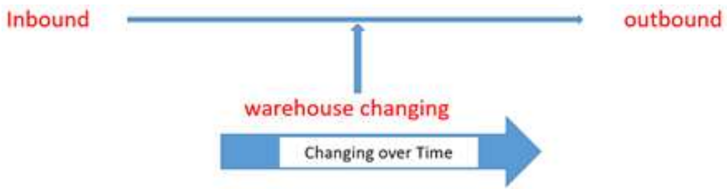

Figure 2: Warehousing in the business supply and value chain

Smart warehousing matches both the supply side and the demand side requirements, but it must also provide an ongoing sustainable intelligences (and worthwhile) solution. This forms the basis of an initial research model, depicted in Figure 2.

DISCUSSION

Future of Smart Warehousing

Today, smart warehousing typically occupies a sizeable integrated facility where systematic-storage of raw materials and/or manufactured items and/or complex item components, is largely managed by networks of integrated digital AI, ML and 3D visualization systems. These digital systems convert input parameters into order fulfilment by delivering intelligent instructions that then: intelligently operate internal, robotic item-movement machines, and specifically position, place, track/record, store a specific item into its appointed, robotically-sized and systematized relational adjustable shelving bin. Order retrieval occurs similarly via bin selection, bin location, bin item extraction, systematic-record-matching, packaging, labelling and shipping.

Incorporating these smart technologies into warehouses likely improves efficiencies, minimizes downtime, and often makes warehousing operations more seamless. For example, today smart warehousing embeds across many supply-demand chains and logistics chains. It deploys: radio-frequency identification technologies (RFID), intelligent autonomous robots, automated digitally-guided vehicles, smart warehouse management and logistics systems, mobile device management, and a raft of integrated Internet-of-Everything smart warehouse technologies tools.

Such toolkits remove reliance upon the human workforce, improve inventory precision monitoring, improve efficiencies, improve accuracy, improve visibility across the supply-demand chain interface, strengthen transparent connectivities with the marketplace, and improve speed across the logistics system. However, this digital system requires considerable initial and ongoing investment, continual ongoing research, and continual system adjustments, along with engaging its' specifically-skilled workforce. Thus, smart warehouses tend to be large, high-throughput, in-demand, high-performance, high efficiency operations that can rapidly self-solve many input-internal-output problems in-situ. Smart warehousing helps: improve the value chain, improve overall quality of delivery, speed net throughput and reliability, lower cost-per-item handled, increase net economic worth, lower overall risk, keep current inventory safe/secure, meet urgent marketplace demands.

Chang et al (2022) offer smart warehousing as a solution to smart retail technologies behavior in smart stores. They suggest hedonic motivation is supplemented via new technologies that arouse consumer curiosity and experienced satisfaction. They show perceived ease of use affects purchasing – with secondary links to quality, price, locational convenience, speed, and recommendations, along with curiosity, joy, immersieness ,and temporal disassociation. Thus, experiences in smart stores helps drives purchasing, and this provides a need for location-secific smart warehousing. Kembro and Norrman (2022) suggest the future of smart warehousing in retailing is automated, autonomous, digital, connected, and technologies linked to retailers. They further suggest five years into the future retailers are likey to offer their own integrated smart warehousing. Thus smart warehousing into the future automates workflows, utilizes intelligent autonomous and robotics systems, drives efficiencies, and optimizes processes and connectivities.

CONCLUSION

This study seeks to expand knowledge on Australia's readiness to adopt smart warehousing. It seeks answers concerning Australia's best future directions in utilizing smart wrehousing into the future. This Australian research study now sets out to first capture and assess existing warehousing supply resources orchestration conditions. Next, it considers enablers and barriers to delivering smart warehousing demand-driven resources orchestration actions - as supply-demand near-real-time transacting solutions. Finally, it maps these supply-demand resource orchestration components of smart warehousing as likely coalesced-contributors towards a sustainable pathway into the future, and within the Australian context.

Data collection is targeted from existing Australian Stock Exchange businesses to broaqdly cross-section different industries (including retailing, health, mining, foods, and construction/engineering). These typically larger institutions or firms frequently draw on storage warehousing as an integral (and often just-in-time) part of their inbound and/or outbound B2B or B2C logistics. Data capture is structured using: (1) a Likert scale (1-5) online (quantitative) Qualtrics survey, and (2) a semi-structured, qualitative, open-ended question section Qualtrics survey inclusion.

Using quantitative data capture techniques, this stagewise combination of contributing components facilitates statistical investigation options using either smart PLS, or structural equation modelling, or possibly multi-level Mplus modelling. Figure 3 enables capture of these component measurement domains into a suitable quantitative three stage framework structure. A series of qualitative open-ended questions attached to the quntitative survey. The qualitative analysis tool NVivo and its theme-based analysis processes can provide word cloud, word tree, project map, and 3D spatial analysis, and these collectively can further verify the quantitative modelling solution.

Figure 3: Proposed Research Framework

Figure 3 is statistical approached via quantitative (SEM, PLS, or MPlus) modelling. This modelling approach can expose comparison between significant standardizedrelationships. It can provide standardized toal effects pathways operating acros the three stage model. It can present and elucidate the extent of demand, supply, and conjoint demand-supply influences, and how these then exert a network influence onto warehouse sustainability intelligences. It also likely offers further insight(s) into where, and how, Australia can best progress its smart warehousing into the future.

Further, by understanding Figure 3's supply-demand network, and the degree each of its' components contribute, it is then possible to code modify a warehouse management system to better represents the Australian smart warehouse situation. This likely includes the warehouse management system being capable of: (1) instantly transmiting each items' collected relevant data, (2) instantly analysing each item's collective data, and (3) instantly intelligently deciding where it can be best-placed to deliver optimal beneficial intelligent (and worthwhile) sustainable outcomes across its warehousing storage and movement requirements.

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