

# A strategic perspective on automated warehouse systems in retail: insights from a multiple case study

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## Abstract

**Purpose** – As the warehouse is increasingly viewed as a strategic component, retailers' willingness to invest in automated warehouse systems (AWS) has increased. These investment decisions are influenced by well-known operational factors, but strategic factors, which have received limited attention in warehousing literature, also play a pivotal role. Addressing this gap, this study investigates how strategic factors influence AWS investment decisions in retail.

**Design/methodology/approach** – Based on a theoretical foundation of technology adoption, strategic intent, and automation strategy, an abductive multiple case study is conducted with eight purposefully selected retailers that had implemented or were in the process of implementing a large AWS.

**Findings** – The study ranks 10 competitive priorities and 21 AWS evaluation aspects and shows how the firm's strategic intent and the AWS investment decisions can be connected via the formulation of a warehouse automation strategy. The findings reveal the content for such a strategy – including 7 categories and 17 considerations – related to, for example, technology innovativeness, efficiency versus adaptiveness, technology-supplier relationships, control and ownership, and risk exposure. The study empirically shows how manager characteristics and owner strategies influence retailers' AWS investment decisions. Four strategic intent profiles are abductively developed: reliability and delivery service; profitable deliveries; scalable logistics for volume growth; and platform building for logistics services. The study also provides evidence of a reciprocal relationship between strategic intent and AWS investment decisions.

**Research limitations/implications** – The study is conducted with a limited number of Swedish retailers, indicating a need for additional studies to test the findings across different contexts.

**Practical implications** – The study offers a framework for formulating a warehouse automation strategy. As a foundation for developing the framework, the study shares empirical insights from retailers in the forefront of AWS implementation.

**Originality/value** – The study contributes as a conversation changer by showing the importance of shifting from a tactical-operational focus to a strategic perspective on warehouse configuration in general and on AWS investment decisions in retail in particular.

**Keywords** Warehouse, Automation, Strategy, Retail, Strategic intent, Competitive priorities

**Paper type** Research paper

## 1. Introduction

The warehouse is increasingly viewed as a strategic component, particularly in retailing. This is driven by the evolving retail context, including e-commerce and omnichannel, whereby customers expect larger product assortments, faster and more flexible deliveries, and a variation of order characteristics (Galipoglu *et al.*, 2018; Risberg *et al.*, 2023). Boysen and De Koster (2024) added: "Warehouses have always been an essential part of supply chains, but despite their fundamental role they were not seen as especially mission critical . . . however, this assessment has changed, and today's warehouses have evolved to technology-enriched fulfillment factories with strategic relevance" (p. 1).

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The strategic perspective on warehouses is not new. Already in the 1980s, [McGinnis and Khon \(1988\)](#) stated that “warehousing is an active participant in developing competitive strategies and competitive advantage” (p. 50). Primarily, this literature stream has considered warehouses as a component of the overall logistics network ([Guthrie et al., 2017](#)) including (1) the optimal number, size, and location of warehouses in the network ([Korpela and Tuominen, 1996](#); [De Marco et al., 2010](#); [Emeç and Akkaya, 2018](#); [Zhang and Swaminathan, 2020](#)), (2) the outsourcing decision ([Maltz, 1994](#); [Akbari, 2018](#); [Akhtar, 2023](#)), (3) the total inventory of each warehouse ([Accorsi et al., 2014](#)), and (4) inventory management aspects ([Min, 2009](#)).

However, when it comes to warehouse configuration (or design), most publications analyze isolated optimization problems and focus on the tactical and operational level ([Kembro et al., 2022](#)), including classic books on warehousing (e.g. [Tompkins and Smith, 1988](#); [Frazelle, 2016](#); [Bartholdi and Hackman, 2016](#)). Frazelle, for example, commented: “It’s my personal favorite, but I have to admit that it’s the last logistics activity that should be considered when developing a supply-chain strategy . . . the warehouse is like a goalie in a soccer game. Like it or not, it’s the last line of defense and needs to be designed accordingly” (p. 12). The tactical and operational focus also concerns journal papers. Multiple reviews have been published in recent years (e.g. [Custodio and Machado, 2020](#); [Fottner et al., 2021](#); [Fragapane et al., 2021](#); [Kumar et al., 2021](#); [Płaczek and Osieczko-Potoczna, 2024](#); [Grover and Ashraf, 2024](#); [Boysen and De Koster, 2024](#)), and they all emphasize the tactical-operational focus. The same applies for reviews on automated warehouse systems (AWS) (e.g. [Azadeh et al., 2019](#); [Jaghtbeer et al., 2020](#)). [Rouwenhorst et al. \(2000\)](#) concluded that “the number of publications concerning design problems on a strategic level appears to be limited, despite the fact that at this level the most far-reaching decisions are made” (p. 524), adding that “more research on strategic issues is badly needed” (p. 527). Twenty years later, [Kumar et al. \(2021\)](#) reached a similar conclusion. [Fragapane et al. \(2021\)](#) added: “Few articles focus on decision-making at the strategic level . . . Instead, most of the reviewed articles focus on decision-making at the tactical-operational level” (p. 422).

There is therefore a knowledge gap in extant literature that lies between the strategic role of warehouses in logistics networks (e.g. where to locate the warehouse) and the tactical-operational focus for warehouse configuration (e.g. selecting the appropriate storage, routing, and picking method); that is, how strategic factors influence warehouse decision-making and configuration. This gap is increasingly important to address, as companies, and particularly retailers, make large investments in AWS ([Azadeh et al., 2019](#); [Kembro and Norrman, 2022](#)). Such investments emphasize the notion that the structural configuration of a warehouse is of a strategic nature with long-term impact, with a possible – but previously not researched – reciprocal interdependence between the overall retail company strategy and the AWS investment. [Yildirim et al. \(2023\)](#) added: “According to [Llopis-Albert et al. \(2019\)](#), managers pay more attention to management and financial issues (which are mainly strategic and tactical focus areas in our framework) . . . In contrast, academic papers in our review mainly focus on operational decisions rather than strategic and tactical decisions. There should be cooperation between the practice and the theory, and a balanced approach among strategic, tactical, and operational focus areas” (p. 127).

Our study addresses this critical gap. Focusing on the retail sector, we investigate large AWS (i.e. automated systems that handle a majority of the material flows in the warehouse) from a strategic perspective. We formulate the following research question: *How do strategic factors influence AWS investment decisions in retail?* and tackle it through a multiple case study with eight retailers that recently made significant AWS investments. We abductively move between empirical insights and theory. The study is based on extant warehousing literature and technology adoption theory (e.g. [Maghazei et al., 2022](#)). As patterns emerged in the empirical data, we looked deeper into the literature on strategic intent (e.g. [Patrucco et al., 2023](#)) and automation strategy in the manufacturing literature (e.g. [Winroth et al., 2007](#)) to further frame and explain our findings.

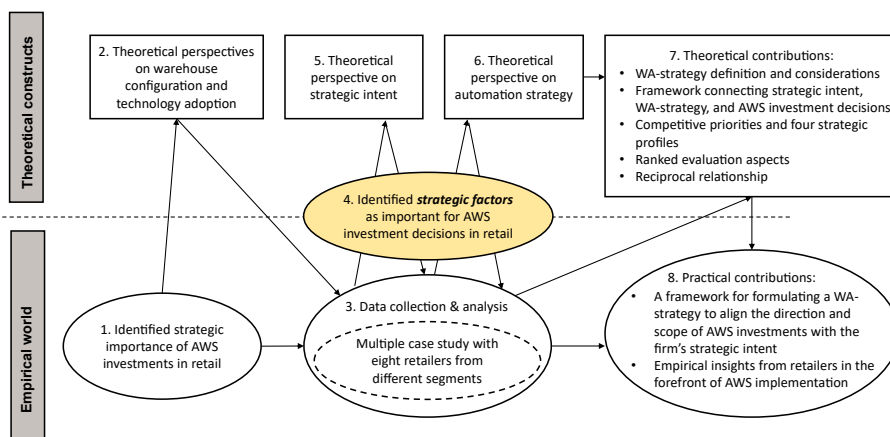
Our study contributes to theory and practice in multiple ways. First, we show the importance of shifting from a tactical-operational focus to a strategic perspective on warehouse configuration in general and on AWS investments in retail in particular. Second, we formulate what can be referred to as a warehouse strategy for AWS investments. Third, we propose a conceptual framework that extends the previously proposed content of AWS decision frameworks and automation strategy, especially by incorporating strategic intent. Fourth, our study contributes as a conversation changer, by comparing warehouses to manufacturing facilities and bringing in new theory to explain and advance our understanding of highly automated warehouses in retail. Fifth, we unravel and explain the strategic complexity of AWS investment decisions in retail by ranking competitive priorities of the firm and evaluation aspects for AWS. Sixth, we empirically show how manager characteristics and owner strategies influence retailers' AWS investment decisions, and then abductively develop four strategic intent profiles. Seventh, we provide empirical evidence of the reciprocal relationship between strategic intent and AWS investments, where much of the extant literature has suggested a one-directional relationship.

The remainder of the paper is organized as follows. As a basis for our abductive study, we first discuss our methodological approach before summarizing related academic literature. We then describe and abductively discuss the study's findings. Finally, we summarize implications and the contribution to knowledge, managerial practice, and future research.

## 2. Methodology

### 2.1 Research design

We conducted a phenomenon-driven study focusing on “identifying, capturing, documenting and conceptualizing a phenomenon of interest in order to facilitate knowledge creation and advancement” (Schwarz and Stensaker, 2016, p. 486). To seek new insights and assess how strategic factors influence AWS investment decisions in retail in a new light, we followed an abductive reasoning approach with iterations between empirical data and theory (Ketokivi and Choi, 2014). During the study, we were “moving back and forth between the empirical world and the theoretical constructs” (Dubois and Gadde, 2014, p. 1280). These steps are visualized in Figure 1 (numbers link the figure to the corresponding text) and described below.



Source(s): Authors' own creation

Figure 1. Overview of the abductive approach

The starting point for this research was (1) the observation that retailers increasingly view the warehouse as a strategic component and are more willing to make large AWS investments (Kembro *et al.*, 2022). In previous studies, we observed that retailers chose different types and degrees of technology. To understand more about these investment decisions, we (2) reviewed literature on warehouse configuration and technology adoption. We used this as a basis to develop a data collection protocol and (3) conducted a multiple case study with eight purposefully selected retailers that had recently made significant AWS investments. Early in the data collection process, the empirical data and theoretical foundation directed us to (4) the importance of strategic factors. This is logical, as making a large structural investment and adopting new technologies suggests that strategic factors play a pivotal role (Maghazei *et al.*, 2022). However, while this approach gave us a unique opportunity to empirically understand how strategy and warehousing interact in retail, we lacked a theoretical lens to provide additional explanation of the emerging patterns. Following an abductive approach, we therefore (5) turned to different literature streams on strategic factors, which led us to identify strategic intent (Hamel and Prahalad, 1989; Patrucco *et al.*, 2023) as a key perspective for our studied phenomenon. This gave us a toolbox to frame the strategic perspective on AWS and to explain some of our findings (see, e.g. section 4.2 on strategic intent profiles).

As our abductive study progressed, both empirical data and literature suggested that strategic intent and AWS investment decisions are linked through the formulation of a warehouse automation (WA) strategy. The next logical step was to (6) dive deeper into literature on automation strategy. We concluded two important insights. First, there is a knowledge gap in extant warehousing literature that lies between the strategic role of warehouses in logistics networks (e.g. where to locate the warehouse) and the tactical-operational focus for warehouse configuration (e.g. selecting the appropriate storage, routing, and picking method). Consequently, as pointed out by multiple researchers, the strategic perspective on warehouse configuration is missing in warehousing literature. More specifically, we could not find any substantial literature on warehouse strategy or automation strategy. Second, our search on automation strategy led us (again) to the manufacturing literature (e.g. Säfsten *et al.*, 2007; Lindström and Winroth, 2010). This literature helped us to (7) clarify and discuss our contributions to the automation strategy literature and to the warehousing literature in general, and (8) further frame our proposed WA-strategy framework. All actions taken to improve the validity and reliability (Yin, 2014) of the study are listed in Appendix 1.

## 2.2 Data collection and analysis

We conducted a multiple case study (Eisenhardt, 2021) with eight retailers that had recently made significant AWS investments (see Table 1). Due to anonymity, we cannot provide detailed information about each company. All retailers are based in/operate from Sweden but have and continue to increase their international presence. The retailers were purposefully selected (from an original sample of 300 invited companies, of which 50 responded to an initial survey and 31 to a second) based on the following criteria: (1) completed or in the process of implementing a large AWS; (2) different degree and type of automation technology (e.g. shuttle system, compact storage and order picking system, A-frame, and autonomous forklifts), (3) different sales channels (omnichannel vs pure e-tailers), and (4) a mix of segments/products (fashion, grocery, pharmaceutical, sports and leisure, DIY, department store, and automotive). The purpose of this approach was to obtain in-depth knowledge and enable both within-case and cross-case analysis of how retailers take strategic factors into consideration for their AWS investment decisions. To further motivate our case selection, we asked the companies to rate themselves how early they perceived that their company and warehouse management adopt technology (theory on diffusion of innovations; Rogers *et al.*, 2014). All eight case retailers perceived themselves to be early compared to competitors (two innovators, three early adopters, and three early majority).

As a first step, we collected data through exploratory surveys (Malhotra and Grover, 1998). The survey questions captured (1) general information about the case retailers (e.g. size,

**Table 1.** Overview of the eight case companies

#	Retail segment	Main sales channel	Turnover (M Euro)	Type of automated system	# Interviewees/ roles	Length of visit
A	Pharma	Stores → Omnichannel	~2,000	A-frames; conveyor belts	2/Logistics Developer, Site Manager E-com Operations	4 h
B	Spare parts	Stores → Omnichannel	~300	Shuttle system; conveyor belts	3/CFO and CEO, COO, Warehouse Manager	4 h
C	Fashion	E-tailer	~340	Compact storage and order picking system; conveyor belts	3/Chief SC Officer, Production Manager	4 h
D	Department store	Stores → Omnichannel	~640	Shuttle system; conveyor belts; autonomous forklifts	Outbound, Head of Sustainability	4 h
E	Sport and Leisure	E-tailer	~100	Compact storage and order picking system; conveyor belts	3/Head of Logistics, Head of Logistics Development, Manager Central Distribution	4 h
F	Grocery	E-tailer	~135	Conveyor belts; automated packaging and sequencing system	1/Logistics Manager	3 h
G	DIY	Stores → Omnichannel	~400	Shuttle system	2/COO, Operations Development Manager	5 h
H	Fashion	Stores → Omnichannel	~1,100	Shuttle system; compact storage and order picking system; conveyor belts	4/Logistics Manager, Head of Production Support, Warehouse Manager, Senior Logistics Consultant	4 h

**Source(s):** Authors' own creation

turnover, type of channel, assortment range, and lead time offerings); (2) strategic logistics challenges (competitive priorities) for their warehouses; (3) the degree to which the companies invest in AWS; (4) evaluation factors for AWS investment decisions; and (5) the extent to which strategy and AWS influence each other. The respondents responded using a perceptual Likert scale ranging from 1 (“agree to a very low degree”) to 7 (“agree to a very high degree”).

Between August and October 2022, we visited and participated in guided tours in the eight retailers' automated warehouses. The visits also included interviews with one or more key

personnel such as supply chain (SC) director, logistics manager, warehouse manager, production manager, and sustainability manager. We recorded and transcribed all interviews, and coded all data using the NVivo tool. The coding was based on themes according to the interview guide (e.g. influence of ROI on investment decision), but new areas and interesting themes were also identified (e.g. influence of management background). The coded data were then analyzed based on a structured iteration between the theoretical perspective and empirical data (Ketokivi and Choi, 2014; Eisenhardt, 2021) with data reduction, data display, conclusion drawing, and verification (Miles and Huberman, 1994). By studying similarities and differences between cases (Eisenhardt, 2021), our aim was to elaborate theory, defining and grounding constructs through conceptualization and abstraction. Two researchers conducted the joint analysis and interpretation of the findings.

### 3. A strategic perspective on automated warehouse systems: establishing a theoretical foundation

The literature review section reflects our abductive approach, as we grounded our study in extant warehousing configuration literature and technology adoption, and then looked deeper into strategic intent and automation strategy in the manufacturing literature.

#### 3.1 Automated warehouse systems in retail

The most obvious evidence of the warehouse's increased strategic role is the retailers' willingness to make large AWS investments with long-term impact (Kembro and Norman, 2022). External key investment drivers include: (1) Industry 4.0 and the rapid development of material-handling technology (Azadeh et al., 2019), including mature, varied, and flexible technologies (McCrea, 2019, 2020), (2) proven business cases with global online giants leading the way and making large investments in automated material-handling technology (Alibaba Cloud, 2019; Fulfilment in our buildings, 2020), and (3) increased competition and plummeting profit margins, resulting in retailers increasingly focusing on cutting operational costs (Larke et al., 2018).

Kembro and Norman (2022) concluded that retailers' early investments primarily focused on AWS in outbound operations (i.e. order picking, packing, sorting, and shipping), and gradually increasing the focus on automating receiving and put-away. Their study points out that the most popular technologies among Swedish retailers include compact storage systems (e.g. Autostore), shuttle systems, location-bound sorting, packaging, weighing, sizing, and palletizing. Another common AWS (particularly in pharma) is the A-frame, which is suitable for large flows of small stock-keeping units (SKUs) (Azadeh et al., 2019). In recent years, technology has become more mature, varied, and flexible, and so the range of AWS has increased. This includes, for example, autonomous forklifts and vehicle-based storage and retrieval (Azadeh et al., 2019), robotic piece-picking (Kembro and Norman, 2022), autonomous mobile robots (AMR) for picking and sorting, and pocket sorting (Boysen and De Koster, 2024). Examples of AWS and applications are listed in Table 2.

AWS investment decisions are guided by several evaluation aspects (e.g. McCrea, 2019, 2020; Yildirim et al., 2023), such as AWS cost and ROI, implementation time, throughput, and speed, picking efficiency, and flexibility, reliability, and scalability. Each AWS investment decision involves a trade-off analysis between different strategic configuration goals (Kembro and Norman, 2020). In other words, different systems can be more or less suitable for achieving economy of scale, handling task complexity, market dynamics, and speed, and increased utilization of warehouse space. Boysen and De Koster (2024) discussed the challenge for any AWS to handle the range of varying demand, varying order structure, and varying lead times. They conclude that a systematic cross-comparison of how well different AWS achieve different goals is lacking. However, for the purpose of this paper it is valuable to make a simple comparison between two of the most common AWS in Swedish retail (Kembro and Norman, 2022): the compact storage system Autostore and the shuttle systems. Both these technologies have well-known pros and cons.

**Table 2.** Examples of AWS and applications

AWS in retail	Example of application
Shuttle system	Swisslog dynamic shuttle system
Autonomous forklift	VisionNav robotics autonomous forklift
Autonomous mobile robots	Jungheinrich autonomous mobile robots
Compact storage system	AutoStore
A-frame	Inther Group A-Frame
Robotic piece-picking	RightHand robotics
Location-bound sorting	Denisort sorting system
Flexible robotic sorting	Geek+ sorting system
Pocket sorting	AIRTRAX Pocket
Automated packaging system	Nöjd automated packaging system
Automated dimensioning and weighing	Cubiscan 275
Robotic palletizing	Mujin palletizing robot

**Source(s):** Authors' own creation

First, Autostore is faster to implement (time from investment decision to full operation) than a large shuttle system. It is less capital intensive; the retailer can start with a small “cube” and expand gradually. The main challenge for Autostore is the limitation of SKU characteristics and size of volume/flows. The SKUs cannot be too big to fit in the totes (nor should they be too small). Furthermore, Autostore does not perform too well for high throughput or high quantities per SKU (e.g. store replenishment). In comparison, a shuttle system performs better for higher throughput and varied SKU characteristics. It is also relevant to consider the “ABC frequency curve”; the Autostore is not optimal for a flat curve, meaning that many SKUs are equally frequently picked (then, the robots must often dig up totes from deep down in the cube). Finally, it is relevant to consider that there is a limit to how big an Autostore can be. Beyond a certain size, it may be necessary to build a second cube (and a third, and so on), which leads to an expanded sorting issue for the warehouse operation (Kembro *et al.*, 2022).

### 3.2 Technology adoption and strategic intent

To understand strategic factors that influence AWS investment decisions, we initiated our abductive study by drawing on technology adoption literature. Specifically, we considered the adoption of advanced manufacturing technology (AMT) literature (Maghazei *et al.*, 2022), as highly automated warehouses increasingly resemble dedicated production lines.

Maghazei *et al.* (2022) argued that a business case is central, and this includes an assessment of economic potential and strategic relevance (Small and Yasin, 1997). Common economic indicators include cost of the technology, return on investment (ROI), payback period, and cost of capital (Burcher *et al.*, 1999; Maghazei *et al.*, 2022). This approach may create a bias against innovative technologies, as managers overlook strategic fit and less quantifiable and longer-term benefits (Small and Yasin, 1997). Managers are also concerned with costly training and short-term productivity dips (Maghazei *et al.*, 2022). Sternberg and Norrman (2017) added: “history is full of technologies never adopted in favor of less optimal designs . . . [and] the previous adoption of technology is one of the strongest inhibitors of novel technology adoption” (p. 746). There is an inherent risk and uncertainty of being the first to invest in a new technology (cf. diffusion of innovation theory; Rogers *et al.*, 2014). Maghazei *et al.* (2022) argued that financial assessment of technology adoption has limitations, and that the remedy is to ensure “an appropriate fit between firm strategies and technology adoption” (p. 563). It is therefore relevant to consider a firm’s strategic intent for AWS investment decisions.

Strategic intent (Hamel and Prahalad, 1989) has been used in the SC and operations strategy literature (e.g. Fawcett *et al.*, 1997; Krause *et al.*, 2001), and recently by Patrucco *et al.* (2023) in their study on purchasing strategy. Strategic intent can be conceptualized (or

operationalized) as competitive priorities of the firm, i.e. the strategic goals and objectives that should be achieved (Patrucco *et al.*, 2023). Patrucco *et al.* (2023) found that competitive priorities and purchasing practices are interdependent, calling for an integration of the two to develop effective purchasing strategies. For manufacturing, Hayes and Wheelwright (1984) emphasized that firms differ in the emphasis they give to each competitive priority, which creates unique strategic profiles (Flynn *et al.*, 1999), and they describe competitive priorities as cost; product reliability (quality-performance); unique product features (quality-features); dependability (accuracy) of specifications, on-time delivery and service; plants' product flexibility; and plants' volume flexibility. For AMT, Burcher *et al.* (1999) listed a range of such competitive priorities, including cost, delivery lead time, delivery reliability, flexibility, and volume variability. In warehousing, strategic intent or strategic priorities have not been explicitly used. However, Kembro and Norrman (2020) discussed different strategic challenges (e.g. economy of scale, task complexity, market dynamics, speed, tied-up capital, and warehouse space), linked to different contextual profiles that retailers must prioritize between when making larger investments in warehouse configurations. They concluded that: "Large omnichannel retailers typically have ... several contextual factors pointing in different directions. This implies the need to invest in more complex and costly configurations or to make trade-off analyses to determine the most important factors and goals. Such a trade-off analysis is probably guided by overall corporate strategies" (pp. 70–71).

Considering that highly automated warehouses increasingly resemble dedicated production lines, it is also reasonable to hypothesize that AWS investments may have implications for future strategic maneuvering. This notion originates from Parthasarthy and Sethi (1992), who investigated manufacturing technology and placed technology and strategy in a reciprocal relationship. This relationship has not been studied before in warehousing literature but suggests that there could be a reciprocal interdependence between competitive priorities and AWS; that is, the strategic intent influences the type/degree of AWS to invest in, while the chosen/implemented AWS will influence the possibilities to change future strategic direction for the company.

### 3.3 Automation strategy

Next, our abductive approach led us to a closer review of the literature on automation strategy (as a link between strategic intent and AWS investment decisions). This literature stream grew in the 1980s and 1990s as part of the manufacturing literature (e.g. Hayes and Wheelwright, 1984; Boyer *et al.*, 1996). It was then further developed during the 2000s, linking manufacturing strategy with automation strategy (e.g. Säfsten *et al.*, 2007; Winroth *et al.*, 2007; Lindström and Winroth, 2010; Granlund, 2014).

For the purpose of our paper, here it is relevant to briefly define what is meant by "strategy". Strategy can be defined in many ways, for example as something that can be planned or as something that emerges. It can be a "tool chosen to accomplish the fundamental objectives of the firm" (La Londe and Masters, 1994, p. 35) or emerging more as "a pattern in a stream of decisions" (Mintzberg, 1978, p. 934). Johnson *et al.* (2005) described it in more detail as "the direction and scope of an organisation over the long term, which achieves advantage in a changing environment through its configuration of resources and competences with the aim of fulfilling stakeholder expectations" (p. 9). From a business perspective, strategy concerns a long-term perspective on firm direction, objectives, and configuration decisions.

In manufacturing, research on automation strategy acknowledges (1) the need for companies to develop an automation strategy and (2) the need for more research on automation strategy (Säfsten *et al.*, 2007; Winroth *et al.*, 2007; Lindström and Winroth, 2010; Granlund, 2014). Granlund (2014) added, "while the importance and need of strategy connected with automation development and decisions and some support for the formulation of an automation strategy can be found, there is less support and descriptions of the actual content of the automation strategy" (p. 29). One focus in literature is on whether the automation strategy is the manufacturing

strategy or if the automation strategy is one of many areas within the manufacturing strategy (Winroth *et al.*, 2007). Warehousing is treated rather peripherally; instead, the term used is “internal logistics”. The general perception is that automation strategy is part of the internal logistics strategy, which is part of the manufacturing strategy (Granlund, 2014). Apart from Parthasarthy and Sethi (1992), most research suggests a one-directional relationship; that is, the company strategy influences the manufacturing strategy, which in turn influences the internal logistics and automation strategy (e.g. Granlund, 2014, Figures 19 and 21).

It is important to note that automation strategy in manufacturing focuses on process technology; that is, automation of material-handling processes (e.g. an automated guided vehicle) to move goods from station A to station B. This is significantly different compared to the retail context (the focus of our paper), where AWS comes in many different types, and for many different purposes (see Section 3.1). The research also circles around what is the right level of automation. Säfsten *et al.* (2007), for example, discussed under-automation, over-automation, and “rightomation”. Granlund (2014) discusses two more important decisions: (1) the choice of what to automate; and (2) the choice of technology. Referring to Hax and Majluf (1991) and Baines *et al.* (2005), Granlund (2014) also commented that some literature has brought up the issue of involving and relying on external partners, arguing for a rigorous supplier selection to ensure a successful automation project. Hofmann and Orr (2005) added, “This is a difficulty associated with multi-functional projects that is rarely considered in the literature” (p. 715).

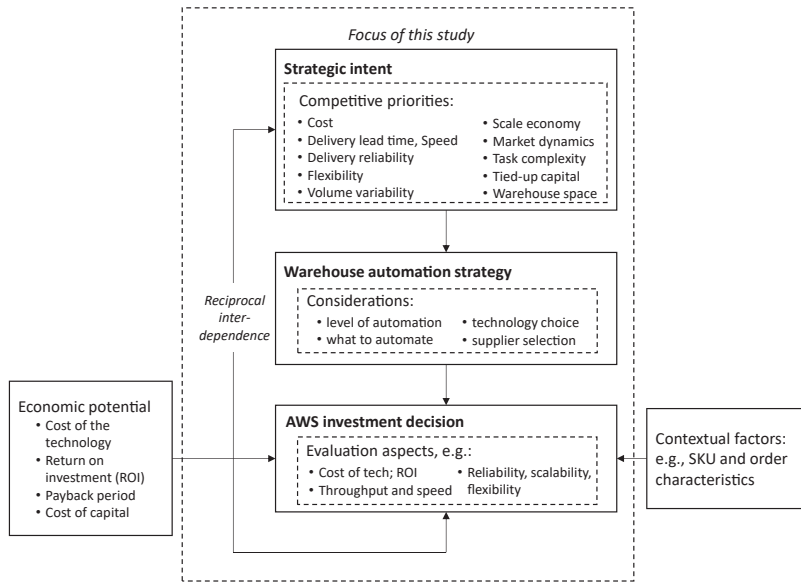
In the past ten years, a review of the manufacturing literature (both keyword search and snowballing based on, e.g. Granlund, 2014) indicates a shift of focus from automation strategy to, for example, “digital transformation” and “digitalization strategy”. In parallel, during the same period (2015–2024) retailers have increased their focus on AWS, so the need for developing knowledge of automation strategy has gradually shifted from manufacturing to warehousing literature. It is important to stress that there is a knowledge gap in extant scientific warehousing literature that lies between the strategic role of warehouses in logistics networks (e.g. where to locate the warehouse) and the tactical-operational focus for warehouse configuration (e.g. selecting the appropriate storage, routing, and picking method). Multiple reviews have documented this gap (e.g. Fragapane *et al.*, 2021; Kumar *et al.*, 2021; Yildirim *et al.*, 2023), and attention for a strategic perspective on AWS in retail is slowly picking up in scientific literature. Yildirim *et al.* (2023) recently investigated mobile robot automation and suggested a managerial decision framework where the strategic level included: (1) evaluation criteria and selection of the type of mobile robot system; (2) identification of key performance indicators; (3) facility layout; and (4) human-robot interaction management.

### 3.4 Toward a framework for understanding strategic factors that influence AWS investment decisions

We use our literature review to create an initial framework for understanding the strategic perspective of AWS investment decisions (Figure 2). The literature, which is largely founded in manufacturing, suggests that economic potential and strategic intent (competitive priorities) are key for AWS investment decisions. It also highlights the importance of developing an automation strategy. The content of such an automation strategy mainly concerns the level of automation, what to automate, and the choice of technology. As we suggest in Figure 1, the automation strategy together with economic potential and well-known contextual factors (e.g. SKU and order characteristics) is the foundation for AWS investment decisions. The investment decisions are guided by several evaluation aspects. Finally, we hypothesize – with some support in manufacturing literature – that there is a reciprocal relationship between strategic intent and AWS investment decisions.

## 4. Insights from the empirical findings and analysis

In this section, we present insights from the empirical findings and analysis, to (1) develop the framework presented in Figure 2, and (2) answer the research question: *How do strategic*



Source(s): Authors' own creation

Figure 2. Overview of theoretical foundation and focus of this study

factors influence AWS investments decisions in retail? The structure follows the order of Figure 2; we start with strategic intent in terms of competitive priorities (section 4.1) and then add the observed influence of owner and management characteristics (4.2). We continue with WA strategy (4.3), followed by AWS evaluation aspects (4.4) and the reciprocal interdependence between strategic intent and AWS investment decisions (4.5). Finally, we summarize section 4 by connecting the dots between strategic intent, WA strategy, and AWS evaluation aspects in an updated conceptual framework (4.6).

#### 4.1 Competitive priorities

First, we surveyed the case companies' current and future competitive priorities (referred to as strategic logistics challenges in the survey; Table 3). The competitive priorities were identified from literature (e.g. Hayes and Wheelwright, 1984; Flynn et al., 1999; Burcher et al., 1999; Kembro and Norrman, 2020) and summarized them for warehousing as cost, delivery lead time, delivery reliability, flexibility, volume variability, scale economy, market dynamics, task complexity, tied-up capital, and warehouse space, with environmental aspects added.

Our findings show that retailers balance multiple competitive priorities, and that the importance of each priority (except from space) increases over time. The case companies reported environmental aspects as the strategically most important priority in the future (6,6). While speed and lead time (6,5) as well as economies of scale (6,5) were also highly rated, the case companies ranked market and demand dynamics (5,9), and growth and scalability (5,9) highly but relatively less important. Social sustainability (6,4), cost focus (6,4), and flow complexity (6,4) were also ranked highly. Among the case companies, it is interesting to note that case B (and to some degree case F) perceived growth and scalability and warehouse space as less of a challenge. One possible explanation is that these companies had recently invested in excess capacity. Meanwhile, case E ranked social sustainability and cost slightly lower. Tied-up capital divided the case companies, where C, D, and E ranked it higher while the others ranked it lower. A comparison with a larger sample of Swedish retailers ( $n = 31$ ) is

**Table 3.** Case companies' prioritization of strategic logistics challenges

	Today										In five years							
	A	B	C	D	E	F	G	H	Mean	A	B	C	D	E	F	G	H	Mean
	Speed and lead time requirements: having shortest customer lead times and being fastest in warehousing	7	5	7	6	7	7	4	5	6,0	7	6	7	6	7	7	6	6
Economies of scale: leveraging scale in warehouse logistics	6	4	7	5	6	7	6	5	5,8	7	4	7	7	7	7	7	6	6,5
Market and demand dynamics: handling changes and fluctuations in needed warehouse capacity	6	3	7	5	4	6	5	7	5,4	7	4	7	5	6	6	5	7	5,9
Growth and scalability: having warehouse solutions that supports strong sales expansion	7	2	7	5	7	5	7	6	5,8	7	2	7	5	7	5	7	7	5,9
Environmental aspects: energy, recycling, and emissions related to warehousing and handling	6	1	6	6	5	6	6	3	4,9	7	na	6	7	7	6	7	6	6,6
Social sustainability: attracting right competencies and create good working conditions	5	6	6	6	5	7	7	5	5,9	6	6	7	7	5	7	7	6	6,4
Cost focus: achieving lowest cost in warehouse logistics	6	5	7	6	4	6	7	5	5,8	7	6	7	7	5	6	7	6	6,4
Flow complexity: handling large complexity in warehouses due to order structures and product flows	7	5	7	7	4	7	3	6	5,8	6	6	7	7	7	7	5	6	6,4
Warehouse space: handling restrictions in warehouse space	2	2	7	6	5	3	6	2	4,1	2	2	6	3	6	3	6	4	4,0
Tied up capital: increasing inventory turnover and reducing capital tied up in inventory	3	1	5	7	6	2	3	2	3,6	3	2	6	6	6	2	5	4	4,3

**Source(s):** Authors' own creation

available in [Appendix 2](#), showing that the larger sample differed by ranking environmental aspects less important in the future while market and demand dynamics, as well as growth and scalability were ranked as more important.

#### 4.2 The influence of owner and management characteristics

During the analysis process, we observed that the case companies (as forefront runners of AWS) often reasoned similarly around competitive priorities and AWS investment decisions. However, we noted some fundamental differences in perspectives of and justifications for their AWS investment decisions. We could not explain those differences with classic contingency factors such as retail segment (type of product), goods size, size of company, market dynamics, demand pattern (e.g. [Faber et al., 2018](#); [Kembro and Norrman, 2020](#)). Nor could we explain the differences with isolated factors from the AMT literature ([Maghazei et al., 2022](#)).

Instead, our abductive analysis suggested that a combination of different inherent company characteristics – we refer to it as different “DNAs” – seemed to have a considerable influence. Based on our literature review, we could frame this as a combination of the owners’ perspective on economic value creation and the managers’ perspective (due to their professional origin and interest) on strategic relevance ([Burcher et al., 1999](#)), which seem to create a preference for or bias against certain technologies ([Small and Yasin, 1997](#)) and investment decisions. We observed differences in channel background, ownership form and value focus, management background and focus, as well as general innovativeness climate ([Table 4](#)) that during interviews either explicitly or implicitly seemed to motivate certain investment decisions. Specifically, they influenced decisions such as: (1) the size of the investment and requirements for payback period, (2) the importance of different financing solutions, and (3) the actual business purpose of the automation (e.g. increasing profitability and/or supporting rapid growth), as well as the decision-making process, and its pace.

Our abductive analysis suggested four retail clusters with different “DNAs” – different combinations of management team origin ownership structure and focus on economic value creation. We refer to these as strategic intent profiles ([Figure 3](#)), which help to explain why the case companies invested in a certain degree and type of AWS. Strategic intent profiles (or categories) are not new in the strategic intent literature. However, for retail and AWS investment decisions, this is an original and important finding extending previous research on contextual profiles ([Kembro and Norrman, 2020](#)). As support for [Figure 3](#), we draw on strategy literature and specifically insights on manager characteristics and owner strategies (e.g. [Katz and Niehoff, 1998](#); [Blackburn et al., 2013](#); [Baron and Barbieri, 2019](#)). The strategy literature generally agrees that manager characteristics and owner strategies influence the long-term direction of the company. [Baron and Barbieri \(2019\)](#) discussed two basic questions for an owner strategy: what are the goals (growth, liquidity, or control), and what are the guardrails, i.e. the financial and non-financial boundary conditions for the company based on the defined goals. As a concrete example – connecting back to [Frazelle’s \(2016\)](#) comparison of a warehouse and a goalkeeper – [Lassas \(2021\)](#) studied owner strategies in football and identified three profiles: win-maximizers, profit-maximizers, and political owners. In [Figure 3](#), we use our empirical data to make a corresponding classification for retail. Later (end of [section 4.3](#)), we also connect each of the four strategic intent profiles with formulated WA strategies.

The first profile, exemplified by case A, focuses on *Reliability and delivery service*. The retailer with long-term owners such as the government emphasizes regulatory compliance, safety of products and employees, with delivery service to customers as the highest priority. The AWS should improve these aspects, leaning toward proven technology, low risk of downtime, and avoiding complex integrations between multiple suppliers. Financing arrangements and capital availability appeared to be a minor issue.

The second profile revolves around *Profitable deliveries*. These retailers (e.g. D, G, H) have a clear “retail-DNA” with a long trading tradition and ownership concentrated in one or a few families (with family members active in the operational management). The focus is on

**Table 4.** Summary of influencing company characteristics

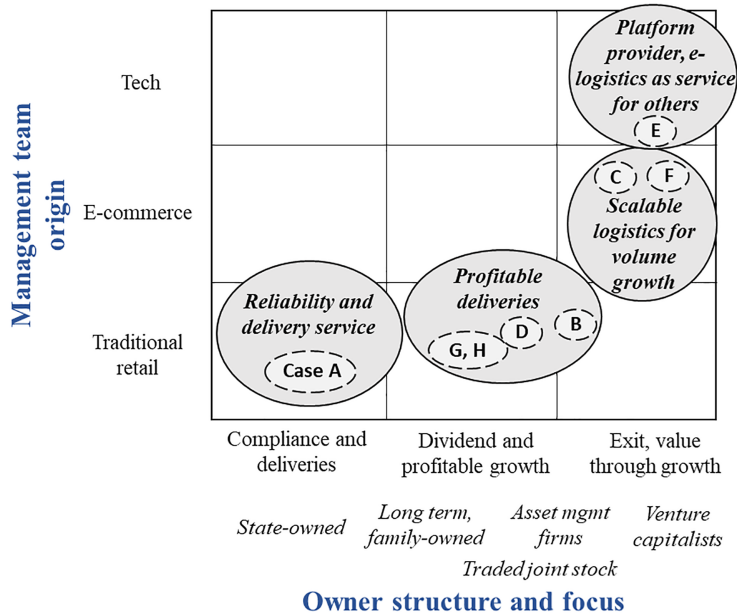
#	Main sales channel	Ownership form	Owner-focused value creation	Mgmt. origin	Corporate innovation profile
A	Stores → Omnichannel	State-owned joint stock company	Compliance with regulations; delivery service incl. speed	Pharma, retail	Early majority
B	Stores → Omnichannel	Traded joint stock company; part of a group owned by long-term asset management firm	Dividend and profitable growth; getting synergies between brands and countries	Retail, logistics	Early adopter
C	E-tailer	Traded joint stock company; owned by long-term asset management firm	Volume growth	E-tailing	Innovator
D	Stores → Omnichannel	Traded joint stock company; mainly owned by funding family	Dividend and profitability; volume growth	Retail	Early majority
E	E-tailer	Traded joint stock company; owned by different venture capitalists and founder	Volume growth	Tech; e-tailing	Early adopter
F	E-tailer	Traded joint stock company; owned by venture capitalist	Volume growth	E-tailing	Innovator
G	Stores → Omnichannel	Family-owned	Dividend and profitability; volume growth	Retail	Early majority
H	Stores → Omnichannel	Family-owned	Dividend and profitability; volume growth	Retail	Early majority

**Source(s):** Authors' own creation

ROI and growth-with-profitability. The implemented AWS should therefore increase the retailers' competitiveness and support new, profitable customer value offerings. A similar aim was found in listed companies (case B), where investors (e.g. asset management firms) had long-term intentions of synergies between firms in different countries or segments.

The third profile focuses on *Scalable logistics for volume growth*. These retailers' ownership structures are more short-term compared to the family-owned, regardless of whether it is a broad shareholding or more concentrated in one or more venture capital companies. Shareholder value can even be generated from an exit, meaning that the owners – when investing in AWS – focus more on selling the retail company than getting shareholder value from profitable retail operations. Sometimes, especially for young e-commerce retailers (C and F), the owners' business models promote a higher priority for growth than profitability; the company valuation is based more on sales growth and growth potential than on profit and profitability. Consequently, both the horizon length and size of investment in AWS often decrease. The financing models become more important if the owners are approaching an "exit", that is, they will soon try to sell the company.

The fourth profile has many similarities with *Scalable logistics for volume growth*. However, our analysis indicated that the retail activity itself is perhaps more a means to the goal of delivering a platform for e-commerce and logistics services to other retailers. We refer to this profile as *Platform building for logistics services*. The ownership structure has a focus



Source(s): Authors' own creation

Figure 3. Four strategic intent profiles based on management team origin and ownership structure and focus

on increasing shareholder value through growth, but the growth is not generated solely through the company's (case E) own retail operation; instead, the future profit is generated from other retail firms' transactions. We perceive a difference in the management teams' interest and competencies, where a "tech-DNA", i.e. a background in and interest in IT and high-tech, is more important than the retail and logistics focus and experience that were distinctive for the other retailers' management teams. This implied a greater focus on innovation (based on the retailer's own technological know-how) and creating their own, customized systems based on simple and scalable technology.

#### 4.3 An approach for formulating a warehouse automation strategy

Investing in AWS is an expensive and complex decision that affects the retailer for many years or even decades. Despite this, none of the case companies had formulated a clear automation strategy at the time of the study. Several claimed to be on their way: "We are currently formulating an automation plan"; "It is part of the overall supply chain strategy"; "We have formulated a vision"; or "We have no formal strategy but guiding principles." Others claimed to have it available in a less tangible format: "It is part of the organizational culture" or "It exists in our minds, and semi-officially on paper." Interestingly, in some sense, this reflects the gap we observed in warehousing literature concerning the strategic perspective on AWS investment decisions in retail.

To address this gap, we noted that many strategic decisions were discussed during our interviews with the case companies; sometimes the case representatives had similar reasoning around AWS investment decisions, but occasionally they differed greatly, indicating varying directions where strategic decisions must be taken. Our analysis of these (similar and differing) decisions revealed seven categories that together constitute what could be considered for formulating a WA strategy: (1) role in logistics network; (2) technology innovativeness;

(3) efficiency versus adaptiveness; (4) relationship with technology supplier; (5) control and ownership; (6) risk exposure and robustness; and (7) sustainability. In [Table 5](#), we use empirical case data to elaborate and motivate each of these WA-strategy categories and to submit a list of WA-strategy considerations. We also provide concrete examples of how the WA-strategy considerations can be used by linking the four strategic intent profiles ([section 4.1](#)) with formulated WA strategies (see [Table 6](#)). Some differences between the WA strategies become clear. The strategic intent profile “Profitable deliverables” is expanding brownfield sites, using long-term partners to fine-tune their AWS with robust operations, while the others are less capital-restricted or more growth-focused. The profile “Reliability and delivery service” mostly considers how to reduce different types of risks. Meanwhile, the profile “Scalable logistics” considers how to get the most growth potential from more limited investments with a shorter horizon and by leveraging partnership with tech-providers. The “Platform providers” profile focuses on independence and creating a unique AWS that can enable new business offerings.

These original insights address the gap concluded by [Granlund \(2014\)](#): “there is less support and descriptions of the actual content of the automation strategy” (p. 29). Our seven suggested categories also extend the previously proposed content of an automation strategy, namely level of automation, what to automate, and choice of technology ([Säfsten et al., 2007](#); [Winroth et al., 2007](#); [Lindström and Winroth, 2010](#); [Granlund, 2014](#)). It should also be reiterated that developing an approach for formulating a WA strategy is new for the warehousing literature in general and retail context in particular. Therefore, inspired by previous strategy definitions (e.g. [La Londe and Masters, 1994](#); [Johnson et al., 2005](#)) we propose a definition of planned-oriented WA strategy as:

a tool that helps decision makers align the direction and scope of AWS investments and configurations with the firm’s strategic intent to ensure that the firm meets its fundamental objectives and achieves advantages in a changing environment in the long term, with the aim of fulfilling stakeholder expectations.

#### 4.4 Evaluation aspects for the automated warehouse systems decision

To increase our understanding of the complexity involved with AWS investment decisions, we surveyed the case companies’ perceptions of 21 AWS evaluation aspects (identified from scientific and popular science literature such as [McCrea, 2019, 2020](#); see [Table 7](#)). This is an extension of previous scientific literature. For example, [Yildirim et al. \(2023\)](#) only listed (without ranking) six criteria to evaluate mobile robot systems.

The highest ranked evaluation aspects included AWS reliability (6,9), order accuracy (6,9), speed (6,9), throughput (6,8), picking efficiency (6,8) and scalability (6,6). The results showed that the importance of almost all 21 evaluation aspects increased over time, and in five years, 12 of the aspects were ranked above 6,0. This suggests that the AWS decisions become increasingly complex over time, but also indicates that the capability to assess and compare evaluation aspects must increase. One case respondent (B) commented: “It is more complex in many ways today to make the decision than it was when our decision was made like 7–8 years ago, in the sense that so much has happened in the world.” Another respondent (C) added: “I would say, yes, it is a complex decision. Because there are many ways to do something . . . you have to really clarify, you have to understand what the process is that you need in general and at what speed do you want to perform this.” Another relevant observation is that all evaluation aspects related to performance are ranked high, yet the case companies choose different AWS. One explanation is that different AWS are a better match for different strategies and contexts. In other words, the AWS assessment and decision-making must be founded in the companies’ (including owners and management) priorities and needs.

The comparison with a larger sample of Swedish retailers ( $n = 31$ ), available in [Appendix 3](#), showed an overall similar pattern in terms of ranking and development. It is interesting to note the retailers’ different views on the relations with automation providers. For the two

**Table 5.** The seven WA-strategy categories, including empirical case data and a list of WA-strategy considerations

1) *Role in logistics network*

C1 – Consider the degree of centralization and the role of the warehouse in the logistics network

C2 – Evaluate the strategic intent alignment of initiating a greenfield versus a brownfield AWS project

All case companies stressed the importance of the warehouse (WH) role in the logistics network. The automation decision was typically part of a larger change to the distribution network (e.g. moving to a new site, or consolidating multiple WHs into one, centralized facility. Setting up a new, greenfield WH enables planning the AWS from scratch, without any predefined boundaries. However, it involves many other decisions (e.g. location, negotiation with the municipality, access to logistics and IT infrastructure). The alternative, using a brownfield WH, removes many logistics and construction decisions. However, it can put boundaries on the AWS dimensions (e.g. brownfield sites may have lower roof height, which excludes high-bay technology solutions) which could lead to an AWS investment decision that is not perfectly aligned with the retailer's strategic intent

2) *Technology innovativeness*

C3 – Consider the strategic intent alignment of being an innovator or early adopter versus early or late majority in adopting new AWS technologies

C4 – Focus on one main technology, or many that need to be integrated

C5 – Invest in standardized or customized AWS; this includes consideration if/how the automation technology can be scaled up and/or copied to other sites

We noted skepticism toward being innovators to avoid uncertain payoffs and risk of downtime. However, two cases (C, H) were proud of being among the first in the world to implement their technology and develop customized solutions instead of buying standardized ones. By being innovators or early adopters, they could outperform their competitors. Another decision is to focus on one main technology (e.g. case A, B, and C) or several different technologies (e.g. D and H). One technology means simplicity in terms of integration, while a combination of technologies handles a wider range of product and order characteristics. However, it requires more integration system-wise and flow-wise. A related choice concerned technological complexity. One case company (E) pursued what they referred to as “simplicity” in the mechanics and intelligence of the system so that their own staff could understand, maintain and develop the AWS. Another (F) wanted to use their AWS as a blueprint for other sites although, when copying from/to another site, multiple operational factors (e.g. order and product characteristics) must be considered. In fact, case B invested in largely different AWS for different countries due to varying customer expectations and competitive priorities

(continued)

**Table 5.** Continued

3) *Efficiency or adaptiveness*

*C6* – Evaluate the strategic intent alignment of investing in static versus flexible automation technologies

*C7* – Balance short-term versus long-term productivity; assess how the AWS can be adapted to future business and customer uncertainty

*C8* – Consider pros and cons of investing in overcapacity to handle short-term (peaks vs off-season) and long-term demand variation (growth vs decline)

The respondents discussed potential lock-in effects. One is that the installed technology is not flexible and cannot easily be moved. Therefore, many of the implemented AWS are high-performing, lean facilities, but they may not necessarily be optimal for handling future changes. Previous investments in relatively static infrastructure must be considered in all subsequent decisions regarding, for example, flows, processes, assortment and order structure. As each technology choice has some degree of lock-in effect, the respondents stressed a holistic perspective and future vision of the warehouse to ensure adaptiveness and long-term productivity instead of short-term optimization. One case respondent (B) commented: “We want to live with the AWS for 15, 20, or 30 years. This is a challenge for the decision-makers, that it is a long-term investment. We have a payback of four years, but it’s a foundation for our continued business journey. . . apart from the depreciation, the AWS will give us a certain capacity or lead times, or environmental advantages.”

4) *Relationship with technology supplier*

*C9* – Decide if the project should involve one or multiple technology suppliers to be coordinated during implementation, ramp-up, and full operation

*C10* – Consider if the long-term goal is to pursue strategic partnerships or arm’s-length relationships with the technology supplier(s)

*C11* – Carefully select technology supplier(s) in early stage, as it can create a lock-in effect and/or provide opportunities for strategic partnerships

The choices of technology and technology supplier go hand in hand according to our case companies. One case representative (B) commented: “It is really a choice of supplier. They all have a range of technologies. . . this also means that the suppliers will come up with similar proposals. You can almost put their proposals on top of each other and it’s like carbon paper. . . they have the same knowledge and experience, and people move between companies.” The supplier choice has a certain lock-in effect as new technology and suppliers must be integrated with the already existing ones. The opportunity to establish strategic partnership is also relevant. For this, several aspects linked to relationship, trust and culture are important. Our study indicated that retailers strive to minimize the number of involved actors that must be coordinated in an automation project. One case representative (H) commented: “We didn’t want a blame game between different suppliers. So, we opted for an integrated system, one supplier that takes overall responsibility.” Another case representative (A) elaborated: “when we have a new facility, new staffing, new systems, new everything else. Should we also have the problem with two suppliers who have different WCS and different PLCs. The risk was that we build ourselves into a solution that doesn’t work and then we don’t get anything shipped out of here.”

(continued)

**Table 5.** Continued**5) Control and ownership**

*C12* – Consider the pros and cons both short- and long-term of owning versus leasing the facility and the AWS

*C13* – Decide if the long-term purpose is to take full control of the maintenance and development of the AWS

Several case companies (C, E, H) argued for the strategic importance of being able to take control and ownership of the AWS in the long term. Concerning the building itself, some opted for leasing (e.g. A) to reduce the need for capital and risks involved with construction and facility management. Others (e.g. F) argued that owning the building increased control over design aspects and strategic investments. A similar reasoning can be applied to the AWS itself. Many retailers making their first AWS investment sign service agreements with the technology supplier. Without a mature organization and internal expertise, these service agreements are essential. But long term, the dependence on an external actor may create large expenses for maintenance and error handling. Another risk is that the focus will be on maintenance rather than technology development and optimization of the system. This has incentivized several of the case companies (e.g. E, H) to build their own competencies to ultimately manage the automation technology in-house. While reducing costs, it can involve new risks, such as staffing shortages, competency gaps and access to spare parts

**6) Risk exposure and robustness**

*C14* – Evaluate how downtime can be avoided by investing in redundancy of, for example, robots, spare parts, generators, power cables, fiber, and servers

*C15* – Assess disruption risks and decide how these can be mitigated and insured against

A critical aspect of AWS is the sensitivity to downtime. If the AWS (e.g. shuttle system) goes down, it is practically impossible to get any products out. Downtime can be caused by faulty robots (e.g. shortage of spare parts), power outage and system crashes. Several case companies had invested in back-up generators for the continuous operation of critical warehouse systems. An important point concerned the computer systems. If they are down for more than a couple of hours, then all systems must be restarted, and all order data may be lost. The case companies therefore invested in redundancy in terms of double power cables and fiber/connections and mirrored server rooms. The case companies also highlighted two higher-impact disruption risks. One was fires. One respondent pointed out that insurance companies can say no to increasing AWS if they are built too close together on a small surface. Another was cyber-attacks. One case company experienced an attack that involved two and a half weeks of total shutdown of the central warehouse. This resulted in a giant bullwhip effect that affected the entire company and SC for a long time. These risks indicate the importance of risk assessment, contingency plans and insurance coverage

**7) Sustainability**

*C16* – Assess how environmental sustainability aspects can/should be included for the AWS investment decision

*C17* – Assess how social sustainability aspects can/should be included for the AWS investment decision

Environmental impact was discussed in terms of building material, life cycle analysis (lifespan, energy consumption), the potential to produce electricity (via solar panels) and footprint. Another observation was that current AWS (1) are not used for reverse flows related to second-hand, repair and rental and (2) will have difficulties in supporting a transition to a circular economy (e.g. handling of unique, second-hand items). Future scale-up of circular logistics networks may require new types of material-handling nodes with different kinds of AWS. Concerning social sustainability, the interviewees confirmed that humans continue to play a critical role for automated warehouses and pointed out that several competencies, including mechanics, technicians and data analysts, are required to maintain and develop implemented AWS. Interestingly, the interviews revealed that work-environment aspects (ergonomics and physical environment) were not considered for the investment decision but played a role in the final AWS design

**Source(s):** Authors' own creation

**Table 6.** Overview of strategic intent profiles, case examples, and warehouse automation strategy

Strategic intent profiles	Case	Owner and management characteristics	Priorities	Financial concern	Warehouse automation strategy (connected to specific WA-strategy considerations)
Reliability and delivery service	A	Long-term stable owners (e.g. government)	Delivery service to customers is the highest priority. Emphasizes regulatory compliance, safety of products, and employees	Capital availability appeared to be a minor issue. Financing granted for well-motivated investments	Invested in a centralized, greenfield facility (C1,2) with focus on reduced energy consumption (C16). Avoids being an innovator (C3). Emphasizes a long-term holistic approach to AWS (C4). Invests in excess capacity to ensure future growth (C7,8). The AWS focuses on simplicity and low risk of downtime in the form of proven technology and a carefully selected turnkey provider with overall responsibility, to avoid complex integration between multiple suppliers (C9,10,11). Avoids risks and ensures robust operations (e.g. power and fiber redundancy) (C14,15)
Profitable deliveries	G, H, D, B	Long-term majority owners (e.g. founding families still involved in management) or long-term investors reaping synergies by consolidating industries. "Retail-DNA" with a good understanding of retail and logistics	Growth with profitability	Return on investment. Larger investments are granted based on a strong business case	Invested in centralized and mostly brownfield facilities (C1,2). Early adopters to implement AWS that helps to increase profitability and gain competitive advantage such as supporting new profitable customer offerings (C3). Investments are characterized by holistic thinking (C4) and future vision (C7,8). Invests in new but proven technology in combination with strategic partnerships to develop the warehouse over time (C9,10,11). Has gained extensive experience of what works and is gradually focusing on building internal competence to run, finetune, and develop highly automated warehouses (C12,13) with robust operations (C14,15)

*(continued)*

**Table 6.** Continued

Strategic intent profiles	Case	Owner and management characteristics	Priorities	Financial concern	Warehouse automation strategy (connected to specific WA-strategy considerations)
Scalable logistics for volume growth	C, F	Short-term owners: shareholder value generated, e.g. through an exit. More focus on selling the firm than profitable retail operations. Management origin in e-commerce rather than retail stores	Growth prioritized higher than profit and profitability	Company valuation based on sales growth. Financing model increasingly important if owners are close to an exit	Invested in centralized, greenfield facilities (C1,2) with focus on reduced energy consumption (C16). Gains market share through cutting edge – but not overly expensive, technically complex, or mixed – AWS that provides competitive advantages within the segment (C3,5). The investment horizon of an AWS may be shorter, the investments lower, and the financing possibilities vary (C7). Invests in excess capacity (C8) and develops strategic partnerships with tech companies to be at the forefront (C9,10,11)
Platform provider, e-logistics as service for others	E	Short- to medium-term owners: shareholder value can be generated by an exit but also by new service-oriented business models. Management with tech-DNA, less in retail and logistics	Growth prioritized, but not only own retail sales. Focus on innovation based on technology know-how, to generate new services	Future profit from serving other retailers with its platform	Invested in a centralized, greenfield facility (C1,2). Greater focus on innovation and creating own (or heavily customized) AWS (C3). These are preferably based on simple and modular technology (C4,5) to create scalability and flexibility (C6,7,8) to quickly and efficiently bring in new flows and business as a service. Controls technology internally instead of being dependent on an external provider (C9,10,11). The innovation is based on the company's own technology know-how and ability to optimize sub-processes (C12,13)

**Source(s):** Authors' own creation

**Table 7.** Case companies' ranking of evaluation aspects for AWS investment decisions

To what degree do you find the following aspects important for evaluating different potential automation solutions?

	Today									In five years								
	A	B	C	D	E	F	G	H	Mean	A	B	C	D	E	F	G	H	Mean
Uptime, reliability	7	7	7	7	7	na	6	6	6,7	7	7	7	7	7	7	7	6	6,9
Scalability, opportunity for up/downsizing solution	7	6	7	6	6	5	7	7	6,4	7	6	7	6	7	6	7	7	6,6
Order accuracy	7	7	7	6	6	7	7	6	6,6	7	7	7	6	7	7	7	7	6,9
Flexibility to handle demand variation	7	5	7	6	7	6	6	6	6,3	6	5	7	7	7	6	6	7	6,4
Total Cost of Ownership (incl service, maintenace etc)	7	7	5	4	5	7	7	7	6,1	7	7	6	7	5	7	6	7	6,5
Throughput, solution's flow capacity	7	7	7	6	6	7	7	6	6,6	7	7	7	6	7	7	7	6	6,8
Picking efficiency (order lines per hour)	6	7	7	7	7	7	7	6	6,8	6	7	7	7	7	7	7	6	6,8
Speed (solution's total order leadtime to customer)	7	7	7	7	6	7	7	6	6,8	7	7	7	7	7	7	7	6	6,9
Response time for support/service	7	7	7	5	5	7	5	6	6,1	6	7	7	5	5	7	6	6	6,1
Service and warranties	7	7	4	5	5	6	6	6	5,8	5	7	5	6	5	7	6	7	6,0
Opportunity for staff reduction	6	7	6	7	6	7	6	6	6,4	6	7	7	7	7	7	6	6	6,6
Surface efficiency (ability to use warehouse area)	2	5	6	5	6	7	7	6	5,5	3	5	7	4	6	7	7	7	5,8
Implementation time	6	5	4	6	3	7	5	7	5,4	6	5	5	7	5	7	7	7	6,1
Integration/compability with current solution	6	7	7	7	6	4	7	6	6,3	4	7	7	4	6	4	7	7	5,8
Future risk for spare part shortages	3		5	6	6	5	6	6	5,3	3	na	6	5	6	4	6	7	5,3
Opportunity for turn-key solutions	4	7	7	5	1	5	3	6	4,8	3	7	7	6	1	6	5	6	5,1
Environmental friendliness and energy efficiency	7	2	6	5	4	2	4	5	4,4	7	2	7	6	6	3	6	6	5,4
Purchasing price	6	7	5	4	4	5	6	6	5,4	5	7	5	5	4	6	5	6	5,4
Innovation, degree of "leading edge-solutions"	5	4	6	6	1	3	3	5	4,1	5	4	7	na	1	4	4	5	4,3
Previous relation and experience with provider	4	5	7	5	2	6	5	6	5,0	5	5	5	3	2	6	5	6	4,6
Automation provider can operate (and recruit staff)	2	5	2	2	2	2	2	6	2,9	2	5	2	2	2	2	2	7	3,0

**Source(s):** Authors' own creation

lowest ranked aspects, relationship with provider and automation provider manages operations, two clusters were observed in the general data – one with retailers managing operations in-house, and another that more clearly develops relationship/collaboration with the provider.

4.5 Interdependence between strategy and automated warehouse systems

Finally, we empirically investigated the hypothesis of a reciprocal relationship between strategic intent and AWS investment decisions. All case respondents confirmed that a decision in the warehouse influences the logistics network, and vice versa (Kembro et al., 2022), they also confirmed that a WA strategy should be part of the overall logistics and SC strategy. What may not be obvious at the time of investing in a new AWS is how that decision will affect the company for many years, or even decades, to come. One respondent (B) reflected: “... are we sure that this is the right way to go now then, because we are locking ourselves into an investment that will shape our next 10–20 years” For this long-term perspective, the connection between strategic issues and AWS is important.

We surveyed the connection between the retailers’ strategy and AWS. Among the case companies, we observed several dipolar patterns where many answered either 1, 2 or 6, 7 (Table 8), i.e. several respondents believed that the firm strategy completely influences the implemented AWS, while others think the opposite. In particular, case companies C and H, but also cases A, B, and G, generally perceived that their strategy influenced AWS investment decisions. Meanwhile, cases F and D argued that the AWS influences future strategic maneuvering. We also noted that case companies A, B, D, and G indicated answers 3–5 for

**Table 8.** Case companies’ perception of interdependence between strategy and AWS

Automation level a consequence of different strategies, or a prerequisite/driving force for different strategies?	A	B	C	D	E	F	G	H	Mean
<i>Economies of scale:</i> our size defines automation level vs our automation level influences how big we can grow	2	1	2	6	na	7	2	1	3,0
<i>Cost focus:</i> our cost level defines our automation level vs our automation level is important to influence our cost levels	1	7	1	7	na	7	4	4	4,4
<i>Flow’s complexity:</i> flows’ complexity define automation level vs automation level influences future complexity increase/decrease warehouse can handle	2	1	1	4	na	7	3	2	2,9
<i>Market and demand dynamics:</i> uncertainty and fluctuations define automation level vs automation level influences strategy for market and demand dynamics	2	4	2	5	na	7	2	1	3,3
<i>Speed and lead time requirements:</i> lead time requirements define choice of automation level vs our automation level influences lead time promises	3	1	1	7	na	6	2	2	3,1
<i>Tied-up capital:</i> requirements on asset turnover control choice of automation level vs automation level influences targets for asset turnover	3	4	3	3	na	7	3	na	3,8
<i>Assortment width:</i> assortment width defines choice of automation level vs automation level influences increase/decrease of assortment width	5	1	1	6	na	7	1	1	3,1
<i>Growth and scalability:</i> growth plans influence choice of automation level vs automation level influences our growth speed	3	1	2	6	na	6	1	1	2,9
	2,6	2,5	1,6	5,5		6,8	2,3	1,7	

Source(s): Authors’ own creation

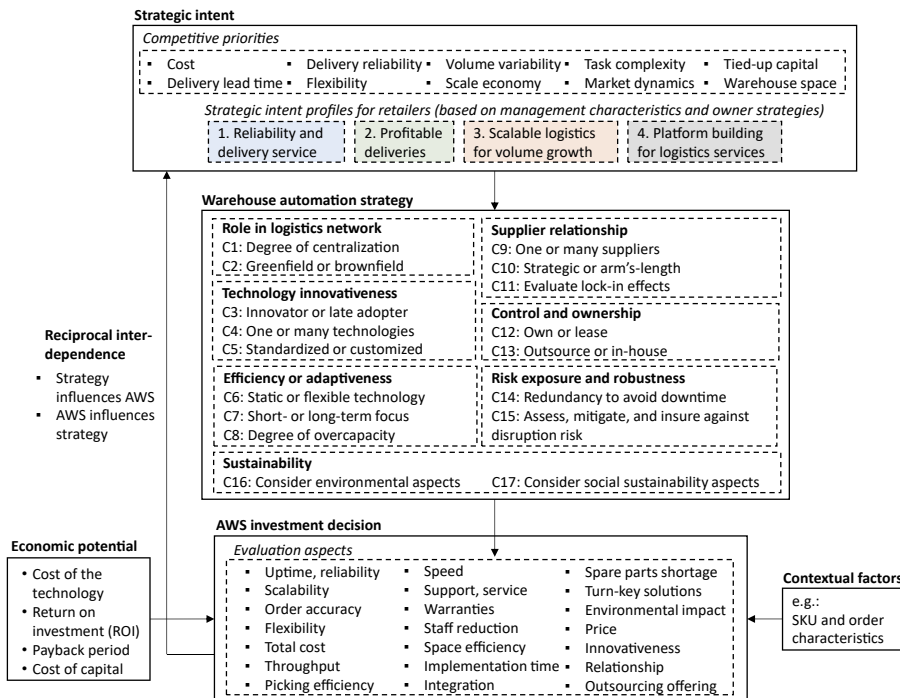
many aspects, suggesting a reciprocal interdependence. Our findings thereby support Parthasarthy and Sethi (1992) who placed manufacturing technology and strategy in a reciprocal relationship. This is an important contribution both to warehousing literature and to extant research on automation strategy (e.g. Granlund, 2014), which has mainly suggested a one-directional relationship.

We compared the case companies with responses from a larger sample of Swedish retailers (Appendix 4). Analysis of averages suggests a reciprocal interdependence, but strategy had a slightly stronger influence on the AWS than vice versa. In conclusion, warehouses are expensive, time consuming, and difficult to redesign. As one respondent (C) put it: “You do have a huge investment that you need to take. Once you got it in, you can’t easily take it out. It’s not so easy always to adjust it to different needs. And it also has a certain capacity that you cannot expand easily, but you also cannot just take it down when you don’t need it, right?” Although automation technology has itself recently increased in flexibility, previous and current decisions for warehouses and automation will have a major impact on companies’ future strategy discussions and decisions.

#### 4.6 Elaboration of the warehouse automation strategy framework

We summarize the above insights and theorize the reciprocal nature of AWS investments by connecting the dots between strategic intent, WA strategy, and evaluation aspects for AWS investment decisions in a conceptual framework (Figure 4). This is an elaboration of the framework presented in Figure 2.

As illustrated in Figure 4, strategic intent is driven by competitive priorities (which for warehousing revolve around cost, delivery lead time and reliability, flexibility, volume



Source(s): Authors’ own creation

Figure 4. The warehouse automation strategy framework

variability, scale economy, market dynamics, task complexity, tied-up capital, and warehouse space). The strategic intent is also influenced by the management team's origin and the owners' focus on economic value creation, as examples of antecedents of stakeholder expectations. Combinations of these, which we refer to as strategic intent profiles, help to explain how the case companies reasoned around level of automation, what to automate, technology choice, supplier selection, and a range of other AWS evaluation criteria. In other words, whether the strategic intent is focused on compliance and secure deliverables, profitability, scalability and growth, or changing business model from retailer to platform provider.

Strategic intent and AWS investment decisions are connected through the formulation of a WA strategy. We define WA strategy as "a tool that helps decision makers align the direction and scope of AWS investments and configurations with the firm's strategic intent to ensure that the firm meets its fundamental objectives and achieves advantages in a changing environment in the long term, with the aim of fulfilling stakeholder expectations". Although an explicit WA strategy is missing in both extant literature and the cases, we suggest that its formulation is vital for connecting strategic intent with AWS investment decisions. Our analysis revealed 7 categories and 17 considerations that constitute what should be addressed in a formulated WA strategy. The categories include owners' and management's perception on role in logistics network, technology innovativeness, efficiency versus adaptiveness, technology-supplier relationships, control and ownership, risk exposure, and sustainability. Our WA-strategy framework addresses the content gap of an automation strategy concluded by [Granlund \(2014\)](#) and extends the previously proposed content of strategic decision framework ([Yildirim et al., 2023](#)) and automation strategy (e.g. [Granlund, 2014](#)).

The formulated WA strategy, representing a combination of strategic considerations, will guide the retailer towards different investment evaluation aspects. Depending on whether the company's "DNA" drives a more offensive or defensive perspective on the role of warehousing and AWS, it will influence which of the considerations and evaluation aspects are ranked most important. The investment evaluation aspects, and their prioritization, are instrumental in selecting what to automate, the technology choice, and supplier selection, which corresponds to extant automation strategy discussion. The implemented AWS will then lock the retailer's performance on its competitive priorities for the foreseeable future and may influence the future strategic choices of the firm. The relationship between firm strategy and AWS must be understood as reciprocal; in other words, it is not only strategy that influences AWS investment decisions, but also the implemented AWS influences strategy.

## 5. Concluding discussion, implications, and future research

This study investigated how strategic factors influence AWS investment decisions in retail. We conducted a multiple case study with eight retailers that recently made significant AWS investments, and abductively moved between empirical insights and theory. Next, we discuss our findings and the implications for theory and practice. Finally, we elaborate on avenues for future research.

### 5.1 Theoretical implications

First, the gap between the strategic role of warehouses in logistics networks and the tactical-operational focus for warehouse configuration is well-documented (e.g. [Fragapane et al., 2021](#); [Kumar et al., 2021](#); [Yildirim et al., 2023](#)). As warehouses have more strategic relevance ([Kembro et al., 2022](#); [Boysen and De Koster, 2024](#)), our study contributes as a conversation changer, by showing the importance of shifting focus from tactical-operational focus to a strategic perspective on warehouse configuration in general and on AWS investment decisions in retail in particular. We propose a conceptual framework focusing on the strategic perspective on AWS, including how different important constructs are related in a reciprocal way. This perspective shift, from operations to strategy, was done in the manufacturing literature decades ago, and it is high time for the warehousing community to follow suit. This

applies at least for AWS in retail, which faces large costs, significant lock-in effects, fast technological development, and an increasingly uncertain environment, so researchers and practitioners need to talk more about strategic issues.

Second, our study elaborates on the notion that warehouses have evolved to fulfillment factories (Boysen and De Koster, 2024), by comparing warehouses to manufacturing facilities and bringing in new theory to explain and advance our understanding of highly automated warehouses in retail. Our abductive study has shown that manufacturing literature (e.g. AMT, automation strategy) as well as business strategy literature (strategic intent, owner strategies) are useful to fully grasp the rich and complex nuances of AWS investment decisions. Considering that production operations (e.g. in automotive industries) went through an automation journey long ago, it is likely that many of the issues faced in increasingly automated retail warehouses have been investigated in different ways in the manufacturing literature (e.g. the issue of psychosocial work environment for humans). This provides an interesting opportunity for researchers to expand the portfolio of theories in future studies on retail warehousing.

Third, we unravel and explain the strategic complexity of AWS investments decisions in retail by ranking 10 competitive priorities of the firm and 21 AWS evaluation aspects. This is an extension of previous scientific literature. For example, Yildirim *et al.* (2023) only listed (without ranking) six criteria to evaluate mobile robot systems. Our findings showed that the AWS decision becomes increasingly complex, as the importance of all competitive priorities and evaluation aspects increases over time. We also draw on strategy literature (e.g. Katz and Niehoff, 1998; Blackburn *et al.*, 2013; Baron and Barbieri, 2019) and empirically show how manager characteristics (e.g. retailer or tech background) and owner strategies (view on growth, liquidity, and control) influence retailers' AWS investment decisions. We then abductively develop four strategic intent profiles, namely reliability and delivery service; profitable deliveries; scalable logistics for volume growth; and platform building for logistics services. Altogether, the mix of competitive priorities, evaluation aspects, management characteristics, and owner strategies make AWS investment decisions a highly strategic and complex endeavor. In particular, the business purpose of the AWS and the role of owners should not be underplayed, and deserve attention in future research. In Nordic retail, several recent ownership changes have shown how differing owner strategies can impact the (re) direction of AWS investments.

Fourth, our study explains how a WA strategy connects strategic intent with AWS investment decisions. This is new territory for warehousing literature, which is why we turned to the manufacturing literature on automation strategy (e.g. Säfsten *et al.*, 2007; Lindström and Winroth, 2010). Our analysis revealed 7 categories and 17 considerations that together constitute a foundation for formulating a WA strategy. These original insights are new for the warehousing literature in general and retail context in particular. They also address the content gap of an automation strategy concluded by Granlund (2014). Our framework extends the previously proposed content of strategic decision framework (Yildirim *et al.*, 2023) and automation strategy (e.g. Granlund, 2014), which primarily emphasizes the level of automation, what to automate, and choice of technology. We bring in strategic intent alignment, arguing that the WA strategy must address, for example, technology innovativeness, efficiency versus adaptiveness, technology-supplier relationships, control and ownership, and risk exposure.

Fifth, we provide empirical evidence of the hypothesized reciprocal relationship (Parthasarthy and Sethi (1992)) between strategic intent and AWS investment decisions. This is an important contribution both to warehousing literature and to extant research on automation strategy (e.g. Granlund, 2014), which has mainly suggested a one-directional relationship. The reciprocal relationship relates to the many technology and technology-supplier lock-in effects, and our observation that highly automated warehouses in retail resemble dedicated production facilities. In brief, it means that the firm strategy influences AWS investment decisions, while the implemented AWS may influence the firm strategy, i.e. previous and current AWS investment decisions may have a major impact on companies' future strategy discussions and decisions.

### 5.2 Implication for managers

Somewhat surprisingly, our study revealed that retailers had not yet formally framed (or conceptualized) the range of critical long-term, automation-related decisions as a WA strategy. However, all interviewees agreed there is a need for it.

We contribute to practice in several ways. First, we offer a framework for formulating a WA strategy (see [section 4.6](#)). As a foundation for developing the framework, we share empirical insights from retailers in the forefront of AWS implementation, as well as from observations from a broader sample of retailers. Managers can use the framework, for example to: (1) discuss the firm's important competitive priorities and how these could be balanced over time; (2) use the WA-strategy categories and considerations to go through important decisions step by step when planning their automation projects; and (3) set up criteria for their AWS in line with the ranked evaluation aspects. Second, the four strategic intent profiles and the discussion regarding owners' and management teams' characteristics (DNA) will help warehouse managers to better understand and prepare relevant business cases that align with stakeholders' value creation priorities. Third, by understanding the reciprocal interdependence between strategic maneuvering and AWS, the study can also help warehouse managers to avoid being locked-in with the wrong technology and/or technology supplier and leverage the implemented technology for retail strategy development.

Interestingly, [Frazelle \(2016\)](#) compared the warehouse with a soccer goalkeeper. He argued that they both represent the last line of defense and should be the last to consider for strategy and design. We find the warehousing-goalkeeper comparison useful, but we disagree that they should be the last to consider for strategy and design. In modern soccer in general, and for progressive teams in particular, the goalkeeper's role – and their needed capabilities – have changed dramatically ([Shahine, 2022](#)). Many coaches today view the goalkeeper as the base of the team's build-up play and starting point of the attack. A “keeper-back” is introduced, playing between center-backs to help play around opposing forwards ([Muller, 2024](#)). The modern ball-playing “sweeper keepers” play accurate short passes and provide purposeful crosses further up the field; they therefore have capabilities to be good in passing with the feet, dribbling past an opponent forward, defending far away from the goal, and finding the offensive teammates with long passes. Although we see the leading soccer clubs playing in a more modern style, the “DNA”, the new owners, or the new coach of the club will influence the type of soccer played (modern or not) and thereby the required capabilities of the goalkeeper.

A similar transformation has taken place for warehouses. Previously considered as a “necessary evil” ([Kembro and Norrman, 2022](#)), they are now regarded as “technology-enriched fulfillment factories with strategic relevance” ([Boysen and De Koster, 2024](#), p. 1). In our study, we emphasize the importance of aligning strategic intent with the invested AWS. We show how the AWS plays a strategic role for fulfilling the retailers' objectives, meeting both competitive priorities and the owners' preference on value creation. For modern retail, we still find the comparison between the soccer goalkeeper and the warehouse fruitful, but for other reasons than [Frazelle \(2016\)](#). If the modern retail warehouse is becoming a more offensive piece of the strategic puzzle, this must influence the WA strategy and the choice, design, and implementation of upgraded capabilities. The implemented AWS must also be aligned with the strategic intent of the firm.

### 5.3 Future research opportunities

Like any other study, this research has limitations. These should be accounted for, while they can also guide future research. The evolution of warehousing and SCM practices, in this article exemplified by the increasingly automated retail warehouses, could be further studied using different theoretical lenses and embracing new methodologies ([Russo et al., 2023](#)).

First, to increase the external validity of our findings, WA strategies should be investigated in various contexts (e.g. various countries, retail segments, and AWS technologies). Contingency theory could help to contextualize observations and explain reasons for

strategic alignment between the strategic role of warehousing and different retail strategies across SCs. It is also worthwhile further investigating our abductive insights into the interrelations between strategic intent, WA strategy, evaluation aspects, and implemented practice. For this purpose, it is relevant to consider innovative warehouse technologies and practices that could be developed and analyzed through an intervention-based approach, action research, and design science projects. Specifically, it is relevant to investigate how the reciprocal interdependence between strategy and AWS differs between more static (e.g. shuttle and compact storage systems) and newer, more flexible AWS technologies. It could also be relevant to consider theories such as dynamic capabilities to understand differences in implementation success, especially for transformative AWS investments.

Other research avenues include the development of sharper operationalization of the four strategic intent profiles to prepare for empirical testing in survey-based research with larger samples. Future studies may also uncover additional strategic intent profiles. From a theoretical perspective, future research could benefit from upper echelons theory and ownership structure theory to further explain the relationships between top-managers' origin and interests, owner structure, strategic intent, and WA investments. Another interesting avenue is to look deeper into the various categories and considerations of a WA strategy formulated in this study. The WA-strategy considerations could also be further integrated with overall SC strategies, comparing cost-efficient versus responsive/agile retail SCs. On the more detailed investment level, it could be investigated how technological advancements and integration of specific AWS technologies (1) should be considered as part of the strategic perspective, and (2) how they align with the competitive priorities of firms and the AWS evaluation aspects identified in this study. It would also be relevant to investigate the adaptiveness and robustness of highly automated warehouses related to new risks and potential disruptions such as cyber-attacks.

Finally, it is interesting to understand environmental and social sustainability aspects, for example, how human factors will be influenced by different disruptive digital and automation technologies related to Smart Warehousing and Industry 5.0 (Kembro and Norman, 2022; Panagou *et al.*, 2024). Returning to the analogy with the modern goalkeeper, future research could further investigate what competencies and capabilities are required for future warehouse workers (see, e.g. Kembro *et al.*, 2024) and what kind of training (and trainers/managers) is necessary to support the progression towards strategic management of new, emerging AWS technologies. A limitation of the investigated cases is their traditional linear business models. Further research should study strategic intent, warehouse strategies, evaluation aspects, and practice for firms transitioning to circular SCs.

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(The Appendix follows overleaf)

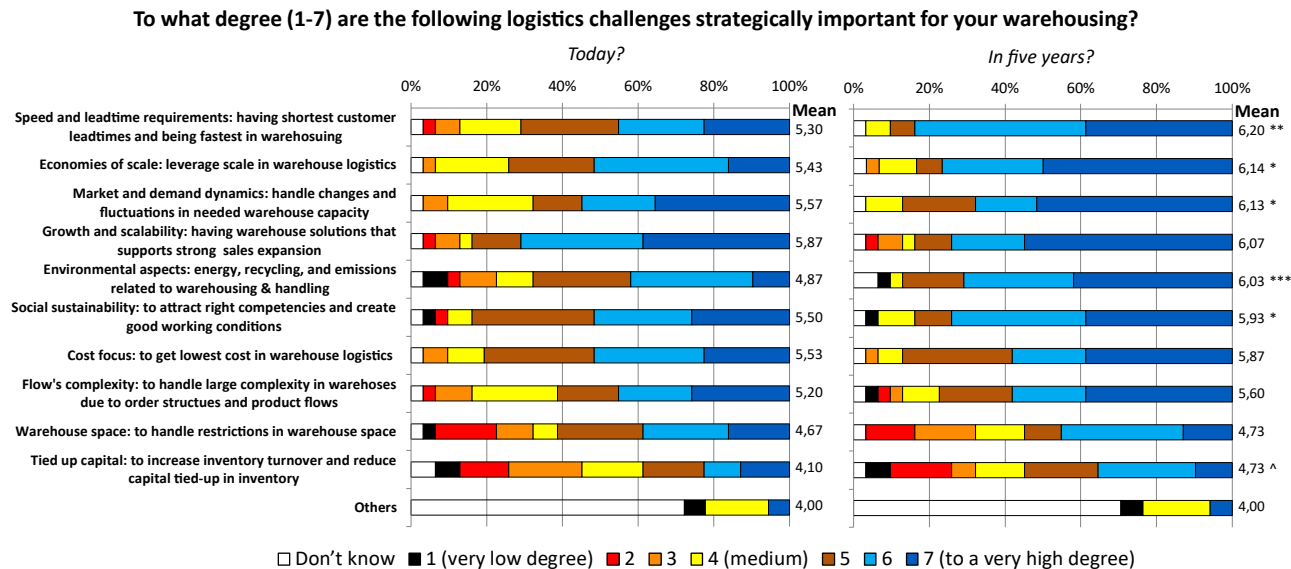
**Table A1.** Research quality

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Construct validity	<ul style="list-style-type: none"><li>• Feedback from peer researchers on interview protocol</li><li>• Terminology explained to informants to avoid misunderstanding</li><li>• Multiple sources of data collected (interviews, site observations, reports, and websites)</li><li>• Multiple informants that represent different internal functions to triangulate responses</li><li>• Investigator triangulation: first individual analysis by researchers, then comparison and joint agreement</li></ul>
Internal validity	<ul style="list-style-type: none"><li>• Interviewees and cases selected following a structured and purposeful sampling approach</li><li>• Multiple informants respond identically on the same phenomenon</li><li>• Multiple informants representing different internal functions included to triangulate responses</li><li>• Investigator triangulation: involvement of two researchers to discuss and judge data and interpretations</li><li>• Raw data (transcripts) were coded on different levels (open, axial, selective) to connect it with different theoretical categories</li></ul>
External validity	<ul style="list-style-type: none"><li>• Justification of phenomenon-driven study; described the logic and criteria applied for interviewee and case selection</li><li>• Contextual information is provided to build theoretical premises for the reader</li><li>• Pilot interview to test interview questions and to increase generalizability of the study</li><li>• Pointing out generalizability limitations</li></ul>
Reliability	<ul style="list-style-type: none"><li>• Used standardized interview protocol</li><li>• Developed and continuously updated database (including, e.g. interview transcriptions, themes, codes, and memos) to ensure complete documentation of the data analysis procedure</li></ul>

**Source(s):** Authors' own creation

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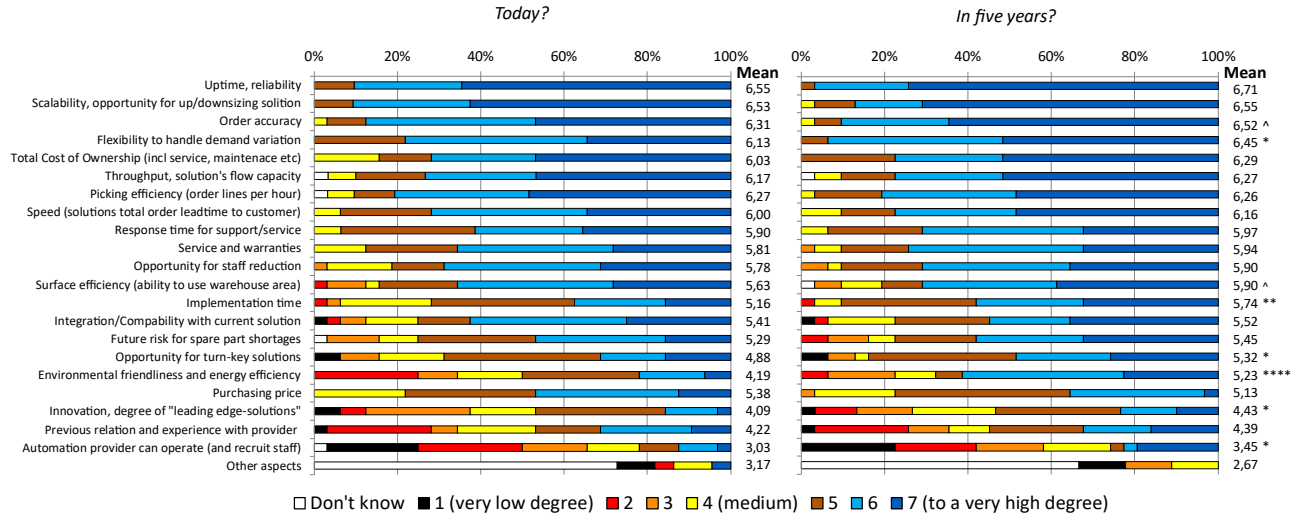
Asterisks indicate significance mean difference with T-test: ^ $p < 0.1$ , \* $p < 0.05$ , \*\* $p < 0.001$ , \*\*\* $p < 0.0001$ , \*\*\*\* $p < 0.00001$

**Note(s):** We compared the case companies with responses from a larger sample of Swedish retailers ( $n = 31$ ). Their competitive priorities seemed to differ slightly. While the importance of all priorities seemed to grow over time, it increased significantly for speed and lead-time requirements, economies of scale, market and demand dynamics, environmental aspects, social sustainability, and tied-up capital. The highest ranked priorities changed from growth and scalability (5,87), market and demand dynamics (5,57), cost focus (5,53) and social sustainability (5,50) to speed and lead time requirements (6,20), economies of scale (6,14), followed by market and demand dynamics (6,13) and growth and scalability (6,07)

**Source(s):** Authors' own creation

**Figure A1.** Prioritization of strategic logistics challenges ( $n = 31$ )

To what degree (1-7) do you find the following aspects important for evaluating different potential automation solutions?



Asterisks indicate significance mean difference with T-test: ^*p* < 0.1, \**p* < 0.05, \*\**p* < 0.001, \*\*\**p* < 0.0001, \*\*\*\**p* < 0.00001

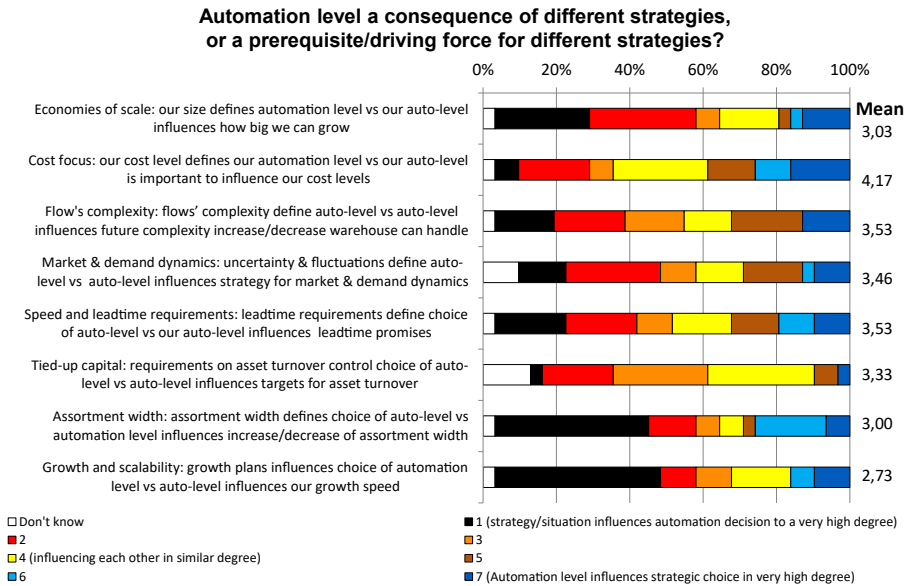
**Note(s):** The comparison of the case companies with responses from a larger sample of Swedish retailers (*n* = 31) showed that the overall patterns were similar. The highest ranked were reliability (6,55), scalability (6,53), order accuracy (6,31), picking efficiency (6,27), throughput flow capacity (6,17) and flexibility (6,13). The lowest ranked aspects (today) included outsourcing of operations (3,03), environmental aspects (4,19), degree of innovation (4,22), and previous relationships with provider (4,22). Five years on, almost all aspects were ranked as more important, except purchasing price. A closer analysis (t-test) of the differences between present and future showed significant increases for certain lower-ranked and higher ranked evaluation aspects such as flexibility, up-time, and order accuracy. Finally, the retailers' different views on the relations with automation providers are interesting. For the two lowest ranked aspects, relationship with provider and automation provider manages operations, two clusters were observed. One with retailers managing operations in-house, and another that more clearly develops relationship/collaboration with the provider

**Source(s):** Authors' own creation

**Figure A2.** Ranking of AWS evaluation aspects (*n* = 31)

Appendix 4

Ranking of interdependence between strategy and AWS



Source(s): Authors' own creation

Figure A3. Swedish retailers' (n = 31) view on interdependence between firm strategy and implemented AWS implementation

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