



HAL
open science

Transcending Food-Miles: Unpacking the Drivers of In-Store Vertical Farming Adoption Among Food Retailers in France

Marie Asma Ben Othmen, Cyprien Julienne, Fahim Shaikh

► **To cite this version:**

Marie Asma Ben Othmen, Cyprien Julienne, Fahim Shaikh. Transcending Food-Miles: Unpacking the Drivers of In-Store Vertical Farming Adoption Among Food Retailers in France. *Journal of International Food and Agribusiness Marketing*, 2024, pp.1-25. 10.1080/08974438.2024.2409109 . hal-04839289

HAL Id: hal-04839289

<https://hal.science/hal-04839289v1>

Submitted on 15 Dec 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Public Domain

1 **Ben-Othmen, M. A., Julienne, C., & Shaikh, F. (2024). Transcending Food-Miles:**
2 **Unpacking the Drivers of In-Store Vertical Farming Adoption Among Food Retailers in**
3 **France. *Journal of International Food & Agribusiness Marketing*, 1–25.**
4 **<https://doi.org/10.1080/08974438.2024.2409109>**

5

6 **Transcending Food-Miles: Unpacking the Drivers of In-Store Vertical**
7 **Farming Adoption among Food Retailers in France**

8

9

10 Marie Asma Ben-Othmen*

11 marie-asma.benothmen@unilasalle.fr

12 INTERACT Research Unit–Innovation, Land Management, Agriculture, Agro-Industries,
13 Knowledge, and Technology, UniLaSalle-France, Mont-Saint-Aignan, France

14

15 Cyprien Julienne

16 Cyprien.JULIENNE@etu.unilasalle.fr

17 MSc Urban Agriculture & Green Cities, UniLaSalle-France, Mont-Saint-Aignan, France

18

19 Fahim SHAIKH

20 Fahim.SHAikh@etu.unilasalle.fr

21 MSc Urban Agriculture & Green Cities, UniLaSalle-France, Mont-Saint-Aignan, France

22

23

1 **Transcending Food-Miles: Unpacking the Drivers of In-Store Vertical Farming Adoption**
2 **among Food Retailers in France**

3 **Abstract**

4 This paper examines the potential of in-store vertical farming technologies in urban food retail
5 as a solution to the increasing demand for fresh, locally sourced food. By enabling a "sell where
6 you produce" model, vertical farming can reduce food miles, enhance traceability, and lower
7 carbon emissions. The study applies the Unified Theory of Acceptance and Use of Technology
8 (UTAUT) to analyze factors influencing the adoption of these technologies among food
9 retailers in Rouen, France, with a particular focus on the role of risk aversion in shaping
10 attitudes and decisions.

11 The findings highlight that performance expectancy and facilitating conditions are the key
12 drivers of adoption intentions among retail store managers. However, perceived risks, such as
13 high investments and operational costs, pose significant barriers, while social influence appears
14 to have little impact on their decisions. The study underscores the importance of conducting
15 economic evaluations and risk assessments of vertical farming practices to ensure their long-
16 term viability. As vertical farming holds the potential to boost fresh food production in urban
17 areas, reduce food miles, and create sustainable supply chains, it is crucial to carefully weigh
18 its benefits and risks to support its successful adoption in urban food retail.

19 **Keywords** local food systems, food supply chains, technology adoption, users' acceptance,
20 vertical farming, urban agriculture

21 **Word count** (excluding references): 7,202 words.

22

1 **Introduction**

2 As urbanization accelerates and population density rises globally, urban designers are
3 increasingly considering cities as potential hubs for local food production (Al-Chalabi, 2015a;
4 Al-Kodmany, 2024). Concurrently, consumers are becoming more disillusioned with large-
5 scale, industrialized food production and distribution systems dominated by multinational
6 corporations (Birch et al., 2018). Concerns about the negative impacts and lack of transparency
7 in global food systems, particularly concerning environmental harm, sustainability issues,
8 health risks, and food safety, are becoming pronounced (Ofori-Parku, 2024).

9 In response to these concerns, urban agriculture, particularly vertical farming technology, has
10 emerged as a promising solution that optimizes land use, incorporates advanced technologies,
11 and supports local food production within urban environments (Benke & Tomkins, 2017). This
12 approach to local food production ensures enhanced efficiency and sustainability and supports
13 access to fresh and locally sourced food in urban areas (Graamans et al., 2018).

14 The interest in vertical farming extends beyond urban farmers to include key players in the food
15 retail sector, such as supermarkets, grocery stores, and food cooperatives that are integral
16 entities to the complex process of delivering food from producers to consumers, influencing
17 distribution, marketing strategies, and food accessibility (La Londe & Masters, 1994).
18 However, many supermarkets, particularly in France, still rely heavily on global supply chains
19 to offer seasonal products at competitive prices. This reliance on international suppliers has led
20 to what Thorsøe and Kjeldsen (2016) describe as “*food from nowhere*” which Konefal and
21 Hatanaka (2014) argue results in the loss of the subtle qualities inherent in locally produced
22 food. Amidst escalating apprehensions regarding climate change and the urgent need for the
23 food and agricultural systems to adapt in ways that mitigate its effects, it has become imperative
24 to transcend food miles not only to confront greenhouse gas emissions originating from

1 worldwide supply chains but also to minimize the resource wastage attributed to the global
2 sourcing and shipping practices that carry high environmental and social costs (Albizzati et al.,
3 2019). Recognizing and addressing these interconnected issues is paramount, prompting local
4 governments and civil society organizations to advocate for implementing local food systems
5 to create more inclusive, resilient, and sustainable ones (Suhartanto et al., 2023). In response,
6 the European Commission took a pivotal step in this direction by launching the "Farm to Fork
7 Strategy" in 2020. This initiative is designed to support the establishment of shorter supply
8 chains, aiming to reduce reliance on long-haul transportation and thereby enhance the resilience
9 of regional and local food systems (Liu, 2020).

10 As Trivette (2019) brings attention to the transformative potential of food retail actors in
11 connecting urban residents with their food sources, a closer examination of the literature on this
12 topic reveals a significant impact resulting from an integrated approach. This perspective is
13 particularly interesting for comprehending the broader environmental and societal implications
14 and the potential for in-store vertical farming adoption by food retail actors, thereby establishing
15 a more interconnected and sustainable relationship between city dwellers and their food supply.

16 Transitioning from this conceptual understanding, a practical manifestation of this integrated
17 approach is observable in European food retail. In order to meet growing consumer demand for
18 fresh, sustainable produce with low ecological impact, several food retail players are
19 spearheading in-store vertical farming initiatives. Exemplified by successful projects in major
20 cities like Berlin and Paris, these endeavors underscore the commitment of retail and wholesale
21 companies to piloting on-site cultivation of herbs and vegetables within their stores (Butturini
22 & Marcelis, 2020). However, as we delve deeper into the discussion, it becomes apparent that
23 unanswered questions persist regarding these retail actors' pivotal role in adopting in-store
24 vertical farming technologies and expanding local food activities. It is important to note that
25 while extensive research has been conducted on the significant changes in retail due to recent

1 technological advancements, the focus has primarily been on the Internet and other emerging
2 technologies like robotics, the Internet of Things (IoT), virtual reality, and augmented reality in
3 the retail industry (Shankar et al., 2021). There is limited understanding of how emerging in-
4 store vertical farming technologies influence the retail sector's potential transformation and
5 ecological transition, as well as their contribution to building local food systems.

6 In France, while industry giants such as Casino and Auchan embraced this concept in 2018,
7 mid-scale retail actors have yet to fully incorporate in-store vertical farms into their operational
8 frameworks. This discrepancy raises pertinent questions about the retail landscape's broader
9 acceptance and adoption trends and challenges.

10 This article aims to fill this knowledge gap by analyzing the drivers of adoption of in-store
11 vertical farming technologies among food retailers in France. Abundant literature underlines
12 the importance of the behavioral intention concept in explaining the decision-making processes
13 and procedures in the context of technology use (Mukherjee et al., 2023a; Shankar et al., 2021;
14 Venkatesh et al., 2012; Venkatesh & Zhang, 2010) Nonetheless, although technology is often
15 viewed as a solution to address the challenges of food supply chains and can contribute to a
16 more sustainable food system, it comes with risks and uncertainties that may hinder its
17 acceptance and widespread use. This research explores retailers' attitudes and decision-making
18 processes regarding adopting in-store vertical farming technologies.

19 Based on data analysis from a survey of 109 food retailers in Rouen City, France, including
20 supermarkets, grocery stores, specialized food shops, and food cooperatives mainly serving
21 urban residents, we develop and apply a Structural Equation Model (SEM). This model explores
22 how retailers' perceived risk, facilitating conditions, availability, and anticipated performance
23 impact their decisions. Furthermore, the research examines the influence of social factors on
24 retailers' adoption of in-store vertical farming technologies. In this study, the Unified Theory
25 of Acceptance and Use of Technology (UTAUT), a well-established framework for predicting

1 and explaining technology adoption behavior (Venkatesh et al., 2003), is considered as a
2 theoretical reference.

3 This paper is structured as follows: the initial section offers a concise overview of vertical
4 farming technologies and their potential contributions to achieving sustainability in the food
5 retail sector. Section 2 provides the theoretical foundation of the Unified Theory of Acceptance
6 and Use of Technology, offering insights into variables that directly predict the behavioral
7 intention of vertical farming technology adoption and outlining the hypotheses and the survey
8 design. Section 3 details the results, leading to the discussion (section 4) and the conclusion
9 (session 5).

10 Background: the potential of in-store vertical farms in crafting sustainability in the food retail
11 sector

12 Businesses aiming for sustainability are often measured by what is known and referred to in the
13 literature as the triple bottom line or the 3P model (Elkington, 1994), highlighting that
14 companies must consider not only their economic performance (profit) but also their impact on
15 the environment (planet) and society (people). In this context, retailers have a crucial role to
16 play in promoting sustainability since they serve as a vital link between the various upstream
17 (*i.e.*, natural resources, resources producers, suppliers) and downstream (*i.e.*, consumers,
18 households and communities) actors involved in the food supply chain (Grewal & Levy, 2007).

19 Previous research has underscored the significance of integrating sustainability into the food
20 retail industry, as evidenced by the development of the concept of environmental marketing
21 strategy, which addresses both environmental and social considerations in shaping corporate
22 strategies (Claro et al., 2013). More recently, there has been a notable surge in the eagerness of
23 certain food retailers to engage in local food initiatives (Aschemann-Witzel et al., 2016). To
24 carve out their unique market niche, these food outlets have initiated locally sourced programs,
25 introducing a broader range of seasonal and local products (Dunne et al., 2011; Lähteenmäki-

1 Uutela, 2014). This strategic shift aims to offer consumers alternatives regarding product
2 offerings and the overall shopping experience (Fischer, 2006; Konefal & Hatanaka, 2014). On
3 the other hand, some food retailers have embraced in-store vertical farming technology, a form
4 of high-yield controlled environment agriculture stacked in multiple layers that promises to
5 produce leafy greens and vegetables within cities, with the potential to reduce the resource
6 intensity use attributed to urban food production and consumption (Petrovics & Giezen, 2022).
7 This strategy enables more local food production, addressing sustainability challenges inherent
8 in operational models by promoting a "sell where you produce" approach and catering to
9 customer needs, drawing in a clientele keen on supporting local food production.

10 In these settings, vertical farms act as self-contained entities within urban areas and are deemed
11 "ecosystemic" as they operate as a unified entity, cultivating and selling produce within the
12 same structure, circumventing, thereby, carbon emissions associated with transportation and
13 enhancing the traceability of food items (Al-Chalabi, 2015b). Beyond these advantages, vertical
14 farming offers retail companies a distinctive system for product offerings. Utilizing cutting-
15 edge production methods that involve multiple layers, techniques, and integrated organizational
16 interactions, in-store vertical farming technologies simplify the entire food production process
17 from planting to retail. This not only creates a promising sustainability potential for
18 organizations but also significantly reduces the ecological footprint of food production and
19 ensures that densely populated urban areas maintain consistent access to fresh, high-quality
20 food.

21 While there is not much research on the advantages of in-store vertical farming and the
22 challenges that retail companies may encounter when implementing it, past studies on the
23 factors that influence innovation adoption by food retailers, indicate that they always prioritize
24 consumers' interests (Esbjerg et al., 2016). These studies have also indicated that adopting new
25 technologies and their resultant products must demonstrate clear consumer benefits and pose
26 minimal risk for retailers. On the other hand, in their research on the impact of supermarket

1 credibility on the purchase intention of novel food, Jung, Sharma, and Mattila (2022) state that
2 both retailers and consumers must comprehend these advantages in terms of business instead
3 of technical jargon. Clark et al. (2022) examined the drivers behind vertical farming's adoption
4 by members of the catering industry. They found that although chefs believe that vertical farms
5 can significantly reduce food miles and produce high-quality, fresh, and visually appealing
6 produce, they have concerns about whether the taste of vertical farm produce can match that of
7 conventional crops. Overall, the quality and taste perceptions of vertical farm produce are the
8 main factors that influence chefs' willingness to use or reject these production techniques.

9 Even though research on vertical farming in the retail sector is sparse, insights from consumer
10 behavior literature can help retailers understand consumer perceptions of produce grown using
11 in-store vertical farming technologies (Adams et al., 2024). For instance, Ares et al. (2021)
12 found predominantly positive attitudes toward vertically farmed produce in several countries,
13 particularly China and Singapore. The study emphasized aligning vertical farming with the
14 United Nations Sustainable Development Goals - mainly SDG 11. Sustainable Cities and
15 Communities, and SDG 12. Sustainable consumption and production - which promote reducing
16 carbon emissions and ensuring reliable food access drive these positive perceptions. However,
17 concerns about high energy consumption and pricing associated with vertical farms also
18 influence consumer attitudes. These findings highlight the complex considerations that shape
19 consumers' perceptions of this innovative food production technology, providing valuable
20 insights for retail stakeholders.

21 Despite positive strides, incorporating in-store vertical farming technologies within the retail
22 industry remains limited, and a noticeable gap exists in the available literature explaining this
23 trend. Similar to Trivette's (2019) argument, this article emphasizes the need to move beyond
24 a primarily direct-to-consumer approach and consider retailers' contributions when promoting
25 and supporting local food. We specifically explore the potential of in-store vertical farming as

1 part of the solution to build sustainability in the food retail sector and, more generally, urban
2 food supply chain strategies. The idea is that in-store vertical farming technologies can
3 potentially reduce our dependence on global supply chains by shifting the focus and operations
4 and offering direct configurations that allow consumers to learn more about the origins of their
5 food and the innovative technology of its production. In this article, we argue that attitudes and
6 perspectives of food retail actors are essential, given their influence on consumers' purchase
7 and eating habits, and, therefore, assessed retailers' behavioral intentions to adopt in-store
8 vertical farming technologies.

9 II. Material and Methods

10 1. Conceptual framework and hypothesis

11 Initially proposed to provide a more accurate explanation and prediction of technology
12 acceptance behavior, the Unified Theory of Acceptance and Use of Technology (UTAUT) is
13 now recognized as one of the most contemporary models for studying technology
14 acceptance (Venkatesh et al., 2003). It was developed from the Technology Acceptance Model
15 (TAM), introduced by Davis (1989), one of the most widely known frameworks for exploring
16 how new users adopt and accept innovative technologies. TAM itself evolved from the Theory
17 of Reasoned Actions (Ajzen & Fishbein, 1980a) and the Theory of Planned Behavior (Ajzen,
18 1988).

19 Today, the UTAUT is recognized to be an empirically validated model that is also parsimonious
20 and effective for explaining and testing a wide range of behaviors. However, while it has been
21 applied in various technology acceptance fields, including healthcare (Ben Arfi et al., 2021),
22 education and learning (Chauhan, 2016), and agriculture (Li et al., 2020), its use in food retail
23 research is still limited with previous research essentially focusing on the adoption of
24 blockchain technology (Mukherjee et al., 2023b; Sheel & Nath, 2020) to improve supply chain

1 sustainability, as well as exploring technological progress in designing innovative strategies for
2 e-grocery (Dirsehan & Cankat, 2021).

3 The UTAUT model includes four key antecedents (i.e., latent variables) that explain users'
4 acceptance of new technologies: performance expectancy, effort expectancy, social influence,
5 and facilitating conditions. These factors consider the inner characteristics of technology and
6 the impact of external support and social influence on users' perceptions of technology. On the
7 other hand, theories on attitudes conceptualize behavioral intention into two main stages, which
8 are the association of 1. beliefs and attitudes on the one hand and 2. attitudes and intentions on
9 the other (Ajzen & Fishbein, 1980). In the first stage, individuals form their attitudes based on
10 their beliefs and cognitive processes. In the second stage, these attitudes shape their behavior
11 and determine how they express themselves. We hypothesize that the four UTAUT variables
12 represent the beliefs of food retailers toward vertical farming technologies, which affect their
13 attitudes (Hypothesis H 1-5). Attitudes, in turn, will lead to the expression of behavioral
14 intentions (Hypothesis H 6).

15 Furthermore, risk perception is also included in the conceptual model to extend our
16 understanding of its relative influence on food retailers' behavioral intention to adopt in-store
17 vertical farming technologies. Indeed, in-store vertical farming presents several risks for retail
18 managers, including high initial investment and operating costs, technological complexity, and
19 uncertain consumer acceptance. Additional challenges include supply chain integration,
20 regulatory compliance, and market competition. Managers must navigate these risks through
21 careful planning and management to ensure the technology's successful and sustainable
22 adoption. Accordingly, risk perception may also directly affect attitudes toward adopting in-
23 store vertical farming technologies. Hence, we include a risk component in the original UTAUT
24 to explain the complex process that yields acceptance.

25 The following paragraphs describe the theoretical definitions of the different UTAUT
26 components concerned by this study as well as the underlying hypothesis of this research.

1 Performance expectancy (PE) refers to the scope to which an individual thinks that technology
2 use could be beneficial to them to reach a higher performance (Venkatesh et al., 2003) and is
3 usually the strongest predictor of behavioral intention. Accordingly, the greater the perceived
4 value of these technologies to food retailers, the more favorable their attitudes toward them will
5 likely be. In this study, vertical farming technologies are anticipated to offer significant benefits
6 to food retailers, such as ensuring a sustainable supply of fresh, locally produced food and
7 minimizing food waste by better aligning supply with demand. Here, perceived effectiveness
8 (PE) is defined as the retailers' recognition of the usefulness and advantages of vertical farming
9 technology. Therefore, the following hypothesis was proposed:

10 H1. Performance expectancy directly, positively, and significantly affects retailers' attitudes
11 toward vertical farming technologies.

12 Effort expectancy (EE) refers to the users' perception of how difficult or easy it is to use new
13 technology (Venkatesh et al., 2003). Many studies consider effort expectancy the most
14 influential factor in determining users' behavioral intention to adopt new technologies (Sun et
15 al., 2013). In this study, EE refers to the extent to which retailers believe it is easy to learn and
16 use vertical farming technologies and include them in their daily in-store logistics. We establish
17 the following hypothesis based on previous studies by Chung & Jung (2019) and Martins et al.
18 (2014) who found that the more convenient and easier to use a new technology is, the higher
19 the behavioral intention to use it:

20 H2. Effort expectancy directly, positively, and significantly affects retailers' attitudes toward
21 vertical farming technologies.

22 Social influence (SE) refers to the importance and impact of people close to or essential to a
23 person, such as colleagues, friends, and family members, who can convince him or her to accept
24 new technologies. Studies have shown the importance of SE in explaining individuals' intention
25 to adopt and their effective adoption of new technologies (Sun et al., 2013b). In our model, the

1 following hypothesis was established based on the results of studies by Venkatesh et al. (2012)
2 and Chung & Jung (2019), which have shown that people's intention to use a new technology
3 increases when influenced by people around them.

4 H3: Social influence directly, positively, and significantly affects retailers' attitudes toward
5 vertical farming technologies.

6 Facilitating conditions (FC) include users' perception of the extent to which the organizational
7 financial and technical infrastructure support the use of the new technology presented to them
8 (Venkatesh et al., 2003). Chen and Chang (2013) have shown that facilitating conditions are
9 significant factors in determining behavioral intention in adopting technologies. In this study,
10 FC refers to resources and facilities that make the adoption process of vertical farming
11 technologies more accessible to food retailers.

12 H4: Facilitating conditions (FC) directly, positively, and significantly affect retailers'
13 behavioral intention to adopt vertical farming technologies.

14 Perceived risk (PR) refers to uncertainty impacting people's confidence in their decisions. Risky
15 situations may occur when the probabilities of particular outcomes are unknown (Im et al.,
16 2008) Moreover, perceived risk refers to users' attitude toward potential risks that may arise in
17 various areas (financial, technical, production, management-related, etc.) due to the adoption
18 of new technology. (Venkatesh et al., 2003). In this study, perceived risk refers to the risk that
19 retailers assume by adopting vertical farming technologies in their stores and its impact on them
20 and their businesses. These could include high initial capital costs, operational tasks, scale-up
21 challenges, market competition, etc; we therefore hypothesize the following:

22 H5. Perceived risk negatively affects retailers' attitudes toward vertical farming technology
23 adoption.

1 Attitudes: In this study, retailers' attitudes are expected to play a role in understanding how they
2 prefer or do not prefer in-store vertical farming technologies. While the study by Rana et al.
3 (2017) used attitudes as a mediating variable for PE and EE, others have found substantial
4 relationships between attitudes and behavioral intentions to use technology (Dwivedi et al.,
5 2019). In our research, we expect attitudes to mediate the UTAUT, along with the risk
6 perception construct and retailers' intentions to use vertical farming technologies in their stores,
7 and we suggest the following hypothesis:

8 H6. Attitudes positively affect retailers' behavioral intention to use in-store vertical farming
9 technologies.

10 Behavioral intention (BI) refers to the likelihood that a person will engage in specific behaviors
11 under certain conditions in the future. It plays a crucial role in determining an individual's
12 acceptance of new technologies (Venkatesh, 2003). In this study, BI is a critical concept in the
13 model and specifically relates to the intention of food retailers to adopt in-store vertical farming
14 technologies.

15 Based on this hypothesis, we developed our theoretical model (Fig.1) to determine the factors
16 influencing retailers' behavioral intention to embrace in-store vertical farming.

17 *Insert Figure 1 here*

18 2. Survey design and measurement

19 The survey used in this study was designed based on the conceptual model presented earlier
20 (Fig. 1) and consisted of three sections. The first section gathered information about the
21 characteristics of the food retail business, such as total area, annual customer count, year of
22 establishment, and the main fresh products sold in the store. The second section focused on
23 attitudes and behavioral factors that could influence retailers' adoption of in-store vertical

1 farming technologies. Respondents were first shown images explaining vertical farming
2 technologies, followed by questions to measure the latent variables discussed earlier. These
3 variables were evaluated using a five-point Likert scale, ranging from "strongly agree" to
4 "strongly disagree." The specific questions used for this purpose are listed in Table 1. Questions
5 designed to measure Performance Expectancy (PE), Effort Expectancy (EE), Social Influence
6 (SE), and Facilitating Conditions (FC) were adapted from the existing scales proposed by
7 Venkatesh and Zhang (2010) and further supported by Sok Foon and Chan Yin Fah (2011). The
8 perceived risk was assessed using a scale developed by Stone and Grønhaug (1993). Behavioral
9 intention was measured with a single item adapted from Venkatesh and Zhang (2010). The third
10 section of the survey included questions evaluating the sustainability practices of food retailers
11 and the in-store experience they provide to customers. It also assessed their commitment to
12 supply chain transparency and their self-perception relative to their competitors.

13 *Insert Table 1 here*

14 The study employed both in-person and online surveys to engage a wide range of food retailers
15 in Rouen City, located in northwestern France. Although the findings may not fully represent
16 the entire food retail sector in urban France, Rouen—home to 110,000 residents—is a leading
17 city in promoting sustainable food systems through an innovative urban food strategy. This
18 strategy focuses on increasing the availability of fresh food, reducing the ecological footprint
19 of food, and fostering urban farming as a response to climate change. The survey campaign,
20 conducted between February and July 2020, resulted in 109 completed questionnaires. After
21 careful review, 94 were selected as usable for further analysis.

22

23 3. Data analysis procedure

1 The data collected from the online survey was analyzed using STATA software version 16.
2 Most retail managers who responded were male (80%), with an average age of 34, and had been
3 operating their stores for an average of six years. While 11% of respondents reported having a
4 business degree, only 8% had food or agricultural sciences training. Regarding store
5 characteristics, the average store size was 750 square meters, though there was significant
6 variation within the sample (s.d. = 118.95). Food supermarkets were the most represented in
7 the sample (45%), followed by food co-ops (28%), greengrocers (23%), and hard discount
8 stores (18%). Notably, 90% of respondents were familiar with vertical farming and had a basic
9 understanding of its techniques, but only 19% regularly sourced fresh products from vertical
10 farms. There was strong agreement among respondents on the potential of vertical farming
11 technology to secure access to fresh food for city dwellers (81% fully agreed) and help create a
12 better customer experience in their stores (69% fully agreed) (Fig. 2).

13 *Insert Figure 2 here.*

14 Figure 3 displays the responses to questions that focused on how food retailers perceive and
15 articulate the risks associated with integrating vertical farming into their stores. Most
16 respondents identified the high initial investments and significant ongoing operational costs as
17 the main risks that could deter them from adopting vertical farming. However, over half of the
18 participants believe these risks may be mitigated over time as technology and processes
19 advance.

20 *Insert figure 3 here.*

21 To explore the relationships between the latent variables described earlier, we employed
22 Structural Equation Modeling (SEM). This robust statistical method accurately measures and
23 describes complex correlations among various factors (Hair, Ringle, & Sarstedt, 2012). SEM
24 was conducted using the Maximum Likelihood method within STATA's command language.

1 The STATA builder facilitated the creation of both path analysis and model parameters. The
2 analysis comprised two main steps. First, we assessed the measurement model by evaluating
3 Cronbach's alpha, a non-parametric indicator of internal consistency, with a threshold of >0.7
4 (Bagozzi et al., 1991). If Cronbach's alpha fell within the acceptable range, it was included in
5 the structural model. The next step involved performing confirmatory factor analysis and
6 examining the results of the structural models to ensure the measures' internal consistency and
7 improve model fit. To address potential non-normality in the measures, we primarily used the
8 Satorra-Bentler Estimator. The goodness of fit was assessed using several indices: the Root
9 Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), the Tucker-
10 Lewis Index (TLI), and the Standardized Root Mean Squared Residual (SRMR).

11 III. Results

12 1. Test of the model: the exploratory factor analysis

13 The exploratory factor analysis was conducted to investigate whether there is a relationship
14 between the items used in the questionnaire to assess food retailers' behavioral intentions
15 regarding adopting on-store vertical farming technologies. Table 2 displays the correlation
16 matrix for the items, revealing that the data are not highly correlated. Additionally, Bartlett's
17 Test of Sphericity was performed, and its significant result ($\chi^2 = 3052.31$, p-value < 0.001)
18 confirms that adequate correlations exist among the measurements. The Kaiser-Meyer-Olkin
19 (KMO) measure of sampling adequacy was 0.922, well above the threshold of 0.5, indicating
20 substantial intercorrelations among the data and justifying the use of factor analysis.

21

22 *Insert Table 2 here*

1 Table 3 presents the results of the exploratory factor analysis conducted for the measurement
2 scale. To verify the reliability and validity of the items, we followed the guidelines established
3 by Hair, Howard, and Nitzl (2020). Both Cronbach's alpha and Dillon-Goldstein's rho were
4 used, with values exceeding 0.7 and 0.8, respectively, confirming the reliability of the items.
5 Items with factor loadings below 0.7 were removed, which led to excluding the items related to
6 social influence (SI4) and performance expectancy (PE3). Additionally, the factor analysis
7 indicated that the FC4 item should be categorized under effort expectancy rather than the
8 facilitating conditions group, as initially planned.

9 *Insert Table 3 here*

10 2. Confirmatory Factor Analysis

11 Confirmatory Factor Analysis (CFA) was conducted to validate the reliability of the measures
12 selected for the structural model, building on the results from the previously performed
13 Exploratory Factor Analysis (EFA). While the factorial structure of constructs such as Effort
14 Expectancy (EE), Performance Expectancy (PE), Social Influence (SI), and Facilitating
15 Conditions (FC) is well-established in the literature on technology use (e.g., UTAUT), the EFA
16 was instrumental in refining and adapting the measurement items to fit the specific context of
17 the food retail sector. This refinement included the introduction of the perceived risk (PR)
18 variable.

19 The Root Mean Square Error of Approximation (RMSEA) values were below 0.05, indicating
20 a good fit (Pituch & Stevens, 2016). The Comparative Fit Index (CFI) and Tucker-Lewis Index
21 (TLI), which are incremental fit indices, both achieved values above 0.95, reflecting a perfect
22 fit. However, the Standardized Root Mean Square Residual (SRMR) values exceeded 0.10 for
23 the Social Influence variable, which did not meet the acceptable fit criteria and led to its removal

1 from the model. Consequently, the baseline Structural Equation Model (SEM) includes only
2 four latent variables: PE, EE, FC, and PR.

3 3. The Structural Equation Model

4 The Structural Equation Model (SEM) was utilized to examine the relationships among
5 Performance Expectancy (PE), Effort Expectancy (EE), Facilitating Conditions (FC), Perceived
6 Risk (PR), attitudes, and behavioral intention to adopt in-store vertical farming technologies.
7 Based on the Exploratory Factor Analysis (EFA) results, one item related to Effort Expectancy
8 was replaced by a Facilitating Conditions item (i.e., FC4, which translates to help availability).
9 Consequently, only three items were included in the Facilitating Conditions latent variable
10 (FC1, FC2, and FC3). Additionally, PE3 was removed from the Performance Expectancy
11 construct due to its low factor loading (0.53, below the acceptable threshold of 0.7).

12 Initially, the model fit was unsatisfactory, as indicated by the fit indices: RMSEA = 0.148, CFI
13 = 0.898, TLI = 0.891, SRMR = 0.328, and CD = 1.000. This poor fit might be due to
14 specification errors. MacCallum (1986) suggests that model fit can often be improved by
15 allowing covariances between omitted latent variables. Modification indices for path
16 coefficients and covariances indicated that adding a covariance between PE and EE would
17 improve the model fit. After these adjustments, the model fit indices improved to RMSEA =
18 0.084, CFI = 0.927, TLI = 0.906, SRMR = 0.081, and CD = 0.999. Table 4 presents the
19 standardized estimates for the different paths of the model and the corresponding critical ratio.

20 *Insert Table 4 here.*

21 The findings indicate that the variable performance expectancy (PE) ($B = 0.471$, $t = 5.365$) and
22 facilitating conditions (FC) ($B = 0.21$, $t = 5.032$) made the most significant contribution to
23 retailers' attitudes toward in-store vertical farming technologies. As expected, the perceived

1 risks associated with vertical farming technology in retail settings have a negative and
2 significant coefficient path ($B = -0.155$, $t=0.751$). Finally, as predicted, the coefficient path
3 from attitudes to behavioral intention is positive and statistically significant (Table 5)

4 *Insert Table 5 here*

5 Discussion

6 Today's food retail businesses must prioritize sustainability in their core strategies due to
7 society's constantly evolving attitudes and norms (Naidoo & Gasparatos, 2018). At the same
8 time, the consumption of locally produced food, sourced with minimal food miles, is gaining
9 increased attention (Megicks et al., 2012; Memery et al., 2015). As customer-facing entities,
10 food retailers have a unique position in the supply chain to influence both their suppliers and
11 customers. This study focuses on the adoption of in-store vertical farming technologies by food
12 retailers in highly dense urban areas in Rouen City, France, as a way to address sustainability
13 in food supply chains.

14 This study is the first to utilize the Unified Theory of Acceptance and Use of Technology to
15 investigate the factors influencing the adoption of in-store vertical farming technology. The
16 research examines the influence of performance expectancy, effort expectancy, facilitating
17 conditions, and social influence on attitudes toward adopting in-store vertical farming.
18 Additionally, the study introduces a new concept of perceived risk, which was not part of the
19 original UTAUT but was developed specifically for this research to provide a more
20 comprehensive understanding of the complexities involved in the empirical data analysis,
21 considering various aspects of the reality of vertical farming technologies adoption by the retail
22 actors.

23 The final model from the data analysis revealed that performance expectancy, facilitating
24 conditions, and effort expectancy were significant predictors of the outcome variable. However,

1 social influence was excluded from the final model as it did not contribute to its goodness of
2 fit. The findings underscore a noteworthy relationship between performance expectancy and
3 food retailers' attitudes toward vertical in-store farming activities. Specifically, the results
4 demonstrate that performance expectancy exerts a positive and highly significant influence. It
5 is noteworthy that getting fresh food products made and delivered in time to city dwellers at the
6 lowest cost possible while ensuring that the product remains intact during transport is an
7 ongoing challenge for urban fresh food retailers, which may explain why performance
8 expectancy proved to have the most potent direct effect on retailers' attitudes toward vertical
9 farming technologies. As food retailers in our sample increasingly perceive the efficacy of
10 vertical farming technologies in quality, cost reduction, risk mitigation, and sustainability, their
11 inclination and motivation to integrate these technologies into their operations intensify. This
12 aligns with Kshetri's (2018) perspective, which posits that performance expectancy
13 encompasses various dimensions crucial to retailers, and a heightened expectation of superior
14 performance across these dimensions correlates with a heightened intention to adopt innovative
15 technologies within the retail and overall supply chain sector (Wong et al., 2020).

16 Our findings reveal that a significant portion of our sample strongly emphasizes sustainability
17 within their businesses, indicating the importance of this dimension to them. Most respondents
18 believe vertical farming could play a crucial role in protecting biodiversity, managing water
19 resources more effectively, and mitigating the impacts of climate change on agriculture.
20 Additionally, 82% of respondents agreed that adopting vertical farming technologies in their
21 stores would significantly reduce fresh food waste. Vertical farming allows for the precise
22 production of food quantities tailored to customer demand while minimizing transportation
23 losses—addressing a critical social, nutritional, and environmental challenge in the supply
24 chain (Parfitt et al., 2010). While food waste is recognized to be generated at different stages
25 of the supply chain, a meta-analysis of the studies dealing with retail food waste quantification

1 by Cicatiello et al. (2017) underscores that, unlike most other stakeholders in the food chain,
2 retailers are eager to implement actions aimed at reducing food waste as it represents a loss in
3 their business and poses a risk to their profit margins.

4 Beyond sustainability, most of our respondents agreed that integrating vertical farming into
5 their stores would enhance the overall customer experience. This finding is consistent with
6 research on retail environments and customer experience paradigms, which shows that merely
7 attracting customers to the store is no longer sufficient (Eroglu et al., 2001; Seock Marjorie,
8 2015). Retail success today hinges less on the products being sold and more on how they are
9 presented and experienced. As a result, retailers are increasingly focused on transforming the
10 store experience into something more engaging, educational, and memorable for shoppers.
11 Moreover, modern stores are evolving beyond their traditional role of simply selling products;
12 they now function as showrooms, museums, warehouses, and fulfillment centers (Mohan et al.,
13 2013). In-store vertical farms have the potential to enhance the customer experience by offering
14 fresh, high-quality produce directly from the source, creating a more engaging and educational
15 shopping environment. In addition to visually demonstrating sustainability efforts, these farms
16 appeal to eco-conscious consumers and add a unique, innovative element that differentiates the
17 store from competitors. Greenery also improves the store's ambiance, ultimately creating a
18 more personalized and memorable shopping experience.

19 Our results highlight that facilitating conditions are crucial in determining retailers' behavioral
20 intention to adopt vertical farming. Even though this finding contradicts the results of a recent
21 study by Mukherjee et al. (2023), putting forth that the facilitating conditions did not promote
22 blockchain technology adoption in the food retail sector, it is consistent with the results of a
23 survey conducted by Shao et al. (2022) on the factors influencing public intention to use micro-
24 vertical farming. The study found that people's perception of the availability of resources

1 needed to grow plants through vertical farming (i.e., facilitating conditions) was a significant
2 motivator in determining their intention to adopt it.

3 The results show that the ease of putting effort into vertical farming (i.e., effort expectancy)
4 positively impacts retail store managers' intention to participate. However, this influence is not
5 as strong as the impact of facilitating conditions, such as having the necessary resources,
6 knowledge, and investments and ensuring that vertical farming aligns with the retail store's
7 business strategy. This suggests that facilitating conditions significantly influence attitudes
8 toward in-store vertical farming technology more than ease of use. This paper also contributes
9 to understanding the role of risk perception by food retailers in shaping attitudes towards in-
10 store vertical farming and behavioral intention. According to our findings, food retailers'
11 decision to adopt in-store vertical farming hinges on their perception of the risks and benefits
12 rather than the actual ones. This perception is crucial in determining whether the technology is
13 adequate for their business performance. The term perceived risk has been commonly defined
14 in the literature as a combination of uncertainty and the seriousness of the outcomes involved
15 (Featherman & Pavlou, 2003). Our research highlights a clear pattern where the negative impact
16 of perceived risk on food retailers' inclination to adopt vertical farming is outweighed by the
17 performance expectancy coefficient in absolute terms. This suggests that retailers foresee more
18 significant performance benefits from in-store vertical farming than the associated risks would
19 indicate. Contrary to our initial assumptions, a high perception of risk does not necessarily
20 correlate with a low perception of benefits. It is important to note that 20% of the respondents
21 already have experience using vertical farming technology or sourcing food from vertical farms.
22 Previous experiences can significantly influence food retailers' perceptions of their ability to
23 manage the risks of adopting vertical farming technologies in their stores. This aligns with the
24 conclusions of Ellis et al. (2008), who emphasize that individuals tend to perceive fewer risks
25 as the level of experience increases.

1 Our findings highlight the apprehensions voiced by retailers concerning the substantial
2 investment and operational costs linked to the implementation of vertical farms. Additionally,
3 over half of the respondents acknowledged that in-store vertical farming would involve a
4 considerable energy dependency to secure a significant power supply for continuous year-round
5 operation. These perceptions align with those reported by Oliveira, Ferson and Dyer (2021) and
6 outline three key challenges facing vertical farm businesses: environmental sustainability (i.e.,
7 energy consumption), standardization, and profitability. Mainly, high failure stems from the
8 increased number of premature business decisions about location, choice, pricing strategy,
9 system design, and other critical issues (Baumont de Oliveira et al., 2022).

10 Drawing insights from the outcomes of the confirmatory factor analysis, the final structural
11 model excluded social influence. Although similar findings on the adoption of in-store vertical
12 farming technologies are nonexistent, our results align with prior research conducted in the
13 agricultural field, which has shown that social influence has little impact on farmers' willingness
14 to adopt innovative technologies. Moreover, according to Li et al. (2020), although the social
15 impact may motivate farmers to adopt new technologies, actual adoption is more probable when
16 there are no hindrances to accessing the necessary resources and knowledge and when the
17 perceived financial risks are low. On the other hand, previous studies suggest social influence
18 could influence but not determine whether people would use vertical farms to grow their food,
19 as shown by Shao et al. (2022).

20 Conclusion

21 With the mounting demand for fresh, locally sourced food in urban areas, it becomes essential
22 to examine how various players in the food supply chain can contribute to the success and
23 sustainability of both the local food system and the overall supply chain. In this paper, we
24 suggest that the adoption of in-store vertical farming by food retailers presents a transformative
25 opportunity to transcend traditional limitations associated with food miles through several

1 mechanisms, including a localized production, “*sell where you produce*” model, enhancing
2 thereby traceability, continued access to fresh produce and reduced carbon emissions.
3 Moreover, we hypothesize that since food retailers form greater interconnectivity in the local
4 food system than farms, their motivations for adopting vertical farming technologies to secure
5 fresh and local food access to city dwellers may differ from those of traditional farmers.

6 The theoretical contribution of this paper lies in exploring food retail actors operating in urban
7 areas, which contributes to the body of research on the use of technology to promote sustainable
8 urban food supply chains and systems while providing additional UTAUT empirical
9 applications and evidence. Previous research has focused directly on rational behavioral
10 intention to adopt technologies while ignoring the effects of less rational factors such as
11 attitudes. By including the attitudes variable in the UTAUT model, this research results provide
12 insights on the relevance of including rational and irrational factors to improve the model
13 specification quality.

14 Even if performance expectancy and facilitating conditions significantly shape attitudes toward
15 in-store vertical farming adoption, risk aversion improved the model's quality. Hence, our
16 findings enrich the original research on using UTAUT and the critical insights that risk aversion
17 could bring to understanding the behavioral intention of adopting technologies.

18 Vertical farming has undergone extensive scrutiny regarding technological and agricultural
19 advancements, yet economic evaluation and risk assessment associated with these practices are
20 still relatively nascent areas of focus within the fields of environment, natural resources, food,
21 and economics. Despite vertical farming’s positioning as an innovative method leveraging
22 technology to enhance yields per unit area, it remains an emerging sector facing significant
23 challenges in profitability and a notable failure rate. While both practitioners and academics
24 emphasize the need for comprehensive economic analyses of vertical farming, progress has
25 been hampered by a lack of valid and easily accessible data. Existing studies often fall short in

1 addressing the critical risks and uncertainties essential for enabling informed and empowered
2 business planning in this field.

3 To address these gaps, effective risk management strategies must be developed to mitigate
4 profit fluctuations and enhance investment security, thereby increasing the profitability margins
5 for food retailers. However, the sector continues to struggle with a lack of adequate knowledge
6 and accessible education concerning the integration and operation of vertical farming systems,
7 including aspects like irrigation, lighting, plant science, and manufacturing systems. These
8 deficiencies contribute significantly to the failure of such systems. Moreover, a scarcity of
9 capital investment sources and misaligned support and expectations from funders further
10 exacerbate these challenges. Failures are often rooted in poor early decisions related to pricing,
11 crop selection, and location.

12 While our research employed a quantitative approach to explore these issues, it would greatly
13 benefit from a complementary qualitative approach, such as semi-structured interviews, to gain
14 deeper insights into how retailers perceive and experience the risks associated with adopting
15 in-store vertical farming. This combined methodology would provide a more nuanced
16 understanding of the challenges faced by retailers, particularly in navigating the uncertainties
17 and risk manifestations that are critical to the successful adoption and integration of vertical
18 farming systems.

19 Ultimately, it is essential to acknowledge the potential challenges associated with directly
20 applying the findings of this research to alternative urban or geographical settings, even within
21 France. Rouen, as the administrative capital of Normandy, represents a unique context as the
22 primary agricultural region in France. Notably, a mere 2% of the food supplied to Rouen city
23 residents originates from local sources. Despite ongoing efforts by policymakers to establish a
24 local food plan, the supply chains for fresh produce continue to rely heavily on extensive
25 networks. Consequently, future research endeavors should aim to collect data from diverse
26 regional and urban settings to ensure the validation of the model proposed in this study. This

1 broader approach will enhance the generalizability and applicability of the research findings
2 across various contexts.

3 Declarations

4 Conflict of interest: The authors declare no conflict of interest. Competing interest: The authors
5 declare they have no relevant or nonfinancial interests to disclose.

6 Ethics approval/declarations: Does not apply.

7 Consent to participate (include appropriate statements): Respondents involved in this study
8 have all consented.

9 Consent for publication: The authors declare that this is an original work that has not previously
10 been considered for publication.

11 Availability of data and material/ Data availability: The datasets generated during and/or
12 analyzed during the current study are available from the corresponding author on reasonable
13 request.

14 Code availability (software application or custom code): The codes generated during and/or
15 analyzed during the current study are available from the corresponding author on reasonable
16 request.

17

18 References

19 Adams, F., Etuah, S., Appiah, G. B., Aidoo, R., Mensah, J. O., Nyekyeyel, J., Appiah, F. N.,
20 Serebour, M., Kwarteng, N., & Asare, P. (2024). Do Consumer Opinions Matter?
21 Consumer Perception and Purchasing Decisions of Greenhouse Vegetables in Ghana.
22 *Journal of International Food & Agribusiness Marketing*, 36(3), 424–446.
23 <https://doi.org/10.1080/08974438.2022.2145536>

24 Ajzen, I. (1988). *Attitudes, Personality and Behaviour* (D. Press, Ed.).

25 Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour*.

26 Albizzati, P. F., Tonini, D., Chammard, C. B., & Astrup, T. F. (2019). Valorisation of surplus
27 food in the French retail sector: Environmental and economic impacts. *Waste*
28 *Management*, 90, 141–151. <https://doi.org/https://doi.org/10.1016/j.wasman.2019.04.034>

29 Al-Chalabi, M. (2015). Vertical farming: Skyscraper sustainability? *Sustainable Cities and*
30 *Society*, 18, 74–77. <https://doi.org/10.1016/j.scs.2015.06.003>

- 1 Al-Kodmany, K. (2024). *Vertical Farms for Future Cities BT - Digital Agriculture: A*
2 *Solution for Sustainable Food and Nutritional Security* (P. M. Priyadarshan, S. M. Jain,
3 S. Penna, & J. M. Al-Khayri, Eds.; pp. 179–197). Springer International Publishing.
4 https://doi.org/10.1007/978-3-031-43548-5_6
- 5 Aschemann-Witzel, J., de Hooge, I., & Normann, A. (2016). Consumer-Related Food Waste:
6 Role of Food Marketing and Retailers and Potential for Action. *Journal of International*
7 *Food & Agribusiness Marketing*, 28(3), 271–285.
8 <https://doi.org/10.1080/08974438.2015.1110549>
- 9 Baumont de Oliveira, F. J., Ferson, S., Dyer, R. A. D., Thomas, J. M. H., Myers, P. D., &
10 Gray, N. G. (2022). How High Is High Enough? Assessing Financial Risk for Vertical
11 Farms Using Imprecise Probability. *Sustainability (Switzerland)*, 14(9), 1–29.
12 <https://doi.org/10.3390/su14095676>
- 13 Benke, K., & Tomkins, B. (2017). Future food-production systems: Vertical farming and
14 controlled-environment agriculture. *Sustainability: Science, Practice, and Policy*, 13(1),
15 13–26. <https://doi.org/10.1080/15487733.2017.1394054>
- 16 Birch, D., Memery, J., & De Silva Kanakaratne, M. (2018). The mindful consumer: Balancing
17 egoistic and altruistic motivations to purchase local food. *Journal of Retailing and*
18 *Consumer Services*, 40(October 2017), 221–228.
19 <https://doi.org/10.1016/j.jretconser.2017.10.013>
- 20 Butturini, M., & Marcelis, L. F. M. (2020). Chapter 4 - Vertical farming in Europe: Present
21 status and outlook. In T. Kozai, G. Niu, & M. B. T.-P. F. (Second E. Takagaki (Eds.),
22 *Plant Factory* (pp. 77–91). Academic Press. [https://doi.org/https://doi.org/10.1016/B978-](https://doi.org/https://doi.org/10.1016/B978-0-12-816691-8.00004-2)
23 [0-12-816691-8.00004-2](https://doi.org/https://doi.org/10.1016/B978-0-12-816691-8.00004-2)
- 24 Chen, K.-Y., & Chang, M.-L. (2013). User acceptance of ‘near field communication’ mobile
25 phone service: an investigation based on the ‘unified theory of acceptance and use of
26 technology’ model. *The Service Industries Journal*, 33(6), 609–623.
27 <https://doi.org/10.1080/02642069.2011.622369>
- 28 Chung, Y.-S., & Jung, C.-H. (2019). A Study on the Factors Affecting Acceptance of Easy
29 Payment Services Using Extended UTAUT Model. *Journal of Information Technology*
30 *Applications and Management*, 26(2), 1–11.
- 31 Clark, A., Ellison, M., Robinson, G., & Hill, T. R. (2022). Consumer perceptions of vertical
32 farming with a focus on the catering industry. *Proceedings of the Nutrition Society*,
33 81(OCE5), 2022. <https://doi.org/10.1017/s0029665122002506>
- 34 Claro, D. P., Laban Neto, S. A., & de Oliveira Claro, P. B. (2013). Sustainability drivers in
35 food retail. *Journal of Retailing and Consumer Services*, 20(3), 365–371.
36 <https://doi.org/10.1016/j.jretconser.2013.02.003>
- 37 Dirsehan, T., & Cankat, E. (2021). Role of mobile food-ordering applications in developing
38 restaurants’ brand satisfaction and loyalty in the pandemic period. *Journal of Retailing*
39 *and Consumer Services*, 62, 102608.
- 40 Dunne, J. B., Chambers, K. J., Giombolini, K. J., & Schlegel, S. A. (2011). What does ‘local’
41 mean in the grocery store? Multiplicity in food retailers’ perspectives on sourcing and

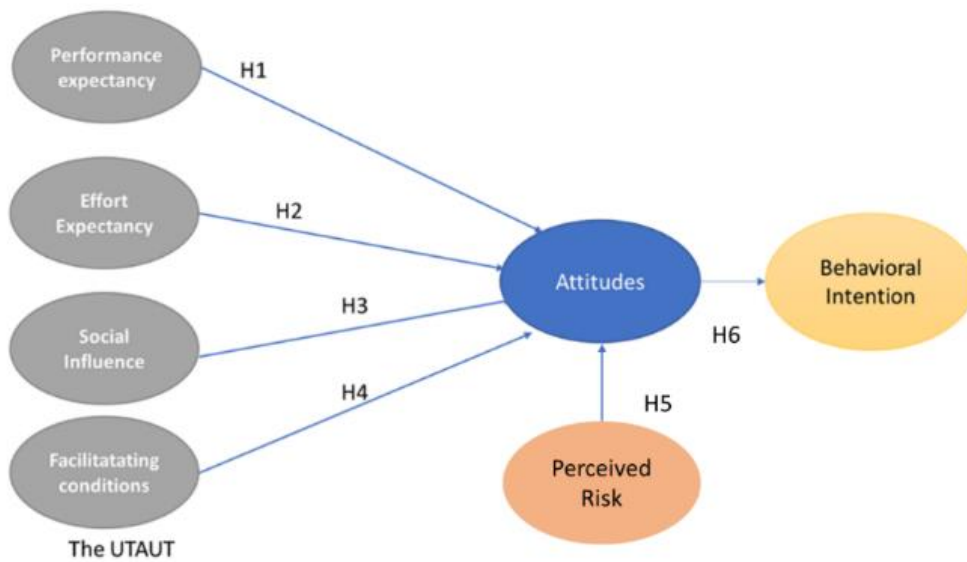
- 1 marketing local foods. *Renewable Agriculture and Food Systems*, 26(1), 46–59.
2 <https://doi.org/DOI: 10.1017/S1742170510000402>
- 3 Dwivedi, Y. K., Rana, N. P., Jeyaraj, A., Clement, M., & Williams, M. D. (2019). Re-
4 examining the Unified Theory of Acceptance and Use of Technology (UTAUT):
5 Towards a Revised Theoretical Model. *Information Systems Frontiers*, 21(3), 719–734.
6 <https://doi.org/10.1007/s10796-017-9774-y>
- 7 Elkington, J. (1994). Towards the Sustainable Corporation: Win-Win-Win Business Strategies
8 for Sustainable Development. *California Management Review*, 36(2), 90–100.
9 <https://doi.org/10.2307/41165746>
- 10 Ellis, S., Ganzach, Y., Pazy, A., & Ricci-Siag, T. (2008). On the perception and
11 operationalization of risk perception. *Judgment and Decision Making*, 3(4), 317–324.
12 <https://doi.org/DOI: 10.1017/S1930297500000887>
- 13 Eroglu, S. A., Machleit, K. A., & Davis, L. M. (2001). Atmospheric qualities of online
14 retailing: A conceptual model and implications. *Journal of Business Research*, 54(2),
15 177–184.
- 16 Esbjerg, L., Burt, S., & Pearse, H. (2016). Retailers and technology-driven innovation in the
17 food sector : caretakers of consumer interests or barriers to innovation ? *British Food*
18 *Journal*, 1–15.
- 19 Featherman, M. S., & Pavlou, P. A. (2003). Predicting e-services adoption: A perceived risk
20 facets perspective. *International Journal of Human Computer Studies*, 59(4), 451–474.
21 [https://doi.org/10.1016/S1071-5819\(03\)00111-3](https://doi.org/10.1016/S1071-5819(03)00111-3)
- 22 Fischer, C. (2006). The Complexities of Modern Food Consumption and Implications for
23 International Food Product Marketers. *Journal of International Food & Agribusiness*
24 *Marketing*, 19(1), 7–35. https://doi.org/10.1300/J047v19n01_02
- 25 Graamans, L., Baeza, E., van den Dobbelsteen, A., Tsafaras, I., & Stanghellini, C. (2018).
26 Plant factories versus greenhouses: Comparison of resource use efficiency. *Agricultural*
27 *Systems*, 160(November 2017), 31–43. <https://doi.org/10.1016/j.agsy.2017.11.003>
- 28 Grewal, D., & Levy, M. (2007). Retailing research: Past, present, and future. *Journal of*
29 *Retailing*, 83(4), 447–464. <https://doi.org/https://doi.org/10.1016/j.jretai.2007.09.003>
- 30 Im, I., Kim, Y., & Han, H.-J. (2008). The effects of perceived risk and technology type on
31 users' acceptance of technologies. *Information & Management*, 45(1), 1–9.
- 32 Jung, I. N., Sharma, A., & Mattila, A. S. (2022). The impact of supermarket credibility on
33 purchase intention of novel food. *Journal of Retailing and Consumer Services*, 64,
34 102754. <https://doi.org/https://doi.org/10.1016/j.jretconser.2021.102754>
- 35 Konefal, J., & Hatanaka, M. (2014). Producing and consuming food: Justice and sustainability
36 in a globalized world? *Twenty Lessons in Environmental Sociology*, 191–208.
- 37 Kshetri, N. (2018). 1 Blockchain's roles in meeting key supply chain management objectives.
38 *International Journal of Information Management*, 39(December 2017), 80–89.
39 <https://doi.org/10.1016/j.ijinfomgt.2017.12.005>

- 1 La Londe, B. J., & Masters, J. M. (1994). Emerging logistics strategies: blueprints for the next
2 century. *International Journal of Physical Distribution & Logistics Management*, 24(7),
3 35–47.
- 4 Lähteenmäki-Uutela, A. (2014). Legal, Ethical, or Responsible Food. *Journal of International*
5 *Food & Agribusiness Marketing*, 26(4), 235–257.
6 <https://doi.org/10.1080/08974438.2013.833565>
- 7 Liu, S. (2020). Food supply pressure in France and Germany during COVID-19: Causes from
8 manufacturing. *Journal of Agriculture, Food Systems, and Community Development*,
9 9(4), 139–142. <https://doi.org/10.5304/jafscd.2020.094.007>
- 10 Martins, C., Oliveira, T., & Popovič, A. (2014). Understanding the Internet banking adoption:
11 A unified theory of acceptance and use of technology and perceived risk application.
12 *International Journal of Information Management*, 34(1), 1–13.
- 13 Megicks, P., Memery, J., & Angell, R. J. (2012). Understanding local food shopping:
14 Unpacking the ethical dimension. *Journal of Marketing Management*, 28(3–4), 264–289.
15 <https://doi.org/10.1080/0267257X.2012.658838>
- 16 Memery, J., Angell, R., Megicks, P., & Lindgreen, A. (2015). Unpicking motives to purchase
17 locally-produced food: Analysis of direct and moderation effects. *European Journal of*
18 *Marketing*, 49(7–8), 1207–1233. <https://doi.org/10.1108/EJM-02-2014-0075>
- 19 Mohan, G., Sivakumaran, B., & Sharma, P. (2013). Impact of store environment on impulse
20 buying behavior. *European Journal of Marketing*, 47(10), 1711–1732.
- 21 Mukherjee, S., Baral, M. M., Lavanya, B. L., Nagariya, R., Singh Patel, B., & Chittipaka, V.
22 (2023a). Intentions to adopt the blockchain: investigation of the retail supply chain.
23 *Management Decision*, 61(5), 1320–1351. <https://doi.org/10.1108/MD-03-2022-0369>
- 24 Mukherjee, S., Baral, M. M., Lavanya, B. L., Nagariya, R., Singh Patel, B., & Chittipaka, V.
25 (2023b). Intentions to adopt the blockchain: investigation of the retail supply chain.
26 *Management Decision*, 61(5), 1320–1351. <https://doi.org/10.1108/MD-03-2022-0369>
- 27 Naidoo, M., & Gasparatos, A. (2018). Corporate environmental sustainability in the retail
28 sector: Drivers, strategies and performance measurement. *Journal of Cleaner*
29 *Production*, 203, 125–142. <https://doi.org/10.1016/j.jclepro.2018.08.253>
- 30 Oliveira, F. J. B. De, Ferson, S., & Dyer, R. (2021). System Framework for Vertical Farming
31 Business Developments. *International Journal of Decision Support System Technolog*,
32 13(1), 34–66. <https://doi.org/10.4018/IJDSST.2021010103>
- 33 Parfitt, J., Barthel, M., & MacNaughton, S. (2010). Food waste within food supply chains:
34 Quantification and potential for change to 2050. *Philosophical Transactions of the Royal*
35 *Society B: Biological Sciences*, 365(1554), 3065–3081.
36 <https://doi.org/10.1098/rstb.2010.0126>
- 37 Petrovics, D., & Giezen, M. (2022). Planning for sustainable urban food systems: an analysis
38 of the up-scaling potential of vertical farming. *Journal of Environmental Planning and*
39 *Management*, 65(5), 785–808. <https://doi.org/10.1080/09640568.2021.1903404>

- 1 Rana, N. P., Dwivedi, Y. K., Lal, B., Williams, M. D., & Clement, M. (2017). Citizens'
2 adoption of an electronic government system: towards a unified view. *Information*
3 *Systems Frontiers*, 19(3), 549–568. <https://doi.org/10.1007/s10796-015-9613-y>
- 4 Seock Marjorie, Y.-K. N. (2015). Retail store environment and customer experience: a
5 paradigm. *Journal of Fashion Marketing and Management*, 11(4), 571–586.
- 6 Shankar, V., Kalyanam, K., Setia, P., Golmohammadi, A., Tirunillai, S., Douglass, T.,
7 Hennessey, J., Bull, J. S., & Waddoups, R. (2021). How Technology is Changing Retail.
8 *Journal of Retailing*, 97(1), 13–27. <https://doi.org/10.1016/j.jretai.2020.10.006>
- 9 Shao, Y., Wang, Z., Zhou, Z., Chen, H., Cui, Y., & Zhou, Z. (2022). Determinants Affecting
10 Public Intention to Use Micro-Vertical Farming: A Survey Investigation. *Sustainability*
11 *(Switzerland)*, 14(15), 1–26. <https://doi.org/10.3390/su14159114>
- 12 Sheel, A., & Nath, V. (2020). Antecedents of blockchain technology adoption intentions in
13 the supply chain. *International Journal of Business Innovation and Research*, 21(4),
14 564–584. <https://doi.org/10.1504/IJBIR.2020.106011>
- 15 Suhartanto, D., Dean, D., Edi Arsawan, I. W., Pradana, M., & Farhani, I. (2023). Eating Good
16 Food and Helping the Community: The Drivers of Online Local Food Purchasing.
17 *Journal of International Food & Agribusiness Marketing*, 1–21.
18 <https://doi.org/10.1080/08974438.2023.2190737>
- 19 Sun, Y., Wang, N., Xitong, G., & Zeyu, P. (2013a). UNDERSTANDING THE
20 ACCEPTANCE OF MOBILE HEALTH SERVICES: A COMPARISON AND
21 INTEGRATION OF ALTERNATIVE MODELS. *Journal of Electronic Commerce*,
22 9(1), 179–185.
- 23 Sun, Y., Wang, N., Xitong, G., & Zeyu, P. (2013b). UNDERSTANDING THE
24 ACCEPTANCE OF MOBILE HEALTH SERVICES: A COMPARISON AND
25 INTEGRATION OF ALTERNATIVE MODELS. *Journal of Electronic Commerce*,
26 9(1), 179–185.
- 27 Thorsøe, M., & Kjeldsen, C. (2016). The Constitution of Trust: Function, Configuration and
28 Generation of Trust in Alternative Food Networks. *Sociologia Ruralis*, 56(2), 157–175.
29 <https://doi.org/10.1111/soru.12082>
- 30 Trivette, S. A. (2019). The importance of food retailers: applying network analysis techniques
31 to the study of local food systems. *Agriculture and Human Values*, 36(1), 77–90.
32 <https://doi.org/10.1007/s10460-018-9885-1>
- 33 Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of
34 Information Technology: Toward a Unified View. *MIS Quarterly: Management*
35 *Information Systems*, 27(3), 425–478. <https://doi.org/10.2307/30036540>
- 36 Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer acceptance and use of
37 information technology: extending the unified theory of acceptance and use of
38 technology. *MIS Quarterly*, 157–178.
- 39 Venkatesh, V., & Zhang, X. (2010). Unified Theory of Acceptance and Use of Technology:
40 U.S. Vs. China. *Journal of Global Information Technology Management*, 13(1), 5–27.
41 <https://doi.org/10.1080/1097198X.2010.10856507>

1 Wong, L. W., Tan, G. W. H., Lee, V. H., Ooi, K. B., & Sohal, A. (2020). Unearthing the
2 determinants of Blockchain adoption in supply chain management. *International Journal*
3 *of Production Research*, 58(7), 2100–2123.
4 <https://doi.org/10.1080/00207543.2020.1730463>

5
6



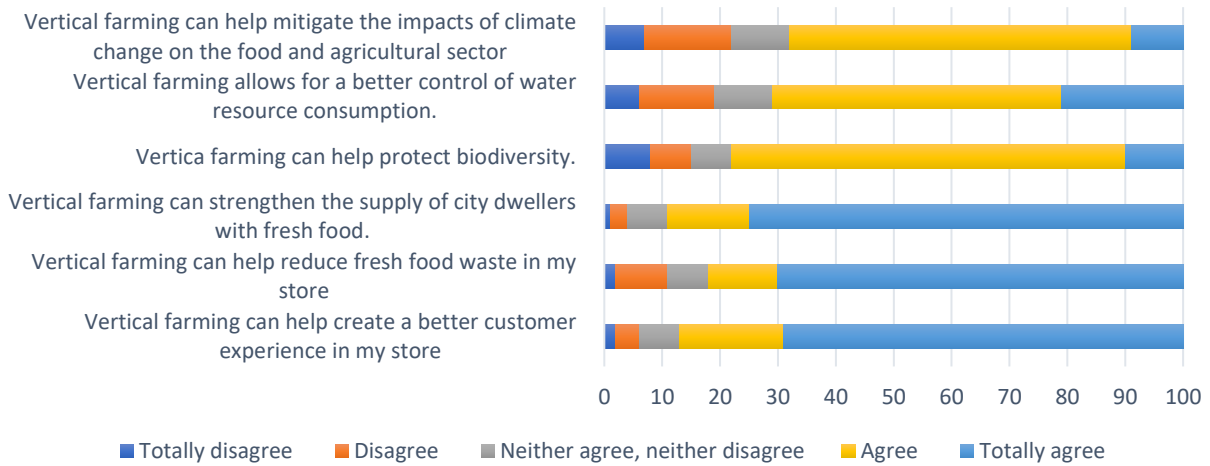
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

Figure 1. Research conceptual model and hypothesis

Table 1 – Measurement items included in the survey

Variables	Measurement items
Performance expectancy [PE]	[PE1] Using vertical farming technology would improve my business performance. [PE2] Using vertical farming technology would save me time. [PE3] I find vertical farming technology useful
Effort expectancy [EE]	[EE1] It is easy for me to learn vertical farming technologies. [EE2] I can easily become skillful in using vertical farming technologies. [EE3] I can easily interact with vertical farming technologies. [EE4] I would find vertical farming technologies easy to use.
Social Influence [SI]	[SI1] People I consider important think I should use vertical farming technologies in my store. [SI2] People I am familiar with think I should use vertical farming technologies as part of my business strategy. [SI3] People who influence my behavior think I should use vertical farming technologies as part of my business strategy. [SI4] Most people around me think I should use vertical farming technologies in my business strategy.
Perceived risk [PR]	[PR1] Using vertical farming in my store is risky. [PR2] I feel that using vertical farming technologies would cause me much trouble if something went wrong. [PR3] I am sure I would make a mistake if I used vertical farming technologies in my store.
Facilitating Condition [FC]	[FC1] My living environment encourages me to use vertical farming technologies. [FC2] My business environment encourages me to use vertical farming technologies. [FC3] Using vertical farming technologies is compatible with my business strategy. [FC4] Help is available if I encounter any problems related to my use of vertical farming technologies.
Attitudes [AT]	[AT1] I appreciate using in-store vertical farming to produce fresh food. [AT2] I prefer using in-store vertical farming technology to produce fresh food. [AT3] I am glad I can use vertical farming technologies in my store to increase the availability of fresh produce to my customers.
Behavioral Intention [BI]	[BI] I intend to use vertical farming technologies in my store.

1

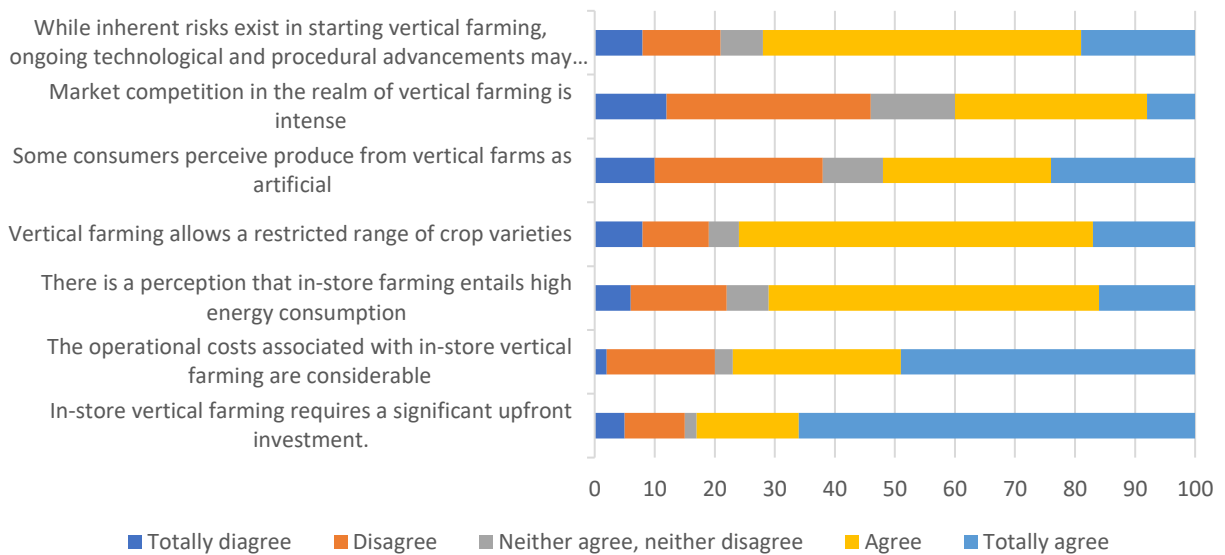


2

3 Figure 2. How do retailers perceive the performance of vertical farming technologies?

4

5



6

7 Figure 3. How do retailers perceive risks from embracing in-store vertical farming?

8

9

10

11

12

13

14

15

1
2
3
4
5

Table 2 – Correlation matrix of the measures

	Performance Expectancy	Facilitating Conditions	Social Influences	Risk Perception	Effort Expectancy	Attitudes	Behavioral Intention
PE1	0.903	0.568	0.503	-0.015	0.536	0.523	0.654
PE2	0.901	0.492	0.479	0.017	0.455	0.397	0.586
PE4	0.895	0.585	0.517	0.016	0.635	0.572	0.669
EE1	0.496	0.597	0.382	-0.072	0.862	0.151	0.523
EE2	0.505	0.638	0.467	-0.102	0.909	0.597	0.597
EE4	0.490	0.596	0.426	-0.039	0.888	0.638	0.572
SI1	0.493	0.507	0.734	0.060	0.515	0.596	0.511
SI2	0.500	0.501	0.750	0.024	0.484	0.047	0.493
SI3	0.544	0.497	0.702	-0.009	0.470	0.500	0.449
SI4	0.387	0.410	0.471	-0.034	0.459	0.544	0.343
PR1	-0.056	-0.101	-0.026	0.821	-0.075	0.387	-0.177
PR2	0.164	0.068	0.133	0.896	0.035	0.471	0.085
PR3	-0.137	-0.104	-0.077	0.892	-0.103	-0.026	-0.276
FC1	0.491	0.897	0.518	-0.013	0.630	0.133	0.586
FC2	0.472	0.898	0.443	-0.024	0.631	-0.077	0.518
FC3	0.627	0.847	0.469	-0.077	0.600	0.544	0.655
FC4	0.520	0.650	0.468	0.025	0.732	0.387	0.632
AT1	0.490	0.596	-0.072	0.515	0.586	0.911	0.518
AT2	0.493	0.507	-0.102	0.484	0.518	0.896	0.443
AT3	0.500	0.501	-0.039	0.470	0.655	0.892	0.469
BI	0.632	-0.130	0.668	0.521	0.677	0.717	1.000

6
7
8
9
10
11
12
13
14
15
16

1

Table 3 – Psychometric properties of the measurement scales

Latent variables	Dimensions	Factor loading	Cronbach's alpha	AVE
Performance Expectancy	PE1	0,708	0,886	0,785
	PE2	0,749		
	PE4	0,743		
Effort Expectancy	EE1	0,776	0,877	0,792
	EE2	0,822		
	EE4	0,828		
	FC4	0,496		
Social Influence	SI1	0,856	0,852	0,84
	SI2	0,879		
	SI3	0,834		
Perceived Risk	PR1	0,818	0,713	0,787
	PR2	0,772		
	PR3	0,814		
Facilitating Conditions	FC1	0,724	0,852	0,744
	FC2	0,638		
	FC3	0,737		
Attitudes	AT1	0,923	0,923	0,866
	AT2	0,982		
	AT3	0,891		

2

3

4

Table 5 – Standardized estimates

5

Mediating and dependent variables	Independent variables	Standard Path (mean score)	Standard Error	Critical Ratio
Attitudes	Performance expectancy	0,471	1,74	0,92
	Effort expectancy	0,189	1,11	0,71
	Facilitating conditions	0,213	1,04	0,84
	Perceived risk	-0,15	0,87	0,76
Behavioral Intention	Attitudes	0,684	0,02	0,91

6

7

8

9

1

Table 5 – Hypothesis test results

Hypothesis test	Results
H1. Performance expectancy directly, positively, and significantly affects retailers' attitudes toward vertical farming technologies.	Validated
H2. Effort expectancy directly, positively, and significantly affects retailers' attitudes toward vertical farming technologies.	Validated
H3. Social influence directly, positively, and significantly affects retailers' attitudes toward vertical farming technologies.	Rejected
H4. Facilitating conditions (FC) directly, positively, and significantly affect retailers' behavioral intention to adopt vertical farming technologies.	Validated
H5. Perceived risk negatively affects retailers' attitudes toward vertical farming technology adoption.	Validated
H6. Attitudes positively affect retailers' behavioral intention to use in-store vertical farming technologies.	Validated

2

3

4

5