Influencing Factors of Autonomous and Unmanned Systems Adoption in Logistics: A Multiple Case Study

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Motivation of the Research

Due to the rise of e-commerce and globalization, the transportation sector experienced exponential growth over the last two decades, leading supply chains (SCs) to research novel alternatives to best serve their customers.

The increase in externalities (i.e., air pollution, climate change, noise pollution, traffic congestion, etc.) is another worrying trend that SCs are trying to solve. Thus, the improvement of middle- and last-mile delivery (the latter was defined by Ranieri et al., 2018 as the most inefficient stage of the supply chain) comes as a natural necessity.

This trend was further pushed by the outbreak of COVID-19, which highlighted the necessity for a delivery system able to provide a fast, resilient, and safe contactless solution to reach isolated or quarantined areas with ease (Abrar, Islam and Shanto, 2020).

These are the reasons why nowadays logistics service providers (LSPs) are looking for sustainable, efficient, and resilient delivery solutions.

Among the various solutions analyzed by the scientific community, Autonomous and Unmanned Systems (AUS – i.e., unmanned aerial vehicles and ground delivery robots) are among the most interesting and studied technologies in the last years.

State of the Art

The extant literature has traditionally developed mathematical models to optimize vehicle routing for the last-mile delivery. One of the most famous and used models is the Traveling Salesman Problem, starting from which Murray and Chu (2015) developed two mathematical programming models (i.e., the Flying Sidekick Traveling Salesman Problem and the Parallel Drone Scheduling Traveling Salesman Problem) where the traditional approach is adapted to a combination of truck and drone last-mile delivery.

Abrar, Islam and Shanto (2020) researched the operational feasibility of ground delivery robots by developing a prototype provided with GPS and a package delivery box protected by password.

Furthermore, the environmental benefits of drones have also been tackled in the literature. Goodchild and Toy (2018) and Figliozzi (2017) studied the environmental impact of drones (considering CO_2 emissions), comparing them to conventional (e.g., diesel vans) and novel (e.g., electric trucks) last-mile vehicles.

Social acceptance is another topic that has been taken into consideration. Specifically, the public perception of a drone food delivery service in Korea has been analyzed in detail, merging the Norm Activation Model (NAM) and the Theory of Planned Behavior (TPB) (Kim and Hwang, 2020).

The resilience advantages of AUS were also described as they proved to be extremely useful during the COVID-19 pandemic. Chamola et al. (2020) report that AUS reduced the burden on hospitals and healthcare staff by rapidly delivering drugs and supplies. Furthermore, drones proved to be helpful during the pandemic for delivering other essential goods (e.g., groceries).

Research Objectives and Research Questions

As highlighted in the previous paragraph, the extant literature focuses only on operational and tactical issues, such as saving time through vehicle routing optimization and decreasing the environmental impact studying the CO_2 emissions. These were the same conclusions of Raj and Sah (2019), which tried to analyze drones last-mile logistics adoption on a strategical level through the critical success factors. However, that research was only focused on UAVs last-mile delivery, thus omitting middle-mile logistics and ground delivery robots. Therefore, this research will aim at providing an analysis of the influencing factors to AUS adoption in logistics in a broader sense (i.e., UAVs and ground delivery robots, middle- and last-mile logistics), to ultimately provide a theoretical framework for this promising technology adoption. In order to achieve such an objective, this research will answer the following research questions (RQs):

RQ1 – How can current influencing factors to AUS adoption be categorized?

RQ2 – How can current influencing factors be tackled to improve AUS adoption?

Methodology and Research Protocol

RQ1 will be answered through a systematic literature review. The extant literature will be systematically scanned to identify the influencing factors, then categorized using a pattern matching approach to create a preliminary theoretical framework.

RQ2 will be answered through a multiple-case study investigation. Starting from the previously identified framework, the results will be confirmed and enriched by identifying enabling factors through structured interviews of logistics companies implementing or considering the implementation of AUS into their middle-mile or last-mile logistics. Both successful and unsuccessful attempts will be included to ensure heterogeneity of data and avoid missing essential contributions that could add value to the work.

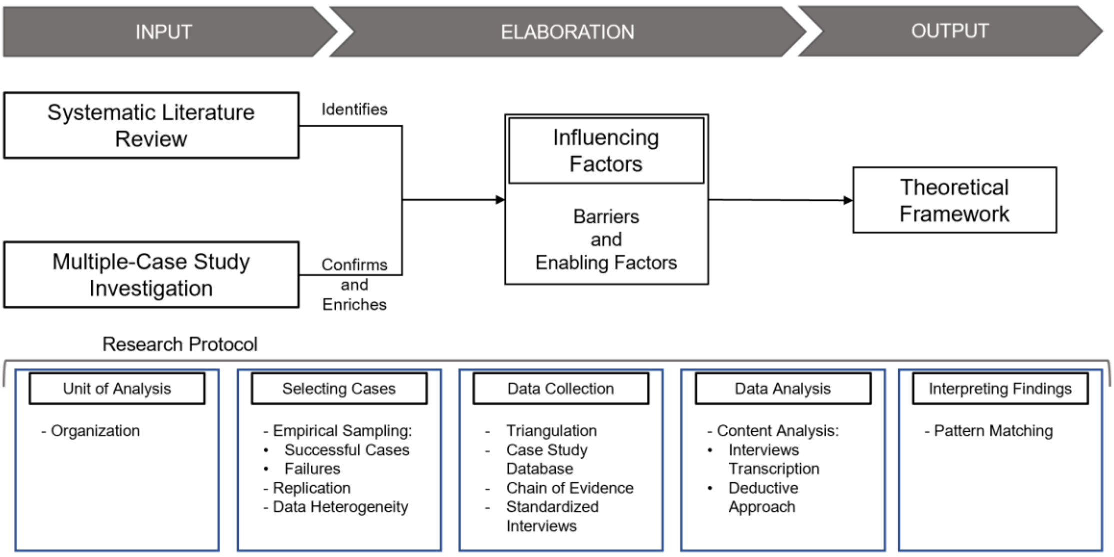

Figure 1. Methodology and Research Protocol.

A detailed representation of the methodology and research protocol is reported in Figure 1.

Potential Contributions to Existing Knowledge and Field Practice

AUS adoption in last-mile logistics has been studied on operational and tactical levels, leaving out the strategical aspects. Due to this lack of AUS knowledge, practitioners do not have the necessary tools to evaluate the potential benefits and the relative influencing factors of AUS adoption. Therefore, this research will provide a theoretical framework to give logistics practitioners the necessary tools and knowledge to assess the integration of AUS in their operations and expand the extant literature on unmanned aerial vehicles and ground delivery robots.

Bibliography

Abrar, M. M., Islam, R. and Shanto, M. A. H. (2020) 'An Autonomous Delivery Robot to Prevent the Spread of Coronavirus in Product Delivery System', *2020 11th IEEE Annual Ubiquitous Computing, Electronics and Mobile Communication Conference, UEMCON 2020*, pp. 0461–0466. doi: 10.1109/UEMCON51285.2020.9298108.

Chamola, V. *et al.* (2020) 'A Comprehensive Review of the COVID-19 Pandemic and the Role of IoT, Drones, AI, Blockchain, and 5G in Managing its Impact', *IEEE Access*, 8(April), pp. 90225–90265. doi: 10.1109/ACCESS.2020.2992341.

Es Yurek, E. and Ozmutlu, H. C. (2018) 'A decomposition-based iterative optimization algorithm for traveling salesman problem with drone', *Transportation Research Part C: Emerging Technologies*, 91(April), pp. 249–262. doi: 10.1016/j.trc.2018.04.009.

Figliozzi, M. A. (2017) 'Lifecycle modeling and assessment of unmanned aerial vehicles (Drones) CO2e emissions', *Transportation Research Part D: Transport and Environment*, 57(October), pp. 251–261. doi: 10.1016/j.trd.2017.09.011.

Goodchild, A. and Toy, J. (2018) 'Delivery by drone: An evaluation of unmanned aerial vehicle technology in reducing CO2 emissions in the delivery service industry', *Transportation Research Part D: Transport and Environment*, 61, pp. 58–67. doi: 10.1016/j.trd.2017.02.017.

Ha, Q. M. *et al.* (2018) 'On the min-cost Traveling Salesman Problem with Drone', *Transportation Research Part C: Emerging Technologies*, 86(May 2016), pp. 597–621. doi: 10.1016/j.trc.2017.11.015.

Kim, J. J. and Hwang, J. (2020) 'Merging the norm activation model and the theory of planned behavior in the context of drone food delivery services: Does the level of product knowledge really matter?', *Journal of Hospitality and Tourism Management*, 42(June 2019), pp. 1–11. doi: 10.1016/j.jhtm.2019.11.002.

Murray, C. C. and Chu, A. G. (2015) 'The flying sidekick traveling salesman problem: Optimization of drone-assisted parcel delivery', *Transportation Research Part C: Emerging Technologies*, 54, pp. 86–109. doi: 10.1016/j.trc.2015.03.005.

Raj, A. and Sah, B. (2019) 'Analyzing critical success factors for implementation of drones in the logistics sector using grey-DEMATEL based approach', *Computers and Industrial Engineering*, 138(August), p. 106118. doi: 10.1016/j.cie.2019.106118.

Ranieri, L. *et al.* (2018) 'A review of last mile logistics innovations in an externalities cost reduction vision', *Sustainability (Switzerland)*, 10(3), pp. 1–18. doi: 10.3390/su10030782.