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Bruna Rigon de Oliveira

Proposição de um modelo de rede de distribuição para compras on-line de um varejo omni-channel

Florianópolis
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Dissertação submetida ao Programa de Pós-Graduação em Engenharia de Produção da Universidade Federal de Santa Catarina como requisito parcial para a obtenção do título de Mestra em Engenharia de Produção.

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Bruna Rigon de Oliveira

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O presente trabalho em nível de Mestrado foi avaliado e aprovado, em 30 de agosto de 2023, pela banca examinadora composta pelos seguintes membros:

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“A menos que modifiquemos a nossa maneira de pensar,
não seremos capazes de resolver os problemas causados
pela forma como nos acostumamos a ver o mundo.”
(Albert Einstein)

RESUMO

Da conclusão da compra à entrega do pedido, a logística desempenha um papel crucial na satisfação dos consumidores. No entanto, diante do avanço contínuo das tecnologias digitais e da crescente adoção do modelo omni-channel pelos varejistas, as expectativas dos consumidores em relação à entrega de pedidos estão atravessando transformações significativas. Diante dessa dinâmica, as redes de distribuição estão se adaptando para oferecer entregas mais flexíveis, ágeis e confiáveis. Nesse contexto, este estudo tem como objetivo propor um modelo de operação da rede de distribuição de varejistas que atuam no formato omni-channel que viabilize diferentes modalidades de entrega de compras on-line. Para alcançar esse objetivo, a primeira etapa dessa pesquisa foi centrada na condução de uma revisão sistemática da literatura para investigar a organização das redes de distribuição omni-channel em termos do processo de entrega de pedidos aos consumidores. Na sequência foi desenvolvida uma estrutura, com base nos achados da literatura, abrangendo três modalidades de entrega de pedidos on-line: entregas domiciliares agendadas, entregas domiciliares expressas e coleta em loja física no mesmo dia do pedido. O funcionamento dessas modalidades se pautou na combinação dos fluxos do centro de distribuição e das lojas físicas do varejista para garantir o atendimento de cada pedido a partir da hierarquia mais adequada. O desempenho desse modelo foi avaliado em um contexto real, comparando-o ao da rede de distribuição de um varejista multi-channel. Os modelos de operação foram traduzidos em modelos computacionais multimétodo, combinando a modelagem baseada em agentes e a modelagem de eventos discretos, simulados por meio do *software Anylogic*. Os resultados revelaram a eficiência do modelo proposto em relação ao tempo de atendimento de pedidos on-line e às taxas de tentativas e falhas nas entregas domiciliares. Com isso, esse estudo contribui para a compreensão das complexidades da distribuição omni-channel e uma forma de resolvê-las, fornecendo informações valiosas tanto para a academia quanto para o setor varejista.

Palavras-chave: varejo omni-channel; logística; redes de distribuição; modalidades de entrega; revisão sistemática da literatura; modelagem e simulação multimétodo.

ABSTRACT

From the moment of purchase to the order delivery, logistics plays a pivotal role in ensuring consumer satisfaction. However, as digital technologies continue to advance, and retailers increasingly embrace the omni-channel model, consumer expectations regarding order delivery are undergoing significant transformations. Faced with this dynamic, distribution networks are adapting to offer more flexible, agile, and reliable deliveries. In this context, this study aims to propose an operational model for the distribution network of retailers operating in the omni-channel format, enabling different modes of online order delivery. To achieve this goal, the first stage of this research centered on conducting a systematic literature review to explore omni-channel distribution networks' organization concerning the order-to-consumer delivery process. Subsequently, a framework was developed based on the literature findings, encompassing three modes of online order delivery: scheduled home delivery, express home delivery, and same-day in-store pick-up. The operation of these modes was based on the combination of flows from the retailer's distribution center and physical stores to ensure the fulfillment of each order from the most appropriate hierarchy. The performance of this model was evaluated in a real context, comparing it to the distribution network of a multi-channel retailer. The operational models were translated into multi-method computational models, combining agent-based modeling and discrete event modeling, simulated through the *Anylogic* software. The results revealed the efficiency of the proposed model in terms of online order fulfillment time and the rates of attempts and failures in home deliveries. Thus, this study contributes to the understanding of the complexities of omni-channel distribution and provides a way to address them, offering valuable insights for both academia and the retail sector.

Keywords: omni-channel retail; logistics; distribution networks; delivery modes; systematic literature review; multimethod modeling and simulation.

LISTA DE FIGURAS

LISTA DE QUADROS

LISTA DE TABELAS

LISTA DE ABREVIATURAS E SIGLAS

ABNT	Associação Brasileira de Normas Técnicas
a.m.	*Ante meridiem*
APS	*Automated Parcel Stations*
B&M	*Brick-and-Mortar*
BOPS	*Buy Online, Pick-up in Store*
B2B	*Business-to-Business*
B2C	*Business-to-Consumer*
CD	Centro de Distribuição
C&C	*Click and Collect*
C&M	*Click-and-Mortar*
C&R	*Click and Reserve*
CL	*Crowdsourced Logistics*
DC	*Distribution Center*
DN	*Distribution Network*
FC	*Fulfillment Center*
HD	*Home Delivery*
p.m.	*Post meridiem*
PRISMA	*Preferred Reporting Items for Systematic Review and Meta-Analysis*
PPGEP	Programa de Pós-Graduação em Engenharia de Produção
ROPO	*Research Online, Purchase Offline*
RSL	Revisão Sistemática da Literatura
SFF	*Ship-From-FC*
SFS	*Ship-From-Store*
SFW	*Ship-From-Warehouse*
STM	*Ship-to-Me*
SLR	*Systematic Literature Review*
3PLs	*Third-Party Logistics Providers*
UFSC	Universidade Federal de Santa Catarina
WoS	*Web of Science*

SUMÁRIO

1 INTRODUÇÃO

Neste Capítulo são apresentadas a contextualização do estudo, a justificativa do tema, os objetivos geral e específicos, a delimitação trabalho e a estrutura do documento.

1.1 CONTEXTUALIZAÇÃO

O avanço contínuo das tecnologias digitais e a crescente adoção do modelo omni-channel pelos varejistas têm induzido transformações significativas no comportamento dos consumidores e rompido as fronteiras entre o on-line e o off-line do setor varejista (Hübner, Hense e Dethlefs, 2022; Salvietti *et al.*, 2022). O comércio eletrônico, em particular, vem se destacando nesse cenário por sua conveniência e flexibilidade, permitindo aos consumidores a pesquisa e a aquisição de produtos a qualquer hora e em qualquer lugar (Bergmann, Wagner e Winkenbach, 2020; Castillo *et al.*, 2018; Fleischer, Graf e Lange, 2020; Hendalianpour *et al.*, 2022; Hosseinzadeh, Esmaili e Soltani, 2021). No entanto, é a sua integração com outros canais e pontos de contato visando, entre outras finalidades, oferecer diferentes opções de recebimento de pedidos, que proporciona uma experiência de compra contínua e consistente aos consumidores (Hübner, Hense e Dethlefs, 2022; Janjevic, Merchán e Winkenbach, 2021; Pereira e Frazzon, 2021; Salvietti *et al.*, 2022).

Com as mudanças no perfil do setor, os varejistas passaram a reconfigurar suas redes de distribuição aspirando a sua adequação às expectativas do mercado (Li, 2020). Para o comércio on-line, a abordagem omni-channel propõe a ampliação dos pontos de recebimento de pedidos para além das residências e locais de trabalho dos consumidores, introduzindo a alternativa de coleta em diversos locais, por meio de distintos modelos operacionais e em diferentes níveis de automação (Janjevic, Merchán e Winkenbach, 2021). A introdução de pontos de coleta em lojas físicas, especificamente, revela-se como uma estratégia vantajosa aos varejistas (Saha e Bhattacharya, 2020) por impulsionar a demanda local, estimular o tráfego nas lojas e facilitar a conexão pessoal com os consumidores, fomentando o *cross-selling*. Ainda, essa abordagem reduz o tempo de atendimento e o custo total por pedido ao consolidar a demanda em poucos pontos de entrega e, em algumas situações, ao utilizar o estoque da própria loja física para suprir a demanda on-line (Gao e Su, 2016; Janjevic, Merchán e Winkenbach, 2021; Teixeira *et al.*, 2022). A coleta também favorece os consumidores, que normalmente não precisam arcar com custos logísticos e podem evitar a incerteza acerca das datas de entrega de suas compras (Gallino e Moreno, 2014; Gao e Su, 2016). Já as entregas em domicílio requerem planejamento e recursos consideráveis por parte dos varejistas. O desafio dessa modalidade reside na incerteza quanto à disponibilidade dos destinatários (Rai, Verlinde e Macharis, 2019) que, se indisponíveis, acarretam falhas na entrega, demandando um esforço logístico adicional que não agrega valor ao serviço prestado. Com as entregas domiciliares, os consumidores usufruem da comodidade de não precisar se deslocar para receber suas encomendas (Montreuil, 2016), embora normalmente estejam sujeitos ao pagamento de taxas de envio (Hübner, Holzapfel e Kuhn, 2016). Por isso, requerem serviços de entrega alinhados às suas necessidades, como entregas expressas aos que priorizam agilidade e entregas previamente agendadas para consumidores que nem sempre estão disponíveis para receber encomendas.

Para possibilitar um conjunto de opções diferenciadas para a entrega de pedidos on-line aos consumidores, as origens devem se diversificar, englobando e combinando estratégias como *ship-from-warehouse* (SFW) e *ship-from-store* (SFS) (Janjevic, Merchán e Winkenbach, 2021). Esse realinhamento das redes de distribuição é fundamental para assegurar a pontualidade e a precisão das entregas em qualquer modalidade oferecida, uma vez que o seu resultado estabelece o primeiro contato físico entre o consumidor e o produto adquirido (Souza *et al.*, 2023), podendo impactar diretamente no seu nível de satisfação. Em virtude desses elementos, esse estudo visa explorar como adaptar a configuração da operação de redes de distribuição de varejistas que atuam no formato omni-channel para viabilizar diversas modalidades de entrega de pedidos on-line aos consumidores?

1.2 JUSTIFICATIVA DO TEMA

Em face da crescente demanda por um ambiente de negócios digital e omni-channel, os varejistas estão confrontados com desafios significativos em relação às suas redes de distribuição, que não podem ser integralmente atendidos pelos sistemas logísticos tradicionais. Essas mudanças no mercado são originadas por uma série de fatores, incluindo a disseminação do comércio eletrônico, as mudanças nas preferências dos consumidores e a demanda por modalidades de entrega mais flexíveis (Fleischer, Graf e Lange, 2020; Hübner, Hense e Dethlefs, 2022; Hurtado, Dorneles e Frazzon, 2019).

Especialistas em logística varejista consultados por Hübner, Holzapfel e Kuhn (2016) enfatizam o desenvolvimento de novos modelos de entrega como o tópico mais importante a ser explorado no contexto omni-channel. Acrescentando à discussão, Liu *et al*. (2022) ressaltam que a flexibilidade nas opções de entrega de compras on-line é um fator crítico para o êxito dos varejistas em um momento em que os consumidores estão buscando por alternativas variadas para receber seus pedidos, de acordo com suas preferências, urgências, taxas de entrega e acesso aos pontos de coleta. Essas alternativas podem incluir, por exemplo, modelos de entrega em domicílio eficientes e flexíveis, e opções de coleta em loja física e/ou em armários inteligentes (Guerrero-Lorente, Gabor e Ponce-Cueto, 2020; Marchet *et al.*, 2018).

Para atender a essas distintas modalidades de entrega, as redes de distribuição devem combinar efetivamente diferentes fluxos (Kembro e Norrman, 2020), para que o atendimento ocorra a partir da hierarquia mais adequada (Guerrero-Lorente, Gabor e Ponce-Cueto, 2020; Peinkofer *et al.*, 2019). Qu *et al*. (2022) contribuem ao indicar que a alocação de pedidos para nós de hierarquia superiores (inferiores) pode reduzir (aumentar) o custo unitário de estoque e as frequências de reposição, mas aumentar (reduzir) o tempo de entrega dos pedidos. Janjevic, Merchán e Winkenbach (2021) complementam que, tendo a necessidade de atender pedidos rapidamente, é imprescindível o uso de instalações próximas às áreas de demanda. Com isso, lojas físicas podem ser grandes aliadas para encurtar o ciclo de entrega (Wan *et al.*, 2022), reduzindo o seu espaço dedicado ao *merchandising* para incluir zonas de atendimento de pedidos on-line que permitam o armazenamento, a separação, a embalagem e a coleta (Hübner, Holzapfel e Kuhn, 2016; Montreuil, 2016; Souza *et al.*, 2023). Assim, redes que combinam estratégias de distribuição de acordo com a modalidade de entrega demandada podem ter uma performance superior em comparação com desenhos de rede tradicionais, que dependem exclusivamente do Centro de Distribuição (CD) para atender pedidos on-line (Guerrero-Lorente, Gabor e Ponce-Cueto, 2020).

Diante da lacuna atual na literatura (Arslan, Klibi e Montreuil, 2021; Hübner, Hense e Dethlefs, 2022; Hübner, Holzapfel e Kuhn, 2016; Janjevic, Merchán e Winkenbach, 2021; Liu *et al.*, 2022; Millstein e Campbell, 2018; Montreuil, 2016; Qu *et al.*, 2022; Saha e Bhattacharya, 2020), essa pesquisa busca explorar estratégias para a operação de redes de distribuição visando atender às demandas multifacetadas das entregas de pedidos do comércio eletrônico. Ao desenvolver um entendimento mais profundo dessas estratégias de operação e ao propor soluções práticas, espera-se que essa pesquisa contribua tanto para o conhecimento acadêmico quanto para a prática empresarial.

1.3 OBJETIVOS

A seguir são apresentados os objetivos que norteiam esse estudo, tendo em vista as considerações anteriormente apresentadas.

1.3.1 Objetivo Geral

Esse estudo tem como objetivo propor um modelo de operação da rede de distribuição de varejistas que atuam no formato omni-channel que viabilize diferentes modalidades de entrega de compras on-line aos consumidores.

1.3.2 Objetivos Específicos

Para atingir o objetivo geral delineado, foram estabelecidos os seguintes objetivos específicos:

a) investigar a organização das redes de distribuição omni-channel em termos do processo de entrega de pedidos aos consumidores;
b) desenvolver uma estrutura de operação da rede de distribuição omni-channel para diferentes modalidades de entrega de pedidos on-line;
c) avaliar, por meio da modelagem e simulação computacional, o desempenho da estrutura proposta em um contexto real.

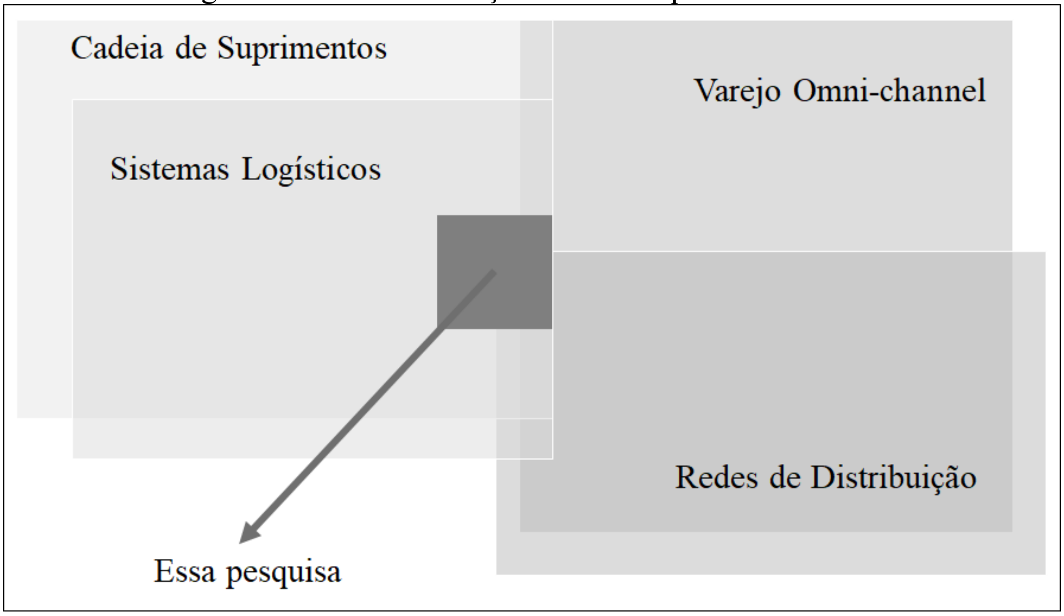
1.4 DELIMITAÇÃO DO TRABALHO

O presente estudo está inserido na área de concentração da logística e cadeia de suprimentos, estando relacionado à linha de pesquisa de modelagem e gestão de sistemas logísticos inteligentes. Essa classificação é dada pela integração de conceitos, tecnologias e métodos avançados para apoiar a tomada de decisão de varejistas.

A pesquisa está delimitada na proposição de um modelo de operação da rede de distribuição para varejistas que atuam no formato omni-channel que viabilize diferentes modalidades de entrega de pedidos on-line. Por isso, o estudo se concentra especificamente em varejistas que operam na configuração omni-channel e atuam na modalidade *Business-to-Consumer* (B2C) para comercializar produtos físicos de pequeno porte não perecíveis. Não estão incluídos no escopo dessa pesquisa produtos alimentícios, devido aos requisitos de distribuição desse mercado, mercadorias de médio e grande porte que não possam ser transportadas por um motociclista, e itens disponibilizados via *direct web* (como músicas e *e-books*), por não dependerem de um serviço logístico físico. Além disso, o escopo desse documento se limita às etapas de análise, modelagem, simulação e recomendação, excluindo a implementação prática devido ao tempo de duração do estudo.

A Figura 1 ilustra a localização dessa pesquisa em relação às temáticas, destacando a relação da cadeia de suprimentos com os sistemas logísticos, as redes de distribuição e suas modalidades de entrega, e a conexão dessas temáticas com o varejo omni-channel. Essas áreas, quando estrategicamente interligadas, podem aumentar a eficiência logística e o nível de serviço prestado ao consumidor.

Figura 1 - Contextualização do estudo por área temática



Fonte: Autora (2023)

1.5 ESTRUTURA DO DOCUMENTO

A estrutura adotada neste documento segue a forma de coletânea de artigos, em conformidade com a resolução vigente 002/PPGEP/2018, aprovada em 07 de novembro de 2018. A resolução está disponível no site do Programa de Pós-Graduação em Engenharia de Produção (PPGEP) da Universidade Federal de Santa Catarina (UFSC), podendo ser acessada pelo seguinte endereço eletrônico: https://ppgep.ufsc.br/legislacao/. A partir dessa definição, a formatação desse documento é guiada pelas seguintes diretrizes:

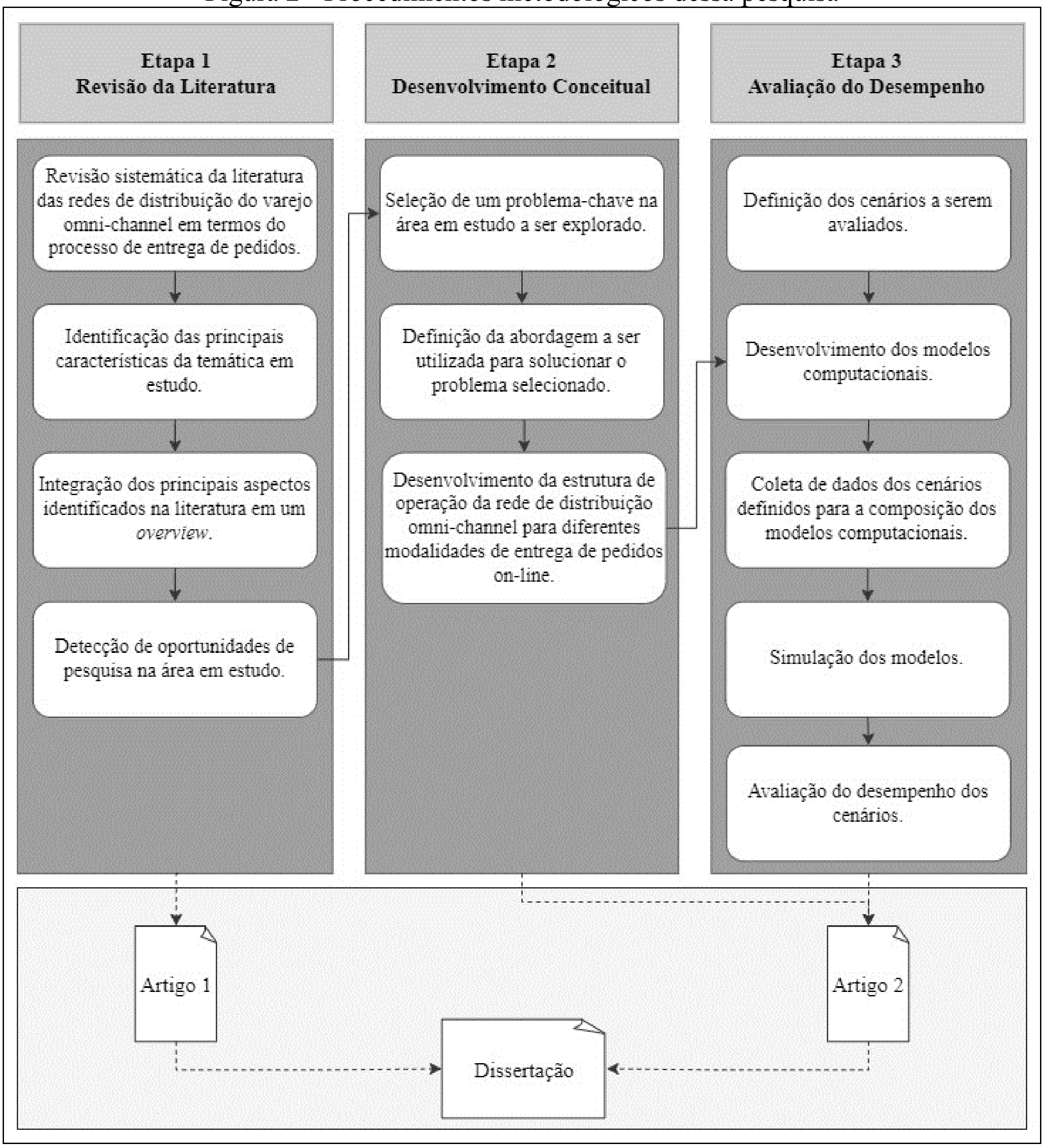
a) os Capítulos 1, 2, 4 e 6 estão escritos em língua portuguesa, enquanto os Capítulos 3 e 5 são apresentados em língua inglesa por se tratar de artigos submetidos a periódicos internacionais;
b) seguindo as normas de formatação da Associação Brasileira de Normas Técnicas (ABNT), as referências utilizadas para a escrita dos Capítulos 1, 2, 4 e 6 estão listadas na Seção de Referências, enquanto as referências usadas para a escrita dos Capítulos 3 e 5 estão ao final de cada artigo, mantendo o padrão específico de submissão;
c) nos Capítulos 3 e 5, a numeração das subseções, Figuras, Quadros e Tabelas seguem a contagem dos próprios artigos;
d) nos Capítulos 3 e 5, a formatação utilizada segue o padrão do periódico selecionado para submissão.

Essa dissertação está estruturada em seis capítulos. O Capítulo 1 apresenta o contexto do estudo, a justificativa de sua relevância, os objetivos geral e específicos, a delimitação do escopo da pesquisa e a estrutura do documento. O Capítulo 2 detalha os procedimentos metodológicos adotados para a execução dos objetivos desse estudo. O Capítulo 3 é composto pelo artigo resultante da primeira etapa metodológica dessa pesquisa, que consiste em uma Revisão Sistemática da Literatura (RSL) para investigar a organização das redes de distribuição omni-channel em termos do processo de entrega de pedidos aos consumidores. O Capítulo 4 apresenta o delineamento do problema-chave a ser explorado, com base nos achados da literatura. O Capítulo 5 é integrado pelo artigo resultante da segunda e terceira etapas metodológicas desse estudo, apresentando a estrutura de rede de distribuição desenvolvida em resposta ao problema-chave definido, o seu desenvolvimento computacional e a análise dos seus resultados em um contexto real. Por fim, o Capítulo 6 conclui esse documento apresentando as considerações finais do estudo.

2 PROCEDIMENTOS METODOLÓGICOS

Para suportar a concretização dos objetivos traçados, delinearam-se os procedimentos metodológicos. A pesquisa foi segmentada em três etapas principais: (i) revisão da literatura; (ii) desenvolvimento conceitual; e (iii) avaliação do desempenho, desmembradas em atividades específicas. A representação do fluxo dos procedimentos metodológicos é apresentada na Figura 2.

Figura 2 - Procedimentos metodológicos dessa pesquisa



Fonte: Autora (2023)

2.1 REVISÃO DA LITERATURA

A primeira etapa dessa pesquisa foi centrada na condução de uma RSL com o propósito de investigar a organização das redes de distribuição omni-channel em termos do processo de entrega de pedidos aos consumidores. Adotando as diretrizes do protocolo *Preferred Reporting Items for Systematic Review and Meta-Analysis* (PRISMA), foram identificados e analisados estudos científicos publicados nesse domínio. Os detalhes do procedimento seguido estão expostos na Seção 3 do Capítulo 3.

A partir do conhecimento obtido da literatura, foi estabelecida uma visão holística dos elementos-chave operacionais das redes de distribuição omni-channel centradas no consumidor. Além disso, foram delineadas possíveis direções para pesquisas futuras. Com isso, essa etapa inicial estabeleceu uma base sólida para as etapas subsequentes do estudo.

2.2 DESENVOLVIMENTO CONCEITUAL

A partir das oportunidades de pesquisa identificadas na fase precedente, foram selecionadas questões de natureza operacional que culminam em um problema-chave para o desempenho logístico dos varejistas omni-channel. Essas questões foram organizadas em um conjunto coeso que forma a base do problema a ser investigado, exibido detalhadamente no Capítulo 4. A estratégia adotada para abordar essa questão central se fundamentou nos elementos identificados e estruturados na etapa anterior, utilizando como ferramenta de suporte a visão holística delineada. Com essas diretrizes traçadas, foi desenvolvida conceitualmente a estrutura operacional da rede de distribuição omni-channel capaz de viabilizar diferentes modalidades de entrega para pedidos on-line, exibida na Seção 3 do Capítulo 5. Com isso, essa etapa desempenhou o papel de traduzir as percepções advindas da literatura em um modelo tangível e aplicável, a ter seu desempenho avaliado na etapa posterior.

2.3 AVALIAÇÃO DO DESEMPENHO

A estrutura estabelecida na etapa anterior configurou-se como um dos cenários em estudo. Para avaliar o seu desempenho em relação a um contexto real, definiu-se um segundo cenário, retratando a rede de distribuição de um varejista localizado no sul do Brasil que opera no formato multi-channel, denominado nesse estudo como *Varejo X*. Com os cenários definidos, deu-se a tradução de seus modelos de operação em modelos computacionais, alimentados por dados provenientes de variadas fontes: (i) informações verbais fornecidas pelo sócio e pela engenheira encarregada do processo logístico do comércio eletrônico do Varejo X; (ii) bancos de dados do Varejo X contendo o histórico de pedidos e os registros dos estoques das lojas físicas e do CD pelo período de um ano; (iii) registro dos tempos de operação no CD do Varejo X; (iv) revisão da literatura relevante para o tema; e (v) pesquisa da opinião de consumidores e potenciais consumidores do Varejo X, através de formulário on-line, em relação às suas preferências em relação ao modelo de distribuição proposto.

Para a obtenção dos resultados, foi adotada a abordagem de modelagem e simulação multimétodo, empregada no *software AnyLogic*. Nessa abordagem, a modelagem de eventos discretos foi empregada para integrar as atividades sequenciais das redes de distribuição, enquanto as decisões complexas do modelo e as interações com os consumidores foram simuladas por meio de agentes. Para avaliar o desempenho de ambos os cenários, os resultados da simulação foram exportados e analisados no *software Microsoft Excel*.

2.4 DISSEMINAÇÃO DOS RESULTADOS

Como meio de divulgação científica, dois artigos foram elaborados a partir dos resultados obtidos nas diferentes etapas do estudo, presentes nos Capítulos 3 e 5 desse documento. O primeiro artigo concentra-se na RSL conduzida na etapa inicial, enquanto o segundo artigo apresenta a proposta de operação da rede de distribuição resultada da segunda etapa, e aborda o desenvolvimento computacional e a análise dos resultados derivados da terceira etapa do estudo. A correlação entre as etapas do estudo, os métodos empregados, os objetivos específicos relacionados e o meio de disseminação de seus resultados são apresentados no Quadro 1. O conjunto desses artigos proporciona uma resposta ao objetivo geral traçado para essa dissertação.

Quadro 1 - Relação entre etapas, métodos, objetivos e meios de divulgação desse estudo

Etapa	Método empregado	Objetivo específico relacionado	Disseminação dos resultados
1. Revisão da literatura.	Revisão sistemática da literatura.	a) Investigar a organização das redes de distribuição omni-channel em termos do processo de entrega de pedidos aos consumidores.	Artigo 1.
2. Desenvolvimento conceitual.	Modelagem conceitual.	b) Desenvolver uma estrutura de operação da rede de distribuição omni-channel para diferentes modalidades de entrega de pedidos on-line.	Artigo 2.
3. Avaliação do desempenho.	Modelagem, simulação e análise.	c) Avaliar, por meio da modelagem e simulação computacional, o desempenho da estrutura proposta em um contexto real.	Artigo 2.

Fonte: Autora (2023)

3 ARTIGO 1 – TOWARDS CONSUMER-CENTRICITY IN OMNI-CHANNEL DISTRIBUTION NETWORKS: A SYSTEMATIC LITERATURE REVIEW

Artigo submetido ao International Journal of Physical Distribution & Logistics Management

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Abstract
Purpose: The purpose of this systematic literature review is to explore omni-channel distribution networks' organization concerning the order-to-consumer delivery process. As consumers' behavior and expectations continually evolve, this review aims to shed light on how retailers can adapt their distribution networks to a consumer-centric approach.
Design/methodology/approach: Following the PRISMA guidelines, 42 papers were selected for analysis, encompassing literature building and landscape assessment. A comprehensive literature overview was then developed, categorizing findings into five fundamental aspects: distribution network structure, delivery destination, picking, packing, and shipping location, last-mile transport strategy, and delivery speed. These aspects provided the basis for identifying key configurations and trade-offs in omni-channel distribution networks.
Findings: This review provides valuable insights into the intricacies of consumer-centric omni-channel distribution networks, illustrating the need for further research and exploration in this evolving field. The literature review highlights that the research on omni-channel distribution networks is still in its early stages, indicating a wealth of opportunities for additional investigation and deeper understanding.
Originality: This review contributes to the body of knowledge by presenting a comprehensive examination of the current state and future prospects of omni-channel distribution networks. By identifying gaps and opportunities, it serves as a reference for scholars and retailers alike, offering the groundwork for future research to develop innovative and scientifically validated solutions for a consumer-centric approach to omni-channel retail.
Keywords: Omni-channel; Distribution Network; Order Fulfillment; Consumer-centric; Systematic Literature Review
Paper type: Research paper

1. Introduction

From the convenience of online shopping to the personal touch of in-store experiences, the rise of omni-channel retail has given consumers the power to shop on their own terms (Lim and Winkenbach, 2019; Momen and Torabi, 2021). They expect to be able to search for and order products anywhere, through any means, at the most convenient time. Further, consumers anticipate receiving or collecting their products anytime, anywhere, and with a minimal time lapse from purchasing to receiving their orders (Bergmann *et al.*, 2020; Castillo *et al.*, 2018; Fleischer *et al.*, 2020; Hendalianpour *et al.*, 2022; Hosseinzadeh *et al.*, 2021; Souza *et al.*, 2022). These consumers' demands can be elucidated by the Hedonic Adaptation Theory, which highlights their natural inclination towards greater convenience and satisfaction (Ying *et al.*, 2016; Klausen *et al.*, 2022).

This consumer-centric era requires structural adjustments throughout retailers Business-To-Consumer (B2C) Distribution Networks (DNs) (Hübner, Holzapfel, *et al.*, 2016; Jiu, 2022; Murfield *et al.*, 2017; Ocicka and Raźniewska, 2016; Rai *et al.*, 2019; Sorkun *et al.*, 2020). One of the main is the integration of facilities, resources, and processes (Freichel *et al.*, 2019; Ishfaq *et al.*, 2016), which can go through different stages of interconnection (Hübner, Wollenburg, *et al.*, 2016). Understanding DNs in an integrated view is of utmost importance for retailers to remain competitive and improve their order fulfillment process efficiency (Hendalianpour *et al.*, 2022; Hübner, Holzapfel, *et al.*, 2016; Marchet *et al.*, 2018). It can enable retailers to fulfill orders seamlessly from any inventory location with a shorter delivery time to the consumers' preferred destination through the most suitable transport strategy (Hübner, Holzapfel, *et al.*, 2016; Ishfaq *et al.*, 2016; Marchet *et al.*, 2018; Murfield *et al.*, 2017; Zhang, Onal, *et al.*, 2019).

Further, critical operational decisions should be taken in omni-channel retailers' networks. One concerns the coverage area and delivery destinations, encompassing Home Delivery (HD) and pick-up points. This entails identifying suitable locations for picking, packing, and shipping operations for each defined delivery destination. Additionally, a well-defined transportation strategy must be implemented for the last-mile journey from the operation site to the destination point. These factors directly influence the delivery speed, which significantly impacts consumers' shopping experience (Hübner, Holzapfel, *et al.*, 2016; Ishfaq *et al.*, 2016; Marchet *et al.*, 2018; Murfield *et al.*, 2017; Souza *et al.*, 2023).

However, research on omni-channel DNs is still in its early stages. Previous studies have primarily focused on specific logistical sub-problems, lacking a comprehensive integration of different aspects (Marchet *et al.*, 2018). Therefore, scholars and practitioners have called for a holistic understanding of this subject (Arslan *et al.*, 2021; Janjevic *et al.*, 2020; Jiu, 2022; Saha and Bhattacharya, 2020). To bridge these gaps, this study examines how omni-channel DNs are organized regarding the order-to-consumer delivery process. Employing a Systematic Literature Review (SLR), this research aims to provide an encompassing overview of the existing literature and formulate pertinent questions to guide future investigations.

The contribution of this research to the relevant literature is threefold. Firstly, it presents a comprehensive literature analysis based on five DN fundamental aspects: DN structure, delivery destination, picking, packing, and shipping location, last-mile transport strategy, and delivery speed. This analysis offers a holistic perspective on the organization of omni-channel DNs, complemented by a bibliometric analysis, that traces the evolution of the literature over time. Secondly, it provides a literature overview that elucidates the intricate relationships among the various components of omni-channel DNs and their potential arrangements. Finally, the research generates an agenda for future investigations based on the gaps identified in the literature for each fundamental aspect, highlighting key areas that require further exploration to advance the understanding of this relevant topic.

The rest of the study is organized as follows: Section 2 provides a conceptual background and introduces relevant terminology related to omni-channel DNs. Section 3 outlines the research methodology employed to conduct this SLR. Section 4 presents the literature building through a bibliometric analysis. Section 5 discusses the literature landscape by examining the five fundamental aspects of DNs. Section 6 proposes an overview that synthesizes the ideas gathered from the literature. Section 7 suggests directions for future research based on identified gaps for each fundamental aspect. Finally, Section 8 closes this study by summarizing its key contributions.

2. Conceptual background and basic terminology

Retail has a rich history dating back to ancient times, with early forms of business conducted at outdoor markets. Over time, physical stores specializing in different sectors - such as food, clothing, and home goods – dominated the retail sector until the 1990s. Since then, with the advent of the Internet and the popularization of digital technologies, new ways of connecting retailers and consumers have emerged, such as e-commerce (Lim and Winkenbach, 2019).

In the early stages of "dot-com" retailing, retailers typically operated through a single-channel, physical or online (Hübner, Wollenburg, *et al.*, 2016). However, the rise of online channels prompted some Brick-and-Mortar (B&M) retailers to initiate the multi-channel trend by establishing Click-and-Mortar (C&M) hybrid operations, using dedicated logistical systems for each channel (Lim and Winkenbach, 2019; Marchet *et al.*, 2018; Shin *et al.*, 2022). This gave retailers more flexibility in meeting consumers' demands through distinct distribution channels (Murfield *et al.*, 2017), while sustaining their market presence (Abdulkader *et al.*, 2018; Sawicki and Sawicka, 2021).

In recent years, the convenience and widespread access to the Internet, along with the wide low-priced product assortment and/or low-cost or free shipping on e-commerce, have made pure players a dominant force in the market (Castillo *et al.*, 2018; Lin *et al.*, 2022; Ocicka and Raźniewska, 2016). Correspondingly, C&M retailers have started the movement of integrating their physical and online operations (Gao and Su, 2016; Lim and Winkenbach, 2019), giving rise to the omni-channel configuration (Shin *et al.*, 2022; Zhang, Zhu, *et al.*, 2019). Omni-channel retailing seeks to create a seamless and consistent shopping experience for consumers across all channels by removing barriers between physical and digital touchpoints, creating a synergic and integrated operation in a way that switching from one channel to another should not lead to the reception of new or different information (Abdulkader *et al.*, 2018; Fairchild, 2016; Hendalianpour *et al.*, 2022; Hüseyinoğlu *et al.*, 2018; Ishfaq *et al.*, 2016; Lee, 2017; Lim and Winkenbach, 2019; Marchet *et al.*, 2017, 2018; Murfield *et al.*, 2017; Sawicki and Sawicka, 2021).

3. Research methodology

To achieve this study goal, a SLR was conducted adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page *et al.*, 2021) guidelines. The step-by-step approach is outlined in the following subsections.

3.1 Design

The PICo acronym (Stern *et al.*, 2014) was used to address the question, "How are omni-channel DNs organized regarding their order delivery process?". *Omni-channel* was considered as the population (P), which aimed to explore studies that examine the *delivery* (I) in the context of the *DNs* (Co), merging into a string composed of the original and similar words found in the thesaurus. The string was searched for in titles, abstracts, and keywords, with no publication year, language, or research area restrictions. Table 1 outlines the inclusion and exclusion criteria.

Table 1 – Inclusion and exclusion criteria

Type	Criteria	Rationale
Inclusion	Title, abstract, and keywords shall display the omni-channel DN as the research focus.	Only papers with a clear focus on omni-channel DNs were included.
	Papers considered as articles in relation to the databases document type.	The articles are reliable sources of information that undergo rigorous quality control processes before being published.
	Papers written in any language.	To include all potentially relevant studies, no language was disregarded.
	All publication years.	As omni-channel is a relatively young approach, all years of publishing were considered to trace the evolution of research and identify key trends and changes.
	Papers from primary research.	Only papers that reported their research's details, methods, and results were included, ensuring that the analysis focuses on studies offering original insights.
Exclusion	Papers applied to virtual stores only.	Papers applied to virtual stores only do not consider the full range of consumers' touchpoints that comprise the omni-channel experience.
	Studies focusing on reverse logistics.	Only the forward distribution was considered; returns were omitted as both require different distribution strategies.
	Studies applied in the perishable products market (e.g., food).	Perishable retailers have distinct DNs, with controlled temperatures and specific packaging requirements, which were not considered in this review.
	Studies focusing on non-B2C markets.	The consumers' DNs differ from the cross-market ones.

Search strategies were applied in Scopus and Web of Science (WoS), which cover the main journals in the research field, from the database's inception to January 23, 2023. The search string applied in Scopus is shown in Table 2 to exemplify the search path. An additional gray literature search covering the first hundred Google Scholar results was performed with the same string on January 10, 2023.

Table 2 – Search string used in Scopus database

TITLE-ABS-KEY ((omnichannel OR omni-channel) AND (ship* OR deliver* OR pickup OR pick-up OR collect* OR ((“last mile” OR last-mile) AND (logistic* OR deliver* OR distribution*))) AND (distribution AND (system* OR network* OR logistic* OR structur* OR configuration))) AND (LIMIT-TO (DOCTYPE, “ar”))

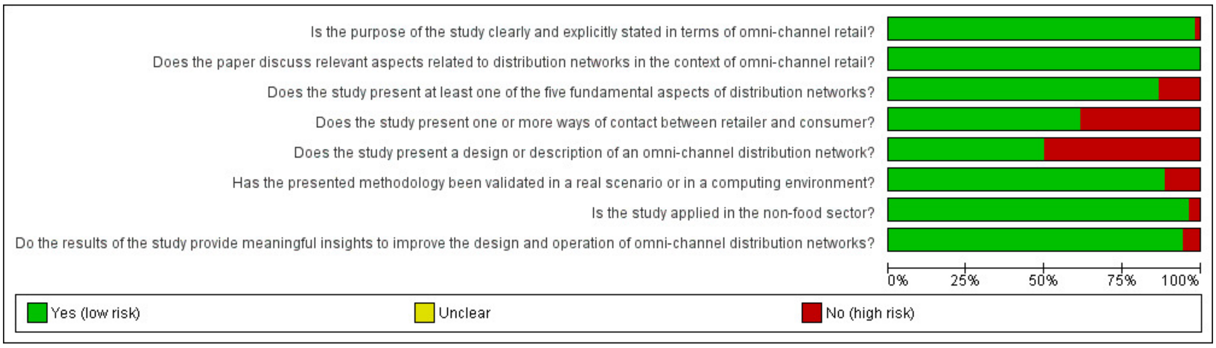
3.2 Screening and selection

Several steps were taken to select the papers to be included in this SLR. Initially, the search string was used to identify the database records. Subsequently, duplicates were removed, and each paper's inclusion and exclusion criteria were evaluated through a screening process. The full text of the approved records was then retrieved, read in its entirety, and analyzed for eligibility through a risk of bias checklist. Finally, only papers meeting the established inclusion criteria and with no risk of bias were selected to compose this study.

Using the Rayyan website (Ouzzani *et al.*, 2016), the identification and screening steps were performed to remove duplicate papers and those irrelevant to the scope of this review, respectively. Initially, 106 papers were found in Scopus (55) and WoS (51) databases, out of which 40 were duplicates and were removed, leaving 66 papers for the screening stage. Titles, abstracts, and keywords were scanned and analyzed according to the inclusion and exclusion criteria presented in Table 1, and 29 papers non-related or loosely related to the researched topic were identified and removed. The full texts of the remaining 37 papers were retrieved from online databases, and in some cases, the authors were contacted to access the papers. This process concluded with the exclusion of one paper that could not be retrieved. Consequently, 36 papers from the databases were evaluated for eligibility. The same steps were followed for papers from gray literature, ensuring there were no duplication among them or with the papers from the databases. Titles, abstracts, and keywords were analyzed during the identification stage to avoid including irrelevant records. Sixteen gray literature papers were identified, and their full texts were obtained for evaluation of eligibility.

Thereafter, the eligibility of each paper was determined by evaluating its risk of bias. For this purpose, the authors developed a checklist named "Checklist for omni-channel DN research bias analysis", based on the critical appraisal tools provided by the Joanna Briggs Institute. The assessment was conducted using RevMan software, version 5.4.1. The checklist comprises eight questions, with each being evaluated on a three-response scale: "yes" (green), "unclear" (white), or "no" (red). For a paper to be considered a low risk of bias in this research, it had to achieve at least 75% positive responses on the checklist. Further, any papers with negative responses to questions 1, 2, or 7 were automatically excluded from the final portfolio as they were not familiar with the main topic of this SLR. The papers that met these criteria and were approved in the bias analysis were incorporated into the final selection for this study. The developed tool and the response scale obtained from the papers' evaluation are shown in Figure 1.

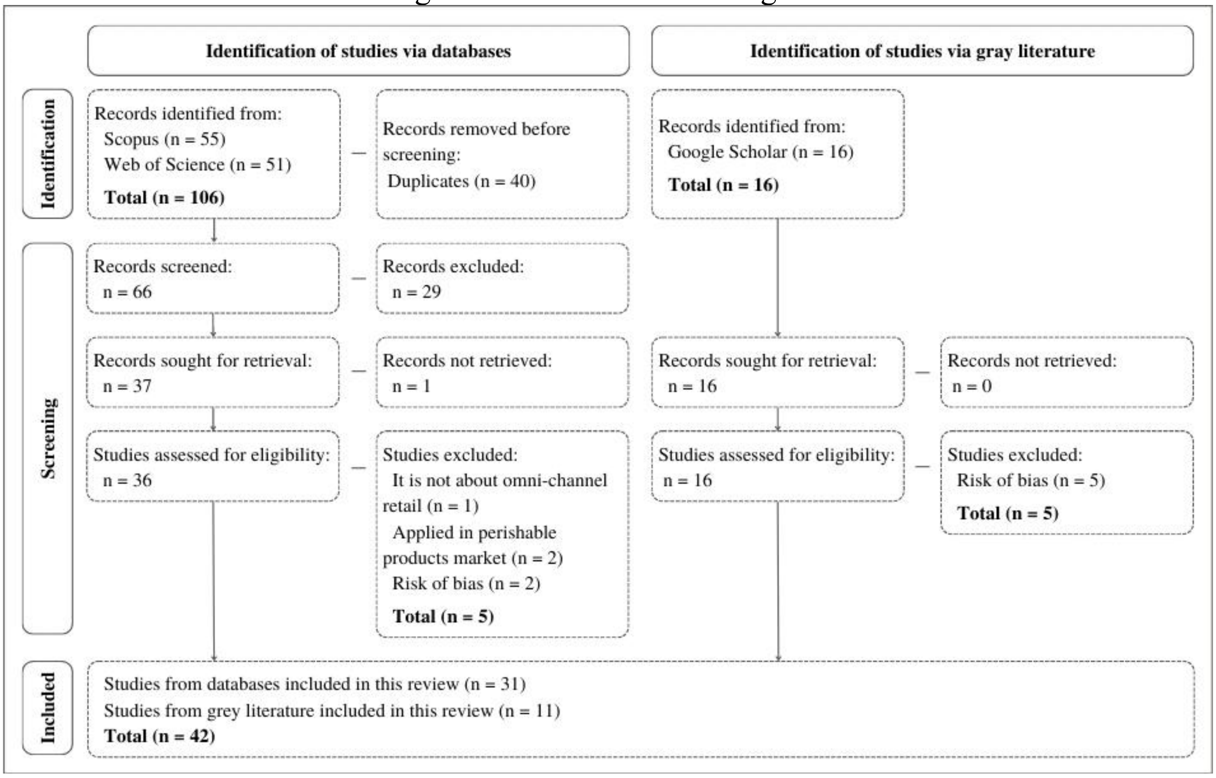
Figure 1 – Risk of bias assessment for omni-channel distribution network research: checklist and results



Source: Authors (2023)

All papers approved in the initial screening were read in full and evaluated using the developed checklist. From papers identified via databases, five were considered ineligible - one due to a negative response to question 1, two due to negative responses to question 7, and two for not achieving the minimum requirement of 75% positive responses on the checklist. As a result, 31 papers from the databases were included in this review. Five papers identified through grey literature were deemed ineligible for not meeting the 75% positive response threshold, which led to the inclusion of 11 papers from the gray literature in the review. In total, 42 papers were included in this study. Figure 2 provides an overview of the number of papers considered at each stage of the PRISMA method and the number of papers removed regarding each criterion.

Figure 2 – PRISMA flow diagram



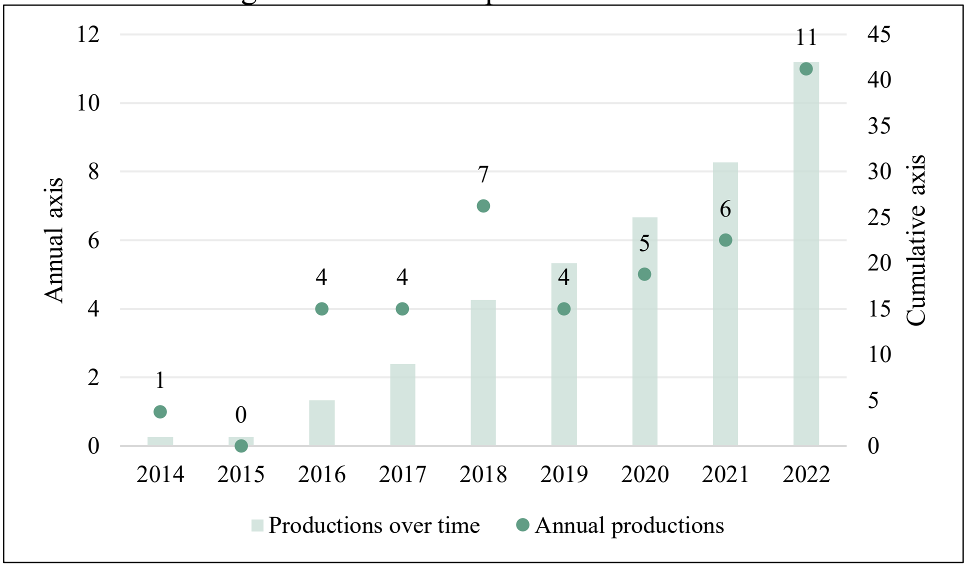
Source: Authors (2023)

The 42 selected papers were thoroughly reviewed to extract relevant information and address the research question that guided this study. All data were recorded in an Excel spreadsheet specifically designed for this research. The findings from this analysis are presented in the subsequent sections.

4. The literature building

To evaluate the literature development on the organization of omni-channel DNs concerning the order-to-consumer delivery process, a bibliometric analysis of the selected papers was conducted. The R-tool *bibliometrix* package (Aria and Cuccurullo, 2017) was employed to verify the research's progression over time. Figure 3 visually illustrates this evolution, showcasing an annual growth rate of 34.95%.

Figure 3 – Scientific production over time



Source: Authors (2023)

The first paper published included in this review was released in 2014, entitled "Integration of Online and Offline Channels in Retail: the Impact of Sharing Reliable Inventory Availability Information" (Gallino and Moreno, 2014). This study analyzed the impact of Buy Online, Pick-up in Store (BOPS) implementation and the consequent availability of real-time inventory information for online consumers on the sales of each channel. Subsequently, in 2016, five papers were published, all sharing a common focus on exploring the integration between physical and online channels (Gao and Su, 2016; Hübner, Holzapfel, *et al.*, 2016; Hübner, Wollenburg, *et al.*, 2016; Ishfaq *et al.*, 2016; Montreuil, 2016).

Since then, research on omni-channel DNs has gained popularity. From 2017 to 2018, topics covered included network redesign, picking and packing locations analysis, delivery speed possibilities, and last-mile transport strategies exploration. Millstein and Campbell (2018) used an omni-channel warehouse location model to redesign the DN of a sporting goods retailer, catering to multiple metropolitan areas. Marchet *et al.* (2018) identified logistics variables adopted by omni-channel retailers and highlighted their usage in omni-channel implementation, while Lim and Srai (2018) investigated configuration dimensions influencing omni-channel performance. Further, Marchet *et al.* (2017) and Melacini and Tappia (2018) studied costs and greenhouse gas emissions for different integration levels. Ishfaq and Raja (2018) evaluated different picking and packing locations for delivery destinations. Lee (2017) examined delivery speed and Amazon's patented anticipatory shipping method. The effectiveness of crowdsourcing and vehicle routing in last-mile was explored by Abdulkader *et al.*, (2018) and Castillo *et al.* (2018). Finally, Murfield *et al.* (2017) investigated the impact of logistics service on consumers' satisfaction and loyalty in omni-channel retail.

From 2019 to 2020, several studies focused on the omni-channel DN structure. Lim and Winkenbach (2019) explored ways to configure the DN while considering product variety and delivery speed; Janjevic *et al.* (2020) proposed a method to reduce distribution costs through the integrated modeling of a multimodal omni-channel DN; and Prabhuram *et al.* (2020) compared the performance of four different levels of integration. Picking and packing activities were delved into operations, design, and resources by Kembro and Norrman (2019, 2020), and packing challenges in omni-channel fashion stores were investigated by Freichel *et al.* (2019). Rogers *et al.* (2020) explored the proposition of warehouse sharing. Additionally, Saha and Bhattacharya (2020) identified an optimal inventory control policy for BOPS. Lastly, Zhang, Onal, *et al*. (2019) conducted a comparison of Amazon's fulfillment time to other retailers' delivery speed.

In 2021, papers began to investigate the effects of omni-channel on the competitive retail environment regarding profit, order fulfillment time (Momen and Torabi, 2021), delivery time reliability, and reduction of lost sales (Arslan *et al.*, 2021). Additionally, other studies designed efficient ways to configure and parameterize a DN (Sawicki and Sawicka, 2021; Snoeck and Winkenbach, 2021) and investigated the transformation of single- or multi-channel logistics into an omni-channel approach (Simangunsong and Subagyo, 2021).

In 2022, research papers evolved from the previous year's discussions to a more practical approach. Hendalianpour *et al.* (2022) developed a model to optimize multi-product, multi-level omni-channel DNs, increasing efficiency, reducing costs, and enhancing consumers' satisfaction. Also, a significant increase in discussions about using stores as pick-and-pack locations was observed. Jiu (2022) studied the implementation of Ship-From-Store (SFS), analyzing decisions on replenishment, allocation, and order fulfillment to reduce operating costs for omni-channel retailers. Lin *et al.* (2022) evaluated the opening of physical stores by online retailers to support order fulfillment in an omni-channel format. Wan *et al.* (2022) addressed the problem of locating stores for implementing BOPS. Teixeira *et al.* (2022) assessed the impact of SFS on physical store performance. Finally, Shin *et al.* (2022) considered BOPS and out-of-stock-home-delivery-service from the perspective of the multi-period stock problem in a scenario with uncertain demand. On the other hand, keeping the Ship-From-Warehouse (SFW) tradition, Millstein *et al.* (2022) developed a model to optimize the quantity, location, and capacity of omni-channel warehouses. Liu *et al.* (2022) examined vehicle routing in omni-channel DNs considering decentralized Distribution Centers (DCs). Qu *et al.* (2022) proposed a joint stock optimization and order allocation model in a multi-echelon and multi-node DN, along with an order allocation mechanism for economic and sustainable operations. Finally, Naclerio and Giovanni (2022) investigated blockchain effects on retail, analyzing its implications in omni-channel and logistics systems to improve last-mile performance.

5. The literature landscape

The literature landscape of the five main aspects of omni-channel DNs has been developed through the reading and analysis of the papers included in this SLR. This session aims to present a comprehensive overview by exploring concepts, methods, applications, and trends found in the literature for the following aspects: DN structure, delivery destination, picking, packing, and shipping location, last-mile transport strategy, and delivery speed.

5.1 Distribution network structure

A key strategic decision in the DN structure involves determining the logistical integration level between online and physical channels. Retailers may opt to utilize existing resources for both channels, implementing different integration levels, or dedicate specific resources for each channel (Ishfaq and Raja, 2018; Marchet *et al.*, 2017, 2018; Melacini and Tappia, 2018; Millstein and Campbell, 2018; Prabhuram *et al.*, 2020).

Ishfaq *et al.* (2016) state that retailers need to establish a distribution strategy that meets the specific requirements of each channel. On the one hand, store replenishment requires high-volume shipments through palletized deliveries at predetermined frequencies (Hübner, Holzapfel, *et al.*, 2016; Hübner, Wollenburg, *et al.*, 2016; Ishfaq *et al.*, 2016; Janjevic *et al.*, 2020; Kembro and Norrman, 2020; Rogers *et al.*, 2020). On the other hand, online consumers demand is characterized by a large number of small orders, often requiring a diverse range of colors, flavors, sizes, or fragrances, fulfilled through multiple delivery options to different destinations (Kembro and Norrman, 2020; Rogers *et al.*, 2020).

For some of these reasons, Arslan *et al.* (2021) point out that traditional DCs are not designed or located to operate as e-commerce Fulfillment Centers (FCs), nor are capable of meeting short delivery lead times, time windows, and customizations. Rogers *et al.* (2020) support this notion, starting that DCs optimized for Business-to-Business (B2B) operations may prove inefficient for last-mile delivery due to significant differences in network design compared to FCs, particularly in distance shipments and load size. Ishfaq *et al.* (2016) add that the online order fulfillment process is inconsistent with the store replenishment one, requiring careful attention to picking, packing, addressing, and delivering to geographically dispersed recipients fractionally door-to-door.

To overcome these differences, several authors (Ishfaq *et al.*, 2016; Ishfaq and Raja, 2018; Marchet *et al.*, 2017; Melacini and Tappia, 2018) advocate for establishing a dedicated fulfillment process for each channel. While this approach requires significant capital investment in logistical facilities and incoming channel DN design, it ensures that each channel's unique requirements are met without disrupting the traditional operation. Finally, by using separate legal entities, retailers can mitigate the risks associated with expanding into new channels, such as regulatory and legal compliance issues, and operational complexities (Hübner, Holzapfel, *et al.*, 2016).

In contrast, consumers' high expectations have led some retailers to approach an integrated DN rather than optimizing efforts individually for each channel (Lin *et al.*, 2022). This reshaping can ensure greater product availability, faster delivery, and improved consumer service by effectively integrating inventory, transportation, and consumer data from all sales channels in different integration levels (Hübner, Holzapfel, *et al.*, 2016; Qu *et al.*, 2022).

Several studies have confirmed that integrating distribution systems enable achieving both eco- and cost-efficiency with low investments and easy set-up (Abdulkader *et al.*, 2018; Hübner, Holzapfel, *et al.*, 2016; Ishfaq *et al.*, 2016; Janjevic *et al.*, 2020; Kembro and Norrman, 2019, 2020; Marchet *et al.*, 2017; Melacini and Tappia, 2018; Qu *et al.*, 2022). A key factor contributing to this dual efficiency is the possibility of inventory pooling and flexible allocation based on demand, especially important in challenging forecast scenarios (Hübner, Holzapfel, *et al.*, 2016). Additionally, an integrated network improves logistical coordination, optimizes order fulfillment (Hübner, Holzapfel, *et al.*, 2016; Marchet *et al.*, 2018), and reduces tied-up capital costs, space requirements, and transportation expenses in the Click-And-Collect (C&C) setting (Hübner, Holzapfel, *et al.*, 2016; Kembro and Norrman, 2020; Qu *et al.*, 2022). These improvements can distinguish retailers in the market by enhancing consumers' satisfaction, leading to sales growth and increased profits (Hübner, Holzapfel, *et al.*, 2016; Marchet *et al.*, 2018). Moreover, integration can reduce carbon emissions, supporting retailers' environmental sustainability (Ishfaq *et al.*, 2016; Kembro and Norrman, 2019; Marchet *et al.*, 2017; Melacini and Tappia, 2018; Qu *et al.*, 2022). However, despite the notable benefits of an integrated setting, it can increase the complexity of network operations. Since each channel has its particularities, the integrated network must be flexible to fulfill orders regardless of the requesting channel (Jiu, 2022).

The decision to use a dedicated or integrated DN depends on several factors, including market size, relative costs, percentage of demand from the online channel, variation in demand across channels, number of physical stores, and DN complexity (Millstein and Campbell, 2018). Some authors argue that separate distribution structures are often an initial step, while integrated DCs and consolidated inventories are more advanced and complex solutions (Hübner, Holzapfel, *et al.*, 2016; Ishfaq *et al.*, 2016). However, others, like Marchet *et al.* (2018), state that as the number of online orders increases, the efficiency of an integrated solution decreases.

Another key strategic decision in the DN structure is whether to centralize or decentralize facilities, which involves storing inventory in a single central location or multiple locations closer to the point of use, respectively (Kembro and Norrman, 2019). This decision depends on several factors, including market size and dispersion, relative costs, and the retailer's competitive strategy.

Centralized facilities can reduce required inventory levels, increase available inventory to meet demand (Shin *et al.*, 2022), and enable retailers to postpone inventory allocation (Hübner, Holzapfel, *et al.*, 2016). Despite that, some retailers surveyed by Hübner, Holzapfel, *et al.* (2016) consider orders' late cut-off points as more effective in reducing online orders fulfillment time than creating regional DCs.

For Lim and Srai (2018) and Arslan *et al.* (2021), geographically dispersed DCs can enable service differentiation and shorter delivery times. Kembro and Norrman (2019) add that apart from reducing order fulfillment time, locating nodes closer to demand can facilitate the implementation of flexible delivery options, such as C&C. Furthermore, Hübner, Holzapfel, *et al.* (2016) highlight that physical stores benefit from decentralized facilities due to their shorter replenishment cycles and higher delivery frequency, enabling quicker reactions to demand variations. Conversely, Qu *et al.* (2022) argue that, although decentralized facilities can broaden sales approaches to some extent, they often lead to an overall increase in inventory, as each node maintains an independent stock, increasing operating costs.

5.2 Delivery destination

When consumers decide to make a purchase, they must choose a channel to buy and to receive their products according to their priorities. To provide a range of options to consumers, retailers need to orchestrate their DNs to dispatch products from different locations to multiple destinations (Hübner, Holzapfel, *et al.*, 2016; Lee, 2017). As suggested by Janjevic *et al.* (2021), this may involve investing in a multi-echelon network with diverse facility types and sizes in different locations. Furthermore, Marchet *et al.* (2018) emphasized that adaptations in facilities and transportation are necessary to meet this evolving demand.

HD, specifically, involves delivering goods to consumers' homes or any location they specify as their delivery address (Hübner, Holzapfel, *et al.*, 2016; Montreuil, 2016). HD can take different forms, ranging from scheduled to unscheduled and attended to unattended, depending on whether consumers have prearranged the delivery shift at the purchase and whether they need to be present to receive their orders. However, due to the large number of small deliveries to dispersed locations, HD requires significant efforts and costs for retailers. On the other hand, consumers benefit from the convenience of not having to travel to pick up their orders (Montreuil, 2016), although they typically have to pay shipping fees (Hübner, Holzapfel, *et al.*, 2016). Further, one of the main challenges in HD is the uncertainty of consumers' availability to receive attended orders. As opposed to stores, their opening hours are unknown (Rai *et al.*, 2019), potentially leading to delivery failures if recipients are unavailable when their parcels are offered.

In contrast, C&C refers to consumers' option to pick up their purchased products at designated collection points, avoiding waiting for HD or bearing shipping costs. These pick-up points can operate in several locations at different automation levels (Janjevic *et al.*, 2020), including retailer's stores, convenience stores, smart lockers for small volumes, and Automated Parcel Stations (APS) for larger packages (Guerrero-Lorente *et al.*, 2020). By introducing pick-up points, last-mile logistics costs are reduced, as they aggregate demand in fewer places, making them particularly attractive for densely populated cities (Janjevic *et al.*, 2021). Moreover, Wan *et al.* (2022) found that the location of pick-up points significantly affects their utility, as consumers tend to choose the shortest distance for order pick-up. In a similar approach, Click and Reserve (C&R) allows consumers to reserve products online and pick them up at a physical store. The main difference between C&R and C&C strategies lies in the payment process: with C&R, consumers only reserve the product on the website and pay for it at the store, rather than paying upfront.

The option for consumers to collect their purchased products in the retailers' physical stores, specifically using the store's inventory, is known as BOPS (Gao and Su, 2016). Through BOPS, online shoppers can check the availability of searched products locations, close the transaction online, and collect the products shortly after checkout (Gallino and Moreno, 2014). The flexibility of BOPS has proven to be a win-win strategy for both consumers and retailers (Saha and Bhattacharya, 2020). Consumers benefit from instant gratification, avoid long delivery times, fees, and stockouts, as well as enjoy hassle-free shopping as their items are already picked and packaged (Gallino and Moreno, 2014; Gao and Su, 2016; Saha and Bhattacharya, 2020). Retailers, in turn, gain in-store traffic, foster closer relationships with consumers (Teixeira *et al.*, 2022), save on last-mile costs (Saha and Bhattacharya, 2020), and increase the potential of incremental sales through cross-selling (Gao and Su, 2016; Teixeira *et al.*, 2022).

However, implementing BOPS also comes with challenges. Gao and Su (2016) argue that it can lead to decreased profit margins for retailers due to the costs and operational disruptions in physical stores. This happens because the ill-designed layout of B&M stores for order picking and packing processes can result in additional handling efforts, leading to costly operations (Hübner, Holzapfel, *et al.*, 2016; Zhang, Onal, *et al.*, 2019). As a result, Saha and Bhattacharya (2020) and Montreuil (2016) suggest that physical stores need to undergo a redesign, adjusting their stock control policies to cater to both walk-in and pick-up consumers, which may require reducing merchandising space to include order fulfillment areas.

Providing real-time information on physical stores' stock availability is a valuable by-product of BOPS (Gao and Su, 2016). Retailers must ensure that their online systems have access to each store's accurate and up-to-date stock information to enable products for store pick-up (Gallino and Moreno, 2014), indirectly disclosing stock availability to consumers (Gao and Su, 2016). This raises a dilemma regarding which products should be made available for BOPS. On the one hand, Gallino and Moreno (2014) suggest that BOPS should encompass all products, providing inventory information to help consumers find their desired items at nearby stores. Gao and Su (2016), on the other hand, argue that the drawbacks may outweigh the potential benefits, as out-of-stock products may discourage consumers from visiting stores, resulting in reduced in-store traffic. Further, Gallino and Moreno (2014) found that while online sales decreased after BOPS implementation, sales in physical stores experienced growth. The authors attributed this to the channel-shift effect, driven by the accurate real-time stock information availability, leading to Research Online, Purchase Offline (ROPO) behavior.

In another approach, smart lockers and APS offer consumers convenient and efficient delivery options (Guerrero-Lorente *et al.*, 2020). These can be strategically placed in condominiums, office buildings, stores, airports, bus and subway stations, and several other locations (Montreuil, 2016). These collection points benefit both retailers and parcel carriers by potentially reducing transportation costs and avoiding the need for multiple delivery attempts (Guerrero-Lorente *et al.*, 2020). Montreuil (2016) supports this view and emphasizes that retailers can pre-position items in neighborhoods, especially those with high demand or those requiring swift delivery. While an extensive network of smart lockers is required, and some delivery effort remains, this option is still considered more efficient than traditional HD (Montreuil, 2016).

Another pick-up alternative mentioned in the literature is Ship-to-Me (STM), where products are delivered to consumers in their vehicles, at train or plane stations, or similar environments. However, implementing STM incurs considerable costs and requires precision, timing, and flexibility beyond the capabilities of most players (Montreuil, 2016).

5.3 Picking, packing, and shipping location

Successful omni-channel retailers need to be able to fulfill demand from any channel using any inventory location (Hübner, Holzapfel, *et al.*, 2016) even though different sales channels generate distinct demand streams concerning order size, delivery requirements, and consumers' expectations (Ishfaq *et al.*, 2016; Kembro and Norrman, 2020). Therefore, DNs should effectively combine different flows (Kembro and Norrman, 2020), as flexible network designs, where fulfillment occurs from the most appropriate echelon, have been shown to be superior regarding facilities, transportation, and environmental costs, as well as maximum consumer coverage, compared to traditional network designs that solely rely on the DC (Guerrero-Lorente *et al.*, 2020). In another analysis, Qu *et al.* (2022) revealed that allocating orders to upper (lower) echelon nodes can reduce (increase) unit inventory cost and replenishment frequencies but increase (reduce) order delivery time and return risk due to longer delivery distances.

DCs have traditionally served as central hubs for product receiving, storing, picking, packing, and shipping operations (Kembro and Norrman, 2019). In SFW configuration, DCs are used to store replenishment and online orders fulfillment. This setup offers benefits such as reduced demand fluctuations, inventory costs, and picking and packing process expenses, as warehouses are located in low-cost areas with infrastructures to maximize worker productivity (Millstein *et al.*, 2022). However, relying solely on DCs for online orders fulfillment can lead to longer delivery times and higher shipping costs for consumers located far from the DC. Additionally, it may limit stock availability for physical stores, especially during high-demand periods such as Black Friday.

For retailers with dedicated network structures, FCs are used to fulfill online orders in a configuration called Ship-From-FC (SFF), while DCs replenish physical stores. FCs are often strategically located closer to consumers than DCs, providing faster and more cost-effective delivery. Based on predictive analytics, they are also designed to stock only items predicted to be ordered soon by local consumers, reducing inventory holding costs (Montreuil, 2016). However, (Abdulkader *et al.*, 2018) noticed that this configuration could incur additional costs, maintain excess inventory, delay inventory turnover, and disrupt product availability between physical and online systems, resulting in an incomplete omni-channel experience.

To cope with the increasing number of online orders, several retailers have adopted the SFS policy, which utilizes the physical store inventory to fulfill online orders. It turns stores into showrooms and DCs, creating the need to establish processes for inventory management (Hübner, Holzapfel, *et al.*, 2016). SFS offers benefits such as reduced online order fulfillment time, as stores are typically closer to consumers than centralized DCs (Lin *et al.*, 2022), and lower order fulfillment costs (Jiu, 2022), as demonstrated by the ABC model results from Marchet *et al.* (2017). Nevertheless, SFS may be less efficient than SFW approach, as DCs have specialized handling processes better suited for larger order volumes (Hübner, Holzapfel, *et al.*, 2016) while physical stores' shelves and stock placement are designed with a marketing and sales focus (Ishfaq and Raja, 2018). In addition, the authors highlight the high real estate costs of urban and suburban physical stores, as well as the significant inventory maintenance expenses associated with these spaces. Beyond that, the SFS strategy might involve lateral transshipment, where multiple stores replenish each other to prevent stockouts and fulfill both in-store and online demands (Qu *et al.*, 2022).

Millstein *et al.* (2022) proposed strategies that leverage the strengths of warehouses and physical stores for online order fulfillment. One such approach is the Ship-From-Store-and-Warehouse, which allows orders to be fulfilled by both places, harnessing the unique advantages each offers, but facing complexity of allocating orders and requiring adaptation of both places for online order fulfillment. Another strategy is Ship-From-Warehouse-With-Store-Backhaul, commonly used by retailers with a wide variety of products, such as clothing. In this strategy, if an online order contains an item only available in a physical store, the B&M sends the product to the warehouse responsible for the final delivery.

Finally, some retailers are exploring partnerships with a core group of suppliers to expand their online product offerings without the need to expand their distribution capacity (Ishfaq *et al.*, 2016). This approach, known as drop-shipping, involves retailers paying an order processing fee to a supplier who directly delivers the products to consumers (Ishfaq and Raja, 2018). Drop-shipping allows retailers to focus on attracting and managing consumers' demand while transferring inventory, order fulfillment, and operations risks to their suppliers.

5.4 Last-mile transport strategy

Retailers need to adopt transport strategies to cover the last-mile between the picking, packing, and shipping location and the delivery destination. For this, retailers have a range of options, including establishing self-owned distribution, outsourcing to Third Party Logistics (3PLs) providers and Crowdsourced Logistics (CL), or even adopting drop-shipping for the entire order fulfillment process (Rogers *et al.*, 2020). This decision is influenced by distance, delivery time, and demand density within a given region (Castillo *et al.*, 2018; Janjevic *et al.*, 2020).

Self-owned distribution involves the use of retailers' vehicles and facilities for delivering goods. By utilizing their private fleets, retailers have greater control over their network, as they are responsible for managing the entire process, including scheduling, routing, and delivery. This control ensures timely delivery and good condition of products, while also reducing transportation costs and improving operational efficiency through optimized delivery routes (Abdulkader *et al.*, 2018; Guerrero-Lorente *et al.*, 2020). However, establishing a self-owned distribution requires significant upfront investments, including purchasing vehicles, hiring professionals, and implementing logistics management systems, along with ongoing fixed costs like maintenance, insurance, and depreciation (Janjevic *et al.*, 2020).

Outsourcing transportation to 3PLs offers potential cost savings and allows retailers to focus on their core competencies, simplifying their jobs logistics-wise. However, long-term agreements with 3PLs can inhibit retailers' flexibility. Besides, the waiting time for shipping goods may be longer than desired due to the need to 3PLs fill vehicles to justify launching a route, which can also be longer than minimally possible due to a dispersed delivery network (Montreuil, 2016). These factors, although negative from retailers' perspective, are crucial for 3PLs to remain competitive, as they need an optimal distribution process to minimize their costs (Guerrero-Lorente *et al.*, 2020). Further, the lack of a formal connection between 3PLs and their customers' consumers can result in communication gaps regarding delivery date, time, and place preferences. To address this issue, Rai *et al.* (2019) proposed the implementation of big data tools that enable consumers to select delivery preferences, request delivery at convenient times, and track their orders in real-time, improving overall delivery experiences.

Finally, CL emerges as a promising solution for retailers to avoid the disadvantages of 3PLs without the need of a private fleet. Specifically designed for delivering small packages within tight time windows, CL becomes particularly suitable when consumers' locations are unknown in advance, and delivery requests arrive dynamically and stochastically throughout the workday (Castillo *et al.*, 2018). Retailers directly seek transportation services from members of the crowd who act as independent contractors, using their own vehicles to provide delivery services. The selected driver collects the order from the retailer and delivers it directly to the consumer (Lim and Winkenbach, 2019). However, it's crucial to acknowledge that CL introduces a level of uncertainty into the distribution process, as drivers manage their own schedules and work as long or as little as they desire (Castillo *et al.*, 2018). As a result, opting for CL involves navigating the trade-off between the flexibility it offers and the inherent uncertainties it brings.

5.5 Delivery speed

As the time lapse from order placement to delivery, the order fulfillment time is one of the most visible service elements to consumers (Castillo *et al.*, 2018; Marchet *et al.*, 2018; Zhang, Onal, *et al.*, 2019). Online shoppers, in particular, expect fast delivery, with the maximum waiting time dropping each year (Zhang, Onal, *et al.*, 2019). As a result, DNs that enable delivery within a few hours after order placement are becoming increasingly relevant for online retailers. Such speedy deliveries help bridge the gap between instant gratification experienced in physical shopping and the online shopping experience (Snoeck and Winkenbach, 2021). Besides agility, delivery reliability plays a significant role, as consumers often base their choice of a specific delivery option, such as HD or pick-up, on the promised delivery time (Liu *et al.*, 2022).

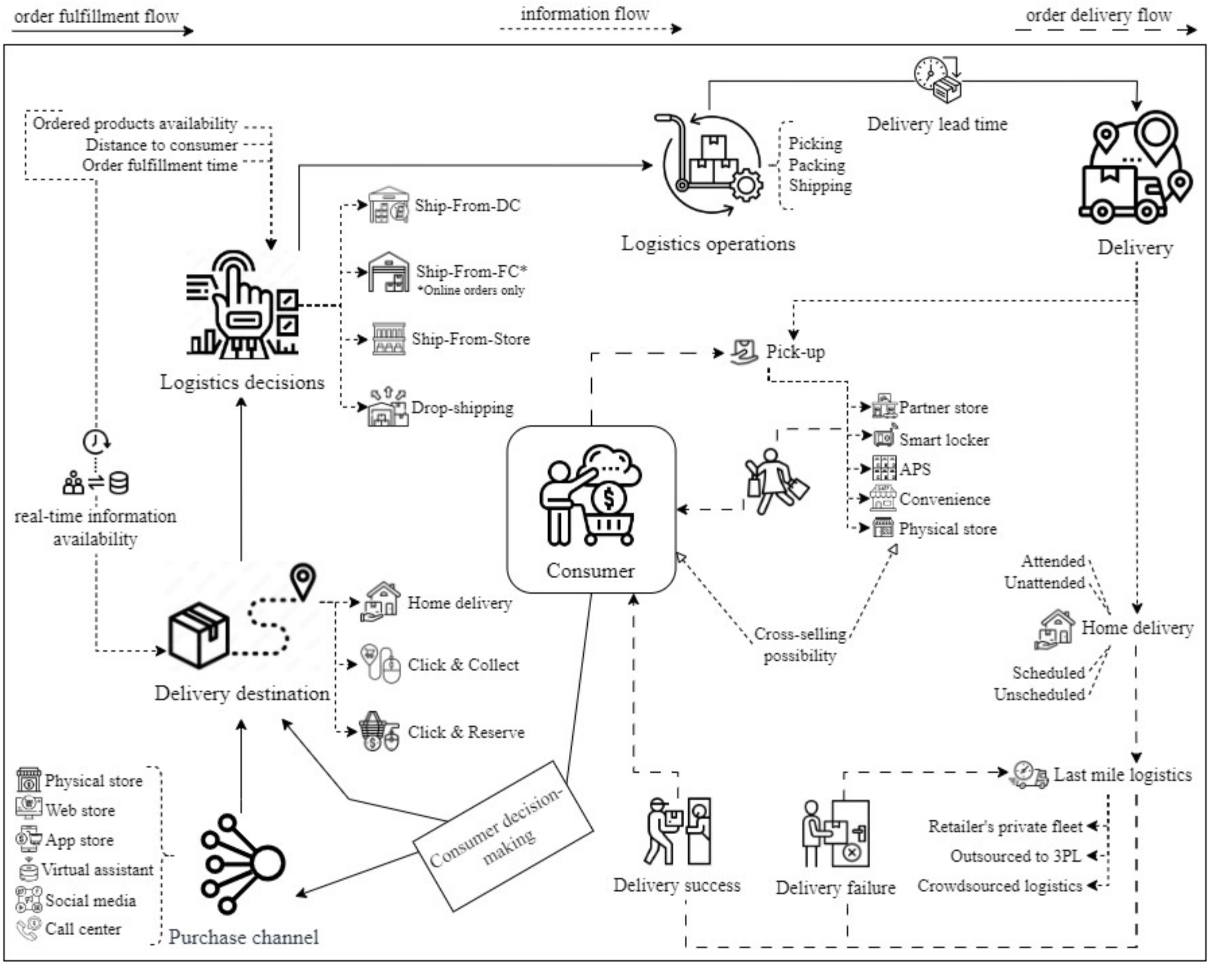
The literature provides different classifications for online order delivery speed. Some commonly mentioned categories include same-day delivery (Castillo *et al.*, 2018; Ishfaq *et al.*, 2016; Lim and Srai, 2018; Lim and Winkenbach, 2019; Marchet *et al.*, 2018; Millstein *et al.*, 2022; Millstein and Campbell, 2018; Snoeck and Winkenbach, 2021); next-day delivery (Arslan *et al.*, 2021; Hübner, Holzapfel, *et al.*, 2016; Ishfaq *et al.*, 2016; Lim and Srai, 2018; Lim and Winkenbach, 2019; Marchet *et al.*, 2018; Millstein and Campbell, 2018; Rai *et al.*, 2019; Rogers *et al.*, 2020; Zhang, Onal, *et al.*, 2019), and two or more days delivery (Arslan *et al.*, 2021; Hübner, Holzapfel, *et al.*, 2016; Ishfaq *et al.*, 2016; Lim and Winkenbach, 2019; Marchet *et al.*, 2018; Rogers *et al.*, 2020; Zhang, Onal, *et al.*, 2019). Other studies have proposed different delivery classifications, such as Janjevic *et al.* (2020), that considered three categories: standard, for next-day delivery; express, for same-day delivery; and instant, for 4-hour delivery. Guerrero-Lorente *et al.* (2020) categorized deliveries as regular or urgent orders. Kembro and Norrman (2019; 2020) distinguished within 24 hours, overnight, next-day, or 2-4 days delivery. Finally, Lim and Winkenbach (2019) proposed Sunday postcode delivery as a means to prevent delivery failures.

On the business side, omni-channel retailers consider short delivery times as a mean to stand out from competitors (Janjevic *et al.*, 2020). To achieve this, designing a well-planned DN becomes essential (Snoeck and Winkenbach, 2021). This includes adopting a flexible approach to distribution channels, making decisions about distribution closer to the final stage of fulfillment, relocating facilities closer to consumers (Rogers *et al.*, 2020), establishing pick-up points, and leveraging fast transportation modes (Janjevic *et al.*, 2020). These strategic measures enable retailers to meet consumers' demands for swift and convenient deliveries, enhancing their market position in the fiercely competitive landscape.

6. The literature overview

This SLR has revealed a wide array of strategic and operational possibilities for omni-channel DNs to deliver a satisfactory service level to consumers. To consolidate and synthesize these findings, a comprehensive literature overview was developed, capturing the essential operational possibilities and trade-offs that shape a consumer-centric DN. The overview, presented in Figure 4, sheds light on the intricate interplay among several factors, including consumers' preferences, logistics decisions and operations, and delivery strategies. Its purpose is to provide a holistic understanding of the different ways in which omni-channel consumer-centric DNs can be configured and operated, while also identifying key areas for future research in this field.

Figure 4 – Overview of key operational possibilities shaping consumer-centric omni-channel distribution networks



Source: Authors (2023)

Omni-channel DNs are designed to prioritize the consumers' needs, placing them at the heart of the networks' operation. Therefore, the operation cycle begins with consumers choosing their preferred purchase channel, with the flexibility to change it as often as desired. Purchases can be made either in-store or remotely through a range of digital platforms, including the store's website, app, social media, virtual assistant, or call center.

For remote purchases, consumers select their preferred delivery destination, which includes options like HD, C&C, or C&R, based on their priorities and estimated delivery times.

The estimation of delivery times relies on real-time inventory information, considering the ordered products availability, the distance from inventory location to the consumer, travel time, and order fulfillment time.

Once an order is placed, retailers face crucial logistics decisions that vary according to their DN strategies. For networks with multiple order fulfillment locations, the challenge lies in identifying the most suitable fulfillment location. With logistics decisions taken, picking, packing, and shipping activities are initiated as part of the logistics operation.

The delivery options, including pick-up and HD, represent the final touchpoint in the forward omni-channel DN process. Pick-up options encompass collecting orders from convenience stores, smart lockers, APS, or retailers' physical stores, the latter being able to offer cross-selling opportunities. HD can be attended or unattended, scheduled or unscheduled, requiring retailers to manage the last-mile logistics. The retailer's transportation strategy for this last-mile journey from delivery destination to consumers' homes may involve utilizing the retailer's own fleet, outsourcing to a 3PL or a CL, or adopting drop-shipping approaches. In case of delivery failure, the last-mile route is retried on the next business day. Ultimately, the forward omni-channel DN process is concluded with the successful delivery of the order to the consumer.

7. The literature future

As omni-channel retail is still a relatively new area of research, there is a vast array of opportunities to expand knowledge of DNs in this domain. To this end, a research agenda based on identified gaps in the literature was organized around the five fundamental aspects of omni-channel retail DNs. Table 3 presents potential research questions and suggests possible methods for their investigation.

Table 3 – Research agenda for omni-channel retail distribution networks

Topic	Possible Research Question	Possible Method(s)
Distribution network structure	How do delivery speed requirements affect the optimal level of integration for different market segments?	Empirical investigation; Case study; Mathematical modeling and optimization; Simulation.
	How does the level of integration affect picking and transport activities?	Empirical investigation; Simulation; Case study; Mathematical modeling and optimization.
	How does the degree of centralization impact the flexibility and responsiveness of DNs?	Empirical investigation; Simulation; Case study; Mathematical modeling and optimization; Network analysis.
Delivery destination	What are the key factors that influence consumers' choice of delivery destination?	Empirical investigation; Survey; Discrete choice analysis.
	How can data analytics be used to predict and understand consumer behavior concerning delivery destination options?	Historical data analysis; Mathematical modeling and optimization; Machine learning; Survey.
	What is the perceived value of providing multiple delivery options from the consumers' perspective?	Empirical investigation.

	What best practices can retailers adopt to prevent delivery failures in the HD setting?	Empirical investigation; Case study; Data analysis; Mathematical modeling and optimization; Simulation.
	What is the maximum distance consumers are willing to travel to pick up their purchases?	Empirical investigation; Survey; Case study; Simulation.
	What is the optimal placement strategy for smart lockers to maximize consumers' convenience and minimize delivery costs?	Mathematical modeling and optimization; Simulation; Case study.
	What is the impact of real-time stock availability information demanded by BOPS on the channel shift effect caused by ROPO behavior?	Empirical investigation; Survey; Case study.
	How can retailers optimize cross-selling opportunities through BOPS strategies?	Machine learning; Empirical investigation; Case study; Field experiments.
	What is the most efficient way to design the layout of a physical store to accommodate BOPS services, considering factors such as consumer flow, space utilization, and employee productivity?	Simulation; Layout design; Empirical investigation; Case study; Data analysis.
Picking, packing, and shipping location	How can retailers optimize their picking efficiency and determine each product's most effective picking location?	Mathematical modeling and optimization; Simulation; Case study.
	What are the trade-offs between converting a physical store into a showroom and using it as inventory for fast delivery in terms of consumers' satisfaction, delivery speed, inventory costs, and revenue?	Empirical investigation; Case study; Simulation.
	How do picking and packing times differ between SFW and SFS models?	Empirical investigation; Case study; Statistical analysis; Simulation.
	How can machine learning algorithms be used to optimize order routing in blended shipping models, such as Ship-From-Store-and-Warehouse?	Machine Learning.
	How can companies effectively manage inventory levels for the drop-shipping model?	Inventory optimization; Empirical investigation; Case study; Simulation; Data analysis.
Last-mile transport strategy	What factors influence the decision to insource delivery services or outsource to a 3PL or CL delivery service?	Empirical investigation; Case study; Simulation; Data analysis.
	How can companies effectively manage the quality and consistency of deliveries when using outsourced delivery services?	Empirical investigation; Case study; Survey; Performance metrics.
	What risks are associated with outsourcing delivery services to 3PLs or CL providers, and how can they be mitigated?	Empirical investigation; Case study; Simulation; Risk analysis.

	What are the challenges and opportunities for companies that use a hybrid delivery model?	Case study; Survey; Simulation; Comparative analysis.
Delivery speed	How can DNs be adjusted to enable same-day delivery?	Simulation; Case study; Data analysis.
	How can retailers optimize their logistics network to improve delivery speed to remote cities?	Network analysis and optimization; Simulation; Case study.
	What are the consumer demands and willingness to pay for a two-hour delivery option across different store segments, and what factors influence this demand?	Empirical investigation; Survey.
	How can retailers use predictive analytics to optimize their delivery speed and anticipate demand fluctuations?	Machine learning; Time series analysis; Regression analysis; Data analysis.

By addressing the proposed research questions, researchers will work on essential topics to better understand omni-channel DNs and propose more innovative and scientifically validated solutions to the field. This advancement in knowledge will not only enrich the understanding of omni-channel DNs but also pave the way for more effective strategies to meet the ever-evolving consumers' demands.

8. Concluding remarks

As we move forward, it is crucial to recognize that the Hedonic Adaptation Theory suggests that consumers' expectations and preferences tend to evolve continuously. With the convenience and speed of omni-channel DNs becoming the norm, consumers may become increasingly demanding, seeking even faster and more personalized delivery options. This SLR has provided valuable insights into the organization of these networks concerning the order-to-consumer delivery process. Based on the findings from the literature so far, it is evident that the research in this domain is still in its early stages, leaving many opportunities for further investigation and exploration to deepen understanding of DNs.

This research provides valuable insights for both academia and the retail industry. For scholars, the integrated view of the consumer-centric omni-channel DN, along with the analysis of its development, current state, and future perspectives, provides a solid foundation for further research in the field. The findings offer retailers a comprehensive understanding of DNs and propose valuable insights to enhance their logistics processes. These serve as a reference to optimize their operations, resulting in cost savings, faster delivery times, and heightened consumers' satisfaction.

Despite the rigorous methodology applied, this review has some limitations that suggest opportunities for future studies. Firstly, the reliance on a limited set of selected sources may have constrained the breadth of the review, potentially overlooking valuable perspectives. Moreover, the predominantly theoretical focus may have limited a nuanced understanding of practical implementation and operational challenges faced by retailers in adopting omni-channel distribution networks.

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4 DELINEAMENTO DO PROBLEMA-CHAVE

Diante das constatações da literatura até o momento, fica evidente que a pesquisa no âmbito das redes de distribuição omni-channel encontra-se em sua fase embrionária, demandando investigações que aprofundem a compreensão do processo de entrega de pedidos aos consumidores. Para contribuir com essa importante vertente da literatura, optou-se por direcionar foco aos três aspectos operacionais fundamentais das redes de distribuição discutidos no Capítulo anterior: o destino da entrega; a localização dos processos de coleta, embalagem e expedição; e as decisões relacionadas ao transporte de última milha, juntamente ao aspecto da velocidade da entrega, resultado da operação. Como resultado, têm-se o desenvolvimento de uma estrutura de operação para redes de distribuição omni-channel capaz de atender a diferentes modalidades de entrega de pedidos on-line, assinalando o cumprimento do segundo objetivo específico desse estudo.

A escolha de investigar os aspectos operacionais é fundamentada na perspectiva de aprimorar o processo de varejistas já consolidados por meio de ajustes direcionados, sem a necessidade de causar disrupções significativas às suas instalações. Essa decisão foi tomada considerando que uma mudança integral na estratégia de distribuição, envolvendo elementos como o nível de integração, a localização de instalações e a descentralização da operação, representa desafios significativos aos varejistas (Hübner, Holzapfel e Kuhn, 2016; Ishfaq e Raja, 2018; Jiu, 2022).

Diante dessa definição, foram selecionadas quatro questões de pesquisa a partir da agenda proposta na Seção 7 do Capítulo 3, cada qual relacionada a um dos aspectos fundamentais:

a) “quais melhores práticas podem ser adotadas por varejistas para evitar falhas nas entregas em domicílio?”;
b) “como os varejistas podem selecionar locais de *picking*, *packing* e *shipping* de forma efetiva?”;
c) “de que maneira os varejistas podem combinar diferentes modelos de entrega de última milha?”;
d) “como as redes de distribuição podem ser ajustadas para garantir entregas no mesmo dia do pedido?”.

Quando agrupadas, essas oportunidades de pesquisa delineiam um desafio que confronta os varejistas em sua busca por competitividade. O processo de distribuição, nessas circunstâncias, revela-se complexo, requerendo a orquestração de diferentes locais de remessa para múltiplos pontos de destino (Hübner, Holzapfel e Kuhn, 2016; Souza *et al.*, 2023) por meio de diversos modelos de entrega, visando garantir entregas ágeis e sem falhas.

Os espaços físico e temporal entre o ponto de origem e o destino escolhido pelo consumidor emergem como um desafio preponderante no contexto das redes de distribuição (Marchet *et al.*, 2018). Nesse contexto, a resolução da questão de pesquisa *b*, que aborda a seleção eficaz de locais para as etapas de coleta, embalagem e expedição, é essencial para propor formas de atender a essa demanda de maneira ágil (Hübner, Holzapfel e Kuhn, 2016; Teixeira *et al.*, 2022). Redes de distribuição que asseguram entregas em poucas horas após a realização do pedido assumem uma importância crescente no cenário varejista, contribuindo para minimizar a lacuna de gratificação instantânea entre as compras on-line e em lojas físicas (Hübner, Holzapfel e Kuhn, 2016; Snoeck e Winkenbach, 2021). Dessa forma, a questão de pesquisa *d* visa propor soluções para os varejistas configurarem suas redes de distribuição para garantir entregas no mesmo dia do pedido.

Por outro lado, há consumidores que atribuem valor à possibilidade de agendar a entrega de suas compras on-line (Liu *et al.*, 2022). Essa solução não apenas atende às demandas desse público, como também minimiza potenciais falhas nas entregas decorrentes da ausência dos destinatários (Lee, 2017), solucionando assim o desafio da incerteza acerca da disponibilidade dos consumidores em suas residências (Kandula, Krishnamoorthy e Roy, 2021; Rai, Verlinde e Macharis, 2019). Assim, a questão de pesquisa *a* objetiva propor soluções para atender a essa específica demanda.

Para combinar efetivamente essas diferentes estratégias de entrega de pedidos on-line, é crucial que os varejistas harmonizem diferentes fluxos (Kembro e Norrman, 2020), para viabilizar o atendimento a partir da hierarquia mais adequada (Guerrero-Lorente, Gabor e Ponce-Cueto, 2020), como abordado pela questão de pesquisa *c*. Essa abordagem tem o potencial de assegurar uma operação mais alinhada com o contexto varejista contemporâneo, promovendo a satisfação dos consumidores e, ao mesmo tempo, enfrentando um potencial problema-chave para o desempenho das operações.

5 ARTIGO 2 – ENHANCING OMNI-CHANNEL RETAIL DISTRIBUTION: A THREE-WAY NETWORK APPROACH FOR ONLINE ORDER DELIVERY

Artigo a ser submetido ao International Journal of Retail & Distribution Management

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Abstract
Purpose: This paper aims to enhance the delivery performance of omni-channel retailers by proposing a three-way distribution network operation structure to fulfill online orders.
Design/methodology/approach: Through a simulation-based approach, the study develops and analyzes a three-way distribution network model for online orders in an omni-channel environment. This approach involves different delivery modes, including in-store pick-up, express home delivery, and scheduled home delivery, and integrates store inventory to improve order fulfillment and responsiveness.
Findings: The results reveal that the proposed three-way network approach significantly improves delivery performance. Incorporating store inventory for the order fulfillment process reduces delivery time, increasing same-day delivery rates. Moreover, the scheduled home delivery strategy effectively reduces delivery attempts and failures.
Originality: This study introduces a three-way network approach to tackle the complexities of omni-channel retailers' online order distribution, incorporating multiple delivery modes tailored to the unique consumers' demands. The research adds practical insight by employing simulation to evaluate the performance of the proposed scenario in a real context.
Keywords: Omni-channel; Distribution Network; Delivery; Order Fulfillment; Multimethod Simulation.
Paper type: Research paper

1. Introduction

From brick-and-mortar to online stores and everything in between, the evolution of omni-channel retail has empowered consumers with an unprecedented range of options. These broad possibilities have led to consumers' behavior and expectations changes (Bergmann *et al.*, 2020; Kembro and Norrman, 2019), requiring retailers to adapt their structures and distribution networks (Lim and Winkenbach, 2019; Montreuil, 2016; Norrman and Kembro, 2017; Rogers *et al.*, 2020) towards a consumer-centric approach.

The shifting trend in distribution revolves around achieving shorter delivery times and offering flexible delivery options for online orders. In this context, distribution networks that are able to provide express deliveries have become increasingly vital in the omni-channel landscape, as they help bridge the gap in instant gratification between virtual and physical purchases (Hübner, Holzapfel, *et al.*, 2016; Snoeck and Winkenbach, 2021). This ability involves embracing a more flexible approach to distribution channels, where decisions about distribution should be made closer to the final fulfillment stage, and facilities should be strategically relocated nearer to consumers (Janjevic *et al.*, 2021; Marchet *et al.*, 2018; Rogers *et al.*, 2020). Then, in contrast to the previous trend of centralization, omni-channel retailers are now embracing a greater degree of decentralization, characterized by an increased number of handling nodes. Notably, stores are assuming a new role as logistics nodes, supporting both Home Delivery (HD) and Click-and-Collect (C&C) services (Kembro and Norrman, 2019).

In an HD setting, several arrangements are possible, ranging from scheduled to unscheduled and attended to unattended (Marchet *et al.*, 2018), depending on whether consumers have prearranged the delivery and whether their presence is required to collect the parcel. One of the main challenges in attended HD is the uncertainty surrounding consumers' availability to receive their orders. As opposed to stores, their opening hours are unknown (Rai *et al.*, 2019), which can lead to delivery failures if the recipients are unavailable when the parcels are offered (Kandula *et al.*, 2021). These unsuccessful deliveries represent a critical issue in last-mile delivery, resulting in high costs for e-commerce players, negatively impacting consumers' satisfaction (Seghezzi and Mangiaracina, 2023), straining the transportation system, and contributing to the increasing emissions from delivery traffic (Kübler *et al.*, 2022). A promising solution to mitigate these challenges is scheduling deliveries (Lee, 2017; Liu *et al.*, 2022; Seghezzi and Mangiaracina, 2023), allowing consumers to choose a convenient shift to receive their parcels.

Given the dynamic nature of consumer behavior and expectations in the omni-channel retail landscape, the need for customizing delivery options based on each consumer's preference becomes increasingly essential (Guerrero-Lorente *et al.*, 2020; Hübner, Holzapfel, *et al.*, 2016; Liu *et al.*, 2022; Marchet *et al.*, 2018; Shin *et al.*, 2022). Therefore, this study proposes a three-way distribution network operation structure to fulfill online orders from omni-channel retailers, providing two same-day delivery choices - in-store pick-up and express HD - along with the flexibility of scheduled HD.

The contribution of this research to the relevant literature is twofold. Firstly, it develops an omni-channel distribution network operation model catering to different modes of online order delivery. Secondly, it assesses the real-world performance of the proposed model through modeling and computational simulation and compares its results with the performance of a real multi-channel retailer operation.

The rest of this study is organized as follows: Section 2 offers a literature review on distribution networks in omni-channel retail and on the Consumer Value Theory. Section 3 presents a distribution network framework for different modes of online order delivery from omni-channel retailers. Section 4 outlines the research methodology and modeling assumptions. Section 5 showcases an application case. Section 6 discusses the theoretical and managerial implications, as well as limitations and future research propositions. Finally, Section 7 closes this study by summarizing its key contributions.

2. Literature review

To gain a comprehensive understanding of the main topics covered in this study, it is provided a literature review focusing on the distribution networks in omni-channel retail and the Consumer Value Theory.

2.1 Distribution networks in omni-channel retail

The omni-channel retail aims to establish a seamless and uniform shopping experience for consumers by eliminating distinctions between physical and digital touchpoints. This involves integrating operations to enable consumers to transition between channels effortlessly, ensuring a cohesive flow of information across all platforms (Abdulkader *et al.*, 2018; Fairchild, 2016; Hendalianpour *et al.*, 2022; Hüseyinoğlu *et al.*, 2018; Ishfaq *et al.*, 2016; Lee, 2017; Lim and Winkenbach, 2019; Marchet *et al.*, 2017, 2018; Murfield *et al.*, 2017; Sawicki and Sawicka, 2021). As distribution networks serve as the foundation of an omni-channel strategy (Hüseyinoğlu *et al.*, 2018), retailers need to reconsider their logistics systems (Montreuil, 2016) to provide delivery options aligned with consumers' needs (Ishfaq *et al.*, 2016).

Among the methods for delivering orders to consumers, HD involves considerable efforts and costs for retailers due to the large number of small deliveries to dispersed locations and the uncertainty of consumers' availability to receive their orders (Rai *et al.*, 2019). However, consumers benefit from the convenience of not having to travel to collect their orders (Montreuil, 2016), even though they typically need to bear shipping fees (Hübner, Holzapfel, *et al.*, 2016). On the other hand, C&C offers consumers the flexibility to retrieve their orders at a designated pick-up point at the most convenient time and location for them, thus avoiding waiting for HD and shipping costs (Guerrero-Lorente *et al.*, 2020; Janjevic *et al.*, 2021).

To efficiently deliver parcels to consumers' chosen locations, omni-channel retailers must integrate and coordinate different flows (Kembro and Norrman, 2020) to be capable of fulfilling demand using any inventory location (Hübner, Holzapfel, *et al.*, 2016). These networks comprise different facilities, including Distribution Centers (DCs) and stores, which are interconnected in handling tasks like order reception, processing, picking, packing, shipping, and ultimately delivering products to consumers, demonstrating higher efficiency compared to traditional networks that rely solely on DCs (Guerrero-Lorente *et al.*, 2020). The Ship-From-DC strategy, also called Ship-From-Warehouse (SFW), can lead to extended delivery times and higher shipping costs for consumers in areas distant from the DC. To address this, delivering online orders through the Ship-From-Store (SFS) strategy (Hübner, Holzapfel, *et al.*, 2016) can reduce order processing time (Lin *et al.*, 2022) and delivery expenses (Jiu, 2022; Marchet *et al.*, 2017) benefiting from the closer proximity of physical stores to consumers.

After all, the demand for rapid access to products has driven retailers to embrace innovative and diverse transportation strategies, which take into account factors like distance, order fulfillment time, and demand density in specific regions (Castillo *et al.*, 2018; Janjevic *et al.*, 2021). Retailers have different distribution options available, ranging from using their own means of transportation to outsourcing to Third-Party Logistics Providers (3PLs) or Crowdsourced Logistics (CL) (Rogers *et al.*, 2020).

2.2 Consumer value theory

Throughout the shopping journey, consumers praise different values, such as reliability, affordability, price, convenience, and personalization. One theory that aids retailers in understanding consumer's decision-making process, encompassing product evaluation (Sheth *et al.*, 1991) and delivery option selection, is the Consumer Value Theory. According to this Theory, consumers are capable of recognizing different forms of value during their interactions with retailers, including functional, emotional, self-oriented, social, and relational value (Zhang and Benyoucef, 2016), all of which can significantly influence their satisfaction (Chen *et al.*, 2016).

Online shopping delivery holds the potential to significantly enhance value perception for consumers by aligning with their expectations for speed, reliability, convenience, and security. One example is the ability to personalize delivery options according to individual consumer's preferences, such as granting the freedom to choose alternative delivery times or locations. It can also solidify the perception that the retailer is genuinely committed to fulfill the specific desires of each consumer, adding functional value to the shopping experience

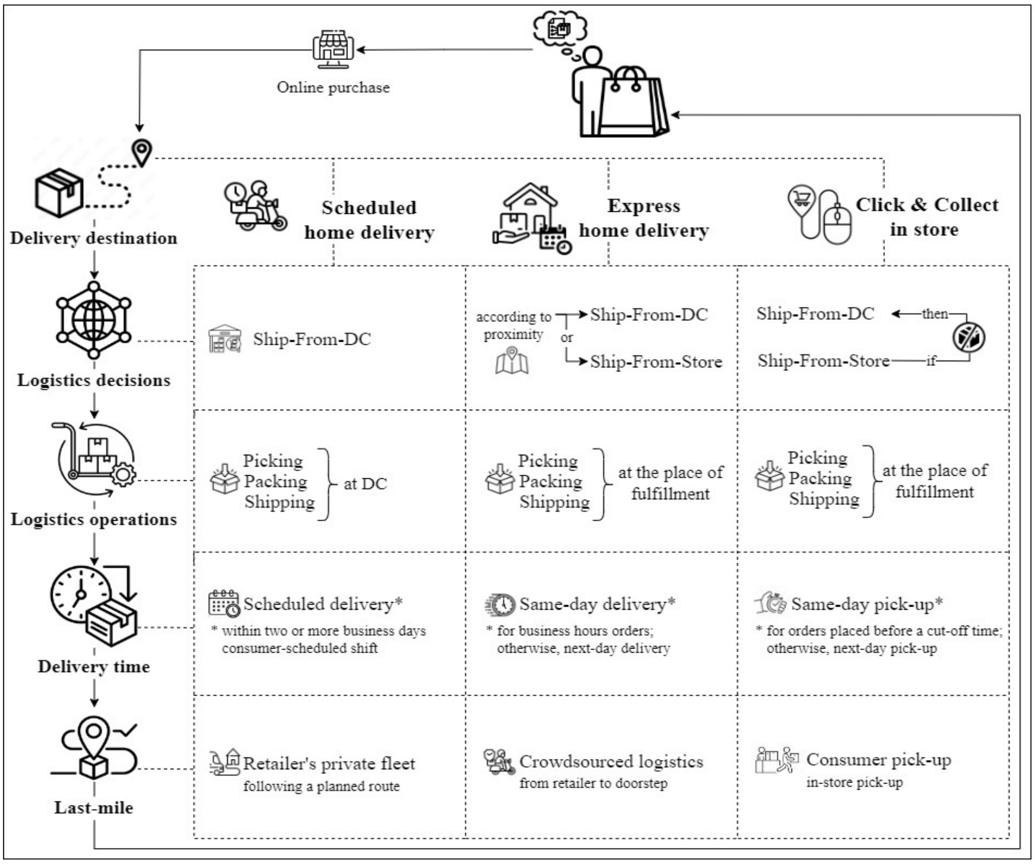
(Cheah *et al.*, 2022; Zhang and Benyoucef, 2016). Then, by understanding the importance of consumer values and aligning them with logistics services, retailers can deliver a value-driven shopping experience to their consumers.

3. Omni-channel distribution network for different online order delivery modes

Providing consumers with faster, adaptable, flexible, and convenient service profoundly shapes their shopping journey (Bergmann *et al.*, 2020; Castillo *et al.*, 2018; Fleischer *et al.*, 2020; Hendalianpour *et al.*, 2022; Hosseinzadeh *et al.*, 2021; Souza *et al.*, 2023). As a result, retailers are reconfiguring their distribution networks to meet these growing demands.

Drawing upon insights from relevant literature on distribution network structuring and the functional value defined by the Consumer Value Theory (Zhang and Benyoucef, 2016), the proposed approach features a distribution network framework for different modes of online order delivery from omni-channel retailers. Three distinct order delivery strategies were identified, thoughtfully selected, and tailored to effectively meet consumers' expectations, offering express HD and same-day in-store pick-up, as well as scheduled HD. This solution synergistically combines the SFS and SFW strategies, capitalizing on the strengths of both DCs and physical stores for efficient online order fulfillment (Millstein *et al.*, 2022). These strategies were designed to cater to scenarios where consumer presence is essential for order receipt (Marchet *et al.*, 2018), encompassing both attended HD and in-store pick-up options. The conceptual framework is visually depicted in Figure 1.

Figure 1 – Distribution network framework to fulfill online orders from omni-channel retailers



Source: Authors (2023)

The proposal of this framework is to provide consumers with three options for receiving their online orders, adding functional value: scheduled HD, allowing them to choose a specific date and shift for order receipt at an affordable delivery fee; express HD, ensuring delivery within a few hours of placing the order at a higher delivery fee; and in-store pick-up, allowing consumers to conveniently collect their orders a few hours after purchase without incurring any delivery costs.

Scheduled HD presents as a smart alternative to conventional HD methods, capable of mitigating delivery failures (Seghezzi and Mangiaracina, 2023). By allowing consumers to choose their preferred day and shift for order receipt, the likelihood of their availability during delivery is significantly enhanced. The retailer's dedicated fleet is responsible for handling the scheduled deliveries, utilizing inventory from the DC. To ensure efficient route planning and eliminate randomness in delivery locations, consumers are provided with available time slots starting two business days after placing their orders.

For consumers who prioritize fast delivery and are willing to pay a premium for it, the option of express HD is provided. In this approach, orders are retrieved from the nearest inventory point, which can be either a physical store or a DC, by a crowdsourced delivery driver, as deliveries with shorter delivery times usually favor outsourcing transportation (Janjevic *et al.*, 2021). Once collected, the contracted autonomous driver proceeds directly to the designated delivery address (Castillo *et al.*, 2018). Delivery is promptly accomplished within a few hours of order placement, assuming it was initiated during regular business hours. Orders placed after the retailer's operating hours are fulfilled at the beginning of the subsequent day.

Finally, to cater to consumers who prioritize the convenience of the online channel for their purchases, and seek rapid order fulfillment while avoid delivery costs (Guerrero-Lorente *et al.*, 2020; Janjevic *et al.*, 2021), the option of in-store pick-up is provided. Ensuring product availability for same-day pick-up involves establishing a distribution network with periodic responses, implementing a cut-off time for grouping and fulfilling orders (Snoeck and Winkenbach, 2021). Upon receiving an online order pick-up request, the store's inventory is promptly checked for product availability. Once confirmed, the product is prepared for collection by being picked, packed, and made ready. In cases where the ordered product is unavailable in the store's inventory, it is sourced from the DC, which delivers consumer-ready orders to the store once daily, after the cut-off time. Orders placed after the cut-off time and with no inventory in the physical store are made available for pick-up on the next business day. Clear and real-time communication with the consumer is crucial for the successful implementation of this strategy (Rai *et al.*, 2019).

4. Methodology

The application of multimethod simulation in retail distribution networks is widely employed due to its ability to provide a controlled environment for analyzing phenomena in a more synergistic manner than traditional simulation methods (Castillo *et al.*, 2018, 2022). In the specific context of omni-channel retail, simulation techniques have emerged as a valuable tool for investigation studies. Therefore, it was adopted an agent-based simulation combined with a discrete-event system to model the order fulfillment flow and associated processes, tracing the products' journey until it reaches the consumer within the proposed framework. This approach aims to provide valuable insights into the efficiency and responsiveness of the distribution network, facilitating the identification of optimal scenarios to meet the demands of omni-channel consumers before its real-world implementation.

4.1 Modeling assumptions

The primary aim of this simulation is to assess the performance of the proposed framework. To ensure comprehensive coverage of all seasonal variations, the simulation spans a one-year period.

To enhance the simulation's manageability, certain simplifying assumptions have been incorporated. Firstly, it was assumed that the DC consistently maintains adequate stock levels to fulfill orders and replenish the stores as needed (Arslan *et al.*, 2021). Furthermore, the replenishment of the stock used by the physical store to fulfill an online order is not analyzed. Additionally, vehicle accidents or breakdowns were not considered in the model (Castillo *et al.*, 2018). Moreover, the specific locations of consumers, their chosen delivery method, and the products and quantities in their orders remain unknown until dynamically and stochastically received throughout the day, thus closely replicating real-world delivery scenarios.

To conduct the simulation, it was employed the AnyLogic multimethod modeling and simulation software. This software enabled accurate and efficient execution of the proposed model, facilitating in-depth distribution network analysis. Following 30 replications of the simulation, it was calculated the average of the results obtained, which were exported and analyzed using Microsoft Excel software.

5. Application case

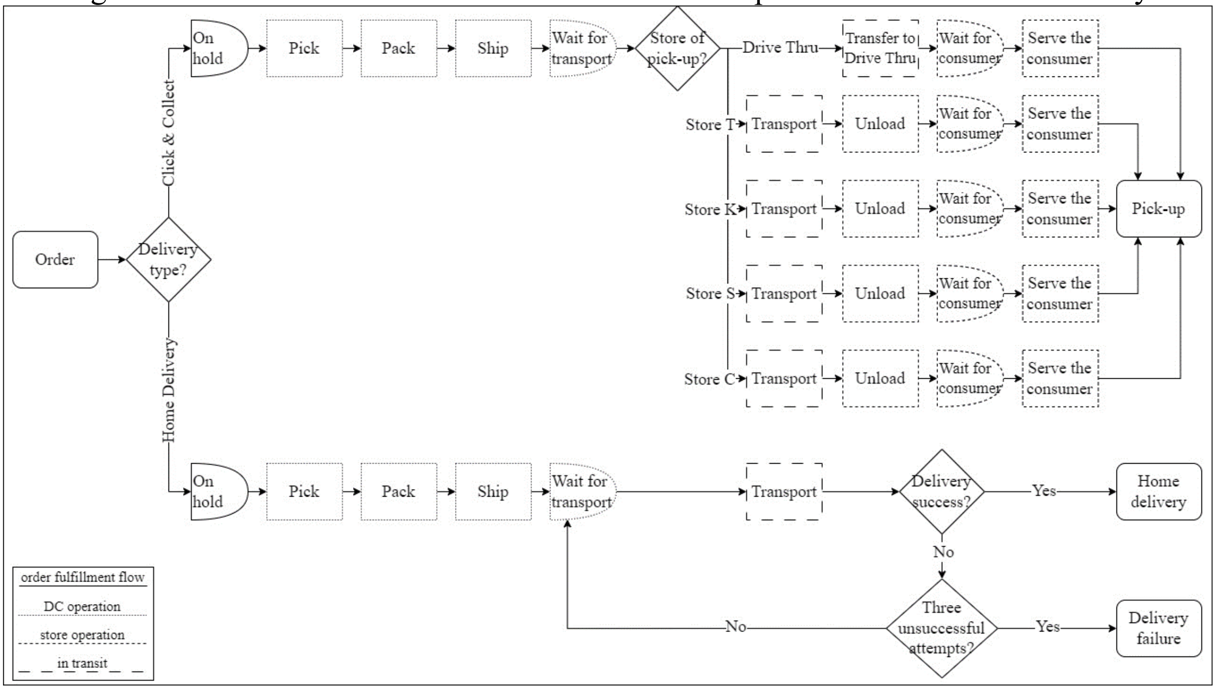
This section aims to outline the scenarios to be computationally modeled and simulated. Additionally, it will present the results derived from these simulations.

5.1 Scenarios

The proposed model was applied to a household goods retailer located in the southern region of Brazil, currently operating in a multi-channel configuration. The retailer has an established e-commerce platform, catering to approximately 14% of the company's orders, half of which originate from the local market. Furthermore, strategically positioned across the metropolitan region are four stores, denoted as Stores C, K, T, and S in this study. Moreover, the retailer operates a DC situated strategically in the metropolitan area, which includes a drive-thru facility. The stores' operations take place from Monday to Friday, between 9 a.m. to 7 p.m., while the DC operates from 8 a.m. to 5 p.m.. Special operating hours are in place during weekends, with Stores T and C opening on Saturdays, and Stores K and S opening on both Saturdays and Sundays.

With this in mind, two scenarios have been constructed. In the first scenario, the distribution reflects the retailer's conventional operation, where online orders are fulfilled solely from the DC's inventory without scheduling, for both HD and C&C. Ready-to-pick-up orders are dispatched from the DC to the stores two or three times a week, depending on store size and demand volume, following a pre-set schedule, with individual trips for each store that take an average time of 1.07 hours each. Consequently, consumers experience a minimum of two business days wait for pick-up at Store C and a minimum of three business days wait for Stores T, K, and S. At the drive-thru, the waiting time is one business day. The distribution network process of this scenario is illustrated in Figure 2.

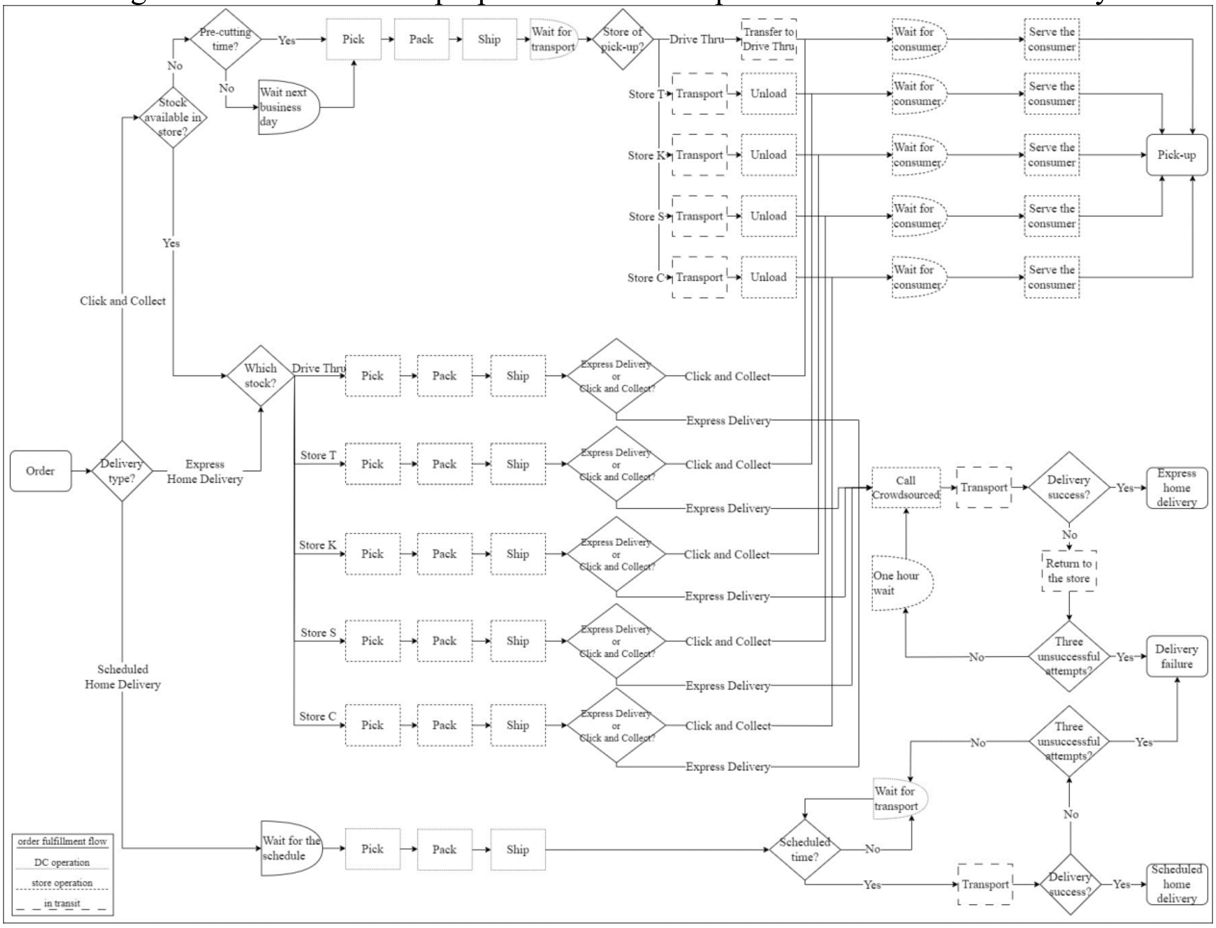
Figure 2 – Multi-channel retailer's actual distribution process: from order to delivery



Source: Authors (2023)

The second scenario, depicted in Figure 3, is composed of the framework proposed in Figure 1. In this scenario, the retailer offers the following delivery options: (i) express HD and (ii) in-store pick-up, both combining SFS and SFW strategies for online order fulfillment and (iii) scheduled HD, sourced from DC's inventory, where consumers can choose a specific date and shift for receiving their parcels. The cut-off time for same-day order pick-up was set at 11 a.m., from Monday to Friday, taking into account the transportation availability from the DC to the stores. The transportation time between the DC and the stores was estimated by the simulation of the route on Google Maps on three different days within the proposed timeframe. The daily route follows a sequence of stops at Stores K, C, T, and S, respectively, as it is the most logical route, taking approximately 2.14 hours until the truck is back at the DC. Since the drive-thru is located at the same address as the DC, it was not included in the route planning. Additionally, the stores that operate on weekends are able to fulfill express delivery and C&C orders whenever the items are available in their inventories.

Figure 3 – Omni-channel proposed distribution process: from order to delivery



Source: Authors (2023)

After establishing the scenarios, data collection was conducted over a one-year period, spanning from April 2022 to March 2023. The data collection process comprised five stages: (i) gathering verbal information from the retailer's partner and the engineer responsible for overseeing the online distribution process; (ii) retrieving databases containing the retailer's order and inventory history; (iii) recording operational times at the retailer's DC; (iv) reviewing relevant literature; and (v) surveying the retailer's current and potential consumers through an online form aimed to understand their reactions to the new delivery options within the proposed scenario, as well as their online order receiving routine, including in-store pick-up times and failed delivery attempts at their homes. The sample of respondents for the fifth stage was determined based on the population of online consumers served by the retailer during the one-year data collection period, with each order considered as a separate consumer. This process was carried out at a 95% confidence level with a 3% margin of error, resulting in a sample of 191 respondents.

The computational model was built upon several established definitions. Firstly, orders dynamically enter the model. For the retailer's current scenario, its local sales history serves as input, with 57.40% of demand for HD and 42.60% for C&C. For the proposed scenario, the same sales volume as the current scenario was considered, and consumer demand was derived from the survey results, indicating 41.00% of demand for scheduled HD, 12.00% for express HD, and 47.00% for C&C.

The pick, pack, and ship operation times were collected on-site at the DC and incorporated into the model as a normal distribution, with the standard deviation set at 20% of the mean. This adjustment accounts for time variations based on the number of items in each order and their specific locations on the DC shelves. Since the retailer does not have this process implemented in its stores, it was assumed that the pick, pack, and ship times in the stores would be 10% longer than DC's. This assumption was made considering that physical stores are primarily designed for product display rather than distribution (Larke *et al.*, 2018), making them less efficient compared to order picking and distribution from the DC, where the processes are specialized in parcel handling (Hübner, Holzapfel, *et al.*, 2016).

For C&C in both scenarios, the estimated time for consumers to retrieve their orders after availability was calculated using a triangular distribution. The minimum time was set as immediate retrieval, the maximum time as one week, and the mode as 17.08 hours, derived from the survey responses.

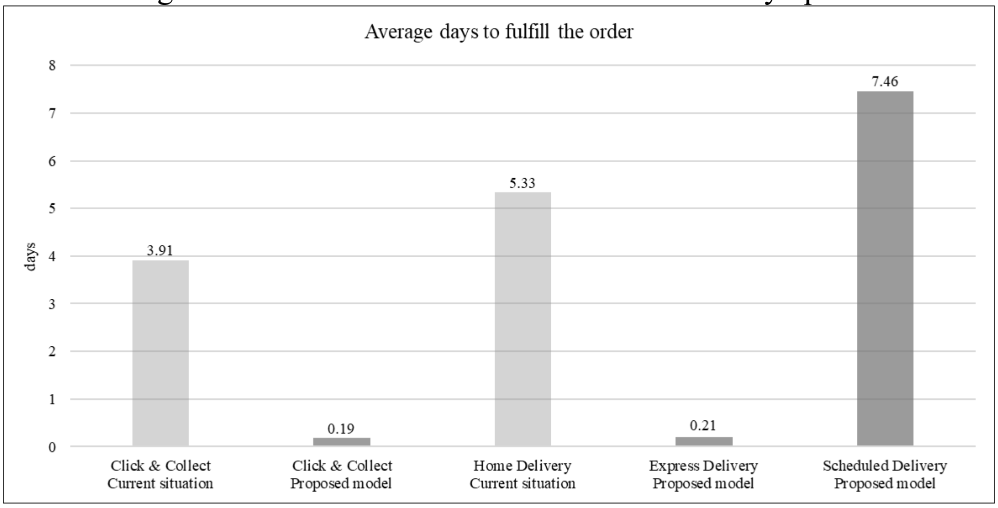
In HD, survey respondents reported an average success rate of 72.00% for the first delivery attempt within the current delivery situation, aligning with the findings of Kübler *et al*. (2022). Accordingly, for the current scenario, this success rate was modeled using a normal distribution, with the standard deviation set at 5% of the mean. Seghezzi and Mangiaracina (2023) identified an 82.00% success rate for typical deliveries and 97.90% for scheduled deliveries. Therefore, a projected enhancement in the success rate was envisioned for the proposed scenario according to the findings of Seghezzi and Mangiaracina (2023) compared to the average used in the current scenario. The success rate mean, estimated at 85.96%, was expressed in a normal distribution, with the standard deviation configured at 5% of the mean, for both scheduled and express deliveries. In cases of failed express delivery, a new attempt should be made one hour later. Conversely, failed scheduled deliveries undergo a new attempt the following day. All orders underwent three consecutive delivery attempts before being classified as failures. With these scenarios established, the following subsection will reveal the simulation results.

5.2 Results

This section unveils the outcomes derived from the computational modeling and simulation of the outlined scenarios. The simulation view is displayed in Appendices 1 and 2. Indicators were analyzed to validate the proposed method within a real-world context, selected with a focus on temporal and procedural aspects centered around enhancing consumer satisfaction and improving the distribution network.

First, Figure 4 illustrates the comparison between the current scenario and the proposed model concerning the average time required for order fulfillment. The segmentation is based on the available delivery options. Light gray columns depict the number of days the retailer currently takes to deliver products to customers' homes and make orders available for pick-up. Conversely, the dark gray columns represent the days it would take to deliver products in the three delivery options of the proposed scenario.

Figure 4 – Order fulfillment time for each delivery option



Source: Authors (2023)

For a thorough comprehension of the fulfillment times, it is essential to consider a couple of definitions. Initially, the C&C process's endpoint is recognized when the product is ready for collection, excluding the waiting time for the consumer's arrival. Additionally, for HD, the consumer's address sourced from the retailer's order history databases was employed for vehicle routing, thereby estimating the time required to reach the consumer's residence. Lastly, the results are founded on calendar days rather than business days since the proposed model considers order fulfillment on weekends in open stores. From these statements, the proposed distribution network achieved a delivery time of 0.19 days for C&C and 0.21 days for express HD, as opposed to 3.91 days for the current C&C and 5.33 days for the current HD. Despite the extended delivery time of 7.46 days for scheduled HD in the proposed model compared to the current setup, it served consumers who preferred receiving orders on specific dates, allowing them the flexibility to choose any date after two business days from order placement.

Given the substantial 95%-time difference in making orders available for pick-up between the scenarios, this variation is further elucidated in Table 1. The analysis delves into comparing the time required to make orders available and the place where these orders were fulfilled, taking into account the specificities of each scenario.

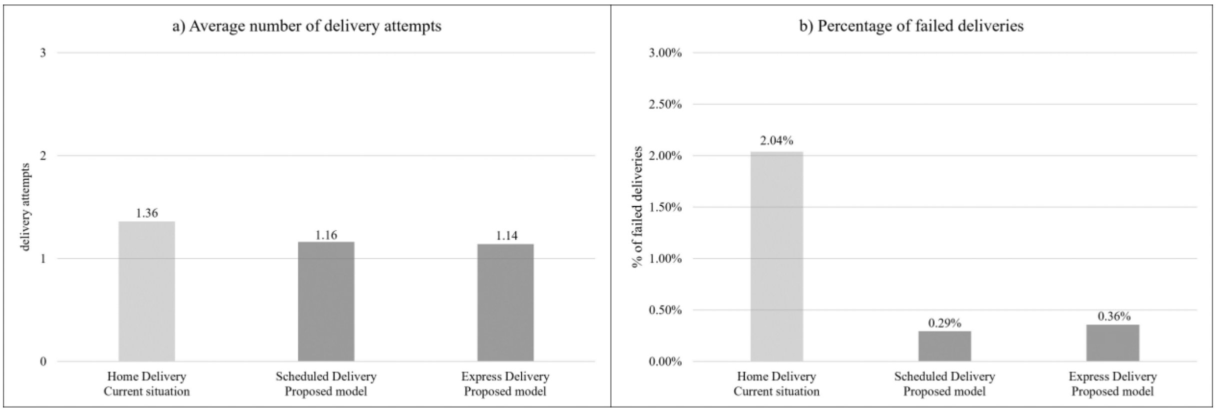
Table 1 – Order availability time and fulfillment location comparison

	Current situation		**Proposed model**	
Fulfilled by:	Store	DC	Store	DC
Same-day pick-up	0	388	2,496	78
Next-day pick-up (after-hours)	0	75	594	68
Next-day pick-up	0	91	2	210
Two or more days pick-up	0	2,900	1	5

In the current situation, all online orders are fulfilled through the DC, as it is the retailer's only physical facility handling this task. A substantial portion of orders becomes available for pick-up after a delay of two or more days post-placement. Out of the 463 orders made available for collection on the same-day and those placed after business hours and collected the next day were retrieved at drive-thru, which is integrated with the DC and receives goods daily. Conversely, the pyramid is inverted in the proposed model, with 93.69% of orders being fulfilled on the same day or placed after hours and collected on the next day. Among these, 95.42% were fulfilled by the designated store. The few orders fulfilled in the next day or in two or more days were handled by the DC and were placed after the cut-off time, making same-day fulfillment unfeasible due to the lack of stock in the physical store. This distinction becomes evident at the final stage, as consumers in the proposed model retrieve their orders in an average of 2.74 days, whereas consumers in the current situation take an average of 6.50 days to collect their orders.

The HD analysis encompassed the evaluation of delivery attempts made until consumers successfully received their products (Figure 5 (a)), along with the percentage of delivery failures after three unsuccessful attempts due to consumer absence (Figure 5 (b)). In the graph, the light gray columns represent the outcomes for the current situation, whereas the dark gray columns illustrate the proposed model results.

Figure 5 – Home delivery: delivery attempts (a) and failed deliveries (b) due to consumer absence



Source: Authors (2023)

The proposed model showcased a reduction in the average number of delivery attempts, dropping from 1.60 in the current situation to 1.52 for scheduled HD and 1.53 for express HD. Within the proposed model, a substantial percentage of orders – 86.94% for express HD and 86.05% for scheduled HD – successfully reached their destination on the initial attempt. The second attempt accounted for 11.99% of express HD and 12.10% of scheduled HD deliveries. Finally, on the third attempt, 0.72% of express HD were fulfilled, leaving 0.36% of express HD orders experiencing delivery failure, and 1.56% of scheduled HD were delivered, resulting in 0.29% of scheduled HD orders experiencing delivery failure. In contrast, the current situation presented 71.53% of deliveries succeeding on the first attempt, 20.67% on the second, and 5.75% on the third. The remaining 2.04% of orders in the current scenario could not be delivered due to consumer absence across the three attempts.

Overall, efficiency stands as a powerful measurement for achieving a company's core objective (Nilsson and Robinson, 2017), and efficient resource allocation plays a crucial role in determining a retailer's operation effectiveness (Achabal *et al.*, 1984). Building upon this premise, two fundamental parameters were analyzed to assess efficiency: the allocation of store employees, and the utilization of trucks for C&C order transportation from DC to the stores.

Table 2 displays the occupancy of these resources in both the current and proposed scenarios, considering the hours worked by each resource. The "truckToStore" resource denotes the transportation method accountable for conveying C&C goods from the DC to the retailer's stores. Furthermore, the "wkrStore" resource represents the stores' employees. Indeed, the last letter in the "wkrStore" blocks' name in Table 2 represents the respective store of the employee. The employee's occupancy percentage only accounts for time spent on pick, pack, ship, and receive orders tasks, with the remainder of their shift being allocated to other assignments.

Table 2 – Resources' occupancy on a workday

Block	Occupancy percentage Current situation	Occupancy percentage Proposed model
truckToStore	22.11%	23.81%
wkrStoreT	4.56%	5.52%
wkrStoreK	6.96%	7.20%
wkrStoreS	2.40%	3.60%
wkrStoreC	3.84%	4.32%

In the current situation, the "truchToStore" resource involves individual trips for each store, taking place two to three times per week. Contrastingly, the proposed model implements a comprehensive routing system that covers all stores daily. Despite the proposed model increasing the frequency of store visits, the impact is relatively modest. This observation is supported by the fact that, on average, the stores are approximately 16 minutes apart from each other, with a standard deviation of 1.53, and 17 minutes from the DC, with a standard deviation of 7.41.

In the current configuration, employees are not involved in the fulfillment process, but handle ready orders for pick-up from the DC. Conversely, in the proposed scenario, employees take on the responsibility of the end-to-end C&C fulfillment process. This includes conducting picking, packing, and shipping when products are available in-store, as well as receiving ready-to-pick-up orders from the DC when stock is depleted. Moreover, in the proposed model these employees also handle the activities of picking, packing, shipping, and calling for a CL for some express HD orders designated to their store. Thus, considering the local online demand volume of 7% in this studied scenario, the increased workload for store employees can be justified by the substantial proportion of orders made available for same-day pick-up and the partial fulfillment of express HD by the stores. However, with the potential increase in this demand segment due to the enhanced service level provided, these results may vary.

6. Discussion

This study contributes to the growing body of research on omni-channel distribution networks, which has garnered increasing attention from scholars (Arslan *et al.*, 2021; Castillo *et al.*, 2018; Hübner, Holzapfel, *et al.*, 2016; Janjevic *et al.*, 2021; Jiu, 2022; Kembro and Norrman, 2020; Marchet *et al.*, 2018; Qu *et al.*, 2022; Shin *et al.*, 2022). It specifically adds value by developing an operational framework for distribution networks catering to different modes of online order delivery. Recognizing the need for innovative solutions in online order fulfillment, a topic emphasized by retail experts consulted by Hübner, Holzapfel, *et al.* (2016), as well as Guerrero-Lorente *et al.* (2020), Liu *et al.* (2022), and Marchet *et al.* (2018), and validated by the Consumer Value Theory (Cheah et al., 2022; Zhang and Benyoucef, 2016), this research addresses the challenge by proposing a three-way distribution network for online orders from omni-channel retailers. Each delivery option within this network is tailored to fulfill distinct consumers' needs.

As the volume of online orders steadily rises (Marchet *et al.*, 2018; Zhang *et al.*, 2019), retailers are faced with an escalating need to strategically locate their inventory closer to consumers, postpone final distribution decisions, and outsource transportation (Janjevic *et al.*, 2021; Rogers *et al.*, 2020). Two proposed delivery modes – C&C and express HD – follow these guidelines and promise to fulfill orders within a few working hours after payment, targeting to bridge the gap of instant gratification between physical and online stores (Hübner, Holzapfel, *et al.*, 2016; Snoeck and Winkenbach, 2021). Figure 4 illustrated the significant reduction in order delivery times for these delivery modes, showcasing a 96.06% reduction in express HD time and a 95.14% reduction in C&C delivery time within their distribution network, all achieved without overburdening the stores' operations. In response to the increasing demand for delivery options that enable faster deliveries (Lim and Srai, 2018; Marchet *et al.*, 2018; Mangiaracina et al., 2019; J. Zhang et al., 2019), the proposed model stands out in this category.

On the other hand, last-mile delivery is one of the least efficient and most expensive processes for retailers, which holds significant implications for both meeting consumers' expectations and incurring costs (Hübner, Wollenburg, *et al.*, 2016; Kandula *et al.*, 2021). Recognizing the critical nature of the last-mile, retailers are increasingly focusing on innovative approaches to streamline this stage of delivery. Among these approaches, the scheduled HD mode, along with the express HD option, reconcile the retailer's shipping logistics planning with the most convenient times for consumer reception, effectively addressing the delivery failure issue highlighted by Kübler *et al*. (2022). As depicted in Figure 5, these alternatives notably decreased the average number of delivery attempts due to consumer absence from 1.36 to 1.16 and 1.14, consequently reducing the additional costs of a new delivery attempt and preventing overloads in the transportation system (Kübler *et al.*, 2022; Seghezzi and Mangiaracina, 2023). By minimizing the number of delivery attempts, scheduled delivery also reduced three-attempt delivery failures by 85.78% for scheduled HD and 82.35% for express HD, increasing consumer satisfaction by adding functional value (Cheah *et al.*, 2022; Zhang and Benyoucef, 2016) and reducing retailer's lost sale rates. This improvement can be attributed to the inherent nature of express delivery, where consumers anticipate receiving their urgent orders within hours, and scheduled delivery, which is planned within a timeframe when someone is likely available to receive the order.

Despite assertions from some authors suggesting that fulfilling C&C orders from stores could be less efficient and disruptive to stores' workflow, potentially adding inefficiencies into a site ill-designed for order picking (Ishfaq and Raja, 2018; Zhang *et al.*, 2019), the incorporation of store inventory for order fulfillment entailed minimal worker time usage. As depicted in Table 2, allocating store employees to picking, packing, and shipping tasks led to a slight rise in resource utilization, justified by the numerous to the logistics of delivering products purchased online. This includes the significant proportion of orders made available for same-day pick-up and the partial fulfillment of express HD by the stores. In the event of fluctuations in the online sales demand volume, further analyses will be required to determine whether the store workflow remains largely unchanged, ensuring minimal disruption to the store's operational flow.

Overall, the proposed three-way distribution network stands as a robust instrument to improve operational efficiency and cultivate a seamless, consumer-centric shopping experience through its strategic delivery alternatives. This model empowers retailer's operations, mainly reducing delivery time for online orders, and increasing the reliability of HD. Further, this study addresses research gaps and proposes solutions to enhance omni-channel distribution networks literature.

7. Conclusion

By proposing a distribution network structure that enables different modes of online orders delivery from omni-channel retailers, this study presented ways to improve the online order fulfillment process in line with the needs of the modern consumer. Employing a simulation-based approach, it has showcased the potential of incorporating store inventory to streamline order fulfillment processes, ensuring timely and responsive deliveries to consumers. Moreover, this study has accentuated the critical role of schedule HD in reducing delivery attempts and, consequently, delivery failures.

Despite the rigorous methodology employed, this study showcases inherent limitations that point towards avenues for future exploration. Firstly, the simulation model employed in this research was built upon certain assumptions to enhance its tractability. While these assumptions were essential for allowing the simulation process, they may not entirely capture the complexities and nuances of real-world scenario. Moreover, this study might not have comprehensively encompassed external elements, such as market fluctuations, regulatory changes, or unexpected events, which could potentially impact the distribution network's performance. Lastly, despite efforts to accurately estimate delivery success rates and other parameters, unforeseen changes in consumer behavior or other dynamic factors could potentially affect scenarios' performance.

To address these limitations, future research could focus on enhancing the practical applicability of this study's findings. One avenue involves conducting an in-depth study on consumer's behavior and preferences to gain valuable insights into their delivery expectations and preferences for different delivery options. This comprehension could lead to distribution network strategies more aligned with their needs. Furthermore, investigating the influence of external factors by conducting sensitivity analyses or scenario-based simulations could provide valuable insights into the network's adaptability amid changing conditions. Moreover, integrating online order fulfillment processes with those of physical store replenishment could represent a logical progression towards enhancing the retailer's logistical operations. Finally, implementing the proposed scenarios across diverse real-world omni-channel retail contexts would enable a more comprehensive validation of the model's outcomes and offer insights based on practice. Through the exploration of these aspects in forthcoming research endeavors, it would be possible to advance even more in the understanding of omni-channel distribution networks. Moreover, this exploration could lead to the development of more effective strategies for optimizing delivery performance, enhancing consumer satisfaction and overall operational strategy.

Despite the intricate complexities of real-world retail operations, the findings of this research underscore the importance of providing different delivery options that align with varying consumers' expectations, shaped by their perceived value in these processes. As the field of omni-channel distribution undergoes continuous evolution, the contributions of this research hold both theoretical and practical significance leaving behind a legacy of a way of organizing the retail distribution network to offer delivery modes adapted to the specific consumers' needs.

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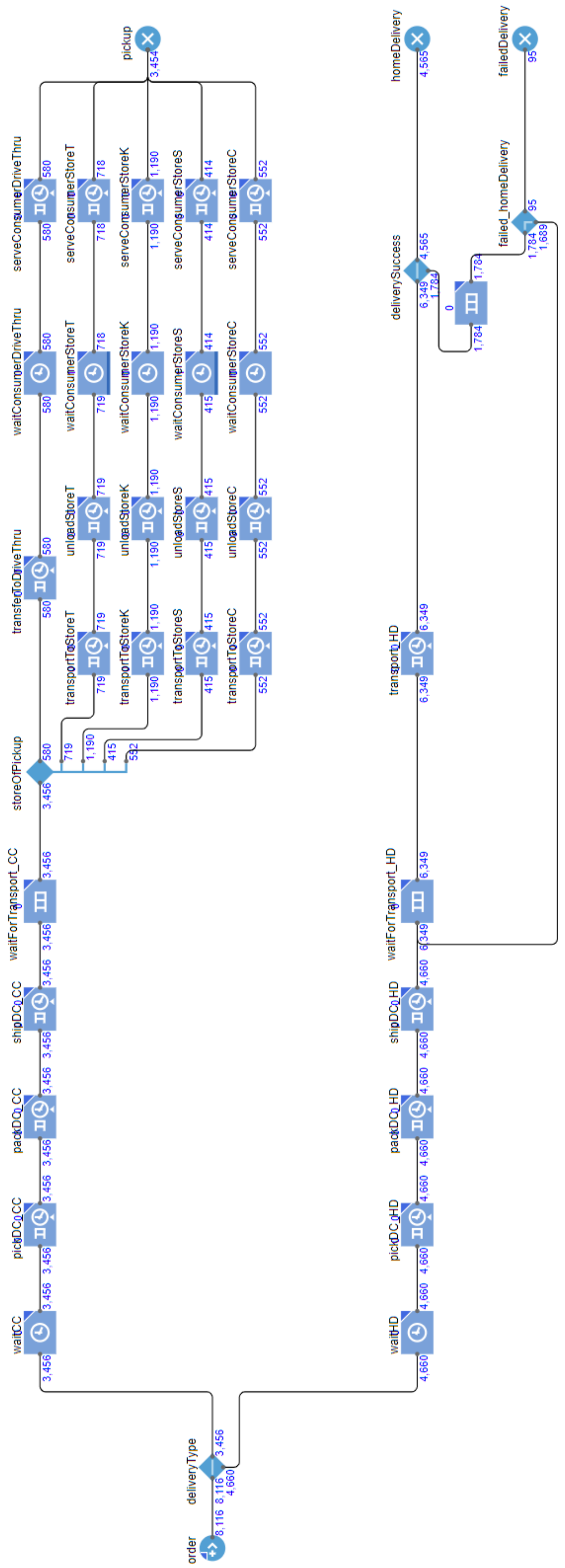
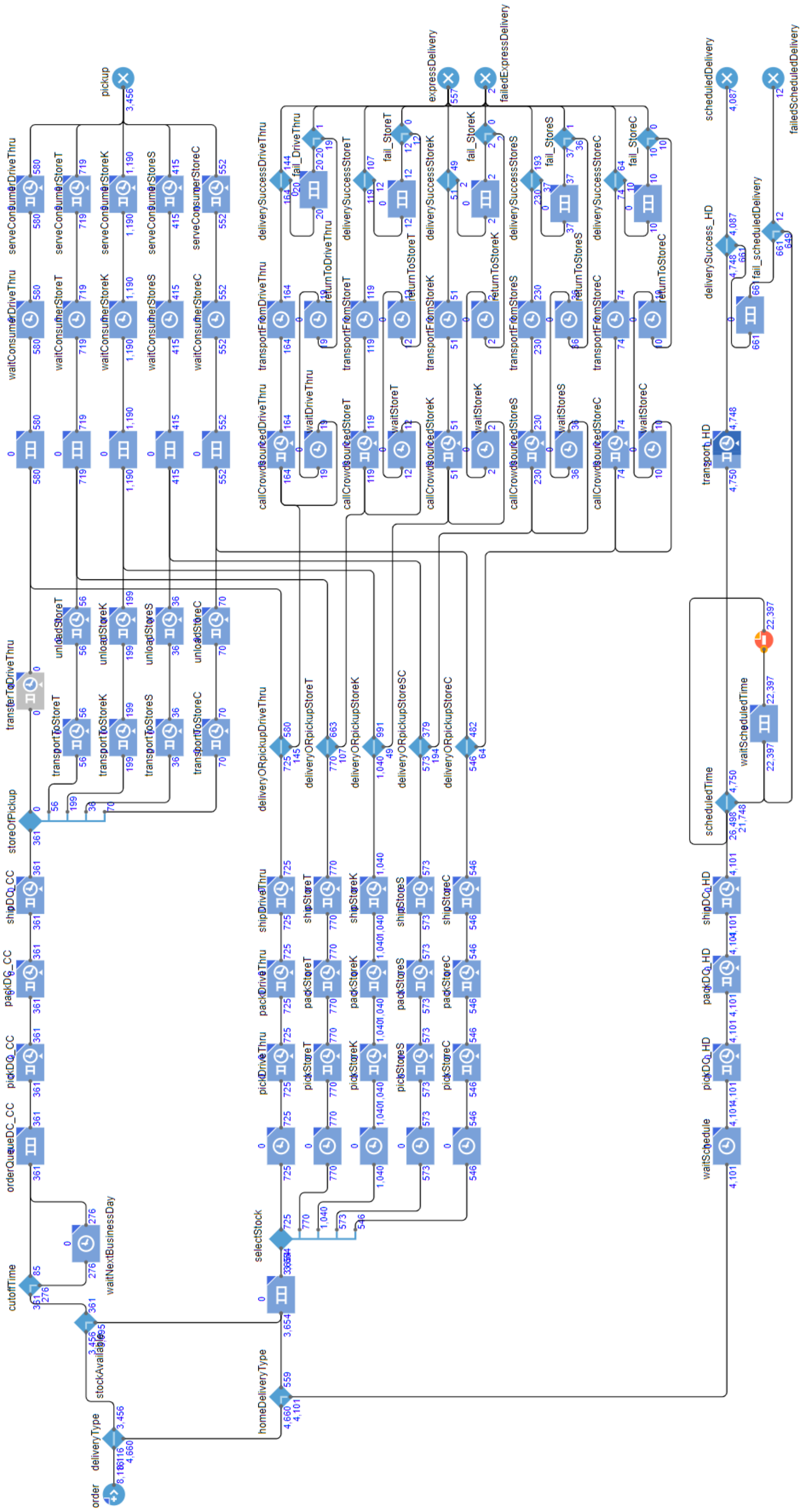
Appendix 1 - Simulation of the current scenario in Anylogic



Appendix 2 - Simulation of the proposed model in Anylogic



6 CONCLUSÃO

À medida que se avança, é crucial reconhecer a dinâmica transformadora que está moldando o cenário varejista. Com a conveniência e a velocidade de distribuição se tornando a norma, os consumidores se mostram cada vez mais exigentes em relação a opções de entrega flexíveis para atender às suas necessidades. Esse estudo demonstrou de maneira elucidativa como as redes de distribuição omni-channel podem oferecer uma variedade de modalidades de entrega para compras on-line, adaptando-se às demandas desse novo cenário.

A primeira etapa dessa pesquisa buscou investigar a organização das redes de distribuição omni-channel em termos do processo de entrega de pedidos aos consumidores, por meio de uma RSL. À luz das descobertas provenientes desta investigação, tornou-se possível identificar diferentes possibilidades de configuração para redes de distribuição omni-channel sob uma perspectiva abrangente, que engloba aspectos estratégicos, operacionais e de eficiência logística. Entretanto, a adoção prática dessas diferentes configurações ainda carece de explorações na literatura, indicando que a pesquisa no âmbito das redes de distribuição omni-channel encontra-se em estágios iniciais, demandando estudos em diversas frentes para ampliar a compreensão em torno do processo de entrega de pedidos aos consumidores.

Não sendo possível explorar todas as lacunas de pesquisa identificadas, optou-se por direcionar o foco para quatro questões de pesquisa de âmbito operacional e da velocidade de entrega, com o intuito de delinear um problema-chave para uma investigação mais detalhada. A proposição de soluções ao problema-chave delineado a partir da literatura desempenha um papel crucial no avanço dessa temática relevante. Assim, a segunda etapa dessa pesquisa baseou-se no desenvolvimento de uma estrutura de operação da rede de distribuição omni-channel para diferentes modalidades de entrega de pedidos on-line, propondo três opções de recebimento de pedidos: entrega em domicílio agendada, entrega em domicílio expressa e retirada em loja horas após a efetuação do pedido.

Na terceira e última etapa da pesquisa, procedeu-se à avaliação do desempenho do modelo proposto, utilizando modelagem e simulação computacional, em um contexto real de um varejista especializado na comercialização de produtos de utilidade doméstica, cujas instalações físicas estão situadas na região Sul do Brasil. Os resultados revelaram uma redução expressiva nos prazos de entrega de pedidos on-line, tanto para a modalidades de entrega expressa em domicílio quanto para a opção de coleta em loja física. Essa melhoria foi alcançada por meio da sinergia entre os fluxos provenientes das lojas físicas e do CD do varejista. Além disso, observou-se uma diminuição no número médio de tentativas de entrega em domicílio devido à ausência do consumidor nas modalidades de entrega em domicílio expressa e agendada. Essa redução resultou, consequentemente, em uma mitigação significativa das falhas de entrega em domicílio.

Assim, esse estudo fornece informações valiosas tanto para a comunidade acadêmica quanto para o setor varejista. Para os pesquisadores, a visão geral das redes de distribuição omni-channel apresentada por meio da RSL, aliada à proposta da estrutura de distribuição que oferece diferentes modalidades de entrega para compras on-line, estabelece uma base sólida para investigações subsequentes nesse campo. As descobertas proporcionam aos varejistas uma compreensão holística das redes de distribuição e oferecem percepções valiosas para aprimorar a operação de seus processos de distribuição de pedidos on-line. Tais achados se configuram como um guia para ajustar suas operações, resultando em entregas mais rápidas e confiáveis e, consequentemente, em maior satisfação dos consumidores.

Embora esse estudo tenha proporcionado *insights* valiosos às redes de distribuição omni-channel, é imperativo reconhecer algumas de suas limitações. Em primeiro lugar, a seleção de um conjunto limitado de fontes para a elaboração RSL pode ter restringido a amplitude da revisão, potencialmente deixando de considerar perspectivas valiosas sobre a temática que poderiam ter influenciado no delineamento do problema-chave selecionado para ser amplamente explorado. Além disso, o escopo dessa pesquisa pode não ter abordado todas as nuances e complexidades inerentes à implementação prática das estratégias sugeridas, sujeitando-se a limitações decorrentes do uso de dados secundários e da aplicação de metodologias de modelagem e simulação, fatores que podem impactar a generalização dos resultados. Nesse contexto, como extensão natural desse estudo, a realização de um estudo de implementação prática do modelo proposto poderia enriquecer a compreensão do seu real impacto. Adicionalmente, as variáveis comportamentais dos consumidores, como preferências individuais e tolerância a atrasos, não foram profundamente exploradas, o que poderia influenciar os resultados em situações específicas. Assim, explorar a otimização da gestão das redes de distribuição, levando em consideração tanto o perfil individual dos consumidores quanto a capacidade da rede, emerge como uma investigação crucial. Consequentemente, embora esse estudo forneça uma base sólida para compreender o papel das redes de distribuição omni-channel nas opções de entrega on-line, é essencial ponderar tais limitações ao interpretar e aplicar seus resultados.

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