Goods distribution in city logistics network: impact of online shopping

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Abstract.

The rise of e-commerce has transformed traditional goods distribution systems, particularly in urban areas. This paper explores the impact of online shopping on city logistics networks, with a focus on how it influences transportation, delivery efficiency, and the environmental footprint of urban freight systems. Online shopping has led to increased demand for last-mile delivery services, resulting in changes to distribution routes, urban infrastructure, and delivery times. The study examines key factors such as traffic congestion, delivery methods, and the growing reliance on technology to streamline operations. Additionally, the research investigates the challenges and opportunities that arise from the surge in e-commerce, including the integration of sustainable practices to mitigate the environmental impact of logistics operations in urban settings. Findings suggest that while online shopping offers significant convenience and growth potential, it also places considerable pressure on city logistics systems, highlighting the need for adaptive policies, technological innovations, and collaborative strategies between stakeholders. The paper concludes by offering recommendations for optimizing goods distribution networks in cities to accommodate the ongoing shift towards e-commerce while ensuring efficiency and sustainability.

Keywords: Supply Chain Optimization, Online Shopping, Delivery Systems

1. Introduction

E-commerce has rapidly expanded due to increasing internet usage, leading to a surge in B2C online shopping and home deliveries. This shift has transformed consumer behavior and supply chain dynamics, while also increasing demand for last-mile delivery, which remains the most expensive and complex segment of distribution urbanization further complicates logistics, with growing populations driving city expansion and increasing trade uncertainties. Efficient city logistics networks are essential for business profitability and customer satisfaction, ensuring timely product availability at competitive prices.to address these challenges, businesses must optimize distribution strategies, considering factors such as delivery costs, traffic congestion, and dedicated distribution centers to enhance efficiency and sustainability in urban logistics. This study is structured into four sections. Section 2 critically reviews literature on online shopping, goods distribution, last mile delivery, and city logistics. It is followed by section 3 that presents the research aim and research questions. Section 4 presents the research methodology.

1.2 Objective

1.Analyze the Impact of Online Shopping on Urban Logistics: To examine how the increasing popularity of e-commerce influences urban logistics networks, focusing on goods distribution efficiency and delivery systems.

2.Evaluate the Challenges in Last-Mile Delivery: To investigate the specific challenges faced in last-mile delivery within city logistics networks, particularly as a result of the growth of online shopping.

3.Assess the Effects on Traffic and Infrastructure: To assess the impact of goods distribution from online shopping on urban traffic congestion, transportation infrastructure, and overall mobility within cities.

2. Literature Review

Within supply chains, downstream distribution from producers to customer plays a significant role in the environmental performance of production supply chain. In a generic distribution network, goods are produced in one or more plants and successively stocked in distribution centers for their distribution to final customers. Firm must establish distribution plans depending on the supply network, i.e. the number of layers, the number of distribution centers operating at the different layers, the fleet vehicles, the set of customers and the type of goods involved, in order to satisfy the customer requirements and minimize total cost (Ambrossio D. and Sciomachen A. 2006). Effective logistics and technologies are critical success factors for distribution systems in most supply chain networks (Thratilis et al., 2005). Traditionally, the critical success factors for an effective distribution system included meeting the requirement of the demand side of the supply chain through delivery of good quality products in appropriate quantities to the right place using the optimal path at the right time with optimal cost (Aghazadeh, 2004). Hence, an effective blueprint for an economically competitive modern goods distribution system calls for the inclusion of a methodology which can collectively deliver reduced environmental impact, lower operating cost and optimized traversed paths. This distribution strategy promotes an approach that seeks to achieve mutually reinforcing benefits for the economy, environment and society (Ilbery and Maye, 2010). Maintaining cost efficiency and a high level of service in the distribution system is crucial for the logistics providers to remain competitive in online shopping (Anderson and Leinbach, 2007).

According to the past decade, it has seen host of firms have seen to extend their supply chains directly to the end customer. Managing this portion of the supply chain, home delivery service for the customer, has been termed the “last mile” issue (Punakivi et al., 2001). With numerous opportunities exist to the customer convenience and operational efficiencies by delivering directly to the customer. Last mile delivery is a crucial part of the supply chain of a product, and it can make or break the relationship to their customers, this is issue become one of the bottlenecks of online shopping (Wang et al., 2014). Last mile delivery service, in which purchased product are delivered to the doors of consumers, is presently requested by the majority of online customer. However, it remains an expensive option. The costs of the last mile delivery of products range between 13% and 75% of total supply chain costs (Gevares et at., 2009). In their quest to reduce costs and improve operation efficiency. Speed and cost are the two factors that are crucial to the success of the last mile delivery. It has been a particular problem from a logistics infrastructure standpoint, most notably because of trade-offs between routing efficiency and customer convenience (Punakivi et al., 2001). Another issue, which firms much address when extending their supply chain to last mile, comes from consumer standpoint. Specifically, the method by which consumers place orders can have a significant impact on transaction costs and customer service. A successful last mile supply chain initiative therefore seems to require attention to the customer order cycle (Thomas J. et al., 2007). The proliferation of instant communication technologies enables logistics providers to seriously consider this new opportunity in last mile logistics. The integration of end-to-end information sharing within the logistics process promises a competitive advantage for online shopping). Hence, the operational challenges stately consumer direct delivery is intimidating. Many firms have failed due to operational and logistical problems met with delivering orders directly to customers. The fulfillment process for consumer direct orders can be broadly characterized as consisting of three stages: order acceptance, order selection and fulfillment and order delivery. Each of these stages is critical to providing excellent customer service at a cost the customer willing to pay (Boyer K.K. et al., 2009).

Table 1. Overview of objectives for city logistics analysis

Objective	Description
Economic	- Develop and improve the freight system towards improving the local, regional and national economy
Efficiency	-Minimization or reduction in transport operation costs related to en-route travel, end-point activity and energy - Focus on congestion, role of freight and costs to freight - Road network deficiencies including road design and geometry, maintenance, signage, local area traffic management and arterial capacity - End-point costs associated with loading and unloading, parking, terminal activities, hours of operation and site access and egress - Energy costs associated with vehicle speed and character and shipment type
Road safety	- Minimization of property damage, injury and fatality-related accidents - Focus on policy related to traffic management, road design, vehicle design, driver training and land use
Environmental	- Focus on mitigation of noise, area and vibration pollution - Perceived threat of large vehicles and intrusive activity in residential areas
Infrastructure and management	- Explore government influence through regulations, pricing controls, taxation and investment - Road construction and maintenance and its relationship with freight sector
Urban structure	- Focus on interaction between freight facilities and urban structure including interaction between freight and urban structure, city size and its effects on freight cost, and freight as a use of urban land

Research Aim and Questions

This research aims to develop a city logistics service network model to distribute goods from an intermodal hub (i.e. seaport/airport), linked to inland dry ports, to a geographically dispersed demand across a larger metropolitan city under the emergent online shopping environment. To achieve this, the following questions will be answered:

3.1 What is the likely impact of an increased online shopping on a city logistics network?
3.2 How would the city logistics network adapt to just-in-time last mile home delivery requirements?
3.3 What models can be applied to optimize service networks (i.e. shopping mall/warehousing/home delivery) to distribute goods in a metropolitan city?

3. Methodology

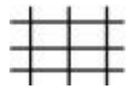
The methodology presented in this work is divided into 4 stages: (a) Literature Review (b) City logistics network development (c) Scenario construction (d) Service delivery optimization models

3.1 Literature review

3.1.1 Road Network

Network analysis is a spatial analysis tool used in GIS to determine the optimal path within a network. A network consists of interconnected linear features, such as roads (edges) and junctions (nodes), which facilitate transportation or communication. Each edge in a network is associated with direction and impedance (cost or resistance) that impacts travel. One key application is in transportation planning, where the goal is to find the shortest or least-cost path or identify all locations within a specific travel cost from a given origin (Husdal, 2000). Road networks are essential infrastructure that connects people, businesses, and services, and their reliability is crucial for daily travel and logistics. The network's connectivity is defined by the availability of functional paths between origin-destination pairs Road network patterns, such as grid, radial, or linear influence connectivity, continuity, and efficiency (Xie & Levinson, 2006). For accurate route-finding in GIS, it is essential to properly simulate real-world road network specifications. Quantifying network patterns using both typology and geometry enhances the reliability of results. Traffic analysis zones (TAZ) are often used to evaluate relationships between road networks and traffic characteristics. In summary, GIS-based network analysis plays a crucial role in optimizing transportation networks, ensuring connectivity, and improving route planning and traffic management.

Table 2. Elements of road network pattern

Types	**Characteristics**	**Representation**
Grid	Mainly grid with 4-legged interactions	
Warped parallel	Curved or rectilinear formations, 3-legged interactions	

Types	**Characteristics**	**Representation**
Mixed	Mixture of different elements	
Loops & lollipops	Loop roads with many branching routes in tree-like configurations	
Sparse	Low connectivity, mainly culs-de-sac	

3.1.2 Distribution centers

The design of distribution systems is one of the key components of logistics systems as they offer great potential to reduce costs and to improve service quality. Distribution centers are the one of the most important components in a supply chain. In the context of a new global economy, the pressure has increased on distributors to rapidly supply products to customers. In such a competitive market, filling customer orders within a 24-h period is becoming the new standard in many industries, including the pharmaceutical, food, beverage, office supply, and furniture industries (Gagliardi J.P. et al., 2008). The global and competitive business environment has identified the importance of a quick and efficient service towards the customers in the past few decades. Distribution center plays an important role in maintaining the uninterrupted flow of goods and materials between the manufacturer and customers. Performance of the DC can be judged on the basis of its ability to provide the right goods, at the right time and at the right place. The lead time or transit time to deliver the goods to the customer is an important parameter for measuring the efficiency and effectiveness of a particular DC in supply chain (Chan T.S. and Kumar N., 2009). Traditionally, distribution centers act as the double role of inventory storage and transfer location. Therefore, it is one of the most important decisions for supply chain management to optimize DCs' locations and their scales under uncertain market environment. However, demand uncertainty and market fluctuation are widespread. In real logistics systems, there are many uncertain factors in distribution center locations such as the randomness of setup cost, the fuzziness of the demand. How to deal with these uncertainties in location planning is a popular research topic. The most common uncertainties can be classified as randomness and fuzziness (Zhou L. et at, 2015).

3.1.3 Location of Shopping Center

Due to the emergence of modern lifestyles, retail shopping has shifted from shopping at small independent shops to large retail outlets and from superior at shops nearest to one's place of residence to regional shopping malls. Malls, being viewed as rejuvenated urban centers, from hubs of retail, social, and community activities, that host restaurants, officers, stores and movie theaters (Government of Ireland, 2005). It is because large shopping malls provide a variety of goods and services and are a place of modernization and cleanliness for attracting shoppers. Key attractions are the ideal concentration of shopping malls. These include department stores, supermarkets, fashion stores, shops selling leisure products, and food service. Hence, choosing a location is the most crucial decision to be taken by retailers. For identifying the selection criteria, the retail site appraisal and choice model (Berry et al., 1988). The model identifies five major parameters and four basis market research items for retail choice. Of these identified elements, some are able to form the criteria for selecting shopping mall location. For example, geographic limits, location type, competitors, and accessibility are suitable to assess the physical conditions of potential sites. Furthermore, it is expected that the benefits of a good location mainly include a competitive advantage and return on investment. A good location mainly attracts shoppers (Cheng E.WL. et al., 2005).

3.2 City logistics network development

Similarly to any complex transportation network, city logistics network requires planning at strategic, tactical and operational levels. The strategic level is concerned with the design of the network and its evaluation. It also addresses the continuous analysis of deployed systems and the planning of their evolution, both as standalone systems and in relation to the general transportation systems of the city and the larger region that encompasses it. In particular, the choice of a specific city logistics structure, e.g., single or two tiered, should be based on cost-cost benefit analyses performed using such strategic planning model (Morchadee et at., 2019). The model should also select the city logistics network, e.g., the access corridors and the streets open to each vehicle type and determine of only two contributors and challenging issues and for two-tiered systems. The city logistics network where consolidation and coordination activities are performed at facilities organized into hierarchical, two-tiered structures with major terminals sited at the city limits and satellite facilities strategically located close to or within the city center. A particularly challenging issue in planning two-tiered city logistics systems concerns the integrated short-term (next “day”) scheduling of operations and management of resources. Coordination and time synchronization of vehicle operations are central elements of the problem and the formulation proposed contributes to both their originality and their difficulty. Two new problems classes are thus introduced, the single and the two-echelon, synchronized, scheduled, multidepot, multiple-tour, heterogeneous vehicle routing problem with time windows (VPRTW).

The use of scenarios to study the future is well known as an approach to studying situations that can lead to important changes and in which it is difficult to create explicit relationships among the events. Scenarios have been widely used for exploring the detection of future events together, as well as analysis of the path that leads to the desired future or prevents undesirable futures (Chermack T.J. 2004). To explore the behavior of the system in the future, the set of variables that is the key to a correct description of any system and the interactions that will shape the future have to be explored. Scenario-generation methods combine a set of behaviors that mix qualitative and quantitative, subjective and objective methodologies in different layers (Harries C. 2003). There are variety of methods used to design scenarios; generally, the choices of the methodology depend on the problem, the resources, and the levels of sophistication of the planners and users Among the best-know methods are the Delphi method, cross impact analysis, simulation and scenario writing (Schnaars S.P. 1987). Cross impact analysis (CIA) is one of the most used techniques for generating and analyzing scenarios. Another success factor of the approach in scenario analysis is that it is a flexible methodology that can be combined with other techniques such as Delphi (Banuls V.A. and Salmeron J.L. 2007), Fuzzy (Asan U. et al., 2004). or Multi-criteria (Cho K.T. and Kwom C.S. 2004) methods to allow true collaborative model building and scenario creation by groups.

3.4 Service delivery optimization models

Optimization aims to find the best solution to a problem based on specific criteria, often involving either maximization or minimization (Kiran M.S., 2015). The Vehicle Routing Problem (VRP) is a well-known combinatorial optimization problem focused on finding the most cost-efficient routes for delivering goods using a fleet of vehicles. VRP aims to minimize travel costs while servicing all customers from a central depot (Rais A. et al., 2014). A variant, the Vehicle Routing Problem with Time Windows (VRPTW), adds time constraints to each task node, enhancing service quality by ensuring deliveries occur within specified time frames (Hu W. et al., 2013). In VRPTW, the objective is to minimize either the number of vehicles, travel distance, or delivery time while respecting customer time windows. VRPTW can be solved using exact algorithms, though heuristic methods like Particle Swarm Optimization (PSO) offer a promising and efficient alternative for finding near-optimal solutions (Hu W. et al., 2013).

4. Results

The GIS-based network analysis provided valuable insights into the design and optimization of city logistics. It successfully demonstrated the critical role of network patterns, connectivity, and impedance factors in route planning. The application of traffic analysis zones further refined the understanding of network efficiency and traffic management. These results can be applied to enhance urban logistics, improve transportation planning, and optimize service delivery in the city.

References

Aghazadeh, S. (2004). Managing distribution channels for improved performance. *Industrial Management & Data Systems, 104*(7), 532-541.

Ambrossio, D., & Sciomachen, A. (2006). A distribution network optimization model for supply chain management. *International Journal of Production Economics, 101*(1), 65-76.

Banuls, V. A., & Salmeron, J. L. (2007). Cross-impact analysis and scenario planning. *Futures, 39*(5), 623-642.

Berry, L. L., et al. (1988). Retail site appraisal and choice model. *Journal of Retailing, 64*(1), 36-57.

Boyer, K. K., et al. (2009). The impact of last-mile logistics on customer satisfaction. *Journal of Business Logistics, 30*(1), 175-195.

Chan, T. S., & Kumar, N. (2009). Evaluating distribution center performance. *International Journal of Logistics Management, 20*(2), 218-238.

Crainic, T. G. (2009). Urban freight transportation: Challenges and perspectives. *Transportation Research Part C: Emerging Technologies, 17*(6), 541-547.

Gevares, R., et al. (2009). Cost analysis of last-mile delivery. *Logistics and Transport Review, 45*(3), 45-60.

Government of Ireland. (2005). Urban retail planning guidelines. *Department of Environment and Local Government*.

Husdal, J. (2000). Network analysis in transportation planning. *Journal of Transport and Land Use, 3*(2), 67-79.

Jenelius, E. (2010). Connectivity and reliability in transportation networks. *Transportation Research Part B: Methodological, 44*(3), 954-967.

Kiran, M. S. (2015). Optimization models in logistics and transport. *Computers & Operations*

Research, *57*, 62-78.
Miller, H. J., & Shaw, S. L. (2001). *Geographic Information Systems for Transportation: Principles and Applications.* Oxford University Press.
Moryadee, C., Aunyawong, W., & Shaharudin, M. R. (2019). Congestion and pollution, vehicle routing problem of a logistics provider in thailand. *The Open Transportation Journal*, *13*(1).
Nicholls, L., & Watson, K. (2005). Distribution strategies for e-commerce. *Journal of Business Logistics, 26*(2), 125-148.
Punakivi, M., et al. (2001). Home delivery and last-mile logistics. *International Journal of Physical Distribution & Logistics Management, 31*(6), 414-426.
Sadeghi-Niaraki, A., et al. (2011). GIS and transportation network analysis. *Transportation Research Part C: Emerging Technologies, 19*(5), 756-769.
Thomas, J., et al. (2007). Customer order cycles in e-commerce logistics. *International Journal of Production Economics, 110*(2), 310-320.
Wang, Z., et al. (2014). Bottlenecks in last-mile delivery. *Logistics Research, 6*(3), 231-245.
Zhou, L., et al. (2015). Managing uncertainties in distribution center location planning. *Supply Chain Optimization, 8*(1), 44-60.