EXPLORATORY SPATIAL ANALYSIS OF THE DISTRIBUTION OF E-COMMERCE LOGISTICS FACILITIES

(電子商取引関連物流施設分布の探索的空間分析)

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Dedication to
everyone who is fighting against COVID-19
at this moment

“... strive not to be a success, but rather to be a value...”

Albert Einstein

DECLARATION

This dissertation is the result of my own work and includes nothing, which is the outcome of work done in collaboration except where specifically indicated in the text. It has not been previously submitted, in part or whole, to any university of institution for any degree, diploma, or other qualification.

Signed: MERENCHIGE CHATHURA KOVIDA DE SILVA

Date: August 20, 2020

EXECUTIVE SUMMARY

With the growth of online retailing, logistics and supply chain systems had undergone a significant change. The contemporary research focused more on the mobility aspect and direct impacts of these dynamics, including the locations of last-mile delivery systems and logistics facilities. However, a lip service had paid on the first-mile logistics facilities and their locations. In that context, this research investigates the location and spatial organization of these logistics facilities. This study performs a multi spatial scale analysis with particular reference to Amazon company who pioneered the fulfillment logistics while Tokyo Metropolitan region as the geographical focus.

Firstly (*1), the spatial organization of* Amazon logistics facility in the UK and Japan is studied. The results indicate the variation of spatial organization patterns with the settlement form and accessibility to transport infrastructure, especially for expressway interchanges. Secondly, *(2)* investigate how the spatial pattern of e-commerce logistics varies on a firm with different products and business focus. The firms include pure online retailers, Third-Party Logistics Firms in fulfillment sectors, and omnichannel retailers in the Tokyo Metropolitan region. The empirical analysis revealed the different patterns of spatial organization between the chosen firms. Thirdly *(3)*, neighborhoods of all large-sized (over 100,000 sq. ft.) Amazon logistics facilities worldwide. The results indicate how the number and type of facilities vary by the urban form at the National scale. The analysis at the neighborhood scale analyzed the spatial patterns of clustering and infill development at dense locations associate with Amazon facility locations. Fourthly *(4)*, develop a location choice model to demonstrate the variations in location choice between different firms related to e-commerce logistics facilities. This multinomial logit model incorporates a range of variables representing firm attributes, accessibility, zonal, and land characteristics. A new measure, to represent the attractiveness of a given location for e-commerce markets is introduced to represent the attractiveness of different locations e-commerce logistics facilities, that are serving national and regional markets. The analysis reveals the relationship between the location choice of pure e-tailers with the multiple variables, including the attractiveness level of each

location to potential e-commerce markets, the existing socio-economic trends, and patterns distribution and trends associated with the transport sector establishments. The location model for the omnichannel store location affirms the differences conditions that influence the location selection of omnichannel store locations.

The core knowledge contributions of this study are as follows: Firstly, to the knowledge of the geography of logistics facilities by emphasizing e-commerce logistics facility locations. Although e-commerce, as seen as a driving force of changing geographies of logistics facilities, the geography and spatial organization of these facility types, had not been studied so far. Secondly, the specific case study of Amazon contributes to expanding the scope of research focused on e-commerce companies and their strategies, which also include the logistics strategies. Thirdly this study contributes to the existing location choice models developed for logistics facilities by introducing new variables to incorporate the e-commerce logistics dimension.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

TMR	- Tokyo Metropolitan Region
UK	- United Kingdom
MNL	- Multi Nomial Logit model
FC	- Fulfilment center
DC	- Distribution center
3PL	-Third Party Logistics

1 INTRODUCTION

One of the remarkable changes in the last few decades is the thriving of online shopping, frequently known as e-commerce or online retailing. Initially, it begun as a marketplace, and most economists and marketers were keen on contributing to the sector. Lately, its progressed into a major theme in knowledge domains of supply chain and logistics. These developments became visible at urban environments with rapidly changing consumer behaviors. From a logistics perspective, the last-mile delivery logistics are at the forefront of contemporary research. At the other end, large-sized fulfilment logistics facilities that serve the first mile emerged in recent years. In that context, this chapter detail out the problem statement, research objectives and novelty and knowledge contributions of this study.

" How fulfilment centers are changing American towns" [1]
"Is The 'Golden Triangle' Still the Centre of UK Logistics? [2]

1.1 Problem statement

With the advancements and growth of Information and communication technology (ICT) penetrated deeply into the individuals' everyday practices while effects are visible in the society irrespective where the locations are- homes, business, offices, and other locations.

In recent years, B2C e-commerce has shown rapid growth and expansion in developed and emerging economies. Information and communication technology-driven e-commerce operations inevitably formulate new spatial and temporal relationships [3]. The effects of e-commerce on the environment can be understood in both short and term contexts. [4][5]. The most popular branch of research is the direct mobility effect, which includes passenger and freight transport changes. Indirect effects of accessibility include supply chain configurations and choice of logistics facility location.

Based on the nature of the transaction and the involvement of different parties in the process, it is classified as business to business (B2B), business to consumer (B2B), and customer to customer (C2C). The B2C sector is showing a stable growth pattern in most developed and emerging economies in the world. The growth and penetration are not limited to the western countries but also to East and South Asian countries, which show its dynamism in the business. From a supply chain perspective with a broader interest in the environment, conceptual models developed to demonstrate the mobility and accessibility effects of b2c e-commerce[4]. Such effects include the travel behavior of individuals, activity choices individuals, freight transport decisions of firms and dynamics in logistics facilities. Majority of the literature published on the effects of online trading discussed the first three types, where only a handful of writings explore how logistics facility decisions influenced by e-commerce [5].

During the early days of e-commerce, Romm in 2002 argued that e-commerce would revolutionize the structure of supply chains and changes are visible today [6]. New logistics facilities that entirely support the e-commerce through functional specialization are rapidly emerging in parallel to the growth of the online retail B2C segment [7]. These facilities are different from traditional logistics facilities and range from large fulfilment centers and small freight stations to locker systems that support the last-mile delivery. The functional requirements of e-commerce are directly influencing the establishment of logistics facilities as a part of the firms' logistics strategy. The priority given for the end customer is a trademark in the whole supply

chain revolution. It increased the importance of home deliveries, which in turn had a shift from supplier centric supply chain systems to customer-centric and pull-based supply chain configurations [8]. Hence the e-commerce logistics facilities can be recognized as a part of broader e- supply chain configurations[9].

On this backdrop, the emergence of the e-commerce logistics model gives rise to new forms of logistics facilities, commonly known as fulfillment centers, which is becoming an integral part of e-commerce operations. These trends are more a representation of the shift of traditional marketing-based e-commerce to fulfillment logistics. Traditionally e-commerce companies only involved in web-based marketing while order fulfillment – pick, pack, and delivery- was carried out by third-party fulfillment firms. Over time, this model replaced with an evolving model, where firms carry out both marketing and logistics to ensure a better customer experience while managing the overall cost structure of the firms. Amazon.com, pioneered in the B2C e-commerce market, has operations at over 20 countries and established different types of e-commerce logistics facilities to support its operations. These, new logistics facilities that entirely support e-commerce through functional specialization (Rodrigue, 2017) are a result of that evolving e-commerce logistics model. These new trends can be recognized as an outcome of the decentralization of distribution systems to be on par with e-commerce dynamics [4]. The functional requirements of e-commerce are directly influencing the establishment of logistics facilities as a part of the firms' logistics strategy. Inventory ownership and location, order picking, assembly, and delivery recognized as main components that are important in developing logistics strategies [10]. These e-commerce logistics, especially the large-scale distribution centers, are a means of achieving scale in business by enhancing its fulfillment and distribution capacity [11].

Although a growing number of studies had touched on the location and organization of logistics facilities, the following research gaps can be highlighted. Firstly, the main focus had been on last-mile delivery logistics facilities [12]. From a node perspective, this includes the location of parcel hubs and delivery stations. From a network perspective, the focus had been on modes of last-mile delivery [13]. From an environmental and policy perspective, the focus had also been on the effects of these growing trends [14]. Secondly, an abundance of literature on optimal locations also focused on identifying the optimal locations to set up delivery stations and last-mile

delivery facilities. Similarly, a growing trend is observed among the optimization route to integrate the route optimization and facility location problems.

Secondly, there has been growing interest in recent years exploring the geographical dimension of logistics facilities [15]. he main focus was on large-sized facilities than the small sized last-mile delivery logistics facilities. The effects of e-commerce highlighted as a critical factor that drives these changes, including logistics sprawl and clustering [16]. Further, a recent classification of logistics facilities in the Paris region recognized e-commerce logistics facilities as a separate typology [17], which deemed the emerging aspects of e-commerce logistics facilities in the context of geography. Further, given the data limitations, most studies unable to distinguish e-commerce logistics facilities from the other type of logistics facilities. A handful of studies tried to explore the real estate impact of these logistics facilities along with the spatial organization of these logistics facilities, based on case studies in the USA and China [18][19]. These studies are primarily driven by the size and growth rate of e-commerce markets in the above counties. However, the expansion of the Amazon logistics network at many other locations opens the gateway to exploring this dimension further at other locations, except the USA and China.

1.2 Research questions

After careful review of contemporary research published on e-commerce, the geography of logistics, and recent developments in e-commerce, this thesis focused on exploring '*how the location and spatial organization of logistics facilities can be understood in the context of urban form, with case studies*.' The study established that urban form at multiple scales as a vantage point exploring the location and spatial organization patterns of logistics facilities. The specific sub-questions explained below.

1. Does the spatial distribution of e-logistics differ from traditional logistics?

It is proposed that the primary means of distinguishing the e-commerce logistics from traditional logistics to compare the spatial distribution patterns of both types. The spatial organization understood at different spatial scales. This include national, regional and local scales. This study employed a national scale to initiate the study. It is the first-tier spatial scale that is useful to understand the organization pattern within a country. On the other hand, the nature of the organization pattern comprehended with a comparison against a similar e-commerce market with different urban forms. Urban forms, in this case, referred to, explain how settlements and infrastructure organized within the country.

2. Does the spatial organization of e-commerce logistics companies vary between different firms?

E-commerce is wide subject area which can be distinguished from multiple dimensions. Similarly, the e-commerce logistics characterized by the type of firms involved in the operation. Basically, four types of firms recognized through the preliminary analysis.

a) Pure e-commerce firms who own/ operate their own logistics facilities –- tailing
b) Pure e-commerce firms who own/ operate their own logistics facilities – products manufactured to the order
c) Third Party Logistics firms facilitate specifically for e-commerce operations

d) Omni channel retail stores - using the traditional store locations to serve online orders (originally recognized as retailing locations, later perform dual operations)

3. Do e-commerce logistics alter the location characteristics of its neighborhoods?

Neighborhood scale analysis employed to recognize the location characteristics around a given development. The analysis focused on understanding what are the location characteristics around the fulfillment logistics centers. Locational characteristics characterized through the built up / not built up area of a particular neighborhood and the average building footprint of the built-up features.

4. How to explain the location choice of different e-commerce logistics facilities of different e-commerce firms?

Generally, models are developed as an abstract means of generalizing a phenomenon. In this study, the location choice modeling employed to explain what factors seem significant with the location choice patterns. Further believed that this modeling initiative useful for future researchers as a tool to explain and predict the location choice of such facilities. It recognized that this would be an extension to contemporary models that aim at explaining the location choice of logistics firms. On the other hand, within the scope of the question, the limitation associated with the available data on firm locations will be acknowledged.

This study mainly considers Amazon as a base case for the study. It is globally recognized that Amazon grows, expands, and uniquely does business compared to other operators in e-commerce. On the other hand, they continued to expand the logistics network, which found to be unique from other logistics facility typologies. In that context, this question focused on whether the locations the firm chosen to inherit any unique characteristics. Further going forward intends to explore whether any significant changes observed at this facility locations.However, it is essential to explore how other firms, including other e-tailers, 3PL forms, and omnichannel retailers who use their existing retail locations, adapt the same within their operations.

1.3 Aim and objectives

This study aims to distinguish the location and spatial organization patterns of logistics support e-commerce as an emerging phenomenon in the context geography of logistics and to explore factors that relate to these patterns. The specific objectives of the study are as follows:

A. Explore the relationship between the spatial organization of e-commerce logistics facilities with the urban form at the national level, by considering Amazon as a case study
B. Compare and contrast the spatial organization patterns of distribution between e-commerce logistics facilities by different firms through a case study in the Tokyo Metropolitan Region
C. Record the location characteristics around the neighbourhood s of Amazon fulfillment logistics facilities
D. Investigate the significance and effects of accessibility and socio-economic trends of a region on the location choice of e-commerce logistics facilities.

1.4 Originality and significance of the research

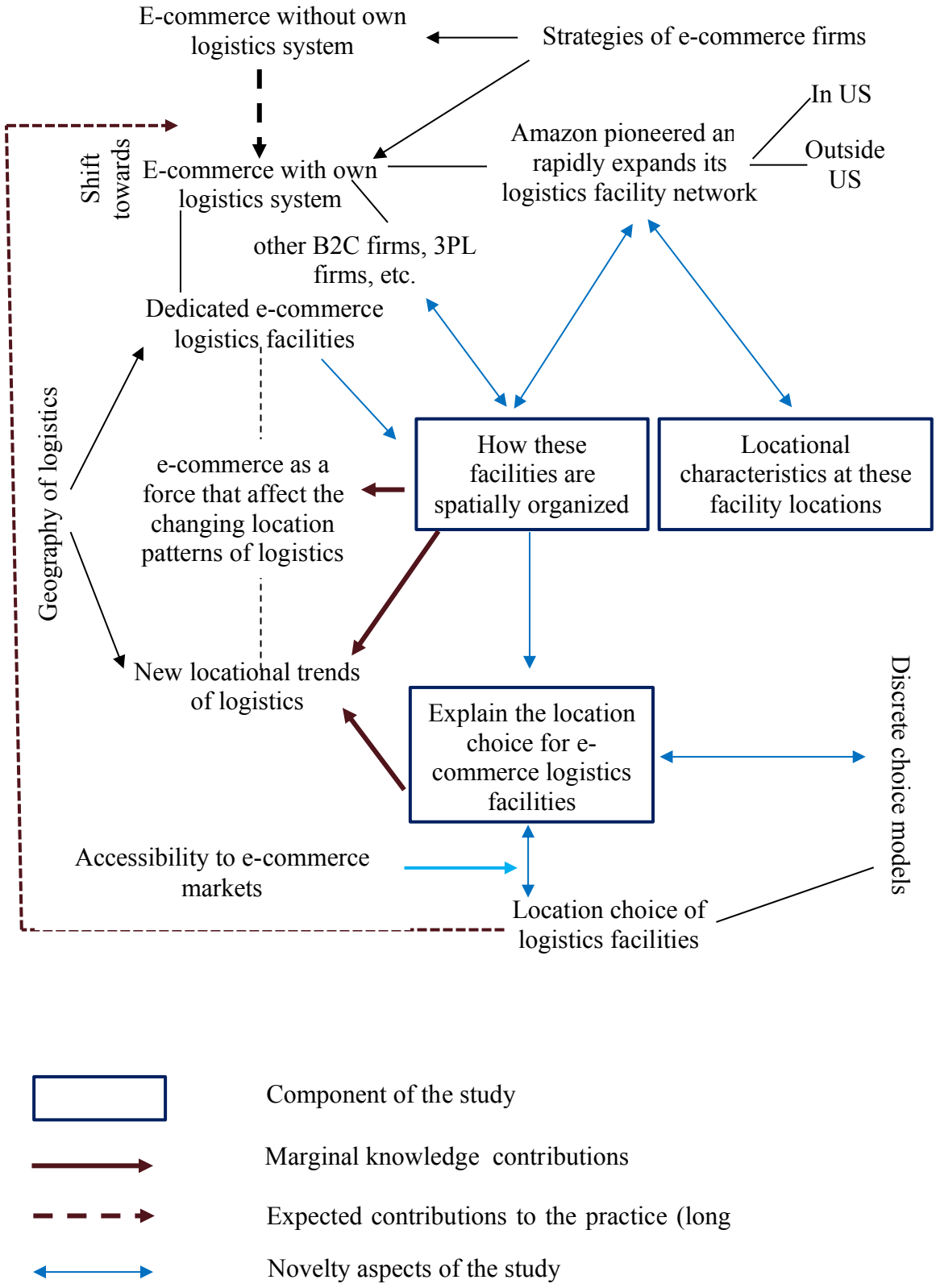
1.4.1 Originality of the study

The originality of the study highlighted in the context of three knowledge domains. Firstly, to the knowledge of the geography of logistics facilities by emphasizing e-commerce logistics facility locations. E-commerce, as seen as a driving force of changing geographies of logistics facilities. Further e-commerce logistics typologies as a distinct typology. However, the geography and spatial organization of these facility types had not been studied so far.

Secondly, the specific case study of Amazon contributes to expanding the research focused on e-commerce companies and their strategies, including logistics strategies. The investigation of Amazon as a case study expected to unravel companies' logistics strategy with a geographical and locational focus. Traditionally, ICT driven e-commerce and urban studies are seen as two disparate domains of knowledge, although the interplay between two domains is recognized.

Thirdly this project also contributes to extending the traditional location theory by exploring how the location choice of E-commerce logistics companies evolve compared to other types of firm location choice. The location choice models that are already developed for the same region enable this understanding, although the variables and modeling framework are different in principle. The proposed measure of regional attractiveness of alternative locations as a logistics service location to constrained market locations is a new variable inclusion to the research location choice modeling ff logistics facility location; in addition, this study incorporates contemporary socio-economic trends at alternative locations as a variable. The novel aspects of this study and critical contributions in the context of three knowledge domains- the geography of logistics, strategies of e-commerce firms, and discrete choice modeling, are illustrated in figure 1.1.

Figure 1.1: Novelty and contributions of the study



1.4.2 Significance of the study

This study is timely, given the rapid changes observed in recent years. The big companies are shifting towards logistics based online operations from being a traditional online marketplace strategy. On the other hand, the emergence of small and medium 3PL firms supports the new entrants to the e-commerce sector. The size and scale operations expected to vary between the locations. However, it is a common characteristic observed in both the developed and developing world. Apart from that, omnichannel business models continued to pose changes to how traditional store locations chosen and used. This shift the focus from retail store locations as small commercial spaces to e-commerce fulfillment warehouses. In that context, it is pivotal to recognize the geography and location of such logistics facilities for given market segments.

These tendencies widely visible across the world during the COVID19 pandemic. Under 'new normal' lifestyle circumstances, online retailing became the primary mode of shipping, and traditional shopping became the alternative. The shares of global and local e-commerce firms rocketed at share markets along with other digital-based platforms. The randomly collected shreds of evidence via the internet and social media channels indicate the effects of this from a consumer perspective. The consumers living in areas with better e-commerce logistics capability had less difficulty adjusting to 'new normal' lifestyles than the other counterparts. The logistics capability defined both in terms of facility locations and deliveries. Facility locations determined whether particular items available while deliveries decide when it will be delivered to the households. The traditional retailers struggle to serve the demand in the absence of outbound logistics strategies. It is unavoidable since outbound logistics was never a part of the traditional retail model.

In that context, the essence of this study can also serve as a knowledge base in developing logistics strategies for online retailing. The clear case of Amazon is particularly useful for new entrants for the e-commerce market and 3PL firms with online order fulfillment. On the other hand, planners and policymakers can see how these trends affect the cities in general.

1.5 Expected contribution to theory and practice

This study enriches the professional practice of three distinct and interrelated planning domains: strategic planning (economic development planning) land use planning, and transportation planning. Strategic planning referred to the planning undertaken at national, sub national or regional levels with more interest on economic goals. Land use planning denote the traditional role of planning and managing land uses at city scale.

1.5.1 Strategic planning

It is pivotal to recognize the emerging sectors at different regions to plan the strategic development of the respective region. This also include the incentives to attract and integrate such sectors with ongoing infrastructure development projects. There is distinction among how different locational factors resemble importance for different activities. This study distinguishes fulfilment logistics as a sector with distinct locational factor compared to traditional locational factors. Further proposes the location choice models as a tool for assessing the regional attractiveness for fulfilment logistics facilities.

These findings need to be assessed at specific contexts to realize actual repercussion and implications. This specifically include the;

a. planning new economic clusters (fulfilment towns, fulfilment hubs),
b. formulation of cluster development proposals to revitalize economy of regions, and
c. harness the development potential at transnational (especially in case of Europe) and inter regional expressway interchanges.

1.5.2 Land use planning

The exact role and title of the land use planners may vary between one country to another. The general purpose in which Land use planners entrusted with still remain the same everywhere. Which is to plan and manage the land uses. Managing include, providing appropriate infrastructure and avoid conflicts between different uses. The understanding of emerging trends related to land uses is a prerequisite in this regard. Explicitly the awareness of the geography of e-commerce logistics remain low.

In that context, the thesis evidently emphasizes on following aspects:

I. Describe the type of regions and locations are at the center of attraction for fulfilling logistics facilities in comparison to traditional distribution centers. The findings highlight different characteristics at different spatial scales. Findings can directly use to assess the attractiveness of different locations by combining with ongoing infrastructure development projects in particular. The location choice model be useful as a tool in such assessments.

II. Comparison between the traditional store locations and net shop locations indicate the changing location preferences of both activities. The changing patterns of demand for commercial real estate can be useful facts in formulating future development plans for cities.

III. The newly introduced accessibility variable support in assessing the attractiveness of a given municipality for e-commerce logistics facilities.

IV. The proposed logit model incorporates two distinct variables to represent contemporary trends at the municipal level. The variables include the ‘rate of change’ of population and other activities related to e-commerce logistics and ‘share of selected activities’ compared to the overall number of the same activity in the TMR region.

1.5.3 Transportation planning

The study of freight movement patterns is a crucial subject in transportation planning at municipal and regional levels. The first step of the process includes the identification of locations of trip generations and attraction. This study demonstrates a methodology to determine how different cities attract e-commerce logistics facilities. Such locations expect to increase the number of freight trips generations. Therefore, transportation planners can include these findings to determine the changes in freight origins. Similarly, the suggested approach to distinguish e-commerce markets will help assess the destinations of e-commerce led freight generations.

1.6 Definition of key terms

E-commerce: In this study, E-commerce is referred to as the online retailing (B2C) and does not include the B2B and C2C channels of online retailing

Logistics facility: an establishment that is either a warehouse, distribution center or similar facility

E-commerce logistics facility: A facility that is solely or partially used to support and fulfill online orders. Large-sized fulfillment centers include the e-commerce logistics facilities over 100,000 sq. ft. And serve the above purpose. This study also used the term Fulfilment center to denote the same. Besides, this includes small-sized facilities that may serve as prime hubs for pure e-tailers and stores that perform the logistics functions specified above as fulfillment.

1.7 Scope of the thesis

Although it is impossible to set sharp boundaries for the study of this nature with multiple domain facets, the following points emphasized to ensure the scope of this study. The spatial organization and spatial structure often used to describe the cities. However, this study particularly considers the distribution of population, accessibility to main transportation modes, and distribution of other main economic activities. This study does not consider the environmental features that affect spatial organization patterns. Similarly, the governance and decision-making processes between individuals, firms, and agencies were not considered in the study.

The data used for the study gathered from secondary sources that include both offline and online sources. This thesis does not depend on primary data collected by the researchers through any sample-based surveys.

As defined earlier, although the term' e-commerce' is used, the study only focused on the B2C category. The logistics facilities can also be studied even in the context of B2B and C2C channels.

In selecting case studies, Amazon in different countries is given prominence over other emerging examples. The selection is due to the research objectives and data availability. It was decided that very little of Amazon logistics facilities been so far studied outside the USA. Similarly, the emerging examples neither reveal its logistics system for public nor clear evidence exists to trace its logistics facility locations, further, in developing the location choice models, some of the selected firm data on e-

commerce fulfillment logistics facilities proven to be inadequate to develop a substantial discussion through statistical analysis.

1.8 Organization of the thesis

The thesis includes eight chapters. Chapter o1 provides a comprehensive overview of the overall research study with a detail account of the problem statement This includes the background of the research, research questions, Aims and objectives of the study.

Chapter two explain the contemporary research related to the study from multiple perspectives. The section includes the growth and trends of e-commerce; e-commerce logistics; geography of logistics facilities; and, location theory and models. Chapter three of the thesis is dedicated in providing the conceptual framework of the study along with methods and techniques used in the study. This conceptual framework relates the key research questions of the study with the location of logistics, e-commerce and location choice models. We argue that this research will be a new dimension for the research on the geography of logistics facilities.

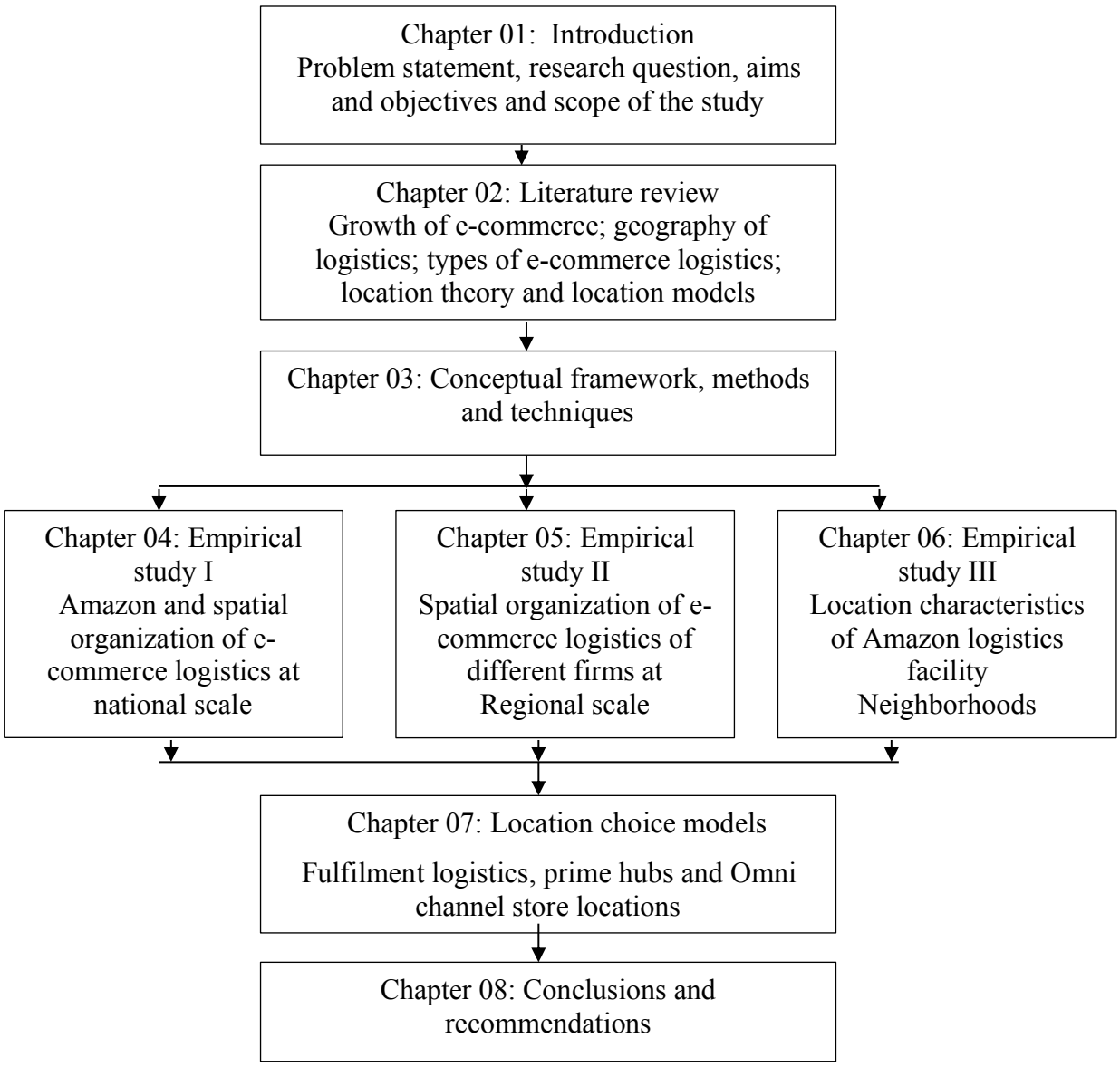
Fourth chapter seek to demonstrate how the spatial organization of logistics facilities can be understood in the context of urban form at national scale. Since Amazon is s pioneering firm in the e-commerce logistics, the firms' locations at UK and Japan are used as the case study. Fifth chapter of the thesis discuss how the spatial organization of logistics facilities varied between different firms who operate different e-commerce logistics facilities. This study was carried out in Tokyo Metropolitan Area, Japan. The chapter explain in detail on how the spatial organization seems to be following different patterns. Chapter six of the study is an empirical study on location characteristics around the e-commerce logistics facility locations of Amazon worldwide. This comparative study is to find out whether these recent trends of mega fulfilment centers had any effect on immediate neighborhood s. This chapter is important in the context of evidences drawn google earth images and time series analysis.

Seventh chapter propose location choice models for these different e-commerce logistics facilities. Two separate models are developed to represent the choice of fulfilment centers (serving national and regional markets) and for prime hub and omni channel logistics facilities (serving local markets). Understanding and modelling of location choice behaviour of this emerging trend expect to serve as the basis for further

research and will be at the interest of policy makers and planners to understand how these new trends going to emerge and evolve in cities and regions under broader socio-economic contexts.

Finally, the eighth chapter is dedicated to describing the conclusions of the study and to propose future recommendations. This further outline the key limitations of the study and propose a directive for further improvements.

Figure 1.2: Organization of the thesis



2 LITERATURE REVIEW

This chapter critically reviews the literature allied to five knowledge domains. It includes; growth of e-commerce and effects on logistics and supply chains, typologies of e-commerce logistics facilities, the geography of logistics and contemporary trends, and location theory and location models. Finally, demonstrate the research gap and emphasize the justification of the study.

2.1 Growth of e-commerce and effects on logistics and supply chains

2.1.1 Growth of e-commerce

Human settlements are always shaped with the innovations and advancements in production systems and human lifestyles. The industrial revolution begins in in 18th century had paved the path for cities we experience today. As it is already recognized, the development of information and communication technologies is obviously affecting many spheres of our lives [20] . Internet based commerce, commonly known as 'E-commerce' has shown a significant growth in the recent years; similarly, 'e shopping', the consumer behaviour is demanding more dynamics and advancements in the e commerce sector. There are different types of classifications based on the type of material (goods or services); nature of stakeholder's involvement (business and consumers) and the nature of firms engaged in business (pure e-commerce and omni channel). The common classification used in literature is: Business to consumers (B2C), Business to Business (B2B) and Consumers to Consumers (C2C). Some researchers synonymous with the term 'teleshopping' which was previously used to refer to use of ICT as a source of obtaining information to make consumer decisions.

There are different models in which E commerce firms follow in their operation. There are firms who just act as a platform of trading by facilitating the market transaction by bridging information flow between supplier and buyers, facilitate the transaction and post transaction experience of the consumers through customer review. Ali Baba company can be identified as the leading international company which operate on this platform. Second type of companies do not limit to the website, but they also facilitate the transaction with their logistics facilities and systems. Amazon, who is the main competitor of Ali baba has its own logistics network. The latter more explicitly explained in the next section (2.2) of the thesis. This include range of logistics facilities in many countries. However, in certain contexts, Amazon do obtain the support of local/ international third-party logistics companies in performing the logistics functions.

2.1.2 Types of e-commerce firms in B2C retailing

2.1.2.1 Pure online retailers and omnichannel retailing

The rapid advancements in internet retailing had pushed the traditional retailers, including multi-channel retailers (MCR) to adopt omnichannel retail (OCR) strategies. The main difference between MCR and OCR is that OCR operates with a fully integrated system, compared to an independently managed system in MCR. One of the core focuses of this is the creation of enhanced customer value and experience [11]The investment on OCR involves a substantial risk with its possible chance of error in planning and complexities [21]. The home deliveries and the logistics system vary with the average cost and value. Further on the retail atmosphere, product type, consumer characteristic and market trends. Integrated inventories are also a part of the whole operation. The last mile delivery plays a significant role in the overall process since it can damage or enhance the customer experience.

2.1.2.2 Grocery products and non-grocery products

Another way of classifying e-commerce based on the type of products handled in operation. Based on the level of perishability, e-commerce can also be classified as grocery product and non-grocery-based product e-commerce. Grocery products often include food items and daily consumables. In the case of grocery products, logistics and transport are identified as the biggest challenger for e grocery sector [22]. Further, it is identified that the location of stores become a critical factor with storage requirements and availability of land next to cities. E-grocery logistics usually require small time windows. Non-Grocery items, on the other hand, include other product which does not have a fasten perishability.

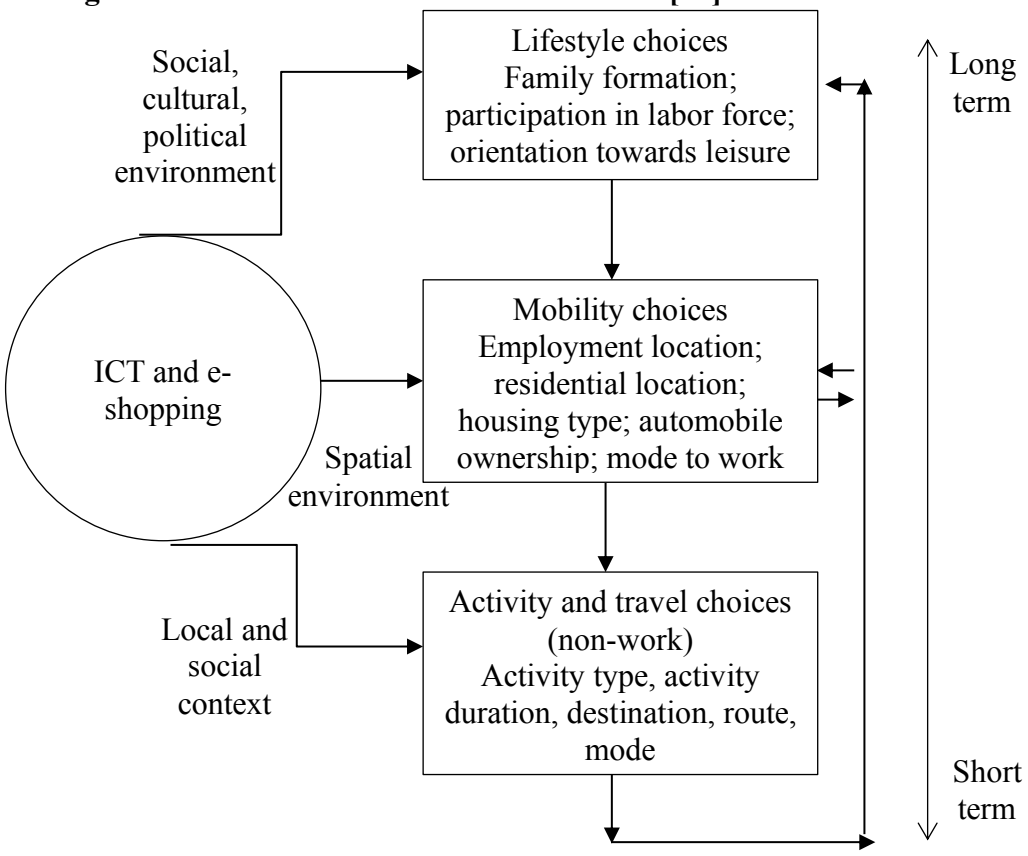
2.1.3 Effects of e-commerce on cities and environment

Although e-commerce is widely used, the holistic effect of e-commerce on environment is yet to be fully experienced. Salomon in 1983, highlighted the possible effects of Information communication technologies on travel choices [23]. Although it does not include all aspects, conceptually proposed the short- and medium-term effects, and this serve as the basis of preceding work that focused on effects of online retailing with empirical studies (figure 2.1).

Prominently, B2C channels of e-commerce channels continued to alter conventional theories of land use and evolution of cities[24]. The effects of e commerce

on consumer behavior at human scale to city scale are a popular topic discussed in contemporary literature. It is also important to distinguish the multiple functions associated with shopping in general to realize on subsequent effects. This include economic function (buying product); social function (meeting others); recreational function (walk to shop, etc.),and psychological function (pleasure obtained by visiting a shop, etc.) [25]. Overall effects of online shopping is categorized as substitution, complementarity, modification and neutrality effects [3]. Further there is no universal consensus on whether online retailing is more environmentally friendly than the traditional modes of shopping [26].

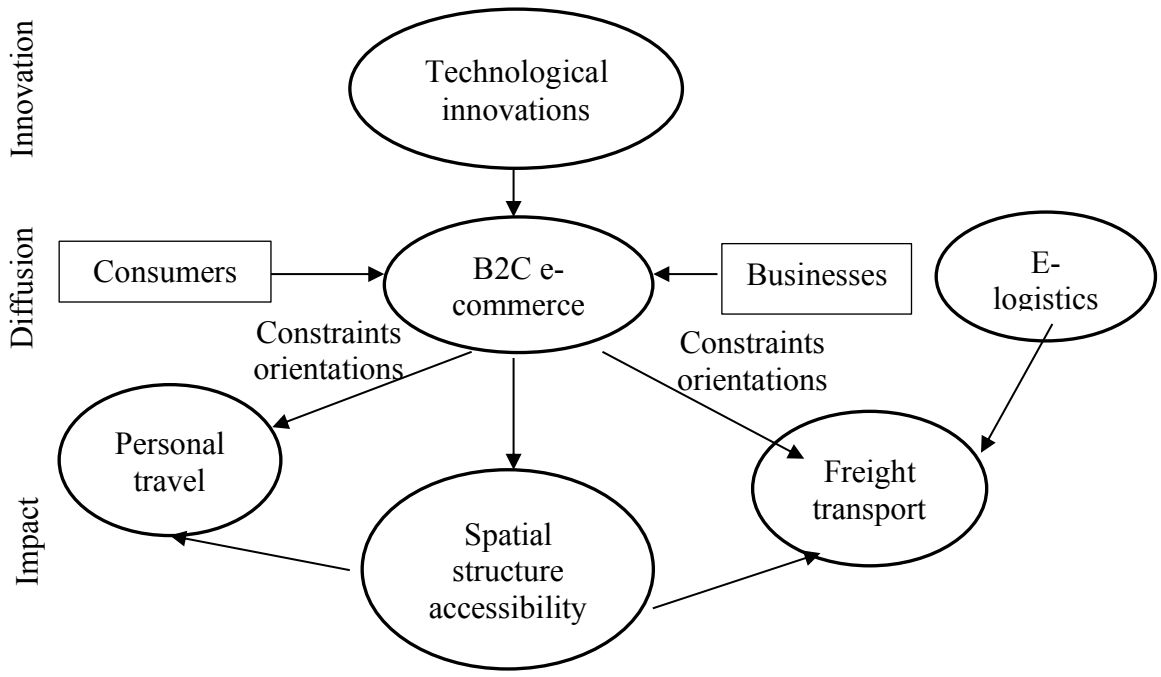
Figure 2.1: ICT and effects on travel choices [23]



Visser and Lanzendorf classified the effects of e commerce as mobility and accessibility effects, where mobility effects refer to more direct impacts driven with the behavior of individuals [4]. Primarily two research stems can be derived from the contemporary research on this category[19]. Firstly on effect on conventional shopping locations by online shopping [27] and the adoption process of consumers. Secondly on the effects of online retailing on shopping travel[28]. These research evolved on the preposition that E-shopping will substitute in store shopping[29]. Such studies focused on several countries including Netherland, US, China and UK. The study in China suggest that since 2009 there is a negative correlation between rapid growth of e-commerce and slowdown of commercial real estate development [30]. Further emphasized that the effect on demand vary with the types of the commercial property. It is also recognized the geographical dimension of the effects of e-commerce. Based on studies in Netherland, Farag highlighted online buying as a urban phenomenon[25].

Indirect accessibility effects in long run are seen more as consequences of direct mobility effects include; changes in activity systems of people, configuration of supply chain and logistics[31], location choices and land use patterns. However, the net effects of these changes are yet to be realized.

Figure 2.2 : conceptual model for the impact of b2c e-commerce on mobility and accessibility [5]



2.2 E-commerce logistics facilities as a new typology

E-commerce fulfilment logistics identified as a key aspect that will trigger changes in the land use patterns and real estate markets of cities. During the early days of e-commerce, Romm argued that e-commerce would revolutionize the structure of supply chains and changes are visible today [6]. It is believed that the logistics problems in the field of e-commerce are different from that of other channels[10].

New logistics facilities that entirely support the e-commerce through functional specialization [7] are rapidly emerging in parallel to the growth of the online retail B2C segment. These facilities are different from traditional logistics facilities and range from large fulfilment centers and small freight stations to locker systems that support the last-mile delivery. The functional requirements of e-commerce are directly influencing the establishment of logistics facilities as a part of the firms' logistics strategy. Inventory ownership and location, order picking, assembly, and delivery are identified as main components that are considered in developing logistics strategies [10]. Based on empirical case study-based research Ghezzi further classified different e-commerce logistics strategies against the key logistics problems (figure 2.3).

Figure 2.3: Main logistics strategies in e-commerce[10]

	Supplier fully managed			Supplier managed inventory			Distributed strategy		
	S	**M**	**C**	**S**	**M**	**C**	**S**	**M**	**C**
Inventory ownership	■			■			■	■	
Picking +preparation	■				■		■	■	
Order assembly	■	■			■		■	■	
Order delivery			■			■			■
	Consignment inventory			**Merchant managed inventory**			**Full in source**		
	S	**M**	**C**	**S**	**M**	**C**	**S**	**M**	**C**
Inventory ownership	■	■			■			■	
Picking +preparation		■			■			■	
Order assembly		■			■			■	
Order delivery			■			■		■	
S- Supplier ; M – Merchant ; C -Courier									

These new e-commerce logistics facilities are emerged at two stems of the supply chain. One at last mile segment while the other at the first mile segment. Although no such comprehensive empirical study exists, there are few general classifications. Table 2.1 present the classification of e-commerce logistics facilities.

Table 2.1: classification of E-commerce logistics facilities [7][32]

Type of facility	Key attributes
Sortable fulfilment centres	Large size (800,000 sq. ft); cross-docking configuration; close to large labour supply (more than 1,500 full time associates); range of products (books, toys and housewares); automated and high-tech operations,
Non- sortable fulfilment centres	Large size (600,000 – 1,000,000 sq. ft); cross-docking configuration; close to large labour supply (more than 1,000 full time associates); large products (furniture, outdoor equipment, etc.);
Sortation centres	Medium sized; automated operation; access to regional centres; orders are sorted by destinations; carry out flexible deliveries
Delivery stations	Low site density; cross-dock configuration; located at the edge of cities; preparation for last-mile deliveries; collaboration with carriers
Returning centres	Depends on operation; close to fulfilment centres; automated and high-tech operations, including Robots
Freight stations/ speciality facilities	Small size; close to high-density neighborhood s; (including Amazon Prime Now Hub centres)

Using the Netherlands as a case study, Weltevreden studied the emergence of customer delivery points, which include locker and service points[33]. The latter types usually installed at the neighborhood scale as an alternative logistics strategy for last mile rather than home deliveries.

Drawing empirical evidence from Shenzen, China, Xiao mentioned that fulfilment centers are located in urban fringe or neighboring cities to capitalize on land availability and access to high-speed infrastructure [19]. From a retailers perspective these fulfilment centers are replacing the traditional stores. It is further expected that these centers will normally locate at locations to minimize costs, maximize market reachability, and more importantly at locations to meet the tight delivery windows [34]. Given the nature of the operation, it is expect fulfilment centers to be larger in size while smaller in quantities [35][36]. Hylton also argue that, fulfilment centers may locate closer to airports than traditional distribution centers, since it obtain the service of integrators, who are centralized in to specific regions[34].

Figure 2.4: Comparing E commerce logistics with other types of manufacturing and distribution logistics[7]

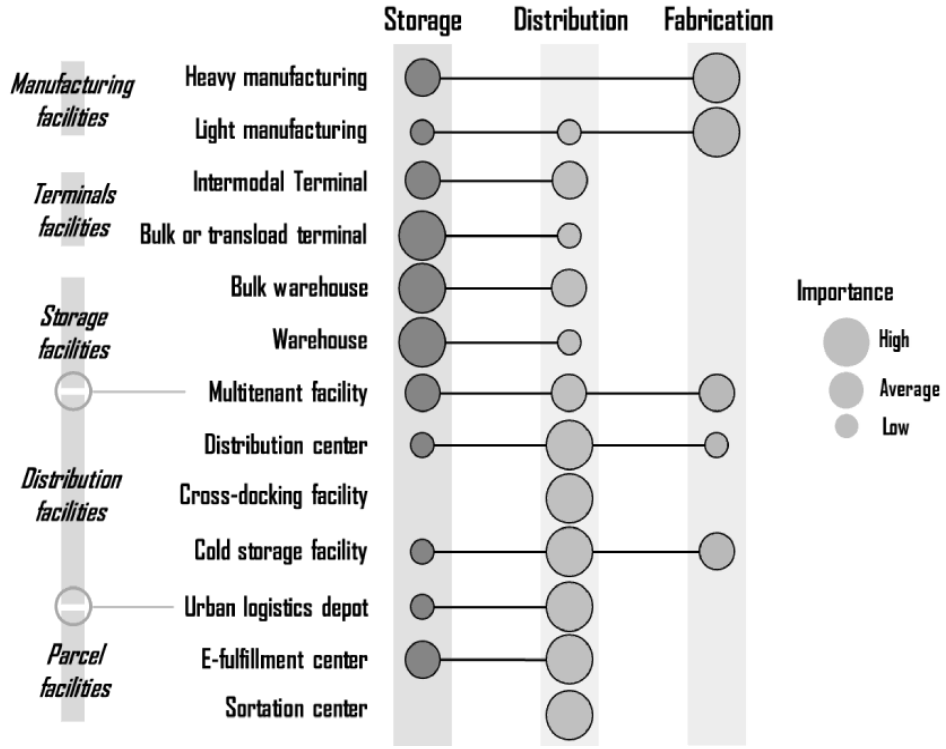
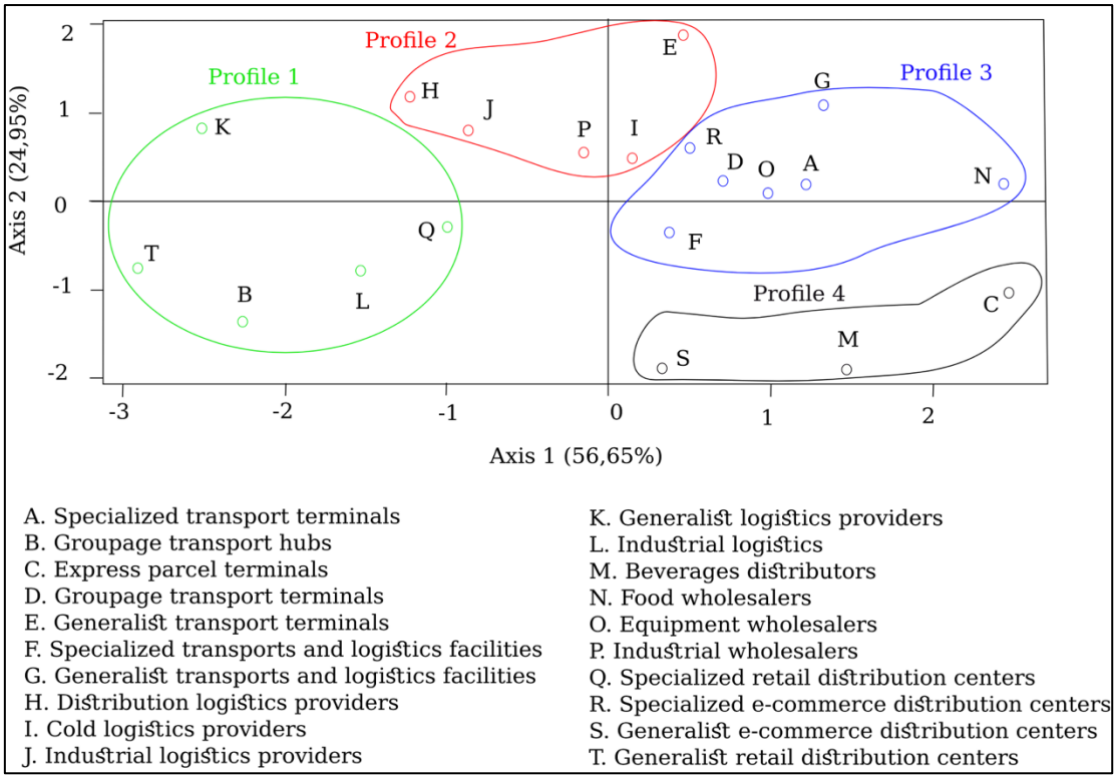


Table 2.2: Type of fulfilment centers with its characteristics, major strengths and weaknesses [37]

Type of fulfilment centres	Main characteristics	Major strengths	Potential weaknesses
Distributed delivery centres	Distributed operation sites; Self-operated.	Easy start-up; Prompt delivery; Operation in control.	Complex inventory management; High inventory costs; Unfamiliar with warehousing procedures.
Dedicated fulfilment centres	Centralised operation site; Self-operated	Avoids the higher inventory costs; Easy to manage; Fast delivery; Reduced long-term costs of operation.	High up-front investment; ecreased flexibility.
Third party fulfilment centres	Centralised operation site; Third party operated.	Least investment; No learning curve; No operational complexity; Limited changes to legacy systems; Minimized operational impacts.	Few options available; Risks in strategic alliances; High operational charge.

Figure 2.5: clusters of logistics sectors, Fig 7 [17]



E-commerce based logistics facilities had also been recognized as a. separate logistics facility typology[17]. Heitz et al, further classified these e-commerce logistics facilities as specialized and generalist's e-commerce distribution centers to distinguish the facilities based on its function and location characteristics. This further affirm that, although it's not visible, a distinguished spatial organization patterns are emerging with respect to this category.

2.3 Geography of logistics facilities

Although it is not specifically, logistics are always play a significant role in reshaping the human settlement landscape and act as an engine of growth from the past. Old cities are developed around seaports which connect between territories while intra territorial models including ferry stations and cart resting stations later evolved into catalysts of growth. Logistics include series of activities, including freight transportation, storage, distribution and other operations. The nodal elements of this process coined in discussing logistics facility locations. The location of logistics facilities linked with the nature of the industry or the sector it facilitates.

2.3.1 Factors of location of logistics facilities

Accessibility is a common factor that determines the location of logistics facilities, Irrespective of the nature of the service it provides[38]. However, the significance of accessibility for different transport infrastructure may vary in different contexts and also from firm to firm. Bowen (2008), with empirical evidence from the US logistics sector, argue that highway accessibility as more significant over accessibility to other modes [39]. By drawing evidence from Belgium, Verhetsel et al. (2015) had demonstrated that land rent is more significant over accessibility[40]. Further emphasize the significance of seaports and motorways in determining logistics firm location. Although logistics systems continuously evolved with technology, human labor plays an essential role in overall operations [41], including both the availability of labor and the cost of labor. Japan is a classic example of the challenges due to a labor shortage and ageing labor market.

Further, Hesse (2004) discuss the importance of land availability in determining a location for logistics facilities. Also, land use planning and zoning regulations remain a decisive factor in location decisions [42]. The application of zoning varies with the nature of the operations performed by respective logistics facilities. Usually, logistics firms attract to dedicated zones, including industrial parks or business parks. Apart from above factors, Onstein et al. (2019) recognized the importance of demand level factors, service level factors, and other contextual factors in making location decisions on logistics strategies in general, where logistics facility location will be a part of the process[43].

2.3.2 Contemporary trends on spatial organization of logistics facilities

The contemporary research on the interaction between logistics and geography is classified into two categories, namely the logistics clustering and logistics sprawling [44] which may also relate to these topologies.

Logistics sprawl referred to the outward expansion of logistics facilities from core urban areas and sub urban areas [45]. It is understood that the land cost , traffic accessibility, and congestion in core areas as key factors for this process [44]. In the recent years highway proximity, the expressway interchanges had become an attraction point of logistics facilities, more specifically the distribution centers[46].

Over the years there are number of research attempts that explain this process while highlighting the effects of those processes at policy level. Some of the work focused on logistics facilities in general while other studies focused on specific sub sector of logistics facilities, namely warehouses, distribution centers and parcel services. In addition to the revealing of trends, the interplay between changing urban forms and logistics sprawl is recognized in the literature [47]. In addition the comparative case study in two cities in Europe (Paris, France and Randstad, Netherland), revealed the differences in logistics facility distribution between monocentric and polycentric urban regions[48]. This further affirms the relationship between urban structure with changing patterns of organization of logistics facilities. The comparison of the change of average distance between the logistics facilities and other business establishments in Atlanta region, US revealed a relative logistics sprawl of logistics facilities by 4.5 km compared to other establishments which was 2.1 km[49]. Similarly the case of Tokyo metropolitan region revealed a relative sprawl of logistics facilities by 2.4 km from the urban center compared to the settlement sprawl of 0.4 km[50]. The relationship between shifting patterns of logistic facilities from core city center against the patterns of low density employment is revealed in San Franisco and Los Angeles based (in US) case studies [51]. While most studies highlight the patterns of sprawl from one urban center, studies based on Canada suggest sprawling not just as a process observed with respect to main urban areas, but also at satellite settlements which play a vital role in overall economic performance [52]. Further there are studies which focused on the spatial organization of logistics sprawl at national scale. This is in contrast to the studies which focused on studies at regional and city scales. Study based on fifty metro regions in US indicate

that logistics facilities are growing at suburban counties compared to central country regions [42].

Further these studies employed a range of spatial analysis techniques to evaluate the process. These methods include average distance, centrographic method, standard deviation ellipse and kernel density estimation. (KDE). Most of the studies focused on this trend of spatial organization of logistics facilities are carried out at metropolitan or sub metropolitan scales. The national scale comparisons employed the number and density of logistics establishment as a measurement in contrast to distance-based measurements applied in regional level studies. A summary of contemporary studies which focused on logistics sprawl patterns of logistics facility organization is presented in table 2.3.

Table 2.3 : Contemporary studies on geography of logistics facilities (sprawl)

Study	**Study are and the period**	**Methodology used**	**Key findings**
Heittz et al (2018)	Gothenburg, Sweeden	Centrrographic method	Logistics facilities sprawl 4.2 km from the urban centre
Dablanc et al (2014)	Los Angeles, US (1998-2009)	Location mapping	Warehouses sprwled from centre 6.1 km
Dablanc et al (2012)	Atlanta, US (1998-2008)	Centrographic method	Warehouses sprwled from centre 4.2 km
Giuliano et al (2018)	Los Angeles, US (2003-2013)	Average distance , gini coefficient	Warehosuign and distribution facilities 5.6km from the centre
Sakai et al (2017)	Tokyo metropolitan region, Japan (2003-2013)	Kernel density estimation	Logistics facilities 6.6 km from the centre
Todesco et al (2016)	Zurich, Swizterland (1995-2012)	Average distance	Warehouses and parcel service (9.5 km and 7.7 km)
Woudsma et al (2016)	Toronto, Canada (2002-2012)	Location mapping, case study	Warehouses (Greater Toronto area. – 1.3 km; Gretaer Golden Horseshoe – 9.5 km; Southern Ontario – 29.5 km)

On the other hand, the phenomenon of spatial clustering is also being studied in the recent years. The spatial clustering is observed between different actors involved in the logistics process, including third party logistics providers, warehouse and storage

providers, and freight carriers[53]. Further it is found that these patterns of clustering not only benefit the individual actors, but also the policy makers in reducing negative externalities. It is also revealed that such patterns of clustering promote the establishments of logistics hubs at local level, which in turn expand with further private sector investments. External scale of economy or agglomeration economies along with demand and policy factors had influenced this process [44].

2.3.3 Contemporary studies on e-commerce logistics facilities: with Amazon as a case study

Several researchers considered Amazon as the primary case studying different dimensions of e-commerce logistics facilities. In particular, some researchers highlight the geographical inferences associated with the Amazon facility locations. The clustering pattern of Amazon FCs in the USA and location at states with low sales tax regulations [54]. Further revealed that Amazon distribution facilities are closer to its shippers' local sorting facilities and closer to significant urban markets. Further pointed out several observations concerning examples. Firstly, the fulfillment centers located at relatively low population states, which are near areas with large population concentrations. Secondly, the fulfillment centers situated in states with low sales tax on relative terms. Thirdly the new fulfillment centers opened near the old ones, which possibly indicate a form of clustering that increases the capacity with a specific geographic reference Distance from Customer concentrated locations and sale tax of states as determinants of Amazon logistics facility network[55]. Hylton, employed Amazon as a case study in investigating e-fulfillment's relationship with transportation infrastructure and geography [56].

One of the central gaps observed in these researches is the US's mere focus as the case study. Such limitation can be arguably untestable with the exceptional growth of Amazon logistics capabilities and facility networks in the US. The decentralized governance framework in the US enables the variations between sales tax at different states. However, this poses a barrier in generalizing the findings to understand the situations at other locations.

2.4 Location theory and location models

2.4.1 Location theory: overview

The location theories are used basically employed to explain the structure and form of cities and regions. These theories not necessarily focused on urban areas but also predominantly agricultural areas. The earliest of location theories include the Walter Chistallers' central place theory (1831), Von Thunens'(1826) theory of agricultural land uses, and Alfred Webber (1909) theory of location of industries. Central theory explained the structure of cities based on the principle of catchment area, while Von Thunen model formulated on the concept of 'Isolated state'. Both theories are originated prior to the beginning of industrial revolution. In contrast the third theory emerged at the middle of the industrial revolution where industries emerge as a significant sector while cost related factors received a prominence in the industrial location theory emerged in 1909.

Further, location theories are employed to explain the agents and processes of selection of locations for residential, commercial, industrial, and other purposes. The location as a function of transport and other moving costs (people and ideas), both from and to suppliers and customers is the fundamental rationale that drive these theories. In general terms, firms expect to locate at locations which minimize total transport costs [57]. In practical terms, this cost is a trad-off between cost to transport raw materials with the cost of transporting the finished product to the customers.

Agglomeration theories further went to explain the spatial organization of different firms by incorporating the above rationale of location theories. That make location theories an integral part of other extended theories in the spectrum of agglomeration economies. These theories basically go on to explain how and why certain type of firm's cluster together or locate in close proximity. There are basically two types of agglomeration economies, which include localization economies and urbanization economies. First refer to the firm in the same industry while the latter consider firms in different industries. The main forces of agglomeration process include the input sharing, knowledge spill-over and, labor market pooling [34].

2.4.2 Location choice models

Based on above principles several types of location models are emerged and developed in recent years. One of the popular works in the recent years is Alonsos' bid rent model (1964) on land uses, that explain the location of different land uses based on the land rent. This model is further applied in many other land use and economic models with certain extensions. This approach is chosen for firm location choice over hedonic approach to location choice and price-choice approach, which are commonly applied for residential location choice. Bid rent approach determine the probability of a given firm being located at a given location. This should not be confused with the idea of given location being chosen by a given firm to locate the facility[58].

The recent applications of location choice models are a combination of location theory and random utility theory [59]. Transportation studies usually employ the location choice models to investigate the effect of accessibility on location choice, predicting future location of firms, population for different purposes [50].

2.4.3 Location theory and logistics facilities

In recent years there are several applications of location choice modelling to explain the location pattern of logistics facilities. These models attempt to explain the location decision on logistics facilities by incorporating range of socio-economic, land and policy related factors.

Most of the studies used the Multinomial modelling framework or nested multinomial modelling framework which again falls under the broad theoretical framework of discrete choice modelling. The traditional discrete choice modelling considers about choices made by people among finite set of alternatives. The application of this principle in location choice modelling, the people is replaced by firms, with set of alternatives defined as the alternative locations. In logistics regression models, the parameters are estimated with maximum like hood function, while Hosmer-lemeshow test and likelihood ratio tests are employed to evaluate the goodness of fit of the models. Further details of these tests are explained in chapter 03 of the thesis.

The previous studies on location choice modelling had defined the zones in various different ways. Some researchers followed the administrative areas choices whereas other researchers focused on pre-determined units, that is usually a further subdivision of the administrative areas. One of the fundamental constrained in this

approach is that, although the number of alternative locations increased, the variability between the data of these locations are low, since the origin of data mostly from administrative based secondary sources. One possible way to overcome this challenge is to incorporate non-administrative data sources, which possible can include the GIS based data that can capture the differences at small sized zonal levels.

A review of these studies indicates some important characteristics in the models. These include:

1. *Accessibility* as a key variable. This is defined in different ways to determine the accessibility for different purposes. This include the accessibility to population and accessibility to employment. Sakai in his study, defined accessibility to population as follows:

$$\text{Accessibility to population} = \sum_m P_m \exp\left(-\log\left(D_{l,m}\right)/2\right) \quad [60]$$

Further accessibility to transport hubs and accessibility to manufacturing establishments are also measures employed depending on the purpose and objectives of the study.

Considering the general use of *Accessibility* as a measure is linked with the concept of market potential and highlighted by Harris in 1954 [61]. This expressed by means of distance and to the size of the market at different locations. The distance can be represented as Euclidian distance, network distance and travel time along the network. The rationale of this is to determine how much an economic activity at a location is attracted to another location.

$$MA_j = \sum_k \frac{M_k}{d_{jk}} \quad [61]$$

2. In addition to the use of *distance* is embedded in the accessibility measure explained above, *distance* itself is used as a separate measure. Some of the distances calculated include, *shipment distance* and d*istance to expressway interchanges*. Over the years the *distance to expressway interchanges* had become a core component of geographical research. Further increasing attractiveness of these interchanges as hotspots for distribution centers is seen as a key trend[46].
3. *Employment* is another variable seen in majority of the research on location choice models. Some research considers about the actual size of employment

at considered zones while the other research considers about the share of employment in a given zone in comparison to the total number of employments in entire study area. In addition, there are attempts to incorporate sector specific jobs availability inside the zone and also at neighborhood zones.

4. *Population density* is another measure used to represent the attractiveness of considered location as a point of attraction in the study area. This is used with original sense while some research employs this as a proxy measure for *land price.* In addition, *Size of population is* employed to incorporate the attractiveness of locations for the
5. *Land price* is another variable that represent the level of demand of alternative locations for particular use. One of the common grey areas observed at almost all the models is that *land price* is defined as a general variable than defining land prices for specific land uses. It is expected that land price to vary between different type of land uses.
6. *Zoning and land use regulation* is also incorporated as another variable that is used in contemporary research. This include the consideration of land use zoning type and extend at alternative locations as an independent variable.

A summary of reviewed location models with respect to logistics facilities is presented in table 2.4.

Table 2.4: Contemporary studies on location choice models (reference to logistics facilities)

Study	Study area and focused group	Purpose / Explanatory variable	Choice set	Methodoogy
Sakai et al (2020)	Paris Logistics facilities	Share of economic activity zones in location *i*; Share of logistics zones which is not the part of economic activity zones in location *i* ; Number of jobs for wholesale industry within 3 km of location *i* ; Population density of a municipality which location I belong; Distance from location I to nearest highway ramp (km); Accesibility to population	23,200 locations of 1km x 1 km polygons	Multi nomial logit model
Sakai (2017)	Tokyo Metropolitan region Logistics facilities with different size (sq.m.)	Average shipment distance; ln (average shipment distance); ln (acessibility to employments);ln(distance from nearest expressway interchange);population density;port area (dummy);ln(average land price); along ring road 2 (dummy); along ring road 3(dummy);share of residential zone; share of commercial zone; share of quasi industrial zone; share of exclusively industrial zone; share of urbanization control zone; share of miscellaneous land use; share of non urban planning zone	1km x 1 km polygons	Multi nomial logit model

Hagino et al 2007, (2011)	Tokyo Metropolitan Region Regional freight facility centers,distribution centres And Factories, business establishments	Population density; Labor accessibility ; Accessibility to manufacturing establishments; Accessibility to transport hubs; Distance to the closest highway ramp ; Land price; Land use regulations; Land price change	Not specified	Multi nomial logit model
Nguyen and Sano (2010)	Tokyo Metropolitan region Retailers, wholsesales and other manufacturer	Zonal population ; Zonal employment ; Land price; Employment size; Floor area	Not specified	Nested Multinomial model

2.5 Research Gap

The contemporary studies had focused on changing geographies and spatial organization of logistics facilities. Two key phenomena are highlighted; logistics sprawl and clustering. These studies adopted distance based and density-based studies. The studies focused on multiple spatial scales, including national and metropolitan scales. In addition to these patterns, the relationship between these trends and patterns along with urban form and structure. This include the relationship between monocentric and polycentric urban structures with the spatial organization patterns of logistics facilities.

On the other hand, with the growth of e-commerce new types of logistics facilities emerged to response the growing demand and technological innovations. Many scholars had tried to explore the direct mobility effects both conceptually and empirically. It is obvious to see it as the need of hour, with effects which are visible on the short run. However, the indirect accessibility effects are a topic that is paid lip service to over the years. Considering the logistics aspects, which has both direct and indirect effects, there had been already considerable focus on last mile aspect of these new typologies. However, e-fulfilment facilities are yet to be fully incorporated into the theory with empirical evidences.

Thirdly the key variables that are used specifically in location choice models are reviewed. It is found that accessibility variables are a common inclusion in location choice models, along with measures of population size and/or density. The ambiguity and vagueness in considering average land price without specifying the use can be highlighted as a key constraint in contemporary location choice models.

3 CONCEPTUAL FRAMEWORK METHODS, AND TECHNIQUES

This section details out the conceptual framework and the research methodology of the study. The conceptual framework demonstrate how research problems are addressed while, methodology section detailed out the research approach, methods, tools and data sources used at different parts of the study.

3.1 Conceptual framework

The conceptual framework intends to specifically illustrate the relationship between key components of the study in responding to the research questions. This study employed the urban form as the vantage point of exploring the location and spatial organization of e-commerce logistics facilities.

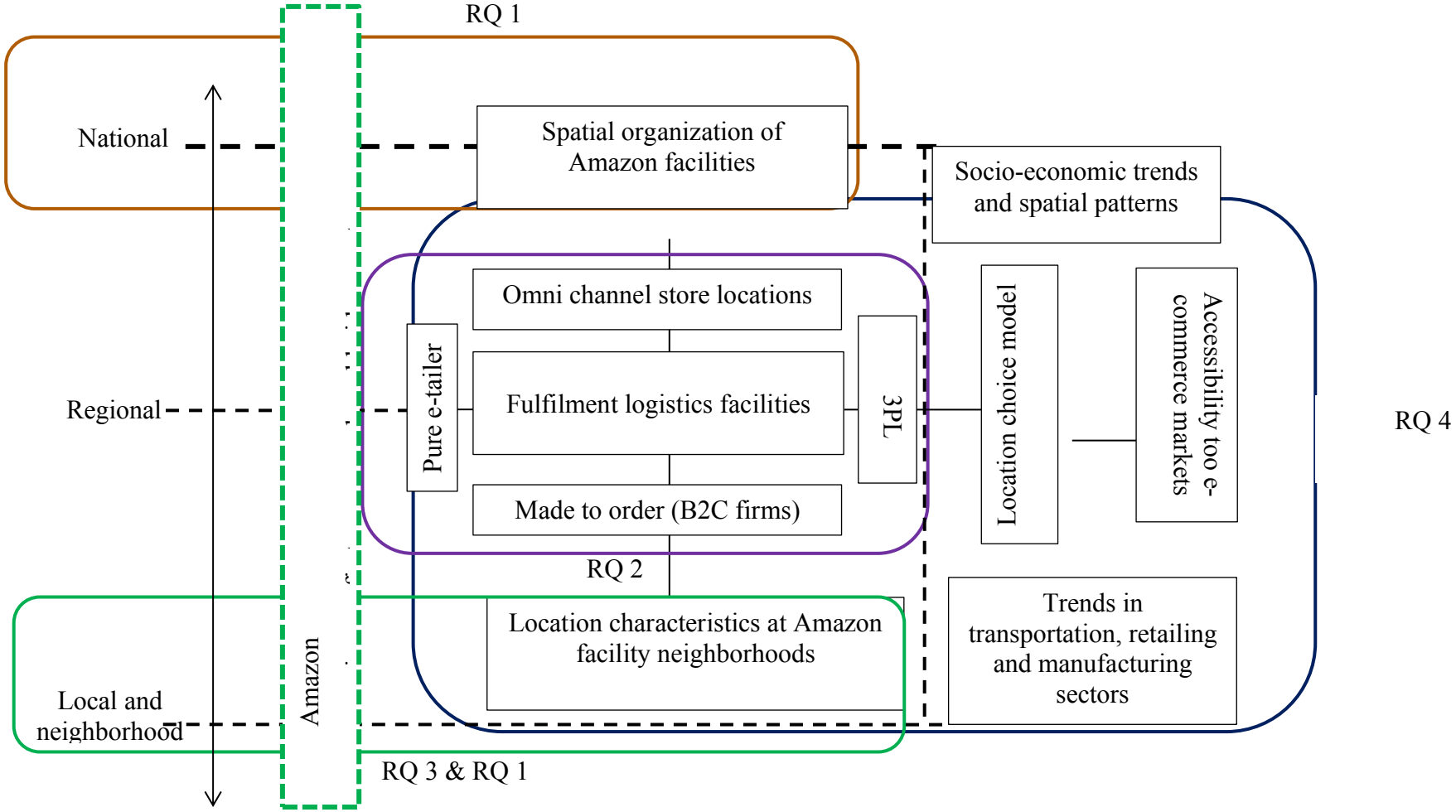
One of the key aspects that connect different studies is the 'scale of analysis'. The spatial analysis focused on national, regional and neighborhood scales. In other words, the spatial footprints of e commerce which transcend geographical boundaries is done through the above multi scale analysis. This also include the selection of Amazon, global firm as a case study. Multi-scale framework is not used as a merely for comparison purpose, but also to tool for unravelling deep insights.

The consideration of multiple types of e-commerce logistics facilities operated by multiple firms intends to explore the diversities related to the e-commerce logistics facilities. Similar rationale being used in developing the location choice models which relate multiple types of firms.

On the other hand, the spatial organization cannot be understood as an isolate process without being grounded through the socio-economic dynamics that happen around. The consideration to dynamics of demography, evolving e-commerce markets, variations between different modes of transport infrastructure, socio-economic trends that influence the trends along with local characteristics is needed to diversify the 'multi dimensionality' of the aim of the study.

Amazon being a pioneer in the e-commerce market has already being a model for many more followers emerged in the recent years. However, the logistics-based e-commerce model is not explored with geographical viewpoint. The focus so far had been more on the outcomes and last mile delivery sections than the initiatives at a broader level. These initiatives can be better realized through exploring what Amazon is doing to improve their logistics capability, which is centred around the worldwide fulfilment logistics facilities.

Figure 3.1: Conceptual framework of the study

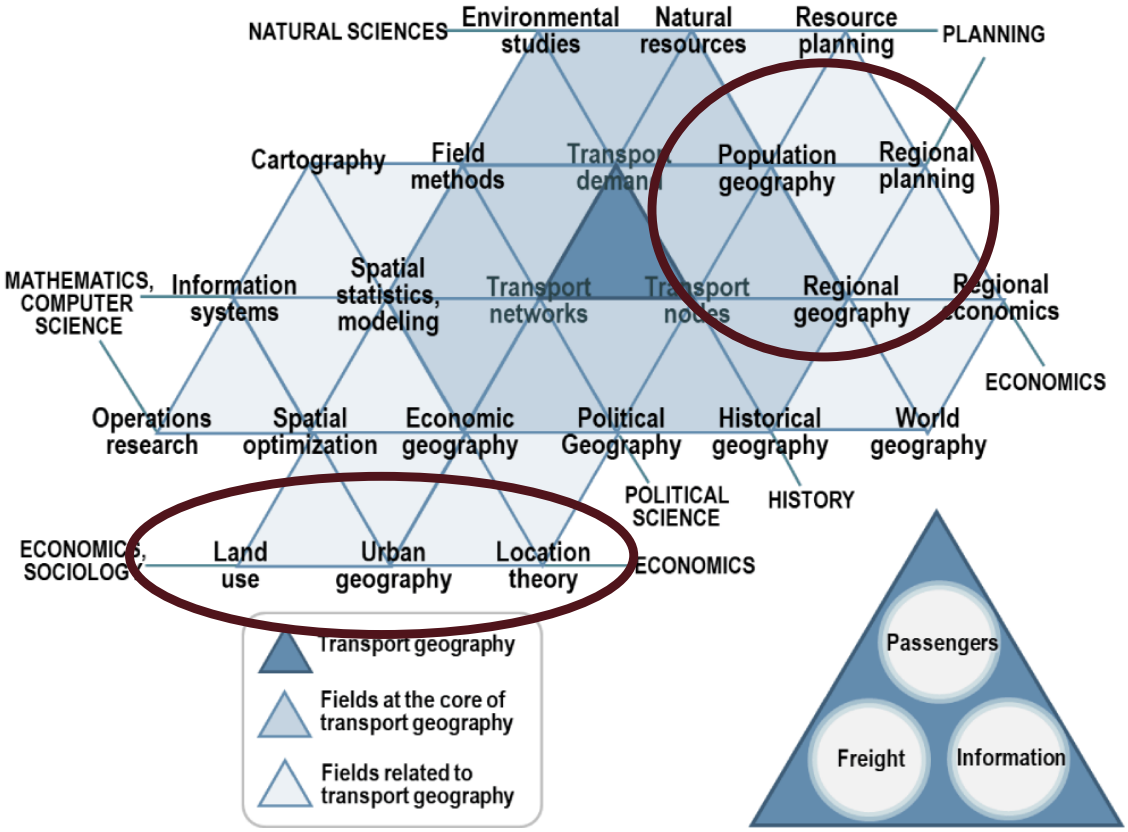


3.2 Knowledge context

The study is within the purview of transport geography, as the parent discipline. Transport geography include range of other sub disciplines which are interrelated. The cross cutting nature of the thesis touched on several sub disciplines including, population geography, regional planning (referred as strategic planning in the study), land use, urban geography and, location theory.

Geography of logistics is the primary Research problem area and strategies of e-commerce companies as the secondary research problem area

Figure 3.2 : Fields of transport geography [62]**; cited from [7]**



3.3 Mixed research method approach

Given the nature of the research questions, this study adapts a mix research methodology. This approach is used in studies that have combination of quantitative and qualitative research questions. It is understood that this as the most suitable approach for this research given the lack of empirical information base available.

3.3.1 Case studies: firms and regions

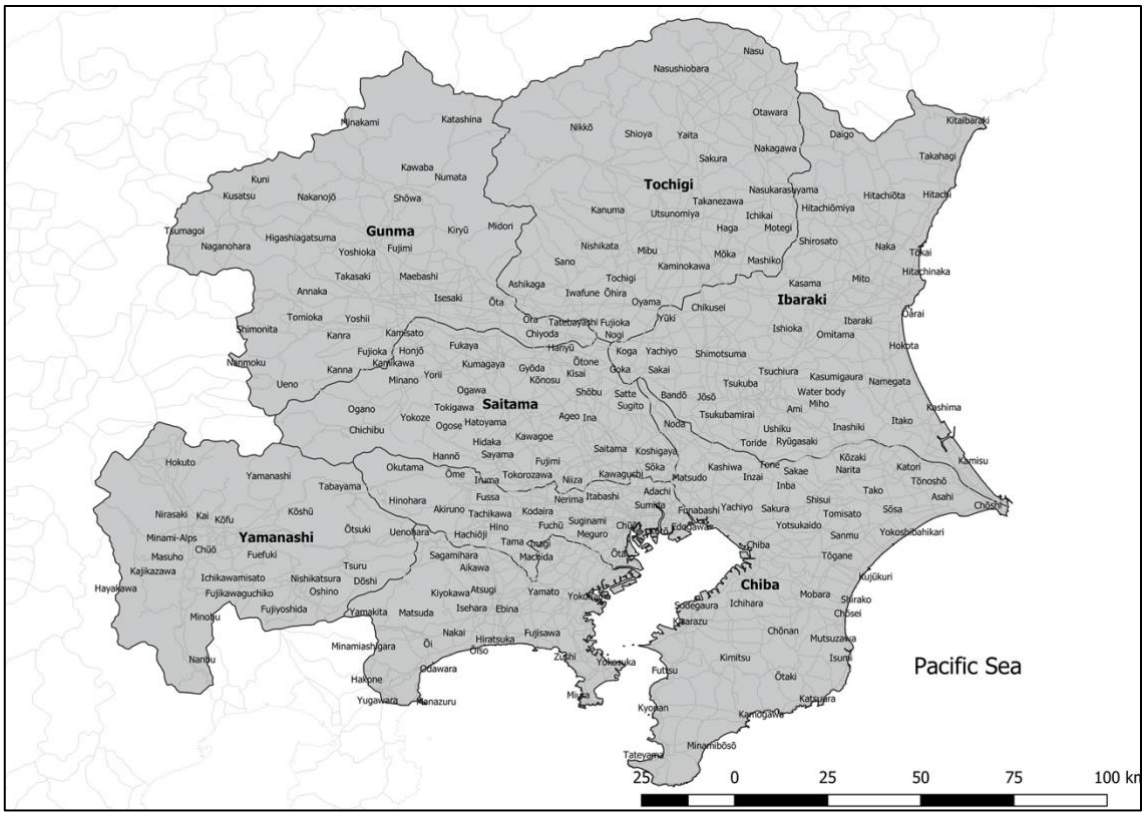
This study use Amazon as a benchmarking case that resembles with the research focus of the study, e-commerce logistics facilities. The reasons for choosing Amazon as a main case study can be summarized as follows:

1. Amazon is a pioneer in online retailing; more specifically they are the first and leading firm who operate online retailing with a self-operated logistics facility network
2. The logistics facility of Amazon expands over 21 countries with a total of 250 million sq. ft. This by far the largest logistics network by a single e commerce firm with a wide coverage
3. Continuous innovations in logistics sector; not limiting to existing logistics facility network

Amazon is the first mover in this sector; this study assumes that the learning curve learning curve and strong business foundation reveal useful insights for researchers and practitioners. With their growth in the retail sector, Amazon fulfilment centers expanded at many locations as part of their logistics system [63]. Detail account of the uniqueness of Amazon in the context of the study is presented in chapter 04. Further this study further used the data of other firms in 2nd empirical analysis. The same group of firms are used for estimating the parameters of the location choice model.

Similar to the prominence given for Amazon as a firm, this study geographically focused on Tokyo Metropolitan region (TMR) as the study region. Tokyo being the most populous metropolitan region in the world. As the United Nations estimations, the total population in the region was 38,140,000 with a geographical area of 13,500 sq.km. The metropolitan region comprised of 07 prefectures and 01 Metropolis. Namely; Kanagawa, Chiba, Saitama, Ibaraki, Tochigi, Gunma, Yamanashi, and Tokyo Metropolis. Detail description of various aspects of Tokyo including socio-economic trends, network and land use characteristics are presented in chapter 05 and 07.

Figure 3.3 : Boundary of TMR (Study area for chapter 05 and 07)



3.3.2 Logit models

Logit modelling framework used for the location choice model for e-commerce logistics facilities. Tokyo Metropolitan Region is used as the study are for model estimation.

This logistics regression method is also belonging to the group of Generalized Linear Model (GLM). The main operating principle of logistics regression model is the link between occurrence or non-occurrence of an event to explanatory variables. In this study is, it is whether firm *i* will choose location *j* for setting up the facility to socio-economic economic trends and land use pattern at respective locations.

For Multinomial logit models, the dependent variable, also called the response variable, follows a Bernoulli distribution for parameter p (p is the mean probability that an event will occur), or a Binomial (n, p) distribution. The probability parameter p is here a linear combination of explanatory variables. The analytical expression of the model is as follows:

$$\text{Log}[p(y = j \mid xi) / p(y = 1 \mid xi)] = \alpha j + \beta j Xi \quad [64]$$

These models will be estimated with maximum likelihood method. Further the parameter β is estimated by maximizing the likelihood function. The log-likelihood can be expressed as:

$l(\alpha,\beta) = \Sigma i=1..n\Sigma j=1..J\ yij\ log(p(y=j|xi))$ [64]

However, unlike in linear regression there is no exact analytical solutions exist for logistics regressions models. In XLSTAT package uses the 'Newton-Raphson Algorithm' for this estimation. Newton-Raphson Algorithm is a method of finding a 'good approximation' for the root of a function $f(x) = 0$.

The logistics regression modelling does not have one exact method of judging the fitness of its results. This is in contrast to the straightforward method of evaluating the results of a liner regression analysis. A collection of summary statistic is calculated by XLSTAT package for users to decide on the applicable modelling fit for corresponding purposes. This include goodness of fit statistics, test of null hypothesis (H_0) and Hosmer-Lemeshow tests.

A. Although several statistics are provided by the model for goodness of statistics, we consider the R_2 (Cox and Snell), R_2 (Nagelkerke), Akaike Information criterion (AIC) and Schwarz Bayesian criterion (SBC). The two R_2 values mentioned above together can explain the variability of the response variable with explanatory variables chosen for the model estimations.

Interpretation: As a rule of thumb, the higher variability is accepted as a better fit of the model.

Similarly, the lower values of AIC and higher values of SBC is considered as characteristics of a better fit model.

B. Test of null hypothesis (H_0; $Y=P_0$) relate to an independent model that gives the explanatory variable. In simple terms, the independent model keeps a constant value as the explanatory variable and measure the value of the response variable. This test check whether the adjusted (estimated model) is powerful than the independent model.

Interpretation: The null hypothesis (H_0) – the adjusted model is not powerful - can be rejected based on the p value obtained for -2Log (likelihood) in the results sheet ($p < 0.05$).

C. Hosmer-Lemeshow test tells how well the data fits with the model. This is used with binary response variables, in this case the Amazon logistics center. The output of the test is a chi-square value and a p-value.

Interpretation: Lower values of the test imply that the model is a poor fit while large values do not really confirm that model is a better fit. This is because the large values can also be resulted from poor test power of the model[65]. However, this test is also taken into consideration along with the other criterion mentioned above.

3.4 Data collection and verification

Both primary and secondary methods are used for data collection. At the initial stage of the study location of Amazon logistics facility locations are obtained from the report published by MWPVL international[66]. This information was updated at several times. The information available in January 2019 are used as the basis for the analysis. This information is later verified through the country specific official Amazon website and google map.

In addition, the national information sources of UK and Japan for the comparative study in chapter 04. The details of the sources are further explained in chapter 04. For the neighborhood scale analysis, the google earth images are used as the information sources. The time series google earth images are downloaded from the google earth desktop application. These google earth images are processed through the supervised image classification.

For socio-economic and land use related data for location model are obtained from the official government statistics portal (e-stat.go.jp) and National land numerical information download service (http://nlftp.mlit.go.jp/) . The base year for data collection was 2015/16. Similarly, the land use data, network data and other GIS supported data files are obtained through the National land numerical information download service of Japan.

Table 3.1: Data sources used in the study (for the case studies in Japan)

Data	Data Source	Year/s
Population and other demographic attributes	https://www.e-stat.go.jp/e (Portal site of Official statistics of Japam)	2005, 2010,2015
Employment – sector wise		2010,2015
Retail and wholesale establishments		
Transport and postal establishments		
Manufacturing establishments		
Land price	http://nlftp.mlit.go.jp/ (National Land Numerical Information download service)	2010-2015
Location of expressway interchanges		
Locations of airports		2015

3.5 Tools and techniques

This section of the thesis explained the tools and techniques used in this study. It basically includes the software and more specifically the techniques available in those packages.

3.5.1 Easymap maker

Easymap maker is web-based platform that enable the mapping of locations with an excel data base that contain postal codes and addresses. It transforms these text data into latitude and longitude data that can be used for spatial analysis. The free version of this API used for mapping the location information of logistics facilities collected from primary and secondary data sources, as mentioned in the previous section.

3.5.2 Geographic information system analysis with QGIS

QGIS is a professional Geographic information system (GIS) application which is Free and Open source software (FOSS). This study specifically used the QGIS 3.2 (Bonn) version that facilitate wide range of add-ins and analysis. This application is used in preparing data for both location choice model and land use simulation model. Several tools of this application are used at different stages of the study.

Table 3.2 Details of tools (specific) in QGIS used in the study

Tool	purpose
Distance matrix	Measure the ecuclidian distances between 2 given points (squre/ linear / summary matrix)
Points in polygon	Counts the number of points inside a polygon
Polygon cetroids	Calculate the true cenroid of a polygon
Joint attributes by location	Support the data managmnet by joining attributes based on spatial relationships

Note: This do not include the basic vector and raster data preparation, analysis and geoprocessing tools used in the study.

3.5.3 Grasshopper directions API

Grasshopper directions API is used to prepare the network-based distance matrix between different municipalities in TMR. This is an open sources tool that enable to retrieve network distance after the input of geo-coded locations.

3.5.4 Google earth and Google map

Google earth is used at different stages of the study. Both as a tool for data verification and source of data collection. The location information obtained from multiple sources are verified with the time series view of the google earth platform. In exploring the neighborhood s of Amazon logistics facility locations (in chapter 6), time series images of google earth are used as the primary data source. Free version of google earth is used for this purpose. Further it is used to verify the location data obtained from secondary data sources. In recent years, this is used as a tool specifically on research on logistics facility locations-based studies. It include the identification and verification of logistics facilities based on morphology patterns[17].

3.5.5 Statistical analysis with XLSTAT

XLSTAT is a flexible MS excel add-on that support the data preparation and analysis with MS excel environment. The statistical analysis performed with this tool include, correlation matrix, principal component analysis (PCA), and estimation of multinomial logit model. The student licensed version of this software is used for this study. Further details of the use of this tool along with above methods and results are explained in detail in chapter 07 of the thesis.

4 EMPIRICAL ANALYSIS I: AMAZON & E-COMMERCE LOGISTICS

Amazon.com is one of the pioneering firms in online retailing in the world. The company advanced from just being a mere online marketplace to an online retailing business model which operate on efficient logistics and supply chain systems. Later this business model for online retailing. They continued to expand their logistics facility network across the world. This chapter include the following aspects. Firstly, provide an overview of Amazon logistics network in the world; secondly analyse the spatial distribution of Amazon e-commerce logistics facility locations in Japan and UK through a spatial analysis.

Note: Parts of this chapter are presented and published at following conferences and journals respectively.

11th International conference on City Logistics,12th -14th June 2019, Dubrovnik, Croatia

Transportation Research Procedia 46C (2020) pp. 149-156

4.1 Amazon as a game changer

4.1.1 First movers in online retailing

Amazon founded by Jeff Bezos in 1994, Washington DC. Amazon began as an internet-based bookseller and has since become one of the leading e-commerce retailers. While business-to-consumer (B2C) remains their main retail segment, it employs a multi-level strategy in its total operations. The main components of the firm are Amazon online marketplace, prime service and Amazon web service (AWS). The richness in technology, artificial inelegance, and handling of big data had largely support the customer expansion of the firm. Amazon prime stands as a special category which also linked with the logistics network of the firm. Accordingly, this special service is being supported by the physical network.

4.1.2 Global e-commerce performance of Amazon

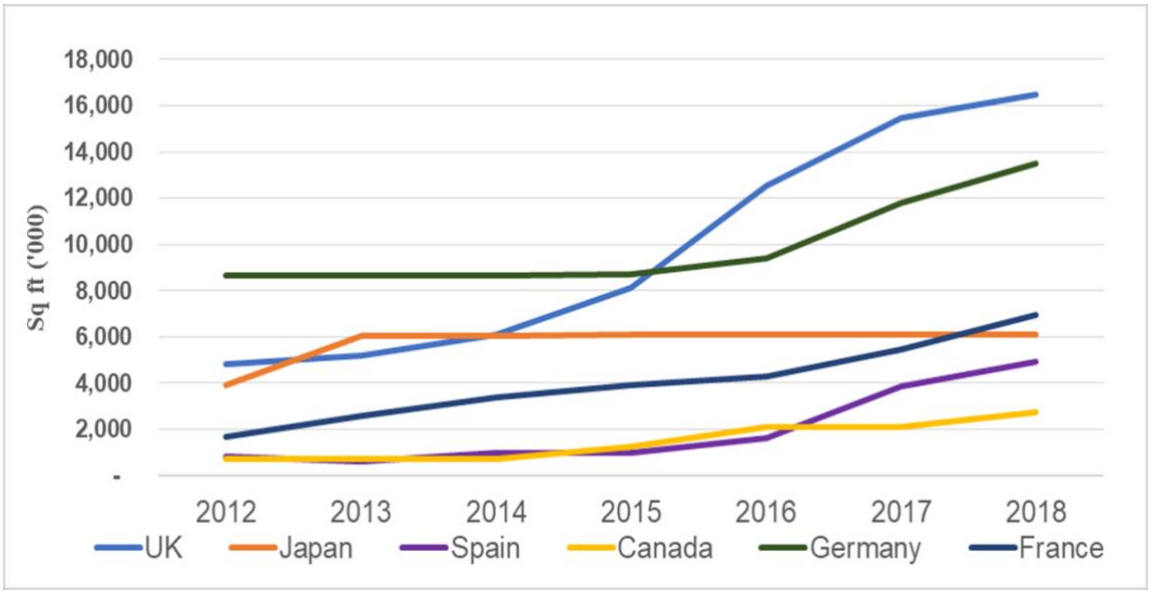
At present (2019) Amazon accounts for 50% of e-commerce sales in US [67].Further in 2018 their global work force on online retailing was 560,000 compared to 30,000 work force in 2010. It served a wide range of product categories and also diversify their service levels to serve range of market groups. This include the special 2hr delivery for prime members in some cities. The establishment of Amazon prime now fulfilment center in Manhattan, US is a reflection on the level of prominence Amazon given for its physical logistics network.

One of the core management principles found in the rapid growth and expansion of the firm, is related to the idea of ‘losing money to make money’. The bottom-line of this process is the continues improvement in the sector. Management theorists Jim Collins conceptualized this process through a concept known as ‘flywheel effect’. This is visible in how annual sales and profits vary, with sales showing an exponential growth compared to a more or less flat net profits curve[67]. This aspect is visible in how the logistics capacity of the firm being increased over the years worldwide.

4.1.3 Logistics facility network and capacity

The Amazon e-commerce logistics network includes a range of facilities at different scales, which is an important consideration for this study. Accordingly, Amazon, which has more than 700 e-commerce logistics facilities operating across 21 countries worldwide. The logistics capacity of the company is doubled between the period of 2015-2018.

Figure 4.1: Expansion of logistics capacity of Amazon (the figure excludes US)



These fulfilment centers are not just parts of Amazon's supply chain, but in some instances also perform the function of 3PL for traditional retailers who are developing their online sales channels. These fulfilment centers are usually equipped with high-end technology and the inventory management system is unique to the company. Amazon classifies their logistics facility network into seven facility types. These include e-fulfilment, replenishment, customer return, and sortation centers, as well as delivery stations, specialty sites, Prime Now and Flex hubs.

How Amazon logistics strategy worked is vary between different countries. This variation is more visible at last mile carrier function. For an example in Japan, Amazon work in collaboration with Yamato and Sagawa for product deliveries. Similarly, they have partnerships with carrier firms at different countries. However, fulfilment facilities remain to be the nucleus of whole operation. There are instances where Amazon also undertake the carrier function. These differences can be better understood through the proposed framework by Ghezzi et al. At the moment Amazon represents the largest and most advanced e-commerce logistics network [34].

4.1.4 Innovations in e-commerce logistics

In addition to their pioneering presence in e-commerce and fulfilment centers, Amazon is known for its technology-based innovations to improve the logistics capability of the firm. This include the warehousing technologies and last mile delivery technologies.

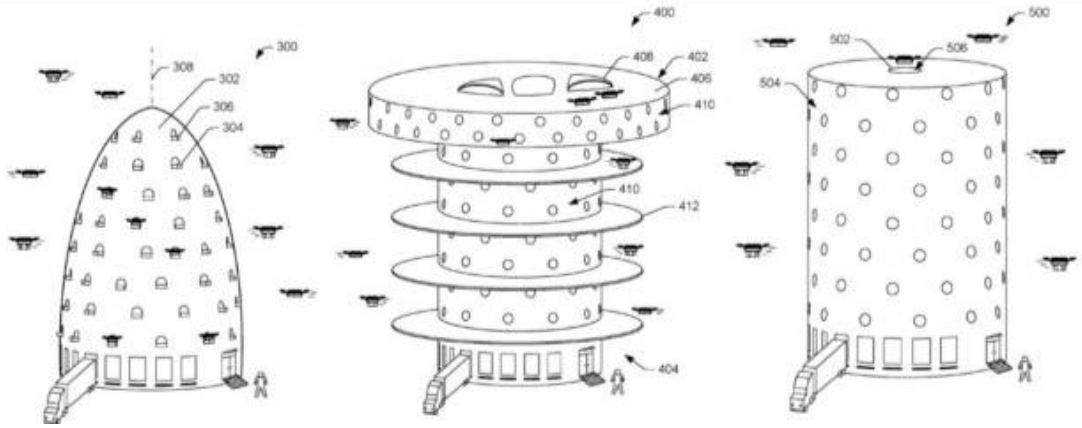
4.1.4.1 Warehousing technologies

Amazon robotic systems installed at fulfilment centers was a trademark service improvement strategy. these robots are at work at small sortable item fulfilment centers. These robots are capable of moving pods where the products are stored. Further at certain fulfilment centers the firm employ different robotic system known as 'Robo-stows'. These high-tech technologies had made the layout, required workforce, and organization of fulfilment centers compared to traditional distribution centers.

4.1.4.2 Last mile delivery technologies

During the last 5 years, Amazon had significant investment to incorporate drone's delivery systems to its logistics network. Drones are capable of delivering products at 20 km range with an average delivery time 13-15 minutes[68]. Since 2013, Amazon so far obtained more than 64 patents for different concepts and technologies associated with the drone deliveries.

Figure 4.2: Multi-level fulfilment centre for unmanned aerial vehicles (Patent No. US2017/0175413A1)[68]

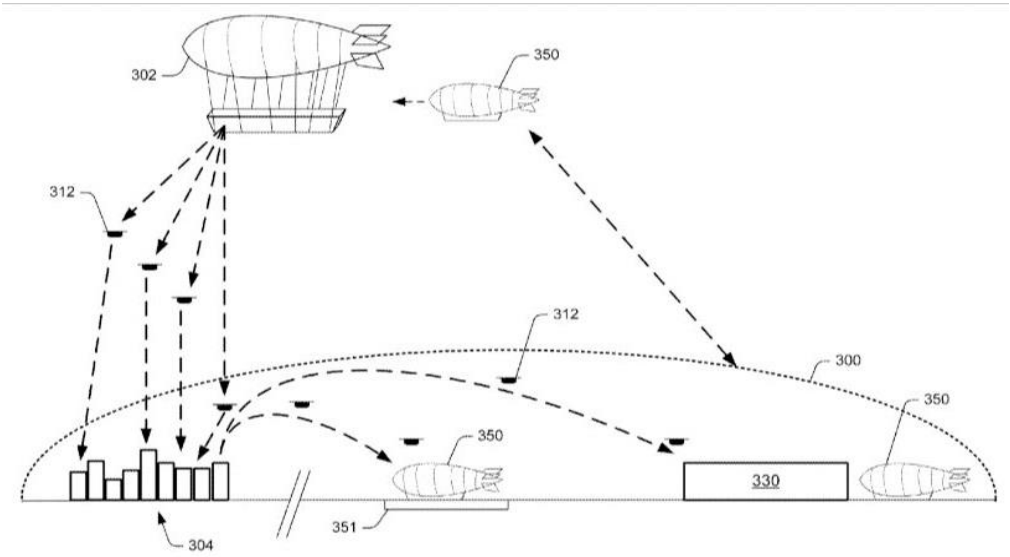


This thesis examined two patents obtained concepts that has a direct relevance for the scope of this study, e-commerce logistics facilities. Firstly, the multilevel fulfilment

center for unmanned aerial vehicles and secondly the airborne fulfilment center. This will be a fixed multi-storied facility that enable the launch and return of drones and other unmanned aerial vehicles that used for product delivery.

Another concept Amazon had obtained the US patent is the airborne fulfilment center. That will be a airship that orbit an area of 45,000 ft [68]. It was not Amazon who consider about such advanced alternatives. But also, the Walmart had a similar patent obtained in 2017.

Figure 4.3: Airborne fulfilment center (Patent No. 9,305,280) [68]



Although these two typologies are still at the concept stage, the realization of these typologies will definitely alter the scope of the subject researched in this thesis. Further it may signify the importance of topic initiated by the thesis.

4.2 E-commerce situation in Japan and United Kingdom (UK)

This section explains the key characteristics of e-commerce (B2C) environment in Japan and performance of Amazon in both counties.

4.2.1 E-commerce in Japan

According to the United States Commercial Service's E-commerce Innovation lab, by the end of 2017, Japan is ranked as the world's third and fastest growing e-commerce markets in the world, with an annual growth rate of 8.7%. Further E-commerce contributes to 2.8% of total GDP in 2016, with 74% of the online population engage in online shopping in the same year [69]. United Nations E-government index

provides a comparative analysis of e-government development had ranked Japan in at 11th place in its index in 2016. Amazon.jp, Rakuten and Yahoo are among the leading e-commerce platforms with a market share of 35%,30% and 17% by early 2017. In addition to e-commerce above companies, several leading department stores, retail outlets, apparel companies and supermarket chains had launched their e-commerce platforms to perform omnichannel business.

4.2.2 E-commerce in UK

According to statista.com, UK is ranked as third largest e commerce market in the world, behind and US and China. Further e-commerce account for almost 8% of the GDP of country. Amazon UK is identified as the market leader along with eBay UK, Argos, Tesco, and other firms (the market share may vary slightly for different products).

4.3 Methods and data sources

According to the World Population Review, the dense urban form of Japan includes 13 cities with a population over 1 million, 190 cities with a population between 100,000–1 million, and 540 areas with a population of less than 100,000.

In Japan, cities with a population of more than 500,000 are categorized as designated cities, while cities with a population of 300,000, and in some case between 200,000–300,000, are classified as core cities (Population of Cities in Japan, 2019). Tokyo Metropolitan is the main urban region of the country with a dense urban conurbation with a population of more than 8 million people. On the other hand, the UK has 12 core cities with populations over 300,000, while there are 24 other cities and 119 large towns with a population of more than 175,000 and between 60,000–175,000, respectively.

The spatial analysis of location and spatial data at national and regional scales is the main methodology in this study. Overall results presented as maps and descriptive statistics.

As a working definition based on United Nations settlement classification, this study categorizes cities into three main categories: Large- (population over 250,000), Medium- (population of 100,000–249,999), and small-size cities (population less than

100,0000). QGIS 3.2 (Bonn) and related plugins are used as the main platform for spatial analysis.

The location of Amazon logistics centers obtained from the article published by MWPVL International and last updated in January 2019 (International, 2018). Further detailed information was obtained from the Amazon website and from business research papers and news segments of leading business analytics services from respective countries. In the case of Japan, boundary and population data for cities were obtained from the portal site of Official Statistics of Japan. The data on national highways and expressways, the location of interchanges, airports, and ports were obtained from the National Land Numerical Information service provided by the National Spatial Planning and Policy Bureau of the Ministry of Land, Infrastructure, Transport, and Tourism. For the UK, the population estimated data based on the 2011 census were obtained through the Office of National Statistics. Infrastructure-related data were collected from multiple sources, including Ordnance Survey, the National Mapping Service, and Open Geography data portal published online. In the UK, the roads considered include 'A' roads and national motorways. These data mainly include the point data of the location of Amazon logistics facilities, airports, and ports, while the population data collected for each administrative city of both countries.

Table 4.1: Details of facilities chosen for the study

Facility type	Japan	UK
Fulfilment centre – unclassified (refer to centershandling all types of items)	06	09
Fulfilment centre – Sortable items	05	01
Fulfilment centre – non-Sortable items	3	07
Delivery stations / Sortation centre	-	49
Receive centre	01	01
Prime now hub centre	07	13
Total	22	90

He et al identified popular methods employed to analyze the spatial dimension of logistics facilities. It includes average distance, centrographic, standard deviation ellipse, kernel density estimation (KDE), Gini coefficient, location mapping, location quotient, and Moran's I. Although e-commerce logistics can be broadly classified as logistics centers, the measurement and its applicability must suit the nature of the operation of each facility. Location mapping was conducted by referring to postal codes

and addresses of Amazon e-commerce logistics in both countries using Google Earth and EasyMapMaker, an online mapping platform.

The study considers population size, density and distance to transport infrastructure as a representation of urban form [70]. The Euclidian distances were calculated between the facility locations and nearest expressway/motorway interchange, nearest airports (domestic and international separately) and ports (excluding fishery harbors).

4.4 Spatial organization of Amazon logistics facilities - UK

It is observed that Amazon, UK has a uniformly distributed pattern compared to the facility network in Japan (figure 4.6 and 4.7). It is closely related with the polycentric pattern of urban form of the UK, which consists of a series of medium-sized cities. Since 2013, facilities started to concentrate in the corridor between North-west London to Manchester via Birmingham.

Amazon had launched delivery stations/sortation centers in the UK since 2013 to enhance its regional delivery capability. As shown in figure 1, the delivery stations, which dominate the facility network has wide coverage and located at both high- and low-density locations. Delivery stations with an average size of 100,000 sq. ft. and perform cross-docking operations. It may not only support the hierarchical operation of the supply chain but may also stimulate logistics demand at dense urban areas.

The prime hub centers located in dense urban areas, with an average density of 3000 persons per sq. km. (figure 4.4). It implies that Amazon managed to get hold of prime land to serve the prime now customers. FCs that handle non-sortable items, usually expect longer fulfilment time is located at relatively low dense areas. In contrast, FCs that handle sortable items located at areas with moderate densities (2000 persons/ per sq. km).

As shown in figure 4.5, all prime hubs located within 5 km range of a national motorway interchange. These facilities located within 20 km from either a domestic or international airport.

Figure 4.4: Population density of immediate neighborhood of the location of Amazon facilities, UK

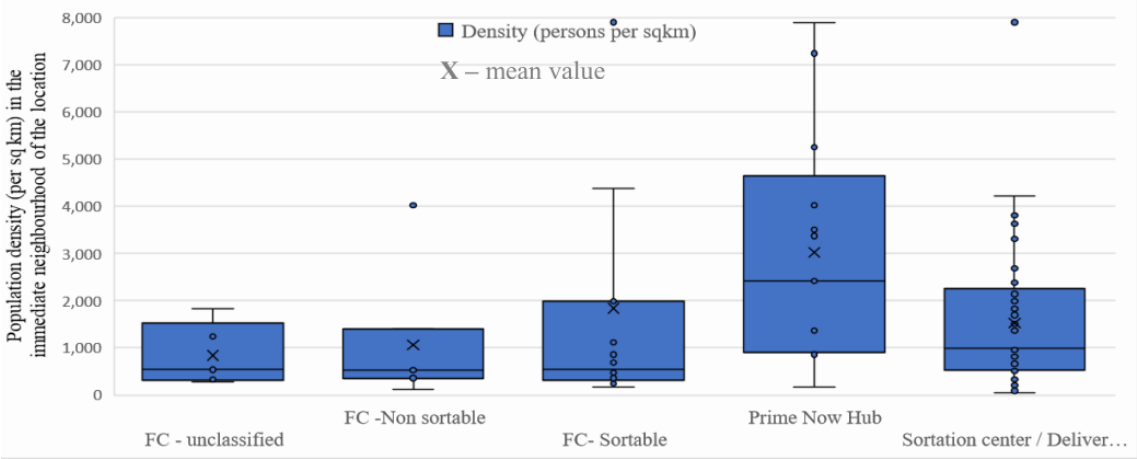
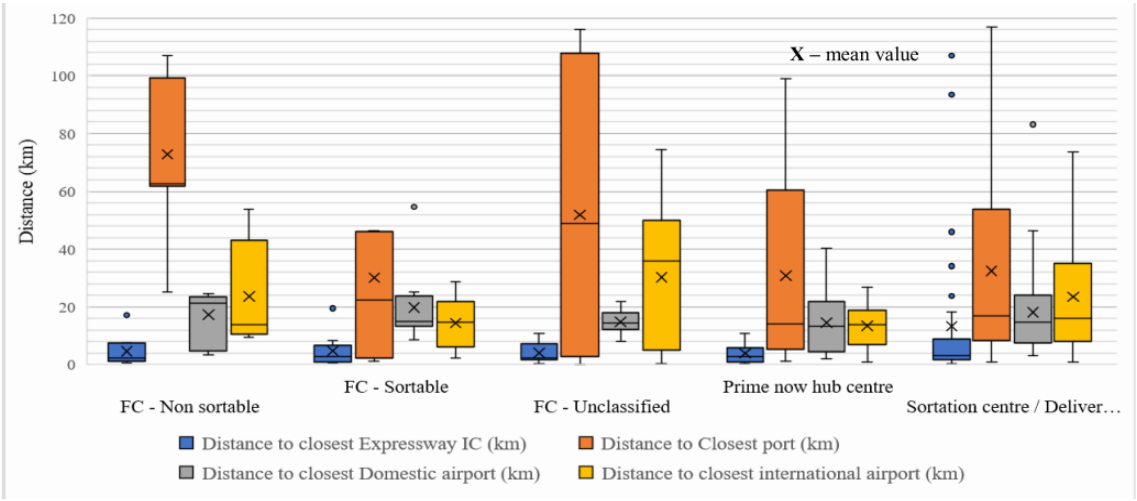
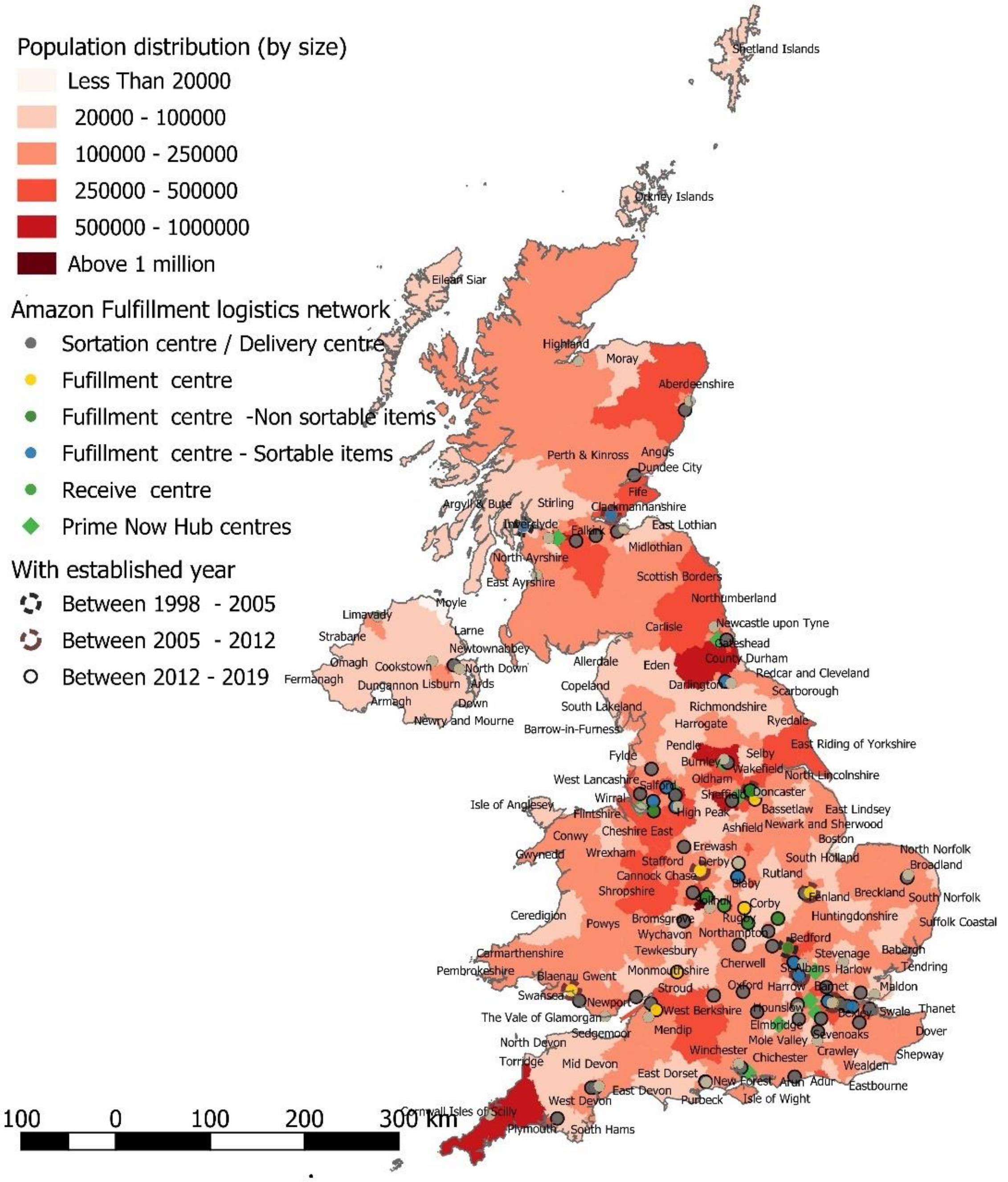


Figure 4.5: Accessibility of Amazon logistics facilities to transport infrastructure, UK



All types of FCs' can be considered important nodes of inbound (first mile) logistics, located on average within 8 km from a Motorway interchange and mean distance of 20 km from a domestic airport. During peak shopping season, Amazon use dedicated aircrafts for freight movement (Prime Air). Access to airports may play a significant role such logistics operations. It is also interesting to note that Amazon is attempting to include drone deliveries, which they have already trialled in the UK. Logistics stations that use drones must be located away from airports and domestics runaways to avoid potential conflicts.

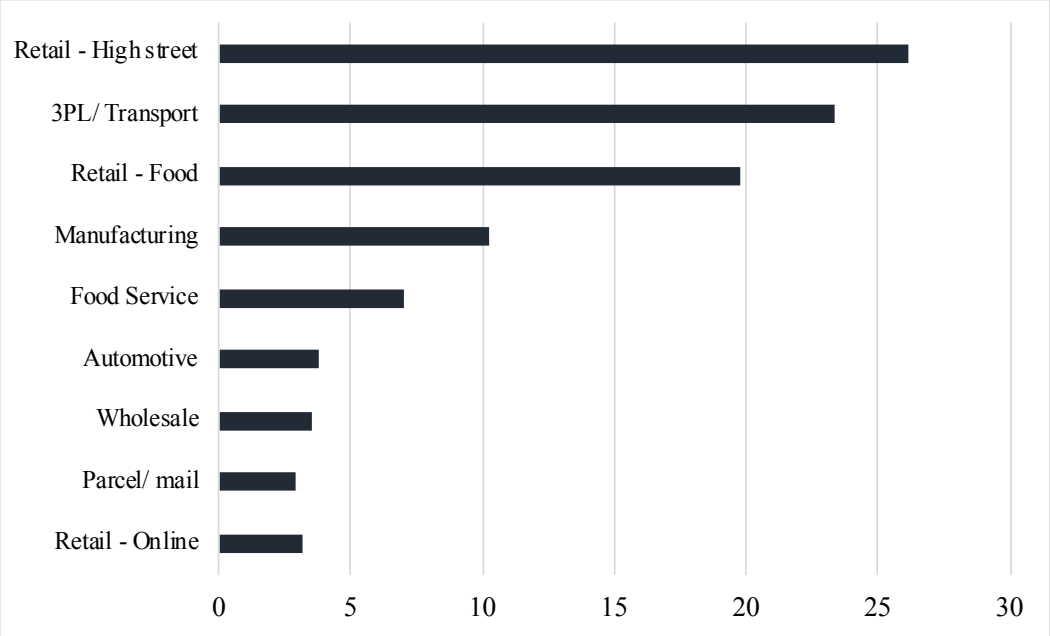
Figure 4.6: Spatial distribution of population and Amazon logistics facilities in UK, 2019



4.5 Comparison of Amazon with organization of traditional logistics facilities - UK

Market research carried out by the United Kingdom warehouse association in 2018, reported retail-online warehouses as an emerging sector. Online retailing warehouse space accounts for almost 3% of the total warehousing space in the UK in 2018[71]. Retail- the high street is the central warehousing sector in the UK.

Figure 4.7: Composition of warehousing sectors (%) in 2018



Different sectors found to be the dominant sectors. The retail-high street is the dominant sector in South West, Yorkshire and humbler, West Midlands and North West regions. 3PL/transport sector dominates the East of England, Scotland, and the East Midlands. The retail food sector found to be the dominant sector in Wales, North East, Inner M25 region, and the South East. Inner M25 region covers the Greater London region (table 4.2).

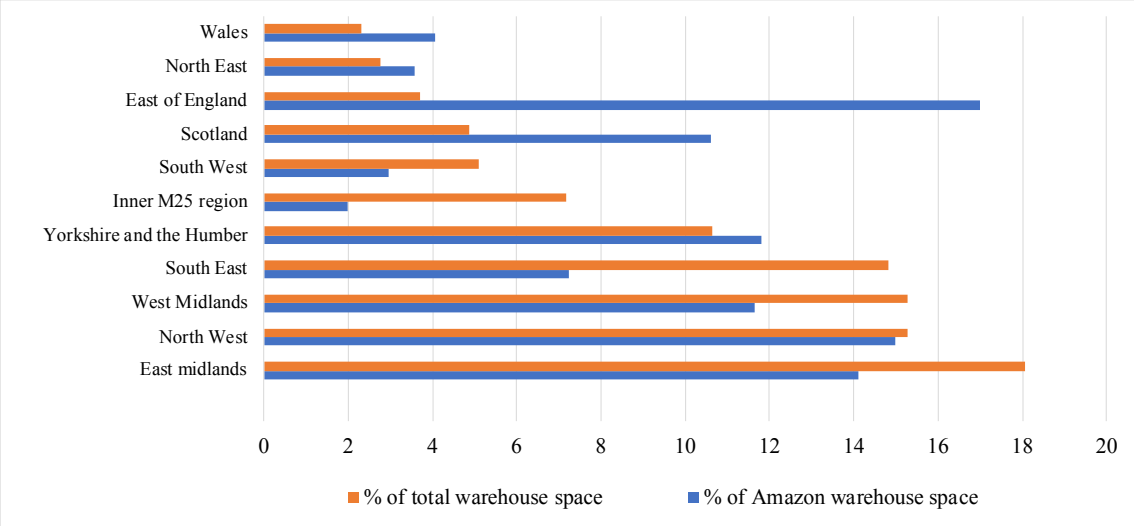
The main distinct feature the is the difference between the spatial distribution of Amazon e-commerce logistics centers in comparison to the warehousing sector (figure 4.8). Amazon logistics facilities largely concentrated in the East of England. In comparison, the East midlands indicate a larger attraction of warehousing sector. The distribution patterns significantly vary between the regions. The North West region is the only region with a similar distribution pattern. It is evident that that, Amazon is taking a distinct path in organizing the logistics facility network.

Table 4.2: Dominant warehouse sector by region in 2018

Region	Dominant tenant sector	Secondary tenant sector
Wales	Retail – food (23%)	3PL/transport (21%)
North East	Retail-food (52%)	3PL/transport (14%)
East of England	3PL/transport (37%)	Retail – high street (32%)
Scotland	3PL/transport (25%)	Manufacturing (21%)
South West	Retail – high street (31%)	Retail – food (25%)
Inner M25 region	Retail – food (32%)	3PL/transport (30%)
Yorkshire and humbler	Retail – high street (34%)	3PL/transport (24%)
South East	Retail – food (27%)	Retail – high street (23%)
West Midlands	Retail – high street (27%)	Manufacturing (16%)
North West	Retail – high street (33%)	3PL/transport (22%)
East midlands	3 PL / transport (35%)	Retail – high street (28%)

Note: Please refer the appendix four for the map of these regions.

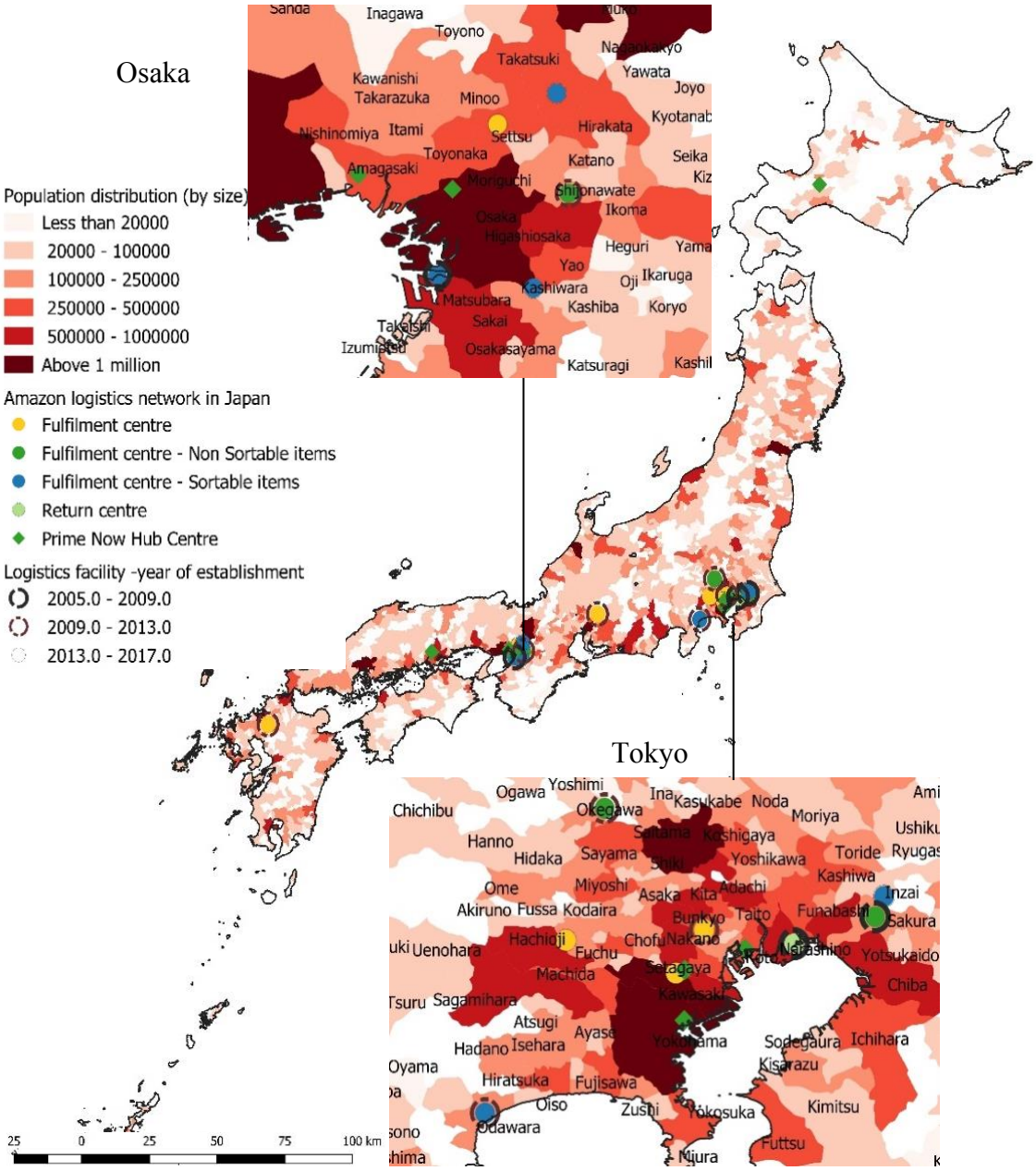
Figure 4.8: Spatial distribution of Amazon logistics facilities and total warehouse space in UK, by region in 2018.



4.6 Spatial organization of Amazon logistics facilities - Japan

The logistics facilities are predominantly concentrated around Tokyo and Osaka metro regions. This pattern overlaps with the urbanization pattern of Japan. Most peripheral regions are shrinking in terms of population size, while Tokyo, Osaka and Nagoya areas continued to attract more people.

Figure 4.9: Spatial distribution of population and Amazon logistics facilities in Japan, 2019



In the case of Tokyo, facilities located at a range of 40-50 km from the central Tokyo area. As shown in figure 4.7 and 4.8, all types of logistics facilities established at relatively higher dense locations, including the large size Fulfilment Centers. It allied with the centralized nature of the urban form of Japan and further agglomerations at already dense locations. The major proportion of facilities located within 4 km of the nearest expressway interchange (figure 4.9).

Figure 4.10: Population density of immediate neighborhood of the location of Amazon facilities, Japan

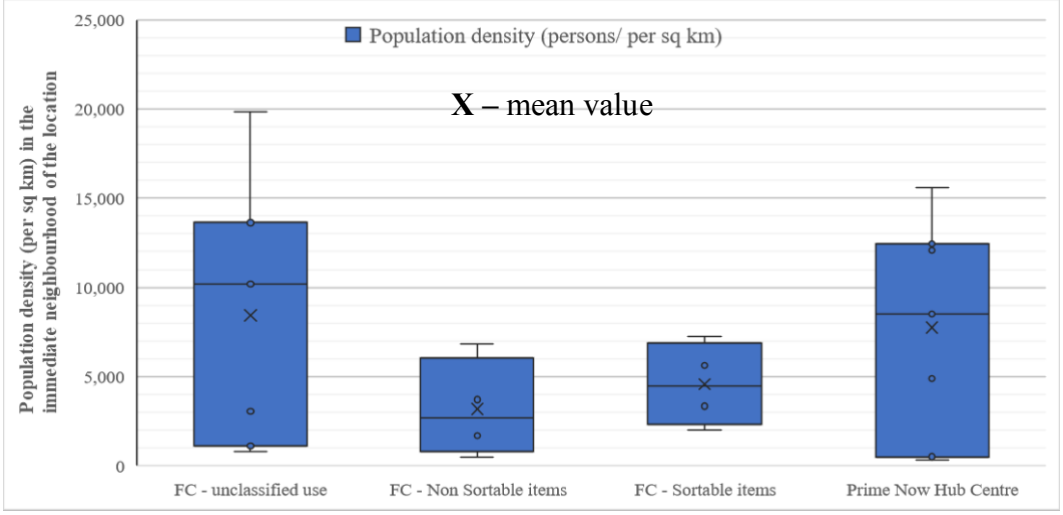
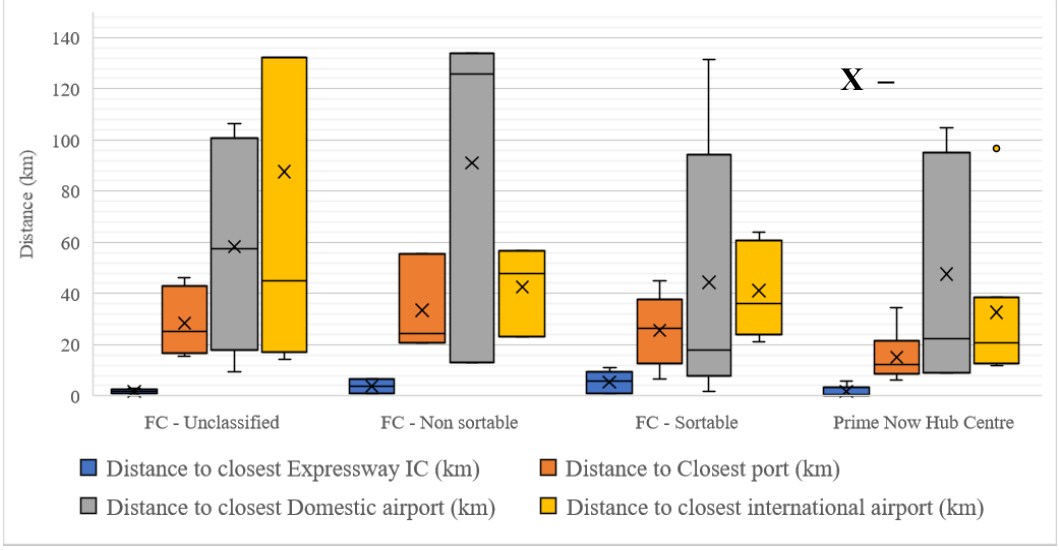


Figure 4.11: Accessibility of Amazon logistics facilities to transport infrastructure, Japan



This trend may be stimulated by the road transportation and logistics system of Japan. In 2018, Japan ranked 5th in logistics performance index of World Bank and known for better logistics competence, quality services and timeliness. The closeness for ports, especially in Tokyo may not represent the real use of the infrastructure, but the evolution of the city around the port area.

4.7 Comparison between Amazon UK and Japan

Distribution activities tend to be located close to locations that offer high accessibility where the cost of transport affects the overall efficiency of the process[41]. Planning and zoning requirements usually promote the location of large-scale logistics inside logistics or industrial parks, which are supported explicitly by related infrastructure facilities.

In the context of e-commerce logistics, there are issues of cost and the reduction of delivery time to meet customer demand. In both countries, the large size fulfilment facilities are clustered around the main population concentrations and located at proximity for road infrastructure. This pattern may support the Amazon in scaling its operation with a better trade-off between fixed assets (land and property) cost and the transport cost.

The medium-sized cities in the UK will be likely to promote the clustering of other e-commerce related logistics facilities of other firms. Furthermore, the present spatial organization and findings on locational characteristics of Amazon logistics facilities in the UK, support the observations of Lupton in 2018, on demand for logistics facilities outside the Golden Triangle[2]. In the case of Japan, large cities remain the most attractive for all types of logistics facilities. In comparison to the US-based observation of Houde, Newberry and Seim [72], in the UK there is no pattern of concentration between old facilities and new facilities.

However, the pattern in Japan suggests the concentration of fulfilment centers mainly at Tokyo and Osaka Metro Regions. The distributed structure of UK logistics facilities is mainly characterized by delivery stations, which is not featured in Japan. The concentric pattern of urban form, better inter-regional mobility and logistics competency of Japan in Japan will be unlikely to produce similar scenario. Instead, prime now hub centers may be established in few more cities to cater to the exclusive demand. Access to highway and expressway interchanges is identified as an important

factor in both countries. Based on a study in the Netherlands, Tchang (2016) found that distribution centers located a mean distance of 2 km from highways. In the case of Amazon fulfilment centers, the mean distance between facility locations and nearest expressway interchange is 8 km and 4 km for UK and Japan respectively.

4.8 Summary of the chapter

The findings reveal the close association between the spatial organization of Amazon facilities with the size of cities, the density of the location and proximity to transport infrastructure. In both countries, FCs handle sortable items located in areas with moderate densities, while FCs handle non-sortable items locate in relatively low-density areas. Prime hubs centers located in highly dense urban areas with higher accessibility potentials. The delivery stations/ sortation may locate with a better trade-off between land cost and delivery cost to ensure better regional spatial reachability while supporting the hierarchy of the supply chain operations.

Future research can focus on several exciting avenues. Firstly, the consideration of multiple factors, including labor markets, land value, the involvement of third-party logistics (3PL) companies, and last-mile delivery strategies used in each country. Integrating these aspects can reveal more insights about the overall effectiveness of these facility locations. Secondly, the studies may focus on dynamism at the regional – local scale. Thirdly, detail statistical analysis may well indicate the significance of different aspects concerning the facility location and later extended for modeling and evaluating e-commerce logistics facility locations. These findings can be coupled with freight movement data to capture the cumulative spatial effects on a broader scale. In conclusion, it is essential to emphasize that, Amazon is a first mover in the e-commerce sector and may leave a spatial footprint of interest to other firms. Such trends will raise interest in relating them with logistics-related spatial phenomena, including logistics sprawl and clustering.

5 EMPIRICAL ANALYSIS II: COMPARING THE GEOGRAPHY OF LOGISTICS OF MULTIPLE FIRMS

There are two main contributions of this chapter. Firstly, to describe the geographical distribution pattern of different types (selected) of e-commerce logistics facilities in the Tokyo region. Secondly, to compare the spatial pattern against the contemporary trends in retail and logistics in the Tokyo region. Accordingly, the specific questions that addressed in this paper; a) How to differentiate e-commerce logistics from traditional distribution logistics and retail stores? b) what is the pattern of distribution of e-commerce logistics, and what is the locational advantage of these locations? c) Do the e-commerce logistics cluster in specific areas of the city? d) Do e-commerce logistics established in areas where there is factor advantage for retailing or logistics?

Note: Parts of this chapter are presented and published at following peer reviewed conferences and journals respectively.

13th International conference on Eastern Asian Society of Transport Studies (EASTS), 9th – 12th September 2019, Colombo, Sri Lanka

Journal of the Eastern Asia Society for Transportation Studies, 13, 957-974.[73]

5.1 Methods and tools

Although many firms engage in online retailing, growing competition in e-commerce and the advancements in big data analytics, companies are careful in publicising company data and information. Further, even the available data lacked a temporal aspect and limited to some geographical regions. It also creates an operation difficulty for researching this nature. Accordingly, four companies selected for the analysis. Since geography is a focus of the study, it is decided to confine the study area to Tokyo Metropolitan region. The details of the case studies and the study region elaborate in subsequent sections.

5.1.1 Selection of firms

We carry out the spatial analysis to explore the location determinants of e-commerce logistics by using the framework mentioned above. Having considered the availability and reliability of information, we selected the e-commerce facility logistics of two pure e-commerce firms (Amazon and Zozotown), one e-commerce fulfilment logistics company (Rakuten) and one omnichannel retailer (Aeon) in Tokyo Metropolitan region. Further these companies also a purposive sample which represents several essential characteristics of the b2c e-commerce market in Japan. Such case study based approaches are used in similar researches carried out in this field ([74]; [75]).

5.1.1.1 Amazon in Japan

Detail description of Amazon was presented in the previous chapter. This section highlights key facts related to Amazon in Japan. By early 2019, Amazon had 22 logistics facilities (15 fulfilment centers and seven prime now hub centers) in Japan [66]. In the Tokyo Metropolitan region, Amazon operates 16 logistics facilities, which include seven prime hub locations and nine large scale fulfilment centers. At present Amazon, Japan is closely competing with Rakuten and Yahoo, Japan to increase market share [76]. Amazon provides same day deliveries and convenient delivery time options for its customers in Japan. The company yet to introduce the 2-hr delivery system which they operate in the US.

In Japan, Amazon relies on third-party companies for transportation activities. Mainly, the company obtained the service with Yamato transport co., Japan's leading courier firm for last mile deliveries. However, several issues raised on the payment

between companies in recent years, which brings a temporary halt for same day deliveries in Japan and later resolved by two companies.

5.1.1.2 Rakuten Super Logistics

Rakuten super logistics is a subsidiary company of Rakuten group of companies that has its origin in Japan. Rakuten is one of the popular e-commerce platforms in Japan. Traditionally Rakuten operates as an online platform (marketplace) that connect customers and vendors. However, the recent initiates taken by the company had signaled its interest in investments on logistics facilities to support the online business. Rakuten super logistics, which originated as a logistics service provider had branded its logistics centers as fulfilment centersthat facilitate e-commerce business. With its very recent investments, Rakuten Super Logistics operate six logistics stations Japan, and four of them located at Chiba prefecture, Tokyo region.

5.1.1.3 Zoztown

Zozotown is an online apparel firm, which also has its origin in Japan. The company expanded its logistics center by establishing a fulfilment center. At present, the company operated two main logistics centers dedicated to e-commerce fulfilment activities. Zozotowns' Just in time (JIT) type fulfilment model makes it a unique case with other selected case studies.

5.1.1.4 Aeon Net Shop

Aeon, on the other hand, is recognized as the largest retailer in Japan. In recent years, the company invested in e-commerce while seeing rapid growth in the business with grocery items. As part of their e-commerce expansion, in 2018, the company had also spent in Boxed, a New York Based e-commerce company with the intention of Aeons' e-commerce logistics system. In Tokyo region, the company has 204 stores, which includes, Aeon store, Aeon Mall, Aeon supercenters, GMS – clothing store, Daiei - supermarket, discounted stores and peacock – specialty stores. As per the aeonnetshop.com, which is the e-commerce platform for Aeon, 72 stores facilitate as grocery e-commerce logistics centers in Tokyo Metropolitan region. Aeon net shop both sell grocery and non-grocery items through the online channel.

In 2018 Nikkei Asian review reported that, Aeon jointly launched an online retail website with Softbank group and Yahoo Japan[77]. This was highlighted as an strategy to compete with Amazon and other e-commerce rivals in Japanese market. The idea of

this partnership was very clear since that is similar to the strategy of Amazon as a single online commerce firm. Aeon already have the physical network which can possibly be utilized its existing store and logistics system, while Softbank expected to be the data driven powerhouse while yahoo Japan can remain to be the platform for online market.

5.1.2 Tools, techniques and data sources

As the initial step of the study, the information on the Japanese e-commerce market, firm dynamics, the status of logistics and then the details of the selected four firms referred to online data sources. The credibility and reliability of the information used are confirmed by triangulating with multiple sources.

As the next step of the research, the location data of the logistics facility locations of the above firms obtained from the postal address. Later, the locations georeferenced with Google Earth and EasyMapMaker, an online mapping platform. The data on boundary, population, retail floor area, number of retail and transport logistics establishments for cities obtained from the portal site of Official Statistics of Japan (https://www.e-stat.go.jp/) . The data on national highways and expressways, the location of interchanges, airports, and ports, land price, physical distribution bases are obtained from the National Land Numerical Information service provided by the National Spatial Planning and Policy Bureau of the Ministry of Land, Infrastructure, Transport, and Tourism (http://nlftp.mlit.go.jp). Further used the information published on the Material flow survey conducted in the Tokyo region by the Tokyo Metropolitan Area Traffic Planning Council (https://www.tokyo-pt.jp/ about/01).

After gathering other relevant data from multiple sources, the spatial analysis is performed using the QGIS (3.2) open source GIS program. GIS is used in geography research with its capacity to visualize data. All analysis was performed using the WGS, EPSG:4326 geodetic system. The spatial study supported with the descriptive statistical analysis performed with MS Excel 2016. The proximity of the logistics facilities to cities was evaluated by calculating the Euclidian distance between the facility location and the geographical center of each municipality in the study region, where cities are defined based on administrative boundary classifications. In the case of accessibility indicators, the network distance between each facility location and the nearest airports and ports calculated.

5.2 Discussion I: Contemporary trends in TMR

This section details out the key trends in TMR with respect to demography, retailing and logistics. Although e-commerce is growing faster in Japan, there are several interesting trends can be seen in the Tokyo region. This section will review on trends related to population sizes, densities, number of retail establishments, number of transport and logistics related establishments, total retail floor area and financial status of the local areas by reviewing them by respective municipal boundaries. The findings later relate in the discussion which focuses on e-commerce logistics.

Shrinking population, which is a National issue Japan also featured in this region. Although the total population is increased by 6% from 2000 to 2015, many local areas experienced a shrinkage during the above period. Yokohama in Kanagawa prefecture recognized as the largest and dense area of the Tokyo region. As observed in figure 5.2 and 5.4 the central Tokyo along with Saitama and Kanagawa prefecture, which form the core of the metro region attract more people compared to significant shrinkages observed in other peripheral areas.

Figure 5.1: Rate of population change in administrative areas in TMR (2005-2015; based on administrative areas)

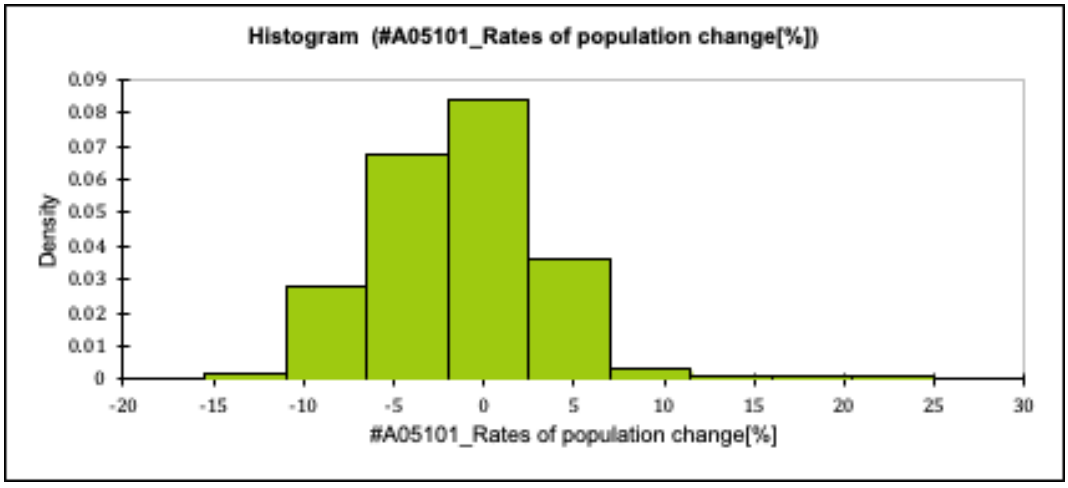


Figure 5.2: Population distribution by size and density in Tokyo region

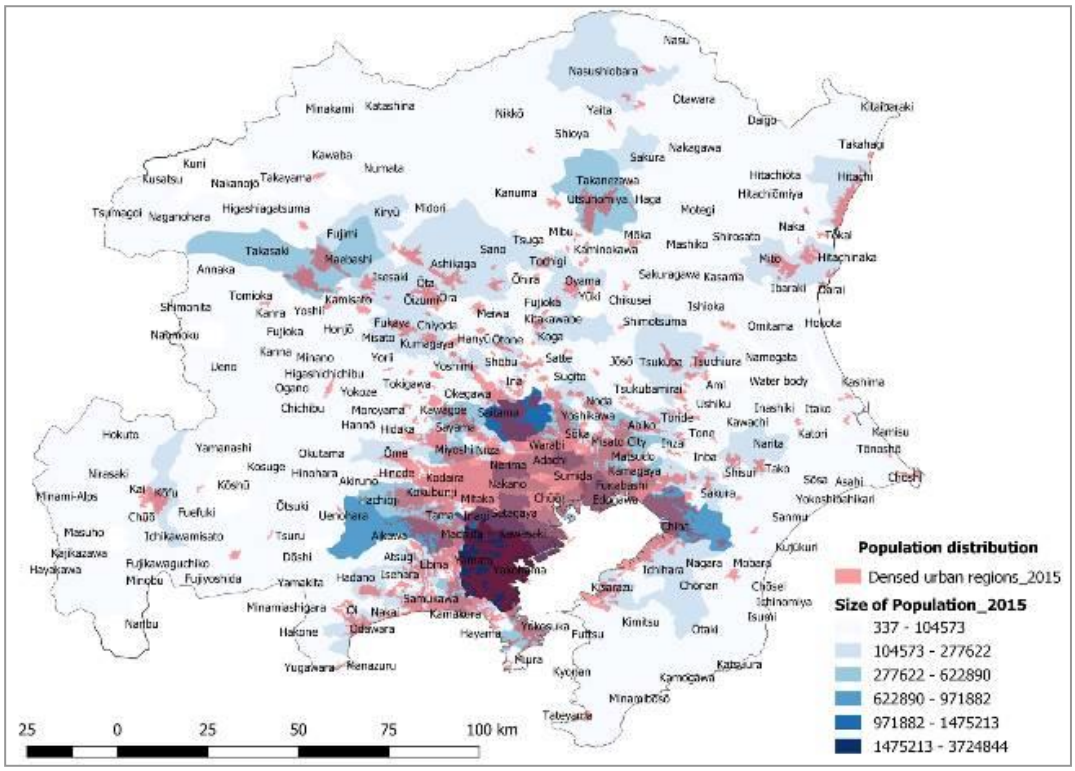


Figure 5.3: Distribution of population aged 15-64 as a % of total population in each municipality in the study region and the distribution of E commerce logistics facilities of Amazon, Rakuten and Zozotown

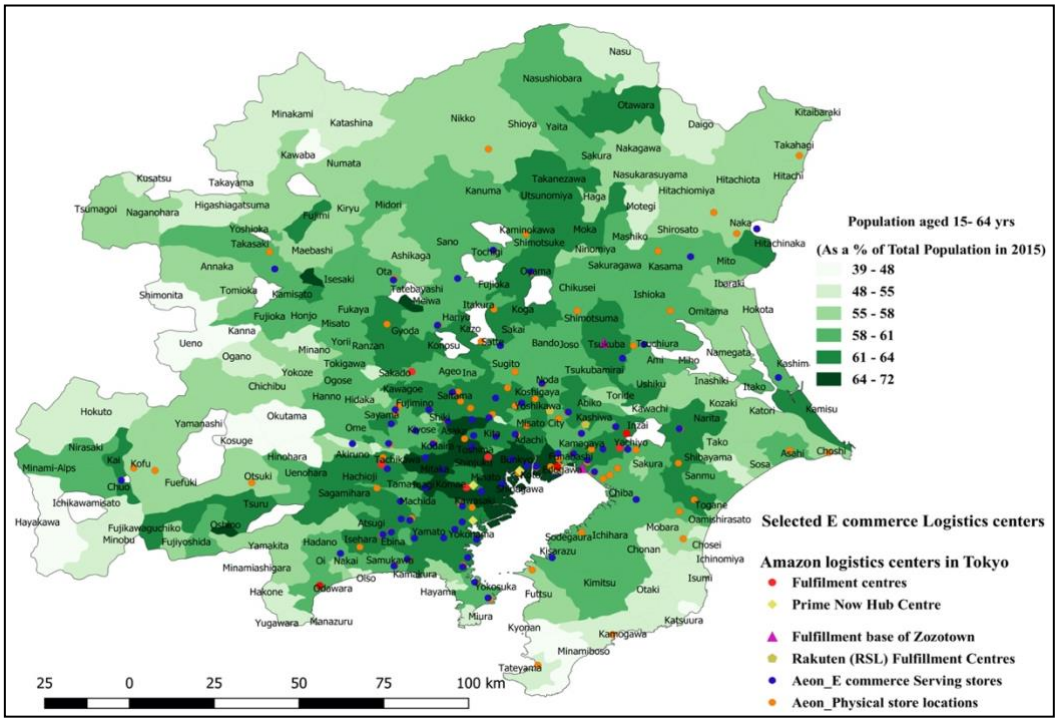


Figure 5.4: Contemporary trends in TMR - Change of population (%) between 2000 -2015

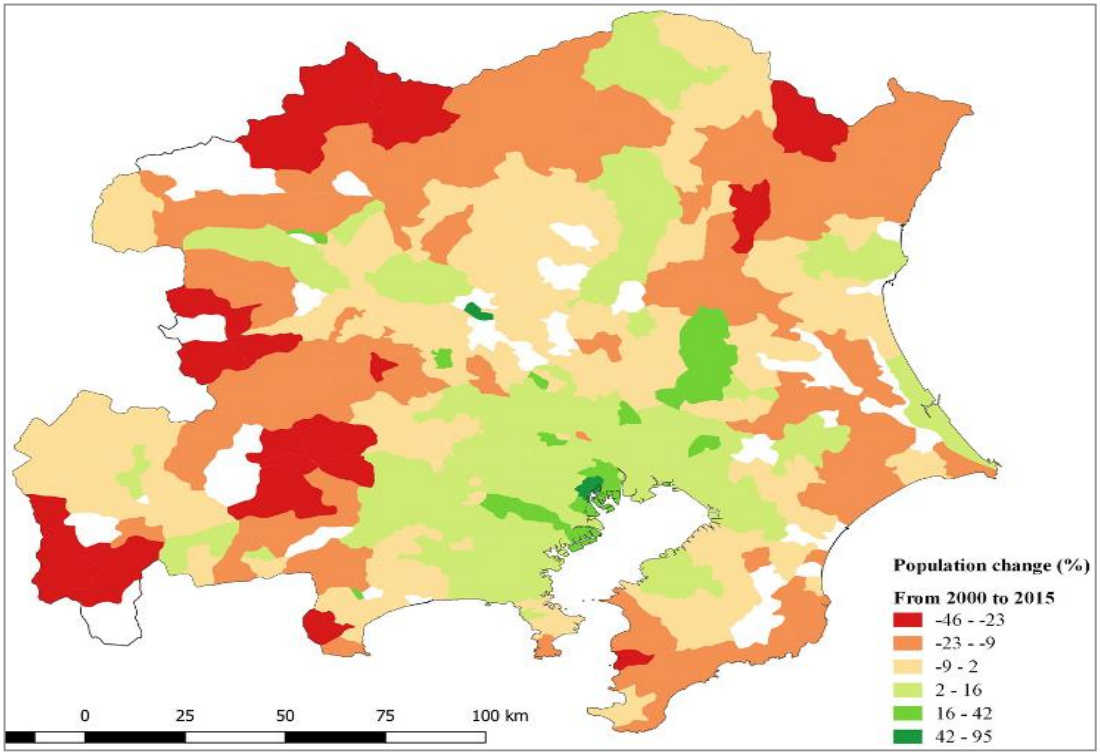


Figure 5.5 : Contemporary trends in TMR - Change of income (%) of municipalities between 2000 – 2015 in Tokyo region

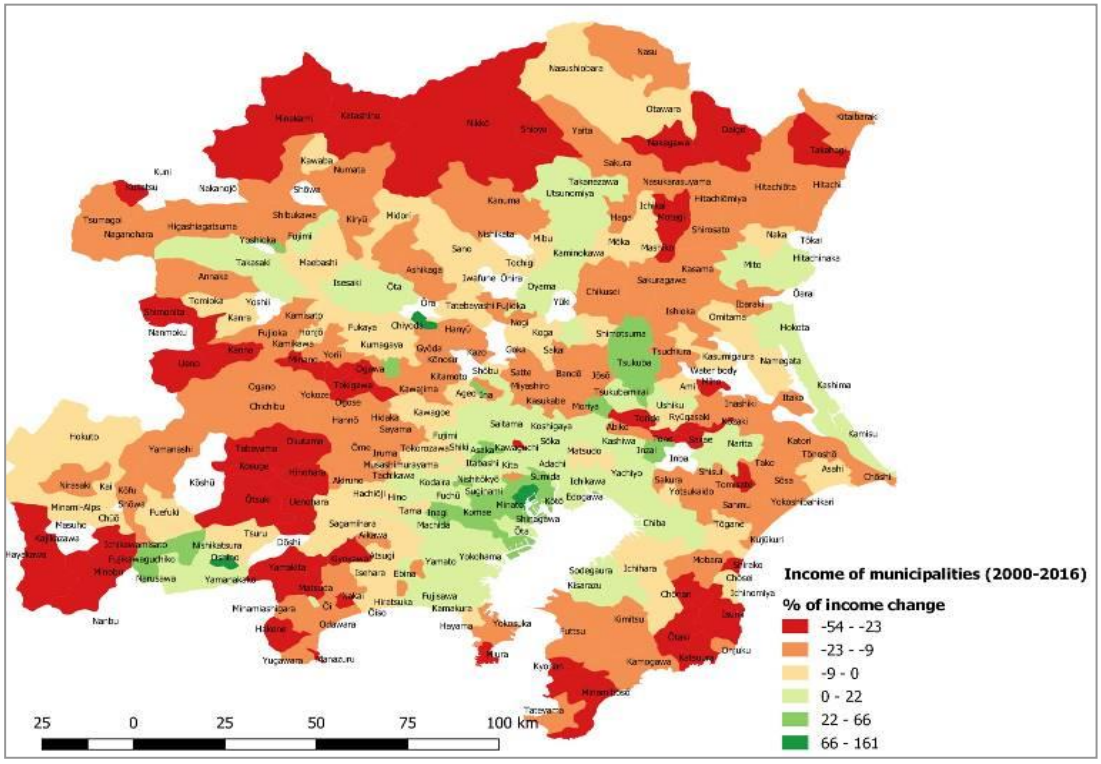


Figure 5.6: Contemporary trends in TMR Retailing dynamics – retail floor area changes between 2009 – 2014

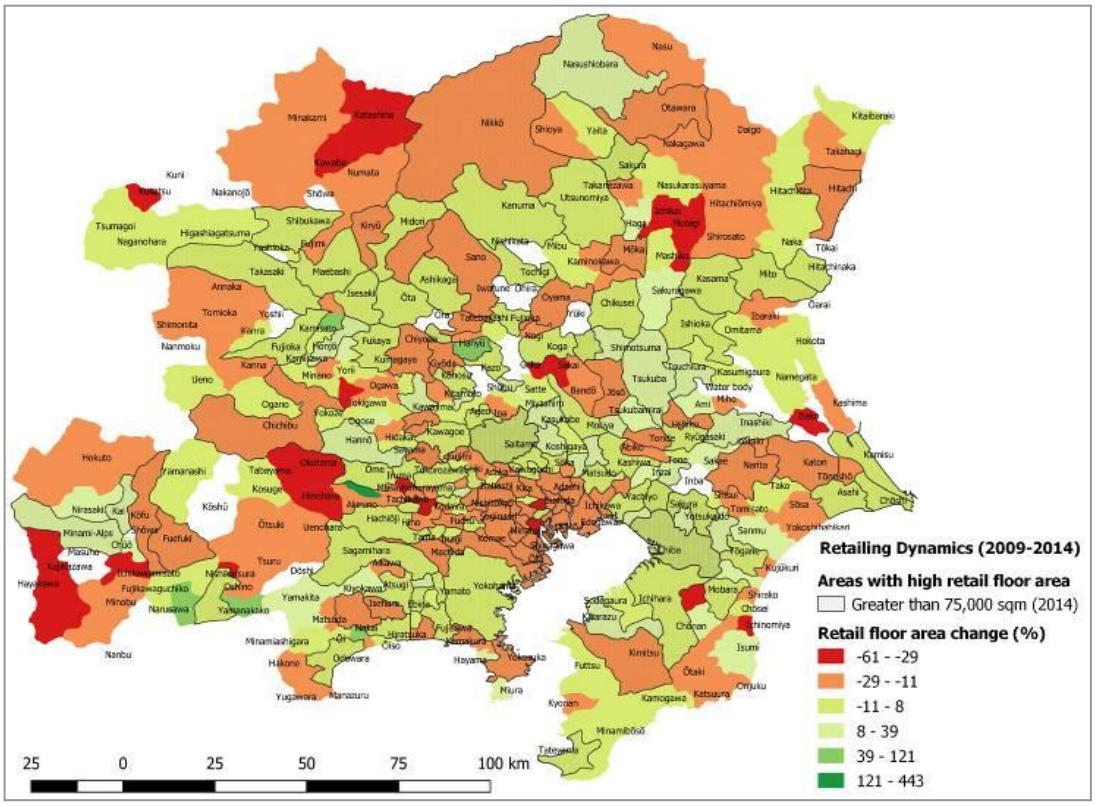


Figure 5.7 : Contemporary trends in TMR - Changes in Transport and logistics establishments between 2009 – 2014

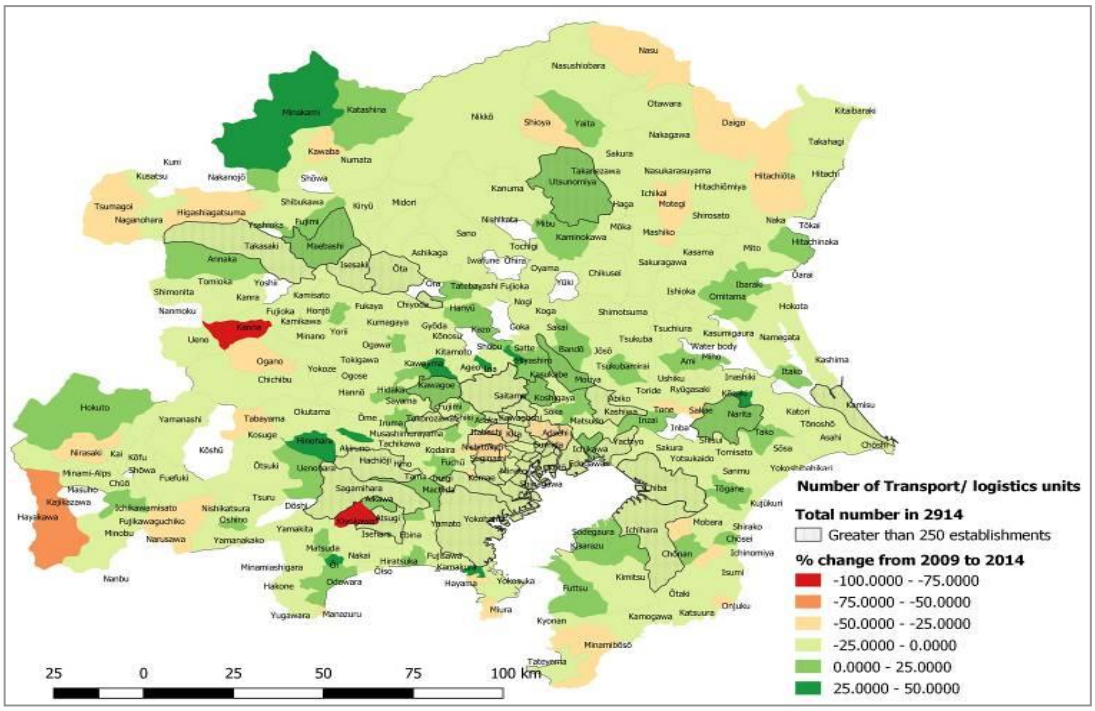
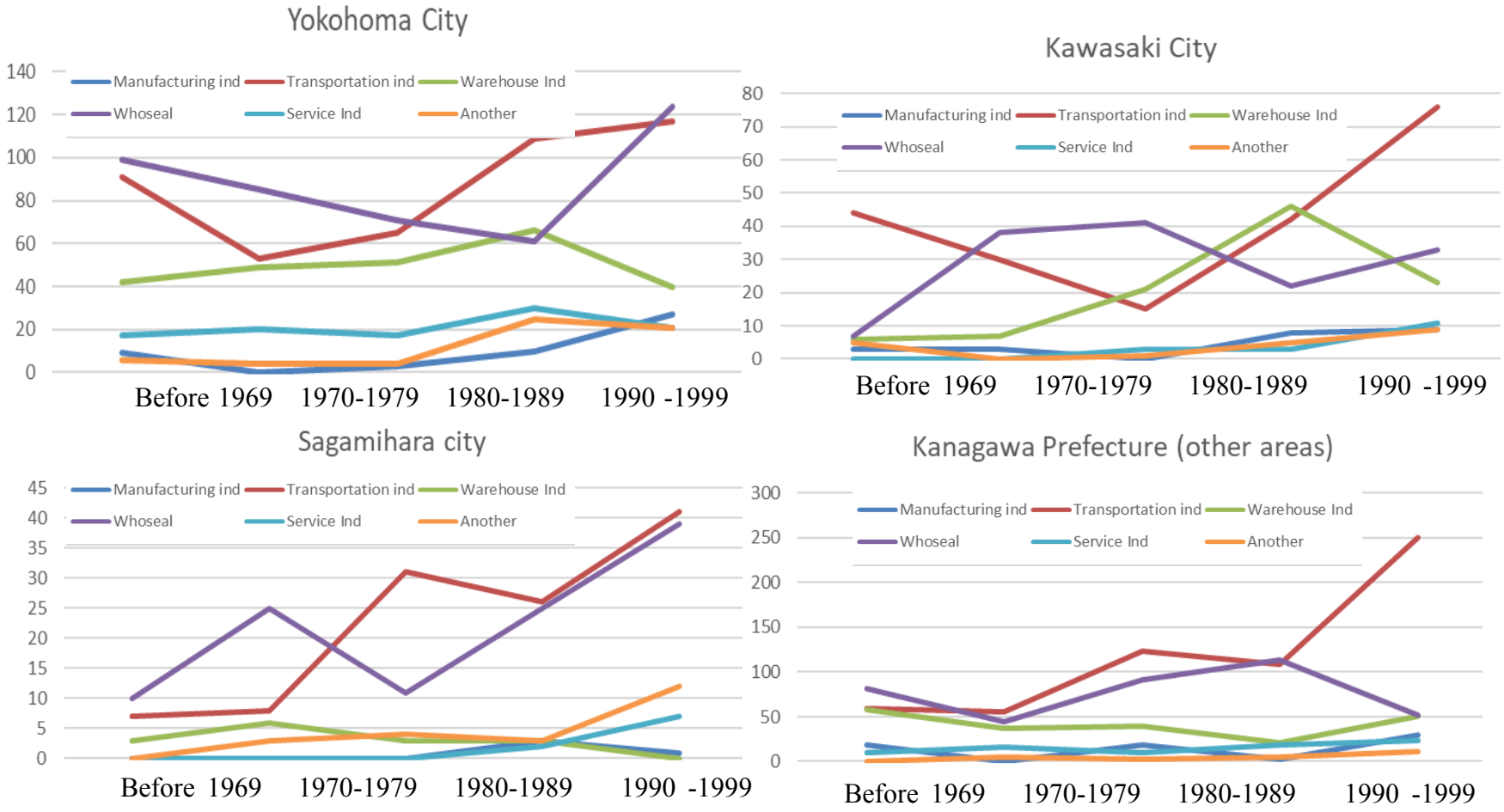


Figure 5.8 : Growth pattern of manufacturing, logistics and transport sector in Kanagawa prefecture (before 1969 – after 2000)

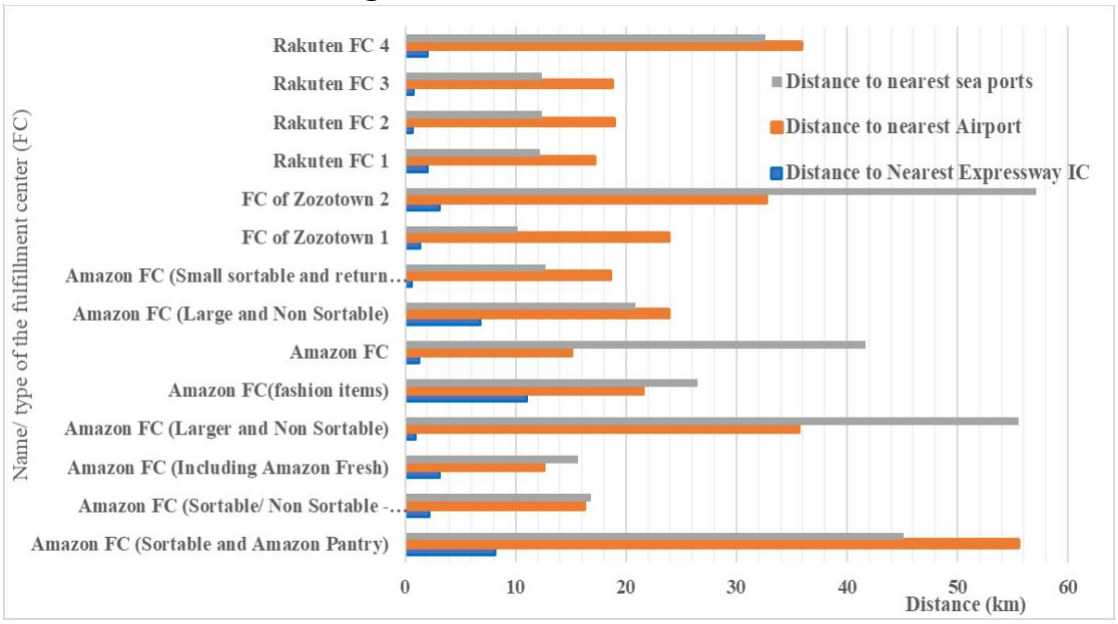


5.3 Discussion II: the spatial distribution of large sized logistics facilities of selected firms

This section explains the spatial distribution pattern of large sized facilities of Amazon, Zozotown and Rakuten Super Logistics.

The fulfilment centers of Amazon, Rakuten super logistics and Zozo town located at a central part of Tokyo, South of Saitama prefecture, north-west of Chiba prefecture or eastern side of Kanagawa prefecture. Several FC centers concentrated in Ichikawa city. Rakuten logistics centers are concentrated towards the east side of Tokyo while Amazon facilities are distributed covering the core area of the region.

Figure 5.9 : Accessibility to expressway interchanges, airports and seaports, from the selected e commerce logistics facilities



One possible explanation for this pattern can be the nature of products sold and the supply chain strategy. Rakuten fulfilment logistics appeared to be gaining the advantage of proximity to airports, which enable global movements. On the other hand, Rakuten.com.jp online selling platform features many Chinese and non- Japanese vendors. It provides a reasonable assumption to argue that the location of Rakuten Super Logistics may target these vendors and further relying on the location and the presence of Third-Party Logistics (3PL) provider in Japan for outbound logistics. For

example, transport, logistics and postal-related establishments had increased in Ichikawa city by 25% during the period between 2009-2014.

Zozotown has a manufacturing dimension in the order fulfilment located in central and north-eastern parts of the Tokyo region. For this manufacturing-based e fulfilment process, labor can easily be a decisive factor in the location selection. In respective cities where the facilities locate, 60-65 % of the population within the active labor force. The fulfilment based in Tsukuba, Ibaraki prefecture indicate the scale of economies dimension of the firm, though its presence in the E-commerce environment. In recent years, many firms set up at Ibaraki prefecture.

Amazon, on the other hand, has three fulfilment centers to deal with fashion items. Since Amazon does not perform a manufacturing function in fulfilment, the locations are more on optimal locations to balance the cost and time of distribution logistics. In considering the functionality of the logistics centers, Amazon fulfilment facilities located at relatively modest density areas in the region. However, Amazon fresh center located in the high-density area. Amazon fresh in Japan have limitations on the products it sells and the area it served. This location is proximity with the prime hub centers which is forming the distribution network.

Tokyo region well connected with other parts of the country with the expressway network. Further, the system inside the region enhanced inter-regional mobility. The Tokyo region globally connected with international airports and seaports. It is revealed from the selected firms that access to expressways (roads) is more prominent than over the access to air and seaports for all fulfilment centers.

All the selected e-commerce logistics facilities discussed in this section are in areas that had seen a growth of 20-30% in transport, logistics and postal activities between 2009-2014. Odawara, where Amazon set up its largest fulfilment center, has a relatively low population density compared to other regions. The attraction of logistics related activities to areas other than Yokohama, Kawasaki and Sagamihara in Kanagawa Prefecture is a trend seen in the last decade (figure 5.5). The growth of the logistics sector at the north-west region of Tokyo mostly follows the development of the expressway network in the region [78].

All the above fulfilment centers distributed in areas which recorded an average land price of 9,00 - 1,130,000 (Yen/ per sqm) for commercial and industrial purposes. The above is relatively a modest value range compared to the highest demand of land for the same use in the Tokyo bay area with a variety of 37,500,000 – 55,500,000 Yen/

per sqm. In Comparison to clustering pattern in fulfilment centers in the USA, the Tokyo region show a distributed pattern of Amazon fulfilment centers[72] .However, Rakuten logistics show a clustered pattern.

5.4 Discussion III- Amazon prime now hubs and Aeon Net shops

Amazon prime now hubs are meant to fulfil the online orders with a short time window (2 hrs). At present, this service limited to some regions of the region, which include certain parts of central Tokyo and Kanagawa prefectures. When to relate this is with the population distribution, the two areas overlap. Another interesting finding is that more than 50% of the area served by Amazon prime now serve recorded a retail floor area reduction of 30 - 60% during the period of 2009- 2014. Amazon prime now facilities established during the periods of 2016 -2018. Therefore, these two facts cannot be related to making further conclusions, where retail floor area change data are not available since 2014.

Figure 5.10 : Amazon prime now hubs service area (2019) and the retail floor area change between 2009-2014

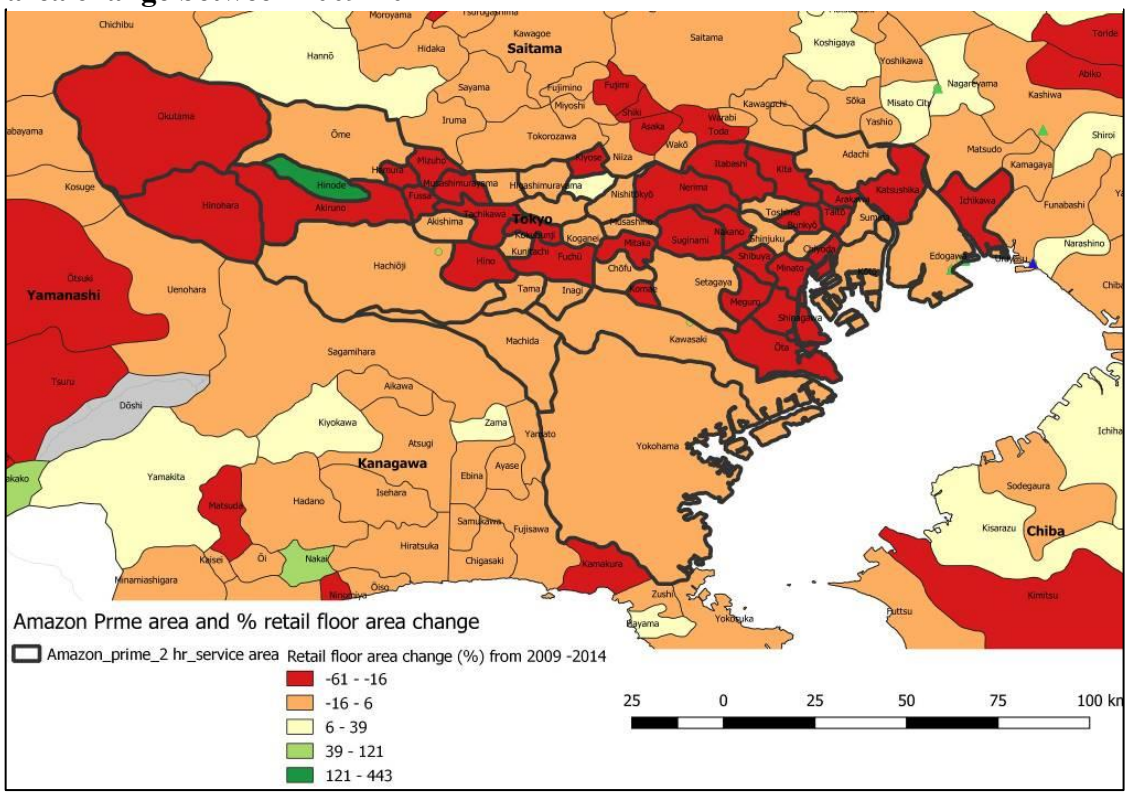
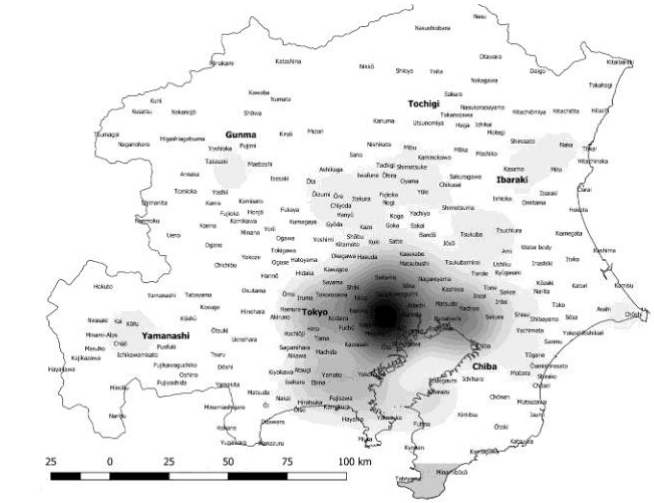
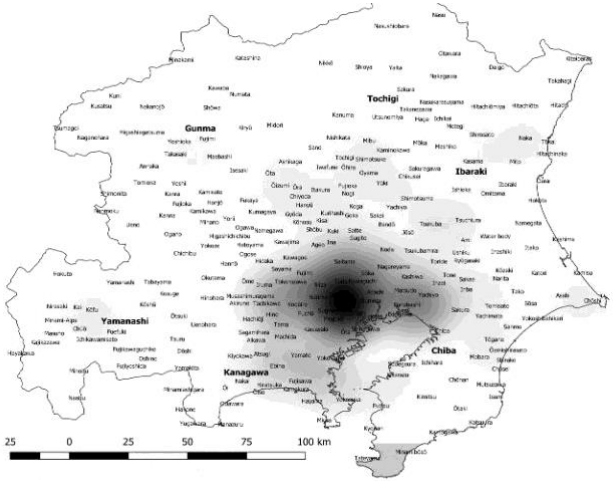


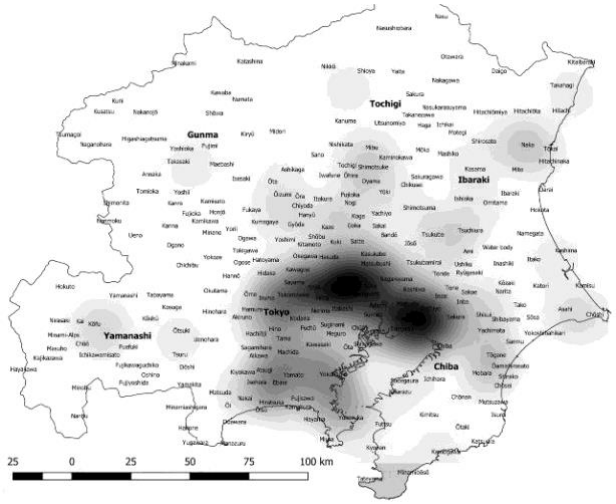
Figure 5.11: Heatmap analysis of distribution of Aeon stores and net shop locations in TMR



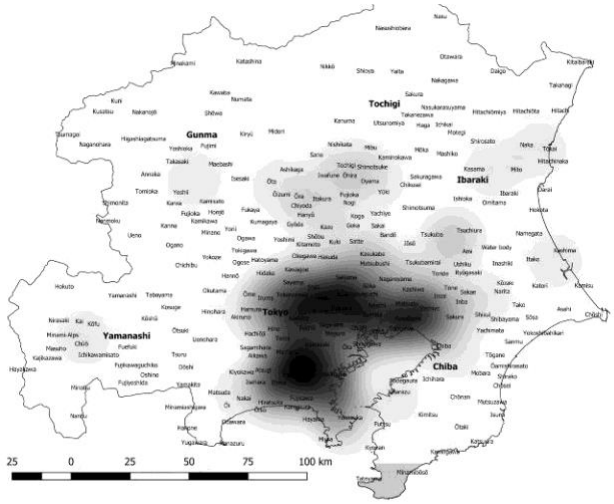
Heatmap of the distribution of All Aeon establishments (left)



Heatmap of the distribution of Aeon establishments (except discounted stores and Aeon GSM stores) (right)



Heatmap of the distribution of Aeon establishments (only Aeon super centers) (left)



Heatmap of the distribution of Aeon establishments (Serving E commerce) (right)

As discussed earlier, Aeon operates a range of shopping centers which assume to be serving different market segments. Aeon online grocery operates with an average time window of 10 hr time window. Once the buyer selected his location, Aeon e-commerce websites indicate whether the area served, and then from which store. Based on the nature of the products served, we assumed that the online orders could be fulfilled either from Aeon supercenters, Aeon malls, supermarkets or from specialty stores. Although there are 162 establishments from the above four categories, to date 72 locations are mentioned as online store locations in the web site. In that context, we analyzed the distribution of these locations using the heat map method with a radius of 20 km. The results lead to assume that the firm still operates more physical stores in the central Tokyo region. However, e-commerce operations are served by stores network which covers more than 90% of the dense areas in the Tokyo region. Having considered the transport systems and recent demographic changes in the region, the present network of omnichannel stores have the potential of serving the entire region with the added few more stores to the network.

5.5 Summary of the Chapter

E-commerce logistics facilities will evolve with the explosion of e-commerce growth. Although early fulfillment centers related to distribution centers, the recent trends indicate the emergence of functionally specified dedicated fulfillment centers. Unlike the distribution centers which focus on storage and distribution to retailers, these facilities carry out retailing by themselves. Therefore, the location of these facilities become a crucial part of the entire supply chain operation of e-tailers. Irrespective of the typology, the locations which serve the purpose will become a more crucial part of entire operations in the future. The policymakers need to be vigilant and thoughtful about these dynamics since it can significantly affect the demand for land, real estate markets, and transportation in cities.

The recent Tokyo region trends demonstrate the densification of the core region of Tokyo while many parts of the Metro region are indicating the signs of population shrinkage, a drastic decrease in the labor force, fall in the retail sector, and a decrease in retail floor space. However, the transport and logistics sectors tend to grow in many parts of the region. The decrease of municipal income in many parts of Tokyo also indicates the economic decline in some parts of the region, which directly affects demand for land and real estate markets.

Accessibility to transport infrastructure, availability of land, and land prices are essential factors that determine the location of logistics facilities. Similarly, the size, density, and distribution of population and accessibility play an essential role in determining the location of traditional retail stores. This study reveals that accessibility to expressways remains a critical factor determining the location of the e-commerce logistics facilities. However, the type of facility and its functionality will either make them located close to airports or too dense urban markets with strong potential for e-commerce. Third-party firms who provide the same service seems to follow the locational patterns of traditional distribution logistics, which indicate the scale of economies in location selection.

In contrast, pure online retailers choose low-density locations with reliable accessibility to expressways in order to ensure higher mobility between markets. The prime now services at present core areas have seen a decrease in total retail floor space in the Tokyo region. The distributed pattern of Amazon in the Tokyo region is different

from the clustering pattern of facilities observed in the USA. The evidence to date in Tokyo demonstrates that omnichannel retailers will likely include e-commerce logistics fulfillment functions to physical stores located in rapidly growing market areas. The firms which have a manufacturing process in the supply chain will likely be located in regions that also ensure the labor advantage.

6 EMPIRICAL ANALYSIS III: ANALYSIS OF NEIGHBOURHOOD LOCATIONS OF E-COMMERCE LOGISTICS FACILITIES

Having understood the spatial organization of e-commerce logistics facilities at national scale and how the organization pattern varies between different firms, this chapter explore the neighborhood scale characteristics at e-commerce logistics facility locations. The purpose of this section is to identify spatial patterns and trends at these facility locations and explore them against the contextual differences. In order to develop a worldview of this aspect, Amazon logistics facility (size over 100,000 sq. ft). locations in the world are chosen as the case study. The geo-coded location data and google earth images (time series) are used as the data sources. the detailed analysis is performed with the QGIS software.

Note: Parts of this chapter are presented and published at following peer reviewed conference.

99th Annual Meeting of Transportation Research Board, 12th-16th January 2020, Washington DC, US

6.1 Methods and data

This study adopted a case study mixed-method approach. The location of Amazon logistics centers along with their capacity and year of the establishment were obtained from multiple sources referenced in an article published by MWPVL International and last updated on January 2019 [66]. This research used satellite images obtained from Google Earth Pro and Google Street View as its main source for documenting the characteristics of the facilities' immediate neighborhood s (defined as approximately 1 km from the center of the facility location).

The neighborhoods classified into four types based on two morphological features, as is illustrated in the proceeding subsection: (1) the degree to which the area was built up and (2) the size of the building footprints observed. In this study, only facilities of at least 100,000 sq. ft. were included (roughly the area used for classifying warehouses). Accordingly, 806 locations from 21 countries were included in the study. The initial analysis revealed that the Amazon facilities in Mexico (2), Brazil (1), Singapore (1), Australia (4), Czech Republic (2) United Arab Emirates (2), Egypt (1), Kuwait (1), and Saudi Arabia (1) were in neighborhood s with the cluster characteristics, which confirmed locations inside industrial clusters or business parks. Amazon facilities in India and China could not be verified. Therefore, the results and discussion section will be based on facilities in the United States (240), Canada (9), United Kingdom (42), Germany (17), France (11), Italy (4), Spain (10), Poland (5), and Japan (10).

The immediate neighborhood s around the facilities were categorized into four types. Each typology is summarized by its key characteristics in Table 6.1 and demonstrated with examples in Figure 6.1. This classification does not confirm whether a facility is located inside a business cluster or industrial park; it is focused on whether the immediate neighborhood shares a similar (homogeneous) character.

6.1.1 Classification framework

The immediate neighborhood s around the facilities were categorized into four types. Each typology is summarized by its key characteristics in Table 1 and demonstrated with examples in Figure 2. This classification does not confirm whether a facility is located inside a business cluster or industrial park; it is focused on whether the immediate neighborhood shares a similar (homogeneous) character.

Figure 6.1: Classification based on built up area % and building footprint of the facility

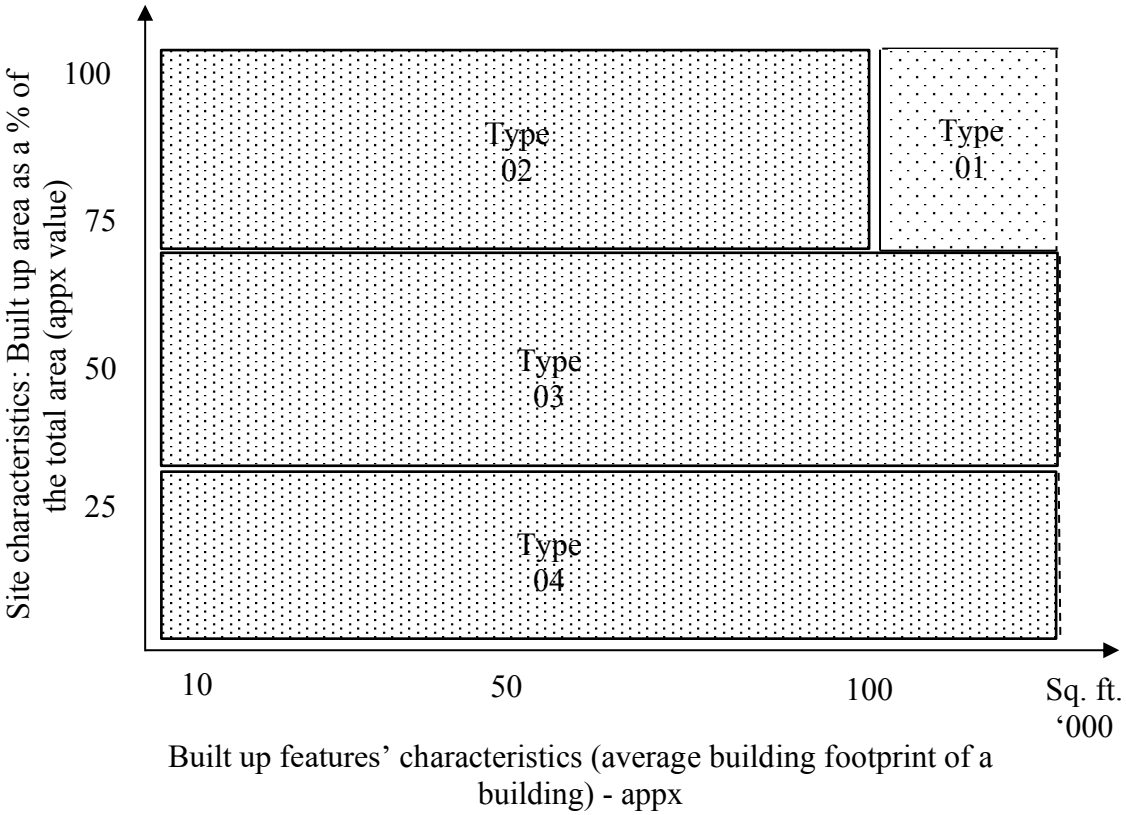
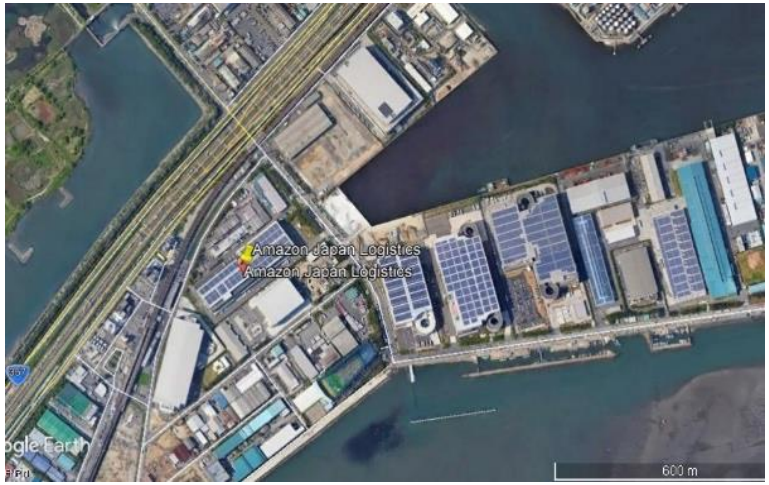


Table 6.1: Spatial Patterns with Key Characteristics of classified neighborhoods

Type	Type of Neighborhood	Key Characteristics	Threshold criterion (appx. Values)
1	Spatial cluster	Predominantly built-up area Similar building footprint Geotagged or titled as an industrial or business park Presence of large parking bays and open spaces	The built-up area over appx. 70% (appx. 2/3rd of the total land area of the neighborhood) Size of area building footprints appx. close to 100,000 sq. ft.
2	Non-cluster High density	Predominantly built-up area Size of area building footprints smaller than Amazon facility Number of building footprints is high and uniformly and densely distributed Presence of sub-roads and alleyways	The built-up area over appx. 70% (4/5th of the total land area of the neighborhood) Size of area building footprints appx. close to 100,000 sq. ft. Average building footprint less than 2,500 sq. ft. (appx)
3	Non-cluster Medium density or mixed-use	Dominated by both built-up areas and Greenfields Number of building footprints is moderate and uniformly distributed (in comparison to types 1 and 2) Geotagged for multiple types of land uses Presence of sub-roads and alleyways	The built-up the area between appx. 30- 70% of the total land area of the neighborhood Average building footprint greater than 2,500 sq. ft. (appx)
4	Non-cluster Low density	Predominantly non-built-up areas (Greenfields) Size of building footprints is smaller than the Amazon facility Number of building footprints is very low and sparsely distributed Presence of a few roads	The built-up the area between less than 30% of the total land area of the neighborhood

Figure 6.2: Classification framework



Type 01: Spatial cluster
Example: Amazon Fulfillment Centre, Ichikawa, Japan (left)

Type 02: Non cluster– High density
Example: Amazon Fulfillment Centre, Kawasaki, Japan (right)

Type 03: Non cluster– Medium density
Example: Amazon Fulfillment Centre Hemel Hempstead, England, UK (left)

Type 04: Non cluster– Low density
Example: Amazon Fulfillment Centre, Kolbaskowo, Poland (right)

Once the facilities were identified for each location, the locations were evaluated and profiled based on the patterns observed:

1. the spatial pattern of the neighborhood before the facility establishment and classification
2. identify whether Amazon was first to the site and/or neighborhood
3. determination if whether it was a site redevelopment (i.e., existing development changed fully or partially for Amazon facility) as it can be observed from the historical google earth images
4. analyze and classify present (2018–2019) spatial pattern of the neighborhood of the facility.

Satellite images were usually employed to assess land-cover changes. Predominantly used areas included forest-cover changes, change in agricultural uses, and changes from green fields to brownfields (urban sprawl). Google satellite images, maps, and street views have recently become available and are now popular for recognizing spatial characteristics and changes. In the case of logistics facilities, satellite images, and street views are used to recognize logistics establishments by observing the morphology of buildings and other surrounding features, including parking areas [79]. This approach is considered as a simple but effective mean for characterizing spatial patterns.

6.2 Characteristics and patterns at neighbourhoods

Examination of the areas surrounding the Amazon facilities (at the time of establishment at the neighborhood) worldwide showed that 48% (out of all 348) were in neighborhood s with cluster characteristics. The business addresses and the site features confirmed that the majority of these sites were industrial or business parks. High-density characteristics were observed in 3% of the neighborhood s. Medium- and low-density characteristics were found in 17% and 32% of the locations, respectively. The typologies on countries are shown in Table 6.2.

Table 6.2 : Spatial Patterns of Neighborhood s Before Amazon Facility

Country	Number of Facilities with Cluster Character Neighborhood s	Non-Cluster: Neighborhood Character		
		High Density	Medium Density	Low Density
US	113	6	45	76
Japan	3	2	2	3
Canada	3	1	2	3
Germany	2	-	3	12
UK	28	1	6	7
France	7	-	-	4
Italy	-	-	1	3
Spain	8	-	1	1
Poland	2	-	-	3

Similarly, in comparing the present (2018/19) spatial characteristics of all locations worldwide, 78% of the facilities were located in neighborhood s with cluster characteristics. High-density characteristics were observed in 3% of the neighborhood s. Medium- and low-density characteristics were found in 7% and 12% of the locations, respectively.

Table 6.3 : Spatial Patterns of Neighborhoods After Amazon Facility (By Country)

Country	Number of Facilities with Cluster Character Neighborhood s	Non-Cluster: Neighborhood Character		
		High Density	Medium Density	Low Density
US	188	6	18	28
Japan	6	2	1	1
Canada	7	-	1	1
Germany	10	-	1	6
UK	37	1	1	3
France	9	-	-	2
Italy	3	-	1	-
Spain	9	-	-	1
Poland	3	1	-	1

With respect, the change between the time of establishment and the present, 61% of the total locations with cluster characteristics were found to have enhanced its cluster characteristics now compared to before the Amazon facilities were established. Furthermore, 15% of the neighborhood s changed from having medium-density characteristics to having cluster characteristics, implying that Amazon had either located its facility at a growing cluster with potential demand or had launched a cluster. Similarly, 24% of the locations changed from having low-density characteristics to having cluster characteristics, which included locations that were virgin locations that later transformed into spatial clusters. The latter may have been influenced by Amazon's presence. The number of facilities that exhibited changes, by country, is shown in Table 6.4.

Table 6.4 : Comparison in Changes in Spatial Patterns (By Country)

	Number of Facility Location Neighborhood s Changed to Cluster Pattern from (% as an of Total Neighborhood s with Cluster Pattern of Each Country)		
Country	Cluster Pattern	Medium-density Pattern	Low-density Pattern
US	113 (60%)	28 (15%)	44 (23%)
Japan	2 (33%)	2 (33%)	2 (33%)
Canada	2 (29%)	2 (29%)	3(43%)
Germany	2 (20%)	2 (20%)	6 (60%)
UK	28 (76%)	5 (14%)	4 (11%)
France	7 (78%)	-	2 (22%)
Italy	-	-	3 (100%)
Spain	8 (89%)	1 (11%)	-
Poland	2 (67%)	-	1 (33%)

6.2.1 First Mover to the Neighbourhood, and Site Redevelopments

This study also evaluated the number of times when Amazon was the first mover to a studied neighborhood. The results revealed that for 41% of neighborhood s, Amazon was the first major player to move into the site. There were recent trends of infill locations within urban areas being getting attracted by e-commerce companies [80]. In planning terms, infill development refers to the development of land in dense urban areas that is already used or vacant for some reason. Further, this study also observed site redevelopments in clustered patterns. Of these neighborhood s, 9% of the locations were site redevelopments, which include both infill developments happened inside dense neighborhood s and site redevelopments inside clustered neighborhoods.

Table 6.5 : First Mover to a Site and Site Redevelopments (By Country)

Country	First Mover to the Neighborhood (% from total Locations)	Site Redevelopments (% of Total Locations)
US	109 (45%)	14 (6%)
Japan	-	6 (60 %)
Canada	2 (22%)	-
Germany	9 (53%)	3 (18%)
UK	11 (26%)	5 (12%)
France	5 (45%)	-
Italy	1 (25%)	-
Spain	2 (20%)	1 (10%)
Poland	5 (100%)	-

Although the observations in this study were not necessarily of extremely high-density neighborhood s, only high-density neighborhood s, 15% of these redevelopments were at previously high- or medium-density neighborhood s. Interestingly, 40% of the sites in Japan were redevelopments. This was closely associated with the previous study [81] on how e-commerce can exert more pressure on locations where there is a concentric urban form. While this Amazon-focused study revealed Amazon's strategy, it also found that other companies are considering similar locations for logistics facility development [82]. This would establish a healthy network among the facilities, and which would help ensure faster deliveries for all. Amazon relies on fast deliveries as a means of enhancing customer satisfaction.

This trend suggests that companies like Amazon are ready to invest in sites well located to gain competitive advantages. Previous research has identified that companies in advanced phases will invest in infill locations in the early phase of the location focus of central locations. The most popular example mentioned in previous literature in this respect is the Amazon Prime hub center at Manhattan.

Figure 6.3 : Site redevelopments in dense neighborhood s in Japan: Kawasaki (top row) and Odawara (bottom row).

Figure 6.4 : Spatial morphological pattern changes around Amazon facilities in two states in the United States: Indiana (top row) and Nevada (bottom row).

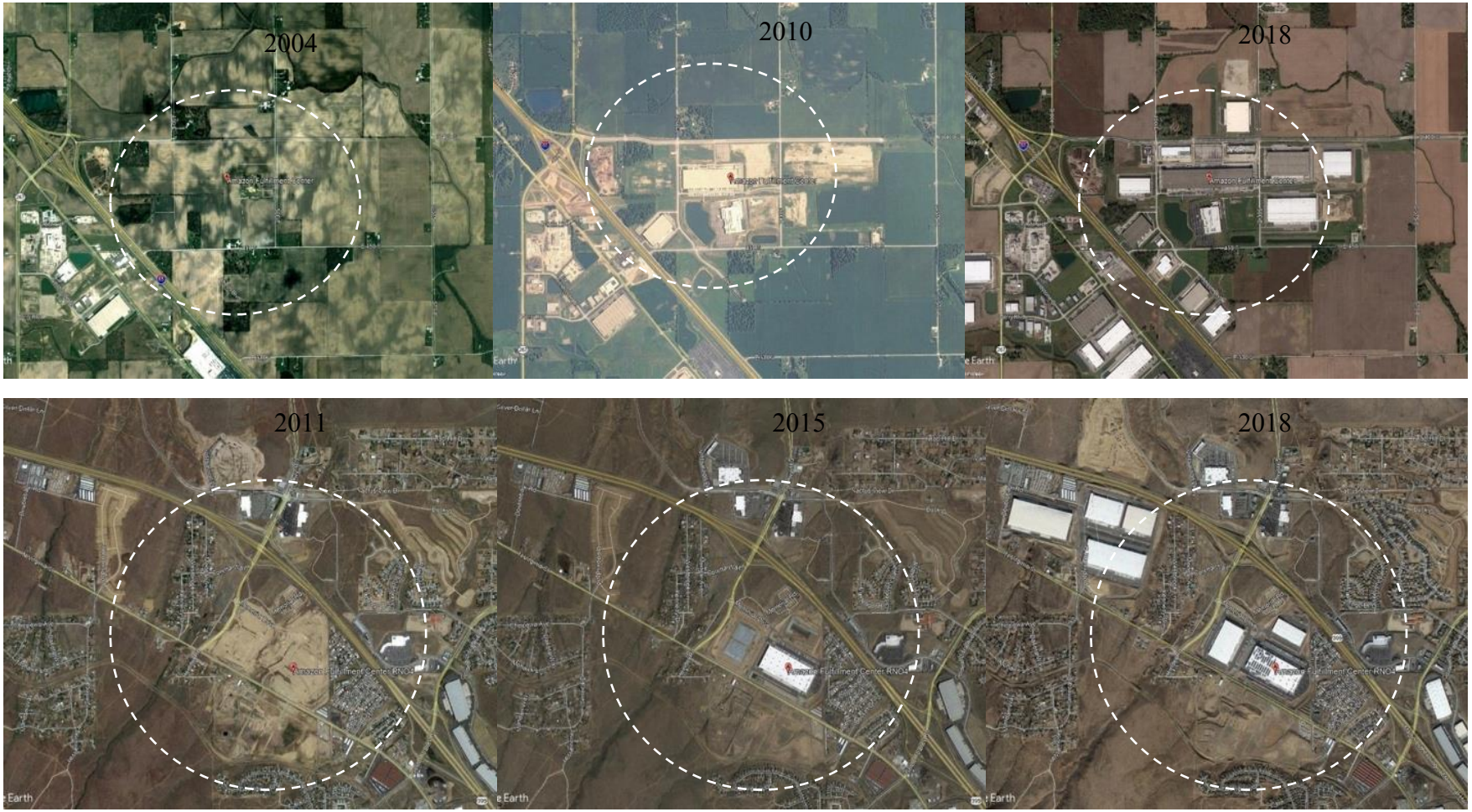
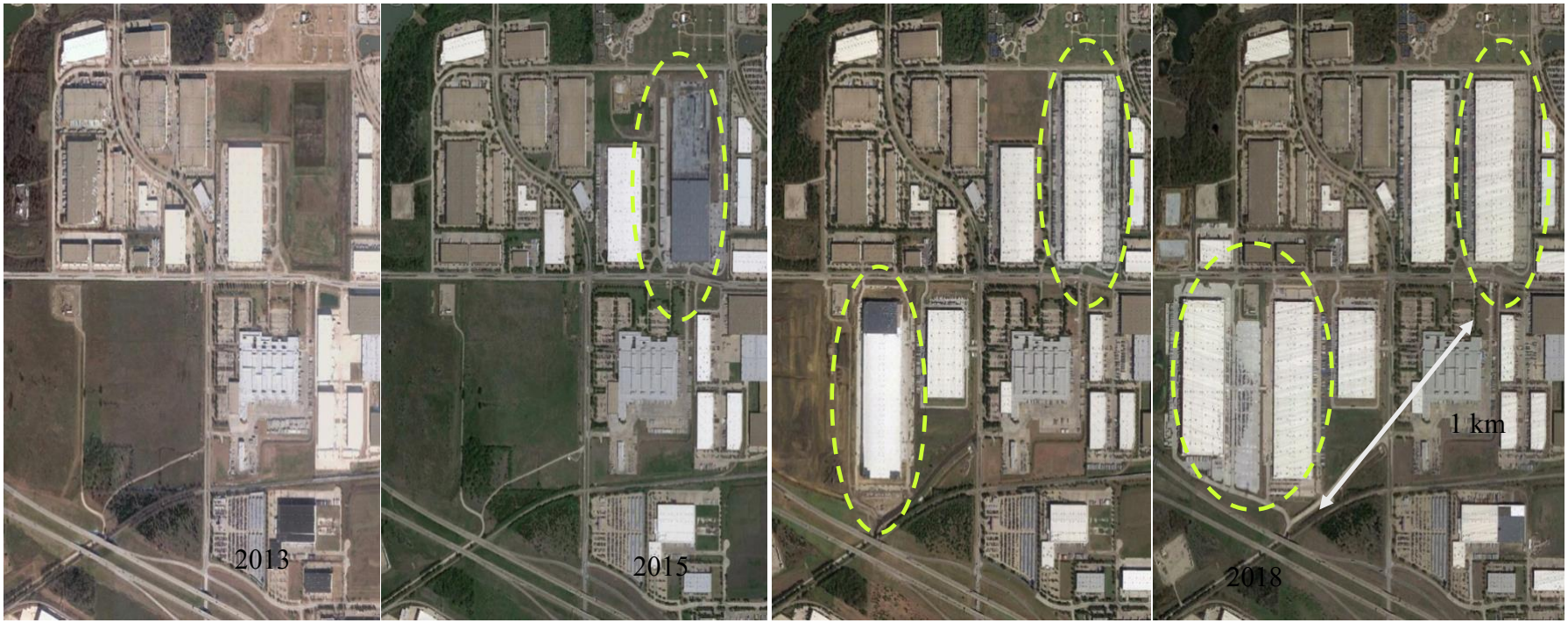


Figure 6.5 : Spatial clustering of Large Sized Amazon Logistics Facilities (Texas, US)



6.2.2 Trends and patterns within spatial clusters

Three important trends observed regarding the spatial clusters analyzed in the study. First, the emergence of Amazon logistics clusters, where the 2 or more large-sized fulfilment facilities are located within proximity. Such development may increase the possibility of e-commerce logistics led business and clustering, which require the adequate contribution of land use planning. Further, given Amazons advancements in technology, this may have profounding social and economic effects on local economies.

Secondly, the expansion of existing cluster patterns by locating the facility at a large size land at the periphery of the existing cluster. This result in creating a different spatial pattern in the neighborhood. Thirdly there are facilities which are located inside an existing cluster. However, the size of the Amazon facility is larger than the average building footprint of the area. The latter trends may even be noted as general trends that may have occurred inside any given cluster.

6.3 Patterns, trends and policy implications: theoretical discussion

The analysis does not review the planning and policy guidelines of each country or city where these facilities located. However, based on spatial patterns and trends observed at Neighborhood scale at Amazon E-commerce logistics facilities, several general policy implications can be highlighted. The key observations and general policy implications are shown in Table 6.

As was mentioned in the introduction section, the spatial and locational aspects of logistics have become a popular topic in contemporary research. However, to the best of the knowledge of the author, spatial morphology-based pattern analysis has not yet been employed to understand trends associated with logistics facilities, specifically at the local and neighborhood scale. Such an approach is useful for firms like Amazon that engage in e-commerce where the locational and spatial prerequisites and requirements are so different in scale. As we learned from the research, this type of approach can be useful both as a basis for relating nonspatial and spatial aspects of modern trends and for further enhancing analyses of land-use trends associated with these locations. Such understanding can enable planners and policymakers to evaluate their land-use plans, transportation plans, and economic development strategies irrespective of location.

Table 6.6 : General policy implications

Observation	General Policy Implications
emerging e-commerce logistics clusters	new locations, outside traditional industrial/ logistics zones; demand for large size land plots; attraction of skilled labor; changes in freight O/D patterns; catalytic sites for development
infill development of logistics facilities at high dense neighborhoods	economies of the frequency with proximity to markets; change of freight movement patterns and congestion at local roads; shift of real estate market; challenge existing zoning and planning guidelines; the need of careful land readjustment and pooling; exert pressure on traditional land-use types, including retailing and housing
expansion of spatial clusters	economies of scale and economies of densities; Pressure on agricultural lands at the periphery of clusters; buffer zones of demarcated clusters;
Redevelopment at existing clusters	Challenging planning and zoning guidelines/ regulations; demand for similar developments; vertical integration inside firms within the established clusters

6.4 Summary of the chapter

This study classified the immediate neighborhood s of Amazon logistics facilities over 100,000 sq. ft. in 9 countries. The results showed that these large logistics facilities not located in areas with cluster characteristics. There were new sites, with low- and medium-density built-form characteristics that were attracted by Amazon's presence and later shaped into clusters. The results suggest that new trends in e-commerce create new spatial trends vis-à-vis the location of logistics facilities. Such trends may challenge the conventional understanding of planners and policymakers to rethink zoning policies and land-use regulations.

Redevelopment phenomena can be observed from this analysis. The scale of these developments can cause drastic changes in freight movement patterns within cities. Therefore, this understanding will aid the land use and transportation planners in assessing future points of freight origination. As understood so far, these locations will be beyond the contemporary understanding of traditional warehouses.

In addition, the morphology-based approach used in this study can be a useful tool, with improvements in understanding logistics trends at the local and neighborhood scale.

Future research may use this morphological approach combined with other types of analysis further to understand the spatial dimensions in the logistics sector or to identify trends in other sectors. Such studies may also focus on specific cities where Amazon has a significant presence with its logistics network. The spatial externalities of these trends are of interest for future research.

7 LOCATION CHOICE MODEL FOR E-COMMERCE LOGISTICS FACILITIES

This section details out the main aspect of the location model developed to resembles the characteristics of the location of e-commerce logistics facilities. The details include model's specification, variables with data sources, results of estimation and predictability of the models. Given the nature of the firms, two types of models are estimated. Firstly, the model that consider the large sized Amazon fulfilment centers, that serve regional and national markets. Second model on prime hubs and omni channel store locations that expect to serve the local markets.

7.1 Model specifications, variables and data sources: Location choice model for fulfilment logistics facilities (regional/ national)

7.1.1 Model specifications

The attributes and variables defined for the location choice model with knowledge gained through the previous empirical studies. The factors commonly considered for location choice models include accessibility, distance to/from transport infrastructure and locations of employment, population density, land price and zoning regulations. The details illustrated in section 2.4 of the thesis.

Additionally, the study proposes to incorporate the socio-economic trends and demographic trends at municipal level and patterns of distribution of activities at each municipality compared to TMR as key variables of the model. It is believed that these variables can better explain the location choice of e-commerce logistics at municipal level. In the study trends refer to the changes observed for a given period between the year 2005 – 2015.

The purpose of the model is to statistically evaluate the location characteristics of multiple types of e-commerce logistics facilities and then to support as a policy analysis tool for evaluating how socio-economic and land use patterns and trends affect the location choice of different types of e commerce logistics facilities.

Based on the classification data obtained from the e-stat data portal, a total of 382 municipal areas in TMR (covering eight prefecture areas) is being chosen as the choice set/ study zones. This include highly dense areas (classified as ‘Ku’ areas) and city areas (classified as ‘Shi’ areas), in addition to relatively dense ‘ mura’, ‘machi’ and ‘cho’ areas. Although there is uniformity observed among the units, it still being taken as the unit given the availability of data in the region.

These municipal areas considered as alternative location choices from hereafter will be referred to as ‘location’ in the chapter. The study performed with published data of 2015. Trends associated with the variables are calculated based on change of activities between 2005-2015. The data sources and method of data extraction are described in detail chapter 03 (3.4)

The deterministic component for the model for alternative location i for facility l is defined as:

$$V_{l,i} = \beta_{POP}\,\mathbf{log(POP)} + \beta_{POP\_DEN}\,\mathbf{log(POP\_DEN)} + \beta_{ROC\_POP}\ \mathbf{(ROC\_POP)} + \beta_{ACC\_MAR\_ECOM}\,\mathbf{log(ACC\_MAR\_ECOM)} + \beta_{DIS\_AIRP}\,\mathbf{log(DIS\_AIRP)} + \beta_{SHR\_TRNS}\,\mathbf{log(SHR\_TRANS)} + \beta_{ROC\_TRNS}\ \mathbf{(ROC\_TRNS)} + \beta_{ROC\_MANU}\ \mathbf{(ROC\_MANU)} + \beta_{ROC\_RET}\ \mathbf{(ROC\_RET)} + \beta_{SHR\_EMP\_S}\,\mathbf{log(SHR\_EMP\_S)} + \beta_{SHR\_EMP\_T}\,\mathbf{log(SHR\_EMP\_T)} \qquad \mathbf{i}$$

1. Accessibility of the location for regional markets [ACC_MAR]

Attractiveness of a given location to other municipalities is defined as:

$$A_i = \sum_j \frac{M_j}{d_{ij}} \qquad \mathbf{ii}$$

A_i : Attractiveness of location *i*

M_j : Size of population at location *j*

d_{ij} *:* Network distance from *i* to *j*

(*i,j*– include all municipal areas considered as choice alternatives)

2. Accessibility of the location for potential e -commerce markets [ACC_MAR_ECOM]

For the above variable mentioned in ii , constrained factor is introduced to represent the potential future e-commerce markets. It is assumed that areas with high proportion of people aged 15-64 and positive rate of change of population are likely to be potential markets compared to areas with higher proportion of people with age 15-64 and negative rate of change of population. This inclusion was considered important given the trends of ageing population and shrinking population in Japanese regions.

Accordingly, a common factor was assigned based after analyzing the above two variables using principal component analysis (PCA), with 50-50 contribution of each variable. The details of this analysis are attached in appendix 2.

After the inclusion of the factor (x_j) the, equation I can be rewritten as:

$$A'_i = \sum_j \frac{x_j M_j}{d_{ij}} \qquad \mathbf{iii}$$

For the standardization requirement the log values of above variables are used in the MNL model. The distribution pattern of two variables demonstrate the variability between two variables (figure 7.1 to figure 7.4). In both calculations the distance remained the same. However, the proposed measure constrained the original market size represented by the size of population.

Figure 7.1: Attractiveness to regional markets (without the constrained factor)

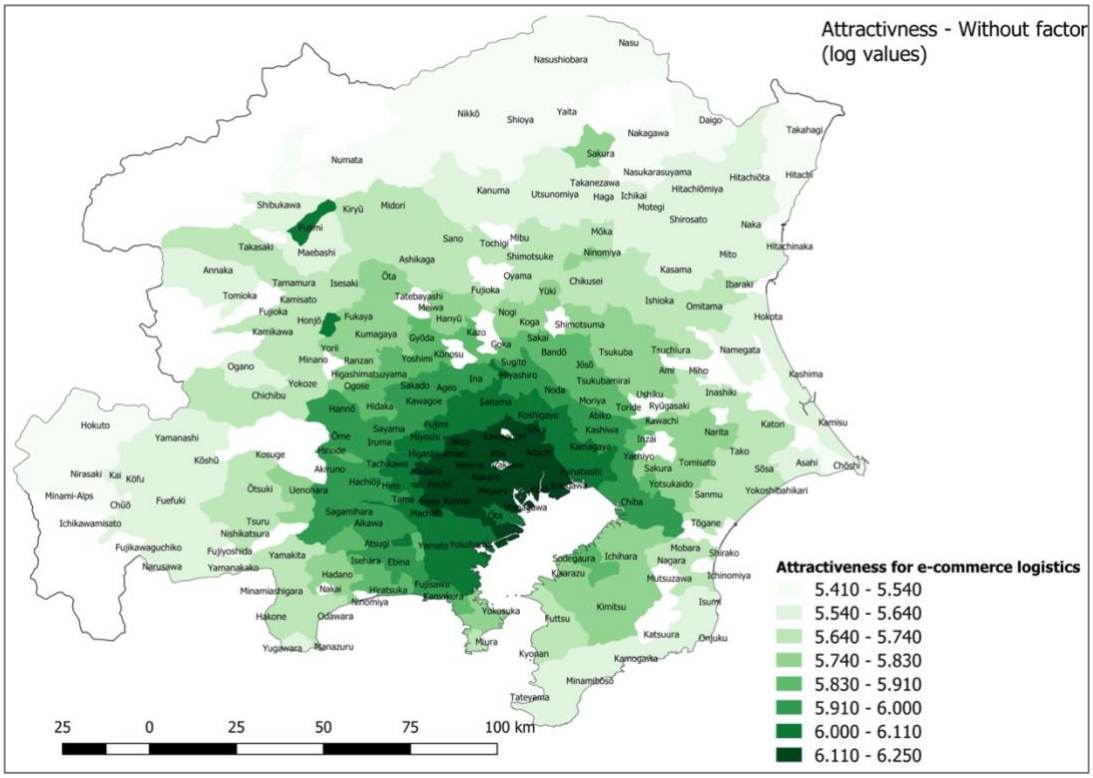


Figure 7.2: Attractiveness potential e-commerce markets (with the constrained factor)

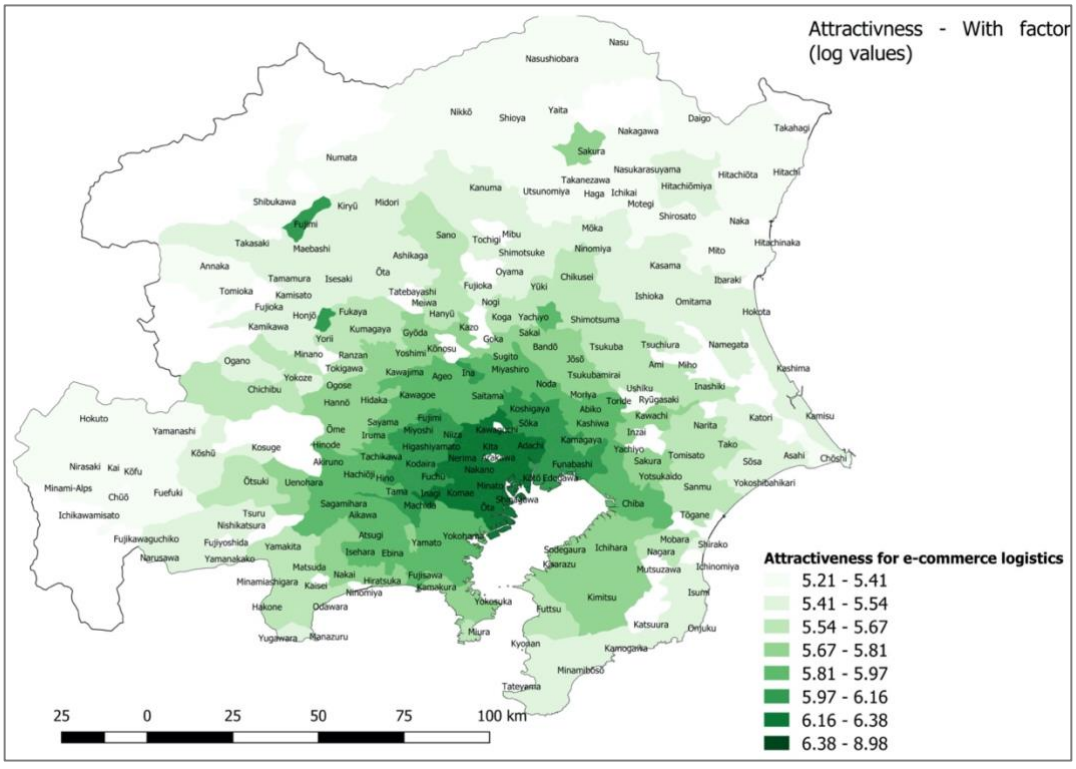
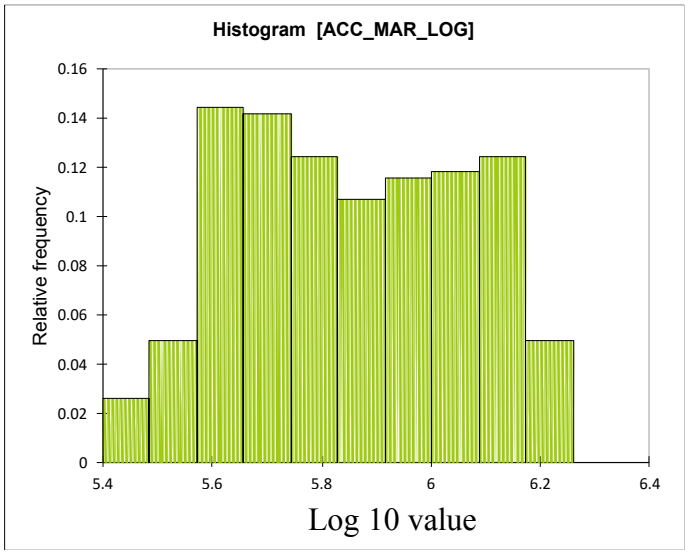
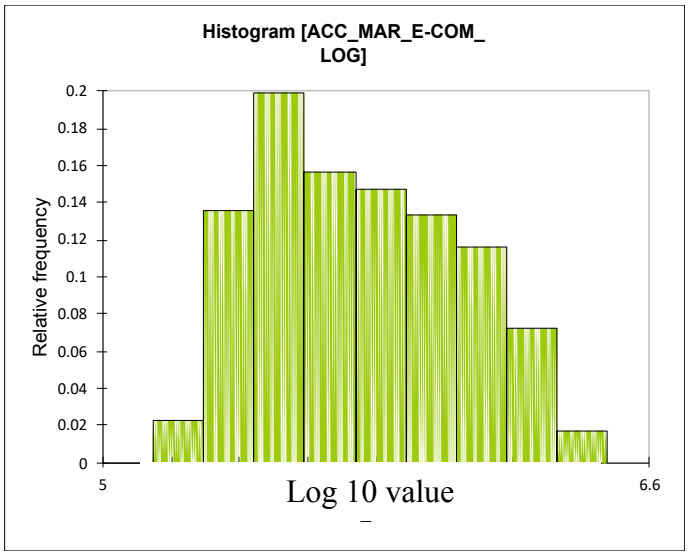


Figure 7.3: Histograms of the log transformed values of two variables





3. Population at location *i* [POP_LOG]

The log value of the population at each municipality is considered in this variable. This used a proxy to represent the size of attraction of the given location.

4. Population density at location *i* [POP_DEN_LOG]

The log value of the population at each municipality is considered in this variable. This used a proxy to represent the size of attraction of the given location.

5. Rate of change of population [ROC_POP]

The rate of change of population at each location described with this variable. This is used as a proxy variable to represent the how the location itself loose/ gain

attraction as a place of residence. The positive value of the variable implies the demand for the area, which may result in small plot sizes; whereas negative value imply the loss of demand as a place of residence, which is expected to be substituted by other land type of land uses with large lot sizes.

6. Share of employment in different sector

Share of employment is used as a variable to represent the level of attraction each municipality has for different sectors. It is expected that jobs in e-commerce logistics centers to be considered service sector, amidst its secondary sector characteristics.

Share of employment in secondary sector is denoted with SHR_EMP_S ; while share of employment in tertiary sector is denoted with SHR_EMP_T.

7. Rate of change in transport and postal related establishments [ROC_TRNS]

The Rate of change in transport and postal related establishments represent another important related to a trend related to transport and logistics sector. It is employed to represent the level of attraction/ repulsion of the given location for this activity. This taken as an independent variable under following assumption.

If, in a given area the ROC_TRANS is a negative value, it is assumed to be an area that is losing its attraction for this activity. A positive value or zero value imply possible attractiveness of the location for this activity type.

Similarly rate of change in manufacturing [ROC_MANU] and rate of change in [ROC_RET] is considered in the model for the comparative purpose with the above variable, which is proven to have a statistical significance at previous estimations.

8. Share of transport and postal related establishments [SHR_TRNS]

SHR_TRNS variable is incorporated to the model to consider the relative attraction for given locations for this activity. This relative measure are often used to recognizing closeting patterns based on the distribution of activities.

9. Distance to nearest airport [DIS_AIRP]

Distance to nearest airport is calculated from the center of inhabitable area of each location. The distance is measured in km.

10. Distance to nearest expressway interchange [DIS_EXP] *

Distance to nearest expressway interchange is calculated from the center of inhabitable areas to nearest expressway interchange. Although, this was considered as an important variable, it is not used in the location model due to two reasons. Firstly, it is found that calculating distance from one center do not incorporate the advantage edge areas of municipalities have on close proximity to expressway interchanges. Secondly it is found that outside the core area of the TMR, expressway follow a trace bisecting two municipalities (physical boundary of the municipality). Therefore, it is found unreasonable to use it in the present location choice model.

11. Average land price for 'particular use'

In contrast to the use of general land price, it is proposed to incorporate use specific land price in the model. However, it was found that the land price is available at 125 areas only. Accordingly, the average land price for industrial is defined as LPRC_IND and for commercial purpose as LPRC_COM.

In addition to the list of variables mentioned above, at the initial stage of the model formulation more than 25 variables (appendices 3) are considered representing the multiple conditions and situations. The number of independent variables is reduced through multicollinearity analysis and best subset method. In multicollinearity analysis Variation Inflation Factor (VIF) detect the correlations between independent variables. It is accepted that the VIF should be below 10.0 or 5.0.

The probability of a given logistics facility type *l* choosing the location *i*:

$$\mathbf{P_{l,i}} = \frac{\mathbf{exp}\,(\mathbf{V_{l,i}})}{\mathbf{1} + \sum_{\mathbf{i}} \mathbf{exp}\,(\mathbf{V_{l,i}})} \qquad \mathbf{iv}$$

In the estimation process, the program estimates all parameters with respect to a reference category, expressed as:

$$\mathbf{P_{1,i}} = \frac{\mathbf{1}}{\mathbf{1} + \sum_{\mathbf{i}} \mathbf{exp}\,(\mathbf{V_{l,i}})} \quad [64] \quad \mathbf{v}$$

The model is estimated using the maximum likelihood method:

$$l(\propto, \beta) = \sum_{i-1}^{n} \sum_{j=1}^{J} y_{ij} \log\,(p(y = j \mid x_i)\,;\ \mathbf{vi}$$

$\propto$ and β are parameters of the model [64]

Table 7.1: Descriptive statistics of the model: fulfilment logistics facilities (regional/ national)

Statistic	Nbr. of observations	Range	1st Quartile	Median	3rd Quartile	Mean	Variance (n-1)	Standard deviation (n-1)	Variation coefficient (n-1)
POP_LOG	346	2.490	4.519	4.893	5.238	4.857	0.251	0.501	0.103
SHR_TRANS_LOG	346	2.685	0.466	0.770	1.019	0.755	0.199	0.446	0.591
POO_DEN_LOG	346	2.147	2.828	3.244	3.855	3.306	0.313	0.559	0.169
DIS_AIRP_LOG	346	1.394	1.419	1.615	1.777	1.584	0.071	0.266	0.168
ROC_POP	346	38.880	-4.318	-1.420	1.765	-1.183	21.912	4.681	-3.956
ROC_TRANS	346	150.000	-12.500	-5.995	-1.216	-6.726	173.084	13.156	-1.956
ROC_MANU	346	253.846	-19.100	-14.627	-9.305	-14.546	222.164	14.905	-1.025
ROC_RET	346	83.592	-15.234	-10.497	-4.983	-10.063	67.217	8.199	-0.815
SHR_EMP_S_LOG	346	0.805	1.267	1.382	1.473	1.366	0.020	0.141	0.103
SHR_EMP_T_LOG	346	0.306	1.777	1.826	1.861	1.817	0.003	0.053	0.029
ACC_MAR_ECOM_LOG	346	0.875	5.563	5.729	5.929	5.742	0.048	0.218	0.038

7.2 Results and discussion

This section first presents the results of the model estimated for Amazon fulfillment logistics facilities, which expect to serve the national and regional markets. Binary logit modeling framework used for the estimation.

7.2.1 Results of estimation and discussion

The models are estimated with different combinations of variables with several iterations. 80% of the observations are randomly assigned for parameter estimation while 20% are randomly assigned for model validation. The XLSTAT package provide the feasible interface for this assignment. Further models are estimated at both 95% and 90% confidence intervals.

Prior to the estimation of modelling parameters, the performance of the models training sample is evaluated with goodness of fit statistics, test of null hypothesis (H_0) and Hosmer-Lemeshow tests. All these options are by default provided with the XLSTAT package. This multi-dimensional framework is important in the context where there is no exact solution compared to the linear regression analysis. Further details of the this are explained in section 3.3.2. The statistics of several models that are shortlisted after a series of estimations is shown in table 7.2. After review of the several criteria, out of these models, the Model -05 is chosen as the best fit model. The chosen model fit relatively better with transformed data, in compared to some of the models used a mix of original and/or transformed data for model estimation. The estimated results of the chosen model and standardized values are shown in the table 7.3 and table 7.4 respectively.

Table 7.2 : Summary statistic of five shortlisted models (Amazon fulfilment center)

Method of evaluation		Model 01	Model 02	Model 03	Model 04	Model 05
Goodness of fit statistics (Variable Amazon logistics center):	Statistic -Full*					
	Observations	245	245	245	245	245
	DF	233	233	233	233	233
	R^2(Cox and Snell)	0.095	0.123	0.090	0.073	0.120
	R^2(Nagelkerke)	0.518	0.613	0.454	0.320	0.480
	AIC	76.535	77.332	71.579	68.926	63.173
	SBC	156.695	165.125	125.389	110.941	105.188
	Iterations	18	20	16	14	14
Test of the null hypothesis H0	Statistic - Pr > Chi^2					
	-2 Log(Likelihood)	0.030	0.003	0.002	0.068	0.001
	Score	0.381	< 0.0001	0.095	0.320	0.071
	Wald	0.923	0.945	0.387	0.422	0.275
Hosmer-Lemeshow test (Amazon logistics center)**:	Statistic - Pr > Chi^2					
	Hosmer-Lemeshow Statistic	0.983	0.105	0.983	0.974	0.910

Notes:

* the original results sheet indicates the goodness of statistics show the values for both independent model and adjusted model (full model). This sheet only incudes the statistic for the full model.

** the Hosmer-Lemeshow test is only performed for Amazon logistics center, which is estimated with a binary logit model

Table 7.3 : Estimated parameters of location model for Amazon FC centers

	Amazon fulfilment centre			
	Coeffi.	Standard error	Wald Chi-Square	Pr > Chi^{2}*
Intercept	-145.592	63.589	5.242	0.022
POP_LOG	0.852	2.548	0.112	0.738
ACC_MAR_ECOM_LOG	10.290	4.487	5.259	0.022
SHR_TRANS_LOG	-6.503	3.099	4.405	0.036
POO_DEN_LOG	-5.276	2.365	4.977	0.026
DIS_AIRP_LOG	-1.222	2.655	0.212	0.645
ROC_POP	-0.104	0.169	0.382	0.537
ROC_TRANS	0.155	0.056	7.667	0.006
ROC_MANU	0.138	0.092	2.217	0.137
ROC_RET	-0.083	0.099	0.717	0.397
SHR_EMP_S_LOG	-6.373	8.705	0.536	0.464
SHR_EMP_T_LOG	60.495	30.884	3.837	0.050

*-95% confidence interval

Table 7.4 : Standardized coefficients of location model for Amazon FC centers

	Amazon fulfilment centre			
	Coeffi.	Standard error	Wald Chi-Square	Pr > Chi^{2}*
POP_LOG	0.243	0.728	0.112	0.738
ACC_MAR_ECOM_LOG	1.250	0.545	5.259	0.022
SHR_TRANS_LOG	-1.649	0.786	4.405	0.036
POO_DEN_LOG	-1.646	0.738	4.977	0.026
DIS_AIRP_LOG	-0.178	0.386	0.212	0.645
ROC_POP	-0.274	0.443	0.382	0.537
ROC_TRANS	1.161	0.419	7.667	0.006
ROC_MANU	0.741	0.498	2.217	0.137
ROC_RET	-0.341	0.403	0.717	0.397
SHR_EMP_S_LOG	-0.501	0.684	0.536	0.464
SHR_EMP_T_LOG	1.741	0.889	3.837	0.050

7.2.1.1 Interpretation of results of logit models

The results interpretations of logit models different from the linear regression models. For an example the coefficient corresponds with the odds ration values measured by the model. Odds Ratio measures the association between an exposure (in this case, the explanatory variables in the model) and outcome (Here, outcome is the existence of Amazon center).

$$\text{Odds Ratio} = \frac{\text{Odds of the outcome in the presence of a exposure}}{\text{Odds of the outcome in the absence of a exposure}}$$

Thus, Odds Ratio represents the odds of existing Amazon center given a particular explanatory variable, compared to the odds of existing Amazon center in the absence of that variable. Based on the 2 variables SHR_TRANS_LOG and ROC_TRANS, odds ratio can be interpreted as below.

Example 01:

For the variable SHR_TRANS_LOG, model coefficient is -6.503. Thus, when all the other variables are constant, the log odds of existing Amazon center are decreased by 6.503 for a unit increase in Shares. Odds Ratio for a location with respect to Shares is; exp (-6.503) = 0.0015.

This implies that the odds of existence of Amazon fulfilment center is 0.0015 times lower for a unit increase in the variable SHR_TRANS, when all the other variables remain constant. In other words, for every additional unit (say %) of Shares, the odds of existence of Amazon fulfilment center increases by 0.0015 times, when all the other variables remain unchanged.

Since the odds ratio < 1, the variable Shares is associated with lower odds of existing Amazon center. This implies that a given location, when the value of Shares increases, the probability that Amazon center exists with compared to the probability that Amazon center does not exist, decreases.

Example 02:

For the variable ROC_TRANS, model coefficient is 0.155. Thus, when all the other variables are constant, the log odds of existing Amazon center is increased by 0.155 for a unit increase in ROC.Odds Ratio for a location with respect to ROC is; exp (0.155) = 1.168

This implies that the odds of existence of Amazon fulfilment center is 1.168 times higher for a unit increase in the variable ROC_TRANS, when all the other variables remain constant. In other words, when ROC increases by 1 unit, the odds of existence of Amazon fulfilment center increases by 1.168 times, when all the other variables remain unchanged.

Since the odds ratio > 1, the variable ROC is associated with higher odds of existing Amazon center. This implies that for a given location, when the value of ROC increases, the probability that Amazon center exists with compared to the probability that Amazon center does not exist, increases.

7.2.1.2 Amazon logistics centres

Access to potential e-commerce markets (with the constrained factor assigned) have a statistically high significance and have a positive effect on the location chosen by Amazon fulfilment centers. The same variables are estimated by using the accessibility of markets (without the constrained factor), which later found statistically insignificant and affect the overall goodness of fit of the model (model 04 in table 7.2).

The other important finding is that, share of transport establishments of the particular municipality in the context of TMR is statistically significant and have a negative effect on the location of the fulfilment facilities. This in comparison to the statistically significant and positive effect that the rate of change (between 2010-2015) of the transport establishments at particular locations have with the location choice. The both results together affirm that the location choice do not cluster at locations which already have a higher proportion of transport establishments in TMR, but at emerging locations where new transport and postal establishments emerged. Although this study cannot confirm, it may indicate either Amazon choose their locations at emerging local transportation clusters or presence of Amazon create this trend. Further time series analysis of the behavior of this sector is required to confirm this pattern. This point is specifically interested in the context where in Japan, Amazon depends on 3PL for undertaking deliveries. It can also expect that the location of such 3PL companies can relate with this observation.

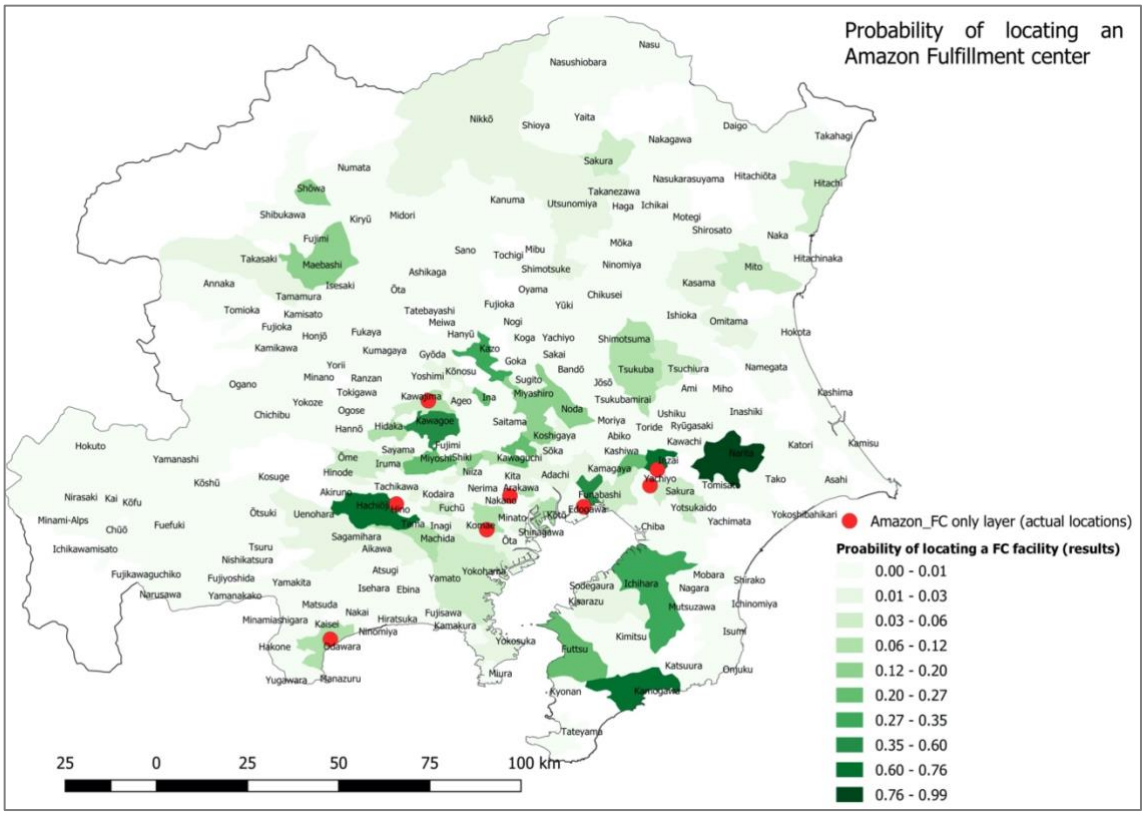
Share of employments in tertiary sector is also found marginally significant for the location selection. This implied that these fulfilment centers are located at municipalities with higher proportion of service sector jobs. This raise an important

point, that facilities operation looks more industrial (manufacturing) though the employees are expected to be similar to the service sector job.

As expected, the location choice is statistically significant and negatively affected by the population density of the municipality. Further, the previous studies based on spatial morphology found that some facilities are located at the edge of the municipal boundary. This demands a finer spatial resolution for modelling to capture further dynamics beyond the municipal concerns.

Apart from the above progressive findings, it is further affirmed that distance to nearest airport is a not statistically significant with the location choice of the Amazon. The negative coefficient may indicate that these giant logistics facilities are not concerned about traditional warehousing locations which expect to agglomerate with manufacturing sector activities. Although it was not statistically significant, the coefficient for rate of manufacturing sector establishments further support the above argument.

Figure 7.4 : Visual comparison of the results of MNL model and Actual Amazon FC locations at TMR



The logit model estimates the probability of a given logistics facility type *l* choosing the location *I* (municipality). As demonstrated in figure 7.4, the estimated

results satisfactorily (not completely) overlap with the actual facility locations in the Tokyo region. However, some of the actual locations were located adjacent the to the predicted areas of the model. This is particularly happened when the facility located at the periphery of one municipality (i.e. Amazon fulfillment center in Kawasaki).

Recommendations for the future

Amidst above discussion points, it is important to note the possible limitations that may prevent a comprehensive discussion on the location choice pattern. As stated above the use of much finer spatial scale as alternative locations can reveal more interesting facts related to the location choice going beyond the municipal characteristics. Further univariate analysis at the early stage of model development the inhabitable area of the municipality and total arable lands in particular municipality had also found statistically significant with the location selection. However, given the scope set with respect to the municipals as alternative locations, those variables are excluded from fitting the model. These two variables have the opportunity to be predicted from land use simulation model.

Similarly, a future model will also need to incorporate the land use zoning at particular locations to explore the possible effects the zoning has on the location choice. That can also be deemed effective only with a small set of locations as alternative locations. In addition, the distance to expressway interchange is not used for model estimation due to the incompleteness of the database. These expect to have significant relationship with the location choice.

7.2.1.3 3PL logistics centres (Rakuten 3PL)

Multi nomial logit model used to explain the location choice of 3PL logistics centres serving e-commerce markets. It was found that none of the variables chosen are not statistically significant with any of the variables chosen for the model estimation at both 90% and 95% confidence intervals. This can also be due to the number of data points (2) available with this facility. It is recommended to incorporate more data points for further estimations (appendix 3).

7.2.2 Validation and the predictability of the model

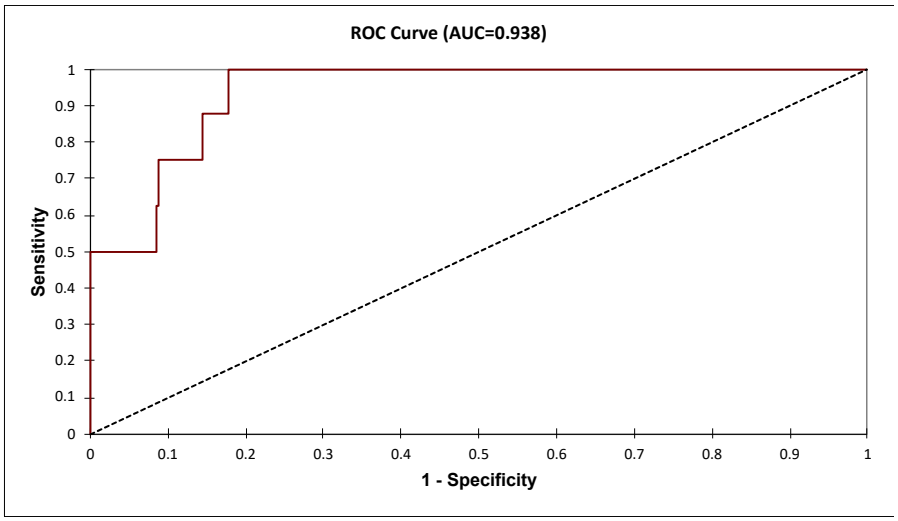
As mentioned at the model specification section, the model is validated with a set of randomly chosen data under rule of thumb of 80:20 from the original data set. The overall validation based on the sample is reported as 94%. Correct (%) of 95.88 in the table 7.5. implied the specificity of the model while 33.33% can be explained with respect to the sensitivity of the model.

Table 7.5 : Classification of validation sample (for Amazon FC centers)

from \ to	0	1	Total	% correct
0	93	4	97	95.88%
1	2	1	3	33.33%
Total	95	5	100	94.00%

Similarly, the ROC curve of the model validation is reported as 0.938 (area under the curve). AUC over 0.9 is considered as excellent[64].

Figure 7.5 : ROC curve (for Amazon FC centers)



However, it is important to note the subjectivity of this results, given the random selection and limited number of data points (with '1') in the dataset, which can be noted as a inherit limitation of the whole estimation.

Table 7.6 : Descriptive statistics of the model: Prime hubs and omni channel store locations

Statistic	Nbr. of observations	Nbr. of missing values	1st Quartile	Median	3rd Quartile	Mean	Variance (n-1)	Standard deviation (n-1)	Variation coefficient (n-1)
POP_LOG	339	0	4.538	4.904	5.241	4.877	0.235	0.485	0.099
SHR_TRANS_LOG	339	0	0.459	0.749	1.011	0.738	0.185	0.430	0.583
POO_DEN_LOG	339	0	2.833	3.246	3.864	3.316	0.312	0.559	0.168
ROC_POP	339	0	-4.175	-1.380	1.780	-1.069	21.235	4.608	-4.309
ROC_TRANS	339	0	-12.244	-5.995	-1.198	-6.359	146.021	12.084	-1.900
ROC_RET	339	0	-15.283	-10.490	-5.007	-10.133	66.537	8.157	-0.805
ACC_MAR_ECOM_LOG	339	0	5.571	5.740	5.930	5.746	0.048	0.219	0.038
LPRC_COM*	339	44	4.653	5.112	5.547	5.129	0.309	0.556	0.108

*- Considering the relative importance of land price variable, 44 alternative locations with missing observations are being removed from the model estimation and validation data set.

7.3 Model specification - Location choice model for prime hubs and omni channel store locations

Having considered the performance of the above model, the variables for this model are chosen to incorporate both logistics related variables and traditional retail related a variable. Further the locations of traditional Aeon store locations are used as a reference category for comparing the results for prime hubs and omni channel store locations. Accordingly, the descriptive statistics of chosen variables are shown in table 7.6.

7.3.1 Results of estimation and discussion

Similar to the explanation's models are estimated by with 80% of the data set and validated through randomly chosen 20% of the dataset. Given the nature of the response variable, prime hubs locations are estimated with a binary logit model while MNL framework is used for Aeon net shop locations. The latter also include the locations of aeon super centers and Aeon Mall locations are also included in the model for comparison purpose.

Table 7.7 : Summary statistic of best fitted models (for all types considered)

		Aeon Mall	**Aeon Super centre**	**Aeon netshop**	**Amazon Primehub**
Goodness of fit statistics	Statistic -Full*				
	Observations	234	234	234	234
	DF	216	216	216	226
	R^2(Cox and Snell)	0.139	0.148	0.283	0.043
	R^2(Nagelkerke)	0.310	0.196	0.423	0.334
	AIC	140.597	327.606	216.090	39.868
	SBC	202.793	389.802	278.286	71.004
	Iterations	18	12	18	16
Test of the null hypothesis H0	Statistic - Pr > Chi^2				
	-2 Log(Likelihood)	0.004	0.002	< 0.0001	0.247
	Score	0.031	0.008	< 0.0001	0.591
	Wald	0.366	0.031	0.002	0.923

Table 7.8: Standardized coefficients of location model for fulfilment logistics facilities (regional/ national)

		intercept	**POP_LOG**	**SHR_TRANS_LOG**	**POO_DEN_LOG**	**ROC_POP**	**ROC_TRANS**	**ROC_RET**	**ACC_MAR_ECOM_LOG**	**LPRC_COM***
Aeon Mall	Coeffi.	-15.131	4.143	1.226	-0.771	0.329	0.012	0.010	1.816	-3.287
	Standard error	11.832	1.461	0.944	1.316	0.092	0.036	0.053	2.169	1.478
	Wald Chi-Square	1.635	8.040	1.685	0.344	12.696	0.106	0.034	0.701	4.943
	Pr > Chi^2	0.201	0.005	0.194	0.558	0.000	0.744	0.853	0.402	0.026
Aeon Super center	Coeffi.	-5.413	2.313	0.061	-0.348	0.043	0.028	0.026	-0.123	-0.942
	Standard error	7.314	0.879	0.575	0.845	0.061	0.020	0.031	1.295	0.898
	Wald Chi-Square	0.548	6.920	0.011	0.170	0.506	1.962	0.683	0.009	1.101
	Pr > Chi^2	0.459	0.009	0.915	0.680	0.477	0.161	0.409	0.925	0.294
Aeon Netshop	Coeffi.	-1.074	2.466	-1.382	1.644	0.210	0.032	-0.005	-1.305	-1.937
	Standard error	8.695	1.053	0.671	0.988	0.071	0.028	0.039	1.571	1.070
	Wald Chi-Square	0.015	5.489	4.244	2.767	8.843	1.335	0.014	0.690	3.277
	Pr > Chi^2	0.902	0.019	0.039	0.096	0.003	0.248	0.907	0.406	0.070
Amazon primehub	Coeffi.	-38.235	4.980	0.999	8.881	0.180	0.073	-0.009	-3.977	-0.869
	Standard error	37.569	4.164	2.141	6.954	0.209	0.104	0.146	7.273	3.184
	Wald Chi-Square	1.036	1.430	0.218	1.631	0.741	0.488	0.003	0.299	0.075
	Pr > Chi^2	0.309	0.232	0.641	0.202	0.389	0.485	0.953	0.585	0.785

- 95% CI level

Except for the Amazon prime hubs model, all other models are found to be significantly powerful than the individual model. This reflected in the test of null hypothesis (H_0), with -log(likelihood) is <0.05. The model on Aeon net shops is statistically more significant than the other types. However, the R_2 on explained variability of the model seems to be not lower in Aeon super center and aeon net shops.

Size of population, which represent the market size had found to be a significant variable for all aeon store locations. Average land price for commercial also identified as a significant factor in the location choice of Aeon Malls, surprisingly with a negative co-efficient. Similar character is observed with regard to the land price variable with the location choice of aeon net shop locations. The coefficient for the land price variable for the location choice of aeon net shop implied that, when all variables are constant, unit increase in land price variable lower the odds by 0.144 times.

Population density and rate of population change variables are also having a significant and positive effect on the location choice of store locations for net shops. This is a statistical confirmation of the similar observation made through the spatial pattern analysis.

Aeon net shop location choice have a negative – significant relationship with the share of transport establishments at alternative locations. This can also be explained by relating the fact that, locations with higher share of transport establishments expect to increase the competition in e-commerce market environment. However, further analysis is required to confirm the above statement.

The changing patterns of retail environments at locations found be insignificant with the location choice for the aeon net shop store locations. However, this by no means the dispose the possible effects e-commerce has on traditional retailing activities. More complex modelling frameworks with retail sales data can be employed to explore the above aspect.

7.4 Summary of the chapter

As illustrated in the chapter, separate models estimated for fulfillment center logistics facilities, prime hubs centers, and omnichannel store locations by considering municipal areas as alternative locations. It is found that the estimated models better fit to explain the location choice of Amazon fulfillment centers and omnichannel store locations (Aeon). The limitation of data points recognized as the poor fit for the models on 3PL logistics and prime hubs locations. However, it is noted that this fitness of models can be improved with the use of more data points, which does not exist at this moment.

The newly introduced variable of accessibility of the e-commerce market with a constraining factor to the conventional market size relates to the location choice of Amazon fulfillment centers in TMR. Besides, the pattern and trend of the location and organization of transport establishment in TMR discovered to be a significant factor. However, the causative nature of the relationship not explained within the scope of the study. As recognized through the spatial analysis, this statistical analysis attests that changing patterns of demographics affect the location pattern.

Similarly, the locations chosen for net shops were sensitive to the population's distribution pattern and changing demographic trends in the study region. It is evident that omnichannel stores will not be a general phenomenon but emerge at niche locations. The average land price of commercial uses found to be a positive and significant determinant of net shops compared to other traditional store locations.

In general, the future location models need to focus on higher spatial resolution irrespective of the focus of the models. Higher spatial resolution, preferably 1km x 1km or similar, will provide the opportunity to incorporate a more detailed assessment of the location choice. Some of the useful aspects of this regard include the variations of access to expressways within a municipal area, land zoning and regulations, and other land use characteristics inherit at the locations. Further, this study does not consider the spatial autocorrelation between firms and zones, due to the limitation of data points and the relatively diversified characteristics observed at alternative locations.

8 CONCLUSIONS

This chapter summarized the main research findings regarding the main research questions of the study. Policy recommendations proposed based on four aspects after highlighting the main limitations of the study. Finally, the section made recommendations for three distinct research areas.

“Every ending is a beginning. We just don't know it at the time"

8.1 Summary of the main findings

The main findings of the study can be summarized with related to the main research questions introduced in the first chapter of the thesis.

1. Does the spatial distribution of e-logistics differ from traditional logistics?

The results based on the Amazon facility distribution confirmed that the spatial distribution of e-commerce logistics facilities differs from traditional logistics. Further affirm that the pattern of distribution of a given firm represented through the characteristics of urban form.

Amazon based case study indicates that e-commerce logistics facilities concentrated on main city areas in a monocentric settlement pattern. A distributed supply chain structure found in countries with a polycentric settlement pattern. The pattern described above observed with a set of delivery stations in the UK that Amazon established to enhance the regional coverage. Such facilities seem unlikely in countries like Japan with a concentric form of settlements. More importantly, the analysis in the UK affirms that the spatial organization of e-commerce logistics facilities of Amazon is different from the conventional clustering pattern of warehouses and distribution centers of the country.

Further, it is understood that expressway interchanges as a critical infrastructure element compared to other transportation modes, including airports and seaports. These trends can contribute to explaining the contemporary phenomena of logistics sprawl and clustering. The two case studies from the UK and Japan also confirmed the differences between the organization of facility location and studies based on the US and China.

2. Does the spatial organization of e-commerce logistics companies vary between different firms?

The spatial analysis at TMR reveals the different patterns of organization among different firms. 3PL and manufacturing based B2C e-commerce firms follow the pattern of traditional warehousing patterns, with proximity to airport infrastructure. The findings justified based on the supply chain aspects of both firms. On the other hand, Amazon fulfillment logistics centers found to be setting a new pattern of location. A similar characteristic observed through the empirical study in the UK.

However, it is unfair to claim this as a general trend of all firms. It will be more reasonable to conclude that Amazon follows a different pattern of locations compared to traditional warehouses and distribution centers; other firms, whose data are neither

available publicly, maybe following the pattern of Amazon. The logistics competency and infrastructure of different countries, along with 3PL firms, are understood to be other determinants of these spatial organization patterns.

3. Do e-commerce logistics alter the location characteristics of its neighborhoods?

The Amazon based study revealed that the location characteristics at different e-commerce logistics facility locations indicate the trends of facility led spatial clustering and infill developments at dense urban neighborhoods. However, it is important to note the specificity of these patterns and trends. The trends and patterns vary with the overall spatial distribution pattern of the facilities of respective country/ regions.

In addition to the explanation partially provided under the second research question, the location characteristics at Amazon e-commence logistics facility locations to be different among countries and at different locations. The results showed that these extensive logistics facilities were not necessarily located in areas with cluster characteristics, as it is generally assumed. There were new sites, with low- and medium-density built-form characteristics that were attracted by Amazon's presence and later shaped into clusters. Infill developments in Japan indicate the demand for land within the central metropolitan region. The evidence of Poland, along with literature, revealed Poland's emergence as a European regional cluster of e-commerce logistics facilities for Amazon. These trends can contribute to explaining the contemporary phenomena of logistics sprawl and clustering. The finding argues that Amazon will emerge themselves as logistics real estate firms in addition to their known presence in e-commerce market performance. In conclusion, it can clearly state that role and influence of Amazon logistics facility locations can be a possible research theme in the logistics sector in years to come. Geomorphology based research methods can serve the basis for detailed spatial analysis.

4. How to explain the location choice of different e-commerce logistics facilities of different e-commerce firms?

The estimated results showed that the location of Amazon logistics centers significantly relates to the share and growth of transport establishments in TMR. Further, the newly introduced accessibility measure proven to be statistically significant compared to the traditional measure of accessibility, in explaining the location choice of

Amazon fulfillment logistics centers. The overall model validation over 90% leaves the possibility of using this as a tool to explore future locations.

The location choice models for the omnichannel store location helped to recognize the municipal level factors that affect the location choice compared to the traditional retail store locations.

8.2 Limitations of the study

There are several limitations to this study. The first limitation is data availability of the number of e-commerce retailers who adopt the logistics-based model. Most of the e-commerce retailers are still operate as mere marketplaces and depend on third-party logistics providers. Since Amazon is a pioneer in the logistics-based e-commerce model, its facilities choose as the basis of analysis; aforesaid selection may limit in generalizing the research findings related to first and third research questions.

Further, the case study-based findings may not be generalized to understand the geography of the entire e-commerce landscape. Further, this study did not intend to suggest any recommendations for neither the practice of logistics, retailing, nor planning practice. Instead, it aims to disclose a future research area that may have strong relevance for the Asian region by describing the spatial organization of e-commerce logistics facilities, which expect to be a popular field in years to come.

The limitations associated with the study in chapter 07 are twofold. The first set of limitations relates to the understanding of dedicated e-commerce facilities worldwide and consideration of facilities only under 100,000 sq. ft., where Amazon distribution centers and prime hub networks are small but located in high-density areas. This study did not consider whether the Amazon itself built these facilities or rented/leased from the developer. The actual decision-making processes and spatial patterns could have indicated a broader interaction among multiple stakeholders involved in the decision-making processes concerning the locations, and that could not be considered in the scope of this study. Such a focus might cover several locations with a comprehensive survey of the stakeholders.

For example, 13% of the warehouse space Amazon operates owned by Prologis company, which specializes in logistics real estate development, and some facilities are operated jointly with 3PL firms [83]. The scope of the study did not allow consideration of whether any spatial policies at the respective locations affected, directly or indirectly, the morphological patterns captured in this study. Amazon facilities have different functional specializations. Apart from the primary distinction among the functionalities, this paper did not explicitly consider the functional aspects in analyzing the patterns. Second, regarding the general methodology, although the threshold criterion used, there was a high degree of subjectivity involved in judging the typology for a given facility

location's neighborhood, similar to the bias found in many forms of image classification. However, the research team employed multiple perspectives and opinions to reduce subjectivity. Future research can consider this aspect by incorporating the machine learning algorithms available in satellite image processing and geographic information systems. Such improved systems may be useful not only for pattern identification but also for measuring spatial changes and for later simulation modeling. This study defined a neighborhood as the area 1 km from the center of a facility, but this could be further improved by overlapping neighborhood s with administrative boundaries relevant to each site.

In preparing the location choice model, the study only focused on the Tokyo Metropolitan Region. This limitation partially undermines the opportunity to relate the national importance of locations chosen to establish the logistics facility, by Amazon.

8.3 General policy recommendations and social implications

8.3.1 General policy recommendations

As emphasized in the introduction, this research contributes to three practical domains, including strategic planning at the regional level, land use planning at the city level, and transportation planning. Based on the analysis, the following policy recommendations proposed for practitioners.

i. The UK based analysis further affirm the hypothesis that the spatial distribution of e-commerce logistics facilities (of Amazon) is different from the distribution pattern of traditional logistics facilities. The comparison indicates how the demand for logistics real estate change with the boom of e-commerce markets. At the regional level, the strategic planners need to exploit such developments to support the optimum use of regional infrastructure. Similarly, it is also vital to evaluate suitable locations to promote such developments. These developments expect to attract both skilled and non-skilled labor force and other industries to the regions (agglomeration)

In the long-run, it may also lead to the development of fulfillment clusters, as it is already seen in some regions in the US and Poland.

ii. On the other hand, urban form characteristics determined the potential sitting of new e-commerce logistics facilities. The facility network's

hierarchy and facility size are vital factors in determining the number of facilities required to serve a given region/ country. Therefore, the urban form and the spatial organization need to be understood not only at locale scales. But also, at national and regional scales.

iii. The attractiveness of the given municipality also depends on the accessibility potential of each location to potential e-commerce markets. The study demonstrates the method of distinguishing e-commerce markets by employing two socioeconomic variables in Tokyo. The variables include the population between 15-64 and the rate of population change. In Japan, the variables described above significantly influenced the present demographic composition.

Such tools will come in handy for local land-use planners to understand the present context of respective municipalities. Similarly, to assess the attractiveness of municipalities for large-sized e-commerce logistics facilities.

iv. At the same time, the shift from traditional stores to omnichannel stores (also including micro hubs and prime hubs) expect to affect the real estate demand. The specific functionality of such stores may attract similar land-use conversions which are not visible to outside.

v. The Tokyo based empirical analysis and logit model reveal the effect of socioeconomic factors on location choice by considering Amazon as the main case study. However, as noted under the limitations of the study did not consider the non-location factors. In reality, the non-location factors bound to socio-political contexts can significantly affect the decision-making process. In addition to the scientific findings offered in the thesis, the following examples highlight the possible influence of non-location factors in location selection. Such holistic understanding may benefit to planning professionals in realizing the reality beyond the scope of the thesis.

vi. Finally, the COVID 19 pandemic around the world, challenged the way of lifestyles. E-commerce became a vital feature of the ‘new normal’ lifestyles that emerged with the crisis. Although it is not empirically proven, the serviceability of regions for e-commerce heavily depends on the location of logistics facilities. The situation is particularly visible in many places around the world (regions and countries). However, Japan is

an exemption with its nationwide high-quality logistics capability, also ensured by private sector companies. Therefore under 'new normal' conditions, it is paramount to have a balanced spatial distribution of e-commerce logistics facilities to ensure equity in serviceability for customers.

The general analysis through municipal income suggests that Odawara city is known to be a 'rich city' compared to many other cities in Tokyo region. The Amazon built its largest fulfillment center in Odawara city at a land previously occupied by a battery manufacturing company.

The shreds of evidence collected through multiple sources indicate that Odawara city invited Amazon to set up this facility at their municipality. As per the industrial promotion guidelines, the councils granted tax incentive packages for the development. The case of Odawara highlight how this e-commerce logistics facility set up at the location with a strong partnership of the local government.

On the other hand, the logistics facility at Tosu city, Kyushu region established at a new location. Unlike the Odawara example, neither an invitation from the local government nor a strong incentive package not mentioned with the Amazon fulfillment center project. In addition, the location of the facility is outside the largest designated industrial park in the city. However, it is evident that this development catalyzes the emergence of a new growth cluster in the Tosu region.

These conclusions presented here derived through the primary case study analysis of Amazon. The geographical focus centered around the Tokyo Metropolitan region. Therefore, it is important to note that these recommendations' real implications vary with the real context under consideration.

8.3.2 General social implications: worldview

As noted in general policy recommendations (vi), the recent COVID 19 pandemic had transferred more burden on e-commerce channels as the main modes of shopping. This shift not limited markets with dominant e-commerce players. But also forcing traditional retailers to carry out home deliveries for the orders made through online or telecommunication channels. These similar trends can be observed at both developing and developed economies.

The sudden demand for home deliveries lead to supply chain disruptions of most e-tailers and traditional retail stores. On the other hand, it led to an equity issue, with

some areas properly served by home deliveries while certain areas lacked the timely home deliveries of basic necessities. The dispute can be argued as an equity issue from a social perspective.

Several factors recognized as the possible causes for aforesaid situations. The general factors include, the lack of stocks; flow of goods from manufacturers/ producers to distribution centres and, staff and other resources shortages. However, the location of logistics centres is playing a significant role when it comes to order fulfillment. The random pieces of evidences collected at different geographical locations confirm that areas where the e-commerce logistics centres located are better served than the areas without the fulfillment facilities. Of course, the outcomes vary with the presence of freight transportation firms.

It is vital to ensure the distributed form of e-logistics to ensure that order fulfillment area done on time and to the level of satisfaction of the consumers. This is pivotal given the circumstances the societies in under 'new normal' lifestyles. Therefore, the policy makers and planners need to consider the stated aspect in allocating land for commercial and/or industrial purposes.

8.4 Recommendation for future research

8.4.1 Theoretical contributions

The proposed conceptual innovations by Amazon further distinguished the e-commerce logistics facilities from convectional distribution centers. While geography remains an essential dimension in the whole scenario, further research can also explore the location choice, applicability, and likely impacts of such developments. The facts and trends can confirm that e-commerce logistics may not emerge as a unique typology in logistics real estate but also will bring further diversifications under the above circumstances. From a research point of view, it will be critical for land use and transportation sectors to determine the suitable urban forms to harmonize with these different land use typologies.

8.4.2 Location choice model

The location choice model presented in the paper only estimated based on municipal level choice alternatives. However, the present study does not include

distance expressway, which expects to be a critical variable. Future studies on the location model, either adopt a nested logit modeling framework to enable variables at different levels or use a smaller sized set of location alternatives.

8.4.3 Integrate with land use simulation models

This feature can enhance the use of the location model for future decision purposes to identify future locations for e-commerce logistics facilities. Further, the integration with land use simulation models can also enable the land-use planners to study likely effects of land use on location and vies versa.

For example, in considering the variables considered in the present study, the inhabitable area, the share of commercial and industrial land use areas within a municipality can be determined through a land-use simulation model.

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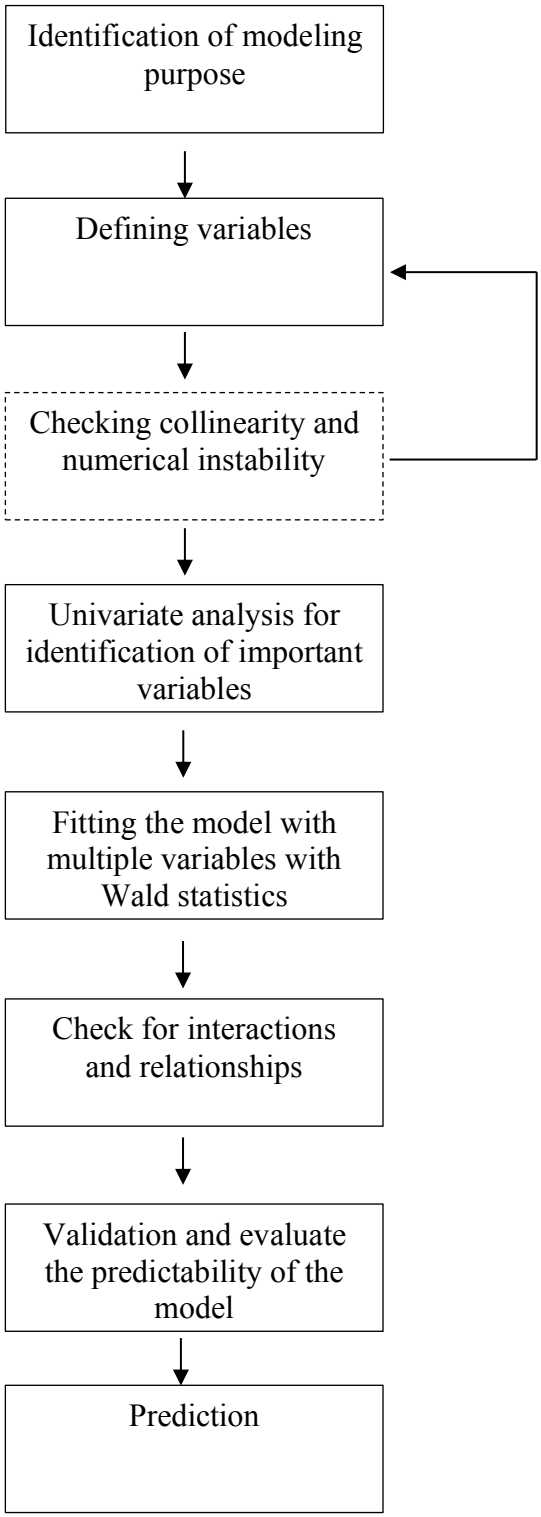
APPENDICES

APPENDIX 1 GENERAL PROCESS OF MNL DEVELOPMENT



APPENDIX 2: PCA ANALYSIS

Summary statistics:							
Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
#A03505_Ratio of population [15-64 years old][%]	382	0	382	45.359	71.759	60.423	4.055
#A05101_Rates of population change[%]	382	0	382	-14.920	23.960	-1.220	4.708

Eigenvectors:

	F1	F2
#A03505_Ratio of population [15-64 years old][%]	0.707	-0.707
#A05101_Rates of population change[%]	0.707	0.707

Factor loadings:

	F1	F2
#A03505_Ratio of population [15-64 years old][%]	0.922	-0.388
#A05101_Rates of population change[%]	0.922	0.388

APPENDIX 3: LOGIT MODEL FOR 3PL FIRM (RAKUTEN 3PL)

Estimated parameters of location model for fulfilment logistics facilities – 3PL (Rakuten)

	3PL fulfillment logistics (Rakuten) - single facility				**3PL fulfillment logistics (Rakuten) - cluster of facility**			
	Coeffi.	Standard error	Wald Chi-Square	Pr > Chi^{2}*	Coeffi.	Standard error	Wald Chi-Square	Pr > Chi^{2}*
Intercept	-1529.624	4123.074	0.138	0.711	-1868.020	3153.012	0.351	0.554
POP_LOG	24.315	143.950	0.029	0.866	77.093	163.664	0.222	0.638
ACC_MAR_ECOM_LOG	12.354	118.144	0.011	0.917	39.838	102.029	0.152	0.696
SHR_TRANS_LOG	4.233	81.226	0.003	0.958	31.318	111.275	0.079	0.778
POO_DEN_LOG	-16.868	88.217	0.037	0.848	-23.380	103.146	0.051	0.821
DIS_AIRP_LOG	3.029	145.854	0.000	0.983	-11.961	78.126	0.023	0.878
ROC_POP	2.581	7.903	0.107	0.744	2.163	11.165	0.038	0.846
ROC_TRANS	0.264	4.900	0.003	0.957	-0.375	5.015	0.006	0.940
ROC_MANU	-0.128	3.639	0.001	0.972	0.731	2.113	0.120	0.729
ROC_RET	-0.423	5.528	0.006	0.939	-0.724	6.960	0.011	0.917
SHR_EMP_S_LOG	115.008	559.258	0.042	0.837	186.741	539.742	0.120	0.729
SHR_EMP_T_LOG	650.858	1931.404	0.114	0.736	565.433	1268.013	0.199	0.656

Standardized coefficients of location model for fulfilment logistics facilities – 3PL (Rakuten)

	3PL fulfillment logistics (Rakuten) - single facility				**3PL fulfillment logistics (Rakuten) - cluster of facility**			
	Coeffi.	Standard error	Wald Chi-Square	Pr > Chi²*	Coeffi.	Standard error	Wald Chi-Square	Pr > Chi²*
POP_LOG	6.795	40.227	0.029	0.866	21.544	45.736	0.222	0.638
ACC_MAR_ECOM_LOG	1.502	14.361	0.011	0.917	4.842	12.402	0.152	0.696
SHR_TRANS_LOG	1.061	20.363	0.003	0.958	7.851	27.896	0.079	0.778
POO_DEN_LOG	-5.209	27.240	0.037	0.848	-7.219	31.850	0.051	0.821
DIS_AIRP_LOG	0.452	21.786	0.000	0.983	-1.787	11.670	0.023	0.878
ROC_POP	6.812	20.856	0.107	0.744	5.707	29.464	0.038	0.846
ROC_TRANS	1.958	36.301	0.003	0.957	-2.780	37.156	0.006	0.940
ROC_MANU	-0.679	19.273	0.001	0.972	3.874	11.188	0.120	0.729
ROC_RET	-1.898	24.788	0.006	0.939	-3.248	31.209	0.011	0.917
SHR_EMP_S_LOG	8.975	43.642	0.042	0.837	14.573	42.119	0.120	0.729
SHR_EMP_T_LOG	18.618	55.249	0.114	0.736	16.175	36.272	0.199	0.656

APPENDIX 4: MAIN REGIONS IN UK

1. Scotland
2. Northern Ireland
3. Wales
4. North East
5. North West
6. Yorkshire and the Humber
7. West Midlands
8. East Midlands
9. South West
10. South East
11. East of England
12. Greater London