

# LOCATING A FREIGHT CONSOLIDATION CENTRE IN PORTSMOUTH, UK

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## ABSTRACT

*This research presents a scientific approach for selecting a suitable location for a Freight Consolidation Centre (FCC) in the city of Portsmouth, UK, on the south coast of England. A detailed review was carried out of a number of different types of FCC across the UK, including their size, terms of use, operator and initial funding stream. After a discussion of the methodologies used, a review of the unique characteristics of the city of Portsmouth and its current and future developments was outlined with a number of potential FCC sites identified. A questionnaire was developed and conducted amongst experts in industry in order to identify the important criteria. The Analytic Hierarchy Process (AHP) was then used to quantify these criteria based on the responses received. Expert Choice decision making software was then used for the implementation of the Multi Criteria Decision Making (MCDM) methodology of AHP to provide a score for each potential location. The research initially identified the most important site-selection criterion and its implementation in Portsmouth, which was achieved by aggregating questionnaire responses. This enabled selection of the most suitable site, with respect to the defined criteria. Recommendations based on the outcomes of the study were made, having critically examined, compared and contrasted them with the literature. Finally, the proposed location in Portsmouth could be examined more as a good location for such an FCC, while the other locations can provide alternatives options.*

**Keywords:** Freight, Consolidation, Freight Consolidation Centre, Portsmouth, AHP, Expert Choice

### บทคัดย่อ

งานวิจัยนี้นำเสนอวิธีการเลือกสถานที่ตั้งศูนย์รวมขนส่งสินค้า (FCC) ในเมืองพอร์ตsmouth ชายฝั่งทะเลตอนใต้ของ ประเทศอังกฤษ การทบทวนงานวิจัยเกี่ยวกับชนิดต่างๆ ของ FCC ในสหราชอาณาจักร รวมถึง ขนาด ข้อตกลงในการ ใช้ ผู้ดำเนินการ และแหล่งเงินทุน หลังจากการอภิปรายวิธีการวิจัยที่ใช้ จะมีการสรุปภาพการทบทวนลักษณะอันโดดเด่นของเมืองพอร์ตsmouthและการพัฒนาในปัจจุบันและอนาคต พร้อมทั้งให้เห็นถึงจำนวนสถานที่ตั้ง FCC ที่น่าจะเป็นไปได้ โดยมีการพัฒนาแบบสอบถามขึ้นมาเพื่อให้ผู้เชี่ยวชาญในอุตสาหกรรมได้ตอบ เพื่อระบุเกณฑ์ที่สำคัญได้ จากนั้นจึงใช้กระบวนการวิเคราะห์ตามลำดับชั้น (AHP) ในการหาจำนวนเกณฑ์เหล่านี้จากคำตอบที่ได้รับ จากนั้นจึงใช้โปรแกรมช่วยในการตัดสินใจ Expert Choice เพื่อให้แสดงผลคะแนนของแต่ละสถานที่ออกมา งานวิจัยนี้ชี้ให้เห็นเกณฑ์ในการเลือกสถานที่ และการนำมาใช้ในเมืองพอร์ตsmouth โดยการใช่วิธีที่ได้จากแบบสอบถาม ซึ่งทำให้สามารถ

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เลือกสถานที่ที่เหมาะสมที่สุด ข้อเสนอแนะจากผลการศึกษาได้มีการนำมาวิเคราะห์เป็นสำคัญและเปรียบเทียบกับงานวิจัยที่ผ่านมา สุดท้ายสถานที่ที่เสนอในเมืองพอร์ตsmouth ได้ถูกสำรวจเพื่อหาที่ที่ควรตั้งศูนย์รวมขนส่งสินค้า ในขณะที่สถานที่อื่นๆ สามารถนำมาใช้เป็นทางเลือกได้

## INTRODUCTION

Urbanisation involving the rapid growth of cities around the world and the ever increasing cost of living, create challenges for the modern supply chain. While the movement of goods plays a fundamental role in this urban economic and social development (Suksri, Raicu, & Yue, 2012), there is a constantly increasing interest in freight consolidation centres (FCCs) as a means to ease local environmental and traffic problems within urban areas (Allen et al, 2012). A freight consolidation centre is defined to be “A distribution centre, situated close to a town centre or other destination, at which part-loads are consolidated and from which a lower number of consolidated loads are delivered to the target area” (Lewis et al., 2010).

McKinnon et al. (2012) set out the main advantages and disadvantages of FCC’s. The advantages include environmental and social benefits of less freight traffic in urban areas, improved planning and implementation of logistics operations, better inventory control, reducing cost of the ‘last mile’ and opportunities for value-added services. However, disadvantages can include high setup costs, difficulties in dealing with a wide range of goods, loss of direct contact with customer, and to impose an extra link in the supply chain and the location may increase delivery costs for some companies.

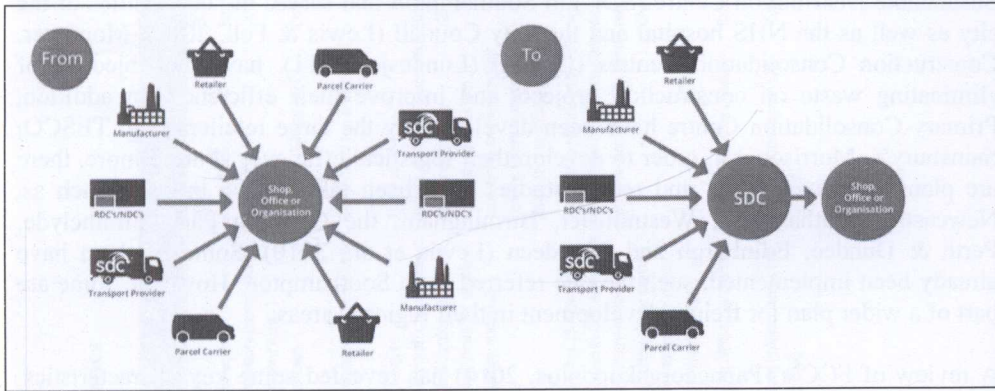
One of the main purposes of an FCC is the efficient loading of vehicles serving urban areas and consequently a reduction in goods vehicle traffic (particularly regarding the logistics of the last mile). Additionally, strategic plans of industry and local authorities include the optimisation of land use through efficient transportation and improvement of local air quality along with opportunities for the operation of electric and alternatively powered goods vehicles. FCC’s represent a tool for the achievement of these long term objectives and subsequently there is a range of other value-added logistics and retail services that could also be provided (Allen et al., 2012), such as collection services, label printing, stock room management and staff training facilities (Campbell et al., 2010).

FCC’s receive deliveries scheduled for the urban area they serve. So, logistics transport companies avoid entering congested areas and transfer their loads at the FCC. The FCC is continually responsible for sorting and consolidating the loads for their delivery, while retailers can use the FCC for short or long term storage of their goods, and subsequently react quickly and efficiently to customer requirements (Campbell et al., 2010). Figure 1 represents the consolidation concept, where the acronym SDC stands for a “Sustainable Distribution Centre”.

However, there are number of factors influencing the existence and the location of the FCCs such as funding and financial issues, conflict of interests and environmental concerns. The aim of this research was to find the key criteria in order to select a suitable location for a FCC in Portsmouth. Objectives included critically reviewing the literature in the areas of the general characteristics of FCCs and locating existing and potential FCCs around the UK. It also included the application of Multi-Criteria Decision Making (MCDM) methodologies such as the Analytic Hierarchy Process (AHP), reviewing the geographic, demographic and transportation characteristics of Portsmouth, identifying

key criteria and alternatives for locating a FCC in the wider region of Portsmouth, the analysis of AHP questionnaire data and making recommendations as to the benefits or otherwise of FCC's.

**Figure 1: Consolidation Concept**



Source: Sustainable Distribution Centre (<http://southamptoncdc.co.uk/>)

Whilst there is no separate Literature Review in this paper, the following sections contain many citations of relevant research and publications, with a full set of References at the end.

## REVIEWING FCC AROUND THE UK

The contribution of freight transport and logistics to the UK economic prosperity is significant. As stated above, the last 25 years has seen the continually growing logistical efficiency not only in the reduced real cost of deliveries and making longer distance supply chains viable, but also benefiting the growth in consumer demand as prices have fallen (Braithwaite, 2011). Indeed, the freight and logistics sector is an important national asset and Braithwaite (2011) identifies two major objectives for sustainable freight transport and logistics; a reduction in both traffic congestion and  $CO_2$  emissions. Without a doubt, these two objectives are irrevocably connected with the concept of the FCC. For that reason, the consolidation practices also contribute to the development of the local and national economy.

However, the consolidation centres can have single or multiple objectives and they are of interest to local planning authorities as well as to the wider business sector. While the list could be extensive, reduction in traffic congestion, environmental impact, delivery cost of the last mile and conflict between road users, represent some of them. Meanwhile, maximisation of retail space and stock availability, increment of speed and reliability of deliveries and the delivery windows, compliance with corporate social responsibility targets and the opportunity for retailers to undertake added-value services and even manage efficiently site congestion at construction sites, can also be included as some of the objectives (Lewis et al., 2010), (Campbell et al., 2010), (Suksri et al., 2012).

In addition, there are factors that influence the nature of the FCC, and some of them are: proximity to the market, stakeholders support, target area, products/goods to be stored, operation of the FCC (public/private), financial issues (e.g. ways of funding), local

authorities, compulsory or voluntary operation, infrastructure facilities (e.g. warehousing providers, road network quality and traffic management) and general policies (Browne et al., 2005).

At present, there is a significant number of FCC's operating across the UK. Most of these centres are focused on the retail sector, extending their services to the public such as the Sustainable Distribution Centre (SDC) in Southampton that serves the universities of the city as well as the NHS hospital and the City Council (Lewis & Fell, 2012). Moreover, Construction Consolidation Centres (CCC's) (Lundesjo, 2011), have the objective of eliminating waste on construction projects and improve their efficiency. In addition, Primary Consolidation Centre have been developed by the large retailers (e.g. TESCO, Sainsbury's, Morrisons) in order to develop their logistical efficiency. Furthermore, there are plans for new FCC's, and recent studies have been taken place in areas such as, Newcastle, Southampton, Westminster, Birmingham, the Olympic Park, Strathclyde, Perth & Dundee, Edinburgh and Aberdeen (Lewis et al., 2010). Some of them have already been implemented, such the one referred to in Southampton. However, some are part of a wider plan for freight development in their regional areas.

A review of FCC's (Papageorgakopoulos, 2014) has revealed some key characteristics. For instance, it can be seen that the objectives for the various FCC's are similar with differences dependent on what the FCC focuses on. In general, it can be deduced that the reduction of the environmental impacts is a major objective, either focusing on optimising delivery movements or reducing congestion effects which will see a corresponding improvement in air quality. In addition, the FCCs are usually run by private logistics providers with a regional or an extended activity, while the initial funding for the start-up of the centre is extracted from public or private resources. The strategic location is a key element of the business. The distance from the target area varies between the centres, as well as the warehousing space availability. Table 1 summarises the key characteristics of seven different FCC's.

## METHODOLOGY

There are a significant number of methods in the context of operations management in order to approach a facility location problem, such as the weighted factor rating method, load distance method or the centre of gravity method (Kumar & Suresh, 2009). However, the problem of the identification of the most suitable location for a FCC in Portsmouth is quite complex and takes into consideration a number of criteria and alternatives. Indeed, the literature has identified the Analytic Hierarchy Process (AHP) as one of the best Multi Criteria Decision Making (MCDM) methods to be used for location selection problems. It has been utilised for facility location problems, such as Yang and Lee (1997) for a facility location selection, Regmi and Hanaoka (2011) for location analysis of logistics centres in Laos and Alam (2013) for the evaluation of the potential locations for logistics hubs.

The AHP was developed in 1971- 1975 by T. L. Saaty (Saaty, 1987). It is a MCDM method that helps the decision-maker facing a complex problem with multiple conflicting and subjective criteria, such as location criteria or project ranking (Ishizaka & Labib, 2009). The AHP is based on the well-defined mathematical structure of consistent matrices and their associated right-eigenvector's ability to generate true or approximate weights, while being a methodology that compares criteria, or alternatives with respect to a criterion, in a natural pairwise mode. In order to do that, AHP uses a fundamental scale

**Table 1: Summary of the Key Characteristics**

	KEY CHARACTERISTICS						
	BRISTOL	MEADOWHALL, SHEFFIELD	NORWICH	HEATHROW AIRPORT	LONDON	SOUTHAMPTON	REGENT ST., LONDON
Consolidation Centre	2004	2003	2008	2000	2005	2014	2009
Opened Sector	Retail	Retail	Retail	Retail	Construction	Retail/Public	Retail
Terms of use	Voluntary	Voluntary	Voluntary	Compulsory	Compulsory (except from exempted items)	Voluntary	Voluntary
Strategic Location	Close to M4 and M5	Close to M1, but serves Meadowhall	Close to A11	Close to A408 and M4	Silvertown	Close to M27 and M271	Enfield
Distance from target area	10 miles	400 m	20 miles	2 km	Depends on the construction site	Depends on the area served	-
Size	465 sq. m.	3,159 sq. m.	29,760 sq. m.	5,235 sq. m.	6,000 sq. m.	1,860 sq. m.	-
Some of the Objectives	Reduce the number of delivery vehicles operating in the area and contribute to improving air quality in the target area	Improve the profitability of the retailers and the landlord while minimising the impact of daily deliveries to the centre	Reduce congestion and emissions, minimise impacts of transport related to people's health and natural, historic environments	Improve methods of delivery to retail units and reduce vehicle movements through consolidation of products	Reduce traffic congestion in Central London and reduce journey times for suppliers delivering materials	Reduce emissions and vehicle movements in key constrained areas and at peak times and improve air quality. Improve transport and business efficiency	Reduce goods vehicles, deliveries and traffic
Some of the Results	In 2008, reduction in delivery movements for participating deliveries and reduction in CO2 emissions	Reduction in Goods Vehicle mileage is minimal. It is assumed sales benefits and reduction in the number of vehicles delivering to the centre	Minimal impact to the region with only 2% fewer delivery journeys in 2011	Reduction in CO2 emissions over the years, while a significant number of kms has been saved as well	In the first 18 months, reduction in CO2 emissions and delivery vehicles congestion. Other targets ended to positive results, above expectations	Forecast to reduce up to 75% the number of HGV travelling into Southampton City Centre retailers one year before the Olympics	Significant reduction in the deliveries of the participating retailers one year before the Olympics
Operator	Private (DHL)	Private (Clipper Logistics Ltd.)	Private (Foulger Transport)	Private (DHL)	Private (Wilson James Ltd)	Private (Meachers Global Logistics)	Private (Clipper Logistics)
Initial Funding	Public (EC supported project under CIVITAS)	VIVALDI (British Land Company)	Public (SMILE project under CIVITAS)	Private (BAA and Ekel)	Private (Wilson James Ltd and BAA)	Public (Southampton City Council)	Public (Crown Estate)

Source: Papageorgakopoulos (2014)

of absolute numbers (Table 1) that has been proven in practice and validated by physical and decision problem experiments (Forman & Gass). Additionally, AHP allows decision makers to model a complex problem in a hierarchical structure, showing the relationships between the goal, criteria and alternatives (Adamcsek, 2008).

### Defining judgmental matrix A

Suppose there are  $n$  criteria. In order to obtain weights to each criterion, the methodology begins by writing down a  $n \times n$  matrix (known as the pairwise comparison matrix)  $A$ . The entry in row  $i$  and column  $j$  of  $A$  (call it  $a_{ij}$ ) specifies how much more important criterion  $i$  is than criterion  $j$ . "Importance" is to be measured on an integer-valued 1–9 scale, with each number having the interpretation shown in Table 2 (Winston, 2003) and can be obtained from the questionnaire survey sent to the decision makers.

**Table 2: Interpretation of Entries in Matrix for Pairwise Comparison**

Value of $a_{ij}$	Interpretation
1	Objective $i$ and $j$ are of equal importance.
3	Objective $i$ is weakly more important than objective $j$ .
5	Experience and judgment indicate that objective $i$ is strongly more important than objective $j$ .
7	Objective $i$ is very strongly or demonstrably more important than objective $j$ .
9	Objective $i$ is absolutely more important than objective $j$ .
2, 4, 6, 8	Intermediate values—for example, a value of 8 means that objective $i$ is midway between strongly and absolutely more important than objective $j$ .

Source: Winston (2003)

The judgmental matrix  $A$  (pairwise comparison matrix) is defined such that  $a_{ii} = 1$ , for all  $i, j \leq n$  and where  $a_{ij}$  represents the pair-wise comparison rating between the objectives  $i$  and  $j$  with respect to the goal being considered.

$$A = \begin{array}{c|cccc} K & A_1 & A_2 & \cdots & A_n \\ \hline A_1 & 1 & a_{12} & \cdots & a_{1n} \\ A_2 & 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_n & 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{array}$$

## PORTSMOUTH AND THE POTENTIAL LOCATION FOR A FCC

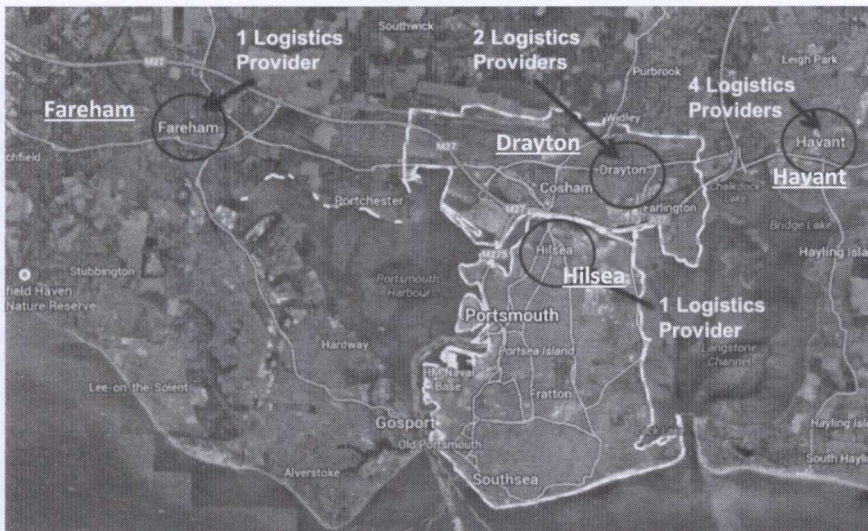
The study has reviewed major retail points of the city of Portsmouth and their locations (road links close to them and their connections), future retail plans as well as some current and recent developments in the city. The City Council is planning for a greener city with less vehicles emissions, open spaces and proper infrastructure that could support these initiatives. In addition, the City Council is introducing ways in which to promote the use of more sustainable modes of transport (Portsmouth City Council, 2013).

Based on the information gathered from the above and the review of the FCCs around the UK, the literature review has been used to relate the concept of the FCC with what Portsmouth City Council is trying to achieve. In order to define a suitable location for a FCC in Portsmouth, a number of criteria have been identified. The first criterion is **Infrastructure**

that includes road network quality with a combination of traffic management of modes of transport, buses and bicycles. **Proximity to market** is vital because the market area has to be easily approachable from the FCC vehicles with sufficient links from the FCC to the market, and this criterion is connected directly to the previous one. The criterion of **Funding** is significant for the start-up of a centre and it can be seen from Table 1 how FCCs have been funded in the past. In addition, **Stakeholders support** represents an important issue. It is not only the initial funding that plays an important role, but also the support from the retailers, the organisations and the companies that are involved in the creation of an FCC. With the support and cooperation of all the stakeholders, a centre could continue operating profitable. Finally, **Terms of use** is another important criterion. It could be separated into compulsory use or voluntary (or optional) for the clients and it is vital in the way the FCC operates. A compulsory operated FCC has a guaranteed number of clients, while a voluntary one needs a specific number of participants each time in order to operate properly and cover its costs and expenses. This criterion could be taken into consideration in order to choose where or by whom the centre is going to be operated. While, these criteria could be utilised for the implementation of the AHP, a number of sub-criteria could be identified as well. So, "Infrastructure" could be separated into two sub-criteria, "Road Network Quality" and "Traffic Management".

This research proposed four alternative locations for the FCC (see Figure 2). It can be deduced from the literature that on a number of occasions, an already existed logistics provider had been chosen to run the centre. So, based on the current logistics industry activity within the greater area of Portsmouth, a number of logistics providers have been identified with local or extended activity. They operate sizeable warehousing spaces, while having their own fleet of vehicles. They are close to the major road links, which makes it easier for access in the core of the city. The **alternative possible locations** are as follows: **Hilsea, Drayton, Havant, Fareham** (whilst keeping the specific logistical companies anonymous).

**Figure 2: Portsmouth and potential locations for a FCC**

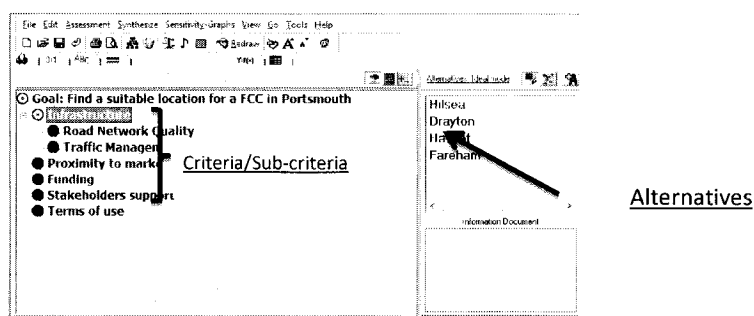


Source: Google maps (<https://maps.google.com>)

## DATA COLLECTION AND THE IMPLEMENTATION OF AHP

The method of AHP requires data in order to be applied and for that reason a questionnaire survey was conducted including ten pair-wise comparisons between the five criteria previously mentioned. A number of industry professionals were contacted in order for them to give their expert opinion. For the scoring process, the numbers used were limited to 1, 3, 5, 7 and 9 in order to make the procedure easier for the respondents. The individual responses were aggregated using the weighted geometric mean. Under this technique, the group becomes finally the “new individual” rather than a collection of independent individuals (Ssebugwawo et al., 2009). The authors also scored the sub-criteria and the alternatives, based on the literature, current and future development plans of Portsmouth, a map and the city’s road network links and the logistics industry situation around the area. Ishizaka et al., (2009) states that Expert Choice is the leading software package for the implementation of AHP, which was utilised for the delivery and analysis of the results (see Figure 3).

**Figure 3: Expert Choice screenshot**



Source: Authors

## RESULTS AND CONCLUSIONS

From the criteria given above, “**Stakeholders support**” (38%) was the most important criterion after the aggregation of the individual responses of the eight decision makers participating in the study, followed by Funding (27%), Terms of Use (21.9%), Proximity to Market (7.4%) and Infrastructure (5.7%). The study revealed **Havant** (43.6%) as the most preferable location for all of the eight participants, while “**Funding**” (65.7%) was the most important individual criterion for that location. It could be commented effectively that Havant was expected to be the most suitable location for the FCC. This fact makes sense from the moment that the scores of the alternatives were given only by the author, contributing as well to the final result. However, aggregation of the responses significantly decreased the inconsistency of the individual judgments.

The questionnaires were completed from people who were working in the logistics industry: companies that have taken part in the consolidation centres, consultancy and research companies in the field of transport as well as from academics in the logistics area. The consistency index for the eight questionnaires varied from 0.02 - 0.25 (an average of 0.145). Following the aggregation of the questionnaires, the consistency index was reduced to 0.008 (well below the 0.10 consistency threshold used in AHP), consequently leading to an



improvement in the final decision. As far as AHP is concerned, it does not guarantee the optimal solution. It is a method that is time effective, provides an outcome, and even professionals can apply it without having a strong mathematical background. Expert Choice software helps by providing a user friendly interface with a variety of graphs and tables. However, the disadvantage of the method is the inconsistency of judgements that sometimes exceeds the desirable threshold. It could be assumed that a more personal type of interview could help to overcome individual inconsistencies, because the respondent would have a better understanding of the process and problem. It is important to mention that the scale used for this approach utilised a novel approach not including the intermediate values and could have caused a slight increase in inconsistency. Even if this is true, the authors believe that this it is not a serious issue because a more complicated scale could result in less participation in the survey.

In conclusion, it is very difficult to guarantee the success of a FCC. It is true though that not every city or area is appropriate for such an investment. The authors believe that a prioritised balanced coexistence of all the above criteria in comparison with local initiatives could have positive results. So, when it is mentioned that a city is a suitable place for an FCC, it means that the situation undergoing in the region creates the potentials for the consolidation of the goods. This study could be used as a guide and consequently as an initial approach for the location of a FCC in Portsmouth or other urban areas in the UK. It could also be used for further study on the factors that made FCCs fail or succeed. In addition, the Havant location could be examined in more detail as a potential suitable location for an FCC, while Fareham, Drayton and Hilsea could represent possible alternatives.

Future trends in warehousing is likely to be influenced by increasing consumer demand for operations to have minimal impact on the environment, uncertain and rising fuel and energy costs, rising customer expectations and improvements in technology sector (Richards, 2014). These trends are likely to lead to an increasing pressure on companies to collaborate and share resources (both warehousing and transportation) in order to reduce costs and their environmental impacts. This could lead to an increase in FCC's in the private and public sector.

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