Supplying Complex Product Service-System (PSS): A Case of Public Bike-sharing

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Abstract

The purpose of this study is to explore the Supply Chain (SC) challenges affecting the delivery of Product Service-System (PSS) within the Bike-sharing industry. The research focussed on exploring the nature of Bike-sharing PSS and the peculiar characteristics of the provision. Literature reviewed showed that very limited academic research had been done in this area. Therefore, the research activity has made significant contribution to the field by providing an accurate description of the Bike-sharing SC through empirical research. By employing a systematic methodology, a framework for PSS Bike-sharing delivery was also developed with direction for future research being provided.

Keywords: Product Service-System (PSS), Supply chain (SC), Bike-sharing industry

Introduction

The industrial revolution in the 18th century changed the UK from agricultural to an industrial society. One of the features of the new society was mass production which led to the development of urban settlements. The steam engine empowered rail transport as an important method of transportation. Overtime, wealth generation enabled individual citizens to own their own cars. The abundance of privately owned vehicles and other forms of transport began to create challenges such as traffic congestion and environmental pollution. In addition to this, health concern of citizens and other social factors have favoured the growing popularity of bike-sharing provision in urban settlements. Though the concept was initiated in 1965, the popularity of bike-sharing came to the fore in many societies such as the UK and France in the 1990s (ITDP, 2013). With over 600 cities having their own bike-sharing schemes worldwide (ITDP, 2013), the initiative is fast becoming an important part of modern society and it should attract interest from industrial and academic research. Similar to other forms of transport, it requires a robust SC arrangement in order to deliver the customer requirement and achieve the anticipated benefits. Its peculiar nature which combines products and services into an integrated offering poses different challenges to the SC. Therefore, the purpose of this research activity is to explore the nature of bike-sharing PSS and the peculiar characteristics of the

provision, understand the SC challenges that surround delivery of the PSS; and develop a framework for delivering the PSS. Finally, it suggests ideas to improve bike-sharing PSS delivery. Within this paper, 'bicycle' is presented as 'bike' as this is a widely accepted short form of the product within industrial and academic literature.

Background

Many cities in Europe, North America and Asia now offer public bike- sharing which helps to promote cycling as an innovative, environmentally friendly and energy efficient form of transport. In some cities it is the starting point for a radical change in urban and transport planning, hence the increase in bike-sharing cities from 68 in 2007 to over 675 by the end of 2013 (DeMaio and Meddin 2013 cited in Paul and Bogenberger, 2014). A report by the Larsen (2013) showed that between January 2000 and April 2003, the number of countries offering bike-sharing schemes has risen from around 5 to around 49 countries (see Figure 1). Bike-sharing schemes have become an indicator for a bike friendly transport policy, stimulating the willingness of the citizens to use eco-friendly means of transport (Paul and Bogenberger, 2014). The Netherlands and Denmark are well-known for their pervasive cycling cultures. France ushered in the 3rd generation of bike-sharing in 1998 with the first public computerised programmed bikes while Italy and Spain increased investment since 2007. Germany has also joined the group of leading countries since 2009. In the UK, London's Barclays Cycle Hire launched in 2010 has grown from 6,000 to 8,000 (Larsen, 2013). A 2013 customer survey, revealed that since the introduction of bike-sharing schemes in 2010, they had recorded around 20 million rentals from users (by Transport for London, 2013). The motivation for bike-sharing programs and anticipated benefits vary from one society to the other. In order to further understand the nature of bike-sharing as a PSS, industrial and academic literature are reviewed and discussed in the next section.

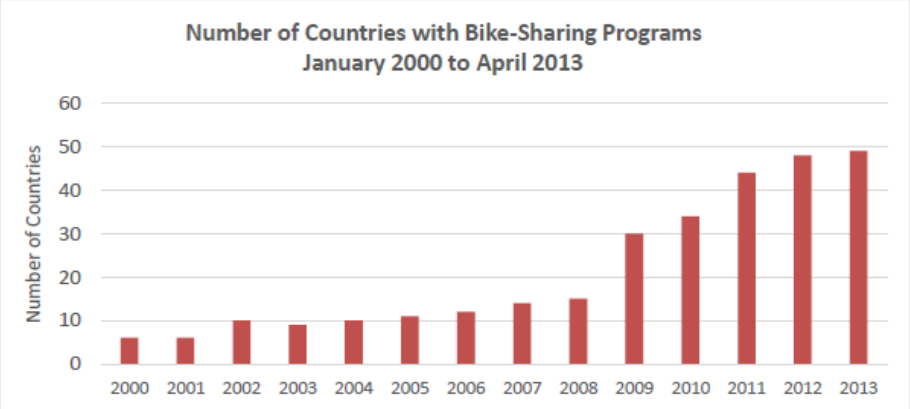

Figure 1: Increase in countries offering bike-sharing (Larsen, 2013)

Literature review

This research activity aims to address the following research questions:

- What would qualify the bike-sharing provision as a PSS provision?
- How could the SC for the bike-sharing provision be represented?
- What are the major factors that drive the bike-sharing provision?
- What are some of the challenges associated with the bike-sharing SC?

Popular definitions of PSS captured by Baines et al., (2007) state that a PSS comprises product, service and networks in order to deliver competitive advantage with lower

environmental impact. Bankole at al. (2012), further described the characteristics of a PSS which are applied to bike-sharing industry within this study. These are:

- A physical product core enhanced and customised by a non-physical service shell. In a bike-sharing provision, examples are bikes and docking stations
- Relatively higher monetary value and importance of the physical PSS core compared to traditional business model. In a bike-sharing provision, the third generation bikes (especially electric bikes) and the docking stations have high monetary value.
- A complex 'business to business' relationship between PSS solution providers and their customers (Aurich et al. 2006). In a bike-sharing provision, the bike schemes are usually agreed between the Bike-share Operator and the Local Authority.

An example of the product, service and PSS elements are provided in Figure (2).

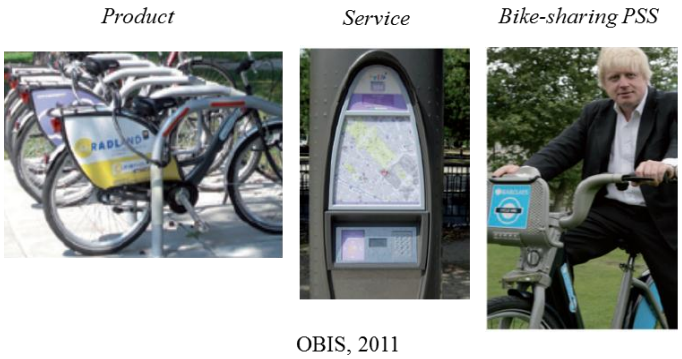

Figure 2: Bike-sharing PSS

Tietze et al., (2013) also reviewed the definition of PSS and stated that a focus on environmental benefit necessitates an extended definition of PSS. They defined it as 'an integrated offering of tangible products, intangible services and the enabling infrastructure providing a product-unspecific functional value. While the user and the offering firm engage into an enduring contractual relationship, the ownership remains with the offering firm as the user becomes the temporary proprietor who enables a high use-flexibility'. This definition is in line with Guidat et al., (2014)'s view and also supports the fact that bike-sharing is a good example of PSS. Lee and Chou (2010), identified bike-sharing as a PSS and reviewed the main bike-sharing schemes with the generations of bike-sharing systems around the world. They conducted a survey to measure the public bike service quality using Quality Function Distribution to identify the difference between importance and satisfaction of customers in order to explore the extent to which bike-sharing provided a quality and effective service to passengers. The result showed there was a big gap between the cognitive importance and real satisfaction of customers, meaning that there is a need to ensure the PSS achieves customer satisfaction. Amaya et al, 2012, considered the environmental benefits of bike-sharing PSS. They described the life-cycle phases in a product and service offering and focussed on the use of the bike-sharing PSS. They identified measures to define the characteristics of the PSS and concluded that the PSS solution was more beneficial to the environment. Meier et al., (2010) discussed general PSS in the context of Industrial PSS (IPS^2) where both the PSS provider and the end-user of the PSS are industrial partners. The PSS provider is able to generate more revenue from the additional service provision and the business relationship generally lasts longer. Furthermore, with the current trend towards sustainability, manufacturing industries are introducing processes which allow maximal

use with minimal resource consumption to compete with traditional economic models. IPS^2 helps to achieve competitiveness through the sale of functionality rather than sale of products. However, these studies did not explore the bike-sharing PSS in terms of the SC.

Lee (2002) described the product SC and classified products as functional and innovative. He identified the characteristics of product demand based on the life cycle, inventory cost, product variety, stock-out cost, obsolescence etc. Product supply characteristics were also identified based on the system breakdown, quality problems, capacity constraints etc. Xiaoqiang et al., (2013) proposed an incentive scheme for coordinating fresh-product SC. They identified major challenges with product logistics such as quantity and packaging, transportation and food-miles as well as the perishable nature of some food products. Renato et al., (2015) investigated products based on size, weight, ease of substitutes and storage conditions. The SC involves manufacturing processes, automation and mass production, which create challenges for the product SC.

Giannakis (2011) highlighted a research gap in service SC due the fact that SC concept has its root in manufacturing. Services may not be easily visualised, especially with its diverse nature, thereby making it difficult to manage. Also, services are intangibles meaning that they are heterogeneous and cannot be stored. The service SC usually involves the transfer of information/knowledge between the SC partners. The study developed a service SC framework which incorporates the roles of people, technology and shared information. Breidbach et al., (2015) separated the development of a service SC into the stages of initiation, probation, and ongoing operation. The authors believe the early stages of the formation of the SC are key determinants of the structure and future of the SC. The SC has a distinctiveness of human agents, therefore demand is usually generated by the customer to initiate the SC formation. The authors described the "expansion scholars" who advocate that service SCs enhance the competitiveness of manufacturing firms and view services as an expansion of a traditional goods-centric SC such as in a PSS. Upon reviewing the product and service SCs, this study takes a similar perspective to the 'expansion scholars' to focus on the PSS SC which is discussed in the following sections. The bike-sharing provision generally requires the user to register with the bike-sharing operator through their website and pay a subscription to be able to use a bike. In other schemes, the bikes can be rented from a terminal or from the docking station using a card reader or Radio-Frequency Identification (RFID) cards (OBIS, 2011). Additionally, code-based rental is available to allow the user to call or send SMS message to a given number and receive an access code with relevant information to unlock the bike from the docking station. To minimise vandalism and theft, custom-made parts are developed which are then assembled in the final product along with electronic or mechanical locks (OBIS, 2011). Some schemes allow users to take the bike from one station and return it to another, while others require the bikes to be returned to the same point.

The first research question stated above has been addressed in this section while the others are addressed in the following sections of the paper.

Research Approach

The process began with the identification of the themes that are relevant to Bike-sharing PSS. Then, literature search was done and the findings reviewed in order to have background knowledge of the subject. The literature included both industrial reports and academic journals. The findings from the review were analysed to inform the design of a research protocol. The research protocol included questionnaire design and validation prior to conducting semi-structured interview sessions with an industrial expert. The data

Figure (3): Research approach

collection was recorded in text as well as audio recording. The findings from the interview sessions were analysed and relevant literature were consulted to gain further understanding of the issues identified. This informed the framework development for Bike-sharing PSS. The framework and other findings were finally validated with the industrial expert in order to proceed with the publication writing. The research approach is described in Figure (3) while the results obtained through the approach are provided in the various sections of the paper.

The Bike-sharing SC

The SC refers to the 'network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in form of products and services in the hands of the ultimate consumer' (Christopher, 2005). This means that it encompasses the various partners involved in adding value to the transactions and activities required to satisfying the customer requirement in an efficient and effective manner. The review of literature provided examples of the traditional representation of the SC with manufacturers, assembly plants, distributors and the customer(s). Also, Amaya et al., (2012) described the lifecycle phases for PSS provision using a bike-sharing case study. They identified phases such as raw material extraction, product manufacturing, product distribution and end-of-life. The review of academic and industrial publication such as the Optimising Bike Sharing in European Cities Handbook (OBIS, 2011) and the American Bike-Sharing Planning Guide (ITPD, 2013) revealed the absence of any publication which captures the bike-sharing supply chain. This meant that a novel contribution to the study of bike-sharing PSS would provide a description of the bike-sharing SC. The interaction with an industrial expert was required in order to understand and capture the bike-sharing SC. The outcome of this effort led to the description of bike-sharing SC in Figure (4) which was validated the industrial expert. Upstream, the major partners are the parts and equipment manufacturer, bike assembler, operational service provider, rental system supplier, digital service provider, marketing service provider and the bike-sharing operator. Downstream, the partners are the local authority, business corporations and end-users.

4.1 Parts and equipment manufacturer - manufactures most of the hardware required for the physical products which are the bike and the docking station. Generally, they supply mainly to Bike Assemblers and the Rental System supplier who purchase the parts for the products in order to manufacture them. The manufacturing process adopts the 'pull' approach where demand is generated from the customer.

4.2 Rental System supplier - purchases parts from the parts and equipment manufacturer to develop the rental system such as the docking station and other parts/equipment required to deliver the rental system.

4.3 Bike Assembler - purchases parts from the parts and equipment manufacturer to assemble the bikes in order to deliver customer requirement for the Bike-Sharing Operator. They help to deliver a crucial aspect of the bike-sharing provision because their activities determine the comfort and the main experience that the customer would have as they use the bikes.

4.4 Operational Service Provider – this function could be delivered by the Bike-Sharing Operator or located as separate operation. It provides operational services that are associated with the bike-sharing and rental activities such as bike re-distribution, repairs and maintenance etc.
4.5 Marketing Service Provider - provides advertising and marketing services that are associated with the bike-sharing in order to advertise the bike-sharing provision to the public and highlight the benefits of the provision. They employ tools like social media and the actual products to advertise and engage with bike-sharing customers.
4.6 Digital Service Provider - provides digital services that are associated with the bike-sharing and rental activities such as touch screen display on the rental unit, card reader, RFID-Reader printer and keyboard. They also provide digital services such as the web design and electronic customer interaction, mobile phone apps etc.
4.7 Bike-Sharing Operator - is a major actor within the supply chain as it engages the Customer (local authority or business corporations) to tender and win the operation of a bike-sharing scheme. Based on the agreement between this partner and the Customer, it could take ownership of the bike-sharing scheme or obtain the license to run the scheme. It employs front-end and back-end systems in order to provide bike-sharing availability to customers as well as maintenance services.
4.8 Local Authority - refers to the government departments who invite Bike-Sharing Operators to tender and award a scheme (or contract) to the one chosen Operator. They may own the scheme or license ownership to the Operator. They are usually the main customer a major stakeholder in the bike-sharing provision and may provide subsidies to fund the scheme. They could influence government policy at local and national level in order to provide infrastructural network to support bike-sharing.
4.9 End-Users - refers to the members of the public who use the bikes. Usually they register with the scheme provider and pay subscription in order to use the bikes. They are classified into categories based on the purpose for which they use the bikes such as work and education users, leisure users, errands users and tourists (OBIS, 2011).
4.10 Business Corporations - refers to organisations who directly contract with Bike-

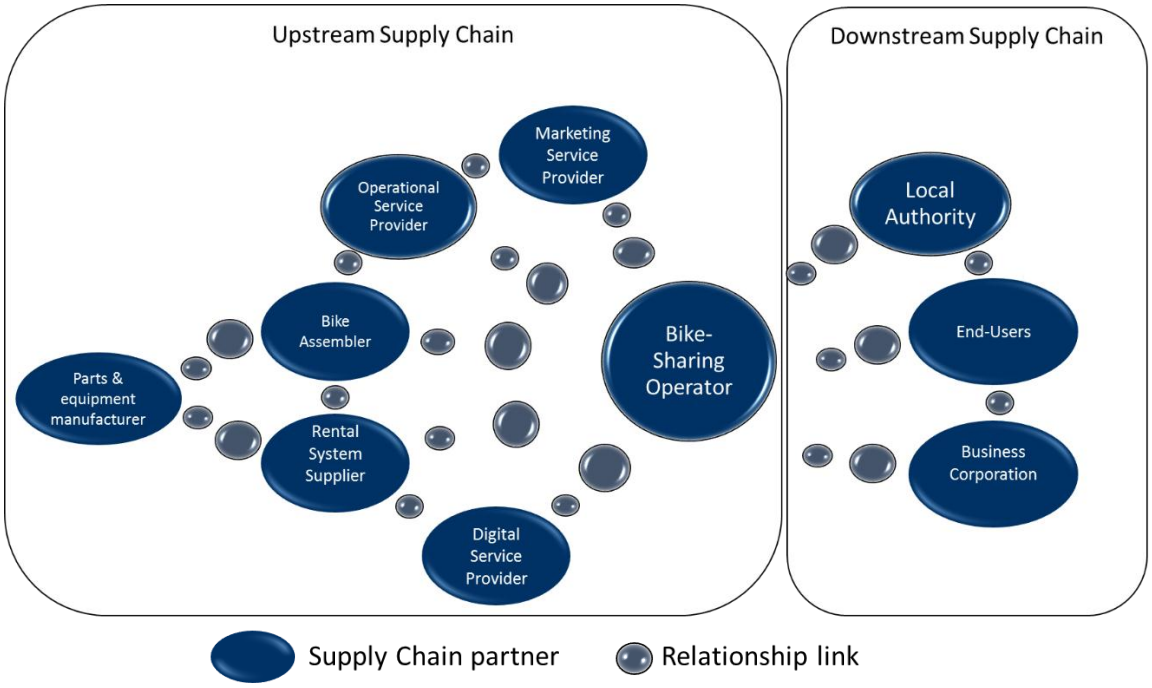

Figure 4: Bike-sharing supply chain

Sharing Operators to provide bike-sharing for their employees, customers or other stakeholders, e.g. hospitals. Unlike the Local authority, they may not have direct influence over the public infrastructure design to support bike-sharing, but they may have indirect influence are significant members of the community.

The bike-sharing SC clearly integrates some of the characteristics of product and service SC which makes it a complex one, especially due to the outsourcing activities.

Bike-sharing PSS Delivery

In order to implement the PSS, it is important to identify the major drivers of the PSS as well as the challenges that impact the bike-sharing SC. These are integrated in the bike-sharing PSS framework.

Bike-sharing PSS features: these are fundamental elements that form the PSS provision. These are listed below.

i. Product – e.g. Bike, Docking station etc.
ii. Service – e.g. Maintenance, registration and payment services, GPS services etc.
iii. PSS – Integrated bike-sharing provision with product and service elements.

Bike-sharing PSS drivers: these are factors that impact how the PSS is delivered. It may create or define the considerations and scope of the PSS delivery.

1) Government Policy and Funding – The PSS delivery requires government policies which are favourable to the PSS in order to be sustainable. It also requires government funding in form of grants or subsidies at the national and local level in order to provide the investment required for the scheme which is determined by the city's size. Implementation cost for large-schemes could be between £1,500 - £2,200 per bike and running cost around £500 - £1,500 per annum. The average cost per rental only decreases when the number of rentals increase.
2) Health of population – The PSS delivery could be driven by current health debates as studies have shown that there are health benefits related with cycling. For example, the UK National Health Service is faced with the impact of high level of obesity in children and many heart-related problems which puts a strain on the health budget. Research findings showing how health problems could be minimised by regular exercise such as cycling, are a positive driver for the PSS (Gallagher, 2012).
3) Customer requirement and performance measures – The Customer and other stakeholders usually have a set of requirements which the PSS must meet as well as measure of performance. It is important for these to be understood and agreed between the relevant parties before the scheme or contract is awarded (OBIS, 2011). Performance measures could include public transport demand management, emissions reduction, city image improvement etc.
4) City Image – The PSS delivery would be driven by city's strategy for public cycling and infrastructure. A major goal of the implementing the PSS is to attract new cyclists. The visibility of rental bikes and docking stations in the city, together with improvements of the cycle infrastructure can attract new customer groups. This would help improve the image of cycling and the city's image and branding (Paul and Bogenberger, 2014; OECD, 2012).
5) Congestion - Bigger cities often have more problems with congestion and limited parking space, which makes cycling more competitive in terms of speed and flexibility on distances up to five - seven km and therefore attractive for daily usage. In some cities, where public transport is crowded, bike-sharing provides an alternative mode of transport (OBIS, 2011).

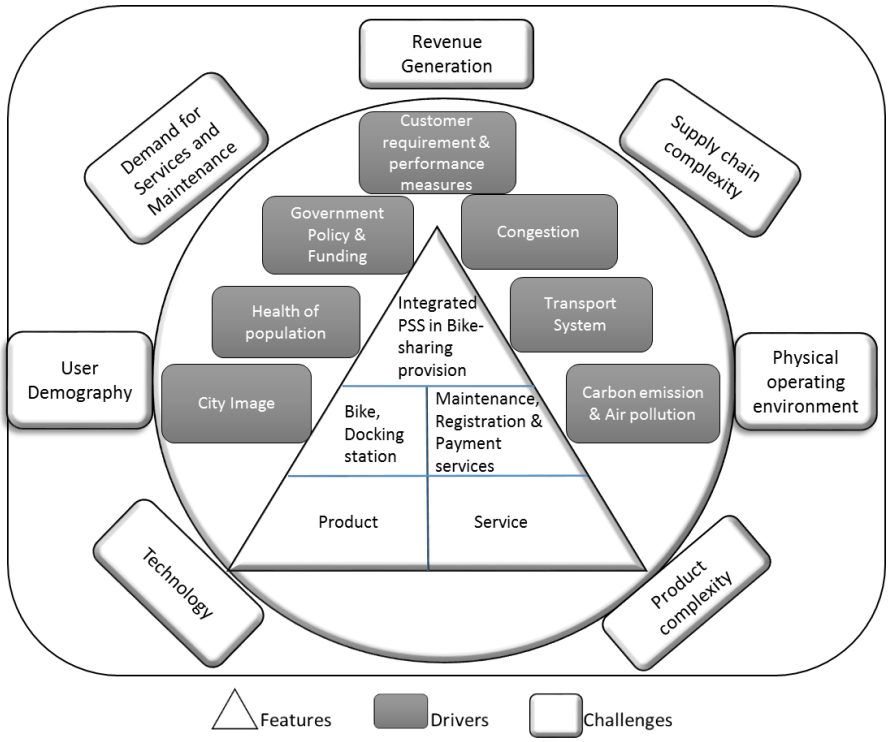

Figure 5: Bike-sharing PSS framework

6) Transport system - This requires implementation of a cycling infrastructure plan for the city or region, important elements of which are; the construction and maintenance of cycle lanes or paths, direction signs for longer cycle routes, safety measures at places of interaction with cars and pedestrians and safe cycle parking places, at public transport stations and bus stops (OBIS, 2011).

7) Carbon Emission and Air pollution - The PSS offers an alternative means of transport for short trips that might otherwise have been made by car. In this way, it helps to reduce carbon emissions (ITDP, 2013). A report by the Guardian stated that the EU could cut its transport greenhouse gas emissions by more than 25% if every country's cycling rate was the same as Denmark's (Walker, 2011).

Bike-sharing PSS challenges: these are the emergent difficulties which are encountered in the process of the PSS delivery.

1) Revenue Generation – Seasonal demand is dynamic so some schemes close down during the winter months while others run all year round. This affects the climate and/or demand, and also costs of redistribution. This would impact revenue generation as the main sources of revenue are registration charges and usage charges. Thus, subsidies are needed to consolidate income on the schemes (OBIS, 2011).

2) Product Complexity – The bikes differ in design and quality as they are custom-built for each scheme, but they share the following general characteristics:

- robust parts to minimise vandalism damage and to facilitate maintenance
- unique design to avoid theft and to make the bikes more visible in public spaces
- one size for all to minimise cost e.g. adjustable seat posts for user suitability

Additionally the bike must be fully integrated with the chosen locking system, either electronic or mechanical (OBIS, 2011).

3) User demography – Small cities may have up to 100,000 inhabitants while larger cities may have double or triple the number. Rentals per bike are usually higher in

large cities than in smaller ones. There are many reasons for this, but generally, mobility demand is higher in big cities, due to higher population and employment density. Therefore, schemes in large cities often offer higher station density, easy-to-use high-tech schemes and higher density of destinations, which influences the number of rentals positively (OBIS, 2011).

4) Physical operating environment – This refers to the landscape in the area, topography as well as the weather conditions. The local climate is an important influencing factor for cycle usage in different seasons. Findings from the OBIS report showed that during the cold season, demand is influenced by the weather and cycling infrastructure conditions (e.g. whether snow and ice have been cleared). In times of the year when usage is lower, the operator could limit availability of bikes or even close down the system for maintenance. (OBIS, 2011).

5) Demand for services and maintenance – The demand for redistribution services to ensure PSS availability could be challenging as this could change rapidly from one day to another. This requires the analysis of traffic flows, to optimise docking station planning and prioritise stations that need to be filled. The knowledge of those usage curves in relation to weather conditions helps to inform cost- orientated decisions about the seasonal availability of the PSS. At times of the year when demand is high, additional staff and maintenance activities might improve service quality (OBIS, 2011).

6) Technology - The software for the PSS usually comes from the bike-sharing operator and is programmed for the each station. The software enables the integration of several locking and station technologies and provides a browser-based front end and back-end system. The scope of operation depends on the hardware design and necessary interfaces as well as the city size. Large cities generally have technologically advanced schemes than smaller cities which may be standardised or bespoke (OBIS, 2011). However, technology update will affect the PSS delivery.

7) Supply chain complexity – The PSS supply chain as shown in the previous section of the paper can be complex due to outsourcing activities with global suppliers. This sometimes leads to problems with integration because different parts have been manufactured by different suppliers. Additionally, information sharing is done through a manual process which means that the process is more time consuming and more subject to error.

Conclusion and Future research

This study set out to address four research questions which were addressed in the following ways:

Firstly, sufficient evidence from academic and industrial literature were provided to support the bike-sharing PSS. Next, product and service SCs were explored which aided the exploration, understand and capture the bike-sharing SC. Finally, the major factors that drive the bike-sharing provision were fully provided and a comprehensive description of the challenges associated with bike-sharing.

Therefore, the research activity has made significant contribution to the field by providing a description of the Bike-sharing SC through empirical research. It employed a systematic approach to develop a framework for Bike-sharing PSS delivery. However, the research activity is limited to bike-sharing industry, so future research could conduct in-depth case studies to perform cross-case comparison from countries who have more experience of bike-sharing and compare with others. Also, there is opportunity to investigate other PSS SCs to create a generic framework across industries. Finally, the research area is still in new so more research effort is needed to further develop the area.

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