Consumers, Clothing Retailers and Production Planning and Control in the Smart City

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Abstract

Though there has been much talk of smart cities, it is still unclear what the concept means and what the role of their inhabitants might be in the development of such cities. There is a tendency to focus on technology and infrastructure and forget that cities are places for people to live. To counter this, smart city planners need to recognise that people's needs can and should influence and shape their environment, rather than concentrating too much on technology or the built environment. In order to understand how smart cities can serve the needs of their inhabitants, we will examine the specific example of the fashion clothing industry and its development of omni-channel retailing. This will show that retailers, driven by technology-smart and fashion-conscious consumers, are reshaping the clothing supply chain to achieve greater integration, flexibility and speed. Central to this process is the manufacturers' ability to create production planning and control (PPC) systems capable of operating effectively in an omni-channel environment. The paper presents a Composite Model of Enterprise Planning which can aid the development of such PPC systems. The paper concludes that changes within the fashion clothing industry indicate how smart cities can develop and are developing, and that although these changes are facilitated by technology, they are driven by the necessity to meet consumers' needs.

Keywords: smart city, omni-channel retailing, clothing, production planning and control

Consumers, Clothing Retailers and Production Planning and Control in the Smart City

Introduction

Though the concept of a 'smart city' is closely associated with the rise of internet-based information and communication technologies, there is a great deal of uncertainty as to what the term means and how policy makers and businesses should respond to it (Glaeser, 2012; Komninos *et al*,2013). However, fundamentally, smart cities, like all cities, have to work for their inhabitants, which means that those producing and selling goods and services have to understand and cater for the needs and lives of their consumers and users. This is why smart city planners have to recognise that people's needs can and should influence and shape their environment, rather than concentrating too much on technology or infrastructure (de Lange and de Waal, 2013; Komninos *et al*, 2013; Schaffers *et al*, 2011). Technology will play an important role in smart cities, but as in other areas of life, this is likely to be more of an enabling role than a deterministic one (Vlacheas *et al*, 2013; Yu, 2015). This can be seen by the innovative way people are using social media (Choi and Burnes, 2013). Accessed by mobile devices, such as smartphones and tablets, people are developing and opening up new and innovative ways to interact with each other and with product and service providers in the virtual as well as the real world (Eklund, 2014; de Lange and de Waal, 2013).

In order to explore the development of smart cities, we will look at the specific example of the fashion clothing industry and its development of omni-channel retailing (Elliott *et al*, 2012). At its simplest, for established retailers, this omni-channel approach makes it possible for a customer to identify a product online, go into a shop to take a closer look, decide whether they want it or not (showrooming), order it on-line whilst in the shop (webrooming) or later at home and either have it delivered to their home or pick it up from the shop (i.e. 'click and collect'), whichever is more convenient (Butler, 2014; Mahar *et al*, 2014). This approach benefits retailers by reducing costs whilst at the same time getting customers into the shop, and thus offer retailers the opportunity to sell more goods than if the customer kept their transaction restricted to the virtual world (Musso and Drucia, 2014). Similarly, many online retailers, such as amazon, are beginning to explore the benefits of having a physical presence rather than restricting themselves solely to the virtual world (Avery *et al*, 2012; Boren, 2014). For example, Boden, the international on-line fashion clothing retailer, has recently announced that it intends to open a number of stores in the UK and US (Hellier, 2015).

As more and more retailers are seeking to achieve a strategic consistency between the different channels-to-market, and to provide customers with a seamless buying experience, forecasting is becoming more complex, which has a knock-on effect for manufacturers' PPC systems, requiring them to cope with a high level of unpredictability (Elliott *et al*, 2012). This is why, in examining the move to omni-channel retailing, we will also look at the crucial role played by clothing manufacturers, who tend to be SMEs, and in particular the implications of smart cities for their production planning and control (PPC) systems (Aslan *et al*, 2012; Schotter and My, 2013).

Traditionally the role of PPC was to ensure that the correct customer order quantity was produced and supplied on time; cost and quality were, to a large extent, secondary issues (Kenworth, 1998). With the rise of Total Quality Management (TQM), PPC is also expected to eliminate all sources of waste by focusing on

cost and quality in order not just to meet, but to exceed customer expectations (Slack *et al*, 2013). To achieve both efficiency and effectiveness, PPC needs to be integrated with other planning and control systems in the enterprise. Consequently, as smart cities develop and their inhabitants come to expect a seamless shopping experience, omni-channel retailers will require a parallel and integrated omni-channel-friendly approach to distribution and manufacturing. This is something that many small- and medium-sized clothing manufacturers with traditional PPC systems may struggle to cope with, especially where they are in a different country to their customers (Khan *et al*, 2008). This is an important issue which both retailers and their suppliers have to address as they try to define and combine the various retail, distribution and manufacturing stages necessary for achieving customer satisfaction.

In order to explore how the benefits of an omni-channel approach to retailing and distribution can be achieved in smart cities and the challenges this poses for PPC, this paper will:

1. Show how enterprise planning in smaller manufacturing businesses can be aligned to the way that smart cities are developing.
2. Investigate how design, manufacturing and PPC systems are changing in response to consumer and retailer pressure for improved service.
3. Examine how emerging technologies are enabling retailers and suppliers to meet the requirements of fashion-conscious consumers for rapid and more frequent product changes.

Given that smart cities and omni-channel retailing are emerging areas, it is difficult to carry out primary research on these topics, therefore, our paper is based on secondary sources. As Briassoulis (2010) observes, the use of a wide and robust range of secondary sources can enable a broader, richer and more in-depth picture of these areas to emerge than might otherwise be the case.

The paper begins by looking at the changing nature of the fashion clothing industry within a smart city environment. This is followed by a discussion of the need for SMEs to integrate their PPC systems within a more comprehensive enterprise planning system, as shown by our Composite Model of Enterprise Planning. The paper then reviews the development and appropriateness of current PPC practices for the fashion clothing industry. The subsequent discussion highlights the main technological PPC developments within the industry and their implications for the emergence of smart cities. The paper concludes that changes within the fashion clothing industry indicate how smart cities can develop and are developing, and that although these changes are facilitated by technology, they are driven by the need to meet consumers' demands.

The Fashion Clothing Industry and the Smart City

There is a great deal of uncertainty as to what a smart city is or how it will affect people's lives (Komninos *et al*,2013). Caragliu *et al* (2011) identify six key characteristics of smart cities, which are as follows: the utilisation of networked infrastructures; an emphasis on business-led urban development; a stress on social inclusion; the crucial role of high-tech and creative industries; the role of social and relational capital in urban development; and social and environmental sustainability. Combine these factors with the increasing trend towards mega cities, the constant changes in technologies and the way they are used, and especially the fact that many people now inhabit a virtual as well as a built environment, and one can see why it is such a difficult concept to define and operationalise (Glaeser, 2012).

The complexity of the factors involved not only go beyond the experience of most urban planners, but also beyond the knowledge of those responsible for planning and controlling production in the businesses supplying goods and services to the inhabitants of smart cities (Graham, 2014). The complexity increases if one also factors in the way that consumers are utilising user-led social media to become co-creators of value, particularly in areas such as culture and fashion (Choi and Burnes, 2013). Many commentators see businesses as leading urban development in the future, but if consumers are becoming more involved in product and service development, then that implies they will have a greater role in how smart cities develop than commentators may have realised (Burnes and Choi, 2015; Hollands, 2008).

To a large extent, the uncertainty about how people will live their lives in smart cities mirrors and is entangled with the debate about the effects of the internet, especially the extent to which clicks are replacing or will replace bricks (Kacen *et al*, 2013). There was a view a few years ago that retailers with a physical presence on the high street would go into terminal decline and be replaced by virtual retailers, as exemplified by the ubiquitous Amazon (Dennis *et al*, 2002). However, research shows that additional channels, such as online, should not be seen as alternatives but as an integrated component within any retail offering (McGoldrick and Collins, 2007; Yang, Lu and Chau, 2013; Kim and Park, 2005). Consequently, what has emerged is a mixture of bricks and clicks. Established retailers have developed their own web presence, but have integrated this with their physical outlets to create multiple channels-to-market.

This is exemplified by today's fashion clothing industry where frequent product changes are required in order to meet consumers' demands for the latest trends in terms of style, colour, fabric and at affordable prices (Wallace and Choi, 2011). The fashion sector is heavily dependent on availability of the full range of products in stores during relatively short (6 to 8 week) selling seasons (Mason-Jones *et al*, 2000). The development of speedy and easily-accessible online retail channels and customers' insatiable desire for the latest fashion trends means that retailers require their suppliers to provide more frequent and timely product changes. Many companies use a combination of manufacturers, with low-cost basic lines supplied by the Far East, fashion lines supplied by North Africa and Eastern Europe, and replenishment/remanufacture from UK manufacturers (Birtwistle *et al*, 2003). An offshore/local sourcing mix is one responsive strategy a retailer may adopt in optimising cost and response time considerations (Ding *et al*, 2011).

Thus, retailers are placing increasing demands on their suppliers to improve significantly the efficiency and effectiveness of their production and delivery processes. A manufacturer's ability to support rapid replenishment is dependent on the appropriateness of its PPC systems and the degree to which they are integrated with the firm's other systems and externally with the retailer's systems. In a very real sense, the ability of smart cities to meet the needs of their inhabitants, whether they be individual consumers or businesses, is dependent on efficient and effective PPC systems. However, at the same time as retailers need to develop better integration with suppliers' PPC systems, consumer pressure is driving retailers to integrate their various retail channels (Hsaio *et al*, 2012). This integration of point of sales networks, paper catalogues, internet website, social network, virtual point of sales, mobile applications, etc. is increasingly referred to as omni-channel retailing (Thoughtworks, 2011).

As customer expectations increase, omni-channel retailing is seen as a key strategy for improving customer satisfaction and retention (Draper, 2013). Smart city technology has increasingly made it easier for consumers to identify the latest fashion, but they have often found that obtaining what they want can be frustrating, given that some items of clothing may only be available online, so cannot be tried on, and others may only be available in a physical branch of the retailer some distance away. Hence the pressure on retailers to integrate all their channels in order for them easily to share information such as stock status and provide the customer with a consistent and high-quality experience across all their channels. The failure to do so can lead to dissatisfied customers and, as Piercy (2012) observes, a poor experience by a consumer of one channel will translate into a negative perception of the entire business.

A recent White Paper by the Korn Ferry Institute defines omni-channel retailing as an advanced and integrated cross-channel customer experience (Elliott *et al*, 2012). Similarly, the UK retail owner Aurora Fashions, which was one of the first to use the term, defines an omni-channel as a single customer journey across multiple channel interactions (Drapers, 2013). Omni-channel retailing is a recognition that people are increasingly living their lives in both the virtual and real world and do not want to be hindered by the technological, organisational or operational limitations or preferences of businesses.

Recently, some of the most successful British retailers have begun to invest in and implement an omni-channel strategy with promising results (Marketing Week, 2013). The incentive for retailers is that the average omni-channel consumer appears to spend some 20 per cent more than their multi-channel counterparts (Bodhani, 2012; SAP, 2011). With the smart city context in mind, channel integration also makes it easier for retailers to 'future-proof' their business against changing consumer preferences and technological developments (McGoldrick and Collins, 2007; Deloitte, 2012; Bodhani, 2012; Nicholson, Clarke and Blakemore, 2002).

Nevertheless, there is a significant downside to the omni-channel approach: it makes the purchase of goods and services and the relationship between retailers and suppliers much more complex. Today's consumer will experience on average 56 interactions with a series of retail channels and touch points between first interest and eventual purchase transaction (Gartner, 2007; Cisco, 2010). This can be a frustrating experience for customers if there is lack of or poor integration between these retail channels or between retailers and suppliers. In fast-moving industries such as fashion, omni-channel retailing makes it difficult for retailers to forecast sales patterns, with obvious implications for suppliers' ability to respond in a timely manner. One reason why many retailers originally kept their physical shops and web operation as separate businesses was because it made forecasting somewhat easier as it was compartmentalised.

Therefore, though omni-channel retailing is ideally suited to technology- and information-intensive smart cities, neither will function effectively if they do not also facilitate the integration of suppliers as well as consumers and retailers. This is why the physical distribution process, especially in terms of internet shopping, has been the subject of much attention (Rabinovich and Bailey, 2004). The focus has been on reducing lead-time (Chopra and Meindl, 2007), improving reliability and availability of supply (Yi *et al*, 2011) and achieving better responsiveness to changes in customer demand in the selling season (Zhang and Huang, 2012). Therefore, the demand for better omni-channel service by price-sensitive customers has resulted in the speeding up the supply process through such developments as the use of web-based applications (Anaza and Zhao, 2013). However, improvements in supply chain performance will be limited if the focus is mainly on distribution channels and does not also incorporate garment design and manufacture. In the next section, we present our model for enterprise planning for SMEs, and then show how, allied to changes in PPC and production technologies, it can overcome the challenges of fast fashion and omni-channel retailing.

Enterprise Planning for SMEs

There has been little published research on the topic of enterprise planning for smaller enterprises, especially in the context of omni-channel retailing (Ellram, 1991; McGarrie, 1998; Teteh and Xu, 2014). However, to cope with such situations, writers have advocated a hybrid approach which attempts to combine the top-down forecasting of Manufacturing Resource Planning (MRP) systems with the bottom-up reactiveness of JIT (Luscombe, 1991; Towers and Burnes, 2008). Figure 1 presents one such approach based on the work of Towers and Burnes (2008). The Composite Model of Enterprise Planning and

Supply Chain Management for SMEs shown in Figure 1 challenges the notion that enterprises compete against one another in isolation and contend that the boundaries, and therefore governance, between participants in the supply chain are blurred and imprecise. It acknowledges the implicit assumption that enterprises are a nexus of contracts (Aoki *et al,* 1990; Reve, 1990), which devise different inclusive contracting arrangements (Williamson, 1979) between participants and which include a range of external and internal relationships (Cox, 1996; Zineldin, 1999). The operations management trading relationship constructs proposed by Slack *et al* (2013) are exchanged between participants in their supply chain to the collective mutual benefit. Further, the model accommodates the basic principles of production control (Luscombe, 1991; Starbek and Grum, 2000; Zäpfel and Missbauer, 1993) and the presence of a planning hierarchy (Higgins *et al,* 1996; Weirs, 2009) within operations management. In developing the theoretical perspective of enterprise planning, the constructs developed by Melnyk *et al* (1985) have been incorporated in the model. The context of the SME is central to the composite model. The strategic influences and attributes of the SME (Bonfatti, 1996; Laubacher *et al,* 1997; Mosey *et al*, 2003; Wyer and Mason, 1998) underpin their strategic and operational requirements. These distinctive and unique attributes of manufacturing SMEs have been developed from Huin *et al* (2002). The model shown below in Figure 1 describes how the contributions from these three dimensions converge in supporting supply chain performance.

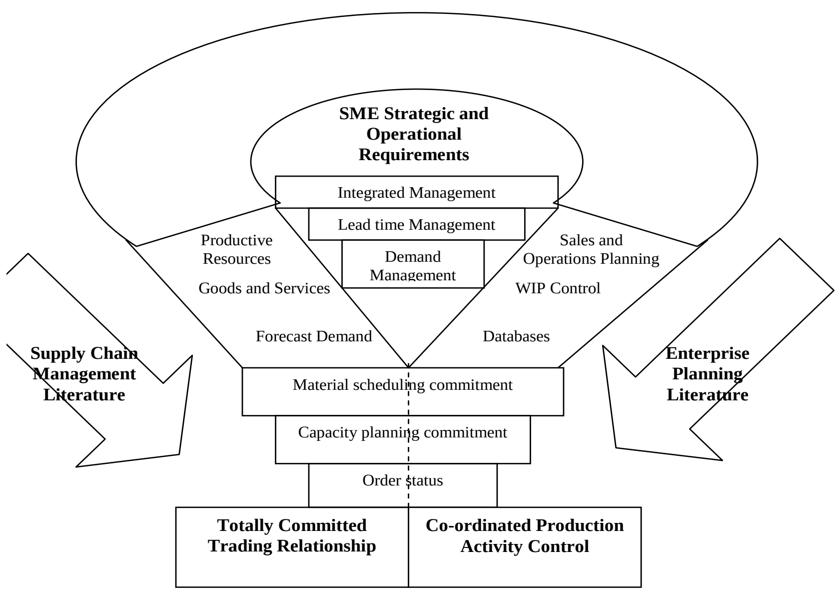

Figure 1: A Composite Model of Enterprise Planning and Supply Chain Management for SMEs
(from Towers and Burnes, 2008)

The left hand side of the model describes those components that contribute to a totally committed trading relationship across the network, derived from the supply chain literature with a customer-focussed orientation. Similarly, the right hand side of the model describes those production planning and control components that contribute to co-ordinated production activity control, drawn from the enterprise planning literature. The small manufacturing business context has relevance because of their particular attributes of size, financial imperatives and organisational structure. An integrated flat management structure, flexible lead time management and responsive demand management are the strategic and operational requirements (SORs) that represent the internal framework of the manufacturing SME. The productive resources, goods and services, and forecast demand are managed in the supply chain context of the SME. This is similar to the sales and operations process, work-in-progress and databases which relate to their individual circumstances (Towers and Burnes, 2008). As the next sections will show, this approach requires manufacturers to adopt enterprise planning, which links all their internal systems, such as PPC and sales, with those of their customers and suppliers.

Developments in Production Planning and Control (PPC)

One of the key lessons that Western manufacturers learned from the Japanese in the 1980s was that the stability and control of production schedules and processes is crucial to reducing waste, improving quality and shortening the time from the receipt of an order to its successful delivery to the customer (Dale *et al*, 2007). The Japanese demonstrated the competitive advantage to be gained from having an appropriate PPC system, as can be seen by their eclipse of the US car industry (Womack *et al*, 1990). However, the move to agile and rapid replenishment systems of supply requires manufacturers simultaneously to reduce costs, provide greater design flexibility, improve quality and increase speed to market (Bhardwaj and Fairhurst, 2010). This environment creates significant challenges for PPC, especially in terms of forecasting and schedule stability, as does the development by retailers of multiple channels-to-market (Ding *et al*, 2011). In order to do this, PPC must combine efficiency with effectiveness. Traditionally, the efficiency of the manufacturing facility is derived from a production orientation geared to internal cost targets. As such, the completion of a specific customer's requirements for order quantity is of secondary importance. On the other hand, the prime objective of effectiveness is to meet or exceed the customer's requirements, regardless of any adverse impact on efficiency (Kotabe, 1998). These competing objectives can lead to a clash between the drive for efficiency and the drive for effectiveness, especially in a fast-moving retail environment (Shockley and Turner, 2015).

It is in addressing its long-term strategic needs that a manufacturing firm has to take account of the challenges posed by smart cities, especially the likely requirement by customers that suppliers align their PPC system with the needs of an omni-channel environment (Elliott *et al*, 2012; Thoughtworks, 2011). In order to achieve this, enterprise planning has to take relationship management seriously by enabling different functions within the organisation, such as marketing, sales, production and finance, to easily share information and communicate with one another and with customers and suppliers (Anthony *et al*, 2014; Gustavsson and Wänström, 2009; Ounnar *et al*, 2007). In the past, as Payne (2002) observed, there was tendency for enterprise planning to be producer-led and customer relationship management to be customer-led, with the obvious potential for conflict. This has now changed somewhat, with enterprise planning being used to facilitate the integration of external applications with internal ones to align with supply chain structures and customer relationship management systems (Payne, 2002). In many cases, enterprise planning practices are now synchronised with customer relationship management to allow manufacturing companies to achieve both efficiency and effectiveness, which places the customer at the centre of the organisation's activities (Pai and Tu, 2011). In the clothing industry, as Bruce and Daly (2011) show, this can involve a portfolio of relationships managed by the buying team. These can include a mixture of local suppliers and overseas suppliers to optimise cost efficiencies and time to store, which is vital for retailers with a rapid response fashion and commodity product mix.

In order to help achieve this internal and external synchronisation, a wide range of PPC technologies, methodologies and philosophies have been developed, which can appear to be in conflict with one another (Zäpfel and Missbauer, 1993; Wiendahl *et al*, 2005; Zadeh *et al*, 2014). These are usually based on one of two approaches to PPC: the top down, push system of material requirement planning, as exemplified by a MRP II, and the JIT, bottom up, pull system as exemplified by Kanban (Mazany, 1995; Morecroft, 1983). The choice of which PPC approach and practices an enterprise adopts needs to be driven by its own specific needs, which in turn should be aligned with its customers' requirements (Land and Gaalman, 2009). In the fashion clothing industry, as in most others, the appropriateness of the link between the internal capability and controls of the manufacturing enterprise and customers' retail channels is vital for meeting the final consumer's requirements (Bruce and Daly, 2011).

Either push or pull can work well where forecasting is reliable and production schedules are stable. However, we are now moving into a smart city, omni-channel environment where this is less likely to be the case. If PPC is to be driven by the inputs from the customers' schedule and translated into realistic production plans, customers' schedules need to be reliable and stable: this is especially so for manufacturing SMEs who have fewer resources available than bigger firms (Berlak and Weber, 2004; Land and Gaalman, 2009). Given that clothing manufacturing tends to be dominated by SMEs, the issue of schedule stability raises problems for producers, their retail customers and the end consumer (Singh *et al*, 2008). In the following section we will present examples of emerging PPC technology used in the fashion sector which are relevant to a smart city environment.

Emerging Technological PPC Applications

Over the last 20 years, clothing producers have increasingly been moving to an agile and rapid replenishment environment in response to retailers' demands for low cost, flexibility in design, high quality and increased speed to market, which have undermined the stability and control of production (Bhardwaj and Fairhurst, 2010; Pujawan, 2004). This is because, on the one hand, the unpredictable nature of demand for fashion products makes it difficult to forecast accurately, as an MRP system requires; and on the other hand, a constant volatility in demand makes it difficult to operate a purely reactive steady state system, as favoured by a Just-in-time **(**JIT) approach.

A number of approaches to e-retail and clicks and bricks have emerged in the clothing industry, which allow smaller retailers to segment and serve their customers better and so increase revenues (Ashworth *et al,* 2006; McGoldrick and Collins, 2007; Yang *et al*, 2013). However, these all rely on clothing manufacturers being able to respond quickly and cost-effectively. This has led to the emergence of a number of innovative approaches to design and manufacture, which are appropriate for the needs of omni-channel retailing and the development of smart cities (Rahman *et al*, 2015; Salleh *et al*, 2013). One example is the use of computer-aided design to produce a garment datum. Numerous garments can be generated out of a single garment datum by combining various fashion features, size grades, fabric physical properties, and surface texture maps. The size of each pattern on a garment can be changed by a grading process and therefore a full-texture mapping technique can be applied. The generation of various digital garments by combining multiple fashion features and physical properties is one of the most important features needed for the practical application of drape simulation in the fashion business (Kim, 2012). Detailed body sizes, which the retailer's system can feed directly into the manufacturer's PPC system, are a prerequisite for made-to-measure or customised manufacture. Nowadays, detailed body sizes can be precisely obtained by using 3D scanners, but the high development cost needs to be offset with medium- to long-term returns (Bye and McKinney, 2010). Detailed body sizes can be predicted with a small number of size features. Traditionally, measuring dozens of body sizes for each human body is time-consuming, and the accuracy of the sizes depends on the experience of the people doing the gauging, i.e. the 'gaugers' (Kim and Damhorst, 2013). By only measuring the feature parameters, the detailed body sizes can be intelligently and automatically predicted. This approach has been shown to improve the accuracy of the measurement, so that even an inexperienced gauger is competent to obtain accurate detailed body sizes. (Liu *et al*, 2014).

3D clothing technologies are also being developed which produce virtual clothing patterns on a mannequin morphotype in cyberspace. This approach combines traditional draping techniques with advanced CAD software. This concept is used for both mass customised garments and also for the mass production of ready-to-wear apparel. The patterns can be directly adjusted in 3D and immediately tried on in 3D simulation (Tao and Bruniaux, 2013). This reduces the manufacturing lead time and produces garments tailored more precisely to the customer's shape and characteristics. The individual customer's requirements are aggregated into the forward forecast to create the production and material plans.

A further development in providing the customer with garments which fit their body shape and other requirements is the emergence of 3D body scan systems (Petrova and Ashdown, 2008). These began to appear on an experimental basis around a decade ago. The Intellifit System was one of the first and its makers claimed that that would revolutionise the global clothing market. Intellifit is a body scanning technology that uses radio waves to capture a person's measurements accurately,directly through clothing, within ten seconds and gives them a print-out of their exact body measurements (Poliven, 2012). The data are then translated into production planning details which are then fed into the top level forward forecast.

The fashion brand Levi Strauss were one of the first to try the system in five of its major US stores. When a fully-clothed person steps into the cylindrical glass booth, the system scans the person and prints out recommended sizes and styles of Levi's jeans cross referenced with his or her measurements. The Intellifit has obvious uses for an omni-channel retailer as it as can quickly match a person's scanned measurements to clothing available for any of its retail channels. Stores who are using the technology report higher off-line and online traffic, better conversion rates, higher purchases per transaction, reduced rates of product returns, higher customer loyalty, as well as improved inventory management (Hanlon, 2005).

Brooks Brothers, a major US fashion retailer, uses an array of new technologies, including the body scanner, seamlessly. They offer mass-customised suits at their New York City retail store using a 3D body scanner to collect customer measurements. Style, fabrics, and design features are selected from a computer screen in consultation with a trained sales professional, who facilitates the discussion of fit preferences, such as loose or form-fitted clothing (Crease, 2010). Brooks Brothers uses a proprietary custom patternmaking system to create an individual pattern based on the body measurements. These details are fed into the PPC system and the garment is manufactured and shipped to the store where a single fitting ensures customer satisfaction. Scan data and patterns for each customer are stored for reorders (DesMarteau, 2005).

Many smaller internet-based companies also offer a variety of custom design and size choices for clothing products ranging from bridesmaid dresses to fleece jackets. Suppliers of military, school, and industrial uniforms are also offering style and size customisations. There are many examples of companies in Europe, the US, Japan and Hong Kong offering mass-customised clothing (Yeung and Choi, 2011). Examples include IC3D (Interactive Custom Clothes Company Designs), American Fit and BeyondFleece. Technology-enhanced made-to-measure (i.e., mass-customised) clothing is now affordable and easy to acquire from companies of all sizes (Cornell University, 2011).

A concomitant development has been an increase in computer-controlled garment production (Oppong *et al*, 2014). This allows 'scan-to-fit' PPC data to be directly inputted into the machines which produce the garment. However, it does not overcome the time taken to transport the garment when the manufacturer is located some distance away from the customer, as has increasingly been the case in garment production (Khan *et al*, 2008). In seeking to overcome similar issues, Japanese car manufacturers encouraged key suppliers to locate mini-factories on their assembly sites. This meant that, in some cases, the lead time from order to delivery could be as little as one hour (Womack *et al*, 1990). As Kaivo-Oja *et al* (2014), point out, with developments such as 3D printing, it is possible to see clothing producers attaching mini-factories to retailers, which is what one would expect in smart cities.

The seasonal and on-trend nature of fashion garments results in much smaller production batch sizes, especially where mass customisation is concerned (Lee and Chen, 1999-2000). Though all-year-round styles and product types are usually produced in larger factories, many fashion garments are produced in SMEs, which makes them suitable for the space restrictions associated with the densely-populated smart city environment. Close proximity to the urban customers would certainly remove one of the main obstacles to meeting the fast delivery requirements of consumers and retailers.

Whilst it is easy to see that computerised mini-factories could become part of the landscape of smart cities, this will only be the case if the information held by retailers, such as that generated by Intellifit and other systems, is speedily transmitted in a usable form to manufacturers. It will also require manufacturers to ensure that the cost of these 'one-off' garments is not appreciably higher than off-the-peg ones.

Discussion

In the age of omni-channels and rapid fashion replenishment, the Composite Model shown in figure 1 allows SMEs to understand the strategic and operational requirements which need speed and also accurate and intelligent decision-making to cope with uncertainty from volatile external demands. This allows PPC systems based on inflexible and inaccurate 'yearly planning forecast' to be replaced with ones based on actual customer requirements, and which can cope with frequent product modifications and short product life cycles (Huin *et al,* 2002: 777). The Composite Model shows how small- and medium-sized clothing manufacturers can align their internal structures to cope with these challenging demands, which are likely to characterise the smart city environment, in order to allow retailers to meet the volatile customer demands typically associated with fashion clothing.

The growth of mega cities such as Tokyo, Seoul and New York raises many problems as to how these enormous population centres can function effectively and efficiently, especially given the issue of environmental sustainability (Buijs *et al*, 2010). Not surprisingly, the rise and potential of smart technologies is being seen as a solution to dealing with the many issues raised by such enormous concentrations of people, hence the rise of the smart city concept (Allwinkle and Cruickshank, 2011; Assadian and Nejati, 2011). However, whilst governments, businesses and research institutes have been busy trying to foresee and plan the development of smart cities, the inhabitants of these cities are already creating what they want, such as Singapore's 'lend and borrow' movement, which allows neighbours to share underused equipment and services (Caragliu *et al*, 2011; Saunders and Baeck, 2015). In a sense, this follows Mintzberg's (1994) argument that realised strategies are based on a combination of intended strategy and emergent strategy. Though some of the individual elements and operation of smart cities can be attributed to past and present planning decisions, others have emerged from decisions and actions by their inhabitants, which reflect how they want to live and what they want to do (Hollands, 2008). This demonstrates that neither the physical environment nor the technological infrastructure are totally deterministic; instead they allow scope for the innovative, creative and entrepreneurial desires of the inhabitants of smart cities (Anttiroikom *et al*, 2014). This is illustrated by Burnes and Choi's (2015) study of the independent music community in Seoul, where fans have used social media to wrest control of music production and distribution from the record labels.

No one would argue that all smart city developments will be as empowering or beneficial for their inhabitants as the Seoul example, but as we have discussed, fashion-conscious clothing consumers are influencing how retailers are organised, the level of service they provide and their relationships with garment manufacturers, who in turn are having to change the way they are organised and operate. As the paper has shown, these various changes comprise five key developments.

The first is the development of omni-channel retailing. In the early stages of internet shopping, most retailers preferred to keep their virtual and physical channels, if they had both, separate or un-networked. However, consumers began to vote with their feet and fingers, preferring those retailers who offered them the best experience across all their channels (Bodhani, 2012; Piercey, 2012; SAP, 2011). Thus, it was consumers' demand for a better and more integrated service, rather than retailers' own strategic or operational preferences, that have driven the omni-channel move.

The second is the pursuit of ever higher levels of customer service. In order to satisfy their customers, fashion retailers now recognise that it is not sufficient just to offer a seamless, omni-channel service. They must also be able to provide the clothing their customers desire in the style, size and material they require, and when they want it, at a price consistent with the product quality. To a limited extent, retailers can accommodate some of these demands by more efficiently moving stock around their system, but that still leaves the issue of getting it to the customer. The frustration with home deliveries has seen a rise of alternative methods of getting goods to customers such as ordering online, but pick up in store, often referred to as 'click and collect' (Butler, 2014). Whilst such developments have improved customer service, they only work if the retailer has the required garment in stock or can get it made quickly. In an era where retailers are trying to minimise stock, but have developed extended supply chains, lack of availability is an increasing problem for customers, retailers and manufacturers (Khan *et al*, 2012).

The third development, the advent of CAD and other computerised links between retailers and manufacturers, is aimed at the availability issue by reducing the lead time between fashion trends becoming apparent, designs being produced and garments being made (Tao and Bruniaux, 2013). The adoption of CAD etc. has facilitated the production of better-fitting, mass customised garments and also the mass production of ready-to-wear apparel (Tao and Bruniaux, 2013). This means that stock is available faster, with more of it likely to fit, and is seen as an extension of the PPC system. This does not, though, totally eliminate poor fit, which is why scan-to-fit systems are growing in popularity (Petrova and Ashdown, 2008). Nor do faster design and better links totally eliminate the problem of too much or too little stock in what are relatively short selling seasons, especially given the increasing vagaries of the weather (Son, 2012). This is something which has to be addressed by manufacturers introducing fast and flexible digital manufacturing systems (Niinimäki and Hassi, 2011).

This has led to the fourth development, computerised garment manufacture. The advent of computer-controlled equipment now allows design and other data to be directly inputted from retailers to create a virtual and seamless connection between forecast demand and the PPC activity. This means that the lead time for garments can be reduced and customised scan-to-fit garments can be produced relatively economically (Oppong *et al*, 2014). If, as smart cities develop, this is also linked to mini-factories being located in retail quarters, it will become possible for clothing retailers, particularly those specialising in short-run fashion garments, to offer their customers an exceptional level of service.

The last but certainly not the least important development is the recognition that SMEs, who tend to dominate garment production, need more appropriate and more effective production planning and control systems (Aslan *et al*, 2012; Schotter and My, 2013). Such PPC systems have to be integrated internally with other business systems and externally with those of retailers and suppliers. As our Enterprise Planning and Supply Chain Model (Figure 1) shows, it is the ability to bring together and align all the necessary internal and external data which enables the various and demanding requirements of fashion-conscious clothing consumers to be met efficiently and effectively.

The five developments discussed above show how knowledgeable consumers are shaping the emergence of an integrated, smart city approach to the retailing, manufacturing and distribution of clothes.

Conclusion

There is much uncertainty as to how smart cities will develop, which is what one would expect. One of the things we can be sure about is that people in smart cities will still wear clothes, many of those people will want to wear the latest fashions and they will want to shop for them across a range of physical and virtual channels, hence the development of an omni-channel approach to retailing. In order to explore how the benefits to consumers of an omni-channel approach can be achieved in smart cities, this paper sought to address the following points:

1. Show how enterprise planning in smaller manufacturing businesses can be aligned to the way that smart cities are developing.
2. Investigate how design, manufacturing and PPC systems are changing in response to consumer and retailer pressure for improved service.
3. Examine how emerging technologies are enabling retailers and suppliers to meet the requirements of fashion-conscious consumers for rapid and more frequent product changes.

As we have shown, the development of omni-channel retailing has been driven by fashion-conscious consumers who, in the age of the internet, are better able than ever before to know what they want, what is available and how much they should pay for it. They also expect high levels of customer service, including a seamless shopping experience across all of a retailer's channels. In order to cope with the requirements of smart city consumers, retailers are not only having to change their own internal operational arrangements, but are also requiring significant changes to how their suppliers operate, in order to create an aligned and integrated retail, distribution and manufacturing system. In some cases this may also include the establishment of mini-factories in the retail quarters of smart cities.

The key responsibility for aligning the requirements of the separate retail, distribution and production systems lies with the clothing manufacturer's PPC system. Unless the manufacturer's PPC system is capable of collecting, analysing and aligning the data from all these other systems, the retailer will not have the stock they need, when they need it and at a competitive price. Our Composite Model of Enterprise Planning shows the underpinning factors necessary for SMEs to develop such an integrated planning and control system. The Composite Model enables organisations to understand the strategic and operational requirements necessary to cope with uncertainty from volatile external demands in a smart city environment. The development of a smart city environment is helping to facilitate the creation of web-based production planning and control solutions central to satisfying the customers' insatiable desire for fresh, stylish and on-trend garments. The inter-connectedness of PPC systems is crucial in an era where fast-moving technological developments have pushed back the enterprise planning boundary so that clothing manufacturers now have to produce more customised clothing in shorter runs to tighter timescales. This is a trend which looks like continuing as smart cities develop.

This paper has highlighted a number of possible issues for future operations management research in this rapidly-expanding area of interest. As smart cities continue to develop, they will provide a rich context in which to gain a greater understanding of how retailers and manufacturers can address the demand management considerations necessary to meet the requirements of their inhabitants. In particular, we will be able to examine the nature and development of new and different internet-based information and knowledge technologies and how these can address the challenge of keeping up with consumer-led fashion clothing requirements.

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