

LOGISTICS OPTIONS FOR RE-DISTRIBUTED MANUFACTURING IN RESILIENT SUSTAINABLE CITIES – A PILOT STUDY

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ABSTRACT

Urban resilience has been defined as the capacity of (amongst others) communities and businesses to survive, adapt, and grow when faced with stresses and shocks. Re-distributed Manufacturing (RdM) exploits technologies, systems and strategies to change the economics and organisation of manufacturing (in particular location and scale). A series of studies are being undertaken, in the city of Bristol (population 450,000), into how RdM can contribute to a city's resilience and sustainability. Such as a 'Maker Walk', that examines the manufacturing hidden within urban areas. The objective of this paper is to report a pilot study within Bristol, to determine a range of logistics solutions that have the potential to support re-distributed manufacturing to enhance its resilience. As well as sustainability by helping address Bristol's traffic congestion and pollution problems. This paper proposes three potential logistics business models: 1) A logistics cooperative based around locally located service providers; 2) An urban logistics consolidation network; 3) A public transport integrated logistics service. These solutions could be used by logistics service providers, policy makers and regional government. The models provide guidance as to the interventions that require both private and public sector involvement.

INTRODUCTION

This paper brings together, from the perspective of delivering logistics solutions, the concepts of resilient sustainable cities together with that of Re-distributed Manufacturing (RdM). According to the Rockefeller Foundation's 100 Resilient Cities initiative "Urban resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience". The UK Engineering and Physical Sciences Research Council (EPSRC) states re-distributed manufacturing involves the exploitation of technologies, systems and strategies to change the economics and organization of manufacturing, particularly in relation to location and scale, with a particular emphasis on more localised manufacturing.

The objective of this pilot study, conducted within Bristol, was to determine a range of logistics solutions that have the potential to support re-distributed manufacturing to enhance its resilience. As well sustainability by helping address Bristol's traffic congestion and pollution problems.

The pilot study focuses on the BS3 area where a Maker Walk had previously been undertaken. The Maker Walk methodology was developed by Mike Lewis and Jude Sherry of Bath University as part of an EPSRC-funded RdM network (RDM|RSC) focused on the impact of RdM on resilience and sustainability in a city setting. One of the motivating aims of the RDM|RSC network was to support examination of the current status of manufacturing activity within a defined geographical area – in this case BS3.

LITERATURE REVIEW

Re-distributed Manufacturing

RdM within the context of the UK EPSRC RdM Networks program, has been defined as technology, systems and strategies that change the economics and organization of manufacturing, particularly in relation to location and scale (Pearson, Noble et al. 2013). Smaller-scale manufacturing has the potential, if applied appropriately with suitable levels of localization, to drastically reduce supply chain costs, improve sustainability and tailor products to the needs of users and consumers.

Such smaller-scale manufacturing has the potential to help tailor products to satisfy the specific needs of consumers differing in terms of geographical location, cultural roots, improve sustainability as well as drive the society towards circular economy (Prendeville, Hartung et al. 2016).

While RdM has the great potential to improve sustainability, currently, very little has been understood on how RdM could help small and medium-sized enterprises (SMEs) for gaining economic benefits due to the constraint of their business model, lack of understanding on customers, limited resource commitment on R&D, marketing and sales, supply chain integration, etc.

Resilience

In their examination of how local economic development Shaw & Newby defined sustainability as "the capacity for continuance more or less indefinitely into the future"(Shaw and Newby 1998). As such it incorporates the many facets of sustainability, economic, environmental, and social etc. Many definitions exist, Bonevac states that there are over 300 definitions in literature, going as far as to say that "Devising criteria and measures of sustainability has become a cottage industry" (Bonevac 2010).

In order to be sustainable the manufacturing sector also needs to have resilience: "the ability of a system to return to its original state or move to a new, more desirable state after being disturbed" (Christopher and Peck 2004). Specifically a firm's vulnerability / capacity to survive and adapt, resist decline and respond to opportunities (Valikangas 2010). Allied to this is the concept of regional resilience which has emerged as a trend that is developing a widespread appeal, in particular when examining how regions have fared during the recent economic crisis (Bristow and Healy 2014).

While the vagueness of the term "resilience" has facilitated innovative multi-disciplinary collaboration, it has also made it difficult to operationalise or to develop generalisable metrics (Meerow, Newell et al. 2016). To overcome this challenge, ARUP has collaborated with the Rockefeller Foundation in order to create the City Resilience Index (Da Silva and Morera 2014). The index was developed through a process of stakeholder consultation across a range of cities globally. The index is intended to serve as a planning and decision-making tool to help guide urban investments toward results that facilitate sustainable urban growth and the well-being of citizens. The hope is that city officials will utilize the tool to identify areas of improvement, systemic weaknesses and opportunities for mitigating risk. Its generalizable format also allows cities to learn from each other.

The index is a holistic articulation of urban resilience premised on the finding that there are 12 universal factors or drivers that contribute to city resilience. What varies is their relative importance. The factors are organized into the four core dimensions (and their goals) of the urban resilience framework (Da Silva and Morera 2014):

- Infrastructure and environment – quality and robustness of the systems that protect, provide and connect citizens
- Leadership and strategy – inclusiveness of governance, involving government, business and civil society, and evidence based decision making
- Health and well-being - ability to meet basic needs of people within a city
- Economy and society – ability of systems to enable urban populations to live peacefully and act collectively

METHOD

An inductive approach to the research is adopted. This initial pilot study limited itself to conducting a STEEPLE analysis of the "BS3" area of Bristol by exploiting data from the aforementioned Maker Walk conducted in the area and secondary sources. The STEEPLE analysis helps assess the factors that influence a target audience and how its constituent members behave. The analysis results are used to guide the creation of the proposed

logistics solutions. These were then analysed using the City Resilience Index (CRI) indicators developed by ARUP and the Rockefeller Foundation.

Viewing the process from a Soft Systems Methodology (SSM) perspective, covers stages one to five of the seven-stage SSM process namely:

1. Enter situation considered problematical
2. Express the problem situation
3. Formulate root definitions of relevant systems of purposeful activity
4. Build conceptual models of the systems named in the root definitions
5. Comparing models with real world situations

STEEPLE ANALYSIS

The purpose of a STEEPLE analysis is to help assess the environmental factors (socio-cultural, technological, economic, ecological, political, legal and ethical) that influence a particular target audience(s) and the way they behave. This study is focused upon the BS3 area within Bristol that was the focus of the Maker Walk study conducted by the RDM|RSC network. When viewed from the SSM perspective this will cover or directly enable SSM stages 1,2 and 3.

Within the context of this work the actors can be considered as follows

- Governmental: covering all levels of government including UK government, the EU/EC, local government (City Council and Mayor of Bristol) and local enterprise partnerships.
- Businesses: within this work the primary concern is the manufacturing sector within the BS3 area. However, business retail and property development are also considered.
- Transport and logistics: covering public transport (road and rail) providers as well as logistics service providers.
- 3rd Sector organisations: organisations such as Community Interest Companies or charities that have an interest or role to play in BS3.
- People: all of the stakeholders in the area such as residents, workers and customers.

Social

Typically residents are well employed, broadly well-educated, mainly between 25-44 years of age, and appear to have young families. That said, there are some pockets of relative deprivation, poor employment and low educational attainment. When examining this from the perspective of manufacturing it appears to be beneficial as the wealth of the area is growing. However, questions can be raised about how accepting people will be of a manufacturing presence in their area. Artisanal businesses such as micro-breweries or furniture makers might be tolerated or even welcomed with open arms. However, industries such as a tannery (which is in fact present within the area) may not be tolerated and a better educated and richer local populace may be better equipped to make their feelings known and grievances acted upon.

Similarly heavy or light –goods vehicle traffic could start to be considered to be a social nuisance creating difficulties for business and manufacturing in the area. In particular those business not trading estates located off arterial routes. Additionally housing developments are planned for areas around industrial estates, as well as the issues raised above, a social demand to live in the area could make industrial areas more enticing for housing development. Negatively impacting on manufacturing but also potentially creating conflict between business and households.

Technological

There are a large number of Technological initiatives (such as 5G and Internet of Things testbeds) taking place in Bristol that companies located in BS3 could potentially take advantage of. Some of the initiatives are currently focused around the BS1 area which on one hand could be positive as if the political will is there it might be possible for BS3 to “piggy-back” on these, on the other they could act as lure for companies based in BS3 especially those wishing to use digital technologies.

Within Bristol there several notable technological developments related to transport and logistics. This includes Bristol being used as a test bed for driverless vehicles (Venturer consortium), as well as the Bristol and Bath freight consolidation centre that aims to reduce the traffic impact of the Cabot Circus and Broadmead shopping areas.

Economic

One of the biggest challenges facing manufacturing companies within the BS3 area is the impact of Brexit. Both in the current uncertainty and the outcome of negotiations between the UK and EU to agree terms of exit. However, an analysis of import/export data from HMRC for 2016 out of those companies contacted by the Maker Walk only four were identified that undertake direct import/export activities, the others are likely to be using intermediaries such as wholesalers.

The cost of doing business could also increase due to inflationary pressures and the business rates revaluation that is occurring in 2017.

However, one economic activity in the area that is of particular interest is that of the Bristol Pound, launched in 2012, which appears to have been successful and suggests that the Bristol area is very supportive of local businesses, something that could be beneficial for the idea of re-distributed manufacturing and its supporting activities.

Ecological/environmental

The idea of congestion charging has been proposed several times within Bristol and this might affect businesses in different sectors and sizes unevenly – some sectors are more dependent on transport than others and smaller businesses might be unable to afford the charge or pass on the costs to their customers. Some sectors might find it easier to pass the charge on to their customers than others. The introduction of a charge may also impact SMEs more than bigger enterprises – they tend to have tighter budget constraints. But SMEs might not only face disadvantages due to tighter financial budgets – they might also face them because they lack scale. Big supermarket chains, like Sainsbury's who have a large retail outlet in BS3, have the ability to consolidate deliveries from different suppliers or switch to night deliveries to avoid paying the charge (whilst potentially upsetting local residents). Local corner shops or small manufacturers are more likely to get frequent deliveries from different sources – and are therefore likely to incur additional expenses when congestion charging is introduced and costs are passed onto them.

One environmental factor that has seen significant change within the BS3 area is that of the volume of light good vehicles using the roads in BS3. Using Department for Transport traffic census data giving the Annualised Average Daily Flow (AADF) traffic levels in BS3 were assessed. Based on data from the five traffic census points within BS3 used for this study car and taxi usage hasn't changed significantly between 2000 and 2015, 90248 and 89739 respectively. However, the use of light goods vehicles has increased by over 7000 (a growth of over 50%), having gone from 13563 to 20837.

The A38 Link road (a major infrastructure projected with BS3) and dedicated priority bus route will mean better access to South Bristol. That could tempt more businesses to set up in the area, which has in the past been considered as a poor relation to the city's northern fringe and its easy access to the ring road and M4 and M5 motorways. The road will pass through Ashton Vale, one of the more deprived areas of BS3 as well as passing close to a cluster of BS3 manufacturing companies.

Political

Bristol City Council also deals with complaints from residents about noise and other pollutants. As the BS3 area becomes more gentrified they may receive complaints about manufacturers based in BS3. As such local politicians and local politics could play a big role in shaping the future of manufacturing in BS3. This is further complicated through the

establishment of the West of England authority that will cover the Bristol City Region and have its own elected mayor.

Legal

When Britain leaves the EU, it is broadly accepted that one of the biggest challenges facing the government will be how to untangle more than 40 years of entwined British and European law. Sorting it all into the desirable and the undesirable could take years, even decades. Even though the government speeding the process up by accepting all EU laws now, before sorting through them all later on. Despite this there will be uncertainty for companies as to the legal framework within which they operate (especially with regards to issues such as Customs Union membership). Companies that operate primarily within the local market may experience minimal changes, but those who export or rely on European workers there will be a period of uncertainty. As previously stated the majority of Maker Walk companies in BS3 are not direct importers or exporters.

Ethical

It can be seen that it's very much in a company's interest to be ethical and behave in a responsible manner. The emerging 'maker community' trend does raise interesting challenges. If at present a maker is operating from their shed or garage and manufacturing on a very small scale what happens if they want or need to expand? Do they try and run a manufacturing business out of domestic property or do they try and work out on an industrial unit. This raises the question of where manufacturing should take place, in business areas or within/next to residential areas. However, small manufacturers have the ability to play a positive role in the community providing employment and services.

LOGISTICS MODELS

Using the STEEPLE study and its analysis as stages 1,2 and 3 of the SSM, the work described here covers the outputs generated SSM stages 4 and 5. Where solutions are developed and compared with real-world models.

Logistics Co-operative

A recent trend has been the emergence of the shared (or sharing) economy. The shared economy is a socio-economic ecosystem built around the sharing of human, physical and intellectual resources, utilising internet technologies. Such models show promise in assisting the transition toward more sustainable mobility systems (Cohen and Kietzmann 2014). Examples of companies who include Airbnb and Uber have shown themselves to be highly disruptive for traditional industries (Cannon and Summers 2014). In some senses they could be considered to be a form of "co-operative" that utilises internet technologies in order to provide a service. However, a key distinction is that such shared economy businesses explicitly operate on a for profit basis (cf. Uber and Airbnb) for the parent company. There are some concerns that the platforms are being used to circumvent employment regulation, although there are both pro and cons to the model (Aloisi 2015).

As can be seen in the map of logistics service providers (see Figure 1) there is a non-trivial number of logistics companies based in BS3. These will range in size from the likes of Royal Mail (who have a delivery centre in the heart of BS3) to a "man with a van" operation. Some form of co-operative or shared economy model (run for the mutual benefit of the logistics providers) could be used to better utilise the logistics service providers located within the BS3 region in the distribution of goods within the BS3, Bristol City and Bristol City region. There is also the possibility to make use of the Bristol Pound. The cooperative could have the following stakeholders:

- Companies (manufacturers and non-manufacturers)
- Local Logistics Providers (logistics companies based in BS3)
- National Logistics Providers (national and international service providers)
- Bristol City Council (facilitators)
- Royal Mail depot (as universal service obligation provider)
- Bristol Is Open (network service provider)

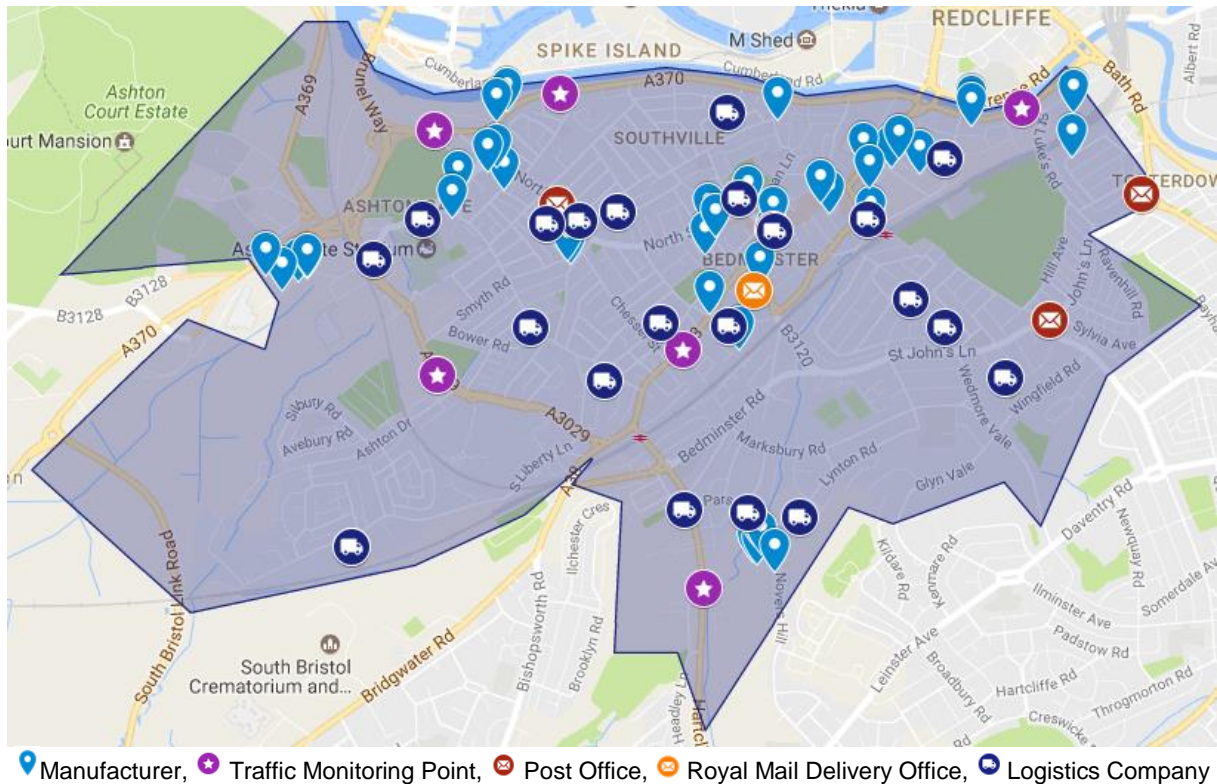


Figure 1: BS3 Maker Walk area indication important locations.

Urban Logistics Consolidation Network

Urban Consolidation Centres are defined as being a logistics facility situated in relatively close proximity to the geographic area that it serves, to which logistics companies can deliver goods destined for the area (Allen, Browne et al. 2012). They are one of the potential strategies to manage last mile logistics which makes up in the region of one third of urban truck traffic (Dablanc, Giuliano et al. 2013). A study (Ville, Gonzalez-Feliu et al. 2013) has identified that when such urban terminals emerged in the 1990s there were over 100 examples of them, yet at the time of writing there were only 20 genuinely significant terminals of this kind in Europe.

The Bristol and Bath consolidation centre (that within Bristol serves the Broadmead and Cabot Circus shopping centres) has shown itself to be a comparatively rare success story. A study of urban consolidation centres conducted by the SUGAR project (Dablanc, Patier et al. 2011) identified that the lesson learnt from its success is that the use of the centre being of a voluntary nature, so hence only the efficiency of the system encouraged retailers to use it and that it necessary for good operator to run the site. Illustrating that any form of UCC must have a clear benefit for the companies using it.

This model expands on the concept used at the Bristol and Bath Consolidation centre and some of the ideas presented above. It moves away from a centralised hub towards creating a distributed network of consolidation or distribution centres that serve all of Bristol as opposed to just the Broadmead and Cabot Circus shopping area. Where any logistics provider or modality could be used to do the "last mile", including self-service. The service could also be used for the "first mile" enabling manufacturers to drop-off items for future collections. Such centres could reduce traffic and hence noise and air pollution particularly if they are combined with innovative transport solutions, whether it is electric tricycles as in the Petite Reine scheme or electric/hybrid vehicles.

Public Transport Integrated

Public transport network (in particular buses) provide timetabled intra/inter-town transport services for the general public. This provides the potential to move goods as well as passengers between locations within an area. Internationally there are services that utilise bus networks to deliver parcels. An example of this is the Cargobus service that operates in Estonia which uses intercity bus networks to transport packages both within the country and to other nearby Baltic States.

Using public transport networks, in particular buses, as a method for distributing goods within a city and potentially a City Region. This could potentially deliver smaller items to customers (business and people) who are located near bus routes or with environmentally friendly vehicles making the first and last mile deliveries. Making use of bus lanes and bus only route to expedite the deliveries.

The BS3 area also has two small railway stations on the Bristol Temple Meads to Exeter train line. As such these stations could be used for a railway based parcels service transporting parcels both within Bristol but also to destinations outside of Bristol. There is also a rail freight depot in the western area of BS3 (Ashton Vale area). However, as a heavy freight depot it is geared towards handling containerised loads as opposed to smaller loads that local businesses may require. Additionally freight is configured to be distributed between freight depots which are comparatively few and far between (especially in comparison to railway stations).

RESILIENCE EVALUATION

Of the core dimensions identified by the ARUP and Rockefeller work the proposed logistics business models are most likely to have an impact on economy and society, and infrastructure and environment.

Economy and society

The proposed models through providing novel logistics solutions could help strengthen local economies and systems several ways. By strengthening the business participating in providing the services. Appropriate logistics solutions may make it more palatable for domestic residents to have manufacturers in urban locations enabling a diverse range of businesses to operate through an attractive business environment. Localised logistics provision has the potential to be more flexible and robust, hence contributing to the resilience of the local economy. New models could help develop a strong brand through the 'uniqueness' of the logistics provision within the area, whilst the provision of these models could nurture a stronger economic and business environment.

Currently the models are focused on BS3, but the natural progression would be to expand them to the whole of Bristol. Additionally if expanded into the 'hinterland' then it would be possible to strengthen the logistics integration of the wider Bristol City Region area.

Infrastructure and environment

Whilst not directly linked to codes etc. the use of new logistics models together with city wide planning could help create an environment that is conducive to both people and business. By reducing vehicle movements within area that have problems with NOx and other pollutants could be reduced. The use of congestion charging could be used to actively discourage vehicle use whilst potentially subsidising greener forms of transport (such as green logistics). The use of more environmentally friendly logistics solutions could help protect and enhance the ecosystems of the city. By reducing vehicle movements NOx and other pollutants could be reduced, improving the health of the overall ecosystem.

The use of new logistics models together with city wide planning could help create an environment that makes a more diverse operating environment. Whilst utilising public transport can make better use of road infrastructure, especially when Bristol is already very congested. It also has the potential to subsidise and strengthen the bus network.

CONCLUSIONS

This work has shown that STEEPLE as part of an SSM approach can be used as a methodology to help enable new logistics business models to be developed. These models when examined from the perspective of resilience using the most appropriate factors from the ARUP / Rockefeller City Resilience Index were all found to have the potential to help improve the resilience of the BS3 area.

LIMITATIONS AND FUTURE WORK

The main contribution of this pilot study is an initial step towards a more in-depth soft systems approach based study on logistics within resilient sustainable cities. This work focuses an area within a city and thus scalability requires further investigation. Other future work raised by this paper includes: Modelling of environmental impact of solutions; Scheduling, route planning and pricing; Methodology to determine most appropriate consolidation centre locations; Study of delivery patterns for businesses in urban areas.

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