ALLEVIATING TRAFFIC CONGESTION AROUND OUR CITIES;
HOW CAN SUPPLY CHAINS ADDRESS THE ISSUE?

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ABSTRACT
Traffic congestion is causing increasing concern in many cities around the world. The use of motor vehicles is rapidly growing, often leading to an increase in demand for urban road use without there being sufficient capacity to accommodate it, causing lengthy delays and contributing to a number of serious local, regional and atmospheric issues. Concern is shared by both society and supply chains, who whilst contributing towards the issue also suffer because of its existence, and a number of differing solutions are emerging.

This research examines the current body of literature to highlight a number of strategic measures that supply chains might utilise in order to tackle the issue of traffic congestion. The extensive multidisciplinary source material included in this review ranges from academic articles in the fields of production management, transport, industrial marketing, and employment and society, to government policy documents on town planning, climate change and workforce management, and is drawn together to contribute a unique high-level view and insight into the issue. Possible measures, such as changes in attitude towards JIT, coopetition, increasing home deliveries and challenging traditional working practices are all discussed.

Keywords: Traffic congestion, dark stores, coopetition, smart work centres (SWC), activity-based working (ABW), JIT, last mile

1. INTRODUCTION
Congestion, meaning an ‘accumulation or heaping’ (Lay, 2011), is defined as ‘the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system reaches its capacity’ (McKinnon, Brown, & Whiteing, 2012). As input volume rises the density of traffic, meaning the number of vehicles per lane per kilometre, also rises. As density rises the speed of vehicles using that section of road decreases (Kerner & Rehborn, 1996). Moreover, as speed decreases, the fuel consumption and CO2 emissions of those vehicles increase (Stopher, 2004). It is a feature of all heavily utilised transport systems where users, who experience substantial variations in travel speed depending on the time of the day, obstruct each other’s freedom of movement (Figliozzi, 2011; Goodwin, 2004; McKinnon et al., 2012; Musso & Rothengatter, 2013).

The root cause of traffic congestion is lack of capacity (May, 1990), defined as ‘the number of vehicles passing through a point in unit time (Bando, Hasebe, Nakayama, Shibata, & Sugiyama, 1995)’, with increases in demand for road use without sufficient investment in new roads, bigger/wider roads, or road improvements (Cole, 2005), or the availability of
suitable alternative modes of travel. Jain, Sharma, & Subramanian (2012), commented that cities lacking efficient public transport systems are inadvertently forcing more people to use private vehicles, further compounding the problem. More widely, the population of the world is continuing to increase and urbanisation, the number of people choosing to live in cities, is also rising at an unprecedented speed - increasing from 28.3% in 1950 to 50% in 2010 (WorldBank, 2011). The result of this is more people living in smaller spaces, the perfect conditions for congestion. Traffic congestion leads to slower traffic speeds, longer journey times, infrastructure bottlenecks, less predictable journeys, and unexpected halts (Sweet, 2011; Thomson & Bull, 2002), resulting in a number of social, environmental and economic issues. Driving at speeds lower than 30 kilometres per hour noticeably increases fuel consumption and greenhouse gas emissions with road traffic-related air pollution accounting for nearly three-quarters of the 23% of global carbon emissions produced by transport (Graham-Rowe, Skippon, Gardener, & Abraham, 2011; McKinnon et al., 2012). The extra time required, due to delays caused by traffic congestion, is usually regarded as being non-productive (Kristoffersson, 2013), with congestion-affected freight vehicles not only contributing to increases in greenhouse gases, air pollution, and noise but also suffering time delays that lead to additional supply chain and logistical costs (Figliozzi, 2011). The majority of customers whose needs our supply chains are designed to service are living in urban areas around the world, as are many of the people who travel to work for these supply chain organisations every day, so there is no shortage of incentives for supply chains to focus on mechanisms for alleviating traffic congestion.

Whilst there is a host of literature outlining the range of mechanisms governments around the world have introduced in an attempt to tackle congestion in their cities; congestion pricing, minimum occupancy lanes, vehicle quota systems, vehicle exclusion zones and cycle lanes to name but a few (Hwang, 2005; Leape, 2006; Moavenzadeh & Markow, 2007; Tresch, 2008; Wardman, Tight, & Page, 2007), this paper examines the current body of literature to specifically identify the current supply chain practices which have the potential to relieve traffic congestion. Therefore, the objective of this paper is to seek an answer to the following research question:

RQ1. What are the supply chain practices that have potential to alleviate traffic congestion?

2. METHODOLOGY

This research utilises a literature review approach to address RQ1. The material included in the review ranged from academic publications in the fields of production management, transport, industrial marketing, and employment and society, to government policy from around the world on town planning, physics, climate change and workforce management, and is drawn together here in a new and unique manner. In addition to academic articles, from books, journal papers and conference papers, the review also included a small number of relevant webpages and newspaper articles that were deemed as adding value to the discussion.

Google Scholar and Scopus were selected as the database sources for this study, as they grant access to an expansive range of material, allowing the full breadth and diversity of the subject to be explored, and both present clear citation data to assist with article selection. The key word search used to conduct the research included the following terms, employed in a number of different combinations: traffic congestion, congestion, traffic flow, traffic jam, solutions, driving reduction, city, urban, logistics, vehicle routing, distribution, road freight, transport, last mile, supply chain management, public transport, sustainability and air pollution, amongst others.

Whilst the search process was fairly systematic, the manner in which articles were selected was often more random, relying upon the expertise of the researcher to manually identify material that aligned with addressing the research question. Analytics tool Qiqqa was
employed for analysing and tagging the articles, to assist with the process of open coding, and for identifying common themes. The range of articles covered a 25 year period (1988-2013) and a total of 106 were included in the overall review.

3. FINDINGS
A number of operational themes were identified that have already received considerable academic attention for their potential to tackle the issue of overcrowded roads. Efficient loading, improved optimisation of vehicle routing, access to better information systems, and the introduction of green performance measures were all recognised as effective ways of improving freight efficiencies that could reduce the required number of vehicles and avoid wasted travel time on the roads. However, this research shifts its focus onto the emergence of four disruptive, high-level strategic changes that supply chains could make in order to address congestion.

3.1 Just-Isn’t-Time
Low inventory strategies such as Just-in-Time (JIT), which can create great economic benefit, can also have a detrimental effect on environmental and social sustainability and congestion (Beer & Liyanage, 2011; Paniati, 2004; Sarkis, 2001). JIT is a production strategy aimed at increasing revenue through a reduction of in-process inventory and its associated carrying costs, by regarding unused inventory as waste, that focusses on having the exact required level of inventory needed for production without the need for any safety stock (Frazier, Spekman, & O’Neal, 1988; Monden, 2011). In order to achieve this organisations adopting a JIT philosophy must select suppliers that can guarantee them the consistent timely delivery of component parts, as there are no allowances for delays with this system, and any non-availability of parts will result in production lines having to stop (Aksoy & Öztürk, 2011). To ensure the continuous availability of parts, without the facility to carry inventory, JIT systems typically deal in smaller lot sizes that require parts to be delivered at short notice, and in smaller batch quantities, resulting in a higher frequency of deliveries being made between supply chain partners (Paniati, 2004; Sarkis, 2001).

An argument exists that organisations adopting this approach are sacrificing ‘transport efficiency for inventory savings and increasing the amount of freight traffic to the detriment of the environment,’ and therefore other road users (McKinnon, 2014). If the need for JIT was eased fewer, more frequent, larger deliveries could be made instead, with a better chance of increased transport efficiencies, with more storage of inventory at the production site being the trade-off for a reduction in the amount of time vehicles are on the road. However, this idea might be difficult to sell to JIT manufacturers unless other tangible gains could be realised, and it would require the suppliers and the manufacturer to take a holistic supply chain view of the wider benefits possible in order to sanction the physical storage location of inventory being shifted further downstream.

3.2 Coopetition
The term coopetition, when rival organisations form formal partnerships for the purpose of securing mutual gains, is defined as a situation where two competitors are able to simultaneously compete and cooperate with each other (Bengtsson & Kock, 2000). Competitors collaborate in certain operational areas for mutual gain, the practice now being considered to be both common and widespread, with the likes of GM and Toyota, Siemens and Philips, and Thomson and JVC known to participated (Luo, 2007). For successful coopetition appropriate activities must be identified, where joint synergies may exist due to an alignment of resources and capabilities, and the transport of finished goods to the market can fit this criteria (Hensher & Puckett, 2004; Luo, 2007). Outbound logistics is viewed as a non-critical activity, where little or no sensitive information need to be shared, but is a task that
carries significant fixed and variable costs. A very famous example of this, where two rival organisations decided to collaborate on the transport function of delivering products to supermarkets, started in 2007 with Nestle and United Biscuits. Despite being fierce competitors in the confectionary aisle the two organisations adopted the philosophy that they ‘compete on the shop shelf and not in the back of a lorry’ and decided to collaborate with the consolidation of their deliveries. It became a great success, both financially and in terms of reducing traffic volume and pollution and, to this day, the Nestlé-UB collaborative relationship continues and has been cited as an example of best practice within the industry (McKinnon, 2010).

Another example of transport coopetition can be found in the Swedish brewery industry. Here, the competitors compete in the delivery of their beers to wholesalers but cooperate in return of empty bottle returns for reuse. Both feel that the delivery aspect gives them an opportunity to promote their own products to the stores, seeing value in this type of exposure, but regard the return of empty bottles as unimportant as it involves no direct interaction with customers (Bengtsson & Kock, 2000).

A willingness to collaborate with competitors on the transportation of products to market, with backloads and reverse logistics operations, with the cross-docking function, and in consolidating inbound logistics operations has strong potential for increasing vehicle utilisation, reducing empty running, and for yielding positive results in the reduction of congestion. This combination of financial, social and environmental gains makes for a very attractive solution, but requires trust and communication to occur between competitors.

### 3.3 Dark stores and home delivery

The UK is widely regarded as the world leader in home shopping, with 6% of all grocery shopping currently conducted online, a figure that is expected to double over the next five years (Benedictus, 2014). Academic evidence suggests that home deliveries conducted by the retailer, made by one vehicle to multiple customers, have the potential to be more efficient than private car travel, multiple customers using their own vehicles to pick up their own items from the grocery store (Cairns, 2005; Rotem-Mindali & Salomon, 2007) –estimating, if a customer is buying fewer than 24 items on a typical shopping trip, home delivery will emit less CO2 per item purchased (Edwards, McKinnon, & Cullinane, 2010). When considering the reduction in the number of vehicles on the road, that a home delivery business model creates, the potential for relieving congestion is clearer still.

Until recently the fulfilment of online orders has typically been carried out at traditional stores, with items being picked as regular shoppers browsed the aisles, which obviously raises a number of efficiency issues. Now, however, changes are occurring to the way in which online orders are processed, fulfilment being accomplished using separate inventories to those used to service traditional non-online customers, in order to improve efficiencies. Dark stores are retail outlets or distribution centres that cater exclusively for the fulfillment of online orders (Butler, 2014). An increasing number of these warehouse-style grocery markets are appearing, which are not open to the general public, that are designed specifically for the purpose of fulfilling the growing numbers of grocery orders made online. Supermarket giant Tesco recently opened their sixth dark store, in Erith South-East London, which includes a giant ‘goods-to-person pickstation’ robot (Benedictus, 2014). The layout is very different from traditional supermarkets, with towers of blue crates replacing isles of groceries and the robot retrieving the necessary items and bringing them directly to the picker, saving valuable space and time whilst creating a safer workplace (Benedictus, 2014).

With potential improvements in efficiencies, reductions in time and CO2 emissions, leading to fewer vehicles on the road, this would appear to be another attractive proposition for reducing traffic congestion. The presence of secured parcel lockers in the supply chain, or a partner organisation adding a parcel pickup function to their normal core business
(convenience store, dry cleaners, coffee shop etc.), could then offer further gains for the delivery function (Suh, Smith, & Linhoff, 2012). Amazon launched such a program across New York, Seattle and London in 2011. Partnering with retail store 7-Eleven, Amazon customers receive a digital pick-up code via email or text messaging when their parcel arrives, and are instructed to use the code in order to pick up their delivery from a password protected locker located inside their local 7-Eleven store (CNET, 2012). There are incentives for retail outlets who host these lockers with the potential of residual trade when customers come into their location to collect a parcel (Bachman, 2013).

3.4 Challenging traditional working norms

The final solution to be discussed is one that totally challenges the way in which people currently live, work and move, to remove/reduce the need for job-related travel. Flexible working practices, including home-working, play an increasing role in the life of the modern professional. Modern ICT technologies and working conditions ‘allow the temporal and spatial boundaries of paid work to be extended’ (Perrons, 2003), and there are many potential benefits, for both employees and employers, from being able to relinquish expensive city centre office spaces and encouraging employees to work from home or from remote work ‘hubs’ (Lyonette, Anderson, Lewis, Payne, & Wood, 2013; Waters, 2007).

Modern ICT technologies, such as the Internet, email, Wi-Fi, instant messaging, cloud computing, mobile devices, wearable devices, 4G networks and teleconferencing facilitate work taking place outside of its traditional locations. With a teleworking/telecommuting workforce people would be able to perform a range of their work duties remotely, either from home or at a work hub close to where they live, instead of having to travel to one fixed physical location every day (Baruch, 2002; Illegems, Verbeke, & S'jegers, 2002). This would obviously dramatically reduce traffic levels at the most important ‘peak’ times. Smart Work Centres (SWC) are state-of-the-art working environments available to individuals and groups working for unrelated organisations, that wish to come together to share workspaces. These centres may also offer on-site facilities such as childcare, bicycle lockers and showers alongside IT equipment, office supplies, mail services, catering, reception staff and meeting rooms. These local work hubs promote flexible working practices, reduce travel time, reduce the stress and cost of daily commuting, reduce the carbon footprints of their users, and reduce the load on transport systems at peak commuting times (GeSI, 2009; IAA, 2009). They also satisfy our need to remain socially connected, promoting social inclusion, with workers able to interact with other co-workers in the same way they would with colleagues in traditional workspaces whilst enabling new members to join the workforce who would have previously been excluded due to geographical constraints.

American multinational company Cisco Systems opened their first SWC in Almere (Holland), in 2008, and their experience has led them to believe that providing workers with a physical workspace close to their residences results in reduced transportation demands, and increased productivity, and the use of cloud-based services facilitates a seamless working experience (IAA, 2009). However, in order to establish an activity-based working (ABW) environment (Wilmot, Boyle, Rickwood, & Sharpe, 2014), where employees are measured on outcomes and have the flexibility to choose when and where they carry out their individual work tasks, major changes to current management culture are also needed.

A completely different approach to reducing job-related travel was taken in Utah, USA. In August 2008, Utah Governor, John Huntsmen introduced a mandatory four-day week for state workers. Workers were required to work for ten hours from Monday to Thursday, in an attempt to cut energy costs and improve the state’s air quality, which also successfully reduced commuting time and travel costs for employees (Marquez, 2008). The state experienced a reduction of three million road miles travelled in the state, with carbon emissions decreasing by 4,546 metric tons, and other greenhouse emissions reducing by 8000 metric tons annually
The scheme ended in 2011 after a change of governor but, due to its popularity, the four-day working week was retained by some of the state’s large cities (Simms, 2013). This is not the first time that a staggering of work hours has been identified as a realistic solution to traffic congestion (Arnott, Rave, & Schöb, 2005).

Moving away from the traditional Monday to Friday, 9 to 5, working ‘norms’ could immediately reduce the demands for road space during peak times. Whether this is achieved by altering the days/times that people need to travel to work, like in Utah, or by utilising ICT technologies to reduce the need for employees to travel to that fixed location at all, any reduction in job-related travel has the potential to alleviate traffic congestion levels.

4. CONCLUSIONS

This review was conducted in order to identify supply chain practices that have potential to alleviate traffic congestion. Analysis of the current body of literature recognised four such practices; changes in attitude towards JIT, coopetition, increasing home deliveries, and challenging traditional working practices. All four practices are already fairly prevalent, in many supply chain operations around the world, but the original motivations behind the decision to adopt them was unlikely to be their potential for tackling traffic congestion. However, if the impact that traffic congestion has on supply chains continues to increase, creating more delays and increasing levels of non-productivity, it could become a more critical factor in future strategic planning.

Many governments around the world have already introduced schemes, in an attempt to tackle congestion in their cities, and this study provides evidence to suggest that supply chain partners and governments could work together to develop mutually beneficial solutions in the future. Their motives are similar, to minimise disruption and keep vehicles moving, and there could be great benefit in holding dialogue or undertaking joint planning. The practice of working remotely, or digitalising the nature of activity-based work tasks so that they can be carried out without the need to attend a fixed place of work, could certainly be jointly explored as it might have radical benefits for both supply chains and large sections of society. Steps are already being taken to investigate this further.

The purpose of this paper was to stimulate discussion on how supply chain decision-making might impact traffic congestion in the future, to influence practitioners and fellow academic researchers, and to encourage further modes of investigation. The role of operations and supply chain management may hold the key to many potential opportunities, that not only increase efficiencies and reduce costs but also contribute towards making the world more comfortable, sustainable, and socially responsible.

5. REFERENCES


