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How Smart Cities will Change Supply Chain Management: A Technical Viewpoint

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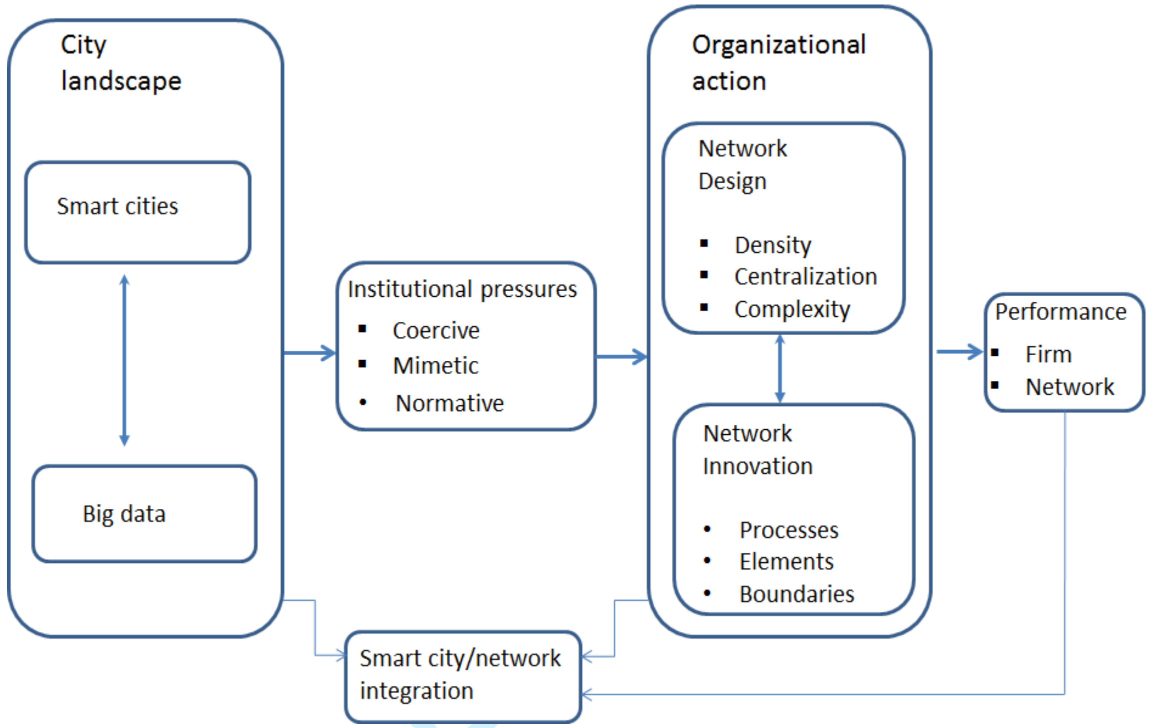

Figure 1: User driven smart city-supplier network framework

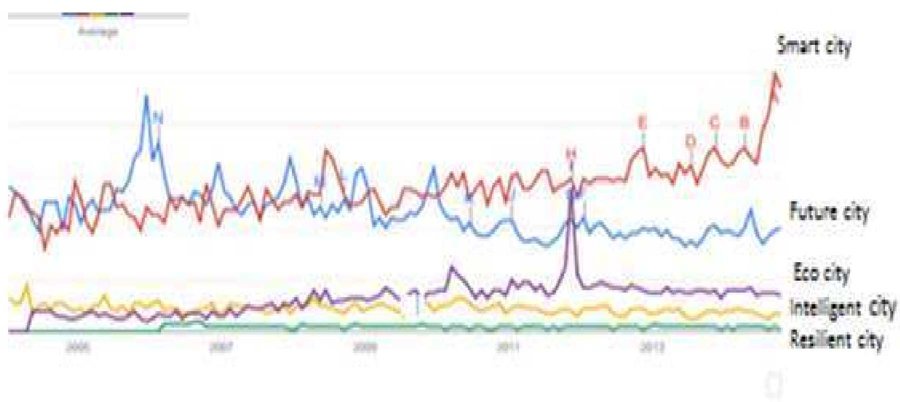

Figure 2: Google trends of five key institutional city driven concepts (2004 – 2014)

How Smart Cities will Change Supply Chain Management: A Technical Viewpoint

Abstract:

Smart city initiatives could expect to radically change the ways businesses are organised. This paper is a first step to understand the role of smart cities in supply chain management, with a specific focus on supplier network. We pose the question: how will smart cities change supply chain management? We develop a conceptual framework for understanding the important factors that appear to affect the integration of smart city initiatives in the supply chain. Additionally we collect examples that illustrate the interplay of smart city initiatives with supply chain management. Ultimately the objective is to identify the key elements driving integration and their influence on supply chain management and also to provide insights on productive methods for developing, introducing and managing smart city innovation.

Keywords: Big data; Framework; Smart city, Supplier network

How Smart Cities will Change Supply Chain Management: A Technical Viewpoint

1. Introduction

The growth of urban areas has been dramatic in the last decade. According to Lierow (2014) it is expected that 70% of the world's population will live in cities by 2050. Cities will be facing challenging problems of accommodating their expansion in population with constrained energy, infrastructure, water, supply, and physical space. In parallel, Oxford's David Bonilla, for instance, questions the sustainability and viability of the dominant "*global*" supply chain structure distributing goods and services into European cities (Bonilla, 2014). This view is supported in the U.S. by Caplice (2013), among others, who points out that the dominant distribution system of the last few decades is facing disruption through the advance of 3D printing, fabrication technologies, additive manufacturing, and also decentralised production[1]. Expectations are an increased focus on the city as a unit for production and consumption, while also the amplification of networks to supply such units. Supplier networks refer to "*a network of firms that exist upstream to any one firm in the whole value system*" (Choi, Dooley, and Rungtusanatham, 2001, 352). Such networks point to how firms collaborate for joint outputs or sales, and draw attention to how the delivery of goods or services may not rely on one single organisation or follow the supply-chain advancement (cf. Chapman and Corso, 2005; Riis, Dukovska-Popovska, and Johansen, 2006; Romero and Molina, 2011).

[1] One of the primary reasons manufacturing is conducted across the globe is to achieve economies of scale; a single huge plant can reduce production costs. But, what if new manufacturing technologies and production processes dramatically diminish these economies of scale? Additive manufacturing and programmable robotics are just two examples. Production can be decentralised into smaller, perhaps regionally-based manufacturing clusters that are closer to population centres. Caplice (2013, 1) suggests this raises the question of: "why ship product half way across the world and funnel them through ports when a more customized product can be built across town?"

The development of what is referred to as “smart cities”, that is, cities “*seeking to address public issues via ICT- [information and communication technology] based solutions on the basis of a multi-stakeholder, municipally based partnership”* (Manville et al., 2014, 9), is on the rise (cf. European Commission, 2013a). Smart city initiatives are linked to big data, that is, large pools of unstructured data that can be captured, stored, managed, and analysed (IBM, 2013; Manyika et al., 2011), and also to future technology and sustainability, and we argue in this article how smart city initiatives and big data mutually affect supplier network design and innovation. The argument for supplier networks as a key focus for the organising of firms (cf. Sloane and O’Reilly, 2013), relate to how smart cities stress the shared use of data, how technological advancement become increasingly distributed among companies, and to how investment may require several firms joining forces, as they also would in initiatives to affect smart city trends.

The aim of this paper is to answer the question of how smart cities will change supply chain management. We develop a user-driven framework to demonstrate the interplay between emerging city technologies, initiation, big data, and supplier networks (where the networks intend to capture the possible collaboration among suppliers in the supply chain, describe increasingly new ways of organising work among companies, and also link to innovation in the network). We use components of institutional theory to link (through social pressure) the societal city landscape to organisational adaption. Previous work on smart cities has focused on the policy and societal levels (Manville et al., 2014). However, there is a need for a framework to explore smart city integration and operational (company and supply-chain) level consequences. No one to date has integrated together smart city initiatives with supplier networks and unlike existing smart city frameworks we focus on operational level issues.

2. User-driven framework: Smart city integration

We propose an integrative framework (see Figure 1) that combines smart city-initiatives and big data with two dimensions of supplier networks: design and innovation. The various parts of the framework are discussed in the following sections (Sections 2.1 to 2.4). In the descriptions of smart cities and big data, we provide some background examples, while the description of organisational actions and performance presents some theoretical ideas that help us to grasp how smart city initiatives may change supply chain management. We then elaborate on these thoughts and provide practical examples in the analysis section.

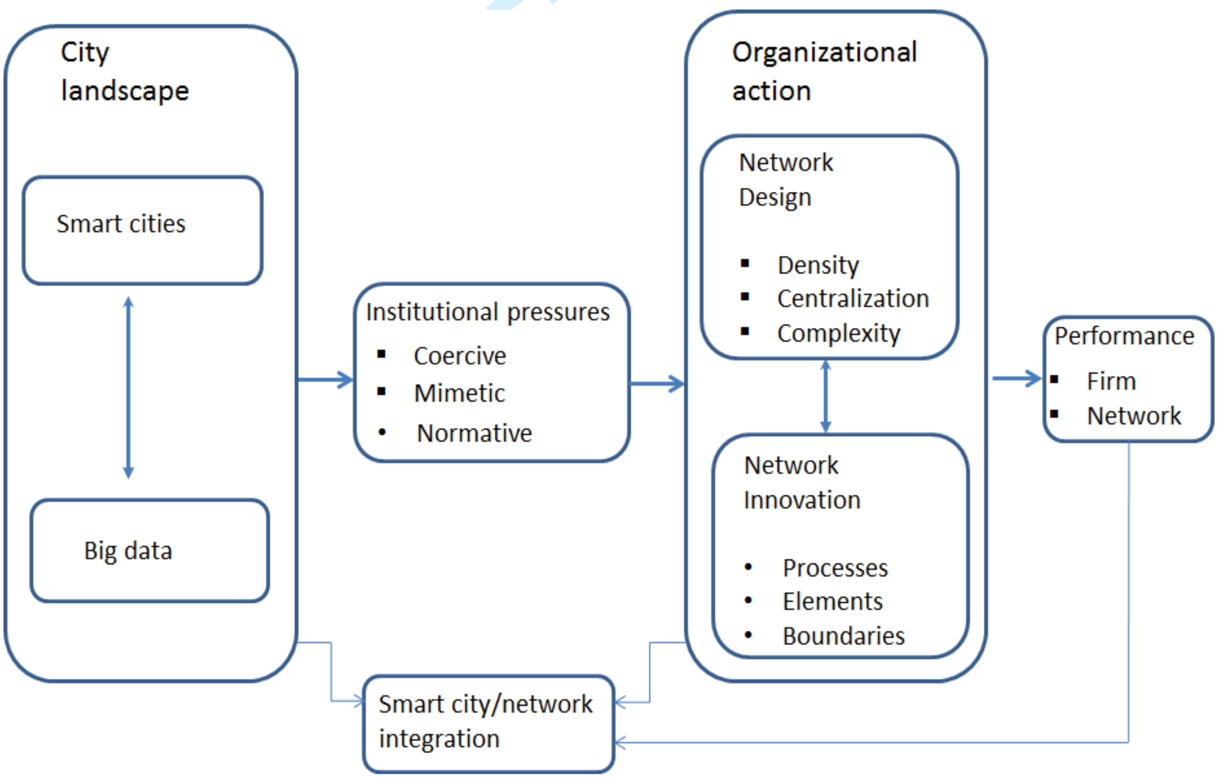

Figure 1: User driven smart city-supplier network framework

2.1 The city landscape (left-hand side of framework)

2.1.1 Smart cities

Smart cities[2] incorporate elements of sustainability and inclusivity, as well as responds to the rise of new Internet technology interfaces (Deakin, 2012). Although the term has been popularised since the mid-1990s, in 2010 and 2011 the term really gained impetus as more places began to compete on sustainability innovation, not least the high-profile smart-city projects in China and Abu Dhabi (Joss, 2009). Figure 2 shows that since 2010 there has been a dramatic increase in the use of the term "*smart cities*".

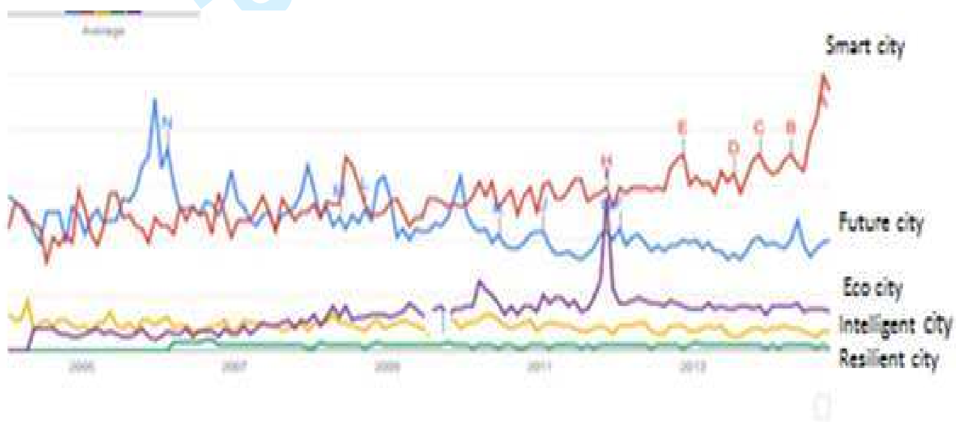

Figure 2: Google trends of five key institutional city driven concepts (2004 – 2014)

This development of city-based production as a source of competitive advantage is not a new idea, however. Economist Alfred Marshall (1919) documented the rise of "*industrial city*" power houses in Britain in the nineteenth century. His view of city clustering was advanced further through the work in the U.S., Europe, and China by Poire and Sabel (1984), Porter (1990), and Sheffi (2012). The current smart city idea is though much related to the mentioned sustainability

[2] Some observers point out that "*smartness*" as a term is more politically neutral than "*eco-city*"[1]. Thus, iterations of the term smart ("*smart city*", "*smart growth*", "*smart development*") are more palatable in countries where a large body of public opinion associate eco-cities with sustainability and greenness and thereby with highly liberal or progressive politics (RPA World Cities Planning Committee, 2014).

concerns, new technology, increased urbanisation, and big data. Still though, smart cities indicate quite many different things, and may include entire city planning, or, for instance, energy-related solutions or other specific infrastructures. The initiatives may be driven by city authorities and communities, be company driven, or be based on combined efforts, which thus combine organisational and city-level initiatives, and integrate them together.

2.1.2 Big data

Smart city initiatives are, it is suggested, dependent on collecting and managing the right kinds of data, analysing patterns and optimising systems functioning (Dirks, Gurdgiev, and Keeling, 2010; Harford, 2014). The digitisation of cities and the proliferation of sensors generate unprecedented amounts of operational and supply chain data. As with smart cities, there is the rise in the application of big data (Marr, 2014). Such data is different to that traditionally used in supply chain management in terms of its coverage, granularity and variety, while it is also related with several concerns in the data capturing and analysis. Analytics face challenges around data quality, comprehensiveness, data collection, and analysis (e.g., IBM, 2013; Kopytoff, 2014), particularly aligning data from data sources and managing the sheer volume of data which is produced. Risks for false correlations are evident as well as inaccurate data input, both leading to issues of finding key problems and effectively solve them (Harford, 2014). With the growth of technology and datasets also come new piracy surveillance and data misuse challenges. Big data is thus only useful if it is complemented by the process of examination and assessment (Kopytoff, 2014). Big data analytics is the process of examining large amounts of unstructured data to uncover hidden patterns, unknown correlations, and other useful information (Rouse, 2012). The data hence needs to be robust, accessible, and "*interpretable*" if it is to provide cities and companies with meaningful opportunities and solutions, while it is still connected with several concerns, not the least related to detecting unusual phenomena (Marcus and Davies, 2014).

Hence, big data suggests being critical for smart city initiatives, where issues of quality, completeness, etc., become precarious. Its function for the cities if both to provide data about, and deliver data to organisations, and hence, the big data could link city initiatives to supplier networks and their formation as part of smart cities.

2.2 Institutional pressure

The integration between smart cities and supplier networks is in this paper analysed through the lens of institutional theory to explore the social pressure on firms. Institutional theory describes pressure as coercive, imitative, and normative (DiMaggio and Powell, 1983). Coercive legitimisation is an organisation's reaction to formal and informal pressures by other organisations or society. Imitative legitimisation is when organisations imitate the success of others facing uncertainty. Normative legitimisation is a result from normative pressures stemming primarily from professionalism and shared norms amongst organisations (Zucker, 1987).

Essentially, it could be suggested that smart city initiatives pressure organisations for change, while they also lead organisations to increasingly conduct similar activities. Looking at the pressure for integration, such pressure would not only come from smart city initiatives, but also from the firms, and companies surrounding them. Institutional research with its focus on imitation and mimetic isomorphism as drivers of network influence (e.g., DiMaggio and Powell, 1983), suggests that network partners tend to adopt the same practices, even if these practices are counterproductive in a rapidly changing environment (Westphal, Seidel, and Stewart, 2001).

It could hence be argued that private organisation and public institution co-evolve and interact mutually through complex social interactions (DiMaggio and Powell, 1983), while there needs to be reciprocal trust between smart city institutions and the supplier network companies, and we link this to the integration between smart city initiatives and the organisations as part of them.

2.3 Organisational action (right-hand side of framework)

Expectedly, and in compliance with other recent trends, smart city initiatives expect to affect the ways work is organised among companies, and also lead to new ideas/innovations (cf. European Commission, 2013b). This would be the case both to meet challenges and deal with opportunities. In the paper we focus on *supplier network design* and *innovation*. The supplier network focus, follows, as pointed to in the introduction, from how data may be shared, how technological advancement often follow from collaborations, how investments may require joint efforts, and how companies increasingly become specialised (e.g., Rosas, Macedo, and Camarinha-Matos, 2011). It also allows for organisations to affect smart city initiatives to higher degree. This is in line with how Batty (2014) suggests in "*The New Science of Cities*" that cities can be seen as more than just places in space - they are systems of networks and flows; the smart cities expression has taken on some of the digital dimensions of connected systems and flexible computing infrastructures. The interlinkages between the sets of infrastructure services and amenities (Cooper and Elram, 1993) that make up the operating and management platform of any city or city region create such functional systems, and the supplier networks would be networks as part of these city systems and represent infrastructure service outputs, for instance.

The concept of supplier networks has been investigated under different perspectives. There have been studies in supply chain management (Choi and Hong, 2002; Choi, Dooley, and Rungtusanatham, 2001), in organisational literature (Gulati, Nohria, and Zaheer, 2000), and industrial marketing (Håkansson and Snehota, 1995), and we use the concept broadly in the paper.

2.3.1 Supplier network design

Supplier network design (e.g., Wu and O'Grady, 2005) refers to how work is organised among suppliers, how they share tasks and data, and collaborate. In this paper we analyse supplier network design as:

- *Complexity* – the number of elements, their connections and possible conflicts among them in the network. This relates to the variety and uncertainty associated with a system (Frizelle, 1998), the number of elements and the degree to which those elements are differentiated (Choi and Krause, 2006), and the amount of coordination load on the network (Choi and Hong, 2002).
- *Density* – the number of actual ties as a ratio of the total possible number of connections among parties (Kim et al., 2011). In a totally dense network all nodes would connect to each other, and density hence refers to the amount of interconnectivity in the network.
- *Centralisation* – how central an organisation is in the network. Density and complexity hence analyses the entire network, while centralisation focuses on one organisation's

"location" in the network. Traditionally supplier networks have been "centralised" around lead firms with more power and resources (Gulati, Nohria, and Zaheer, 2000).

2.3.2 Supplier network innovation

Supplier network innovation is emerging as a critical area for many companies (cf. Shaw and Burgess, 2013). It combines information and technological developments with logistics and marketing procedure innovation (cf. Bello, Lohtia, and Sangtani, 2004). The supplier network innovations connect to process innovations including change management (Voropajev, 1998), business process reengineering (Hammer, 1990), continuous improvement (Upton, 1996), and Kaizan (Imai, 1986). Flint (2007) maintains that competing in process and supply chain is more sustainable than in products. This is due to the fact that cost savings in supply chains can have a stronger impact in the long term, as opposed to the relatively high volatility of new product introductions. Bello, Lohtia, and Sangtani (2004) further point to how service effectiveness can be enhanced through such innovation. In this paper we focus our analysis on three key innovation dimensions:

- *Processes* - the network processes involved in the innovation (e.g., Ulusoy, 2003). This entails adopting a concept of extended network that includes all the processes from product development to delivery of products to customers. Different types of innovation involve different processes of the supplier network - procurement, inventory management, demand management, order fulfilment, production, logistics, distribution, and product development.
- *Elements* - those elements influenced by the supplier network innovation. These include introducing a new technology to automate the process, a modification of an existing one,

changing the internal micro- or macro-structure of the organisation, new projects, and re-allocation of normal tasks among the internal actors/employees.

- *Boundaries* - a supplier network innovation can be introduced with different implications in the internal or external supplier network - or at the national or global level (Bello, Lohtia, and Sangtani, 2004).

2.4 Performance

Lastly, in order to fully position our framework we consider the performance of the initiatives and their integration. Any change should be perceived as a favourable improvement compared to the previous situation or system (cf. Rogers, 1995, and it should be able to generate results that can be observed. This includes two key components: firm performance (Roper, Du, and Love, 2008) - labour productivity, sales growth, employment growth, and cost decreases; and supplier network performance, cost, time, quality, service level, and flexibility.

3. Analysis

In this section, we bring together smart city initiatives with supplier network design and innovation, to discuss how smart cities affect such operational levels. The outline of the sections is based on the right-hand side of the integrative framework presented in Figure 1 and connected with various examples to illustrate their point.

3.1 Pressures for integration

In the smart city integration, *coercive pressures* (cf. DiMaggio and Powell, 1983) come from city government and professional regulatory agencies (Braunscheidel et al., 2010; Cohen, 2014) and also the threat of losing competitive advantage. Some cities such as Vienna, take a holistic view on the smart city, implementing initiatives to cover everything from energy, infrastructure, green spaces, and mobility to all aspects of urban life and development. Other cities focus on a very specific "*element*" of smartness, but aim for geographical coverage in a city. Yokohama in Japan, for example, is pioneering a specific project based on the installation of energy management systems across the city. Barcelona has developed a smart city program including public Wi-Fi and energy self-sufficiency (Cohen, 2014). These initiatives put pressure on companies to adopt, or as other examples indicate: co-evolve with the city authorities. In Skellefteå, Sweden, Skellefteå Kraft (governmentally-owned power company), SQS and Explizit (Software Specialists) are working with city planners to implement sensors to measure, monitor and communicate, and more efficiently allocate resources such as electricity, water, traffic, and waste. In Malaga, as a comparison, a consortium of eleven companies spearheaded by Endesa, focus on renewable energy, smart metering, smart distribution and electric vehicle projects.

Imitative pressures and also *normative pressures* (DiMaggio and Powell, 1983) would mean that various organisations imitate each other's behaviour. The former would amplify successful actors and their followers; the latter that firms are more likely to interact with smart city policies, if they perceive that a considerable number of other firms have already adopted these technologies. The leaders of the smart city agenda are the technology and information technology (IT) firms. In 2005 Cisco dedicated $25m to researching smart cities over a five year period in its Connected Urban Development programme. Cisco was swiftly joined by other technological firms including IBM which set up a "*Smarter Cities*" initiative in 2009 and

Siemens which created its own "*Infrastructure and Cities*" division in 2011, both of which being examples of imitative pressure.

These few examples seem to suggest that institutional pressure foremost is coercive, and secondly imitative. Initiatives are city driven, company driven (with a focus on large, multinational organisations, or networks of firms), or driven by cities and organisations in combination, and norms have yet to be developed. The examples also indicate how followers do so based on perceived threats rather than based on opportunities.

3.2 Integration between smart cities and supplier network design

Smart cities may provide firms with infrastructure to leverage big data, governance mechanisms to support multiple stakeholder collaboration, and IT infrastructure to disseminate it (e.g., wireless urban sensors, public Wi-Fi), indications of the *network* as the increasingly important organisational unit. Smart cities however also generate obstacles to production planning in terms of practices such as congestion charges, low emission zones (i.e., vehicles shall comply with low emission requirements or pay a fee), or car free policies that may negatively affect the performance of city supply chain systems (Browne and Gomez, 2011). The smart city will therefore force firms to design new distribution strategies to urban centres such as urban freight consolidation centres and/or seek for alternative transportation modes such as electric scooters and compact bike lane vehicles (MIT, 2014). So, based on both opportunity seeking and pressures for change, new designs of work expect to take place. Analysing supplier network design as the consequence of smart city initiatives, in the dimensions of complexity, density, and centralisation, the following can be assumed:

3.2.1 Complexity

Smart cities impact on the ability to access and store information across the supplier network, because more people are involved in exchanges within the network (Caridi et al., 2010). The interplay between smart cities and network "complexity" can be understood by the emphasis given to uncertainty. The greater the complexity and uncertainty, the more social comparison between both firms and cities could be used as a basis for making decisions. In the smart city setting a high number of interactions between stakeholders with conflicting objectives may complicate the decision-making processes, thereby increasing the network complexity (Anand et al., 2012; IBM, 2013). Additionally the urban trend towards micro-retailing with multi-tiered structures, multiple modes of transportation, a multitude of distribution points implies more complex distribution networks (Blanco and Fransoo, 2013).

The big data applications can benefit from the input generated by a higher diversity of sectors in a structurally complex network. However, Skilton and Robinson (2009) argue that tight coupling among firms is more difficult to achieve in complex supplier networks, so failures in information exchange may be a problem. The impact of smart cities and big data will largely depend on the degree to which firms can achieve couplings by using different type of coordination and control mechanisms.

3.2.2 Density

Smart cities, big data and network density appear to have a mutually reinforcing relationship. On one side, smart cities and big data initiatives positively affect the establishment of ties in the network, thus increasing the density (cf. Kim et al., 2011). Furthermore, network effects (as the value of the network increases as the number of participants increases) could also explain firm adhesion to smart city initiatives. Therefore, more network density will imply more interactions and reinforce network effects, motivating firms to adhere to smart city initiatives. The reverse also applies; that high network density can positively affect smart city and big data initiatives. For example, open data are enabled by a high density network (Manville et al., 2014), while the data may also compensate for lost ties: logistic providers can, for instance, use big data to compensate for the lost links due to the retailers' evolution to direct-home consumer services (Brunson, 2013).

3.2.3 Centralisation

Smart cities and big data may stimulate more centralisation of information flows. Rather than companies being in the centre, data expects to be. Cai and Xu (2013), for example, report on big data mining techniques used by city transport planners in Beijing, to explore the impact of adopting plug-in hybrid electric cars in the taxi fleet on the life cycle of greenhouse gas emissions. This experiment was based on individual real time vehicle trajectory data for more than 10,000 taxis in one week and meant that planning was "local" while data was centralised. Firms can also learn to exploit big data through using real time information from sensors, radio frequency identification and other identifying devices to understand their business environments at a more rough level (Davenport, Barth, and Bean, 2012). The implementation of big data though depends on an enormous storage capacity and processing powers. Thus it will create opportunities for companies that are located in the middle of large amounts of data flows (e.g., information about products, buyers, suppliers, consumers, etc.) and are capable of aggregation and analysing them (cf. IBM, 2013; Manyika et al., 2011), indicating how certain companies may indeed become central in the supplier networks based on their access to and storage capability of, big data.

To summarise the supplier network design, complexity and density expect to rise, while company centralisation in the network may be shifted to data centralisation, or be replaced by companies with capacities to handle and store large amount of data. The complexity and density may foremost benefit the smart city initiatives and big data collection, while prove challenging for companies involving themselves in these initiatives.

3.3 Interplay between smart cities and supplier network innovation

The supplier network innovation aspects, smart city initiatives and big data expect to lead to many new ideas among organisations, and in their networks. Such ideas, in turn, may be grasped as opportunities, or be ways to solve obstacles as consequences of the initiatives. Below we describe and exemplify the process, elements, and boundaries related to such innovations.

3.3.1 Processes

Different types of smart city innovation will involve different "*processes*" - procurement, inventory management, demand management, order fulfilment, production, logistics and distribution, and product development. Big data here expects to play a critical part. City authorities and networks can use ever-growing bodies of data to improve understanding of citizen behaviour and service usage, and build transparency and accountability by opening up their records and statistics for public consumption - the growth of "*open data*". In Germany, progressive manufacturing companies in Germany are already investing in smart city-driven systems, which they believe will enable faster responses to changes in consumer demand and product innovation. This potentially opens up greater market opportunities for companies and more options for consumers.

Many big data applications are implemented far from the purposes for which the data was collected (Mayer-Schonenberger, 2013). For example, location information that mobile companies gather (so that they can efficiently route calls) can be used to make predictions on future capacities (Hayashi, 2014). Mobility patterns of consumers throughout the day can be tracked and combined with other sources such as credit card transactions, pictures posted on social networks, government, and open databases (cf. Harford, 2014). This may support the development of a "heat map" with geographically displayed information such as density of commercial transactions, average expenses, consumption location, etc., that may help to plan distribution or fine tune inventory levels (Manyika et al., 2011; Martinez and Rodriguez, 2012). According to Huang and Van Mieghem (2013), the use of clickstream tracking for inventory management in non-transactional websites can reduce the inventory holding and back ordering by 3% and 5% cost.

Shu and Barton (2012) suggest how firms can individualise trace data (ITD), that is, real time data as diverse as RFID tags on products or Internet Web Site logs with user's every click. They argue this generates both opportunities (e.g., to give early warnings to problems that may emerge later) and challenges (e.g., managers may overreact to normal variation present in real world systems).

Big data also becomes relevant in other mobility aspects. Traffic systems can provide short term predictions of the rates of traffic flow which can improve vehicle routing and transport planning (The Copenhagen Wheel, 2015; Manville et al., 2014; Schwartz, 2011). Electronic sensors in trucks or other modes of transportation can provide critical data such as real time data position, temperature, vibration of humidity which is especially useful for improving the distribution processes for perishable products. Smart traffic systems can be combined with smart parking to provide additional data to improve routing of deliveries. The increased use of sensors and Internet connectivity within cities have improved network processes by: "…*simplifying company processes, improving productivity, increasing efficiency, improving the ability of the supply-chain to deliver faster and better and reduce the cost through better coordination with information sharing. From a transaction cost perspective, reducing governance cost externally has internal benefits both forward and reverse along the supply chain"* (Chong et al., 2009, 151-152).

Industry standards are emerging for big and standard data interfaces that will facilitate smart manufacturing information flows. In the UK, the *Future Cities Catapult* (2014) suggests that big data will be called upon to "run things" and not just to deliver analytics. As big data and smart cities evolve it could remake factories into optimised and highly automated plants, goods will achieve greater speeds to market, with stepped up profits for companies since more goods can be routed to market faster. In industries like food and beverage, sensors that generate machine-driven information and automatic alerts already are widely used to measure the temperature and the humidity of containers that food products are shipped in, and also to track shipments from their points of origin to their final shipping destinations. "*The presence of standards and regulatory compliance requirements is one of the major drivers for the implementation of sensor systems. Governments across the globe have strict laws that mandate the use of sensors and other electronic devices that sense the risk involved in food contamination*." (Sankaranarayanan, 2014, 1)

By being involved in the debate on smart cities, companies can also help shape the market, for example, to see policies developed and implemented to match their own innovation, and research and development strategies, thus indicating how organisations are not only affected (positively and negatively) by smart cities, but may also affect their development.

The use of big data is not unproblematic though, and as discussed in the section on big data above. This relates to poor data quality (see e.g., Davies, 2014 on Mercedes self-driven trucks, where risks associates with data not being secure, how liabilities may not work, and how wrong decisions may be made about truck-drivers rests), how data from various sources may not be combinable, or fit the suggested purpose. False correlations and incorrect representation (such as the Google flu-spread prediction, Harford, 2014; Marcus and Davis, 2014) may lead to false decisions, and niche markets may not we well captured by such data. Indeed, organisations also face problems with using data, also should its quality be good and accurate (IBM, 2013), which delimits the use of big data.

3.3.2 Elements

As for the second characteristic, *elements,* new offerings would expect to rise from foci on climate change, sustainability, competitiveness, infrastructure, logistics or place-making. Technology would be in focus here, but also include products and services developed in other areas of the business that need adapting to the urban city context, rather than development from scratch. Linked to big data, new algorithms are needed which can summarise these vast quantities of process data.

3.3.3 Boundaries

The third characteristic, *boundaries,* suggests that an innovation can be introduced with different implications throughout the network. Different city functions such as health, energy, water, waste, communications, building and transport are to be integrated into networks intended to optimise their efficiency and outputs. New cities are being built with technology at their core to facilitate the creation of such integrated networks. Empirical examples include the South Korean, Songdo City which is technology designed to connect every component of the city including schools, offices, and homes. Residents will be able to control functions of their homes remotely. In Rio de Janeiro, IBM have created a central control system which integrates and analyses data from 30 city agencies including weather forecasts, traffic conditions and information from the emergency services (Cisco, 2014; Singer, 2012), thus also connecting city initiatives with consumers. Organisations within smart city "*boundaries"* could be using "*Machine to Machine*" networks to improve operational connectivity between factories, dockyards and shipping and realise the full benefit of close collaboration within a global supplier network based on the interoperability of inventory processes (Manville et al., 2014).

Additionally, new competitors could take advantage of both opportunities and restrictions and launch new competing business models. As smart cities deinstitutionalise existing ways of organising work, supplier networks form by altering the normative, cognitive, and regulative environments. They inadvertently reduce barriers to entry for new entrepreneurial firms by (a) increasing the availability of needed resources; (b) changing the nature of relations between sets of organisations; and (c) diminishing the ability of competitors to compete. When existing organisations are deinstitutionalised, resources – land, labour, machinery, employees and so forth – become available to entrepreneurs typically at a reduced cost. For example, when high technology firms failed in Silicon Valley in the 1980s displaced engineers were quickly hired by surrounding competitors or new start-ups. As organisational forms are deinstitutionalised the boundaries defining competitive relations and separate resource niches between organisational populations often blur which can cause a shift in how existing and emerging forms compete for resources. Organisations ability to defend their product space would also be severely weakened. When a form and the industry associations that support and promote that form become less legitimate, they are less able to persuade potential and current customers/investors or retailers in their value, utility, and overall quality of the product.

Related to boundaries, Toms and Filatochev (2004) though point out how city-based production systems could inhibit the growth of firms by promoting the formation of inward looking anti-entrepreneurial cliques. But while this may be the case, Katz and Bradley (2013) point out how cities indeed seek to reinvent themselves.

Hence, supplier network innovations suggest to foremost link to processes and then to big data. Here adoption of big data allows for supplier networks to receive input data that help in their planning, while it may also misguide the organisations. Resulting consequences also change boundaries and introduce new organisations, while the innovations (the elements) as such – but for continuous technological advancement – would not be as prevalent. An obstacle here connects to how processes, elements, and boundaries would need to develop in parallel (cf. European Commission, 2013a). Risks are, for instance, that organisations become trapped in the transition to new technology, while not reaching their full functionality (cf. Schiller, 2014). Rudin (2014) describes related aspects connected to the development of self-driven cars, where traffic risks are not reduced, for instance, and Schiller (2014) points to how self-driven cars may even lead to more traffic.

3.4 Performance

The examples we have used to illustrate smart city integration are at a small scale. Further it is evident in, for instance, the UK that there is a lack of clear examples of financial returns or economic benefits (Future Cities Catapult, 2014). Organisations and cities are still in an experimental phase of smart city production planning and there is a need for more substantive evidence of how public and private institutions can work together effectively on deploying city technologies in supplier networks. There also needs to be evidence of the demonstrable payoffs for citizens and cities, at city scale and not only in costs. Hard evidence of returns on investment are necessary for production planners, developers and for cities. The strongest performance examples for strengthening for now would be those that demonstrate cross-sector production activity with performance effects that were scalable (Manville et al., 2014).

4. Conclusion

In this paper, we draw on institutional theory to posit an integrative framework relating smart cities, big data, and supplier network design characteristics and innovation mechanisms. Despite the importance of this issue to both practitioners and researchers, we have yet to see a common framework for integrating smart city initiatives with supplier networks. Studies have analysed IT and disruptive innovation adoption in supply chains (Wu et al., 2013), but there are no studies which have focused on smart cities.

We have suggested that when smart cities are combined with big data and decentralised production networks the impact on supply chains/supplier networks can be significant. Therefore the main theoretical implication of this paper is the notion that the relationships between smart cities, big data, and supplier networks cannot be described by simply using a linear cause and effect framework. Accordingly we have proposed an integrative framework that can be used in future empirical studies to analyse smart city implications on supplier networks.

4.1 Managerial implications

The presented framework has several managerial implications. First it suggests that smart cities have limited capacity of improving supplier network processes, but they can support improvement initiatives. Secondly, we posit that despite benefits, smart cities can lead to obstacles for effective supplier network management. The framework helps to raise awareness of obstacles related to supplier network design and innovation, where organisations need to understand big data issues, and realise how the completive landscape may change as new actors enter. Opportunities driven by supplier networks rather than city initiatives connect to processes that link companies together in new ways, while such processes would be affected by conflicting objectives as networks become increasingly complex.

The social pressure, which suggests being coercive and imitative, indicate how organisations follow rather than lead developments. In the creation of new opportunities, niche markets not necessarily identified by big data, innovations related to sustainability and health aspects, for instance, and efforts taken on by networks of firms, may help organisations to take lead on developments. Additionally, through engaging in developments, the supplier networks can help shape the smart city initiatives, rather than the reverse. However, performance needs to be carefully pre-calculated.

4.2 Further research

This paper raises some interesting directions for future research. Drawing on Manville et al.'s (2014) and the European Commission's (2013a) distinction between "*top down*" or "*bottom up*" smart cities implementation approaches, a potential research direction could focus on the implications of firms proactive and reactive strategies. More specifically, it would be interesting to investigate under which condition firms should take the lead or adopt a more conservative approach with respect to smart cities.

Researchers should also investigate to what extent smart cities and big data shift the power structure within supplier networks. Smart cities and big data may have a significant role in altering power distribution within supplier networks, for example by providing firms with critical data on consumption patterns. According to a study by McKinsey Global Institute, big data will provide enormous opportunities for firms that are in the middle of large information flows that process millions of transactions or that interface with large numbers of consumers (Manyika et al., 2011). To examine how this will affect power relations within supply chains or network would be an interesting research line.

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