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Section ARTICLES

Super-Proximity and Spatial Development

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ABSTRACT: Our world is getting smaller all the time. Connectivity and accessibility in space have improved to an unprecedented degree compared to past centuries, thanks to the enhanced design and effective implementation of transport infrastructure networks and increasingly also as a result of advance cyber infrastructure networks. Our connected and accessible world has indeed become «a small world». Technological innovation has become a buzzword in the past decades. The design, implementation and adoption of digital technology, in particular, have prompted entirely new forms of spatial interaction and communication, with a significant and unprecedented impact on transport, trade, tourism, migration, and social contact networks. In today's increasingly innovation-driven society, almost every activity, action, task, communication, interaction, movement and decision is supported by new technological artifacts and inventions. This paper introduces the notion of «super-proximity» to highlight the force field of physical and virtual infrastructures at various geographical scale and time levels, and to sketch the spatial-economic implications of this universal megatrend towards zero distance-frictions. The paper will be concluded with some prospective observations on the future spatial implications of the e-society and their analysis.

JEL Classification: R1; R4; O3; O18; H54.

Keywords: super-proximity; density; accessibility; connectivity; proximity; infrastructure; innovation; Maslow; digital technology; spatial interaction and communication; transportation; networks; suprastructure.

RESUMEN: Nuestro mundo está siendo cada vez más pequeño. La conectividad y la accesibilidad han aumentado en un grado sin precedentes en relación con los siglos precedentes gracias a las mejoras en el diseño y en la puesta en práctica efectiva de redes de infraestructuras de transporte y, también, como consecuencia del avance de las ciber-infraestructuras. Nuestro mundo conectado y accesible se ha convertido efectivamente en «un pequeño mundo». La innovación tecnológica ya fue una referencia y un factor obligados en las pasadas décadas. El diseño y la implementación y la adopción de la tecnología digital, en particular, han impulsado

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nuevas formas de interacción espacial y de comunicación, con un significado y un impacto sin precedentes en el transporte, el comercio, el turismo, las migraciones y las redes de contactos sociales. En una sociedad como la de hoy, crecientemente liderada por la innovación, casi toda actividad, acción, tarea, comunicación, interacción, movimiento y decisión tienen como base nuevos artefactos tecnológicos y nuevos inventos. Este artículo introduce la noción de «super-proximidad» para subrayar el campo de fuerzas que las infraestructuras físicas y virtuales determinan en los niveles de la escala geográfica y en el factor tiempo, así como para bosquejar las implicaciones económico-espaciales de esta mega-tendencia universal hacia la reducción a cero de las fricciones que supone la distancia. El texto se cierra con algunas observaciones prospectivas sobre las futuras implicaciones espaciales de la e-sociedad y su análisis.

Clasificación JEL: R1; R4; O3; O18; H54.

Palabras clave: super-proximidad; densidad; accesibilidad; conectividad; proximidad; infraestructura; innovación; Maslow; tecnología digital; interacción y comunicación espacial; transportes; redes; supra-estructura.

1. It's a Small World

Our world is getting smaller all the time. While centuries ago, it took months or even years to reach the other end of the globe, nowadays we can reach any point on our planet in a few hours or days. Connectivity and accessibility have improved to an unprecedented degree compared to past centuries, thanks to the enhanced design and implementation of transport infrastructure networks and increasingly also as a result of cyber infrastructure networks. The space and time dimensions of transportation and information have almost collapsed to infinitesimal proportions, with an infinite real space-time proximity as the ultimate representation of the advanced space-economy.

It is noteworthy that nowadays physical and virtual connectivity infrastructures are not developed as independent entities: they act as both substitutes and complements (Batty, 2013; Neal, 2012). For example, the news on the «Arab Spring» took only a few seconds to reach the whole world (in contrast to long-lasting news transmission through postal services in the past); and it took reporters to be physically present on the spot only a few days. Our connected and accessible world has indeed become «a small world».

In this contribution, I will sketch the transition from a physically connected world to a virtually connected global system. This paper will use the notion of «super-proximity» to highlight the force field of physical and virtual infrastructures at various geographical scale and time levels, and to sketch the spatial-economic implications of this universal mega-trend towards zero distance-frictions.

The paper is organized as follows. Section 2 will provide a concise overview of the extant literature on the relationship between transport infrastructure and regional economic development. Then, in Section 3, the anticipated spatial effects of digital technology will be mapped out, as a result of the large-scale introduction of ICT. Next, Section 4 will conceptualize the above spatial connectivity and accessibility trends by introducing the notion of «super-proximity» in order to provide a broadly based understanding of the various forces involved with the rise of the «small world». Proximity features already for several decades in the geography literature. It may according to an early publication of Hansen (1959) be interpreted as the relative nearness of one place or person to all other relevant places or persons. From this description, it is clear that proximity may have a geographical dimension, but also a social —or any other— dimension.

The relevance of the notion of «super-proximity» in spatial planning will be illustrated by means of a presentation of empirical research on urban transport management through the use of digital information. This example offers an illustration concerning smart e-management of complex transport systems in urban areas. The paper will be concluded with some prospective observations on the future spatial implications of the e-society.

2. Transport Infrastructure and Regional Development

The efficient use of productive resources (e.g., capital, labour, knowledge, technology) is usually regarded as a prominent source of economic progress, in particular in an open and competitive economic system. International or interregional trade —one of the most important contributors to the wealth of nations or regions— is a welfare-enhancing vehicle, not only because of Ricardian comparative-cost advantages, but also because of the productivity-raising effect of reliable and fit-for-purpose infrastructure for a multiplicity of users. Thus, trade, transport and welfare are mutually interwoven phenomena (see also Krugman, 1991).

The role of transport infrastructure in inducing national or regional growth has received major attention in the past decades. This has led to much applied research on the anticipated effects of new infrastructure. Over the past decades a large number of studies has been undertaken to assess the economic impacts of infrastructure, not only roads, but also ports and railways. There is a widely shared belief that new infrastructure generates many benefits for the country or region concerned, as better infrastructure allows a more efficient use of scarce resources in the country or region at hand (Nijkamp, 1988). The focus on transport infrastructure has also led to much policy interest in infrastructure, e.g. in World Bank circles and in the EU. It has promped the development of a wide array of evaluation tools, such as social cost-benefit analysis in transportation planning. But the fundamental question whether transport infrastructure helps to mitigate welfare disparities is still an open question (see e.g. Celbis, 2015).

Since the early writings of Adam Smith, it is an accepted belief in economics that geographical accessibility and network connectivity are essential conditions for welfare improvement through trade and transport. Consequently, infrastructure provision is usually seen as a critical tool of public policy. There is an extant literature on the assessment of the implications of infrastructure for regional development (see e.g. Banister and Berechman, 2001; Crescenzi and Rodriguez-Pose, 2008; Rodriguez-Pose *et al.,* 2012). One of the first studies in this field has been undertaken by Mera (1973), followed later on by seminal and often quoted studies by Aschauer (1989), Munnell (1990), Duffy-Deno and Eberts (1991) and Lakshmanan (2011). These studies came up with positive welfare outcomes of public infrastructure, although their findings met sometimes criticism due to possible misinterpretations caused by the direction of causality, spurious correlations from non-stationary data, and omitted variables. Some authors recorded also a negative relationship between infrastructure and growth, for instance, Eisner (1991), Tatom (1991), and Evans and Karres (1994). In subsequent studies by Holtz-Eakin and Schwartz (1995) and Boarnet (1998), a more thorough analysis was carried out by investigating also networks and spillover effects. In a comparative meta-analytical study by Nijkamp and Poot (2007), based on many quantitative studies, the authors arrived at the conclusion that —next to public expenditures for education and research— infrastructure investments tend to provide generally positive welfare outcomes for the economy concerned. These findings were in later studies confirmed by Celbis *et al.* (2015) and Elburz *et al.* (2015).

In a review article by Nijkamp (1988), the following caveats were mentioned in scientific impact assessment of transport infrastructure:

- performance measurement in terms of input indicators (e.g. investments, width and length of infrastructure, etc.);
- performance measurement in terms of output indicators (e.g., gross value added, productivity rise, number of jobs, etc.);
- sensitivity of findings for the spatial scale of impact assessment (e.g., local vs. regional);
- definition of infrastructure *per se*, in terms of productive or consumptive contributions to the economy;
- time horizon covered by the investigation period (e.g., one year vs. a few decades);
- distinction between direct effects, indirect effects and long-term generative affects;
- systemic effects on the entire economy concerned (e.g., wage effects, price effects, etc.);
- sensitivity of the results for the initial situation vs. a mature situation of the economy concerned (e.g., incremental or marginal effects vs. integral effects);
- implications of removal of serious bottlenecks in the infrastructure use vs. marginal improvement of existing conditions;
- implications of infrastructure segment improvements vs. comprehensive network adjustments;
- ways of financing new infrastructure provisions (e.g., private vs. public modes of financing);
- presence of positive and negative externalities involved in the building and operation of infrastructure;

— heterogeneity of different types of infrastructure, with varying consequences for regional welfare.

It is noteworthy that over the course of time the interest in infrastructure impact assessment has shifted from a purely physical transport link effect to a broader transport network effect, including various spillover effects on a systemic basis. Recent examples can be found inter alia in Alvarez-Ayuso *et al.* (2016), Cantos *et al.* (2005), Chandra and Thompson (2007), Condeco-Melharado (2011), Delgado and Alvarez (2007), and Gutierrez *et al.* (2011). The final wisdom in transportation planning suggests that physical infrastructure has overall a positive economic impact.

As time passed by, new forms of infrastructure came into being. The most prominent new form of infrastructure originated from the emergence of ICT, and is coined digital infrastructure (sometimes also called «suprastructure») related to information and communication transfer. This new technology has exerted an unprecedented effect on the welfare of nation, regions and cities. This will be discussed in the next section.

3. e-Technology in Space

Technological innovation has become a buzzword in the past decades. It is often seen as the critical vehicle through which economic progress is achieved. There is an avalanche of literature on the concept, origin and impact of technological innovation on the economic performance of regions or nations. Also the regional science literature witnesses a broad interest in the spatial aspects of innovative activities, including its governance aspects. Both evolutionary geography and spatial endogenous growth theory have offered major contributions to a better understanding of the nature and importance of technological progress for the socio-economic profile of cities and regions (see e.g., Boschma, 2005, and Nijkamp, 2008). A major strand of literature addresses the productivity enhancing capability of new technologies and the implications for regional growth and competitiveness (see e.g. Kourtit *et al.,* 2014). A more recent strand of research zooms in on the distance friction reduction of new technologies, especially in the area of ICT (see van Geenhuizen and Nijkamp, 2012).

The design, implementation and adoption of digital technology have prompted entirely new forms of spatial interaction and communication, with a significant and unprecedented impact on transport, trade, tourism, migration, and social contact networks. This development has induced an intense interest from the side of both the research and the policy community.

On the research side, the transition to the digital world has led to the emergence of many fashionable concepts in relation to regions and cities, such as digital regions (or cities), cyber-regions (or -cities), Silicon Valley regions (or cities), and the like. The digital world has even led to the concept of a «global» region or city. Clearly, besides the introduction of a new jargon, the introduction of cyberspace technology has also exerted great impacts on human, business and technological interactions in space. It has prompted also the rise of a new branch of geography, viz. cyber geography or internet geography (see Malecki, 2001). The emergence of this new field of research was instigated by the proposition of the «death of distance» (see Cairncross, 1997), as the result of the space-friction reducing character of digital technology, such as the internet. Further analysis of this phenomenon has led to a debate on the «world is flat» hypothesis (see Friedman, 2007) versus the «world is spiky» hypothesis (see McCann, 2008). Although both hypotheses are likely to have some validity, it has gradually become clear that cyberspace technology seems to reinforce the economies of density, proximity and connectivity of large cities and mega-cities, with the consequence that digital technology seems to induce more spatial concentration of human and business activity in large agglomerations. Thus, spatial ubiquity does not necessarily imply spatial dispersion. On the contrary, it seems plausible that the «death of distance» will prompt the rise of densely populated urban agglomerations (either in the form of large or mega-cities or in the form of poly-nuclear urban configurations).

On the policy side, the wide-spread use of advanced digital technology has exerted an unprecedented influence on the public sector, in the form of a wide variety of e-governance initiatives (e.g., electronic application for building permissions, electronic information supply by public authorities, local public alert systems in case of emergencies, etc.). Local e-governance has seen a booming development in the past years, and it is plausible that this development is still in its infancy. From a strategic perspective, the introduction of digital technology (see Caragliu *et al.,* 2011, Deakin, 2013; Hollands, 2008; Kourtit and Nijkamp, 2015) has also led to a world-wide interest in so-called «smart cities». Smart cities are based on a knowledge-intensive and high-tech orientation so as to achieve the highest socio-economic performance level of the city concerned. It goes without saying that cyber technology is a critical instrument in this field (see e.g., Allwinkle and Cruickshank, 2011; Carter, 2013; Dawes, 2009; Edmiston, 2003; Evans-Cowley and Hollander, 2010; and Musterd and Murie, 2010).

The above concise overview of the significance of digital technology for spatial development is by no means exhaustive or representative. But it highlights the systemic importance of ICT for spatial development, in particular urban areas. This new type of infrastructure —often termed «suprastructure»— will have an unprecedented impact on the evolution of the complex space-economy of our world.

4. Conceptualization of «Super-Proximity»

Infrastructure and suprastructure are broad concepts that are often associated with public overhead capital. In the context of the present study, our focus is on the spatial dimension of both physical infrastructure and virtual suprastructure, so that the issues to be addressed here are particularly zooming in on the geographic linkage aspects of infrastructure and suprastructure.

It is hard to imagine our daily life in the modern world without ICT. In today's increasingly innovation-driven society, almost every activity, action, task, communication, interaction, movement and decision is supported by new technological artifacts and inventions (e.g., androids, smartphones), with different functionalities at basic levels (Latour, 1992; Waelbers, 2009). In this context, Verbeek (2006, p. 364) argues that a continuous process of renewing and improving the quality of «technological artifacts» and tools, used in business and everyday life at both short and long distances (see Tranos *et al.,* 2013), forms «active mediators» that actively «co-shape people's being» needs and behaviour in our modern way of life (e.g., their perceptions and actions, needs and motives, communications and interactions, and experiences and existence). In other words, these resources create an important action platform to the benefit of urban (sub)systems.

As mentioned above, the specific geographic linkage orientation leads to due emphasis on three geographic space-shaping elements: *density*, *proximity* and *connectivity*. Density economies are related to geographic-economic scale advantages, while proximity economies concern mainly interactions among agents that are subjected to distance frictions of various kind. Finally, connectivity has to do with network links and transportation/communication patterns among network users. These three categories can be described in slightly greater detail as follows:

- economies of *density*: joint advantages of spatial concentration of various actors, actions and activities (see e.g., Nijkamp, 2008; Glaeser *et al.,* 1992; Andersson *et al.,* 2014; Arribas-Bel *et al.,* 2016);
- economies of *proximity*: benefits from physical or socio-psychological access of actors, stakeholders and activities to each other (see Boschma, 2005; Torre and Gilly, 2005; Tranos *et al.,* 2013);
- economies of *connectivity*: joint spatial advantages that emerge from network linkages or social capital —physical or virtual— among a diversity of groups of people, firms and activities (see Kourtit and Nijkamp, 2012, 2013, 2015).

It seems plausible that *proximity* is a central concept in this force field. This will now be further discussed.

There is a recent strand of literature on proximity analysis (see e.g., Torre and Wallet, 2014). A broad and interesting review of the proximity literature is given by Caragliu (2015). The concept of proximity is not only related to (inverse) geographic/physical distances between points or actors in space. Proximity may relate to any gravitational force that creates an above-average attractiveness between these points or agents that supersedes the physical gravity friction between them. According to Caragliu (2015), it makes sense to generalize distance (or inversely, gravitational attractiveness) in terms of *relational* proximity, defined as the intensity of interactions and cooperation among local actors, including firms and individuals. In his study, he makes a distinction into geographic (material or physical) proximity and non-geographic (relational, social or other) proximity.

Geographic proximity (**GP**) is the degree of spatial closeness among actors, measured in material terms (e.g., kilometres, time, etc.). The reverse of geographic proximity is of course the geographic distance often used in transport, mobility and trade models. Next, non-geographic, virtual or *relational proximity* (**RP**) is considered to be the intensity of non-physical interactions and cooperation among actors in space, including firms and individuals. This can be subdivided into:

— *Social proximity*: similarities of actors in terms of their social capital [shared common culture, behavioural codes, natural trust, and sense of belonging (see e.g. Basile *et al.* 2012)].
— *Institutional proximity*: the degree of homogeneity and compatibility of regional actors or stakeholders in terms of the set of constraints, guidelines, norms, and codes of conduct they voluntarily agree to follow.
— *Organized proximity*: different ways of being close to other agents, regardless of the degree of geographical proximity between agents, the qualifier «organized» referring to the arranged nature of human arrangements or activities (see e.g., Carayannis *et al.,* 2013; Torre and Lourimi, 2013).
— *Technological proximity*: the degree of shared technological experiences and benefits from a common knowledge base, in particular in terms of industry-related knowledge.
— *Cognitive proximity*: similarity of agents in terms of cognitive maps, domains of perception and cognitive programmes.

Comprising the latter five categories of relational proximity under the heading of **RP**, we may thus argue that the total proximity between actors or regions (denoted as **TP**) can be decomposed as follows:

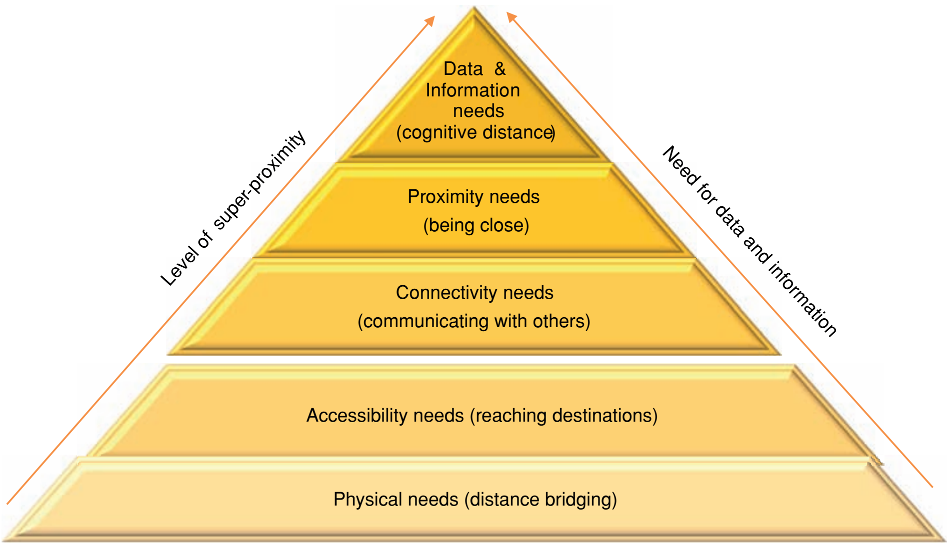
$$\mathbf{TP} = a\mathbf{GP} + b\mathbf{RP},$$

where a and b are distributional parameters indicating the relative strength of **GP** and **RP**.

Now the concept of *super-proximity* will be introduced. Super-proximity is formally defined as both a spatial and a non-spatial intensive degree of interaction and closeness among agents that reaches a maximum total advantage from closeness among relevant actors or agents. Clearly, there may be a trade-off between **GP** and **RP**, in the sense that a relatively low level of **GP** may be compensated by an extremely high level of **RP**. If we assume that the locational socio-economic landscape of agents is (co-) determined by **TP**, we may in principle observe a heterogeneous spatial landscape of agents where geographic concentration and dispersion may both simultaneously take place, depending on the two main constituents of **TP** and the varied preferences of agents for each of these determinants.

The «super-proximity» concept reflects the highest possible long-term added value or utility-enhancing performance of a multifunctional and synergic innovative urban system as a result of strongly interlinked density, proximity and connectivity advantages (physical or virtual) among a heterogeneous set of organizations, people, goods, and services. Proximity may be seen as a societal need that manifests itself in different functions in a hierarchical system of needs. The hierarchical fundamental needs of creative —physical or virtual— «active mediators», with the focus on smart mobility, intense communication, (big) data and information access, and data exchange between different actors in the urban space —as the source of a «buzz economy» (see Storper and Venables, 2004)— tends to be critical in maximizing the added value from its assets on the basis of «super-proximity». A better understanding and conceptualization of the multiple levels of prioritized quality factors and conditions in a systematic hierarchy of these resources in combination with physical and virtual dimensions can be obtained by employing Maslow's pyramid (1943) on hierarchy of needs as an analytical metaphor for a transition from physical proximity towards modern virtual proximity, leading to a high synergic added value from «super-proximity» (see Figure 1).

Figure 1. Adjusted Maslow's needs pyramid (1943)



Source: Author's own work.

This pyramid consists of different levels of suprastructure related to data, information and communication transfer, while representing needs and requirements set by demand and supply among heterogeneous classes of stakeholders in a globalized digital world. In this context, the interpretation of this transition model suggests that the basic lower-level needs and requirements must be met before shifting from traditional assets and historical data and information systems to more advanced information technologies for which innovation and skills are necessary cognitive conditions.

This simple conceptualisation makes also clear that the «death of distance», the «flat world» and the «spiky world» ideas may be different —though not mutually contradicting— manifestations of the proximity principle in space. The spatial map of interactions and locations is determined by the relative power of **GP** versus **RP**.

The policy implication of the super-proximity principle is far reaching. Spatial development including urban and regional dynamics is not only determined by proximity infrastructure in a traditional sense (roads, (air)ports, railways, etc.), but also by virtual proximity (e.g., through internet, GPS, GSM, sensors, detection camera's, digital communication networks, etc.). Both deserve to be an integral part of urban and regional policy. Thus, given the combined benefits of **GP** and **RP**, a balanced urban and regional strategy should respect both the real and virtual proximity (in terms of both infrastructure and suprastructure). The next section will be devoted to an illustration of the potential of suprastructure for urban planning.

5. Urban Traffic Management in a Digital City [1]

Super-proximity has both a spatial, a virtual and a time dimension, as it means that human activities can be coincide in almost the same place (physical or virtual) and in almost the same time. This concept plays a critical role in the management of the public urban space, e.g. crowd management, incident control, contingency management, and so forth. In other words, super-proximity has a particular relevance in short-term urban policies that address instantaneous interventions on e.g. demand, behavior or incidences, while it may also play an important role in preventive strategies (e.g., security control). Clearly, digital technology is able to reduce space-time frictions significantly and is the critical vehicle for *super-proximity*.

Digital space-time information is a *sine qua non* for modern effective traffic management in cities. Successful traffic incident management requires a high level of collaboration and coordination of traffic control agencies and relies in particular on flexible communications and information systems for incidence management (IM). «Early and reliable detection and verification of the incident together with integrated traffic management strategies may provide important contributions, which improve the efficiency of the incident response» (Steenbruggen *et al.*, 2014, p. 93). Therefore, it is crucial to have real-time situational interfaces in traffic management systems for monitoring purposes. «Situation awareness for mobility (the ability to understand on the spot the status and consequences of an incident in support of decision making) is essential to reach almost any other objective of IM improvement» (Steenbruggen *et al.*, 2013a, p. 236).

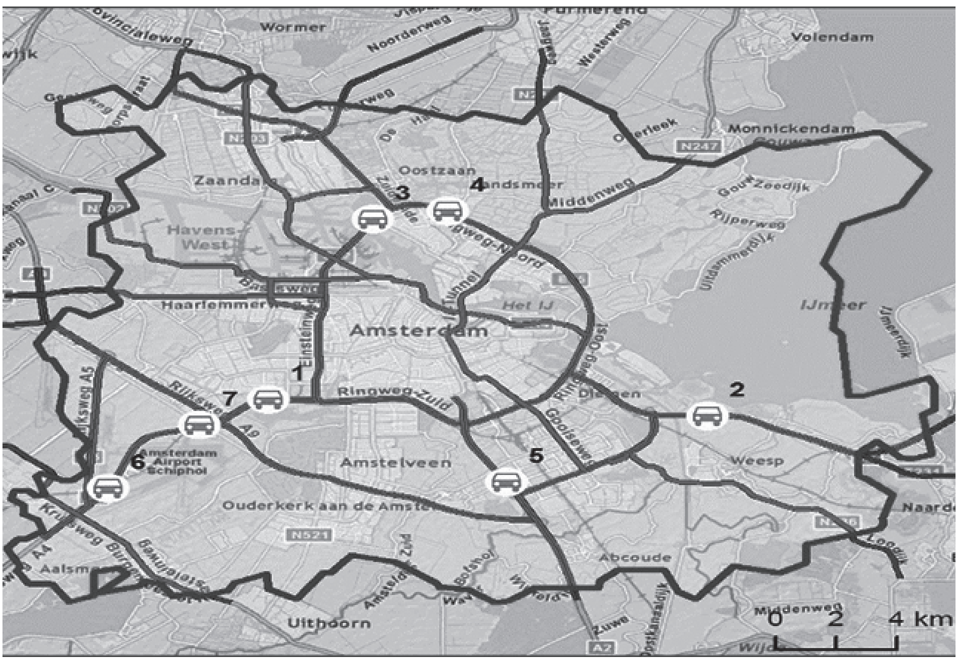
The measurement of mobility dynamics usually relies on established technologies, such as cameras or loop detectors. These are dependable methods, but their costs and installation complexity has prevented so far a full coverage of the road infrastructure, leading to a selective installation on highways and some major urban roads. This limits situation awareness and hampers decision-making ability for transportation in general, and IM in particular. In the last ten years, a number of technologies have been introduced to satisfy the growing demand for timely and accurate spatial-temporal information on mobility flows and their origin-destination patterns. These approaches exploit technology-based mobile devices and sensor networks as a way to collect spatio-temporal data on people and mobility without the need of installing an ad-hoc infrastructure. These super-proximity tools cover

[1] The author wishes to thank John Steenbruggen for his input to this section.

the entire network and all mobility modes, and are thus a perfect complement to existing loop/camera detection in order to provide universal coverage of the entire network, transportation modes and territory at reasonable costs. For an overview of the use of telecom data in the field of transportation, I refer to Steenbruggen *et al.* (2013a, b).

This section will illustrate of the use of mobile phone to improve the situational interface of a traffic management centre. In order to understand how the mobile phone network is geared towards road traffic incidents, occurring on ring roads and immediate highway connections in the metropolitan area of Amsterdam the traffic management centre uses various information sources, including smartphone data in real time. The following criteria were used to select relevant incidents: events had to happen between the period 01-01-2010 and 31-12-2010; events had to fall within a specific area to match the mobile phone operator cells coverage (see Figure 2), and events had to be of a certain critical magnitude. In the analysis four different digital measurements were used. Three of them capture the aggregated use of the mobile phone network: «number of received calls (Terminating Calls - TC), number of executed calls (Originating calls - OC), and number of text messages (SMS), both sent and received» (Steenbruggen *et al.,* 2013b). The fourth measurement contains the sum of these counters (the so-called Index of Human Activities - IHA).

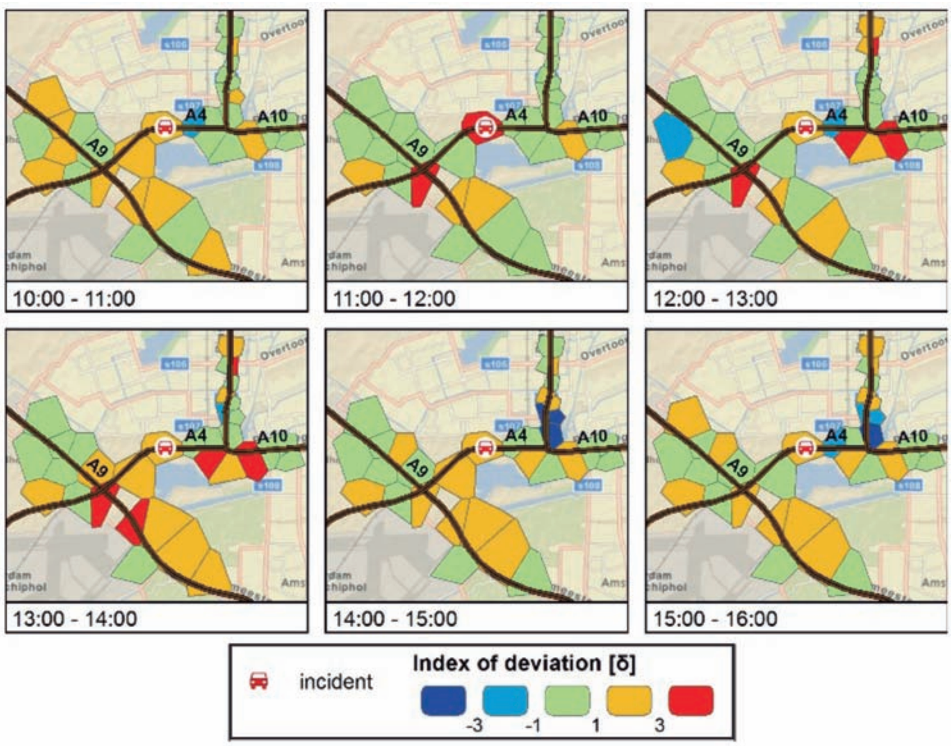
Figure 2. Area for the analysis and the location of selected incidents in Amsterdam



Source: Steenbruggen *et al.* (2010), p. 25.

A more detailed and simple example of a single incident analysis based on digital information management will now be given (see Figure 3). This incident took place on 10-06-2010 (Thursday), on 1.9 km of the A4 highway, between its intersections with highways A10 and A9 of the Amsterdam ringroad. It started at 11:48 and was managed until 13:37. The accident was caused by a previous traffic jam, and thus a relatively high number of travelers affected by the abnormal situation may be expected. The incident can be classified as «major», as it involved this time three cars and a truck. The direction of the flow was «toward the city» (eastern); nevertheless, the lanes on both sides of the highway were blocked. This means that repercussions for the traffic flow should be expected in both directions. To understand and manage the traffic complications caused by this incident, in terms of repercussions on the telecom network, 33 cells within a distance of 3 km from the incident location were considered. A simplified hour-by-hour sequence related to the Index of Deviations for the Index of

Figure 3. Index of deviation of the IHA counter before, during, and after an incident (highway A4 at km 1.9, date 10-06-2010, time period between 11:48-13:37)



Source: Steenbruggen *et al.* (2010), p. 28[2].

[2] Rijkswaterstaat data base «MoniGraph» 3.0 (2016), *https://staticresources.rijkswaterstaat.nl/binaries/MoniGraph%20Handleiding%20versie%203.1.0_tcm21-13729.pdf.*

Human Activities (IHA) is presented in Figure 3. This figure shows that for the hour that the incident happened (11:00-12:00), we can observe a high anomaly precisely at the incident location. In the next two hours, the anomalous situation appears to spread out to the nearby intersections of the A4 with the A9 and the A10, which can be interpreted as the activity of people who got stuck while trying to enter the affected segment of the A4. Moreover, serious traffic implications in the further part of the network is also visible, namely at the junction of the A10 with the S106. The road sections around the incident, mainly sections of the A4 and the A9, were also within the class of increased IHA deviations. After 14:00, the situation seemed to slowly come back to normal, as there are more green and orange colours present on the maps.

To validate the IHA on the telecom network, so-called speed plots were used based on detection loop data provided by the traffic management centre (see Figure 4), selected two km before and after the incident location. For the time interval the whole 2 hours» time slot was chosen, before and after the accident occurred. This is between 10:00-16:00 hrs. As clearly indicated on the plot, the right-hand side of the highway was affected by the incident where a large decrease in speed is shown (see red area on plot 4A). It started exactly when the incident was detected on 11:48 and lasted till around 13:30. Also, we can clearly see that after the exact incident location at km 1.9, traffic speed seemed to stabilize back to normal. The left-hand side of the highway was not affected by the incident. Only just before 16:00 hrs, the left-hand side of the highway seemed to be affected by regular traffic jams.

Figure 4. Speed plots related to incident on highway

Figure 4A. Speed plots during and after incident 1 (10-06-2010, 11:48-13:37) on the right-hand (same period) side of the highway

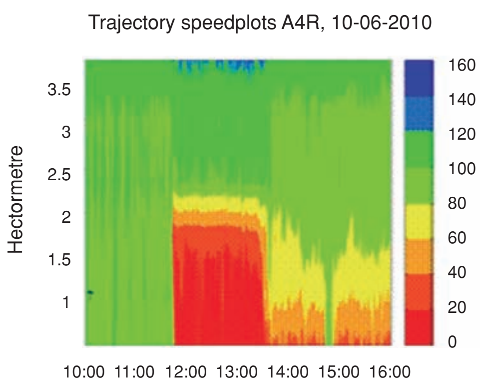
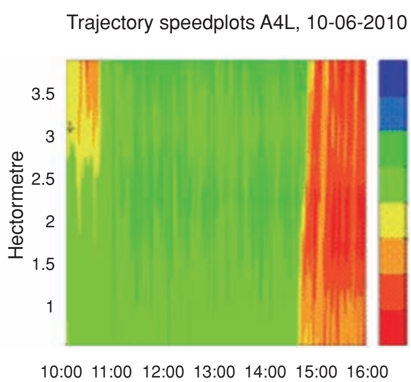


Figure 4B. Speed plots on the left-hand side of the highway (same period)



Source: Rijkswaterstaat data base tool «MoniGraph» 3.0 (2010)[3].

[3] Rijkswaterstaat data base «MoniGraph» 3.0 (2016), *https://staticresources.rijkswaterstaat.nl/binaries/MoniGraph%20Handleiding%20versie%203.1.0_tcm21-13729.pdf.*

The above sketch of the potential of digital information management in traffic planning shows that the digital era has far-reaching effects on urban planning. It enhances the speed of decision-making and provides much better insights into complex decision situations. Consequently, digital suprastructure has two major benefits: it improves the effectiveness and enhances the benefits of public intervention of a smart city in a global sense, and it helps to solve real-time issues in the case of «super-proximity».

6. Prospect

Infrastructure and suprastructure are the cornerstones of urban and regional development. They provide productivity-enhancing opportunities for cities and regions, through economies of density, proximity and connectivity. The present paper has highlighted the importance of proximity as a core concept in understanding and explaining the competitive position of cities and regions. Our study has in particular addressed the emerging importance of suprastructure (virtual infrastructure) in generating a high added value from virtual or relational proximity characterized through various dimensions (e.g., social, technological, etc.). In this context, the notion of *super-proximity* has been introduced to emphasize that spatial dynamics (e.g., urban or regional development) is the result of various gravitational forces —of both a material and a virtual nature— that in combination shape the space economy. Consequently, a given level of economic development of a city or region can be achieved with different combinations of physical and virtual proximity measures.

It should be added that especially large urban agglomerations have turned into big data machines, with an enormously complex system of physical and virtual interactions. The rise of digital technology has provided many new opportunities for efficiency increase and service improvement in the public sector, but at the same time the business sector is also able to reap many benefits from advanced ICT use. And therefore, it is pertinent for public policy to ensure a high degree of relational proximity in cities and regions, in addition to physical accessibility and connectivity provisions. This issue prompts of course the question whether and how virtual infrastructure may become a discriminating part of a specific urban or regional development strategy, given the fact that various suprastructure provisions tend to become ubiquitous and less spatially differentiated. It is clearly a great future challenge to develop novel methods for spatial impact analysis in the context of an overall policy strategy on city-specific or region-specific super-proximity as an overarching principle for improvement of performance and competitiveness of cities and regions.

Finally, digital technology may also diminish the gap between policy-making bodies and citizens. e-Governance is a modern way for cities to provide open access liaisons to people. This may lay the foundation of on interactive and participatory strategy in future urban and regional planning, as citizens and administration are more geared towards each other. In other words, the trend to «super-proximity» may benefit the legitimacy of our democratic systems.

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