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ECONOMIC BASIS FOR FUNCTIONING OF A SMART CITY

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Abstract: The paper attempted to define the basis of city transformations that conform to the smart concept. The objective of the paper is to relate the concept of a smart city, which is quite frequently discussed in literature related to the subject, with functioning and development of the city's economy, in a way that would allow monitoring economic processes taking place in the city, and also to find a response to the question as to the extent to which the smart city creates a new city economy. Does it expand the city economy by new elements, generate new economic mechanisms, allow the implementation of growth paths different than those to date? This objective is particularised by a description of selected issues of urban economics. With this in mind the paper discusses an approach to managing supply and demand on the basis of theoretical assumptions defined by Mudie and Cottam (1993) transposed on realities connected with provision of municipal public services in conditions of a smart city. Furthermore, sample solutions were presented related to the smart city, which reflect theoretical conclusions contained in the paper. The paper ends with a presentation of logics related to growing economy in a smart city. The economy of a smart city, ultimately an intelligent economy of the city, is created in a laminar way. Under the pressure of technological, social and political surroundings the city is permeated by social and culture intelligence, forming gradually a new economic quality. In the paper we emphasised that the concept of a smart city still remains a question of the future to a much bigger extent than one of the present time. A smart city slowly emerges from the combination of diverse megatrends and development trends characteristic for communities and economies of the second decade of the 21st century.

Keywords: Cognitive city, demand management, intelligent city, smart city, supply management, urban development, urban economics.

JEL codes: H41, H44, O33

Introduction

The concept of a smart city is being adopted in an increasingly widespread way. Theoreticians of urban economics, urban planning or urban management present diverse concepts of a smart city. City authorities are intensely investing into the ICT infrastructure. Offers of various technological companies force households and local communities to use municipal services under new intelligent procedures. A smart city in its model form does not exist yet; it is still in the process of its construction, and almost imperceptibly transforms diverse spheres of municipal life. It also causes changes to the economy of the city. Intelligent economy of the city appears in general outline as a component of a vision for the future of the city. Already today we can speak of the issue describing the progress of economy in a smart city.

The objective of this paper is to correlate the concept of a smart city that is frequently taken up in literature of the subject with functioning and development of city economy in a way that would enable monitoring economic processes in the city, and finding out the extent to which a smart city creates a new municipal economy. The creation of a new smart economy of the city is understood here in a wider sense than what is generally called smart economy in literature. In this aspect it may be understood as certain types of organisation of innovative processes aimed at facilitating the development of knowledge economy. The paper endeavours to ascertain the degree to which the concept of a smart city expands the municipal economy by new components, generates new economic mechanisms and allows the implementation of development paths different than those existing to date. This objective is presented in the paper by a description of selected issues of municipal economy. In this respect characteristics have been provided to the approach to managing demand and supply in a smart city, pursuant to theoretical assumptions defined by Mudie and Cottam (1993) transposed onto realities related to the provision of municipal public services in conditions of a smart city, which reflect the theoretical reflections contained in the paper.

For the majority of cities functioning worldwide a smart city tends to be merely an idea, a concept to a much bigger extent than reality. Yet the process of creating smart cities has already been commenced, and is presently in its initial phase. This may be seen from supply and demand relations and a change in the behaviour of entities involved in city economy which are presently functioning in the realities of new intelligent technologies used for municipal services.

1. New intelligent technologies in functioning of local communities

Presently we may observe two intertwining megatrends that define a town and urbanity in the past decades. They include post-modernity (Czornik and Gibas 2012) and technologisation (Melosik 2016). In the spirit of post-modernity in towns completely new attitudes of the inhabitants come to life, which generate

new types of behaviour – on the one hand they impose on the sector of private and public services expectations never encountered beforehand; on the other hand they are favourable to the appearance of citizens' initiatives (of smaller or larger social groups), which owing to those expectations are capable of modifying the reality on their own in an *ad hoc* way or exert strong pressure on the town, its inhabitants and municipal authorities in connection with ideas promoted by them. Such new types of social participation tend to function on a generally definitely established (and hence in many cases also stereotype in nature and excessively politicised) democratic structure of the local self-government or beyond such structures. They may comprise one-off actions, “fleeting concepts”, but on the other hand they also may become rooted permanently in the identity of the given city. The second of the above mentioned ideas – technologisation – is in many cases perfectly in line with post-modernity. This arises from the fact that it not only entails an ever increasing technical capacity, thanks to which there is more infrastructure in cities, including: automation systems, electronic accessories, optical fibre systems *etc.* and specialist technical solutions serving the needs of providing various types specific services with the use of that infrastructure. The contemporary form of technologisation means an increasing involvement of participant/user in the utilisation of technologies, coming close to joint creation of solutions or behaviour. In this aspect the development of mobile technologies, the Internet and social networks created with their use opened up completely new interaction models within the structure: inhabitant – inhabitants – town – municipal authorities – service providers.

On the basis of changes taking place in the past few years outlined synthetically above the concept of a smart city was born, which has quite quickly gained lots of followers. Smart city has become a certain key word, an all-embracing and attractive notion that allows propagating the idea of such changes to the city not only to business, but also to social movements, as well as municipal authorities and research communities, which comprise the following:

- dynamic responding to needs and behaviour of city inhabitants – the user can remain in close interaction, *e.g.* by using ICT technologies, with city authorities and organisers of municipal public services;
- including town users in the process of compiling information in the city and connected with the city – in such a way the user becomes a carrier of information by providing information about selected issues in an ongoing way (*e.g.* send notices on hazards to the security), but also thanks to the fact its behaviour is being monitored and aggregated with the behaviour of other users (vision monitoring, monitoring of road, using geolocation services in mobile devices, analysing the contents of notices in social media portals *etc.*);
- usage of ICT technologies for compilation, processing and providing access to data, including big data, data relating the town, for needs of dynamic submission of feedback for the needs of managing the town and for streamlining the everyday functioning of its users.

Hence in a wider concept a smart city may be understood as a “good” city; a city offering high living quality; a city that is governed in a modern way, with a high social participation, with numerous interactions between the authorities, the inhabitants

and the remaining town users. This concept of a city implies a city in which processes of service provision, first of all public ones, and social participatory processes are supported by solutions in the scope of ICT technologies, first of all those that allow interactions between the authorities, inhabitants and the remaining town users, and enable obtaining quick feedback, and in many cases are based on big data obtained from the city space”.

It is worth bearing in mind that for the present a smart city still remains a certain concept, and in many cases a slogan. This is not an issue that can hardly be considered as theory of urban development. Despite the fact that recently smart city is being readily used as an object of scientific research, it should rather be treated as an issue for the experts or a certain model for city governance. Authors of a major British foresighting undertaking relating to the future of cities (Moir *et al.* 2014) present statistics of the occurrence of terms describing urbanity, and indicated that in English literature the dominating terms summarising the scientific discourse or related to policy programming are sustainable cities, and then smart cities. They also draw attention to the fact that recently appeared at least a few key words, which present a hybrid approach to development (Table 1) – they seem to be very close to the deliberations adopted in this paper.

Table 1. Hybrid concepts of towns of the future

Name	Main components
Attractive city	Social and economic
Smart city	Environmental and managerial
Digital city	Environmental and managerial
Resilient city	Economic and environmental
Intelligent city	Economic and administrative
Networked city	Economic and administrative

Source: (Moir *et al.* 2014).

An analysis of the contents of the above presented table shows that it is not easy to provide an unambiguous differentiation of the intertwining concepts. This concerns in particular the differentiation of notions of smart city and intelligent city. As a rule the term smart cities is basically used for advanced municipal systems which make use of data and technology to achieve the effect of integrated managements and interoperability, but may also contain wider meanings that reflect social and political manifestations of smartness. Authors of the cited British foresight emphasise that in numerous cases the term intelligent cities is used alternatively to smart cities, although the concept basically dates back to the concept of virtual cities from the 1990s. Quite frequently the term intelligent city is used to describe the utilisation of municipal infrastructure and virtual space, aimed at strengthening local innovation systems, problem solving and creation of public services more appropriate for the current needs of the users (Komninos 2012: 201-208). However, there are also

certain approaches that describe relations between those concepts in a different way. For example Zygiaris (2012) in his seven-layered model of the smart city assumes that the technical set of instruments does not determine the intelligence of a city. This is due to the fact that the latter one comprises three last levels of the model and namely: level of open integration, level of application and the level of innovativeness. Recently an increasing popularity is gained by the notion of a cognitive city, which is characterised by the ability of memory creation based on experience and observation (Moyser and Uffer 2016). This concept will be discussed in more detail in the further part of this paper.

2. Towards a new intelligent economy in a town

The smart city concept arose from an impact of several megatrends present in the life of a contemporary city. Our paper places emphasis on post-modernity, in which present societies and local communities live, and technologisation, which comprises not only modern business, but also everyday functioning of people in places of their residence, work or recreation. Technological development is present in modern economies, including also the economy of cities. It is generated by large scale business, which seems to be “attacking” all spheres of the economy with new technologically advanced products. As an effect the social intelligence of a city, which is reflected in the human and social capital, must also become smart (Deakin 2014: 15-19). The formation of a smart city’s economy may be presented as a process of collective learning. In this respect many styles of learning may be observed (Campbell 2012: 40-52, 101-180). Intelligent economy is permeating into cities via many channels of marketing and social communication. With this in mind it is possible to formulate a general research question: whether and in what way intelligent products and technologies created on the basis of ICT that are generally available in the city form an economy of a smart city. The question regarding economy of a smart city in understanding of a smart city is in reality made of a series of questions which may be grouped into two sets. The first set may be called elementary questions – about new elements in the city’s economy. The second set concerns structural transformations in the municipal economy and formulates a research problem as a problem of the creation of an economic structure of the town of a new quality as an intelligent economy.

The basic questions concern the following:

- new resources created and/or expanded based on systems and networks of intelligent technologies, including those that form a new structure of the city,
- new municipal products/services, which have appeared in the city based on intelligent technologies,
- new supply/demand relations between old and new entities of the city’s economy,
- new forms of organisation of various spheres of the city’s economy, including the sphere of city/municipal services,
- new factors of economic growth in the city.

The above questions are of a factorial nature. The response to those questions allows the identification of new components present in the city's economy. They may, but do not have necessarily to become factors transforming the town's economy.

Structural questions refer to complex notions. They suggest diverse complex phenomena, processes, actions occurring in the city's economy, as a result of which the following may occur:

- new specialisations of the city's economy,
- new sectors of the city's economy,
- new municipal markets,
- new business models,
- new municipal development paths.

The above presented items gradually outline a new city's economy, which has been born on the basis of intelligent technologies and products and the intelligent behaviour of diverse entities operating in the city.

The question as to new resources created during the establishment of an intelligent city may in a certain simplification be brought down to the question about human resources and infrastructure permanently installed in the city. Devices and procedures generated by new ICT technologies are appearing in an individual way: in households, in work places, in public spaces that assure their availability to every individual entity. This kind of supply pressure, which in the majority of cases is initiated by business, sometimes by the authorities and municipal organisations, gives rise to an inclination to advance qualifications in all groups and local communities of a city. It may attract human capital with high competencies connected with the common everyday usage of ICT to the city. In this way, the commencement of intelligent development initiates the increase of human resources with high intelligent competencies in the city. The resources comprising a new generation of people appear in the town as soon as the "intelligence" acquires a social character, and *social intelligence* is thus created (Deakin 2014: 218-219).

The second important resource are municipal technical infrastructure used to handle ICT, produced in most cases as a result of implementation of development projects in the sphere of intelligent growth of a city or municipal e-services. The installation of such municipal infrastructure appears to be of a "mass" nature, although not necessarily in all cases must it be strictly correlated with the implementation of a certain strategic line under the development of the city towards the concept of the smart city. The fact that such infrastructure expands the municipal resources and in the future may be used as infrastructure of a smart city appears to be of great importance.

New municipal products or services created on the basis of intelligent technologies and those that meet technical standards of a smart city tend to appear in cities on the one hand under the impact of business offers of diverse companies, and on the other hand under the impact of diverse administrative procedures and standards that impose changes to ways in which services are provided. Furthermore, this opens considerable possibilities for citizens community activity, which may be easily manifested by social networking platforms, in control processes of meeting ecological standards or in control of following access rules to social services. All this

gradually gives rise to new services that serve households, companies operating in the city and municipal entities serving the inhabitants and assuring the effectiveness of diverse functional and spatial systems of a city.

Changes in supply and demand relations may be perceived as an evident syndrome of a new intelligent economy of a city. The offer of new products and services comprising an inherent variety of intelligent technologies based on operating procedures tends to create practically automatically new relations with clients and with citizens of the city, offers new possibilities for presentation of the supply offer and causes changed behaviour on the demand side. The universal acceptance of new presentation methods of the product offer and provision of municipal services requires adopting a change in behaviour both on the part of the entity offering the service, and on the part of service recipient. Changes on the part of recipients – users of municipal services may be considered as a process of social change, on which depends the rate of establishment of a new economy of the city.

The developmental progress of a smart city is also manifested in new organisational forms of municipal economy, including the municipal economy directly organised by the town's authorities. New resources, new products offered to the town and new forms of relations with the clients and entities offering the services exert a dynamic pressure on the organisational structure of municipal economy. This may already be seen nowadays in the water supply and sewage disposal systems and in waste disposal and organisation of municipal transport. Completely new organisational structures appear in the sphere of energy effectiveness of the town, which affects housing economy and spatial development based on passive building industry.

A keystone of questions pertaining to new elements/components of the city's economy is a question about new factors of economic growth in the city. Intelligent technologies and products as well as intelligent municipal resources may be perceived as an avant-garde of technological and creative economy. On the whole this may significantly increase the attractiveness of the city for external investors and for demanding residents representing different segments of the creative class. The concept of a smart city seems to be closer to the technological economy developed within the logical sequence: from scientific research and research and development works to new technologies and intelligent technologically advanced products present in municipal economy. A smart city based in the first place on ICT may prove to be favourable to the development of economic activity based on artistic creativity. Nowadays major culture events are in reality also events based on the utilisation of intelligent technologies and products. A smart city may also generate obstacles to economic growth. In such a case this is caused by the excessively high cost of functioning of smart municipal services and adverse external effects generated by an excessively developed infrastructure of those services.

The creation process of a new economy of a smart city may be observed via certain synthetic categories depicting the high advancement level of this process. In the first place this is about new intelligent economic specialisations. Intelligent specialisation of a city is a certain form of representation of those resources and capital, which jointly form innovation potential and creative capital (Malik 2013). The new specialisation of the city formed thanks to the city smartness will have the

features of smart specialisation. In practical terms this does not need to be a smart specialisation in the full meaning of that word.

New economic specialisations, once they have reached a certain state of embedding in the city, become a basis for a change of the city's sectoral structure. In this aspect it may be said that the creation process of an intelligent city directly generates new smart specialisations. New, albeit not necessarily smart specialisations, may also be established in an indirect way, as an effect of the growth of attractiveness of a smart city and attracting to the city other forms of activity and investors representing economic sectors which to date have not been existing in the town.

The development mechanism of a smart city becomes clearly apparent in the sphere of the market and the competition. Intelligent products and services, even with view to their virtual component, begin to launch new markets, such as in the system of internet sales. They also cause changes in the structure of old markets by placing new products on them and a change in market behaviour of old and new market participants. The core part of market changes is a change in the relation between demand and supply: other forms of contact and information flow, rate of response to changes and adaptation to new circumstances.

Companies involved in co-creation of an intelligent economy of a city – which generally applies to ICT in management of own resources and assets and contacts with the customers – begin to gradually implement new business models. The place of traditional solid corporation based on large scale economies is now assumed by a company capable of undertaking high risk in placing on the market products generated on the basis of innovative solutions, frequently from the sphere of cutting edge innovations. In the sphere of municipal services and urban economy, the appearance of new management models may be perceived primarily in the application of management methods worked out on the theoretical and practical basis of a concept called new public management. This concerns primarily trends of that concept which propose advanced commercialisation of public services and business style of managing public issues (Hood 1991). Such an approach, although as such is not smart, allows municipal companies to enter in a more effective way the functioning system of intelligent municipal services.

The economy of a smart city comprises two segments: a traditional segment, based on sectors and economic specialisations functioning to date in the city, and a new segment, which is being generated with respect to various forms of research and development activity, manufacturing and services of technological entities and creative economy companies. The municipal economy, including the sphere of municipal services, is present in the first and the second economic segment. A smart city should be perceived as a concept *in statu nascendi*. Many cities enter the growth path of a smart city; some of them in a declarative way and with a clearly defined strategic concept, while others based on a strategic drift. However, in any case this is an entry on a new growth path with all consequences of a change to this growth path, e.g. a loss of a part of the development potential, getting stuck on the path, break down of the hitherto competitive strength (Gwosdz 2014: 63-86). In a smart city we generally tend to seek a “strategic occasion” for radical improvement of the competitive position of a city. A question as to the nature of the development

path chosen by a smart city allows making a final assessment of the strength of its intelligent economy.

3. Management of demand and supply of intelligent municipal services; conceptual assumptions

The implementation of solutions related to the smart city understood in the above way comprising an appropriate structure also means that public authorities gain new possibilities of managing demand and supply of municipal services they provide on the territory administered by them. This does not necessarily apply to deliberations concerning ways of organising public services so characteristic for the end of the 20th century (see for example Savas 1987 and Osborne and Gaebler 1993), which marked the beginning of a new line of thought in entrepreneurship behaviours of public authorities, or concepts related to new public service remaining in certain opposition (see *e.g.* Denhardt and Denhardt 2002 and successive editions). This arises from the fact that those deliberations used to focus on the logic of forming relations with service providers, because the general belief was that their “setting up in a new way” would enable possibilities of increasing the effectiveness of provided services. As an effect the discourse progresses around two elementary notions: model for the provision of public services and organisation system of the service offer (Kuźnik 2012). On the other hand, as regards the smart city the focus of the discussion was being transferred from the level of actors/stakeholders onto the level of compiled and integrated data, serving as basis for decision making. This is where the concept of a cognitive city comes into play, which is considered as a smart city making use of the achievements of theories connected with cognitiveness (Kaltenrieder *et al.* 2014).

The functioning of a cognitive city is the continuous learning process, based on behaviour of its inhabitants. The inhabitants are involved in establishing the municipal system of data, which are processed automatically, and this allows the creation of the effect of learning and interaction, not only under individual municipal sub-systems, but also between them. The inhabitants not only receive notification, *e.g.* of a hazard, free parking places, events, *etc.*, but also its reaction using for example applications for a mobile phone or real behaviour provides feedback to the system. This permits responding in real time to specific events. Ongoing verification of population clusters allows the redirection of road transport streams or public mass transport. A decrease in usage of energy from renewable sources in households allows the commencement of its usage or storage in the infrastructure of municipal services; the identification of anomalies in the functioning of selected systems (including by the increasingly popular social media applications like “report a pothole in the road”) allows quick repairs or taking up measures to counteract risks which may arise as a consequence. Also in situations in which reaction in real time is not necessary, the integration of data and systems enable the achievement of various types of advantages, which in many cases have an economic dimension. Ongoing monitoring of the operation of snow ploughs or waste disposal vehicles

allows the accurate depicting of their actual work load, and as a result optimising the work or improvement of the negotiation position of the ordering party (local self-government) in the process of service contracting. The formation of joint or interoperational systems, as for example for social welfare, education and police or other preventive services allows providing effective care to persons endangered by exclusion, household violence *etc.*

Going back to the concept of managing demand and supply of municipal services, all this allows the inhabitants benefit from municipal resources in an increasingly effective and more sustainable way, and the providers of municipal services can continue adapting their way of operation to enhance the efficiency and the cost effectiveness (Khansari *et al.* 2013). Increasingly frequently also the motivation for building a real-time pricing system is being considered as important (Gelazanskas and Gamage 2014). Ways of achieving financial and non-financial benefits from implementation of smart city solutions, which had been identified in Poland during workshop works in a group of approximately one hundred representatives of local self-government authorities have been presented in frame No. 1. Nevertheless those effects are achieved thanks to new types of costs, which are connected with development of a *trusted* infrastructure of data exchange (Cao *et al.* 2016). In addition a considerable obstacle, and maybe even certain doubts of a moral nature, appear in connection with the loss of privacy of the inhabitants, which appears to be an inherent property in the process of deploying solutions under the scope of smart/cognitive city (van Zoonen 2016). The author analyses certain dilemmas connected with privacy in categories of purposefulness (from the supply of services to supervision) and types of data (ranging from on-personal data to personal data). On the other hand, the Announcement published after the Polish 7th Congress of the Innovative Economy of the National Chamber of commerce (Baron 2016) contained the following observation: *particular importance has been gained by yet another megatrend: big data. Given the fact that millions of everyday events, such as change of traffic lights, validation of tickets, news in the social media portals, applications submitted to authorities, photos made by mobile phones etc. are being recorded in millions of data bases, humanity is facing an opportunity and a risk that such data would be merged and used at a scale never possible to date. Some people see it as a Big Brother or Orwell's world, while for the others this is a chance for adopting a completely new model of town management. In this model a key bundle of variables will not comprise traditionally understood economic or political decisions, but to a bigger extent the reflection of real preferences and behaviour of the inhabitants and other town users. Clearly this new data stream is a beginning of a new reality in management of municipal services.*

Table 2. Ways of achieving financial and non-financial advantages from implementation of smart city solutions

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- Effectiveness achieved as a result of an increase in the quality and output of urban infrastructure.
 - Reducing the risk of drawing conclusions from available data – execution of analyses based on a single data packet is encumbered by a bigger error than the inference executed in condition of the entire ecosystem.
 - Profitability arising from reducing costs of the existing municipal services.
 - Profitability arising from the sale of new services, such as: dispersed energy management, telemedicine, availability of wideband intelligent networks.
 - Profitability arising from reducing energy consumption, its saving or the sale of energy generated and introduced into the system.
 - Participation in domestic and international market and financial mechanisms, which encourage the use of renewable energy sources and limiting CO₂ emissions (white certificates, green certificates, emissions trading).
 - Achievement of image related effects – projects of a strong social character not only receive positive social response, but may also interest investors seeking initiatives that generate financial and social advantages.
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Source: (Baron 2016).

Mudie and Cottam (1993) indicate that the traditionally understood management of demand and supply comes down to decision-making under three tactical approaches. The first one consists in anticipating demand fluctuations, which enables planning the production capacity and potential action based on relatively low level of this capacity. The second one concerns acting on a low capacity level and adapting demand to it. The third one is connected with “catching up”, *i.e.* matching the capacity to demand. Although theoretically the transposition of those three approaches obtained from business literature onto the practice of providing municipal public services is possible, yet in reality for many years it was not considered to be feasible. This is due to the fact that the public sector may not always consciously allow itself not to satisfy a part of the demand. As a rule it may not do so because services organised by it are of a common nature. Such situations, as lack of access to municipal infrastructure in selected parts of the city, incomplete snow clearing from roads or inability to assure safety in selected districts are to a large extent considered more than anomalies or crisis states. Such hypothetical situations, as for example assuring school education only to a part of children at the appropriate age or offering services by an authority office to only selected inhabitants are absolutely out of question. For this reason in traditionally understood municipal economy instead of avoiding the assurance of the supply of public municipal services also the standard of those services gains special importance– because the determination of this standard allows achieving the anticipated effectiveness (economic one) in the process of service provision (Barczyk *et al.* 2013). But is this really so and does it really have to be a smart city? Is there no other way of managing demand in a world in which a dynamic interaction takes place between the producer and the service client?

It is evident that for entities that provide municipal public services the first tactical approach is of particular importance. The third one is possible (and occurs frequently) – yet it poses a lot of difficulties and may generate considerable costs,

growing in an incremental way, for example when on suburbanisation areas with an increase in the number of buildings it became necessary to make big investments in the water supply and sewage disposal systems; or if it is necessary to build new education facilities due to a demographic peak. On the other hand, the second approach may be adopted basically only and exclusively in the realities of a smart city. As regards the first approach (anticipation of fluctuations in demand) the tool instrumentation of a smart city, and especially processing mass data, allows excellent matching of demand to the service, and as an effect extrapolate trends and create models and simulations. There is a good reason why in certain cities – even on days when mass public transport is free of charge – it is still necessary to validate “the free ticket”. After all, the client has to leave a trace in the system to allow modelling the said system and to take decisions based on that model with respect to traffic of subway, trams or buses. This type of action seems to be the most intuitive and the most popular application of the smart city technology. The economic relation we have in this case will lead us to the demand to adapt the value of supply at a small margin of error. This supply may be in the form of own involved capacity to provision of the given service or contracting the given volume of the service at a given price level. The extent to which the smart city may minimise the risk of economic ineffectiveness in such a relation may be illustrated by the example of introducing a new system of municipal waste management in Poland. The obligation of picking up all waste, in exchange for bearing by the inhabitants a permanent “rubbish fee”, has been transferred onto the commune authorities. These in turn contracted services of waste removal in special companies. Yet it was only in practice that the actual volume of waste being hauled away should be and what are its fractions, and consequently what is the entire cost scale of the process that has been reorganised from scratch. As an effect a certain part of local government authorities had to adopt corrections to the value of the charge, or to relations with service provider. If precise data concerning the volume and structure of waste in households were known earlier, the scale of errors in the assessments would most probably have been smaller.

The second approach (matching demand to capacity) – as we have already emphasised – is only feasible in the reality of a smart city and only in certain scopes of municipal services. The most characteristic example (which frequently goes beyond the municipal sphere) is the management of energy in intelligent systems. By changing the price in real time the client can be motivated to increase or reduce the demand for energy at the given time. Similarly in conditions of complete information concerning congestion and traffic of public mass transport it is possible to affect transport preferences of an inhabitant. If, for example, before leaving home an inhabitant is able to compare the actual time needed to reach work using different means of public mass transport with the time of arrival using private transport and possibilities of parking the car at the destination place, his willingness to substitute one form of transport by another one will be bigger. This is naturally on the assumption that such selection is not affected by other factors, as for example the necessity of handling some other issues “along the way”, prestige, comfort *etc.* In addition it should also be assumed that even if substitutions does not take place, knowledge of traffic conditions would all the same cause the balancing of the use of

available “capacity” – in this case the drivers would tend to choose less know roads, knowing that they would reach their destination quicker than over overloaded roads.

In the third approach (“catching up” supply in relation to demand) the role of the smart city technology is probably the lowest. Nevertheless if we were to assume that decisions on “catching up” are as a rule of a non-continuous nature as they are connected with a one-off investment, additional contracting or a change in the model of service provision, but also in this situation the availability of real mass scale data depicting the actual condition allows the development of more precise feasibility studies and profitability analyses. A good example may be the hypothetical process of preparation of investment lands. Investors are expecting that their location should have at least a basic municipal infrastructure. The municipality may consequently be facing the dilemma of development or reconstruction of the water supply line. If, based on an intelligent metring of the system, it is able to create its current model, then it can easily simulated with its use the loading of a given part of the system by subsequent investments. As a consequence it may either take a decision on development taking into account specific parameters to be changed, or take a decision on making negotiations only with such investors, the technological cycle of which would not be requiring reconstruction of the existing system. In such a way data obtained with the use of smart city solutions constitute an important set of data used for the cost-benefit analysis.

4. Managing demand and supply of intelligent municipal services; new problems and challenges

Based on conceptual assumption presented by Mudie and Cottam to managing demand and supply, a list of economic issues may be generated which are presently connected with the usage of the smart city technology. They are as follows:

- utilisation of analytical data related to the history of provision of the given service,
- utilisation of data pertaining to preferences and satisfaction of clients,
- shifting resources (flexible usage of resources),
- subcontracting to increase the capacity flexibility,
- bigger involvement of the client to reduce the necessity of keeping up the capacity,
- segmentation of customers,
- initiating additional services that enable the usage of the power reserve,
- communicating about the service (encouraging to certain forms of behaviour – including planning of now and high traffic periods),
- price fixing,
- making inventory of demand and managing queues.

Analytical data concerning the sales history or the scale at which the given service is provided are most frequently compiled in municipal systems. Basically nowadays it is difficult to ascertain the smart aspect, because in practical terms all service providers carry accounts in some computerised form. On the other hand, the ability of using those data in a cross-sectional way is becoming a universal

challenge. As a rule they are being compiled not only in separate sets, but also in separate IT systems. Even if their integration is possible in line with interoperability rules, joint data analyses are undertaken seldom or – for operating needs – sharing of data between systems does not take place frequently. Joint analyses of data for the first time in Poland took place on a relatively large scale recently on the occasion of the creation of local regeneration programmes for the second decade of the 21st century. This happened because state and local regulations connected with granting co-financing from European Union means forced the self-governments to carry out diligent execution of the diagnostic part in the spirit of evidence-based policy. In addition this type of thinking has become possible thanks to the gradual implementation of GIS systems in cities. This process enforced the compilation of geocoded data, GIS tools as such offer analytical modules allowing the execution of logical operations on the base (bases) of data.

The utilisation of data on preferences and client satisfaction appears to be a more complicated issue. On the one hand there is a lot of such data compiled in the spirit of the smart city – yet beyond the public system. This is connected with the functioning of numerous appraisal mechanisms used mainly in mobile applications. Operators of community systems or applications based on geolocation may at a low level of errors compile opinions concerning: places or services; times when a given service or attraction is used; profiles of users visiting them, commenting or assessing *etc.* The quantitative analysis, data mining of trends in social media appears to be the currently most powerful tool for getting to know preferences and opinions. Yet on the other hand the public sector clearly remains in this respect behind the private sector. Preferences concerning certain forms of behaviour may be learnt in a rather passive way from selected infrastructural systems (monitoring of security, monitoring of road traffic or fully intelligent transport systems – ITS, metering of the water supply network *etc.*) or based on monitoring behaviour of an inhabitants in a social layer (voting in a civil budget, participation in local events *etc.*). But does it do just that? However, this does not affect the fact that those sources do not contain any information concerning the satisfaction level. The latter one is in the majority of cases not studied at all or is studied in a sporadic way, by traditional sociological methods. Selected cities adopt solutions which are partly interactive – *e.g.* applications given the working name in this paper of “call in a pothole in the road”. This type of municipal safety portals – provided they are user friendly and transpose both on active social attitudes and on dynamic response of municipal services – may considerably contribute to building relations between self-government administration and the inhabitants.

Subsequent issues form *de facto* an entire group, which may be described as assuring short-term flexibility of power, *i.e.* the capacity to provide a service in conditions of peak demand for it. The majority of municipal public services is characterised by a constant annual demand, yet in its internal structure a clear amplitude is visible of seasonal changes or changes during the day. This means that in the provision system of particular services either the capacity to providing services is maintained at the highest possible demand level (which leads to ineffectiveness connected with stoppages), or this ability is minimised (in such

a way leading to failure to satisfy a part of the demand in peak periods). A natural solution for this type of inconveniences is the flexible usage of available resources, *i.e.* shifting of resources to different applications. In the majority of cases in this aspect we can hardly speak of an approach connected with the smart city, because dispatching selected municipal brigades to carry out different tasks or replacing the road maintenance equipment from winter type to one used in summer are nothing new, nor do they require a developed analytical basis. However it is necessary to bear in mind that the essence of establishing a smart city is seeking solutions that exceed sectoral standards. The time has not come yet to think of such solutions in Poland, nevertheless it is worthwhile to bear in mind for example the *Dan Bus Company* – bus operator in Tel Aviv, the electric autobus fleet of which is treated as a stand-by power storage (electricity supply). In a situation of blackout buses that have not been used can return power to the intelligent transmission network. Taking our deliberations a step further, it may be imagined that in the future the entire municipal infrastructure included in any way into the power circuit, would be used in stoppage periods as a dispersed energy storage obtained from renewable sources.

The next possible solution is subcontracting aimed at enhancing the flexibility of capacity. Once again, to distinguish the reality of the smart city from the traditional concept of municipal public services, it could be assumed that perhaps in this case there is no kind of novelty. Starting from summoning additional preventive divisions from another town to secure a major mass event (which is not directly a form of subcontracting, but an option that functions on a similar principle) by renting additional bus fleet in a situation of one-off increased transport demands or for example for the time of repair works of the tracks to replace rail transport means, up to seasonal employing of employees or specialised companies for handling specific events, distribution of a considerable amount of formal correspondence. Yet one can imagine that in the reality of a smart city this type of subcontracting does not have to be specifically planned as to the date and type of service. This is due to the fact that interactive systems may in response to the notified demand first satisfy it using own capacities, and then benefit from the pool of available resources that are ready, or even potentially ready. Given the fact that currently in some European cities on suburban areas tested is the call a bus service – *i.e.* arranging bus drive, in most cases a minibus, along a specified route if several applications are received in the system by mobile phones, we may foresee the subsequent stages of evolution of such a service. It is sufficient to assume that on the basis of observations of the average demand, the carrier permanently providing the given service assures the minimum required number of vehicles. On the other hand carrier companies acting in the surroundings may report to the system the readiness include own vehicles into the line in the given place in a defined short period (practically similarly to calling a taxi). In other words, the permanent carrier minimising its costs may make use of external resources – entities that want to minimise losses arising from stoppages of their assets (vehicles). In real time such quick response is only possible in circumstances in which all vehicles (used permanently and those subcontracted) are subject to geolocation, and the demand is measured in an ongoing way by the transport managing system.

Bigger involvement of the client aimed at allowing reducing the capacity that has to be kept up is in other words not much more than transferring onto the client a part of responsibility and costs connected with service implementation. In reality of the smart city this transfer takes place in a real way both onto the client, and on the system. Paradoxically in such a situation this does not need to be a phenomenon adverse for the client. This may be best illustrated by a change in the attitude to provision and usage of administrative services, *i.e.* the so-called e-administration trend. The client is ready to carry out certain activities alone (although in many cases in reality he would have to carry them out anyway, devising for example an application in hard copy) in exchange for handling comfort. And so – if system solutions prove to be favourable – the client is interested in: gaining user accounts, certificates trusted profiles in IT systems; drawing up documentation in electronic form; making required payment electronically and submitting documents via electronic mail. The client uses this opportunity because in this way savings in travel costs or time are possible, and this also allows contacts with the authority office 24 hours a day. On the side of the authority, on the other hand, it becomes possible to limit front-office, and at the same time the scale of work inputs in the back-office becomes reduced, because documentation is not only devised in a digitalised way, but also frequently is initially verified by the system (*e.g.* it is impossible to submit an incomplete application). However in smart cities such a scale of shifting of responsibility and costs will tend to increase and will certainly not concern only administrative services. We already are familiar with pilot type implementations of solutions consisting in individual and specific tagging of waste generated by households. If under the system a user is forced to prepare every bag with sorted waste with marking of individual bar code or RFID sender, being fully aware of full identification of the source of origin of the waste the user would undertake all measures to segregate and prepare the waste in the correct way. This will clearly reduce resources of capacity, and consequently costs connected with the process of waste segregation by the operator of the given service. In such a situation it is nevertheless difficult to make a judgement about the advantages of the given solution for the client. For a part of the clients it is of an oppressive nature (imposes the necessity on them of being more diligent), and for others it is desired (owing to high ecological awareness they are content with the fact that the system is becoming increasingly perfect).

As regards municipal services, such aspects as client segmentation, launching additional services to allow the utilisation of power reserves and providing information concerning the service (encouraging to adopting certain forms of behaviour – including planning periods of low and high traffic) should in the majority of cases be considered in a joint way. Basically the smart city, thanks to the advantage connected with ITC technologies, has more effective tools for managing the resources. In addition a client of smart city services may receive information about them in real time, thanks to which the service provider-client relation does not necessarily have to have a routine nature, but may arise directly from the ongoing demand and supply situation. As an example – as regards the call a bus solution – a functioning model may be assumed, in which the carrier handles the system of basic bus lines and has appropriate potential to satisfy the demand in the highest peak period. Concurrently

off the peak time a part of the fleet can be directed to handle the call a bus system, and the potential clients of this system (such as inhabitants of the urban sprawl areas) are aware that launching of this service depends on the current situation on the core area of the town. It is also easy to imagine shifting selected solutions to the municipal sphere, which are for example known from cheap airlines. Let us take into consideration balancing the operating load of sport facilities, e.g. a public swimming pool. The swimming pool operator may control this load in a dynamic way, by fixing a higher price for the entrance ticket bought on site, *a vista*, and a lower one when the ticket is bought in an electronic reservation system. What is more, the ticket price in the reservation system may be changed dynamically to “fill the gaps” in encumbrances. This requires appropriate communication of the price system, in combination with well-developed client application on a mobile device. Thanks to this the potential client may be enticed by an attractive price, and during an hour or on another way at an “unattractive time” go to the swimming pool if the system assumes that this pool would be considerably non-congested. On the other hand, a price reduction or other bonus packets may be used to entice the client to change the reservation time, in a situation when the system records exceeding of the limit of number of places.

As shown among others by the above mentioned example, such issues are on the other hand frequently also connected with fixing of the price. On the one hand it may be presumed that the realities of a smart city allow the exact calculations of costs borne for the provision of a service or a packet of services – which would allow the determination of the most advantageous final price (price, charge, tax) for the user. Yet on the other hand possibly complete information on demand and supply obtained in real time allows controlling demand and adapt it to the supply using the price. Apart from the public sector, but in municipal conditions, this mechanism has been adopted for example by Uber. In towns in which this service is popular, the user has a choice during peak hours: wait for the arrival of the vehicle or pay the multiple value of the basic price to pass by the queue. setting up real-time pricing systems mentioned in this paper sooner or later becomes a fact in intelligent systems of media supply systems, especially in the power engineering sector which is based on renewable sources. The renewable power industry depends on climatic conditions and the time of day. Hence it should be assumed that in a situation in which the system starts to anticipated energy shortages, certain client segments would be motivating – or even directly force – to choose power consumption in different times of the day by way of applying the mechanism of an increased price. Who knows, perhaps in the future on the consumer market instruments could appear that are known from financial markets, such as for example buying at advance options for power or water consumption in a specific time interval?

This in turn leads to the issue of inventorying the demand and managing queues. In a smart city this is no longer a simple list of applications awaiting examination, a queuing device in an office, total data from statements concerning the deposition of municipal waste or statistical information about income of the inhabitants who may need social assistance. In a smart city information concerning supply and demand becomes practically complete and available in real time. If it is already possible to

indicate the number of unoccupied places based on parking systems and navigate vehicles to those spaces with the use of mobile applications, perhaps we are only a step away from solutions consisting in submission of request for short-term reservation of such a place (for example for a 2-minute arrival time) or reservation of places by way of an auction. Also similar is an auction system, or one based on preferential packets in the supply of utilities. As regards the above described example of intelligent power networks based on renewable sources, the present system of the so-called power disposal may become a dynamic system with time, and operate in real time. As an effect the selected groups of clients, and even individual clients, would be “automatically” receiving certain power admissions or limitations in defined time intervals. What is more, a step further the recipient would be able to buy a “premium” option, in which those limitations would partially or fully eliminated. As regards social welfare it is easy to imagine a dependence of frequency at which a guardian makes his visits on the actual physical state of the client. It is sufficient that the client being taken care of – for example an older person – is monitored for example with the use of a simple device such as a “watch”, which sends over to the telemedical system information concerning whether the given person is moving in a regular way (*i.e.* executed minor things in the house); what are the person’s health parameters, such as pulse or blood pressure; or whether such a person leaves the area of residence or uses specific devices at home (such as washing machine, television set, electrical stove – data from smart grid). This would allow automatic selecting of persons requiring the most urgent assistance (or control) and working out the route for social welfare employees. In such a way the logic presented in this part of the paper completes a type of a circle going back to the usage of compiled analytical data concerning the scale of provision of the given service discussed in the beginning.

Final remarks

The logic in the creation of an economy of a smart city may be presented as on Fig. 1 in the form of a few levels of accrual of its particular components. The economy of a smart city, ultimately an intelligent economy of a town, is formed in a laminar way. Under the pressure of technological, social and political surroundings the city is permeated by social and culture intelligence, forming gradually a new economic quality.

The lowest level is comprised by new behaviour of economic entities operating in the economy of the city – companies that offer various products and services in the city and for the city, households, municipal entities and local authorities that finance the development of intelligent city infrastructure. It is important to emphasise that the mixture of technological and social pressure concentrated in business offers of major technological business forces municipal economy entities to learn the usage of new technologies and new products. This as an effect causes a change in behaviour.

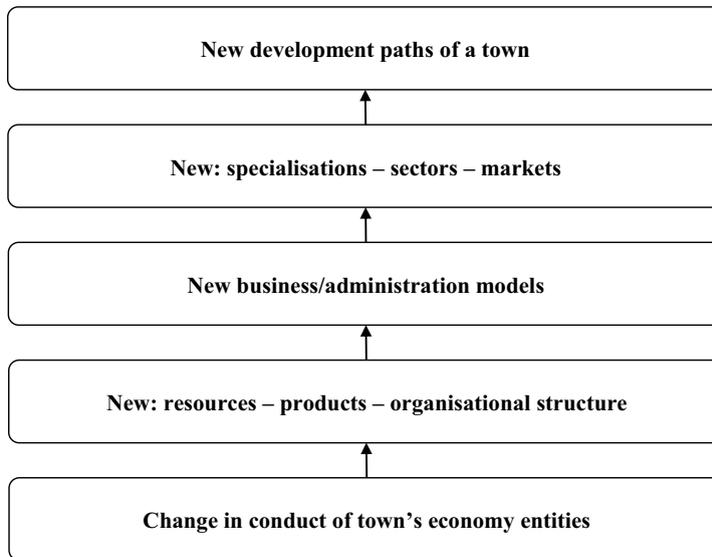


Fig. 1. Logic of creation of smart economy of a town

Source: Own study.

The massed change of behaviour of all groups of entities of the economy of the city creates new intelligent resources in the city's economy. On the one hand a new intelligent municipal infrastructure based on ICT, and on the other hand, new resources of human and social capital. Intelligent human and social capital creates at an accelerated rate the demand for new products and municipal services. Citizens, households, local communities and municipal companies enter new procedures of moving within the town space, either adapted from the outside or created in an autonomous way, as well as of using municipal services and facilities. Organisation changes comprise gradually organisational entities that are a part of the city's economy.

Further accrual of smart city economy depends on the extent to which it starts to create its own complex and effective organisational structure capable of using new models of business/management appropriate to the requirements of a contemporary technological creative economy and modern public management. The level of "New models of business /management" starts the intelligent economy of the town. The two lower levels define the economy of creation a smart city.

New intelligent economy of the city is starting to acquire features of durability and competitive ability as of the time when in its structure start to appear such components as new specialisations and sectors of the city's economy already present on external markets, including also global ones. New specialisations and economic sectors transform the existing local markets, and what is more important they create markets of new municipal products. The mechanism of creation of new economic specialisation in a city or in a region is a complex process (Klasik and Kuźnik 2016).

We only wish to emphasise that it is a final effect of earlier changes and allows perceiving a new quality in the form of an intelligent economy of a city.

The formation of an intelligent economy of a city is ultimately manifested by the possibility of initiating a new development path. It will have traits of an autonomous path, differing from the old path to the extent to which the competitive position of its new speciality and sectors would be strong, and the extent to which the attractiveness will grow of markets of diverse municipal products and services.

In the paper an attempt was made to define the basis on which economy in a smart city is functioning. Questions posed in the initial part of the paper were to allow the working out of a certain scheme for monitoring processes of formation of a smart and its intelligent economy. In the contents of this paper we emphasise that the concept of a smart city continues to be a thing of the future rather than one of the present. A smart city is slowly emerging from the combination of diverse megatrends and growth tendencies characteristic for societies and economies of the second decade of the 21st century. The intelligent economy of a city may be perceived presently at the level of new forms of behaviour and new resources, products and procedures that gradually organise contacts different than those to date between entities of the town economy and users of municipal services. Higher formation levels – new business models, economic specialisations and sectors, new growth paths – these are still elements of the future, which gives necessity to posing questions and work out visions of the future of smart cities. For the time being the empirical material depicting the gradual formation of an intelligent economy of a city may be broken down into first elementary questions and levels of accrual. The paper placed emphasis in this respect on issues of relations between demand and supply, which best reflect the initial period of formation of a smart city.

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