Public Goods and the Fourth Industrial Revolution

Inclusive Models of Finance, Distribution and Production

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5.1 Chapter overview

In the early agrarian stages of civilization development, most of the needs were met within the boundaries of the household or local community. However, the development of urban settlements forced the emergence of collectively satisfying some needs (initially mainly sanitary and hygienic). Over time, thanks to the achievements of subsequent industrial revolutions, it was possible to develop these services (water supply, sewage), and their scope gradually increased (transport, education, electricity and heat, and social services). These changes were a response to the needs generated by the industrial revolutions: in the case of the first, labor was needed living near factories (population density, risk of epidemics), in the case of the second, the importance of skilled labor grew (importance of education, living further from the factory – transport). The third revolution brought automated production, factories requiring qualified workforces and transport of raw materials over long distances became necessary (Rifkin 2015; Gajewski et al. 2016; Harari 2016; Schwab 2016; Schwab and Davis 2018; Rosiek 2020).

Both urbanization and technological advances have been and continue to be important factors in changing the scope and method of delivering and financing local public goods (LPGs), including public utilities. The purpose of this Chapter is to identify Fourth Industrial revolution (REV4.0) solutions in various systems of public service provision in cities. Socio-economic development, accompanied by an increase in the consumption of goods, reinforces the importance of this type of service. The assumptions that technological achievements of REV4.0 enable public utilities to improve the quality of services provided and increase the efficiency of operations have been verified by surveys conducted in 12 largest Polish cities. The results of the research indicate the need to develop a new model of production and distribution of LPGs of an inclusive nature, in which entities responsible for meeting the needs of local communities will cooperate with each other and maximizing profit will not be the most important goal of doing business.

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5.2 Local public goods in the process of provision of public utility services within urbanized areas

5.2.1 Local public goods in municipalities

In a dynamically changing world, cities are also changing. Depending on the country and region, we observe the phenomena of their shrinking or growing. Structural transformations of local economies are visible, including the collapse of traditional activities and the development of modern forms of production, based on new tools brought by REV4.0. The cities, as centers of production of various goods, services and knowledge, perform both residential, service and recreational functions, as well as create conditions for resident self-realization. In relation to public space, their communication and investment function is important. The essence of the development of modern cities is to balance between the functions provided and the needs of residents as their co-owners. The quality of life of local communities is influenced by many factors widely described in literature. One of the most important are LPGs.

LPGs are goods whose benefits are limited in space and accrue to the inhabitants of a given locality (see Chapter 2). The availability and maintenance of LPGs is the responsibility of the local jurisdictions (in Poland it is a municipality or a district). The specificity of local goods and their type is influenced by both the nature of the area in which they are supplied (administrative layout, structure and level of development of the local economy, historical and political heritage) and the number and structure of the population (age, employment, origin). The local community, when reporting a demand, makes a choice as to the type and quantity of LPGs, a behavior already noted in the mid-20th century by Tiebout (Tiebout 1956; Stiglitz 1982). Through their representatives in local authorities, or through an instrument such as participatory budgeting, residents have an impact on the expansion of existing and the creation of new public goods (Petermann Reifschneider 2006). Although entire communities can use LPGs, there are situations when there is congestion above a certain number of consumers (Banzhaf 2014). Then their availability or usefulness decreases.

The creator of LPGs is the local authority and its policy and vision of development. The agreement between the authority and the local community has an impact on the supply of LPGs (Oakerson and Parks 2011; Kleer 2015). In turn, the way they are delivered is changing, for instance under the influence of REV4.0 and its technologies – more on that later in the Chapter. In towns that have more accurately responded to the needs and preferences of residents, providing LPGs particularly valued by them, positive net migration is maintained. There is also an influx of the *creative class* (Florida 2004). This, in turn, translates into higher budget revenues from taxes, as well as the creation of new enterprises, the creation of new jobs and new investments, and consequently growth and local development.

Depending on the country and region, different delivery systems for LPGs can be identified. State and non-state actors may be responsible for their distribution. However, the rules for their provision and payment are regulated by public authorities. In recent years, the importance of non-state providers of LPGs and collaborative hybrid systems has been increasingly emphasized (Post et al. 2017).

LPGs are diverse. They include city parks, swimming pools, tennis courts, as well as infrastructure, i.e. power, heat, water supply, municipal construction and even traffic lights. Some goods have a short production time, while others have a long one. A special type of local good is infrastructure, with the use of which it is possible to develop cities and improve the quality of life of residents. It is possible to distinguish technical infrastructure (water, sewage, heating, gas, road, etc.) and social infrastructure of a residential nature, serving to meet educational needs, as well as used to conduct administrative, social, cultural or healthcare activities. The main features of infrastructure, especially technical infrastructure, include: high intensity of terrain and capital, high degree of technical and economic indivisibility, long investment cycle and long service life, as well as a service nature, widespread access to infrastructure facilities, close connection with the area on which it is located, limited possibility of using market mechanisms and the need for public management of activities. In the case of network infrastructure, it is very important to determine its capacity and the so-called readiness to provide a service.

Infrastructure, thanks to which it is possible to reduce the operating costs of entities using it, contributes to the diversification of the local economy while enabling the use of modern technologies, and increases productivity as well as work efficiency. Infrastructure investments stimulate activity related to accompanying services, affecting the level of employment and income of the local community. Well-planned infrastructure is not only a prerequisite for the mobility of society, but also favors capital flows. In addition, it raises the standard of living of residents by creating amenities and providing consumer goods. LPGs, and especially infrastructure as a material resource, make it possible to provide public utility services to urban residents.

5.2.2 Specificity of public utility services in urbanized areas

Services, or activities related to the tangible or intangible needs of consumers, can be defined as an economic activity that generates added value and provides benefits to recipients. The specific features of services are: immateriality, simultaneity of the process of providing and consumption, non-uniformity (diversity) and impermanence (Rudawska 2009). The concept of service, although often used as a synonym for good, is not tantamount to it. Good is a broader term, including activities (services) related to the direct or indirect satisfaction of the needs of society, with the proviso that they do not lead directly to the production of products (Wąsowicz 2018).

The specificity of both public goods and services is their public utility. That is, they meet the basic needs of society, which are widely felt and associated with objects serving a specific area. In turn, these facilities (infrastructure) are characterized by durability and technical indivisibility. Public utility services (PUS) of a local nature meet municipal needs, i.e. elementary, meaning those that in any situation should be met for each of the members of a given local community. This involves the need to ensure their full availability. They condition the ability of the population to live and to conduct economic activity in larger concentrations of people.

Activities aimed at satisfying the current and uninterrupted needs of the population through the provision of services generally available resulting from the residence of the population are referred to as municipal management. It is carried out with the use of technical infrastructure (devices: energy, transport, communication and environmental protection). The result of municipal management are municipal goods. These are PUS are provided in the field of public transport, waste management, water supply and sewage management, energy and heat supply, as well as the shaping and maintenance of urban green areas. They are characterized by the need to provide reliably (in a certain time and space). Failure to supply these goods or to ensure their adequate supply entails important consequences in social and economic life. A characteristic of municipal goods is the difficulty of their storage. Some of them are created on the natural monopoly market, by enterprises with municipal infrastructure facilities, which can be divided into three groups (Wąsowicz 2018):

- Centralized – such as water intakes, sewage treatment plants, power plants, gas plants, depots for public transport vehicles,
- Networked – that distribute what has been produced in central equipment (e.g. overhead contact line, and in the case of local public transport (LPT) – track),
- Service to customers – support the process of providing services or directly determine their quality (e.g. rolling stock in the case of public transport).

The specificity of these devices determines the method of supplying municipal goods of a public utility nature. There is a close relationship between production and their consumption. These goods are simultaneously produced and consumed, which determines the need to have adequate production capacity (Dziembowski 1983).

Ensuring the provision of PUS, and in particular the provision of municipal goods, is the domain of the local authority. Some of these services, due to their specific features, require a supra-local provider. Supply of electricity and gas, transport services, postal services, telecommunications services are carried out in different ways, with the heterogeneous participation of local and government authorities. The conditions and method of providing such services are determined by separate legal acts applicable to individual countries.

The functional division of services of general interest divides them into: administrative, technical and social services. Administrative services are entirely provided by public entities and are related to the official service of citizens. Technical services, also known as municipal, are provided to the local community and have the greatest impact on obtaining and maintaining a certain standard of living of its individual members (Satoła 2018). This group includes the following types: public transport services, pipeline and sewage services, supply of thermal energy to the population, cleaning of streets and squares and removal of impurities from real estate, arrangement and maintenance of urban greenery, maintenance of streets and city squares. In turn, social services are provided in the field of social assistance and healthcare, public education, culture, sport and tourism, support for people with disabilities, counteracting unemployment and social exclusion (Cibor 2014).

PUS can be implemented by public sector entities appointed by local jurisdictions (in Poland it is a municipality), as well as by private entities performing their own tasks of the local authority on the terms set out in the regulations. Some services – especially administrative and social services – are available free of charge and financed by taxes. The provision of technical (municipal) services, the prices of which are not market-based, is associated with the need for residents to bear certain financial burdens in the form of fees. The application of prices/charges depending on the type of public service is intended to cover all or part of the costs of providing them. The fees are also intended to motivate correct behavior to prevent excessive consumption and to promote the rational use of environmental resources, e.g. water (Stiglitz 2000). Some of the public utility services are provided by entities operating on a commercial basis, but the prices they apply (e.g. rates for water supply and sewage disposal) are subject to approval by the authorities constituting the competent local authorities. When determining their amount, factors determining the cost of providing a given service as well as those related to the payment capacity of residents using them are taken into account (Satoła 2018). The operation of a market mechanism setting the price for services of general interest, based on demand and supply, is in this case limited. PUS are characterized by social inclusion, meaning non-discrimination of citizens using them (Finger and Künneke 2011), which determines the need to provide these services at specific, socially acceptable, regulated by the authorities prices. On the other hand, the implementation of PUS may be carried out by enterprises owned by public entities and other entities operating in economic infrastructure sectors. The provision of public utility services requires public co-financing, as profit-making is secondary to those who make them. The most important premise for doing business is to meet the needs of the local and regional community, i.e. meet the general public interest.

5.2.3 Public utility services in European Union legislation

In the European Union countries, the process of reforming the model of providing public services through de-monopolization, externalization, commercialization and privatization of entities operating in the economic infrastructure sectors has been carried out for several years (Wąsowicz 2018). In these processes, several interpretative uncertainties have emerged around the definition of services of general interest.

One of the Treaties of Rome, establishing the EEC, used the concept of civil service based on French and German legislation, which means activities carried out in the public interest using the public sector or the private sector under the supervision and control of designated state bodies (Wąsowicz 2018). The exemplification of the implementation of the provisions contained in the Treaty was the Community Regulation (Regulation EEC 1969), which defined the public service obligation. This term means a commitment by an enterprise to act which it would not have undertaken at all or would have accepted to a lesser extent if it had been guided by its own financial benefits. From the wording of the Regulation emerges the concept of services covered by the public service obligation, understood as those which enterprises would not provide sufficiently or on the expected terms if they were guided only by cost-effectiveness. Based on its economic calculation in business practice, an enterprise is not interested in providing services of a certain quality and range, at the expense of the financial results achieved. Therefore, the concept of services covered by the public service obligation is inextricably linked with public service tasks (Wolański 2011).

Under European Union law, public utility services are treated as part of services of general interest (SGI). These are services, which the public authorities of the Member States of the Community include as services for the general good. They are covered by a public obligation to provide. EU legislation distinguishes three categories of SGI: economic services, non-economic services and social services (EC 2011). Services of general economic interest (SGEI) refer to activities of an economic nature whose products that are a general public good would not be supplied by the market without public intervention or would be provided under other conditions in terms of quality, safety, prices, equal treatment or universal availability (Lissowski 2017). A general obligation to provide those services was imposed on their suppliers by the act of entrustment and on the basis of the criterion of general interest. They are covered by European internal market and competition rules and are provided for a fee. Article 106 of the Treaty on the Functioning of the European Union states that enterprises entrusted with the management of SGI are subject to European law in so far as their application does not prevent the performance of the tasks entrusted to them (OJ EU 2010). In turn, non-economic services of general interest (NSGI) are provided by entities that are not companies operating on a market basis and include, for example, the activities of the police, the judiciary, statutory social security systems. The

third group are social services of general interest (SSGI). These services meet the needs of citizens from the most vulnerable groups. They are provided on the basis of the principle of solidarity and equal access and can be economic as well as non-economic. They include social security systems against the most important life risks and several other important services provided directly to individuals. (EC 2011).

It is worth adding that the European Union's *White Paper on Services of General Interest* presents a definition of PUS as services of high social importance which, according to the Member States or the Community, are subject to certain obligations due to the criterion of general interest (EC 2004). Such services include, in particular, services provided by network companies, i.e. transport, postal and energy services. The particular importance of SGI is due to their characteristics such as their mass character, universal availability, uninterrupted supply, safe use, higher quality or lower price than in the case of services provided only on the basis of the free market. The primary body responsible for defining, organizing, financing and controlling SGI is the relevant national and local authority. Although the Quality Framework for Services of General Interest in Europe enshrines a common Concept of Services of General Interest in Europe, Member States are free to define (in accordance with EU law) what national, regional and local authorities consider to be a service of general interest, based on the specific characteristics of the activity. SGI is a term from the EU legal framework, while PUS are defined individually in each membership country and doesn't have to cover the same scope.

To sum up, services, including PUS, are characterized by immateriality, heterogeneity, simultaneity of the process of provision and consumption, and impermanence. For these reasons, innovation in the service sector differs from innovation in the manufacturing sector. PUSs have a much lower ability to absorb innovation than the so-called knowledge-intensive business services. The latter are services with high intellectual value added provided by entrepreneurs operating at the interface of science and industry. In the case of PUSs, whose main goal is to meet the collective needs of local communities, innovation is manifested in other aspects, inter alia the systematic improvement of the quality of their provision.

PUS as specific intangible economic goods are *produced* by a special group of service enterprises. Utilities owned by local authorities are referred to as municipal utilities. They were handed over to municipalities and, through privatization processes, were transformed into market entities (e.g. municipal companies). In many cases, private companies are responsible for the supply of municipal goods. These are entities that are not owned by the public sector. Public utility tasks in urban areas can also be carried out by entities in the form of a budget unit, a self-government budget establishment. However, these are not enterprises.

The rules for financing utilities vary from country to country due to the use of different shares of taxes, fees and prices for the services provided. Regardless of the entity providing the service and the method of financing, they play an

important role in the local community, raising the standard of living of residents. PUS providers have a specific obligation toward their recipients, based on meeting needs at an appropriate level so as to ensure their proper social and economic functioning. The quality of PUS (a set of features that determine their ability to meet with satisfaction the specific needs of recipients) consists of technical quality and functional quality. Technical quality refers to the effects of contact with the service provider, while functional quality is influenced by the way the service is provided. A distinctive feature of services, including PUS, is the inability to evaluate them before execution. Natural and contractual measures can be used to describe the result of the *production* of this type of services, which will be presented later in the study on the example of water supply and sewage services, waste management and LPT.

5.3 Systems for production and distribution of public utility services in cities on the example of local public transport, management of municipal waste and water and sewage management

5.3.1 Privatization v. publicization of public utility services

With the development and increase in the wealth of societies, the number of socially desirable goods and services increases. There is also a growing consent to their collective satisfying. However, this still does not prejudge that these goods and services must be met from public resources. In the literature and in practice, two approaches related to this clash (see Chapter 2). After the Second World War, in many countries one could observe the growth of public structures and the provision of services from public resources, and then thanks to M. Thatcher and R. Reagan, strong privatization trends. Nowadays, in different countries and in different sectors, both trends occur in different intensities. The arguments of both parties are justified (Tables 5.1 and 5.2).

In the literature and in practice, three basic models of delivery of PUS are distinguished: public, private and public-private. It should be noted that this division is most often used on the criterion of property ownership and the criterion of actual management. Thus, in the public model, both of aspects remain in entities that are publicly owned or under the total control of the public authority. In the market model both ownership of infrastructure and management remain in the hands of private entities. In the case of the public-private model, generally speaking, the ownership of the infrastructure remains public, and the implementation of the task is transferred to private entities based on various types of contracts.

5.3.2 Models for the production and distribution of public utility services

It is not only these two criteria that determine whether a model is public, private or mixed. Therefore, the following is a division of PUS production

Table 5.1 Advantages and disadvantages of privatization of public utility services

Advantages	*Disadvantages*
Use of private sector know-how	Less willingness to invest in long-lived infrastructure
More innovation and flexibility	Propensity to optimize costs, which can be at the expense of quality
Introduction of technical and organizational innovations	Choosing for the implementation of tasks that are good and allow to achieve the assumed effects
Making employment more flexible	Possible maintenance of worker wages at lower levels in order to maintain the competitiveness of the services provided, lack of proper protection of employees
Relieving the budget (including reduction of debt ratios)	Possible unjustified increase in prices for services provided in order to realize profit
Greater efficiency of the services provided	Price exclusion of the poorest users or recipients
Attracting investors	Competition affects the improvement of service quality only to a certain level, unlimited price competition can lead to a deterioration in the quality of services provided
Improving the quality of products and services through competition	
Payment for effects	
Independence from the political situation	

Source: own study.

and distribution models due to additional, equally important criteria, such as: responsibility for the implementation of the task, ownership of the infrastructure, existence of a regulator, financing of investments, actual management and control (Table 5.3). Any model, in which at least one element is non-public or non-private, is considered a mixed model. In this view, the

Table 5.2 Advantages and disadvantages of publicizing public utility services

Advantages	*Disadvantages*
Certainty and continuity of service provision	With a great need from the political situation
Greater control of price increases for services (possibility of limitation)	Budgeting affects irrational spending
Ensuring inclusivity and guaranteeing universal access to services	Difficulty in assigning responsibility
Ensure investment in new and restoration of infrastructure, especially network infrastructure	Operating under a monopoly can lead to lower efficiency
Public consultation and social surveillance, greater transparency	Low propensity to innovative activities
The possibility of financing investments with a long and very long life, e.g. related to flood protection, undertaking strategic and intergenerational activities	

Source: own study.

Table 5.3 Models for the production and distribution of services of general interest

Models	*Responsibility*	*Ownership*	*Regulator*	*Investments*	*Management*	*Control*
Public						
Do the job yourself	publ	Publ	publ	Publ	publ	publ
Monopoly of own subject (public-public model)	publ	Publ	publ	Publ	publ	publ
Completely private (uncontrolled competition)	**Priv**	**Priv**	**none or public**	**Priv**	**Priv**	**none or public**
Public-private (mixed)						
Partnership (PPP)	publ	publ/priv	publ	publ/priv	Priv	publ
Market	publ/priv	Priv	publ	Priv	Priv	publ
Dedication to delegated private management	publ	Publ	publ	Publ	Priv	publ

Source: own study.

private model is one where the state does not interfere in the implementation of the task/service, to distinguish it is called completely private or a situation where, while there are regulations and the possibility of control, but due to the very high fragmentation of service providers (or corruption) its implementation is difficult. This includes services that are considered public services/tasks in other countries. These are rare and extreme cases of failure on the part of the state to carry out the task and leaving it completely to the market (e.g. access to drinking water in some areas of Asia). It is also possible that with critically high price competition or existing high demand, contractors intentionally abandon regulatory requirements in order to reduce costs.

What is worth emphasizing is that in mixed models, regulation (legal framework, existence of a market regulator) and control are always in the hands of public authorities, while responsibility for the performance of a service/task only in the model with the most market characteristics, is partly transferred to a private entity.

It is worth paying attention to the public-public model, in which the task is performed by an enterprise, but under the complete control of public authorities. Such cooperation may lead to increased efficiency of tasks and greater transparency in financing. Such a solution is often beneficial for the budget of the local authority, because the debt of the entity performing the entrusted service/task is not included directly in the debt ratio of the municipality. However, such a solution may also have disadvantages, as the entity performing a public task may be subjected to pressure from the public authority (e.g. delaying unpopular decisions due to the electoral cycle).

In some studies, delegated public management includes public companies and public-private companies while, according to the authors, these models should be treated separately, because they have different characteristics, especially in highly publicized models, such as in Germany or Poland. The diversity of classifications founded in the literature justifies the necessity of the conducted analysis and the new classification proposed above.

Subject literature notes that certain regularities occur over decades. Klein (1994) recalls that in the 19th century, railways, canals, roads, and even waterworks were financed and created by private companies. There were both internal (regulations) and external factors (wars and crises) that contributed to the nationalization of these sectors in various countries. Its peak of this process occurred during the 1940s and 1950s. Rising costs and declining service efficiency have contributed to re-privatization in various forms in many countries and sectors. This process was strongest in the 1970s and 80s, and in the countries of Central and Eastern Europe after the fall of socialism in the 1990s. The question that can be asked is: is this process being repeated? The analysis carried out in the further part of the study indicates that in some sectors there are symptoms of re-takeover of enterprises by public entities, this time at the local level, and thus the processes of re-municipalization (re-publicization) are emerging. It can therefore be said that the cycle of ownership transformations presented by Klein and Roger in the PUS sector (Figure 5.1.) is repetitive.

On the other hand, the trend of developing public-private partnerships is still strong, and is further strengthening is indicated (Infrastructure Futures 2020). It seems, however, that the contemporary approach to PPPs differs from that of 30 years ago, whose philosophy was based on supplementing the competences of public sector entities with the competences of private entities. However, the objectives of both groups remained divergent, which often led to the realization of unjustified profit by entrepreneurs (from the point of view of recipients of services). Currently created PPPs are based on a different philosophy, i.e. on the commonality of the goals of private and public entities, and this direction should become the dominant framework.

5.3.3 Overview of models of production and distribution of public utility services in selected countries of the European Union

The presented models of PUS production and distribution are implemented differently in individual industries studied by the authors, as well as in different countries. Both of these factors affect the strength of public-private relations in individual European Union countries.

Organizing LPT, the water supply and wastewater treatment (WSWT) and municipal waste management (MWM) is carried out in accordance with the principle of subsidiarity and therefore remains within the competence of member states, in accordance with Protocol 26 to the Treaty on the Functioning of the European Union. The EU institutions do not interfere

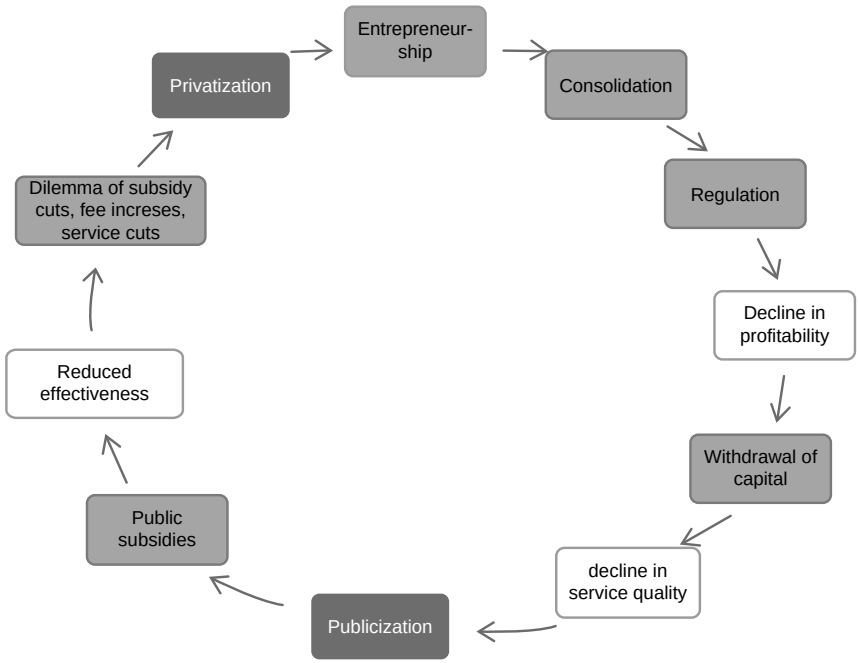

Figure 5.1 Cycle of privatization/publicization of services of general interest (Klein-Roger).
Source: own study based on: Klein, 1994; Klein and Roger 1994.

with the chosen model of performance of tasks, provided that they comply with the objectives and regulations of the Community.

Of course, the very specificity of the sector affects the shape of the PUS delivery model. In the case of LPT, it is possible to introduce competition to a certain extent, in the case of the water supply and sewage sector, the limitation is to operate in the conditions of a natural monopoly, while in the case of municipal waste management, competition usually appears in the area of waste collection and transport, less often in the process of their utilization management.

In each sector that has been selected for analysis, a common feature is their very expensive infrastructure – in the case of the first two it is line infrastructure, and in the case of waste, point infrastructure (installations for sorting, recovery, recycling and disposal of waste) (Table 5.4).

In Western Europe, across the second half of the 20th century, the share of car journeys increased at the expense of public transport. At the end of the 1970s, this led to the inability of LPT to self-finance its operations. There occurred a process redefining the role of public entities in collective urban transport. Originally, the financing and organization of LPT was carried out mainly through municipal entities that performed transport and at the same

Table 5.4 The most common models for the production and distribution of PUS on the example of the following sectors: local public transport, water supply and wastewater treatment and municipal waste management

Local public transport	*Water supply and wastewater treatment*	*Municipal waste management*
Operator + competition for sections of the network (monopoly on these sections)	Own completion of task	Entity managing the system + competition for waste collection in individual city zones
Partnership (PPP)	Partnership (PPP)	Partnership (PPP)
Competition for the entire network (one private entity carries out the task)	Market	Competition for the collection and management of waste in the city (one private entity carries out the task)
Competition for customers (uncontrolled competition of private entities)	Dedication to management	–
Monopoly of own entity (public-public model)	Monopoly of own entity (public-public model)	Monopoly of own entity (public-public model)

Source: own study.

time managed transport networks. During the last decade, the approach to the organization of public transport in Europe has been changing, and a strong trend of ensuring competition between carriers in various forms emerged. Models for the organization of the provision of LPT services in different European countries, highlighting the main and alternative models (to illustrate the diversity of concepts occurring within a given country), are presented in Table 5.5.

In the case of WSWT services, we are dealing with entities operating in conditions of natural monopoly and it should be emphasized that not only the subadditive nature of costs determines this, but above all the safety of the services provided, especially in the case of water supply. In different countries, however, the models of providing these services differ, for example in countries such as Germany or Poland, public-public models are more common, while the United Kingdom is closest to the market model. In the other countries analyzed, the models discussed earlier are present with varying degrees of intensity (Table 5.6).

While in the 1960–90s a strong privatization trend was visible in the WSWT sector (in the countries of the post-communist bloc after 1990) and it took on various forms and intensity, today the reverse tendencies are increasingly visible – the re-taking of infrastructure and management by entities under the control of public authorities, such as in Paris or Berlin. This process should be explained by the fact that water is not a good like any other, but it is also a human right. Leaving the water supply in the hands of private entities

Table 5.5 Production and distribution of PUS on the example of local public transport in selected EU countries

Country	*Dominant models*	*Comments*
Germany	In the field of road public transport, operated by public and private enterprises, the dominant model is one where expenses are covered by operating revenues, compensation resulting from tariffs and timetables and other revenues from other sources. Operators provide services on the basis of the laws of the Länder authorities (state authority) and not contacts with local authorities, which have the responsibility of providing such services. For a given line, the authorities of the Länder issue a license valid for 8 years for buses and up to 25 years for trams, metro and light urban rail. The license specifies the obligations of the carrier regarding timetables, fare system, operational work. In practice, the leading role in the provision of passenger transport services is played by a publicly owned company – Deutsche Bahn AG.	The strong position of municipal enterprises does not exclude the increasing role of private entities that act as subcontractors. Sometimes even half of public operator services are outsourced to private carriers
France	The organization of LPT services rests with the local authorities (the exception is the Paris region). Municipalities are responsible for operation, servicing and pricing. However, they commonly transfer their prerogatives to associations of municipalities, specially established for this purpose. Typically, the public party owns the transport infrastructure. The most common form of organization of public transport is based on open tenders for the entire network of a given area. The entities selected through the tender are private or public enterprises.	In some cities, e.g. Marseille, there is a classic model with limited competition. The entrusted local transport services are provided by a municipal enterprise. In Paris, the leading role in the provision of urban transport services is played by state-owned companies – RATP, SNCF.

(*Continued*)

Table 5.5 (Continued)

Country	*Dominant models*	*Comments*
United Kingdom	Since the mid-1980s, most bus transport services, except London, are outside the control of the state. Responsibility for LPT depends on the administrative area and the means of transport. In the largest agglomerations outside London, the responsibility for the organization of public transport lies with public transport boards. In other cases, the county or local authorities coordinate transport services. Outside the capital, there is a free market within bus transport services. Although these services are provided commercially, an important factor supporting their financing is the refund of fuel taxes. Local authorities issue tenders for additional services to complement the commercial offer in areas where it is insufficient. There is a trend of concentration of local public transport services by several main groups of operators.	In London, the responsibility for the organization of public transport lies with the municipal authorities. The London Transport Authority is responsible for transport in the greater London area except suburban rail services. In the capital, tenders with a fee settlement model (which has a fixed value and results from the operational work performed, not transport) concern specific lines. In several cities (e.g. Edinburgh, Nottingham) there are carriers owned by the local government.
Spain	The organization of LPT is very decentralized. Each of the 17 autonomous communities is responsible for local public transport. Public transport is carried out by private or municipal enterprises, obtaining a license for services preceded by a tender procedure. The liberalization of the public transport market, which has been carried out for many years, takes into account the application of improvements in competitive conditions.	In the largest urban centers (Madrid, Barcelona, Valencia), the position of public enterprises acting as so-called internal operators is still strong.
Poland	LPT is the municipality's own task. In the largest cities, public transport management units have been separated from the administration structures, which	There are cities where LPT is carried out only by a municipal enterprise. There is no separate control and management unit, and the management of urban

(*Continued*)

Table 5.5 (Continued)

Country	*Dominant models*	*Comments*
	entrust the provision of transport services to municipal enterprises (in whole or in part) or organize open tenders, usually with fees for the implementation of transport work on selected lines.	transport is carried out through the appropriate department of the city hall.
Czech Republic	LPT services are almost entirely contracted on the basis of direct entrustment to municipal companies, depending on the region for a period of 8 to 15 years. Every year, the clause defining the scope of operational work and the prices of the service is revised.	Some local authorities decide to tender for certain bus services, e.g. in Prague.
Hungary	Local authorities are responsible for timetables, networks, ticket prices, payment of compensation on the basis of a tender or entrustment. However, direct conclusion of contracts with an internal entity for the provision of urban public transport services is still the dominant form of contracting.	In small towns, LPT services are sometimes provided by private entities under less formal rules.

Source: own study based on K. Wąsowicz (2018), Efficiency of public utilities of local public transport, Wyd. Foundation of the Cracow University of Economics, Krakow.

can lead to excessive increases for end users, especially if the contracts were signed a long time ago and did not contain adequate safeguards (Lobina 2017a, 2017b; Wagner and Berlo 2017; Cumbers and Becker 2018; Lobina et al. 2019; remunicipalisation.org). On the other hand, the implementation of these tasks in the form of public-private partnerships continues to develop (Marques and Silvestre 2017; Frone and Frone 2018; Thellbro, Bjärstig and Eckerberg 2018; Lima, Brochado and Marques 2021; Sarmento and Renneboog 2021).

Waste management is a complex, interdisciplinary concept, encompassing both planning activities, as well as the implementation of projects and technologies and their control. Municipal waste collection, transport and management processes across Europe are usually public in nature, with few market-based elements. In all countries, municipalities are burdened with the obligation to ensure cleanliness in their area. Municipalities, however, do not own the waste, but *govern* it in the sense that they organize a system of its collection and management in their area. The exceptions are the Czech Republic and Germany, where some municipalities claim ownership of all

Table 5.6 Production and distribution of public utility services on the example of water supply and wastewater collection in selected EU countries

Country	*Dominant models*	*Comments*
Germany	Has a varied WSWT structure comprising public and private sector companies, Drinking water companies and wastewater companies are generally separate entities. As regards wastewater, the majority are own-operated municipal utilities. WSWT are core duties of public services in the general interest within the competence of the municipalities or other public corporations.	The specific regional and local parameters determine the supply and disposal conditions on site. WSWT therefore always require locally adapted solutions. Local statutes determine that each citizen and commercial company is obliged to connect to and utilize the public drinking water supply and sewers of the local government or responsible special purpose association. Exceptions might occur outside municipalities in rural areas.
France	Municipalities are legally responsible for WSWT services and customer service. Supervised by the state, they have the freedom to choose how to operate their public services. This freedom of choice of management is derived from the constitutional principle of free administration of local authorities. Local authorities can then decide: • to directly manage the service (*régie*) • or to entrust the management of the management to a third party, selected in the framework of public tendering processes, through a concession or public service delegation (*gestion déléguée*). Ways and means of managing investment, retribution and maintenance vary	The municipality is accountable for the service level, including the monitoring of customer complaints (subject to a national performance indicator) and ways to answer them. The ministries in charge of water define the standards for quality, continuity of service and resource preservation. Municipalities are responsible for guaranteeing the application of these norms and for ensuring the quality of service. They have to report yearly on these topics, which are also subjected to national performance indicators. In addition, the delegated private partner (if any) must publish a report on actions taken analyzing the quality of service.
United Kingdom	Water services are organized under the direct private management model in England and Wales, with the latter operated on a not-for-profit basis. In Northern Ireland and Scotland, services are organized according to the delegated public management model.	Customers are entitled to guaranteed minimum standards of service, as laid down by the governments. If a company fails to meet any of these standards of service, then it is required to make a specified payment to the affected customer. In England and Wales, the Water Services Regulation Authority – known as Ofwat – monitors the scheme and recommends changes; the Utility Regulator and the Water Industry Commission carry out similar roles in Scotland and Northern Ireland.

(*Continued*)

Table 5.6 (Continued)

Country	*Dominant models*	*Comments*
Spain	Water services are organized according to direct public management, delegated public management and delegated private management the share of public companies and private companies in the market is circa 1/3 per each group in water supply and	Municipalities supervise the quality of service to customers at local level. Each municipality has the legal authority to establish the quality of service.
Poland	The biggest part of the market is served by public companies under delegated public management (municipal companies such as limited liability companies, joint stock companies, etc.). A part of the market remains under direct public management by municipalities (budgetary unit). Public-private companies are rare. the water services utilities often treat wastewater delivered by slurry tanks, manage sludge (incineration, drying, fertilizer production, composting etc.), in addition they produce and sell energy from biogas and sludge as well as from heat pumps, photovoltaic panels and provide other services like network infrastructure construction, rainwater management etc.	In terms of quality of water services, consumers are protected by the Office for Competition and Consumer Protection. According to the Act on the Collective Supply in Water and Collective Discharge of wastewater, every water utility is bound to issue a local service regulation including general obligations of the utility in relation to the consumers. The Chief Sanitary Inspectorate checks drinking water quality while the Inspectorate for Environmental Protection is obliged to check the treated wastewater quality.
Czech Republic	Several management models co-exist in the Czech Republic (market size is expressed in the mean volume of water supplied to end customers): 1 Delegated private management (dominate on the market) a directly – based on contracts among municipalities and private entities b indirectly • through associations of municipalities that rent the asset to private entities • through publicly owned companies that rent the asset to private entities 2 Delegated public management either through public water	The Ministry of Agriculture (Department of Regulation and Supervision of the Water Industry) supervises the quality of the service. It concerns particularly technical matters such as service connections, metering, interruption of water supply, water quality, technical specifications for contracts, and the disclosure of information regarding the calculation of water and sewage tariffs. The Law on Consumer Protection contains additional requirements. Regional water authorities (part of the state administration) and municipalities ensure the supervision of the service quality

(*Continued*)

Table 5.6 (Continued)

Country	*Dominant models*	*Comments*
	companies or through a public multiservice company (usually municipal technical services company) 3 Direct private management (private ownership and operation of public water systems) 4 Direct public management	at local level. Tasks are broadly defined and partially shared among multiple institutions of the state administration – ministries and municipalities. In addition, mandatory service quality parameters may be included in the operational contracts when the public/private management model is applied. Finally, some service providers set and maintain voluntary quality-of-service charts. They are accessible to all customers and include voluntary penalties in the event of non-compliance.
Hungary	The public water infrastructure used for the provision of drinking water, wastewater disposal and waste treatment services can be owned exclusively by local municipalities or the state. It is also the responsibility of the local governments and, in certain cases specifically defined in the legislation, of the state itself to provide customers with these services. The asset owner (the municipality or the state) signs a contract of service provision with the service provider (utility company). The contract can be one of three different types: asset management contract, concession or rent-operation scheme. Each type of contract involves different legal provisions and obligations. The 'concession' contract provides the widest range of rights and the largest responsibility to the operator. The smallest responsibility and narrowest scope are given to the service provider by the 'rent-operation' type of contract.	The Hungarian Authority for Consumer Protection is responsible for settling accounts, billing, payment of fees and tariffs, metering, prosecuting the violation of provisions laid down in legislation and upholding business regulations concerning the restriction or suspension of public water utility services concerning public users. In all other issues, the regulatory authority - the Hungarian Energy and Public Utility Regulatory Authority (MEKH) - is responsible for supervising the quality of services. MEKH also has a department for consumer protection.

Source: EurEau 2020, Rosiek 2020a, Rosiek 2019.

waste and do not allow competition even on the market for the collection of secondary raw materials. Table 5.7 presents the models of organizing the provision of municipal waste management services in various European countries, distinguishing the features common and those that are characteristic of a given country.

The presented analysis of models of production and distribution of public utility services, although it refers only to three industries selected by the authors, i.e. LPT, WSWT services and municipal waste management, indicates a large variety of these systems. The predominant ways of performing public tasks depend both on the sector in which they are carried out and on traditions and political and economic tendencies. The development of new technologies and their availability may, in turn, affect the quality of services provided and systematically change the models of production and distribution of PGs, including public utility services, particularly important for the smooth functioning of cities and raising the standard of living of their inhabitants.

5.4 The impact of modern technology on the quality of provided public utility services in cities

5.4.1 Modern technologies in the area of providing public services in modern cities

The last few decades have been a period of dynamic development of modern technologies that are widely used in all areas of life. Their mass use creates a new socio-economic order. New methods of functioning in the economic space are being created, including projects based on completely new concepts, as well as traditional projects enriched with modern solutions. Also in the sphere of public utility services, significant changes are taking place – modifications, transformations, the emergence of new ways and forms of delivering and providing these specific services.

Changes caused by the dissemination of advanced technologies are particularly visible in LPT. The use of advanced technologies, especially information and telecommunications, affecting the process of people's movements (also in urban space) resulted in the creation of the so-called transport telematics. The combination of information and communication technologies in LPT services is particularly applicable in:

- BRT (Bus Rapid Transit) systems, which are tools for the development of fast bus transport,
- Modern technologies in rolling stock,
- Creation and use of transport process components, equipped with intelligent controllers adapting their operating parameters to the conditions of a given communication network and enabling the imaging of all operational events,

Table 5.7 Production and distribution of PUS on the example of municipal waste management in selected EU countries

Country	*Dominant models*	*Comments*
Germany	There is a division into services related to the collection of municipal waste and services related to their management. The management function over the MWM system in German cities is exercised by the relevant office, located in the structures of the municipality. Operational activities in the field of municipal waste collection are performed by entities selected under a public contract. Entities involved in waste management are usually companies, holdings, whose ownership capital comes from the city and private owners. Fees for MWM are borne by property owners and cover the costs of waste management in the city. Toll collection is carried out by the magistrate. The municipality is responsible for all issues related to the collection of municipal waste.	The MWM market is characterized by a continuous improvement in the efficiency of separate waste collection systems, resulting in a reduction in the size of the non-segregated waste stream. A significant contribution to the process of minimizing the stream of non-segregated waste is also the implemented national waste prevention program, shaping appropriate consumer behavior.
France	Waste management in France is managed by inter-municipal associations, which are a community of municipalities of a given region. They commission the collection and processing of waste. Regional installations owned by the Inter-Municipal Association were put into operation to specialized commercial entities for a period of 10–20 years. The organizer of the waste collection and management system in individual cases remains the Inter-Municipal Associations, which coordinate the activities of the system and monitor the entire MWM in the area of local governments forming the Association on an ongoing basis. Waste in France is collected by three types of organizations. The entity responsible for the collection of household waste is a public entity. In turn, waste producers independently organize the transport and disposal of waste. In addition, the collection of waste is the responsibility of the so-called *éco-organismes*, which organize collective segregation within the REP network (*Responsabilité élargie du producteur*)	The provisions of French law gave the possibility of functioning of non-commercial entities of waste segregation, which were created on the initiative of private entities. They shall act with the consent of the public authorities. An example of a private *éco-organisme* is ADIVALOR, which has undertaken the disposal of m.in plastic products and deals with the disposal of agricultural waste, including plastic waste. ADIVALOR is the only unit of this type in Europe, which, despite its private nature, has integrated a large number of entities throughout France.

United Kingdom	The collection of municipal waste rests with the local authorities (municipalities). Municipalities purchase export and disposal services. Providers of these services are compulsorily selected in tenders, in which a few municipal entities may also take part. Export contracts are usually awarded for 5–7 years. Disposal services are also purchased by municipalities in tenders. The length of the contract is 15–20 years. Residents pay a local (quasi-tax) fee for collecting waste from the property. Entrepreneurs are obliged to document the way of dealing with waste, they are obliged to achieve certain levels of recycling. Entrepreneurs must send documents confirming the achieved level of recycling to the Environmental Protection Agency once a year.	They have extremely developed mechanisms for recording control, supervising enterprises under producer responsibility in MWM.
Spain	The local government conducts a waste prevention policy, supervises and controls municipal management in a given area, is responsible for the collection, transport and treatment of municipal waste from households and companies, through specialized enterprises selected through a tender procedure (subject to public procurement law). The municipality collects fees from the owners of the property from which it finances the indicated services. Any entrepreneur introducing waste from household packaging to the market in Spain is obliged to ensure the collection of packaging materials.	In the field of packaging collection systems, there is an integrated system for licensing packaging waste in the country (Integrated Management System). However, participation in these schemes is not mandatory. It is also possible to create a private return system.
Poland	The municipality is the basic – statutory – body for the performance of MWM tasks. The performance of tasks by the municipality can be carried out in two ways: • the management of the system and the conduct of tenders for the selection of private entities providing export services, • entrusting the tasks of managing the system to another legal person, in a tender or non-tender mode - called in house. The in-house mode is a special procedure for entrusting the management or/or operation of the MWM system to your own municipal company. The municipal council determines, by way of a resolution, the upper rates of	For the MWM system, regional Municipal Waste Treatment Installations, operating in waste management regions designated on the basis of waste management plans, are crucial. The municipal waste management region is an area of neighboring municipalities with a total population of at least 150,000 and served by regional installations.

(*Continued*)

Table 5.7 (Continued)

Country	*Dominant models*	*Comments*
	fees borne by property owners for municipal waste collection services. The rates of fees for municipal waste management are adopted on the basis of the estimated costs of municipal waste management in the municipality, using a selected conversion rate, e.g. for the number of inhabitants living in a given property.	
Czech Republic	In Czech cities, the local government is responsible for ensuring the collection and treatment of municipal waste generated by residents. To this end, the city organizes tender procedures for the collection and management of municipal waste from households. The entity collecting and using waste is usually enterprises whose majority shareholder is the city. Companies, with a ten-year public contract, are responsible for collecting and processing municipal waste generated on inhabited properties located in a given area. Public companies in some districts subcontract waste collection tasks to private subcontractors located in those districts. Fees for the management of municipal waste arising on inhabited properties located in Czech cities are borne by the owners of these properties, paying the appropriate fee to the city's bank account	Waste management is one of the most dynamically developing sectors of the country economy. Since 2004. More than 90% of European legislation is implemented into national law. They have created a system based on a rational approach to issues related to the production and disposal of waste. The principle of producer responsibility is also effectively implemented in municipal waste management. Thanks to this, covering the costs of separately collected waste management is the responsibility of the recovery organization.
Hungary	The way waste is managed is regulated by waste management plans, which are acts of local law. Autonomously selects and determines the model for the provision of these services. Municipalities can decide whether the collection of waste will be carried out by their own enterprise or by a private company selected in accordance with the public procurement law. The fee for the collection of waste borne by consumers is set by the municipality. Waste producers who can ensure the collection and management of waste on their own can leave the municipal system and use competing private companies, paying market prices.	The public service is provided as part of a fee charged by the municipality and covers only a certain amount of waste. The remaining ones, their manufacturer must get rid of on his own, signing a contract with one of the companies operating on the market and competing.

Source: Own study based on: UOKiK, 2012; Wąsowicz, Famielec, Chełkowski, 2020.

- Integrated charging and passenger information systems, using the technology of analysis, exchange, data storage,
- Safety systems, including driving assistance systems, monitoring systems or emergency services notification systems.

Another PUS industry, whose shape and character are defined by modern technologies, is municipal waste management. It is a multifaceted process based on the transport, movement and processing of waste (which arises as a result of human living activities) and supervision over these activities. The use of innovative solutions supports the management of waste flow, minimizing their quantity, as well as enhancing the opportunities for their reuse or effective disposal. New technologies used in municipal waste management are applied in the collection, verification, sorting, recovery, transfer, disposal, and storage of waste. Technologies supporting the optimal functioning of municipal waste management in a given city are usually used in the implementation of the following tasks:

- Planning municipal waste management with the use of integrated IT systems,
- Waste collection, verification, sorting and transfer to other units,
- Recording the serviced real estate in the field of municipal waste disposal, charging fees for residents in accordance with local rates, generating decisions, statements, reports in accordance with the applicable tax ordinance,
- Controlling the proper management of waste by property owners,
- Recovery, utilization, liquidation and storage of waste using autonomous devices and innovative pro-ecological technologies.

Water and sewerage services appear to be the most *static* of the public utility services in question. However, these are only appearances. Providing safe drinking water, as well as meeting the growing requirements related to the level of wastewater treatment and sewage sludge disposal, enhance the importance of automation and monitoring of these processes. A separate issue is the monitoring of water supply and sewage networks both in the context of failure and overload. In the case of a water supply network, it is an absolute requirement for safety and limiting water losses. In the management of sewage networks, congestion caused by rainwater and accidental water, as well as illegal discharges of sewage into infrastructure, are important. Therefore, the use of modern technologies in the WSWT sector is increasing, including:

- Monitoring of water quality parameters,
- Monitoring of network failures,
- Mathematical modeling of network operations in various conditions,
- Installing sensors enabling data collection in real time for sensor-based management systems,

- Trenchless infrastructure repair and modernization technologies,
- Smart water networks,
- Artificial intelligence (AI)-based demand-driven distribution technology,
- Automatic management of wastewater treatment processes,
- Phosphorus recovery technologies,
- Water infrastructures secure against cyber-physical attacks.

Table 5.8 presents a set of modern technologies commonly used in individual sectors of public utilities in urban areas.

Based on the analysis of the use of modern technologies in individual sectors of public utility services (see Table 5.8), in 2020 the authors prepared a survey that was addressed to selected Polish cities in order to verify the use of new solutions in the area of providing LPT services, municipal waste management and water supply and sewage management. Twelve major cities were selected for the study. Nine of them are taking part in the work of a team from the Technical University of Vienna on the creation of smart cities: Krakow, Poznan, Lodz, Gdansk, Wroclaw, Katowice, Lublin, Bydgoszcz and Szczecin. With the intention of obtaining a representation of each of the areas of Polish, the research sample was supplemented with three more: Warsaw (the capital), Bialystok and Rzeszow.

Based on the indication of modern technologies currently used or planned to be used in the near future (highlighted in Table 5.8), the values of the total number of indications by individual cities were determined, according to the criterion: value 2 – for modern technologies already in use, value 1 – for planned technologies in the next two years, and value 0 – for unused and unplanned technologies. In this way, innovation rankings of selected cities (Table 5.9) were created for individual industries in which a higher number of points obtained mean a higher position in the ranking.

Using the rankings of saturation with innovative technologies for the LPT industry, municipal waste management and water supply and sewage management, a ranking for the innovativeness of municipal economies of individual cities was created (Figure 5.2). It was created as follows: the positions of cities in the rankings of individual industries were added and ordered according to the lowest value of the aggregated ranking positions. With the same point value, the order determined a smaller value of the standard deviation of the ranking positions of individual cities.

5.4.2 Quality as a paradigm for the provision of public utility services?

The main goal in the functioning of LPT, municipal waste management and water supply and sewage management is to increase the comfort of life of society, which requires taking into account quality criteria that ensure better and more complete satisfaction of the needs of the local community. Therefore, the identification of the forms of delivery of PUS should take place through the analysis of meeting the expectations of residents, in the context of

Table 5.8 Innovative solutions in the area of providing public utility services in cities

Innovative solutions in the area of services		
Local public transport	*Municipal waste management*	*Water supply and wastewater management*
1. Design and modelling system: • Communication networks (timetable planning) • Automatic generation of routes/trips • Tasks for vehicles and drivers • Simulation of vehicle traffic in the network • Analysis of the operating costs of the transport system	1. Mobile applications searching for waste collection dates for a specific address, reminding about the upcoming export, providing all the necessary information needed for proper waste sorting, informing about Points of Selective Collection of Communal Waste and air quality, enabling reporting potential problems	1. Flow monitoring systems and modeling of water supply network flows in order to make both investment and real-time decisions (detection of failures, illegal water abstraction), Sensor-based management systems Smart water networks AI-based demand-driven distribution technology
2. Intelligent motion control system	2. Baskets independently sorting and segregating thrown waste	2. Flow monitoring systems and modeling of water supply network flows and using data to make decisions in real time, e.g. in the case of heavy rains and the use of duct retention or flow-delaying tanks Data also used to make investment decisions Sensor-based management systems
3. Prioritization system at intersections for public transport vehicles	3. Underground waste containers	3. Use of energy from renewable sources, biogas, heat recovery, solar energy
4. BRT system (fast bus transport)	4. Compostable, biodegradable garbage bags	4. Energy recovery on water mains
5. Passenger stream counting system	5. Waste segregation verification system	5. Remote (radio) meter reading
6. Video monitoring system (covering all events that may occur inside and outside the vehicle)	6. Return machines for packaging waste	6. Remote reading of electronic meters, an application that allows you to control water consumption
7. Modern integrated ticketing systems (based on mobile ticket	7. Attachment carriers (operating all year round) as:	7. Recovering Nutrients Installations for the recovery

(*Continued*)

Table 5.8 (Continued)

Innovative solutions in the area of services		
Local public transport	*Municipal waste management*	*Water supply and wastewater management*
machines, e-tickets, cashless payments)	• mowers • equipment for the care of greenery • sweepers • washing machines • snow blowers	of phosphorus from sewage sludge
8. Information for passengers on the Internet (dynamic websites)	8. Electric street sweeper	8. Reuse of water from treated wastewater
9. Visual and voice information system inside the vehicle	9. Electric garbage trucks	9. Passive sewage treatment plant
10. Real-time bus stop information system for passengers	10. Garbage trucks for separate waste collection (multi-chamber)	10. Potable reuse facilities, using multiple barrier technologies and intense monitoring
11. Mobile applications to determine the conditions and method of travel by public transport	11. A system for optimizing and monitoring the routes of waste collection vehicles (so-called "oute design")	11. Mobile applications for customer relations and crash reporting
12. An integrated transport system using a mobile application designed for passengers, drivers and cyclists, giving the opportunity to make informed decisions and better plan the route	12. Autonomous vehicles for the extraction and disposal of waste	12. Early warning systems Local hydro-meteorological, monitoring systems Modeling of atmospheric phenomena
13. A system for passengers integrating rail, metro, tram, bus additionally combined with services such as car-sharing, public bicycles or buses on the phone	13. Automatic waste collection system (e.g. PRESKO)	13. Promoting the restoration of water resources
14. Comprehensive "one-stop-shop" service platform, containing in one place full information about available transport services and payments	14. Autonomous sorting plants for raw material waste	14. Technologies for the use of non-potable water (salty, grey and recovered from industrial processes) to a quality enabling safe use for defined purposes (agricultural, domestic, consumption)

(*Continued*)

Table 5.8 (Continued)

Innovative solutions in the area of services		
Local public transport	*Municipal waste management*	*Water supply and wastewater management*
15. Operational centers in smart mobility systems	15. Recycling of electronic waste	15. Technologies for non-invasive network repair and maintenance
16. Mobile applications for buying tickets	16. Recycling of mixed plastics (e.g. milk carton)	16. Rapid Water Quality Testing
17. Standard Near Field Communication (NFC) – a mobile phone that acts as a smart card (e.g. opens gates, identifies the owner, even if the battery is discharged)	17. Technologies of full recycling of polystyrene (so-called thermal-catalytic recycling)	17. Water quality control systems, new pollution, small distribution systems, individual intakes, priority facilities
18. Mobile applications informing in real time about the vehicle	18. Thermal recycling	18. Integrated water databases with access for various stakeholders, e.g. companies, residents
19. Electric buses	19. Technologies for the acquisition and use of biogas for energy purposes	19. Nanotechnology in water desalination
20. PRIMOVE electric buses induction charging system in normal passenger traffic	20. Advanced technologies of thermal waste disposal and energy acquisition (chemothermal technologies)	20. Secure water infrastructures against cyber-physical attacks
21. Hydrogen-powered buses	21. IT systems supporting the waste management process (e.g. ecoSanit, Ulysses WASTE) in the following areas:	
22. Safety systems, including both driving assistance systems (forward collision warning system) as well as monitoring and notification systems for intervention services	• Compilation of electronic declarations • Production of qualitative and quantitative forecasts of waste	21. Use of green and blue infrastructure to reduce weather and climate pressure on grey infrastructure, to protect water resources and water-dependent ecosystems
23. Mobile communication with drivers and new personnel management tools	• Production of reports resulting from the relevant provisions • Complaint management	
24. Autonomous vehicles	• Creating waste collection schedules	22. Systems for monitoring and controlling the collection of wastewater from non-drainage tanks
25. Depot management system (automated OC lines and setting up rail vehicles)	• Financial settlement and fees • Monitoring the collection of waste	

(*Continued*)

Table 5.8 (Continued)

Innovative solutions in the area of services		
Local public transport	*Municipal waste management*	*Water supply and wastewater management*
26. Modern components, characterized by reduced labor intensity, increased service life and extended service intervals, equipped with intelligent controllers that adapt their operating parameters to the conditions occurring in a given communication network and enable the imaging of all operational events occurring throughout the life cycle of the component (e.g. optimization of the process of driving vehicles for maintenance, including the need for repairs at low levels)	• The management of waste containers • Creating a database (e.g. declarations, land registers) • Exchange of data with other entities • Information/educational activities (e.g. a separate web portal) • Communication with property owners (e.g. SMS) • Generating notifications • Help desk • Creating applications for mobile devices • Creating the possibility of integration with additional modules/programs	
27. Multifunctional stops for local collective transport, integrated with the environment (intelligent stops, which, in addition to providing up-to-date traffic information, also allow passengers to perform everyday activities, such as paying bills, sending packages or topping up mobile phones)		
28. Multimodal stops	22. Integrated systems supporting management in a municipal waste management enterprise (Business Intelligence class IT solutions)	23. Educational applications to raise environmental awareness
29. Integration platform of systems: timetabled, ticketing, passenger information, control and traffic control, fleet management and more		
30. Integrated systems supporting	23. Applications for the transfer and exchange	

(*Continued*)

Table 5.8 (Continued)

Innovative solutions in the area of services		
Local public transport	*Municipal waste management*	*Water supply and wastewater management*
management in a municipal local public transport enterprise (Business Intelligence class IT solutions)	of unnecessary and unused items	
31. Big Data in the study of demand and supply in urban transport	32. Open data structures in a real-time public transport management system using data cloud technology	
24. Brigades for the repair of household equipment.		
33. Open protocols and data transfer to national navigation systems (integration of mobile data systems from different carriers) that can be read by typical, publicly available GPS devices and applications	25. Educational applications to raise environmental awareness	
34. Interactive dialogue using social media and third-party applications	26. Waste collection and storage system adapted to the needs of persons with reduced mobility and other disabilities	
35. Transport system adapted to the needs of persons with reduced mobility and other disabilities		
36. Marketing to create added value for the customer – transport service as a "lifestyle" product		

Source: own study.

the properties desired by the users of the indicated services. The consumer is primarily interested in the quality of the public utility service. Treating the concept of quality of services in public transport, municipal waste management and water supply and sewage management as a set of features describing this quality from the customer's point of view, is the starting point for determining the range of features that can characterize the level of quality of municipal services in the city. These features, due to the expected quality of PUS, can be

Table 5.9 Ranking of cities by the degree of use of innovative solutions in the area of providing public utility services in urban areas in 2020

City	*Position in the ranking of saturation with innovative technologies in:*		
	local public transport	*municipal waste management*	*water supply and sewage management*
Bialystok	10	2	10
Bydgoszcz	11	10	6
Gdansk	4	9	2
Katowice	3	4	4
Krakow	2	1	1
Lublin	8	12	10
Lodz	5	7	8
Poznan	7	5	4
Rzeszow	6	11	10
Szczecin	12	5	8
Warsaw	1	3	7
Wroclaw	9	8	3

Source: own study.

called *postulates for municipal services*, which reflect the preferences reported by residents toward the surveyed municipal industries. Bearing in mind the conditions set for public transport, municipal waste management and water supply and sewage management in urban areas in the European Union countries and the criteria that appear in European standards on the quality of the described services, this study has created a set of postulates regarding the quality of municipal management in the city (Table 5.10).

In order to assess the quality of municipal services from the point of view of consumers, the assessments of postulates in Table 5.10 were compiled, expressed in the form of fifty detailed questions, on a five-point Likert scale, where five means the best rating. For each of the quality characteristics, the basic measurement tool is an original survey addressed to customers of LPT companies, municipal waste management, water supply and sewage management, who assessed each of the quality measures of the services provided. The applied research method allowed for determining the average value of consumer satisfaction for each qualitative characteristic.

A multi-criteria ranking was used to assess the quality measures for municipal service systems in the LPT industry, municipal waste management and water and sewage management in individual cities (Młodak 2006). To create a ranking of multi-criteria characterized cities, a synthetic variable was used, the construction of which was based on zero unitarization (MUZ). The MUZ method requires several stages. In the first stage, diagnostic variables are divided into stimulants, destimulants and nominants, followed by their normalization to the variables (Kukuła 2000). In the next stage of the MUZ method, normalized variables are aggregated, by means of an arithmetic mean.

The values of the synthetic variable are normalized in the range [0,1] and

Figure 5.2 Ranking of innovative municipal economies of the surveyed cities in 2020. * same point value and standard deviation.

Source: Own elaboration based on Table 5.7.

allow them to be ordered according to the intensity of the studied phenomenon. The higher the value of the variable reaches the object (closer to 1), the higher the place it occupies in the ranking of the studied objects (and vice versa).

In the area of quality of LPT, municipal waste management, 8 out of 10 characteristics, and in water and sewage management 6 out of 8 characteristics (presented in Table 5.10) has a stimulant character, 1 destimulant trait and 1 nominant. In case of characteristics, the lower the value of which means the better the assessment of the functioning of LPT, municipal waste management and water and sewage management, the authors included the amount of fees. Nominants (maximum quality if the values are in a specific set) are the percentage of respondents using modern technologies. Bearing in mind the natural limitations in this matter among the elderly, it is assumed that the optimal range for the indicated characteristic is from 30% to 70%. Table 5.11 presents the results of the ranking of the quality assessment of LPT, municipal waste management and water and wastewater management created using the MUZ method in 2020.

As in the case of innovation of municipal economies, a ranking was created for municipal economies of individual cities (Figure 5.3.) using the criterion of assessing the quality of services provided. It shows that the largest Polish cities occupy the highest positions.

Table 5.10 Social standards defining the quality of communal services in the city

Postulates concerning the quality of municipal economy in the city		
Local public transport: • availability of the communication network • frequency of running • running punctuality • travel safety • certainty of travel • speed and directness of the journey • the amount of the toll • travel convenience • information about the transport offer	Waste management: • comprehensiveness of collection • frequency of colection • timeliness of collection • winter maintenance of infrastructure • certainty of collection • maintenance of cleanliness in the city • size of fee for collection • ease of waste segregation • informaiton about waste collection	Water and sewage management • universal access to the service (possibility of connection) • the quality of the water supplied • technical efficiency • technical activity • reliability of water supply and sewage collection • fees for water supply and sewage collection • easy communication of consumption information
- modern technologies used		

Source: Own study.

5.4.3 Determination of the impact of modern solutions on the quality of public utility services using statistical methods

To examine whether the ordering of assessments regarding the quality of LPT services, municipal waste management and management water supply and sewage system, are consistent with the saturation of innovative solutions of these services, i.e. whether the degree of use of modern technologies translates into the quality of public utility services provided, Spearman rank correlation coefficients were calculated. The coefficient takes values from −1 to 1, and its positive result indicates a concordance in the orders of objects, while a negative one indicates a discrepancy (opposite rankings). In the conducted research, the value of the rank correlation coefficient of 0.909090 indicates almost full compliance of the orders of the quality of services provided and the degree of saturation with modern technologies in the LPT industry. This is statistically significant (p–value = 0.002569 and is less than 0.05). The graph shows a correlation diagram in which the points represent the quality of services provided in the LPT industry with a corresponding aggregate measure of the degree of innovation used in public transport (Figure 5.4).

The line in the graph shows the regression function with the equation $y = 0.1239 + 0.0199 \times$. Its positive slope confirms that the greater use of modern technologies corresponds to a higher quality of services provided (an increase in saturation with modern technologies by 0.1 will improve the quality of services provided on average by approx. 0.00199), this relationship is statistically significant (p-value for the regression coefficient is 0.000142). In the case of municipal waste management, the value of the rank correlation

Table 5.11 Rankings of the quality of local public transport, municipal waste management and water supply and sewage management created using the MUZ method in 2020

Local public transport			*Municipal waste management*			*Water supply and sewage management*		
Rankign position	*City*	*Value of the synthetic variable*	*Ranking position*	*City*	*Value of the synthetic variable*	*Ranking position*	*City*	*Value of the synthetic variable*
1.	Warsaw	0,697139	1.	Bialystok	0,817388	1.	Krakow	0,742135
2.	Krakow	0,678581	2.	Krakow	0,794845	2.	Wroclaw	0,682271
3.	Poznan	0,644975	3.	Warsaw	0,717536	3.	Gdansk	0,573962
4.	Gdansk	0,634838	4.	Katowice	0,716049	4.	Poznan	0,526492
5.	Katowice	0,610780	5.	Wroclaw	0,715595	5.	Bydgoszcz	0,519922
6.	Lodz	0,607612	6.	Szczecin	0,625591	6.	Katowice	0,506917
7.	Rzeszow	0,604024	7.	Poznan	0,582519	7.	Warsaw	0,494801
8.	Wroclaw	0,542023	8.	Lodz	0,567022	8.	Rzeszow	0,481615
9.	Lublin	0,530615	9.	Gdansk	0,548575	9.	Szczecin	0,465999
10.	Bydgoszcz	0,512521	10.	Rzeszow	0,547351	10.	Lublin	0,459615
11.	Bialystok	0,507766	11.	Lublin	0,545708	11.	Lodz	0,444165
12.	Szczecin	0,370787	12.	Bydgoszcz	0,460741	12.	Bialystok	0,419264

Source: own study.

Figure 5.3 Ranking of municipal economies of surveyed cities according to the assessment of the quality of public utility services provided in 2020.

Source: Own elaboration based on Table 5.10.

coefficient of 0.928321 indicates an almost full correlation of quality and the degree of use of modern technologies in this industry. The relationship, as in the case of LPT, is statistically significant (p-value = 0.00207). The chart additionally presents a correlation diagram of the quality of services provided in the municipal waste management industry using modern technologies in this industry (Figure 5.5).

In this case, the regression function has the equation y = 0.3856 + 0.0158 ×. An increase in the use of modern technologies by 0.1 will improve the quality of services provided on average by approx. 0.00158. This is also statistically significant (p-value for the regression coefficient is 0.000217).

In the case of water supply and sewage management, the value of the rank correlation coefficient of 0.919580 indicates an almost full correlation of quality and the degree of use of modern technologies in this industry. The relationship, as in the case of other described areas of municipal management, is statistically significant (p-value = 0.002289). The graph presents a correlation diagram of the quality of services provided related to water supply and sewage collection using modern technologies (Figure 5.6). Here, the regression function has the equation y = 0.1809 + 0.0126 × . An increase in the use of modern technologies by 0.1 will improve the quality of services provided in the management of water pipeline and sewage by approximately 0.00126. This is statistically significant (p-value for the regression coefficient is 0.000087).

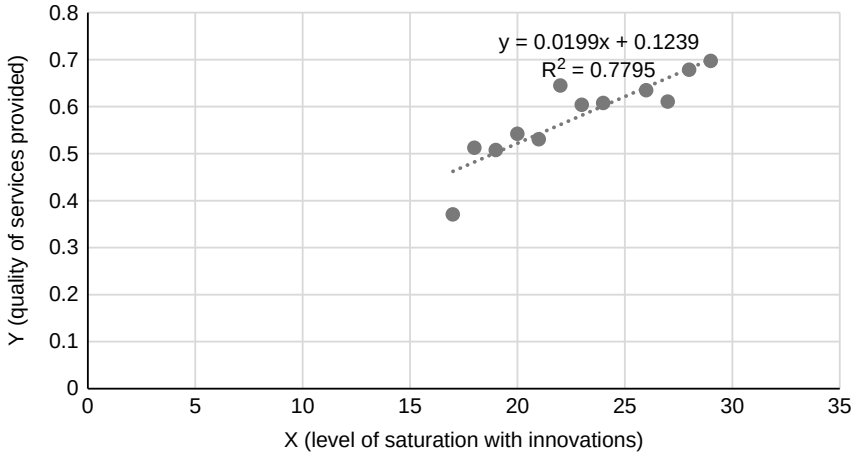

Figure 5.4 Correlation diagram showing the dependence of the local public transport industry services provided by the aggregate quality of services provided on the degree of saturation with modern technologies in local public transport.

Source: Own elaboration based on Tables 5.9 and 5.11.

5.5 A model approach to an inclusive distribution system for local public goods and services in a smart city

The REV4.0 forces both global and local economies to adapt to dynamic changes. This also applies to models of production and distribution of local public goods and public utility services. This sector, due to its specificity and financing rules, is susceptible (although to a much lesser extent than others) to technological innovations, analytics and Artificial Intelligence (AI), which is confirmed by research conducted in selected 12 major Polish cities.

Current solutions, where all responsibility for creating and maintaining in readiness for expensive technical infrastructure ensuring the functioning of cities (water and sewage, electricity and heat/cold, waste, public transport) lies mainly with local authorities and municipal entities, and residents only partially, often in an equivalent way, participate in the costs of its operation. This approach seems to be unsustainable in the future, also in the context of a growing population and growing challenges, such as those related to climate change.

Public utility services in cities are implemented by a special group of enterprises belonging to the municipal management sector. Their tasks related to activities such as LPT, WSWT and municipal waste management are activities that primarily meet public needs. On the other hand, when provided with high standards and respect for the principles of sustainable development, they serve to protect the natural environment in cities and improve the city

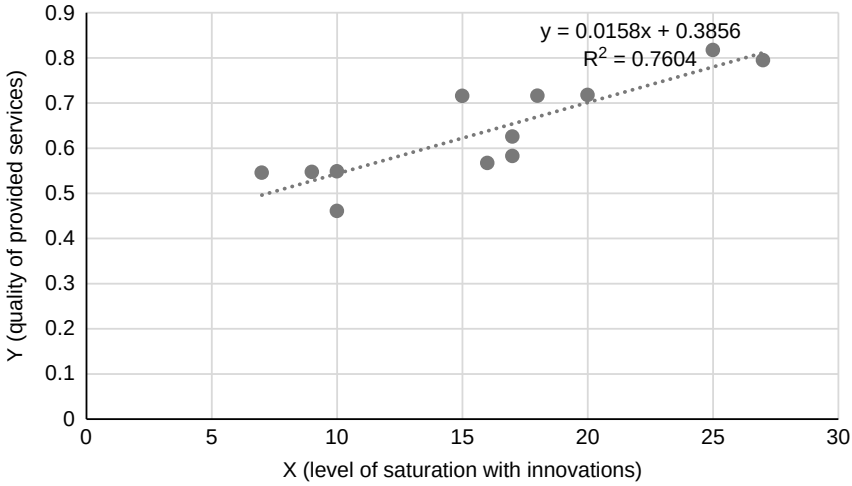

Figure 5.5 Correlation diagram showing the dependence of the aggregate quality of municipal waste management services on the degree of use of modern technologies in municipal waste management.

Source: Own study based on Tables 5.9 and 5.11.

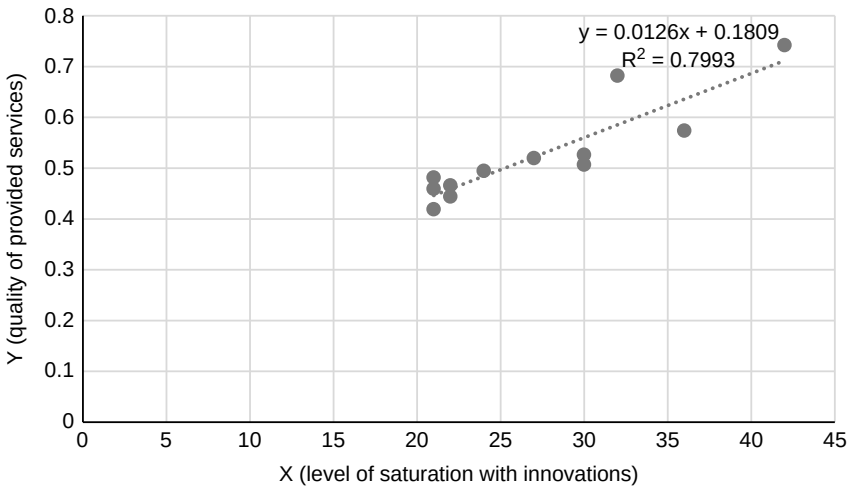

Figure 5.6 Correlation diagram showing the dependence of the aggregate quality of services of the management of water pipeline and sewage on the degree of use of modern technologies in the water supply and sewage management.

Source: Own elaboration based on Tables 5.9 and 5.11.

residents' quality of life. It is important that entities cooperate when carrying out their tasks.

In the case of public local government property collected in the form of municipal companies performing municipal management tasks, we are dealing with the identity of the source of the initial capital, which determines the purpose of their activity. Combining entities appointed to perform various municipal tasks may seem pointless on the surface. However, it is justified in the case of cities managing property to ensure the availability of municipal goods for their residents. The processes of searching for the most appropriate forms of cooperation between entities operating in the same or similar management sphere with the same ownership capital origin lead to a form of economic integration in the form of a holding structure. Its aim is to create a new management level of owned funds by increasing efficiency, concentration, and integration under common management of resources constituting the entities forming the holding (Stecki 1999). The holding structure of economic concentration is a form of creating economic relations that is beneficial and purposeful in cases involving public funds. The city, being the keeper of its property, gains the opportunity to create a municipal structure that can ensure the functioning of the entire sphere of public utility within one enterprise. By deciding to link existing municipal enterprises into one holding structure, the city gains an important tool for influencing the management processes taking place in the local economic space.

Increasing the effectiveness of the entities responsible for providing PUS, is facilitated by the development of partnership links, which Hausner compares to an archipelago. It consists of relational companies understood as "islands differently equipped and with different production, well communicated, between which multilateral and intensive exchange takes place. They are a co-dependent and co-creation system" (Hausner 2016, p. 113). The new business model made up of entities (islands) forming networks of relations (archipelagos) and new forms of exchange (allocation of resources) must be inclusive. This means that each island can voluntarily turn on, that is, co-create the archipelago, contributing its resources and its energy. Although each island retains its autonomy in the archipelago, there is a convergence of distinctiveness and subjectivity. The islands are to be aware of their own and other differences, but instead of isolating and competing, they are to seek interactive and partner relations with other islands (Hausner 2016, p. 115).

Nowadays, the model of providing PUS in urban areas is based on the assumption that the more services sold, the better for the entities providing them, regardless of the form of ownership and method of financing (i.e. whether the service is self-financing, profitable, or deficit-inducing and supported by public funds). Based on the analysis of the models used to provide PUS in the cities highest ranked in the rankings (Table 5.11), the authors attempted to develop a postulative model for the distribution of municipal goods. In the proposed model, the innovative change concerns the attribution of responsibility to individual participants of the municipal economy.

It is a mixed, inclusive model in which the responsibility for the performance of public utility tasks is assumed by the local authority. The infrastructure used for their implementation is supposed to be in the public domain, but in economically justified cases it can be created as part of a PPP. The role of the organizer of the PUS delivery system and the supervisor is performed by the local authority, which has a mandate to represent residents received through general elections. The contractors of the tasks are both municipal and private enterprises (Figure 5.7).

The local authority, through the units designated in its structure, determines the framework conditions for the production and distribution of public utility services in the city. It delegates other tasks to enterprises selected through a tender or entrustment, capable of creating a network of relations (and in justified cases even a holding structure). The participants of the system are also residents/consumers who report a demand for local goods and services (m.in participatory budget, public consultations). Using modern technologies, they actively join the process of controlling the quality of services provided, for example through applications (apps) for quality assessment, submitting proposals for changes, reporting failures (Figure 5.8).

In this model, particular emphasis is placed on the social usefulness of the municipal economy, while adopting the principle of spreading the public utility service provider's operating costs. The division occurs between the consumer of the service incurring a partial payment unequal to the aggregate costs of functioning of the entire system, and the co-financing of municipal activities from public funds in the name of implementing the public interest of members of the local self-government community. This means implementing the TTT model – Tariffs, Transfers, Taxes, which provides financing for the creation of expensive infrastructure and prevents residents/consumers from excluding themselves from using municipal goods due to too high prices. The assumptions of financial flows in this model are presented in Figure 5.9.

It should be emphasized that this model requires mature, informed and competent local authorities. Otherwise, a clear conflict of interest may arise due to the fact that a municipal utility is owned by the city. Consequently, the local authority has a dual capacity as owner and contracting authority. Theoretically, this may result in the city's actions to the detriment of the company.

An important element of the new concept of providing PUS is the introduction of requirements for assessing the performance of entities not only on the basis of financial criteria, but also an analysis regarding the use of energy, the circulation of raw materials and water. By creating a formal framework and requirements in this respect, the public authority encourages entities operating in the system to cooperate with each other, using the waste of one entity as a raw material for another (including: energy, waste heat, water reuse). In this way, a transition takes place from a "use as much as possible" model to a model based on minimizing the consumption of resources. This is the basis for creating in practice an archipelago in which entities (islands)

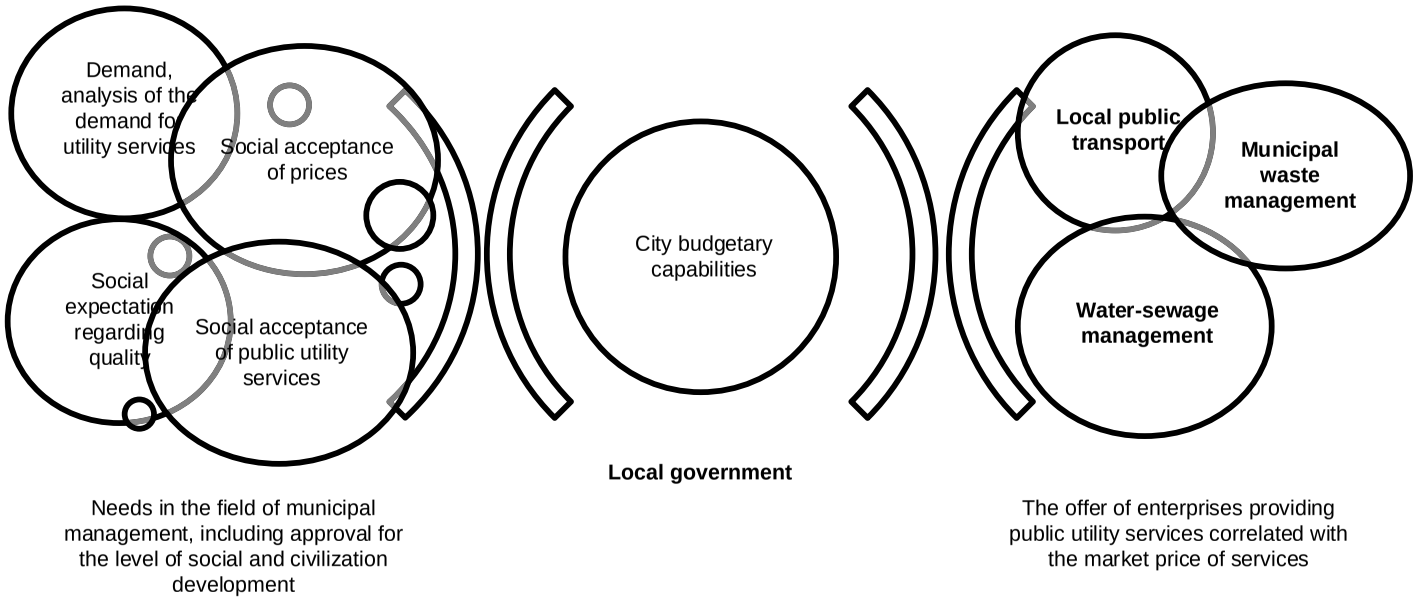

Figure 5.7 Boundary conditions of the organizer of municipal management in an inclusive model of distribution of local public goods and services in a smart city.

Source: Own study based on Wąsowicz 2018.

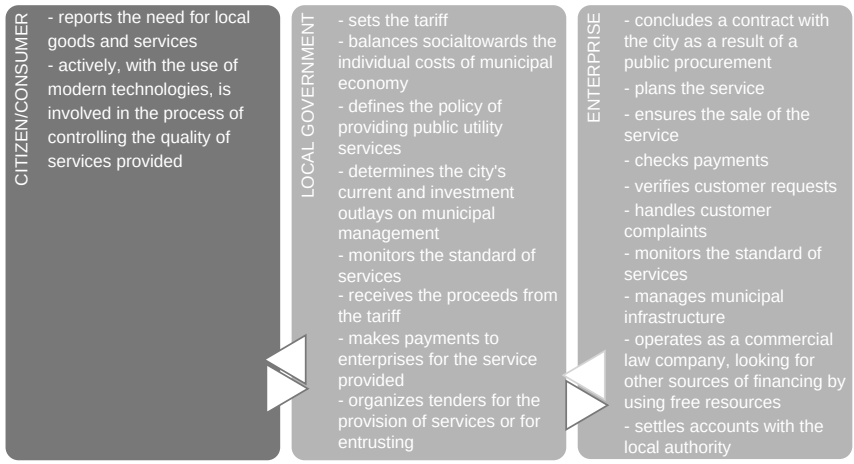

Figure 5.8 Responsibility matrix in the inclusive model.

Source: own study.

performing municipal management tasks cooperate with each other, generating added value for the local community, while acting in accordance with the assumptions of the circular economy. In practice, this means implementing the principles of sustainable development in urban areas.

In order to meet the challenges of the changing economic environment and meet the expectations of residents/consumers, the new model of distribution of municipal goods must therefore be based on cooperation between entities responsible for their supply, local and government authorities and the local community. All cooperation must be based on the assumptions that the well-being of citizens is crucial in making economic and social decisions, in accordance with the idea of sustainable development.

5.6 Chapter summary

REV4.0 technologies can contribute to strengthening the links between the actors that make up the city (islands) and generate economies of scale in the form of greater benefits (archipelagos). Modern technologies enabling the collection of large amounts of data from sensors and other sources and their processing in real time, create the opportunity to optimize costs and improve the quality of services provided. The 5G network and giant databases analyzed in real time, AI and IoT will enable responding to emergencies, difficult to predict situations related to congestion or, for example, the occurrence of dangerous weather phenomena (e.g. torrential rain) in a much more flexible and faster way. Information about the activities of residents and businesses can be sent immediately,

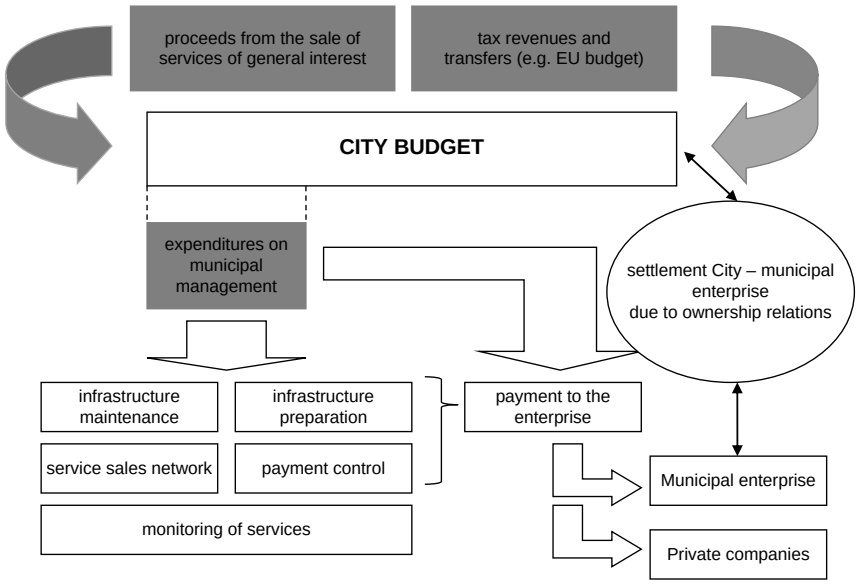

Figure 5.9 The general concept regarding financial flows in an inclusive model for the distribution of local public goods and services in a smart city.

Source: Own study based on Wąsowicz 2018.

and quick monitoring will make it difficult to behave like a free rider. However, these technologies can cause older or poorer people exclusion, especially those who cannot use modern communication tools. It is therefore the role of local authorities to ensure that seniors are included in the use of these tools.

Soon, an important aspect affecting the scope of operation of entities providing public utility services will be extended producer responsibility. Today, problems and costs with waste and sewage are passed on to residents, but in the future they will be more burdensome for producers. Public utility companies will cease to be a passive provider of *readiness to provide services* and their implementer. Instead, they will become entities dynamically reacting to changes in many factors in the city's organism. Their main competences will be the ability to engage the production potential at the disposal of different market participants and the ability to achieve the expected effects with the consumption of decreasing resources. Therefore, an ongoing analysis of models and trends in this area is necessary in order to identify legal and administrative instruments that will enable a faster response of the PUS, so that it does not lag behind and can not only be a beneficiary of change, but even a stimulator, thus giving the opportunity to create a smart, inclusive city.

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