



Article

Smart City: Sharing of Financial Services

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Abstract: Contemporary life is closely interconnected with numerous phenomena, which have appeared in our life in recent decades. The concepts of a smart city, digitalization of the economy, and the sharing economy are among them. These factors create new opportunities for businesses operating in modern markets. The article considers the sharing services in digital payment operations for achieving the Key Performance Indicators (KPI) of a smart city. The goal of the research is to determine the costs of sharing economy implementation in the financial sector of a smart city. The study takes the example of Rome's experience. The authors consider KPIs selected by the municipality of Rome as a measure of smart city implementation and their provision by sharing services in financial operations. The authors specify the structure of the costs of shared financial services for a smart city and for Fintech companies operating with open banking, which is followed by the cost functions peculiar to these operations of Fintech companies. The authors demonstrate the point at which a Fintech company starts earning a positive profit on these services via operating leverage.

Keywords: digitalization; sharing economy; financial services; Fintech; smart city

1. Introduction

The general trends of urbanization worldwide have resulted in the development of the smart city concept. This concept comprises the comprehension of the environment, which is open and user-centric, providing continuous innovations and testing of futuristic services and products. According to Pašalić et al. (2021), smart cities are oriented around the provision of advanced and innovative types of services based on the intelligent use of ICT infrastructure to population of the cities; they also affect the standard of living for the city residents and the management of resources. A smart city contributes to all of the spheres usually identified within its structure (Popova and Popovs 2022). All of these smart city domains have a significant effect on the development of the entire concept. All of them contribute significantly to increasing life quality, facilitating business progression, stipulating circular economy implementation, and improving governance processes, etc.

One of the manifestations of a smart economy is a sharing economy, which contributes to all of the smart areas. The sharing economy is the peer-to-peer exchange of goods and services for the purpose of giving or receiving access, which is facilitated by online community services (Hamari et al. 2016). The authors believe that after the acceptance of the second payment directive (Brener 2019) by the European Parliament, the new sharing economy element appeared, and it involves sharing financial services. The sharing object in this case is the customer payment account, which becomes available as the sharing resource for Fintech companies. Fintech companies create business strategies for delivering financial services while they apply digitization (Barroso and Laborda 2022). Fintech companies, as a new phenomenon of the contemporary business environment, are in the focus of scientific research, nevertheless, although most of the research on Fintech deals with technological solutions or the social impact of the companies, the economic side of the Fintech companies' operations is not well described or discussed. Within the smart city, the term Fintech company may correspond to the management of the smart city in the case where the



Citation: Popova, Yelena, and Olegs Cernisevs. 2023. Smart City: Sharing of Financial Services. *Social Sciences* 12: 8. <https://doi.org/10.3390/socsci12010008>

Academic Editor: Nigel Parton

Received: 3 November 2022

Revised: 12 December 2022

Accepted: 14 December 2022

Published: 24 December 2022



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Fintech solution is developed by the smart city itself or by an entity working in the smart city. With the purpose of measuring the current status of the smart city goals achievement, smart cities develop a list of KPIs. The authors consider whether shared financial services provided by the Fintech companies may allow smart cities to achieve their KPIs and what cost function is associated with such service a provision.

Correspondently, this research aims to determine whether the sharing of financial services are within the scope of the smart city goals and to assess the financial cost of implementing the sharing financial services in a smart city. The research takes the example of Rome as a representative of European smart cities.

To achieve these goals, the authors assess Rome's smart city KPIs against the possibility of attaining them by implementing the shared financial services. This analysis shows the dimensions of the smart city, which are exposed to implementing the shared financial services. The next step is the assessment of the costs related to the provision of sharing financial services. Finally, the authors assess the operational leverage of the Fintech companies and financial institutions. The operation leverage method helps us to calculate how well a company uses its assets and resources to reduce the fixed costs, such as those associated with its servers and equipment, to generate profits.

The scientific value of this research is determined by the fact that Fintech companies are considered to be providers of sharing services. It is essential to mention that the Fintech companies are not only on the edge of state-of-the-art technologies, but they also implement the latest trends in the economy. Considering sharing services in relation to Fintech companies is a rather new approach in the scientific field.

The practical value of the research is important for the local authorities of smart cities; the municipalities can consider the operations of Fintech companies as a significant contribution to the development of the smart city and sharing economy, thereby supporting the urban environment.

The research has certain limitations.

It uses the example of one smart city, Rome, but other smart cities might have different KPIs, and therefore, the sharing features may have various implementations in different cities.

The next limitation concerns the fact that the authors considered the costs of the financial services, but not the costs of the exact product or service to which financial services are applied.

Another limitation regards the operation leverage method. Although the authors applied the method, the determination of the revenues and transaction price is beyond the frameworks of this research.

The next limitation is related to assessing the Fintech businesses in smart cities. This study's primary research subject is shared financial services, and all other types of Fintech interaction with the smart city are beyond the scope of this study.

The concept of financial service sharing in the European Economic Area (EEA) is relatively new. The European parliament accepted this concept in 2016 within the second payment directive acceptance (Brener 2019), which became obligatory for all financial institutions from 13 January 2018. The European Commission entrusted the development of the technical standards for such services to the financial institution itself, which slowed down the process of such service implementation.

The key value of this article is to show the possibilities for smart cities to achieve their goal by sharing financial services, and it gives the main approaches to managing such services from the financial and accounting points of view.

2. Literature Review

The smart city concept appears to answer the contemporary urban development challenges (Wataya and Shaw 2019; Popova and Sproge 2021; Vinod Kumar and Dahiya 2017). The smart city introduces the latest technologies to make conventional networks and services more efficient and beneficial for city residents, businesses, and authorities (Lai

et al. 2020; European Commission 2014; Etezadzadeh 2016). It assumes the intensive use of state-of-the-art technologies since only these technologies can meet the ever-growing requirements of the modern urban processes (Dhar and Stein 2016; Anthopoulos et al. 2018; Ardito et al. 2019; Serrano 2018; Popova and Zagulova 2022). Smart cities provide residents with advanced and innovative services, which are available due to the existence of interactive infrastructure and the new and intelligent use of ICT (Pašalić et al. 2021). Researchers (Dhar and Stein 2016; Anthopoulos et al. 2018; Ardito et al. 2019; Serrano 2018) consider smart cities that are represented by subsystems such as smart economy, smart environment, smart governance, smart living, and smart mobility.

It is expected that scientific research in the smart city area is mainly devoted to the technical issues and solutions related to technological tasks. There are substantially fewer comprehensive economic studies in this area (Popova 2020, 2021). However, the economy comprising the financial sector is the basis of all of the operations of urban life. This article considers the financial solutions in some smart city areas.

The financial sector is the subject of economic research. The scholars write about the ability of Fintech companies, for example, to decrease the costs of services (Abraham et al. 2019) and to operate with a low capital cost (Khan and Malaika 2021). For example, Baker and Wurgler (2015) consider the assets and costs of the bank. Dhar and Stein (2016) and Makarchenko et al. (2016) consider the high level of digitalization of the financial services necessary for the timely and legal provision of operations with money in the smart city. The digital literacy of the population and their trust in internet banking ensure the constant growth of this sector (Salloum et al. 2019; Mehrad and Mohammadi 2017; Abrol 2016). People, businesses, and governmental structures widely use it in smart cities (Alalwan et al. 2017; Allen et al. 2021; Al-Saedi et al. 2019; Caballero-Morales et al. 2020).

A large part of these tasks can be solved via the Fintech companies dealing with the operations, which the traditional financial organizations take as additional services, for example, the transactional ones. Nevertheless, the customers are more interested in using payment services provided by fintech companies, since they apply the more advanced technology (Bansal et al. 2015). The contemporary facilitated in legislation is also favorable for the development of Fintech companies, which are supported by the second payment directive (PSD2) which was accepted by the European Parliament in 2015 (Brener 2019). The principal objective of this directive is to protect the customer and to increase the security of payments by setting rules for third-party payment service providers (Mersch 2019).

The functioning of Fintech companies in the financial markets is an important, integral part of the smart city concept: smart cities introduce the latest technologies to make conventional networks and services more efficient and beneficial for the city's residents, businesses, and authorities. To comprehend the interaction between Fintech companies and smart cities, it is necessary to take into account facts such as strict legal regulation implemented by the national bank of the country where the Fintech company is operating (Agarwal and Zhang 2020; Buchak et al. 2018; Darolles 2016; Granja et al. 2017; Rubio et al. 2020) and a changed approach to the financial services and operations (Murinde et al. 2022). This new approach is focused on the client, and in a smart city, it means adding new payment templates, such as utility invoice payments, or showing more information for financial service-related businesses and their contracts, such as insurance policies for leasing agreements or mortgages.

It means that the Fintech company is an integral part of achieving the KPIs of a smart city. The beneficiaries of a smart city (the residents, businesses, and authorities) require the customization of the product, services, and solutions, and the simultaneous maintenance of a high level of security and profitability of the business, which fully corresponds to the standard customer-centric approach (Medini et al. 2021; Teece 2010).

One of the sectors of the smart city is the smart economy, and one of the most noticeable implementations of smartness in the economy is changed attitudes towards ownership. It also refers to services, for example, co-working spaces and car-sharing, etc. This phenomenon is called in the scientific literature, the sharing or collaborative economy.

According to [Medini et al. \(2021\)](#), the sharing economy provides the circulation of valuable resources, which can take place both through direct interaction with the consumers or with the participation of intermediaries. The sharing economy is greatly applicable to the financial sector, where account information services, payment initiation services, and payment instrument issuer services can be used as resources for interactions via third-party providers. The effects of the sharing economy in the financial sector depend on factors such as the customers' acceptance of new services, the financial institutions' readiness for the sharing economy (technical and organizational aspects, etc.), and the third party's readiness.

3. Materials and Methods

The authors used research methods that were appropriate for achieving the set goal.

To review the literature on smart cities, financial services, and the shared economy and to map the existing problems, the bibliographical research method was applied ([Rovira et al. 2018](#); [Mikki et al. 2018](#); [Bramer et al. 2017](#); [Martín-Martín et al. 2018a, 2018b](#)). The authors used research databases, for example, ScienceDirect, Elsevier, and Scopus. Only full-text manuscripts in English were considered, and the majority of them were Open Access articles. The key words used for searching were "Open Banking" or "PISP" OR "PSDII" and "smart city" OR "smart cities" ("PISP"—payment initiation service provider; "PSDII"—the second payment service directive). Another search was connected with smart city KPIs. From the resulting list, the authors selected research papers published within the 2015–2022 period. The final list of the research papers comprised 125 articles. These documents and their references allowed the authors to assess which financial services in the smart city can be associated with the sharing economy and to analyze the smart city KPIs.

The costs and milestones of shared financial services were ascertained through semi-structured interviews with business representatives. The StarBridge Ltd. business clients were interviewed. Four representatives took part in these semi-structured interviews.

The revealed costs were subdivided into fixed and variable costs ([Li et al. 2019](#); [Swamidass 2000](#)). Fixed costs were determined as being typically indirect since they do not relate to creating any specified goods or services. The specified variable costs refer to specific service/product and correspond to the changes in the production of the financial service.

The Operating Leverage (OL) approach was used by the authors to determine whether a firm passed the break-even point and was making a profit.

4. Results

4.1. Customer's Acceptance of New Services

Fintech solutions are essential to market players, and customer satisfaction is one of the key elements of the industry. The number of Fintech customers and their transactions using Fintech solutions are growing rapidly ([Dospinescu et al. 2019](#)). The demand for Fintech services is very high; they are based on the shared economy principles in which one application allows for the observation and management of different elements, which is represented by various industries in the traditional economy.

Since the research object of this article is Fintech, and the purpose of defining the critical elements of the financial institutions' readiness for Fintech, the authors should describe the Fintech types. The authors classified the types of Fintech, and they are represented in the tree diagram (see Figure 1).

The first group of the Fintech includes two main business models which represent financing:

- Credit and factoring, which are usually represented by banks.
- Crowdfunding—in accordance with ([Mollick 2014](#)), it can be represented by any cultural, social, or business groups or individuals who apply their efforts to receive relatively small contributions from a relatively large number of individuals; these

contributions are presupposed for funding some venture businesses, and this process is implemented via the internet without the involvement of standard financial intermediaries.

From the perspective of the sharing economy, credit and factoring are currently not the subjects for the sharing economy. PSD2 does not transform this type of service for third-party availability. Another group of Fintech, which does not represent the sharing economy is assets management, and the authors did not consider this type of business model.



Figure 1. Fintech segmentations. Source: generated by the authors.

The crowdfunding business model is fully based on the sharing economy principles. In this case, the sharing object is the funds gathered by the community for the purpose of investment (Paoloni et al. 2019). Considering that this is a distinct type of business, crowdfunding acts more like a third-party provider which uses the PSD2-defined obligatory payment services within the Fintech solution to organize internal processes for the crowdfunding investors' funds collection. The third group of Fintech is payments. Payments, due to PSD2, are a direct object of the sharing economy. Therefore, the authors assessed the financial institutions rendering these services for their readiness to implement the sharing economy concept. Other Fintech types, from the point of view of the business' relationship to payments, are the third-party providers, who use the PSD2-defined obligatory payment services within the Fintech solution to organize their internal processes.

The business aspect of these financial institutions related to the sharing economy is open banking. O'Leary et al. (2021) determined the elements of business processes necessary for assessing the readiness of financial institutions for open banking implementation. Based on these ideas, the authors developed the actual elements, allowing for the assessment of the readiness of financial institutions for open banking operations (see Figure 2).

The estimation of all the above-mentioned elements and processes is necessary for determining the readiness of the financial institution for open banking and for becoming a part of the sharing economy.

Digital Infrastructure	Human Components
	⇒ Need for competition/negative sentiment toward established banks
	⇒ Customer Expectations
	⇒ Smartphone/Mobile Banking Penetration
	⇒ Unbanked individuals
	Technological Components
	⇒ API Standards
	⇒ Internet Infrastructure
	⇒ Culture of Technology/Innovation
	⇒ Services SLA (Service Level Agreement)
Digital Assets	Account information services
	⇒ Iban account number(s)
	⇒ Each Iban account balance in each account currency
	Payment initiation services
	⇒ List of the payments type
	⇒ Each Payment type parameters
	⇒ Request for payment initiation
	Customer authentication services
	⇒ WEB authentication
	⇒ SDK authentication
	Payment instrument issuer Services
	⇒ List of the payment instruments
	⇒ Request if enough funds to make a payment.
	Third-Party Provider management system
	⇒ Third-Party providers Sandbox
	⇒ Third-Party identifications certificate management
	⇒ Customer's consent management in relation to each Third-Party provider
	Additional services (optional) outside of the PSD2

Figure 2. Elements of financial institution readiness for open banking. Source: generated by the authors.

To continue, in O’Leary’s ([Municipality of Rome 2021](#)) study devoted to the assessment of the openness of the data within open banking, the authors of this article defined the main elements which should be estimated in the process of assessing the readiness of the third party for open banking:

- Local regulators should license third-party providers to provide Account Information Services (AIS) or Payment Initiation Service (PIS).
- Each third-party provider should organize its services so that it receives the customer’s consent to access their accounts and financial instruments.
- Each third-party provider should provide the proper cyber security management.
- The third-party provider should maintain capital adequacy, as defined by the legislative acts.

4.2. Smart City as a Third-Party Provider

A smart city can be assumed as a third-party provider. The assessment of the Fintech sharing economy elements in a smart city is based on each of the smart cities’ subsystems, exemplified by the project “Roma Smart City” ([Municipality of Rome 2021](#)). The subsystems of the smart city were considered on the basis of other research (e.g., that conducted by [Vinod Kumar and Dahiya \(2017\)](#) and [Popova and Popovs \(2022\)](#)). All of the dimensions of smart city are examined for their possibility to achieve KPIs via applying sharing financial services.

Vinod Kumar ([Popova and Popovs 2022](#)) defined the smart economy as an economy that covers elements which influence economic competitiveness, such as innovation, entrepreneurship, trademarks, labor market productivity and flexibility, and the integration of (global) national markets. Thanks to the 300,000 companies operating in its territory,

Rome is one of the urban areas with the most remarkable presence of real businesses in Italy ([Municipality of Rome 2021](#)). To enhance this particular and distinctive context, the municipality's administration intends to invest in tools that encourage the revitalization, growth, and development of the economic, entrepreneurial fabric of the city, thereby enhancing the assets available and promoting the best practices of the area. Its model of economic growth is aimed at:

- Simplifying and facilitating the relations between the public administration and businesses to establish a continuous, mutually beneficial dialogue for the benefit of the whole community.
- Promoting competitiveness between businesses to improve employment levels, the constant development of human capital, efficiency, and productivity.
- Encouraging the creation and development of synergies and the sharing and transfer of knowledge to facilitate the identification and adoption of virtuous measures for entrepreneurial development with positive spill-overs on the entire economic and social fabric of the territory.

Table 1 demonstrates that based on the KPIs of the smart city, financial objects such as payment accounts, which are exposed to the sharing economy environment, play a notable role in the smart economy.

Table 1. KPIs of Rome smart city. Source: generated by the authors; the KPIs were taken from [O'Leary et al. \(2021\)](#).

KPI Name	KPI Description	Shared Payment Services
Places used for coworking	The number of places used for coworking. Coworking is often regarded as the “new model of work”, which is a typical case of the sharing and collaborative economy (Durante and Turvani 2018)	Payment Initiation services to organize B2C or B2B payments for the co-working place integrated into a co-working management system
Number of online proceedings (simplification administrative) relating to the opening of a business/commercial activity	The number of businesses registered online	Payment Initiation services to organize B2C or B2B payments for the services of the business register
Number of requests submitted online	The digitalization of different types of business models	Payment Initiation services to organize B2C or B2B payments for the requests, which demand payments
Presence of the economic development plan for at least 3 years	Government KPI not directly connected to the shared payment services	
Number of knowledge sharing events (conferences, meeting, etc.)	The number of the conferences and events organized in the city	Payment Initiation services to organize B2C or B2B payments for the requests, which demand payments (such as conference participations)
Presence of the city brand on the platforms of e-commerce	City brand on internal platforms of e-services	City may issue their own platform with the possibility to present different financial institution accounts and Payment Initiation services to organize B2C or B2B payments for the requests, which demand payments (such as conference participations)
Number of subjects adhering to the brand of the city	Government KPI not directly connected to the shared payment services	
Value of the sales of the products of the city	Total number of operations initiated by companies within the city	In case if these sales are conducted on the internet, the Payment Initiation services may be also used
Presence of a control room for the development of economic (in the classification by city, district, etc.)	Government KPI not directly connected to the shared payment services	
Number of initiatives for the enhancement of smes (small and medium enterprises)	Government KPI not directly connected to the shared payment services	

The authors also considered the shared financial services for all of the smart city dimensions.

4.2.1. Smart Environment

This can be determined as the state of the natural environment, the levels of various types of pollution, environmental protection initiatives, and resource management techniques used to gauge the smart environment (Winkowska et al. 2019). Due to the growing level of attention being paid to environmental and natural resources, the protection of the territory and the preservation of the landscape are the priority objectives for Rome. The achievement of these objectives requires the encouragement of a circular economy, the enhancement of the public space, the minimization of the amount of waste that is to be disposed of in landfills, the increase in the recycling of municipal waste, greater attention and sensitivity to urban decor and hygiene, and the conscious use of scarce resources. In 2017, the city administration launched the “Plan for the reduction and management of post-consumer materials of Rome Capital 2017–2021”, which strengthens the city’s commitment at an environmental level, providing for actions and projects which directly involve the citizens and businesses. This will make it possible to transform Rome into a virtuous metropolis that is capable of cutting down the per capita production of post-consumer materials.

In particular, the city administration intends to achieve the following objectives (Municipality of Rome 2021):

- Reduce emissions that are released into the atmosphere (CO₂, nitrogen oxide, and fine dust, etc.), positively contributing to the contrast of the greenhouse effect and ensuring a better quality of life for the environment as a whole.
- Manage scarce resources and encourage the reuse of products in light of the substantial climatic and environmental changes underway and the necessary “intelligent” adaptation of lifestyles, with a view to achieve sustainability and make savings.

The KPIs, which have been set by the municipality of Rome and are essential for assessing the smart environment implementation, are numerous. Nevertheless, these smart environment KPIs are not directly connected to the shared payment services, and therefore, the authors did not consider this dimension of the smart city.

4.2.2. Smart Governance

The constant growth of technological developments provokes all kinds of the government to reassess their role in the future society, which will function as a knowledge-based one. That role is known in the research literature as “Smart governance” (Rodríguez Bolívar and Meijer 2015). The management of a complex system, such as a smart city, requires an organization that is capable of guaranteeing all of the stakeholders’ active and collaborative participation and allowing the entire full overcoming of the model of governance of projects based on the separation of roles, skills and responsibilities.

From this point of view, the Rome smart city plan offers a perspective on the evolution of the city. It identifies a transformation path that begins with defining a relational and management model for multiple players. The model aims to create all of the context conditions within which integrated and synergic innovation actions can be developed and which citizens and the various components of society can participate.

The objectives of smart governance are:

- To develop the transversal skills of the administration and city users.
- To improve the relationships with the city user by reducing the digital split.
- To develop and enhance the urban technological infrastructure by ensuring interoperability and application cooperation between the administration’s ICT systems.

Following these objectives, the municipality of Rome has selected smart KPIs to measure the implementation success, but due to the fact that these smart governance KPIs are not directly connected to the shared payment services, the authors did not consider this dimension of the smart city.

4.2.3. Smart Living

The term “smart living” refers to a movement that embraces technological developments which enable people to experience novel modes of life (Probst et al. 2014). A complex strategy must combine the needs of an urban scale with the local needs of the neighborhoods, with particular attention being paid to the qualification of the infrastructural system of public spaces and the environmental system. Through a network of public areas and corridors dedicated to soft mobility, coupled with large environmental systems and local and urban public spaces, an ambitious process of urban “regeneration” is triggered, which follows the principles of “sustainability” and “quality” and “fairness” (Municipality of Rome 2021).

The objectives of the smart living are as follows:

- To redesign and modernize the functionalities and services.
- To create a labor market by strengthening the ability to attract valuable and competitive production chains.
- To regenerate the settlement habitat by adapting it to modern quality of life standards, also ensuring social relations and inclusion.
- To make public spaces safe and livable and activate internal and connecting mobility inspired by sustainability.

Following these objectives, the municipality of Rome has selected smart KPIs to measure the implementation success. Due to the fact that these smart living KPIs are not directly connected to the shared payment services, the authors did not consider this dimension of the smart city.

4.2.4. Smart Mobility

Smart mobility is the smart city element focusing on freight or passenger transportation (Nagy and Csiszár 2020). Transport technology is affected by globalization, re-urbanization, and social aspects of city transport. In the case of passenger transportation, we should speak about private cars, which prevail (Pons-Prats et al. 2020) in public transport and public transport itself. Apart from passenger transport, the delivery service has become more notable in the cities. The significant increase in transaction requires deliveries to be performed on the market platforms or single internet shops, thereby increasing the delivery traffic (Nagy and Csiszár 2020).

Following the Rome plan (Municipality of Rome 2021), the priority objectives are as follows:

- To connect the different mobility solutions to guarantee that all of the citizens are integrated with them and there are simple options between the different modes of transport to access key destinations and services in the city.
- To improve road safety in terms of enhancing traffic control and accident prevention tools.
- To encourage “clean” mobility, which is capable of effectively contributing to reducing atmospheric and noise pollution, greenhouse gas emissions, and energy consumption.

To achieve these objectives, the municipality of Rome specified the smart city KPIs for this area. These KPIs and the possibilities of using the shared payment services are presented in Table 2.

Table 2. KPIs for Rome smart mobility. Source: generated by the authors; the KPIs were taken from O’Leary et al. (2021).

KPI Name	KPI Description	Shared Payment Services
Number of metro stations with tap payment	Smart city governments organize tap payments within the metro with the use of PIS	Payment Initiation services organize B2C payments for metro
Number of intermodal car parks	Government KPI is not directly connected to the shared payment services	
Medium parking places for intermodal parking	Government KPI is not directly connected to the shared payment services	
Presence of Local Public Transport (tpl) timetable updating systems	Government KPI is not directly connected to the shared payment services	
Integration with the main mobility players (google maps)	Government KPI is not directly connected to the shared payment services	
Presence of an app for communicating with the citizen	Smart city government authorities develop the app, which apart from the communication function allows payments	Payment Initiation services organize B2C payments within the app for additional services
Integration of systems for booking shared vehicles	Smart city governments organize booking payments with the use of PIS	Payment Initiation services organize B2C payments for shared vehicle reservation
Monitoring system for shared vehicles	Government KPI is not directly connected to the shared payment services	
Number of remotely managed traffic lights	Government KPI is not directly connected to the shared payment services	
% of intelligent parking spaces (remotely monitored)	Government KPI is not directly connected to the shared payment services	
Smart sensors (stereoscopic cameras) for monitoring pedestrian flows per km ² (ZTL, pedestrian areas and 30 zones)	Government KPI is not directly connected to the shared payment services	
Number of charging stations for electric vehicles	Smart city governments organize the payments within the charging stations with the use of PIS	Payment Initiation services organize B2C payments for electric charging
Number of electronic or digital parking payment transactions	Smart city governments organize the payments in relation to digital parking with the use of PIS	Payment Initiation services organize B2C payments for parking payment transactions
Presence of a Control Room for monitoring city mobility	Government KPI is not directly connected to the shared payment services	
% Long platform truck (LPT) cars equipped with passenger counters	Government KPI is not directly connected to the shared payment services	
% integrated Mobility as a Service (MaaS)	Government KPI is not directly connected to the shared payment services	
% Electronic and digital travel documents issued	Smart city governments organize the payments with the use of PIS	Payment Initiation services organize B2C payments for digital travel documents
% Surface vehicles equipped with tap payment	Smart city governments organize the payments with the use of PIS	Payment Initiation services organize B2C payments surface vehicles
% Electronic tickets sold in Self-service mode	Smart city governments organize the payments with the use of PIS	Payment Initiation services organize B2C payments for digital travel documents
Amount relating to long platform truck (LPT) % deriving from electronic payments	Government KPI is not directly connected to the shared payment services	
Number of info-mobility requests managed via instant chat (WhatsApp)	Government KPI is not directly connected to the shared payment services	

4.3. Financial Institutions and Smart City Expenses on Open Banking

The definition of the expenses is affected by the open banking-related processes and the KPIs of the smart city related to the open banking products. The authors analyzed the list of the processes defined the related expenses to both of the players: the financial institutions (service providers) and the smart city (third party). The sharing economy, at its core, involves the outsourcing of technology. In case there is open banking, this is a technology that is used for accessing the customers’ accounts and providing technology for initiating payments. Following that tendency, additional managerial attention is requested for “the ability to manage inter-organizational relationships with outside service providers.”

The expectation of the customers from the open banking are officially agreed upon between the service provider and the customer, which is called the Service Level Agreement (SLA).

Therefore, in planning the internal processes regarding open banking, researchers should stress process automation and maximum service stability; this approach influences the involved parties' costs. The costs in relation to each process are shown in Table 3.

Table 3. Costs related to processes. Source: generated by the authors.

Processes	Description of Process	Financial Institution	Smart City
Need for competition/negative sentiment toward established banks	Do not form expenses in relation to open-banking		
Customer Expectations	Customers' expectations are mainly connected to controlling access to their accounts and payments and therefore linked to the security of services (Bani-Hani et al. 2019)	Factor authentication provision: - Expenses for OTP in case if SMS used.	No expenses
Smartphone/Mobile Banking Penetration	Financial institution shall provide the third party with the SDK (Saurabh et al. 2021)	Hosting expenses: - Payment for domain. - Expenses for server hosting.	Mobile app maintenance: - Mobile app store fee. - Expenses for server hosting.
Unbanked individuals	Do not form expenses in relation to open banking		
API Standards	The API is the obligatory element of digital banking and tool for the communication between financial institution and third party (Windasari et al. 2022)	The same infrastructure as smartphone/mobile banking—no additional expenses	The same infrastructure as smartphone/mobile banking—no additional expenses
Internet Infrastructure	Internet infrastructure does not cause additional costs since it is interconnected only with the customers' experience, and not directly related to open banking.		
Culture of Technology/Innovation	Do not form expenses in relation to open-banking		
Services SLA	The Service Level Agreement (SLA) provoke the financial institution to organize infrastructure in a most effective way from the perspective of business continuity.	- No downtime server infrastructure management. - Administrators staff 24 × 7 salary expenses.	No expenses
AIS services	The services of Account information rendering via API	The same infrastructure as smartphone/mobile banking—no additional expenses	The same infrastructure as smartphone/mobile banking—no additional expenses
PIS services	The services of Payment initiation rendering via API	The same infrastructure as smartphone/mobile banking—no additional expenses	The same infrastructure as smartphone/mobile banking—no additional expenses
Customer authentication services	The service, of customer authentication via API equivalent to the typical customer authentication in financial institution.	The same infrastructure as smartphone/mobile banking—no additional expenses	The same infrastructure as smartphone/mobile banking—no additional expenses
Payment instrument issuer Services	The service of amount availability verification per customer payment instrument (account and card)	The same infrastructure as smartphone/mobile banking—no additional expenses	The same infrastructure as smartphone/mobile banking—no additional expenses
Third-party provider management system	The service of third-party sandbox management.	The same expenses as for SLA. No additional expenses	No expenses

The structure of the costs for the financial institutions are clearly divided into fixed costs and variable costs. The smart city, in its turn, supports the applications (web and mobile), which have fixed costs only. There are no variable costs for the smart city related to the open banking solution applied to the smart city processes.

4.3.1. Costs of Financial Institution

The financial institution (fi) has two types of costs: fixed costs (FC) and variable costs (VC).

$$TC_{fi} = FC_{fi} + VC_{fi} \quad (1)$$

$$FC_{fi} = f(SLA; AC; HC_{fi}) \quad (2)$$

where:

- The Service Level Agreement (SLA) services costs involve no downtime server infrastructure management.
- AC are the costs of operations of the administrative staff in terms of 24×7 .
- HC_{fi} are the hosting costs of the financial institution, consisting of domain payments and server hosting costs.

The variable costs of financial institutions are determined by the formula:

$$VC_{fi} = OTP * Q \quad (3)$$

where:

- OTP is the Cost to deliver to the customer One Time Password.
- Q is the quantity of the transactions.

OTP in its turn is determined by the following function:

$$OTP = \beta (Ch_1; Ch_2; Ch_n) \quad (4)$$

where:

- Ch_1 represents the SMS channel of password delivery.
- Ch_2 represents the push channel of password delivery.
- Ch_n represents any other channels of password delivery.

As a result, the variable costs of financial institutions are presented as follows:

$$VC_{fi} = Q * \beta (Ch_1; Ch_2; Ch_n) \quad (5)$$

4.3.2. Costs of Smart City

As it is shown above, the smart city has only fixed costs (FC_{sc}), which can be described by the following function:

$$FC_{sc} = \mu (HC_{sm}; App_{st}) \quad (6)$$

where:

- HC_{sc} are the hosting costs of a smart city, consisting of domain payments, application hosting costs, and application middleware hosting.
- App_{st} are the mobile app store fee, which is the fee of Appstore, Google Play, and similar services, which offer the applications for download in a smart city.

4.3.3. Operating Leverage

The authors used the Operating Leverage (OL) method to understand the point when the break-even point has been overcome and the company makes a positive profit. A percentage change in sales results in a proportionate change in the operating income, which can be calculated by the degree of operational leverage. This idea assesses a company cost structure without accounting for financing and tax expenses. Since most of the production costs are set throughout a range of unit volumes, a business with a high share of fixed costs will see an abnormally substantial (and positive) shift in their operating income if the

number of sales increase. In this case, management should avoid a drop in sales, as this might result in a sharp drop in the operating income.

$$OL = \frac{FC}{FC + VC} \quad (7)$$

where OL is Operation Leverage, FC is the total fixed costs, and VC is the total variable costs.

The Operating Leverage method is a cost-accounting method, which estimates how much a company or project can raise their operating income by increasing the revenue. A company with significant operating leverage creates sales with a high gross margin and low variable costs. It is necessary to mention that the determination of the sources of the revenue is beyond the framework of this study.

The operating leverage method allows us to estimate how efficiently a business allocates its resources and assets to minimise the fixed costs, such as its servers and equipment to produce profits. The stronger a company's operating leverage is, the more profit it may generate at a fixed asset level.

$$OL_{fi} = \frac{(TP_{fi} - VC_{fi}) * Q}{(TP_{fi} - VC_{fi}) * Q - FC_{fi}} \quad (8)$$

where:

- OL_{fi} —the Operating Leverage for the financial institution.
- TP_{fi} —the transaction price for the financial institution, which is the price of one transaction, which the financial institution customer shall pay to process the payment in favor of the smarty city products and services.
- VC_{fi} —the variable costs of financial institution.
- FC_{fi} —the fixed costs of financial institution.
- Q —the quantity of operations.

The structures of the expenses for financial institutions and smart cities are different. Therefore, for the smart city:

$$OL_{sm} = \frac{TP_{sm} * Q}{TP_{sm} * Q - FC_{sm}} \quad (9)$$

where:

- OL_{sm} —the Operating Leverage for the smart city.
- TP_{sm} —the transaction price for the smart city, which is the price of one product or service sold by the smart city to their customers.
- FC_{sm} —the fixed costs of the smart city.
- Q —the quantity of operations.

Unlike smart cities, financial institutions have variable costs related to each service provision such as the use the SMS, mobile application push or alternative methods such as One Time Password (OTP)—a one payment signing factor for payment initiation.

The costs investigation is represented by the break-even point which is specified for Fintech companies operating in open banking; the break-even point is presented via the Operating Leverage method, and it is followed by cost functions peculiar to the operations of the Fintech companies.

5. Conclusions

The authors classify the financial services such as Account Information Services (AIS) and Payment Initiation Services (PIS) rendered under the second Payment Directive as new subjects of sharing economy to be shared financial services. Rome's smart city KPIs were assessed against the possibility of them being achieved by implementing the shared financial services. The results assessment shows that the shared financial services may

allow the smart city to achieve its KPIs in the smart economy and mobility subsystems of the smart city, leaving other subsystems unaffected. Within these subsystems, smart city management may integrate shared financial services into the solutions, which customers use to conduct payment for services they receive within the smart city. The smart city itself or companies offering services within the smart city may provide the solutions mentioned above, and under the second Payment Directive, they may be addressed as the third-party providers.

The authors analyzed the costs of the financial services related to financial institutions and smart cities. In the case of the smart city, there are no variable costs associated with the Account Information Services (AIS) or Payment Initiation Services (PIS) rendering, and all of the costs are fixed. The absence of variable costs made shared financial services implementation within smart cities more economically predictable.

The structure of the shared financial services-related fixed costs for the financial institutions is the same as it is for the smart city. The main qualitative difference is the necessity to align with the Service Level Agreement (SLA). The SLA uses metrics calculated as the financial institution IT system's availability per cent. The Financial Institution may achieve the highest per cent of availability by increasing the effectiveness of the business continuity processes. Usually, this target is reached by using twin equal IT systems, using different infrastructures (premises, electricity, and internet, etc.) and automatically balancing the systems between them. All of these measures incur additional expenses for such infrastructure maintenance.

The authors used the Operating Leverage method, which presented the formulae for financial institutions and smart cities, which can help to find the point when each of the analyzed entities will reach a profit.

Managerial Implication. This study is the first one to empirically analyze and assess whether sharing financial services may help a smart city to achieve its KPIs with the example of the smart city of Rome. Additionally, the study gives a clear overview of what benefits the residents, businesses, and smart city authorities may receive by accepting these sharing financial services.

Practical/Social Implications. This study proposed financial services expenses and Operational Leverage calculation approaches to financial institutions and smart cities, representing practical implications. The research results show that smart cities do not have variable costs related to sharing financial services. This fact has notable social implications, since it will not provoke a possible increase in buying product expenses.

Future Research. The further researches may become the continuation of this study and be expanded to other smart cities, and assess the costs of the smart city products or services in addition to sharing financial services. The authors believe that sharing financial services will improve the tools of Industry 4.0 in smart cities (Fülöp et al. 2022). Conducting a series of research assessing the sharing of financial services in the objectives of Industry 4.0 may be valuable, which could involve a section including sharing financial services manufacturing and risk management. This future research will naturally continue the topic initiated by the authors in this study.

Author Contributions: Conceptualization, O.C. and Y.P.; methodology, O.C. and Y.P.; validation, O.C.; investigation, O.C. and Y.P.; data curation, O.C. and Y.P.; writing—original draft preparation, O.C.; writing—review and editing, O.C. and Y.P.; supervision, Y.P.; funding acquisition, Y.P. All authors have read and agreed to the published version of the manuscript.

Funding: This project is financially supported by project No. 1.1.1.2/16/I/001 of the Republic of Latvia, funded by the European Regional Development Fund. Research project No. 1.1.1.2/VIAA/3/19/458 “Development of Model of Smart Economy in Smart City”.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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