# How to Become a Smart City? Balancing Ambidexterity in Smart Cities

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## ABSTRACT
Most cities have limited resources to become a smart city. Yet some cities have been more successful than others in becoming a smart city. This raises the questions why were some cities able to become smart, whereas other were not able to do so? This research is aimed at identifying factors influencing the shift towards becoming a smart city. In this way insight is gained into factors that governments can influence to become a smart city. First, Literature was reviewed to identify dimensions and factors enabling or impeding the process of becoming a smart city. These factors were used to compare two similar type of case studies. The cases took different paths to become a smart city and had different levels of success. This enabled us to identify factors influencing the move towards smart cities. The results reveal that existing infrastructures should be used and extended in such a way that they can facilitate a variety of different applications. Synergy from legacy systems can avoid extra expenditures. Having such an infrastructure in place facilitates the development of new organizational models. These models are developed outside the existing organization structure to avoid hinder from existing practices and organizational structures. This finding suggests that smart cities focussed on structural ambidexterity innovate quicker.

## CCS Concepts
**• Applied computing~E-government**

## Keywords
e-government; smart cities; transformation; innovation; ambidexterity; exploration; exploitation

## 1. INTRODUCTION
The potential of ICT to improve public policy and service delivery is enormous, but poorly understood [1]. Governments worldwide have posed high levels of ambitions about the use of ICT for creating smart cities, but often progress lags behind ambitions [2]. Smart cities focus on the use of ICT to improve city operation to accomplish public values like security and safety. Smart cities can be viewed as e-government at the city level.



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Public organisations and in particular cities from all over the world are looking to create digital applications to innovate their city operations. For this purpose, smart cities are rethinking their existing business models and are developing new kinds of business models. The concept of business models originates from the dot-com era and is focused on profit generation from digital applications [3]. Although the term business model is intuitive clear for most people, it is hard to define. Business models for smart cities are about creating value for its stakeholders [4]. In public administration, the term business model is less appropriate as governments are not focussed on making a profit. Instead of the term 'business model' we prefer to use the term "*public organizational model*", as governments are focused on creating public values such as transparency, equality, and security rather than on making profit. The main objective of governments are about ensuring public values and for this they use instruments like legislation, policies and providing services. New public organizational models can have the form of public-private arrangements [5]. These arrangements can be formal or informal, but have the objective to create public value. New public organizational models are developed in many areas including surveillance in cities, managing traffic, better energy consumption and so on. In smart cities these public organizational models are aimed at innovating practices by making more efficient use of resources and tackling societal problems. Some examples of organizational models in smart cities are predictive police in New York [6], energy consumption, private and public transportation improvement [7].

Apart from innovating, public managers have to keep operating their processes and services at high service levels at same time. Being able to exploit current resources and services and explore new paths of innovation is known as *ambidexterity* [8]. Ambidextrous organizations are organizations that are able to improve the efficiency of current production of products and service delivery and have the ability to innovate its products, processes and services [8]. Smart cities should become ambidextrous organizations as they need to run their existing processes and services and being able to innovate at the same time.

Exploitation is based on actions like efficiency [9], refinement, selection, implementation and execution [10]. In contrast, exploration is based on actions like innovation [11], experimentation, flexibility, variation and risk taking [10]. Innovation is conceptualized here as a range from "minor changes to existing products, processes, or services to breakthrough products, and processes or services that introduce first-time features or exceptional performance" [12 (p. 7)]. Literature makes a difference between structural and contextual ambidexterity (e.g. [13]). *Structural ambidexterity* is based on the idea of spatial separation of exploitation and exploration [14]. In contrast, *Contextual* ambidexterity integrates exploitation and exploration, as being different things happening at the same time [13].

Ambidexterity is necessary to have both exploitation and exploration. For cities exploration is needed to become a smart city and new public organizational models need to be developed. Some cities have been successful in being ambidextrous and to move towards becoming a smarter city, whereas other cities are lagging behind. This article aims to identify factors influencing the shift towards becoming a smart city. Literature is reviewed resulting in 5 dimensions and 37 factors affecting the creation of innovative public organizational models for smart cities. These aspects include 1) policy and legal; 2) human resources; 3) information systems; 4) systems architecture; and 5) ICT infrastructure aspects. These factors were used as an input to analyse two case studies. The case studies helped to identify factors that contribute to the becoming a smart city.

In the next section we discuss the research approach. This is followed by a background of the concepts of smart cities and ambidexterity. In this section the 5 main elements of public organizational models are presented with a detailed list of 37 factors influencing their development. The fourth section contains the description of two cases of smart cities, one positioned on the top, whereas the other one is positioned on the last tier in Brazil. A comparative analysis is made based on the 35 factors influencing the development of ambidextrous smart cities. Finally, conclusions are drawn and findings are discussed.

# 2. RESEARCH APPROACH

Ambidexterity is a concept that is used scarcely in the public sector. Therefore we adopted an explorative, qualitative, research approach. We analysed the literature and identified factors contributing to the creation of ambidexterity. Our literature review identified only four papers in the field of public sector (e-government) ambidexterity [14]. These papers were used to create an initial list of factors. A structured content-analyses was conducted for the four papers to identify the factors and dimensions enabling public sector ambidexterity. The structured search resulted into five dimensions 1) policy and legal aspects; 2) human resources; 3) information systems; 4) systems architecture; and 5) ICT infrastructure, and 37 factors which are described in Table 1. These long list of factors do provide insight, but tell us less about which were dominating factors influencing the development of ambidextrous smart cities. Therefore, we decided to compare 2 similar case studies with each other. One case was highly successful, whereas the other was not. This enabled us to explore the factors influencing the success of smart cities. The cities were comparable in terms of the following characteristics.

1) **Size (Population)**. The size of the city population influences the number of societal challenges and the resources available (like financial, human, infrastructure, etc.) to deal with these challenges.

2) **Smart city services**. The presence of Smart Cities services focused on Urban Mobility, Transport, Energy consumption and other domains.

3) **Openness**. The presence of an Open data Portal (ODP) with open data sets provides an indication for the efforts of a city to foster innovation, and their willingness to co-create with other parties;

The next step was to identify cities using the Ranking Connected Smart Cities [13]. One city ranked in the top tier and once city ranked in the lower tier meeting the three characteristics (Size, smart city services and openness). This resulted in the selection of the cities of Rio de Janeiro and Fortaleza. The factors form literature were used to compare the cities.

# 3. Background

In this section we introduce the concepts of smart cities (section 3.1) and ambidexterity (section 3.2).

## 3.1 Smart cities

Cities have been struggling to deliver innovative public services for improving socio-economic development and quality of life [14]. One of the responses to those challenges is the creation of smart cities. Smart cities have been defined using different concepts [11]. Definitions contain a spectrum from smart urban space to sustainable environmental [15]. Birkinshaw and Gibson [16] characterises smart cities and use the dimensions 1) management and organisation, 2) technology, 3) policy, 4) governance, 5) people and communities, 6) economy, 7) built infrastructures, and 8) the natural environment. In other work [17-20] six key dimensions for defining smart cities were identified: 1) smart economy, 2) smart mobility, 3 a smart environment, 4) smart people, 5) smart living and 6) smart governance.

The smart city concept has broadened over time and in practice any ICT application has been considered as contributing to smartness of cities. Smart cities have become synonymous with ICT for cities. Form this view smart cities can be viewed as e-government for cities. The concept of 'smartness' is often hardly defined and poorly explained and seems to refer to any developments using ICT. Smartness often is considered to refer to the mechanisms to improve the use of resources in a city. A city can be called 'smart' "when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and influence quality of life, with an efficient and effective management of resources, through participatory governance" [21]. In other words, ICT enables the better use of resources and results in outcomes such as less congestion, less pollution, and better sustainability and security. A city can only become smarter of the inhabitants are empowered to make use of the new opportunities [22].

## 3.2 Ambidexterity

### *3.2.1 Classifying dimensions*

Public organizational models are aimed at realizing public values. Business model encompasses many elements [4, 23, 24]. Figure 1 shows the typical elements of public organizational models. These elements will be used in this research to classify the factors influencing the development towards a smart city. The categories will be discussed next.

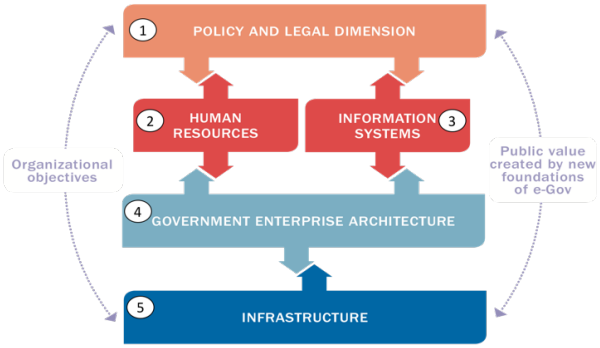


**Figure 1: Objectives and resources for providing services and governance**

The "*policy and legal dimension*" identifies the legal framework for contemporary public policy and service delivery, describing the policy aspect of creating legislation for innovation and budget allocation.

The "*human resources dimension*" refers to the human capital and competences. Civil servants are crucial elements because their motivation can enhance the quality and speed of public policies and service delivery, while their disappointment or demotivation can hinder the implementation of public policies and legislation. Also citizens and staff from other organizations can play a role.

The "*information systems dimension*" refers to existing and new systems and also to legacy systems. Data is stored in systems and these systems are becoming more important and need to provide more information with the best performance possible. This dimension also contains the business processes necessary for providing services and carrying out policies.

The "*government enterprise architecture dimension*" guides the planning and creation of functionalities and other aspects of operation of public organizational models.

The "*ICT infrastructure dimension*" refers to technology factors. This contains communication equipment, access, security etc.

The factors for each dimensions will be discussed in detail in the next subsection.

### *3.2.2 Policy and legal dimension*

There is an inherent tension between exploitation and exploration, which is called "ambidexterity" [25]. Exploitation should ensure stability and compliance, whereas exploration should result in innovation. For smart cities this means that on the one hand, civil servants should execute their daily processes and routines, whereas, on the other hand, they should also innovate. All too often innovations or new applications require changes in legislation. The public expects a short time to implement these changes. However, this might be complicated by the division of branches of governments in the executive, legislative and judiciary. While executive branches need to deliver services, legislative branches are responsible for legislation and policy-making. This system safeguards governments from making bad decisions, but it produces tensions with the expectations of societies that governments should be dynamic and able to adapt quickly.

Policy-making cycle is based on agenda setting, formulation, implementation and evaluation [26]. The creation of new policies or changing existing ones takes time.

### *3.2.3 Human resources dimension*

People are at the very heart of government. People create and/or make use of infrastructures to create value for societies. A minimum quality of infrastructure technology and high levels of human resources in governments make it possible to create business models based on innovation in methods and techniques [27].

Data analysis is about having the right people to do the job. Velocity, variety, volume, value, variability and veracity are often mentioned characteristics of big data [28]. This data can be produced by citizens, private companies, governments and non-governmental organizations. For example, using sensors' cars can be monitored to provide the best routes in real time or learn how to reduce consumption of energy [28]. For this, governments need specialized expertise, like data scientists or big data analytics groups.

### *3.2.4 Information systems dimension*

Information is the very foundation of all administrative processes and are used as a basis for decision-making. Information systems are used to collect and process data. Although their use is essential, their development is often cumbersome and the developments of information systems is prone to failure [7, 29]. One reason is that information systems are sociotechnical constructs in which both elements (human resources and information systems) need to be given attention. Also data quality differs and need to be dealt with.

### *3.2.5 Government enterprise architecture dimension*

Government enterprise architecture (GEA) should facilitate the planning and change in the existing landscape with the aim of developing flexible, scalable, secure and reusable infrastructures. Governments are different, and the architecture of their systems depends on both their goals and missions and on their target audiences.

GEA should ensure that the business processes, data, applications and infrastructures are coherent and can be used for developing new public organizational models. Furthermore in a GEA data stewardships principles are often defined. This is the existence of mechanisms for responsibly acquiring, storing, safeguarding, and using data [30].

### *3.2.6 ICT infrastructure dimension*

The use of existing infrastructures should decrease the complexity of developing new applications and result in fewer failures and more reliability and security. Infrastructures can be used as the foundation for developing public organizational models. Furthermore, when existing building blocks are re-used, development and maintenance might be easier and at lower-costs. This requires good agreements between the various public parties involved in operating and creating of infrastructures. Infrastructures are used by various types of users and are modular by nature; they need to be flexible enough to be used in a wide variety of situations, and interoperable to support the operation of public organizations [31].

Infrastructures come into existence due to complex interactions between technology developments and use and interactions among different stakeholders. As a result, some parts of infrastructures have been designed in a top-down manners, whereas other parts have evolved bottom-up [32]. The development of infrastructure modules can be guided by setting certain constraints and standards at the central level in the GEA dimension. At the same time, the local level should be encouraged to develop new infrastructure components to create secure and reliable infrastructures. Infrastructures are continuously evolving; new elements may be added, and others may be removed. New technology developments and applications often result in new infrastructure elements [33].

Citizens and businesses are served using different channels, including call centres, physical counters, and smartphones. Multi-channel service provisioning requires infrastructure building blocks to use different applications for different contexts, such as smartphones, laptops, front offices of public organizations, and call centres [34, 35]. Multi-channel management requires infrastructures that ensure the orchestration of channels to ensure consistency of data, service provisioning and answers to questions.

## 4. CASES

The large number of factors categorized in the five dimensions show the variety of possible influences, but do not give insight into which factors are important for smart cities. Two similar cities from

which one successfully came a smart city, were investigated to explore which factors influence the quest to become a smart city.

## 4.1 Rio de Janeiro Smart City

Rio de Janeiro city hall in Brazil is smart city with a big and linked open data (BOLD) infrastructure. The BOLD infrastructure was used to create a new public organizational model. The BOLD infrastructure has three different data sources: Center of Operations Rio (COR) focusing on real-time response, the Call Center 1746, focusing the short-term focus and the collection of statistical data from public services such as health, education, etc., focusing on the long-term focus.

COR was created in 2011 aiming to reduce deaths from landslides on hills. Over time COR t became the central organisation and building to plan and react to any major event on the city. The events could be since car accidents to big events that change the routine of the city (e.g., the FIFA World Cup in 2014, Reveillon 1st January and the Olympics games in 2016).

Rio created a Call Center 1746 (1746) to receive complaints about the public services and municipal infrastructure. This data is used to organise the public service maintenance. Every year the city receives more than 3 million calls from mobile phone application (Android, iOS and Windows Phone), landline telephone (Call Center) and requests submitted using the 1746 website.

Statistic data sets are collected daily. For example, data about the weather and climate (e.g. rain, sea level, river level), health, education, social aid and transport. The IT department of Rio de Janeiro city hall estimates that more than 100 Gigabytes per day of data is collected. This effort is also part of the Resilience project what Rio is leading the C40 cities, a network of the world's megacities committed to addressing climate change. The C40 supports cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change.

The Smart City initiative of Rio de Janeiro was created to solve problems related to landslides and also to improve the public transportation and traffic for big events aforementioned. Civil servants and public managers identified the possibility to use this huge amount of data sets to not only plan and react, but also to predict scenarios and to create action plans based on them. Therefore, a Big Data group called P3NS4 – Ideas Room (PENSA) was created. PENSA consisted of specialists from different backgrounds including geography, engineering, public administration, physics and computer science. The majority of them were studied at renowned engineering and public administration schools in the world: Delft University of Technology (TUD), Massachusetts Institute of Technology (MIT), New York University (NYU) and Stanford University. Part of them were financed by the City Hall leadership program "*Líderes Cariocas*".

The heterogeneous background enabled PENSA to combine data collected by COR, 1746 and statistical data sets to create management reports for the mayor, secretariats and civil servants at operational level. To boost the results, PENSA created informal cooperation with mobile applications providers such as Waze Social GPS (www.waze.com) and MOOVIT (www.moovitapp.com). In this way, PENSA could improve the quality of public service delivery without raising any costs and using huge amount of real-time data from people.

The new public organisational model in which Waze participated allowed the Transit department to plan better the distribution of guards, speed traps and operational people (winch). This data-driven organizational model was developed based on informal relationships. This also allowed to plan the World Cup and Olympics games buildings based on the dynamic number and movement of people in the city during the day and night. 10 electronic signs were installed positioned at places having the highest indexes of traffic jams. The information displayed to the 3 million Rio drivers was based on the top routes used by people during the last month. The electronic signs are updated every 15 minutes. Alternative routes are also displayed including a comparison of the time spent on traffic with the regular route used. This contributed to reduce more than 15% of traffic jams on the peak period (Morning and Night).

The second new public organisational model was created with MOOVIT (www.moovitapp.com) and enabled people to identify the best public transportation (faster, cheaper, etc.) to use in real-time. After the disclosure of an API with GPS of buses at Rio Open Data Portal (www.data.rio), MOOVIT improved its service by showing the bus traffic situation and how long it would take before a bus to arrive at the bus stop and at the destination. Further, MOOVIT helped civil servants and public managers to improve the decision-making for the BRT buses (segregated rapid lines) and re-organise the regular lines (rationalisation) at very low cost, doing 100 million trips by 12 million of Rio metropolitan inhabitants. This allowed the city to expand and connect the public transportation system (subway, light rail and BRT) and to improve the quality of 60% of buses (air-conditioning, new buses, etc.).

## 4.2 Fortaleza Smart City

Fortaleza is a smart city in the Northeast of Brazil. The mayor purposed as a goal on his campaign the creation of smart city focused on urban mobility. The area was chosen on the basis of a survey on citizens' demands and a diagnosis made by the civil servants, which were included in the Government Plan Fortaleza 2040, the long-term city plan. Urban mobility was the topic with the biggest number of requests and complaints.

To plan and implement the smart city, the mayor invited specialists from the University of Fortaleza (UNIFOR). The specialists created a Science and Technology Foundation (CITINOVA) in the city. CITINOVA was responsible for developing the means to innovate public administration through agreements with universities and private companies. Due the relationship with UNIFOR, University of Arizona (UnofA) was invited to create a private association named International Institute of Innovation of Fortaleza (I3FOR).

I3FOR invested around USD 300.000 with basic operational conditions. This investment was allocated to the equipment's acquisition and personnel hiring. The first smart city public organisational model created was the Immediate Action Plan on Transport and Traffic (PAITT). PAITT has the objective to improve traffic and public transportation in the short term and 12 civil and traffic engineers were involved. Collecting GPS data from buses, they identified the top five worst lines and created BRS (rapid lines not segregated). Some lines increased to 80% to 200% the speed, reducing on average around 30% of time spent on traffic jams.

The second new public organisational model developed by PAITT used data from the system of bicycle racks and rentals, the *Bicicletar*. The engineers identified the most used routes, which time, period and places where bikes were rented. Based on this

analysis, they re-organised all the system to improve the bike usage and urban mobility of Fortaleza inhabitants.

## 4.3 Comparative analysis

The present article is intended to provide insight into dimensions and factors resulting into ambidexterity organizations. These factors should help other cities to become a smart city. Table 1 lists and summarizes the dimensions and factors identified in the literature review. The table shows that a combination of factors influence the quest towards becoming a smart city. The factors identified in the literature were used to compare the two cases. From the 37 factors in total, Rio acted on 34 factors and Fortaleza showed a change on 21 (see table 1 and 2). Rio is the former capital of Brazil and the main touristic place in the country. Rio has one of the biggest GDP in Brazil and has the double of the Fortaleza size. Fortaleza historically is far for the Brazilian dynamic economies, such as Rio and São Paulo. Rio always been at top 5 Smart Cities and Fortaleza reached the 29th position (over 50) this year. Both cities are focussed on urban mobility, but took different approaches.

Human resources are a key ingredient for exploration of new opportunities. Both cities used external experts and created a community of people covering different disciplines. A key aspect to new innovations and public organisational models is to mobilize human capital outside the own organisation. Nevertheless, the city of Rio was better able to capitalize on external human resources due to its reputation, size, and budget available. Rio employed people having different backgrounds and let them collaborate in multidisciplinary teams. The composition of such teams provided to be important factor contributing to the creation working applications addressing these needs. All team members are required to have a minimum level of knowledge of statistics modelling, computer coding and public administration. For this people were educated and this empowered them to do their job.

The smart city strategy was guided by policies for data usage and also so-called enterprise or information architecture efforts. For Rio it was important that this enabled the creation of synergy from legacy systems when developing new smart city apps. Using existing systems can avoid extra expenditures and accelerate development of new systems. This aspect was less addressed in Fortaleza.

GEA should ensure that infrastructures facilitate a diversity in application and public organizational models. The provision of passport renewal services is completely different from letting people participate in the allocation of budgets. The following characteristics were found to be relevant for infrastructures [36].

1. **Real time response**. In some situations, real-time actions are necessary, such as the use of traffic data to manage congestion or response to accidents.
2. **Short-term focus.** There are some services that are important for governments, but can be scheduled better to increase efficiency and reduce cost. Examples are types of surgeries (cataract) and garbage collection.
3. **Long-term focus.** Storing data over a longer period and analysing data can help s to predict car accidents and traffic jams and measures can be taken to prevent them.

Both smart cities created an open data portal. The way data was released and shared was different. The city of Rio took an approach to create a flexible infrastructure that could be used for different purposes. This enabled them to collect and share large volumes of data in real-time. Once this was realized for one purposes it became possible to scale it up and use the infrastructure for other purposes. In the past, public organisations developed their own applications and information systems, resulting in a fragmented landscape. Governments create infrastructures to provide generic functionalities that can be used by different public agencies to develop electronic services. Infrastructures provide the operational foundations for developing and executing all kinds of applications within a short time frame in an agile manner. Good infrastructures facilitate the reuse of existing building blocks, which avoids duplication of effort and saves the cost of developing them repeatedly over time. The creation of a shared infrastructure and collecting all kinds of data in real-time is a major difference between the cities. The creation of such an infrastructure requires large investments and might not be feasible for smaller cities having limited resources.

Having such an infrastructure enables ambidexterity by serving two purposes. Firstly, it can be used for providing current services. Secondly, a flexible infrastructure can be used to create new innovative applications. Hence, from the comparative analysis we conclude that having a shared infrastructure is a key component for employing an ambidextrous strategy to become a smart city.

# 5. CONCLUSIONS AND DISCUSSION

Ambidexterity is the ability of organisation to simultaneous exploit resources and explore new paths. In this study we identified factors affecting this based on the literature. Thereafter 2 similar cases were investigated to explore which factors might contribute to becoming a smart city. Ambidexterity is a complex combination of factors and dimensions. Each factor of the dimensions is part of the methods and processes for achieving enhancement and cost reductions.

Many of the factors were found to be similar between the cases. This might not be surprisingly as cities might mimic each other (mimetic isomorphism) [7]. Nevertheless, the smart cities were different on a number of factors. The results show that access to human resources is a key components and the creation of a shared infrastructure that can easily be extended. In particular, the ability to mobilize human capital outside the own organisation is a key aspects found in both cities.

The analyses also suggest that governments should not take a one-size-fits-all approach to providing services. The context may vary and can be approached using different means. For instance, providing services should follow different channels for those who have no access to the Internet. Knowledge about the channels most appropriate for the people in the city is needed.

A dominating difference between the cities is related to the way infrastructure was prepared and utilized. This suggest that when developing public organisational models, an adaptive infrastructure should be ready to support various public organizational model. A shared infrastructure reduces costs and can increase the quality at the same time. For example the example of Center of Operations where more than 29 secretariats and three level of governments (national, regional and local) worked together, sharing the same facilities and data sets. The level of quality to respond for extreme events on the city (car accident, landslide, etc.) was reduced significantly by utilizing the already developed infrastructure.

Public organisational models should be based on societal and public values and the objectives of public organisations, instead of cities mimicking each other. New Public Organizatonal Models should be developed within a short time frame, in which flexible infrastructures serve as a enablers. This requires that ICT

infrastructures facilitate a variety of different applications and public organisational models.

Smaller cities might not be able to follow this strategy as they have not the necessary resources. For them we suggest to cooperate with other cities to create a shared infrastructure and also to have access to human resources. Such a shared infrastructure can be used to run existing services (exploitation) and to create new innovative services (exploration). In this way they can have the budget and resources to create ambidexterity and accomplish their ambitions.

This research is explorative by nature and the results cannot be generalized as only 2 cases were compared. The research does demonstrate that the cities took similar approaches and on many factors were similar. Some factors were different which can explain the differences in the level of ambidexterity. In further research a survey will be developed to survey a broader range of cities.

**Table 1. Dimensions and factors of public organisational models for public policies and service delivery**

| Dimension | Factors | City 1: Rio de Janeiro | City 2: Fortaleza |
|---|---|---|---|
| **Policy and Legal** | 1. Long legal time required for procedures | 1. Yes | 1. Yes |
| | 2. Recognition of service as a public right (channel for services with protocol and service level agreement SLA) | 2. Yes | 2. No |
| | 3. Digital government plan, taking legislation into consideration | 3. Yes | 3. No |
| | 4. Legislation on general principles, standards and guidelines for implementation | 4. Yes | 4. No |
| | 5. Scenario diagnosis and setting agendas | 5. Yes | 5. Yes |
| | 6. Synergy and no disputes between branches | 6. Yes | 6. Yes |
| | 7. Citizen participation in ranking demands | 7. Yes | 7. Yes |
| | 8. Digital government plan aligned with long-term plans of public organizations | 8. Yes | 8. Yes |
| **Human Resources** | 9. Flexible careers for every task and position | 9. Yes | 9. No |
| | 10. Plan of goals for agencies and secretariats | 10. Yes | 10. No |
| | 11. Bonus for civil servants for reaching goals during the year | 11. Yes | 11. No |
| | 12. Leadership program for civil servants | 12. Yes | 12. No |
| | 13. Data analysis with statistic data sets and other | 13. Yes | 13. Yes |
| | 14. Big data group | 14. Yes | 14. Yes |
| | 15. International relationship with renowned universities | 15. Yes | 15. Yes |
| **Information Systems** | 16. Resilient plan for the city | 16. Yes | 16. No |
| | 17. Trade-offs of features and characteristics | 17. No | 17. No |
| | 18. Choose small and well architected plans instead of larger projects that are likely to fail on delivery | 18. Yes | 18. Yes |
| | 19. Incremental approach to development | 19. Yes | 19. Yes |
| | 20. Avoid casual planning and decision-making | 20. Yes | 20. Yes |
| | 21. Presence of leadership in projects to improve performance; | 21. No | 21. Yes |
| | 22. User involvement and support on the projects; | 22. Yes | 22. Yes |
| | 23. Transaction costs well-addressed | 23. Yes | 23. Yes |
| | 24. Channels to receive complaints and service demands | 24. Yes | 24. No |
| | 25. Open Data Portal | 25. Yes | 25. Yes |
| | 26. Urban Mobility Open Data Sets | 26. Yes | 26. Yes |
| **Government Enterprise Architecture** | 27. Digital plan aligned with architecture of systems | 27. Yes | 27. Yes |
| | 28. Predicted architecture choices impacting on business models | 28. Yes | 28. Yes |
| | 29. Governmental common approach to provide services (Integrated plan, implementation and evaluation - end of departmental organisation) | 29. Yes | 29. No |
| | 30. Data policy for analysis of useful data sets | 30. Yes | 30. Yes |
| | 31. Common framework and standards for data and systems | 31. No | 31. No |
| **ICT Infra-structures** | 32. Modular and flexible by nature | 32. No | 32. No |
| | 33. Reduce and avoid costs over time by reuse or optimization | 33. Yes | 33. No |
| | 34. Interoperability (Open data and architecture) enabling data analysis and big data analytics | 34. Yes | 34. Yes |
| | 35. Enable centralized services for a multi-channel approach | 35. Yes | 35. No |
| | 36. Shared facilities for public policy and service delivery (Center of Operations) | 36. Yes | 36. No |
| | 37. Sensors all over cities | 37. Yes | 37. Yes |

**Table 2. Differences and similarities of public organisational models for public policies and service delivery taken by Rio and Fortaleza**

| Dimension | Factors | Differences and Similarities between Fortaleza and Rio |
|---|---|---|
| **Policy and Legal** | 1. Legal time required for procedures<br>2. Recognition of diversity of societies, tasks, public policies and channels for service delivery<br>3. Digital government plan, taking legislation into consideration<br>4. Legislation on general principles, standards and guidelines for implementation<br>5. Scenario diagnosis and setting agendas<br>6. Political disputes between branches<br>7. Citizen participation in ranking demands<br>8. Digital government plan aligned with long-term plans of public organizations | Rio took more time to develop in comparison with Fortaleza (eight vs four years). This may be influenced the type of approach. Fortaleza directly went to the issue, creating a plan for urban mobility and smart city.<br><br>On the other hand, Rio created a more complex plan, aligning policies to enable collection of data from people, open government and data policies, digital government plan and plan of urban mobility based on the legacy systems and civil participation (1746, Waze, Moovit). |
| **Human Resources** | 9. Flexible careers for every task and position<br>10. Trained and motivated civil servants<br>11. Data analysis with statistic data sets and other<br>12. Plan of goals for agencies and secretariats<br>13. Bonus for civil servants for reaching goals during the year<br>14. Leadership program for civil servants<br>15. Big data group<br>16. International relationship with renowned universities | While Fortaleza has a big data group with civil and traffic engineer (PAITT)s, Rio has a multidisciplinary team of Big Data (PENSA). Both have exchanging technology with renowned universities in the world, helping the development of Big Data analytics.<br><br>However, Rio has a leadership program that enable civil servants to earn bonus (two salaries) at final of the year if reach specific goals for each department. The bonus changed the bureaucratic-orientation to the service-oriented approach in Rio. Doesn't matter which department you work, if you follow the personal goals, the results boost the quality and quantity of public service delivery. |
| **Information Systems** | 17. Resilient business models<br>18. Trade-offs of features and characteristics<br>19. Larger projects are likely to fail on delivery<br>20. Leadership in projects is fundamental;<br>21. Lack of user involvement and support<br>22. Transaction costs not well-addressed<br>23. Haphazard planning and decision-making<br>24. Incremental approach to development<br>25. Channels to receive complaints and service demands<br>26. Open Data Portal<br>27. Urban Mobility Open Data Sets | Both cities have Open data portal and urban mobility data sets. Further, the two cases revealed synergy from legacy systems to new public services can avoid extra expenditures and giving the same boost that new ones.<br><br>However, only Rio has a resilient business model, including leads the Resilient cities in the world. Rio also has each of 1000 civil servant at *Líder Carioca* program is in charge of any public policy or service delivery, which is enhanced by bonus program leading to user involvement and full support. The rest of factors were not identified on the cities, including trade-off studies, |
| **Government Enterprise Architecture** | 28. Architecture choices impact on business models<br>29. Aligned objective and scope for success business model<br>30. Governmental common approach to provide services (Integrated plan, implementation and evaluation - end of departmental organisation)<br>31. Data policy for useful data for analyst<br>32. Digital plan aligned with architecture of systems | Both cities have a digital plan aligned with the existing ICT architecture. They both know the potential and challenges that cities have and deal with them. There is a data policy from the ground that improve data collection, curation of data sets to be useful for big data groups. This enable a governmental common approach to provide service, with interoperability between system and data sets.<br><br>However, while Rio has a holistic approach of public policy and service delivery, this was only noticed in Fortaleza for the urban mobility. |
| **ICT Infra-structures** | 33. Modular and flexible by nature<br>34. Reduce and avoid costs over time by reuse or optimization<br>35. Interoperability (Open data and architecture) enabling data analysis and big data analytics<br>36. Enable centralized services for a multi-channel approach<br>37. Shared facilities for public policy and service delivery (Centre of Operations)<br>38. Sensors all over cities | Both cities have interoperable system and data sets due the digital government plan created. Also have sensors over the city, but Fortaleza has sensors focused on urban mobility (traffic and transit) while Rio has for all the public policies and services. It reduces and avoid costs over time by reuse or optimization.<br><br>However, Rio has a citizen service with a multi-channel approach (Rio 1746) and the shared facility for formulation, implementation and evaluation of public policies and service delivery (Center of Operations Rio - COR). |

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