What is the Source of Smart City Value?
A Business Model Analysis

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ABSTRACT

Smart cities have attracted an increasing international scientific and business attention and an enormous niche market is being evolved, which engages almost all the business sectors. Being engaged in the smart city market is not free-of-charge and corresponding investments are extensive, while they usually concern innovation development and always demand careful planning. However, until today it is not clear how the smart city creates value to its stakeholders or simply how profit is being created. To this end, this paper performs an investigation on the smart city business models and utilizes decision making process with the contribution of smart city experts in order to conclude on the most appropriate one. This paper's findings demonstrate that business models that are followed in practice by smart cities are different to the ones suggested in literature. Moreover, the decision making processes that were followed showed that the optimal choice is the ownership business model group and from its contents preferred the Open Business Model (OBM), with the Municipal-Owned-Development (MOD) as an alternative option.

Keywords

Smart city; business model; value proposition; decision making.

1. INTRODUCTION

A novel smart city market evolves radically and it is estimated to reach US $3 trillion by 2020 and exceed the size of all traditional business sectors (Amarnath, 2010; Kohno et al., 2011). Giles (2012) located the source of this money on embedded operational efficiency, as well as on new entrepreneurship. Many vendors have entered this market and develop either end-to-end or focused solutions, like IBM (2012); Alcatel-Lucent (2011); Schneider (2014); Hitachi (2013); Huawei (2014); Siemens (2014); Oracle (2014); Microsoft (2014); Fujitsu (Hisatsugu, 2014); SAP (2014), CISCO (2014) etc.

However, most corresponding investments are still based on public funding. Anthopoulos and Fitsilis (2014a; 2014b) demonstrated that smart cities (34 and 100 examined respectively) mainly concern public projects, with only 2 cases representing private investments and about 10 concerning PPPs. These findings question the reluctance of the private sector to place own funding on smart cities. CISCO (Falconer and Mitchell, 2012) justified this phenomenon due to city complexities (multiple parties, stakeholders, and processes) and different interests. Another potential reason for this reluctance is described by Giles (2012), who claimed that the value of the smart city market is still under development and enterprises prefer to secure their involvement with government support, standardization and business models. To this end, various smart city standards are under development by standardization bodies (i.e., PAS180 (BSI, 2014), ISO 37120:2014 (ISO, 2014) etc.), which reduce smart city uncertainties, but they do not provide information about the source of smart city profit and other potential values. This paper addresses this fact and aims to answer the following research questions:

RQ1: *what smart city business models exist and are followed by smart cities?*

RQ2*: which are the most appropriate business models for a smart city?*

These research questions are very important to be answered due to the above observation, but also due to the continuous transformation of smart city approaches, which require careful planning (Anthopoulos and Fitsilis, 2014a). Moreover, the answers to these questions will be useful to clarify who must undertake a smart city initiative; why such an initiative must be implemented (value proposition); and how a smart city can sustain in economic terms. From the answers of these questions both the smart city industry and local governments will be benefit, since they will realize the roadmap for smart city success, from corresponding requirements (key-resources); to the value that the smart city proposes to its customers; and to the relationship management processes that must be taken care. Additionally, RQ2 is very important to be answered for a smart city planner, since he has to select the optimal business model and as well as to be familiar of the selection process.

A business model analyzes the sources and processes that contribute to an organization's value (Osterwalder and Pigneur, 2010) and in this respect its application in a smart city can demonstrate its value(s) source(s). Although smart cities concern innovative solutions within the urban space and corresponding business model innovation is expected to appear or has already appeared, traditional business models have been applied in smart cities too.

In an attempt to answer the above questions, this paper follows three research methodologies: literature review; case studies; and multi-criteria decision making with the contribution of smart city experts. First, literature findings are explored regarding business modeling, their classification and patterns. Then existing smart city business models are demonstrated according to literature findings (Alcatel-Lucent, 2012; Turban, 2002) and the outcomes from case studies. All the identified smart city business models are assigned to patterns presented by (Osterwalder and Pigneur, 2010). Finally, the identified models have been given to smart city experts, who decided regarding the optimal for a smart city, with multi-criteria decision making processes.

The remainder of this paper is organized as follows: in the background section 2, a brief theoretical analysis regarding smart city and business model is performed. Then, section 3 contains the research methods and answers to the research questions and finally, in section 4 some conclusions and some future thoughts are given.

2. THEORETICAL BACKGROUND

2.1 Business Models

A business model describes the rationale of how an organization creates, delivers, and captures value (economic, social, cultural, or other forms of value) (Turban, 2002; Morris et al., 2006). According to Timmers (1998), a business model concerns "an architecture of the products, services and information flows". This definition recognizes actors, roles, potential business value and the source of revenue. Alternative tools for business model composition and visualization exist, among which the most popular are the *business model matrix* (Walravens, 2012) and the *business model canvas* (Osterwalder and Pigneur, 2010). The *matrix* focuses on control and value parameters, while the *canvas* contains four components and focuses on value proposition (Bucherer and Uckelmann, 2011):

- The *Infrastructure* component describes the key partners in value proposition, which perform key activities and require key resources to implement the value proposition.

- The *value proposition* specifies what is actually delivered to the customer.
- The *customer* component includes the customer segments addressed by the company, such as related channels and customer relationships.
- The *financial* component comprises the costs as well as the revenues.

Although there could be various value propositions, business models can be classified in five patterns according to (Osterwalder and Pigneur, 2010):

- *Unbundling*, which can be utilized by firms that perform all the three fundamentally different types of businesses: customer relationship; product innovation; and infrastructure businesses.
- The *long tail* according which a firm try to sell less for more. This model can be addressed by the offering of a large range of niche products, each of which sells relatively infrequently.
- *Multi-sided platforms*, which bring together two or more distinct but interdependent groups of customers.
- *Free* that continuously benefits at least one substantial customer segment from a free-of-charge offer.
- *Open* that can be used by companies to create and capture value by systematically collaborating with outside partners.

Furthermore, business model innovation concerns the development of novel business models (Bucherer and Uckelmann, 2011).

2.2 Smart City and Business Models

Various scholars (i.e., Giffinger et al., 2007; Komninos, 2002; Janssen and Kuk, 2011; Churabi et al., 2012; Anthopoulos et al., 2014) define smart city with means of integrating the Information and Communications Technologies (ICT) with the urban space and provide the city with solutions that enhance city's 6 dimensions: *people, economy, governance, mobility, living* and *environment*.

Anthopoulos and Fitsilis (2014a) showed that smart city evolution's timeline passed through various phases: starting from late 1990s, where the ICT supported social participation and cohesion; they evolved to urban spaces attracting investments; later to ubiquitous technologies installed across the city; and recently to solutions that support environmental sustainability. Today, the smart city paradigm is being utilized for large-scale new city construction, to existing urban facilities' upgrade or even for small-scale constructions, like campuses and expositions (Expo 2015 S.p.A, 2013).

Regardless their form or size, almost all well managed smart cities follow the multi-tier architecture (ITU, 2015). This architecture involves the emerging Internet-of-Things (IoT), meaning that many smart cities could utilize data from sensors, buildings and users-as-sensors with their applications, without necessarily install large-scale facilities. This architecture demonstrates smart city components as follows:

- *Natural Environment* (local landscape and natural resources);
- *Non-ICT-based hard infrastructure layer*, which contains facilities like roads, bridges, buildings and utilities (water, energy etc.);
- *ICT-based hard infrastructure layer* that contains ICT-based equipment like broadband networks, smart buildings, IoT etc.;
- *Services layer*, which aggregates various types of smart services provided by smart city stakeholders via corresponding facilities;
- *Soft infrastructure layer*, which concerns smart-services' end-users, software applications and data.

Business models could refer to any or all the smart city components. For instance, smart city vendors develop and deploy facilities; operators earn from facility utilization or service provision; service providers earn from their service delivery etc. To this end, various traditional business models can be deployed in a smart city.

On the other hand, the IoT offers great potential for innovation business models, since it interconnects product stream with information stream (Bucherer and Uckelmann, 2011; Gao et al., 2015). Corresponding business models capitalize the seventh information laws, regarding its share-ability; perish-ability; value increment with accuracy, combination and use; more does not mean better; and non depletability. These IoT characteristics and information laws indicate the information value, which concerns *delivery of right information, in the right granularity, at the appropriate condition, in time, anywhere at an appropriate price*. This risen value has introduced several innovative business models (Table 3).

3. RESEARCH METHODOLOGY

A multi-method approach was followed in an attempt to answer this paper's research questions. More specifically, literature review was the first method, which discovered existing business models as well as business models that are being followed in smart cities. The second method was the case study analysis, according which, 11 smart cities were explored for their business models and equal corresponding experts as well as 3 representatives from international organizations were interviewed in order to identify the business models that were followed in their smart city projects. Finally, the ELECTRE and ELECTRE TRI decision making processes were executed with the contribution of these experts in order to identify the most appropriate smart city business model.

3.1 Literature Findings

Authors performed a literature review on SCOPUS® and Google Scholar® with the combination of "smart city" and "business model" keywords. This review was performed on December 2014 and updated on July 2015 and contains outcomes from articles that were published until that date.

Table 1: Literature Review Outcomes (First Round)

	SOURCE	***Results***
1	SCOPUS®	27
2	Google Scholar®	892

Table 2: Literature Review Outcomes

	SOURCE	***Results***	***Articles After Screening***	***Citation***
1	SCOPUS®	22	6	Janssen and Kuk (2011); Molinari (2012); Walravens (2012; 2013; 2015; 2015b)
2	Google Scholar®	892	20	Amarnath, (2010); Nam and Pardo (2011); Anthopoulos and Fitsilis (2013; 2014b); Perera et al. (2014); Lindgren et al. (2010); Lee et al. (2010); Mulligan and Olsson (2013); Ferro and Osella

	SOURCE	*Results*	*Articles After Screening*	*Citation*
				(2013); Kitchin (2014); Jin et al. (2014); Vilajosana et al. (2013); Kohno et al. (2011); Alusi et al. (2011); Johnson et al. (2013); Schaffers et al. (2012); Deakin (2011); Silva and Maló (2014); Valja et al. (2013); Casprini et al. (2014); Dlodlo et al. (2013); Ballesteros et al. (2015)

Authors performed screening on the initial results (Table 1), leaving out editorial, articles generally speaking about smart city alone or business modeling alone, as well as smart technologies in doing business or business models for individual smart solutions –i.e., smart grids or smart buildings-. Finally, duplicates, as well as articles that initially appeared in conferences and later evolved to journal articles were left out (Table 2). A starting point in analyzing the status of smart city business models is to clarify the modeling contents with responses to the following questions:

- Q1: *who produces value*?
- Q2: *what type of value can be produced?*
- Q3: *who are the value beneficiaries?*
- Q4: *which are the corresponding cost and revenue structures?*

With regard to Q1, when value producer in smart cities is the smart infrastructure owner, Amarnath (2010) and Faktory (2014) provide efficient information (Fig.-2) (Table 3).

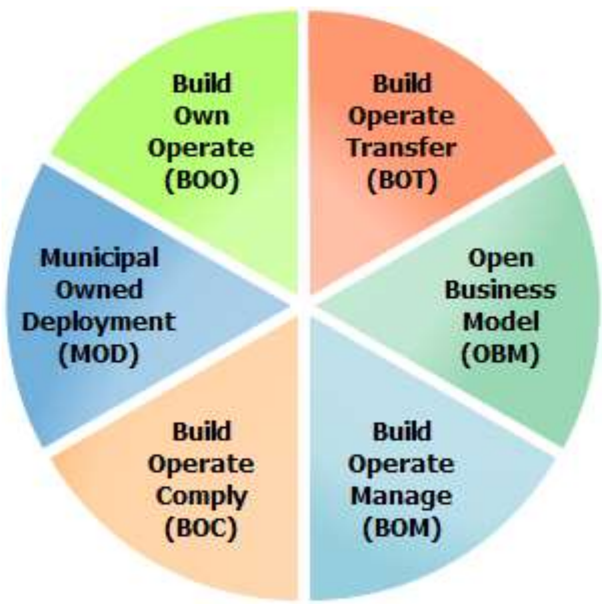


Fig.-2: Smart City Business Models (Amarnath, 2010; Faktory, 2014)

These business models suggest that value creators could be (Amarnath, 2010) *integrators* that interconnect various sectors or even perform end-to-end integration; *Network Service Providers* that offer collaborative networks, data analytics and enterprise working solutions; *Pure-Play Product Vendors* that provide "hard assets" like smart meters; and *Managed Service Providers* that offer services like monitoring, on-site consulting etc. Beyond the above, novel businesses can utilize open assets (i.e., open data) to create and deliver smart services (i.e., apps) within the smart city nexus. Smart infrastructure enables new innovative strategies via connecting people, institutions and companies, where enterprises can recur at crowdsourcing via outsourcing a task and learn from civic open innovation (Casprini et al., 2014). This infrastructure enables various use cases regarding all smart city dimensions –i.e., mobile parking payments, alerting waste collection services etc.-, which offer novel business opportunities (Dlodlo et al., 2013).

Moreover, IoT extends the above models, since smart infrastructure is being installed by various vendors independently and business model innovation can be developed (Silva and Maló, 2014). More specifically, IoT becomes one of the smart city service enablers (Elmangoush et al., 2013), since it addresses Machine-to-Machine (M2M) communication that can be applied in all types of smart services.

On the other hand, value (Q2) considers that smart city meets its challenges, in terms of enhancing urban life with regard to the six dimensions. This value is being created via smart service delivery and alternative value propositions can be provided. Value beneficiaries (Q3) are both smart service providers (supply side) and service consumers (demand side, since providers compose value propositions to their consumers. Finally, cost and revenue (Q4) depend on value proposition and vary according to the type of business that is being developed.

Taking into account all the above information, authors explored literature findings and aggregated the identified business models for smart cities in 6 groups (Table 3):

- *E1. Internet of things:* corresponding business models.
- *E2. Network ownership:* utilize smart infrastructure and basically communication network ownership.
- *E3. Web-based:* address public sector value propositions that can be delivered via e-government practices (Table 4).
- *E4. E-commerce:* concern internet-based business like online selling, advertising etc. (Table 5)
- *E5. Business model innovation*.
- *E6. Ownership business models:* address smart city project ownership or management.

Table 3: Smart City Business Models

<table>
<tr><th></th><th>Business Model</th><th>Description</th><th>References</th></tr>
<tr><td colspan="4">E1. Internet of things</td></tr>
<tr><td>1)</td><td>Direct information payments</td><td>Digital goods’ direct selling</td><td rowspan="14">Bucherer and Uckelmann (2011);
Gao et al. (2015);
Perera et al. (2014);
Casprini et al. (2014);
Dlodlo et al. (2013);
Silva and Maló (2014);
Elmangoush et al. (2013);
Jin et al. (2014);
Vilajosana et al. (2013);
Kitchin (2014);
Valja et al. (2013)</td></tr>
<tr><td>2)</td><td>Advertisements</td><td>Digital advertisements</td></tr>
<tr><td>3)</td><td>Fremium</td><td>Smart service provision, which combine free-of-charge delivery (Free) with charges on extras (Premium)</td></tr>
<tr><td>4)</td><td>Pay-per-use/Pay-As-You-Use/Pay-As-You-Go</td><td>Application of different charge levels, according to content or service use.</td></tr>
<tr><td>5)</td><td>Discovery services</td><td>Information discovery and intelligence services</td></tr>
<tr><td>6)</td><td>Decision making add-ons</td><td>Software add-ons on existing applications</td></tr>
<tr><td>7)</td><td>Electronic Data Interchange (EDI)</td><td>High level data access contracts.</td></tr>
<tr><td>8)</td><td>Service-Level-Agreements</td><td>High quality of service availability contracts.</td></tr>
<tr><td>9)</td><td>Alert services</td><td>Services that offer pre-analyzed information alerts.</td></tr>
<tr><td>10)</td><td>Co-creation</td><td>Information co-creation and co-deployment services.</td></tr>
<tr><td>11)</td><td>Data-mining</td><td>Data-mining and data-warehousing services.</td></tr>
<tr><td>12)</td><td>Product-as-a-Service</td><td>Services that enable product payment per-use instead of ownership.</td></tr>
<tr><td>13)</td><td>Information Service Provider</td><td>Services that offer pre-analyzed information.</td></tr>
<tr><td>14)</td><td>End-user involvement</td><td>Crowd-sensing services</td></tr>
</table>

15)	Right-time Business Analysis and Decision making	Real-time product monitoring services.	
16)	Open data product and service creation	Open data utilization for new products or services	
E2. Network ownership models			
17)	Private	Network installation and operation by a single private provider.	Anthopoulos and Fitsilis (2013; 2014b); Alcatel-Lucent (2012)
18)	Exclusive	Network installation with public procurement processes by a private contractor.	
19)	Managed	Constructor assigns private network management to a single operator. Various providers can rent the network and offer communication services.	
20)	Open	Various constructors can install and operate their private networks with procurement processes.	
21)	Private	A single constructor can install and operate its private network.	
E3. Web-based			
22)	Content Provider	Static and/or dynamic digital content provision services (i.e. for a product or an organization etc.).	Janssen and Kuk (2011); Deakin (2011); Molinari (2012); Ferro and Osella (2013)
23)	Direct-to-Customer	Direct service provision (information, communications or transactions)	
24)	Value-net-integrators	Information collection, process and deployment services, which focus on particular customer groups (i.e., businesses)	
25)	Full Service Provider (FSP)	Organizations provide full services (collaborating with various segments or other organizations) directly or via allies owning customer relationships	
26)	Infrastructure service provider	Infrastructure rental or Product-as-a-Service (PaaS)	
27)	Market Creation	Demand and supply matching services (i.e., volunteer network structuring)	
28)	Collaboration	Tools provision for civic-engagement, decision making, crowd-sourcing etc.	
29)	Virtual Communities	Groups of common interests are structured and share content	
E4. E-commerce			
30)	Value chain integration	Productivity, efficiency and accessibility increase	Turban (2002); Yovanof and Hazapis (2009); Walravens (2012) Ferro and Osella (2013)
31)	Social networks	Utilize social networks for promotion and selling	
32)	Direct online marketing	Online advertisements, newsletters and campaigns	
33)	Digital malls	Online marketplaces	
34)	Information agents	Information service providers	
35)	Affiliate marketing	Online advertisements	
36)	Tendering	Online spaces with tendering options	
37)	Reverse auctioning	Online spaces with reverse auctioning options	
38)	Group purchasing	Virtual communities with common purchase interests	
39)	Customization	Services for custom product or service design and deployment	
E5. Business model innovation			Nam and Pardo (2011)
40)	Create business opportunities	Smart facility offering to attract businesses	Ferro and Osella (2013); Lindgren et al. (2010); Vilajosana et al. (2013)
41)	Smart city know how to other cities	A city becomes a consultant to another	Anthopoulos and Fitsilis (2013; 2014b);
42)	Develop high speed networks and smart grids for energy management	Network and smart-grid network installation	Amarnath (2010); Lee et al (2010); Kohno et al. (2011); Mulligan and Olsson (2013)
43)	Develop new ideas for the urban space	Urban space enhancement services	Johnson et al. (2013); Ballesteros et al. (2015)
44)	City as a product	Create cities from scratch	Kohno et al. (2011); Alusi et al. (2011)
45)	Climate change management	Solutions deployment for climate change monitoring and response	Anthopoulos and Fitsilis (2014b);
46)	Develop standards for smart city solutions	Standards' development and deployment	Anthopoulos and Fitsilis (2014b);
47)	Develop cloud services and open	Smart cloud service and open data provision	Walravens (2012; 2015);

	data		Ferro and Osella (2013); Kitchin (2014);
48)	Engage mayors internationally to preserve climate change and establish urban resilience.	City alliances of common interest (i.e., ICLEI, European City Innovation Network etc.)	Anthopoulos and Fitsilis (2014b);
E6. Ownership business models			
49)	Build Own Operate (BOO)	The smart city planner independently builds the city infrastructure and delivers smart city services	Amarnath (2010); Faktory (2014)
50)	Build Operate Manage (BOM)	The smart city planner appoints a trusted partner to build the city infrastructure and provide smart city services for a specific period	
51)	Build-operate-transfer (BOT)	The smart city planner appoints a trusted partner to develop the city infrastructure and services (PPP)	
52)	Build-operate-comply (BOC)	The smart city planner provides a more open environment, creating a platform for development and allowing private entities to build services atop, as long as they agree to certain regulations and funding levels	
53)	Municipal-owned-deployment (MOD)	The city takes responsibility for the entire project	
54)	Open Business Model (OBM)	The smart city planner allows any qualified company or business organization to build city infrastructure and provide city services	

Table 4: web-based business models applied by cities and their interrelations

id	Web-based business model	Business model pattern
1.	*Full service provider (FSP)*	*Unbundling*
2.	*Content provider*	*Direct service provision*[1]
3.	*Direct-to-customer*	*Direct service provision*[1]
4.	*Value-net-integrators*	*Open*
5.	*Infrastructure service provider*	*Unbundling*
6.	*Market*	*Open*
7.	*Collaboration*	*Open*
8.	*Virtual communities*	*Open*

[1]*Direct service provision does not concern a pattern*

Tables 4 and 5 illustrate how web-based (Kuk and Janssen), e-commerce (Turban, 2002) and network-ownership (Alcatel-Lucent, 2012) business models respectively, match the patterns that were presented in section 2.1. These outcomes demonstrate that open pattern appears most in web-based models, while unbundling instances exist too. Traditional business models exist even in web-based cases and the city operates as a direct content and service provider. In (Table 5) each service group was considered to be offered by an individual provider (or groups of stakeholders), while the assignment of a pattern in (Table 6) considered the network facilities to be the key-resource for value proposition.

Table 6 shows that the unbundling pattern appears most in the examined cases and more specifically in all cases where key-infrastructure exists. This is a reasonable outcome, since all smart city forms require different types of facilities for smart service provision (networks, grids, sensors, etc.). Things change when the IoT is utilized as the key-resource, which results to the corresponding business models (Table 3).

Table 5. E-Commerce business models

id	e-Commerce Business Model(s)	Cases	Business model pattern
1.	1. Social Networks	America-On-Line (AOL), Kyoto (Japan), Bristol (U.K.)	*Free*
2.	1. Membership 2. Social Networks 3. Affiliate marketing	Copenhagen Base, Craigmillar Community Information Service (Scotland)	*Open*
3.	1. Value chain integration	Seoul, Beijing, Helsinki, Geneva-MAN (Switzerland), Antwerp (Belgium)	*Unbundling*
4.	1. Affiliate marketing 2. Value chain integration 3. Membership	Taipei (Taiwan), Tianjin (China), Barcelona, Brisbane (Australia), Malta, Dubai	*Unbundling*
5.	1. Value chain integration 2. Social networks 3. Direct online marketing 4. Digital malls 5. Information agents 6. Affiliate marketing 7. Tendering 8. Reverse auctioning 9. Group purchasing 10. Customization	Hull (U.K.), Cape Town (South Africa) Trikala (Greece) Tampere (Finland) Knowledge Based Cities (Portugal) Austin (U.S.A.) Blacksburg Electronic Village (U.S.A.)	*Unbundling*
6.	1. Value chain integration	New Songdo (S. Korea), Dongtan (S. Korea), Osaka (Japan), Manhattan Harbour, Kentucky (U. S.A.), Masdar (United Arab Emirates) Helsinki Arabianranta (Finland)	*Unbundling*
7.	1. Customization 2. Social networks	Dongtan (S. Korea), Tianjin (China), Austin (U.S.A.), Amsterdam, Copenhagen, Taipei (Taiwan)	*Unbundling*

Table 6. Network ownership business models

id	Business Model	Cases	Business model pattern
1.	Open (Public Network)	Bristol (U.K.), Amsterdam, Cape Town, South Africa, Helsinki, Antwerp, Belgium	*Open*
2.	Private (Independent Private Developer)	Malta, Dubai, New Songdo, Taipei, Taiwan, Tianjin, China, Dongtan (S. Korea), Osaka, Austin (U.S.A..), Manhattan Harbour (Kentucky, U.S.A.), Masdar (United Arab Emirates)	*Unbundling*
3.	Exclusive (Selected Provider)	Seoul, Beijing, Helsinki Arabianranta (Finland), Blacksburg Electronic Village (Australia)	*Unbundling*
4.	Managed (Appointed Provider)	Geneva-MAN, Trikala (Greece), Barcelona, Brisbane, Tampere (Finland), Hull (U.K.), Knowledge Based Cities (Portugal)	*Unbundling*
5.	Not Applicable	America-On-Line (AOL) Cities	*Information Service Provider* [1]
6.	Not Applicable	Kyoto (Japan)	*Information Service Provider*[1]
7.	Not Applicable	Copenhagen Base	*Open*
8.	Not Applicable	Craigmillar Community	*Open*
9.	Not Applicable	Information Service, Scotland	*Open*

[1]*Direct service provision does not concern a pattern*

3.2 Case Studies

Except from the above literature findings, a sample of smart cities were explored with regard to the business models that they follow. This occurred with physical visits and interviews with the corresponding smart city leaders (Table 7) for the purposes of a research project. Smart city leaders were considered experts in terms of smart city value understanding and corresponding source identifications. Experts' identities and affiliations are left out for privacy issues with respect to their requests. Case studies were selected according to their appearance in literature and in order to present outcomes from almost the entire globe. The experts were selected either due to their personal appearance or to the appearance of their organization in smart city literature. The outcomes are of extreme interest, since the interviewers consider the smart city from different lens. Table 7 depicts the extracted value propositions, which have been assigned to business models and patterns.

Table 7: Outcomes from visits and interviews by smart city experts

id	Case	Interview Date	Proposed Value	Business Model	Pattern
1.	Tampere	25/4/ 2012	Create business opportunities	Open network with expert free-lancers	Open
2.	Trikala	10/10/ 2014	Smart city know how to other cities	Direct sale	Unbundling
3.	Geneva	30/8/2013	Develop high speed networks and smart grids for energy management	Open access network (rent to operator)	Open
4.	Zurich	2/9/2013	Develop high speed networks and smart grids for energy management	Open access network (rent to operator)	Open
5.	Australian cases (Brisbane, Queensland, Melbourne)	20/7/2013	Develop new ideas for the urban space	Full service provider	N/A
6.	New Songdo, Seoul	19/2/2014	City as a product	Full service provider	Unbundling
7.	London	28/4/2014	Climate change management	Full service provider	Unbundling
8.	Smart Vienna	4/4/2014	Develop standards for smart city solutions	Value-net-integrators	Open
9.	New York City DoITT	3/10/2014	Develop cloud services and open data	Information service provider	Unbundling
10.	World Bank	29/9/2014	Develop cloud services and open data in developing countries' cities	Information service provider	Unbundling
11.	UN ITU	18/10/2014	Standardize smart sustainable city infrastructure	Open access network (rent to operator)	Open
12.	UN Habitat	2/10/2014	Engage mayors internationally to preserve climate change and establish urban resilience.	N/A	N/A

These findings demonstrate that open access network is the most favorite among the other network ownership models. Results provide with answer RQ1, since a portfolio of 54 business models (Table 2) and some business model innovation (Table 7) exist and are followed by smart cities. Moreover, the grounded hypothesis is validated, since almost all of these business models can be assigned to existing patterns.

3.3 Decision Making on Smart City Business Models

In an attempt to answer RQ2, parts of the interviews with the smart city experts (Table 7) concerned business model selection with the decision making methodologies. Decision making is a process that concerns the optimal -among alternatives- choice, with the application of particular criteria (Yates, 2010). Various terms deal with decision making and concern, *the decider* who is the person that selects a solution to a specific problem; *alternative* is a solution to the problem; *alternatives' set* is the group of available solutions, which have to be homogenous and remain unchanged during the process lifecycle; *implication* is an indirect result of the decision making; *preference* is the prioritization of a solution compared to its alternatives; *preference scale* is the classification of the alternatives according to various criteria; *decider's preference profile* concerns the characteristics of a decider -i.e., experiences, values etc.-, which affect his decision; *criterion* is a parameter, the value of which influences the decision making process; *criterion scale* is the set of values that a criterion can take; *monotony* describes a criterion, the values of which, when they increase or decrease, the corresponding *preference* changes respectively; and *criterion weight* is a value that describes the importance of the criterion to the decider (Yates, 2010).

The decision making process combines decider's personal estimations with the estimated implications of each choice and does not necessarily result to the optimal solution. Instead, it returns the choice that best satisfies the decider, compared to the alternatives. In the *Multi-Criteria Decision Making (MCDM)* process the alternatives are classified according to more than one criteria (Yates, 2010) and consists of the following steps:

- *1st step - decision purpose definition*: alternatives' definition and classification.
- *2nd step – criteria definition*: it has to result to monotonous, complete and redundant criteria.
- *3rd step – selection model definition*: criteria are grouped in classes and structure an assessment model.
- *4th step – decision making*: decider uses the model and concludes on the alternative.

For the purposes of this paper, the *ELECTRE* (Elimination Et Shoix Traduisant La Realite) multi-criteria decision making process (Rogers et al., 2010; Pang et al., 2011)) is followed. This method was introduced in 1965 and has been updated several times since then. The most famous version is the third one, named *ELECTRE TRI* (Mousseau et al., 2000). The reasons that made the authors prefer these methods against other decision making processes concern their broad applicability on every type of decision problems; their ability to define alternatives and selection criteria in detail; and the increased accuracy that their combination secures.

In this paper, the decision purpose concerns the identification of the most appropriate business model for a smart city, while the overall selection process is useful for similar problems. The alternatives are the six business model groups (E1-E6) and their contents. The selection criteria were chosen to be the 5 (from totally 6) smart city dimensions (*I1: Economy, I2: Governance, I3: People, I5: Living* and *I6: Environment*), which have been utilized by United Nations Habitat for city key-performance indicators' definition. Another index (I4) was defined and concerned city infrastructure, in order to reflect the city type (new or existing) as well as the smart city type according to their classification (Anthopoulos and Fitsilis, 2013). All these indexes are qualitative and their values range between 1 and 10.

3.3.1. ELECTRE I

During the interviews, panelists gave answers, which expressed their opinion with values to the above indexes (Table 8), which range for each index: I1 - Economy: 6 (3-9); I2 – Governance: 6 (3-9); I3 –

People: 3 (5-8); I4 – Infrastructure: 5 (4-9); I5 - Living: 3 (5-8); and I6 – Environment: 3 (5-8). Moreover, these values define as the most important criterion to be the I1, which sounds normal -since the process seeks for a business model- and to this end I1 receives weight value 100, while the remaining criteria receive relative weights (Table 9).

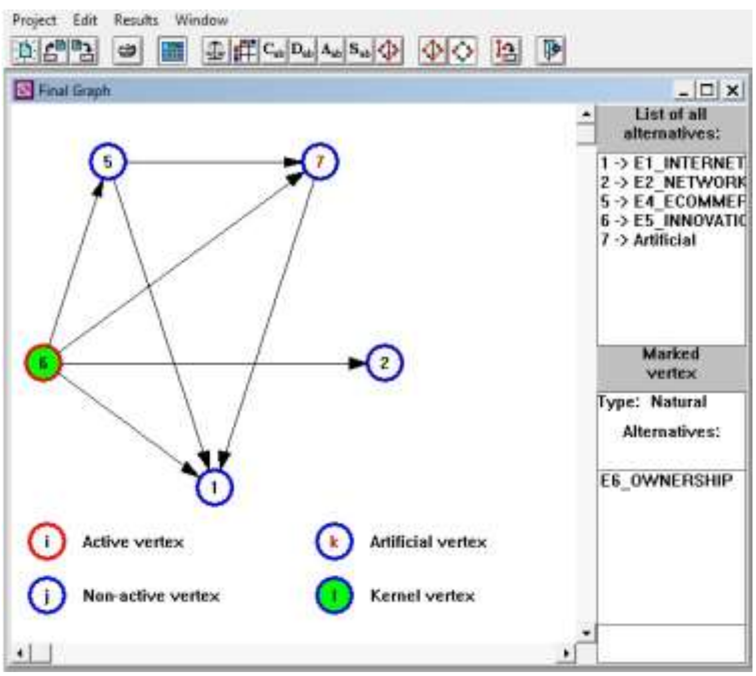
Table 8. Values for Alternatives Per Criterion

	I1	*I2*	*I3*	*I4*	*I5*	*I6*
E1	3	3	8	4	8	5
E2	9	5	5	9	6	5
E3	6	9	8	5	5	5
E4	6	8	8	5	5	5
E5	8	8	8	5	5	6
E6	9	8	8	9	7	8

Table 9. Criteria's Relative and Normalized Weights

	Relative	*Normalized*
I1	100,000	50,00%
I2	33,333	16,68%
I3	16,666	8,33%
I4	16,666	8,33%
I5	16,666	8,33%
I6	16,666	8,33%

Fig.-3: ELECTRE I results



Weights' total sum for all the criteria is 199,997% and as such, normalized weights can be calculated (Table 9). Cutting level λ (Pang et al., 2011; Mousseau et al., 2000) for the above values is *0.7* and expresses a reliable decision. Veto threshold takes values between *1/3* and *2/3* of maximum value range for criteria I1, I2 and I3:

- I1. Economy: 3 (value range 6)
- I2. Governance: 3 (value range 6)
- I3. People: 0.5 (value range 3)

All the above values demonstrate relative supremacies, which were given as input to ELECTRE I© software and results can be depicted on (Fig.-3). Graph contains the alternative models (nodes), while arrows illustrate that the source node is more preferred compared to the destination node. According to these results, the alternative *E6 - Smart City Ownership model group* has been awarded to be the optimal choice.

3.3.2. ELECTRE TRI

This method was used to return the most suitable business model in terms of its ability to describe smart city value source, according to the participants, which is member of the previously identified E6 - ownership group. More specifically, it uses the same indexes with ELECTRE I process (I1-I6) in order to classify the 6 alternatives (*A1: BOO; A2: BOM; A3: BOT; A4: BOC; A5: MOD; A6: OBM*) in 3 categories (good, intermediate and bad). Experts provided with new values the alternatives (Table 10), which result to criteria ranges: I1 - Economy: 4 (4-8); I2 – Governance: 4 (5-9); I3 – People: 4 (4-8); I4 – Infrastructure: 2 (7-9); I5 - Living: 4 (4-8); and I6 – Environment: 2 (6-8). I1 has been rated the most important criterion again (Table 11).

Table 10. Values for Alternatives Per Criterion

	I1	***I2***	***I3***	***I4***	***I5***	***I6***
A1	4	9	4	7	4	8
A2	5	8	4	8	4	7
A3	6	6	4	8	4	7
A4	7	6	4	8	4	7
A5	7	8	5	8	5	7
A6	8	5	8	9	8	6

Table 11. Criteria's Relative and Normalized Weights

	Relative	***Normalized***
I1	100,00	30,78%
I2	50,00	15,38%
I3	50,00	15,38%
I4	25,00	7,70%
I5	50,00	15,38%
I6	50,00	15,38%

ELECTRE TRI uses two templates: *best* (*r1*) distinguishes good from intermediate alternatives, while the *worst* (*r2*) differentiates intermediate from bad alternatives.

Table 12. Templates' values for Criteria

	r1	*r2*
I1	6.5	5.5
I2	7.5	6.5
I3	6.5	5.5
I4	8.5	7.5
I5	6.5	5.5
I6	7.5	6.5

Table 13. Indifference Thresholds' values for Criteria

	r1	*r2*
I1	0.35	0.30
I2	0.40	0.35
I3	0.35	0.30
I4	0.45	0.40
I5	0.35	0.30
I6	0.40	0.35

Table 14. Preference Thresholds' values for Criteria

	r1	*r2*
I1	1.0	0.85
I2	1.15	1.00
I3	1.00	0.85
I4	1.30	1.15
I5	1.00	0.85
I6	1.15	1.00

Table 15. VETO Thresholds' values for Criteria

	r1	*r2*
I1	2.30	1.95
I2	2.65	2.30
I3	2.30	1.95
I5	3.00	2.65

The *good* class contains the best choices; *intermediate* consists of the ones that require further analysis in order to be classified in good and bad choices; and *bad* class consists of the alternatives that have to be discarded. Templates for each criterion receive values between *0-1/3* of range; *1/3-2/3* of range; and *2/3-1* of range, which validates that *r2=1/3* of range and *r1=2/3* of range (Table 12). Moreover, indifference thresholds for each criterion are set to an approximate 5% of each template (Table 13), while preference thresholds are approximately 15% of each template (Table 14). Finally, veto thresholds are set to an approximate 35% of the template value (Table 15), while the experts placed veto to I1, I2, I3 and I4 criteria. The cutting level λ for the above values is 0.8 and expresses a reliable decision for an alternative, compared to the template value. These values were given as input to ELECTRE TRI© software and (Fig.-4) and (Fig.-5) contain the results regarding credibility degrees and preference relations accordingly.

Fig. 4: Credibility degrees

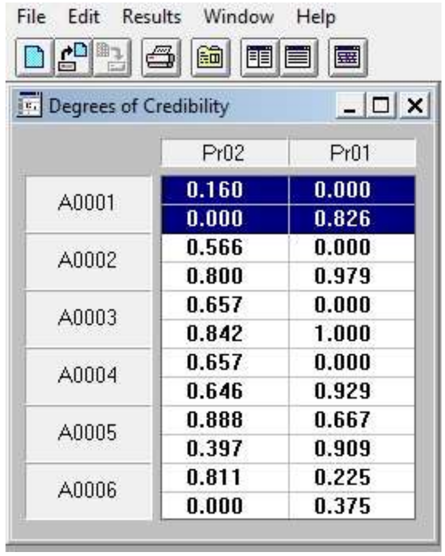


Fig. 5: Preference relations

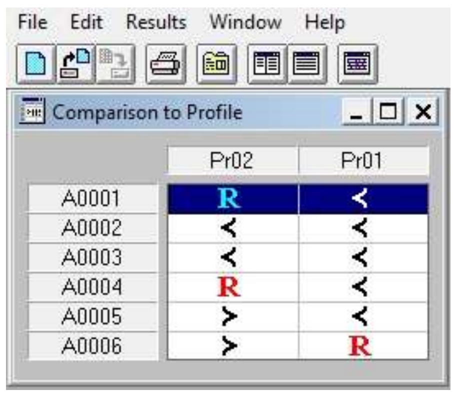


Table 16. Preference Thresholds' values for Criteria

	Pessimistic Assignment	***Optimistic Assignment***
A1	Bad	Intermediate
A2	Bad	Bad
A3	Bad	Bad
A4	Bad	Intermediate
A5	Intermediate	Intermediate
A6	Intermediate	Good

Finally, alternatives were assigned to the three classes according to optimistic and pessimistic assignments (Table 16). The optimistic assignment demonstrates that A6 (OBM) is a good choice while, the pessimistic assignment depicts that no choice is good, but A5(MOD) and A6(OBM) concern intermediate choices that require deeper analysis.

3.4 Discussion

The multi-method approach that this study followed, returns useful findings. More specifically, a broad number of 54 business models have been applied in smart cities, according to the literature findings and the examined cases, while almost all of them align to three patterns (open, free and unbundling). These findings answer RQ1, while they validate this paper's grounded hypothesis. .. A quite unexpected outcome comes from the examined cases and concerns network's commercialization, where theoretically proposed business models do not appear in practice and the open access model is mostly preferred.

Important findings have also been extracted regarding the values that the investigated smart cities propose. Today, smart cities promise to manage urbanism, climate change and resources in agglomerations. However, these values do not clearly appear when the question goes to the business model. More specifically, all the examined business models return value to stakeholders in terms of local government's internal efficiency (web-based models); revenue (network providers); city attractiveness (e-commerce models); or standardization (value integrators). Finally, the IoT is being discussed extensively and corresponding business model innovations are being developed.

These outcomes are of extreme interest to both the smart city industry and the local governments. Today, skepticism appears that the smart city comes rather to serve technology push, which is enforced by vendors instead to implement its promises (Soderstrom et al., 2014). To this end, this study demonstrates how the proposed values will be delivered to smart city stakeholders and the means, which would involve vendors in smart city market.

With regard to the research question RQ2, ELECTRE I and ELECTRE TRI showed that the ownership business model group is the most preferred for smart cities, and the Open Business Model (OBM) is suggested to be the optimal choice, with the Municipal-Owned-Deployment (MOD) to follow. The OBM had been suggested by literature findings too and it was not a surprise. On the contrary, the MOD was an unexpected outcome due to its complexity and the sustainability questions that this choice rises, but it can be justified by the fact that today, smart city development is based mainly on public funding.

4. CONCLUSIONS

This paper addresses a significant problem regarding money and value sources of the smart city. More specifically, although smart city concerns a fast growing market, it is not clear how value is created. This problem's importance is big due to the investments' size and to the documented private sector's reluctance to enter this market without public funds. Vendors justify this reluctance with complexity barriers. In this regard, this paper investigated smart city business models and grounded 2 research questions concerning their variety, classification and preference.

In an attempt to answer this paper's research questions, a multi-method approach was followed. More specifically, literature findings regarding smart city business models were collected and discussed. Literature returned 6 business model groups, which consist of 54 alternatives and have been utilized by various smart city cases. Business model patterns were assigned to the identified smart city business models and successful matching to three patterns was observed (open, free and unbundling). Moreover, this paper examined 11 case studies and documented that the adopted business models are quite different to the ones discovered in literature.

Finally, the multi-criteria decision making methodologies ELECTRE I and ELECTRE TRI were designed and executed with the contribution of smart city experts, in an attempt to identify the optimal business model for a smart city. The followed processes can become a pattern for future similar problems. Participants suggested the ownership business model group and from its contents preferred the Open Business Model (OBM), with the Municipal-Owned-Development (MOD) as an alternative option.

Although this paper concluded on the most appropriate smart city business model, its success has to be validated further with business model frameworks like e^3value (Valja et al., 2013), which concerns a future perspective of this paper. Some more future thoughts concern the continuous evolution of smart city business modeling, due to both the increased innovations that generate novel value propositions, as well as to the evolution of the IoT. Future similar studies can demonstrate whether corresponding business attitudes change.

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